Reports to the Secretary of State for the Home department on the use of phosphorus in the manufacture of lucifer matches.

Contributors

Thorpe, T. E. 1845-1925.
Oliver, Thomas, Sir, 1853-1942.
Oliver, Thomas, Sir, 1853-1942.
Cunningham, George.
Royal College of Physicians of London

Publication/Creation

London : HMSO, 1899.

Persistent URL

https://wellcomecollection.org/works/xhs98prp

Provider

Royal College of Physicians

License and attribution

Wellcome Collection
183 Euston Road
London NW1 2BE UK
T +44 (0)20 7611 8722
E library@wellcomecollection.org
https://wellcomecollection.org

REPORTS

TO

THE SECRETARY OF STATE FOR THE HOME DEPARTMENT

ON THE

USE OF PHOSPHORUS IN THE MANUFACTURE OF LUCIFER MATCHES;

BY

PROFESSOR T. E. THORPE, LL.D., F.R.S.,
PRINCIPAL CHEMIST OF THE GOVERNMENT LABORATORY;

PROFESSOR THOMAS OLIVER, M.D., F.R.C.P.,
PHYSICIAN TO THE ROYAL INFIRMARY NEWCASTLE-UPON-TYNE;

DR. GEORGE CUNNINGHAM, M.A., D.M.D.,
SENIOR DENTAL SURGEON TO THE LONDON HOSPITAL.

Presented to both Houses of Parliament by Command of Her Majesty.

LONDON:
PRINTED FOR HER MAJESTY'S STATIONERY OFFICE,
BY EYRE AND SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.

And to be purchased, either directly or through any Bookseller, from
EYRE AND SPOTTISWOODE, East Harding Street, Fleet Street, E.C., and
32, Abingdon Street, Westminster, S.W.; or
JOHN MENZIES & Co., 12, Hanover Street, Edinburgh, and
90, West Nile Street, Glasgow; or
HODGES, FIGGIS, & Co., Limited, 104, Grafton Street, Dublin.

1899.

[C.—9188.] *Price* 4*s.* 11*d.*

CONTENTS.

INTRODUCTORY MEMORANDUM BY THE CHIEF INSPECTOR OF FACTORIES.

As the important Reports which follow are necessarily lengthy, and, to some extent, cover the same ground from different points of view, it seems desirable to prefix a short summary of the main conclusions to be drawn from them.

Origin and scope of inquiry.

In the early part of 1898 the attention of the Home Office was specially directed to the danger attending the manufacture of lucifer matches as carried on in the United Kingdom. It was discovered that certain cases of phosphorus necrosis among workpeople had been intentionally concealed, and that others had escaped record. It became known that Switzerland was preparing to follow the example of Denmark, in prohibiting the use of yellow phosphorus for the purpose, while Belgium had offered a substantial reward for the discovery of an effective strike-anywhere match made without yellow phosphorus. In France renewed efforts were being made to find an efficient substitute for yellow phosphorus, and to lessen the danger by hygienic precautions, more particularly by attention to soundness of teeth. Improved methods of manufacture, claiming to secure safety by largely replacing hand labour in the dangerous processes by machinery, had recently been introduced from America by one firm; but, with this exception, it became apparent from the reports of the inspectors that the conditions in British match factories generally were unsatisfactory, and that if the use of yellow phosphorus was to be continued, more stringent control of dangerous conditions than was possible under existing statutes and regulations would be necessary.

It was felt, however, that before deciding upon the measures to be adopted, fuller information must be obtained upon the scientific and technical points involved, and particularly as to the improved methods and precautions adopted at home and abroad, and their results. Accordingly, in 1898, Professor Thorpe and Professor Oliver were requested* to inquire and report upon the subject; and shortly afterwards, in view of the evident importance of the practical dental question at issue, Dr. Cunningham, senior dental surgeon to the London Hospital, was asked to investigate and report from that standpoint.

Their reports, presented in January 1899, will be found to throw the fullest light upon the position of the question at home and abroad. For the purposes of the inquiry, France, Belgium, Holland, Norway, Sweden, Denmark, Germany, and Austria, were visited, and every facility was given by the respective Governments and by manufacturers. Information was also obtained from Russia, Italy, Switzerland, and the United States.

* The letter to Dr. Thorpe and Dr. Oliver, containing the terms of reference, is printed on p. xii.

Results of the inquiry.

Among the most interesting and practically important features of the reports are the description of labour-saving machinery, in use in America and on the Continent, obviating much of the exposure of workpeople to yellow phosphorus; and the conclusive evidence which is given of the necessity of attention to soundness of teeth. Dr. Cunningham has examined large numbers of match-workers, at home and in France, and has obtained further results from other sources. He finds that in the absence of special arrangement for regular dental supervision, the teeth are deplorably bad, a condition which all authorities now agree in regarding as inviting necrosis of the jaw.

Mr. Morton Smale, Dean of the Dental Hospital of London, and Examiner in Dental Surgery at the Royal College of Surgeons, writes:—

"I am of opinion that phosphorus necrosis can only originate under the following circumstances:—

"(1.) When dental caries has exposed the pulp (nerve) of a tooth.

"(2.) During the healing process after tooth extraction.

"(3.) During the time there is some lesion of the gum.

"Cases have been recorded which appear to bear evidence to the contrary; but the teeth had not been examined by a dentist, and severe ravages of dental caries may arise which only a skilled person can discover.

"In the hope of permanently arresting phosphorus necrosis, I would strongly urge that the suggestion should be carried into effect—that a dentist should be appointed to all match factories, whose duty it should be to keep the teeth of the workers in order, and be empowered to prevent any employés with a lesion in the mouth working in the factory.

"It is well known that bad teeth are the cause of much pain, dyspepsia, intestinal troubles, and malnutrition, and if these were prevented, as I believe would largely be the case, the manufacturers would be largely saved compensation and loss of service from pain or illness, and would probably be the actual gainers in the end."

This matter must claim prominence in any revision of the conditions under which the use of yellow phosphorus is permitted.

Varieties of phosphorus.

Phosphorus is used in this industry in two forms—

1. Ordinary "white" or "yellow" phosphorus, which is highly poisonous if swallowed, and gives off poisonous fumes which Dr. Thorpe shows to consist mainly of low oxides of phosphorus.
2. Red or amorphous phosphorus, an allotropic variety, which does not fume, and is hardly poisonous even if swallowed.

The danger of phosphorus necrosis is limited to persons using the former.

Ordinary and safety matches.

"Safety" matches are tipped with a composition containing no phosphorus. They ignite with some difficulty if rubbed upon certain ordinary surfaces, such as glass, but practically require a special surface, covered with a composition of which *red* phosphorus forms a part. The manufacture of these matches is attended with no danger of phosphorus poisoning.

Ordinary matches ("strike anywhere" matches), of wax or wood, are tipped with a paste containing yellow phosphorus in a proportion varying from 3 or 4 to 30 per cent., but in this country not more than 6 or 7 per cent., and often less than 5 per cent. The tendency is to reduction of the proportion, and this would seem to carry with it lessened danger to the workpeople. Fumes are given off freely from such a paste until thoroughly dried. Hitherto it has not been found practicable to substitute red for yellow phosphorus in the paste, owing to its more ready and violent ignition in presence of the other ingredients; but attempts are still being made to overcome this difficulty, and also to find other substitutes.

Dangerous processes.

The special danger of phosphorus poisoning associated with this manufacture extends to those engaged in the following successive processes, which are fully described in the Reports:—

1. *Mixing* the yellow phosphorus with other ingredients to form the paste.
2. *Dipping* the wood or wax stems, arranged in bundles or frames, in the paste, spread for the purpose on a flat slab.
3. *Drying* the bundles of matches after dipping.

4. *Boxing* the dried matches. This, as usually carried on in this country, involves much handling of the matches.

The mixing and dipping are done rapidly on a large scale by few hands, and the drying is automatic, apart from the putting the dipped bundles in the drying chamber and removing them when dry.

Existing regulations.

For the purposes of the Factory Acts, lucifer-match works are non-textile factories (1878, s. 93, and Sch. 4, Part I.), and it is specially enacted that children shall not be employed in dipping (1878 s. 38, and Sch. 1), and that women, young persons, and children, shall not take meals, or remain during meal times, in any part of the works in which any process except cutting wood is usually carried on (1878, s. 39, and Sch. 2).

In 1892 the "manufacture of lucifer matches, except such as are made of red or amorphous phosphorus," was certified by the Secretary of State as a dangerous process under s. 8, 1891, and subsequently Special Rules (p. xi) were drawn up and established in the several factories concerned.

The Special Rules require that in the four dangerous processes there shall be efficient means of ventilation, natural and mechanical; that, in all, there shall be effectual means to prevent the fumes from entering the rest of the factory; that (except boxing) they shall only be carried on in an apartment or apartments separate from the rest of the factory; and that no person shall be employed, without medical certificate of fitness, who has suffered from necrosis or has had a tooth extracted.

The rules further require that proper washing conveniences, with hot and cold water, shall be provided and used before meals and before leaving the works; that any person complaining of toothache or swelling of the jaw shall be at once medically examined. Notification of every case of necrosis is obligatory under the rules, and this is also imperative under section 29 of the Act of 1895, which requires notification of phosphorus poisoning contracted in a factory and workshop.

Insufficiency of present regulations.

While the rules have led to improved conditions and lessened risk, it is now clear, especially in the light of the appended reports, that further advances are imperatively necessary, and that the rules must be strengthened accordingly. Some of the works in this country are old, and lend themselves with difficulty to the improved structural arrangements found in the more efficiently equipped factories. In most of them methods now shown to be obsolete are in use, involving unnecessary risk to the workpeople employed, and the dangerous processes are largely carried on by persons in whom the danger is further aggravated by unsound teeth. It cannot be said that due diligence has been generally exercised, either in observing the letter and spirit of the existing rules, or in introducing the improvements and precautions which have been brought forward, to some extent, in this country, but more extensively abroad, since the rules were framed. Particularly is this to be noted in respect of the substitution of machinery for hand labour in the dangerous processes; in attention to the condition of the teeth of the persons engaged in those processes; and in reporting known cases of phosphorus poisoning, or even watching for their occurrence. The failure under the third head has in some instances amounted to deliberate and long-continued concealment.

It should be added, however, that of late, some British firms have voluntarily taken action in the direction of efficient dental supervision and introduction of elaborate machinery, lessening the exposure to phosphorus; and also that the greater advances in these respects which have been made in foreign countries would seem to have been due very largely to the initiative of the manufacturer,—factories with model conditions in some or all respects being found side by side with factories in which obsolete methods and the dangers inseparable from them still remain. Nor is the concealment of cases of necrosis, or at all events imperfect record of them, confined to the United Kingdom, as the reports of Dr. Thorpe and Dr. Oliver clearly show. In Germany, Austria, and Switzerland there has been added difficulty from the surreptitious manufacture of matches as a home industry, necessarily under conditions which aggravate the dangers to health—a disastrous practice, which has not been attempted in Great Britain.

Number of factories and of workpeople.

There are at present on the registers of the Factory Department 25 match factories (16 in England, 2 in Wales, 2 in Scotland, 5 in Ireland), but in one of these yellow phosphorus is not used.

According to the Annual Returns for 1897, there were employed in all processes in these 25 factories 4,152 persons.

—	Males.	Females.	Total.
Adults (over 18)	643	2,015	2,658
Young persons ("Full-timers" under 18)	425	1,067	1,492
Children ("Half-timers" under 14)	2	0	2
All ages	1,070	3,082	4,152

Numbers employed in dangerous processes.

Less than half of these persons are engaged in work which involves any exposure to phosphorus. According to the figures furnished by the inspectors in 1897–98, there were then employed in 23 match factories, in which yellow phosphorus was used, 3,134 persons distributed as follows :—

— (1.)	Mixing, Dipping, and Drying. (2.)	Boxing. (3.)	All Phosphorus Processes. (Cols. 2 and 3.) (4.)	Non-Phosphorus Processes. (5.)
Male	237	8	245	—
Female	21	1,255	1,276	—
Total	258	1,263	1,521	1,613

These figures do not include the persons working at the Diamond Company's factory at Liverpool, where 337 hands (out of a total of 514) are employed in the processes of cutting, dipping, drying, and boxing by machinery under conditions very different from those existing in other British match factories. They are, however, exposed to phosphorus to a limited extent, but hitherto no instance of necrosis has been recorded.

Number of cases of necrosis.

Apart from change in the total numbers employed, there is constant change as regards the individual, a circumstance which makes it additionally difficult to state any trustworthy attack-rate, especially in view of the long exposure which is required before ill-effects become apparent. Nor are the records of attacks, prior to the last year or two, to be regarded as at all complete. In the five years, 1894–98, which have elapsed since the rules became established, 36 cases of necrosis have become known. Sixteen of these were in males, and 20 in females. Although the males employed are fewer in number, they are engaged in processes (mixing and dipping) which would seem to entail more danger than boxing ; but it is very probable that the more permanent character of the men's employment adds materially to their share of necrosis.

Recorded Cases of Phosphorus Necrosis in Match Factories in the United Kingdom in the Five Years 1894–98.

—	Mixing, Dipping, and Drying.	Boxing.	Total.
Male	13	3	16
Female	0	20	20
Total	13	23	36

Three of the above cases are known to have ended fatally. All three were men engaged in dipping. Where cases have been kept under medical observation, at home and abroad, it appears that at least 80 per cent. recover, but often with more or less disfigurement.

Several factories, including some in which the conditions are far from satisfactory, so that the workers are exposed to more than average risk, have escaped without record of necrosis. As to these, it has to be remembered that cases of phosphorus poisoning may have passed unnoticed, and that, where the numbers are small or the workers constantly changing, the statistics of a short term of years, even if complete, are inconclusive.

Poisonous action of phosphorus:

Phosphorus may be regarded as exerting a merely local action, or as becoming absorbed into the system and producing more remote effects, or in both lights.

(1.) Local action.

It might not unreasonably be anticipated that the more or less acid fumes of oxidised phosphorus, either directly or in solution in the saliva, would promote decay of the teeth, and Dr. Thorpe shows experimentally that they exert a solvent action. The other observations bearing upon this point are negative. Bad as the condition of teeth among phosphorus workers is, in the absence of special dental care, it does not appear to be worse than that of persons of the same class engaged in other industries with which direct comparison has been made. There is, however, a suggestion that some local change is brought about, which renders the teeth difficult to extract.

There is conclusive evidence to show that the malady which has become familiar in connexion with this trade, necrosis of the upper or lower jaw, arises from exposure to the action of yellow or white phosphorus, and that the use of red amorphous phosphorus is practically free from risk. How far the mischief is attributable to inhalation of fumes, and how far to handling of the phosphorus paste, does not clearly appear, but both must be regarded as elements of danger to be removed by all practicable means.

It has next to be noted that while this causation is beyond doubt, the evil effects are very far from being either immediate or constant. The reports which follow show that the form of phosphorus poisoning met with in this trade is essentially a chronic process, taking, with rare exceptions, many years before producing its characteristic result—necrosis. Indeed, cases are recorded where the disease has first shown itself long after the patient had left the factory. Secondly, that unless there be caries of teeth or some exposure of the jaw, necrosis, and the conditions allied to it, do not result. Thirdly, that grave as phosphorus necrosis is, it attacks only a small minority even of those workers in phosphorus who, from the condition of their teeth, must be regarded as especially exposed to danger.

(2.) General action.

In the present state of knowledge it must not be assumed that yellow phosphorus is altogether harmless apart from its tendency to cause necrosis of the jaw, or even that the necrosis is a direct result of access of phosphorus to carious teeth. There are many considerations, practical as well as theoretical, which point to a different conclusion.

In whatever way the phosphorus may be supposed to bring about in the course of years the changes in the jaw which end in necrosis, there are difficulties in the way of accepting the view that the poison is merely conveyed through the carious tooth to the bony tissue. A purely local causation such as this should produce more rapid and more invariable results.

It seems reasonable to believe that the long continued absorption of a powerful drug, like phosphorus or certain of its oxides, must produce some effect upon the system, not necessarily associated with overt symptoms of poisoning, either local or constitutional. A gradual change in the nutrition of the jaw, lessening the resistance to inflammatory processes, but incapable in itself of giving rise to necrosis, would seem to offer the simplest explanation of the long duration of exposure which is necessary before necrosis results, even in the most favourable circumstances. Upon this assumption it is easy to understand why a constantly-present local irritation from carious teeth, possibly aggravated by access of phosphorus, should in susceptible subjects

sooner or later set up inflammatory changes, leading (with the assistance of septic or tuberculous organisms) to suppuration and necrosis; and why the same local conditions always fail to produce any such effect at first.

Continental authorities have called attention to a tendency to fragility and fracture of the long bones, and slow process of repair, and this observation if established would lend support to the hypothesis of wide constitutional changes, of which necrosis and fracture are accidental results.

On the Continent there is recognised further a general impairment of health, *phosphorism*, attended with varying symptoms, to which persons working in match factories are liable. Upon this point there is difference of opinion, but there appears to be more general agreement as to the greater risk incurred by persons suffering from phthisis, syphilis, alcoholism, anæmia, and indeed from debilitating conditions generally, including want of proper nourishment; and this again is in harmony with the view that an important factor in phosphorus necrosis is lowered resistance of tissues, however produced. Such conditions may be thought of as not only predisposing to disease, but possibly determining the time of attack where exposure to phosphorus has continued for years without apparent effect.

The negative results of certain experiments upon animals are inconclusive. Assuming that the phosphorus is presented in the same state as in the case of match makers, and that the same consequences are to be expected in animals as in man, and that the conditions as to general health are equal, it has still to be remembered that the great majority of workers in phosphorus, and even of those among them who have carious teeth, escape necrosis altogether, and that the few who suffer do so only after years of exposure. Similarly inconclusive negative results are afforded by the experience of factories in which the manufacture of yellow phosphorus matches has for years been carried on under conditions which the experience gained elsewhere upon a wider scale shows to be dangerous.

Should yellow phosphorus be prohibited?

The first and most important question which presents itself is whether the use of yellow phosphorus is to be prohibited as in Denmark, or allowed under conditions, necessarily very different from those which have prevailed hitherto, stringent enough to ensure the safety of the workpeople.

The advantages claimed for safety matches are, that while the cost is very little more than that of yellow phosphorus matches, their manufacture involves no risk to the health of the workpeople, and their use is attended with much less risk of accident from fire or poison. In this country the strike-anywhere matches of yellow phosphorus retain their hold upon the public favour by custom and by convenience, but for foreign and colonial use, especially in hot and humid climates, they are said to keep better and to resist damp.

So far as the home consumption is concerned, it does not seem that the prohibition of the use of yellow phosphorus would involve any serious hardship, and this course has already been adopted by Denmark and decided upon by Switzerland, care being taken at the same time to prohibit the use or importation of yellow phosphorus matches. But neither of these countries has or had any export match trade to lose. The United Kingdom, Belgium, Sweden, and Japan, manufacture largely for export, and it is feared that immediate prohibition of yellow phosphorus would at once divert that portion of the trade to other countries, unless international agreement upon the subject were arrived at. If grave injury to the health of the workpeople were inevitable, the loss of the trade might well be regarded as the smaller sacrifice of the two, but the result of the inquiry points to a different conclusion. With due selection of workpeople, strict medical and dental supervision, proper structural and administrative conditions, and substitution of machinery for hand labour in the phosphorus processes, it seems that the dangers hitherto attending the use of yellow phosphorus can be overcome.

Other preventive measures.

The preventive measures—short of actual prohibition of yellow phosphorus—which have been adopted or suggested are as follows:—

1. Limitation of the use of yellow phosphorus. In Belgium it is forbidden to use a paste containing more than 8 per cent. of yellow phosphorus, and in Holland the regulations are somewhat more stringent if the

proportion exceeds 5 per cent. In the United Kingdom it would seem that these limits are not exceeded.

In Russia a tax is imposed upon the manufacture of yellow phosphorus matches, with the result that safety matches are displacing the strike-anywhere kind.

2. Substitution of machinery for direct handling in the dangerous processes of manufacture. In this direction great progress has been made in recent years on the Continent and in America, but little has been effected in this country with the exception of the factory at Liverpool, where American methods have been introduced. By the use of suitable machinery it is possible to eliminate nearly all the handling of the paste on matches, and to reduce greatly the number of persons engaged in the dangerous processes; but the fumes have still to be reckoned with.
3. Efficient mechanical ventilation, directed not only to the purification of the general atmosphere of the workrooms, but more particularly to carrying off the fumes at the point where they are produced. In this respect, again, the Reports describe conditions in certain factories much in advance of those found in match factories generally.
4. Complete separation of departments.
5. Limitation of fumes. Mixing should be done in closed vessels. Dr. Thorpe shows that fuming is checked by keeping the temperature low. Turpentine has the effect of preventing fuming, and it has been suggested that advantage should be taken of this property by adding a small quantity of turpentine to the paste and by charging the draught directed across the dipping stone with turpentine vapours. Thorough drying after dipping arrests the fuming which persists in matches which are at all damp. It seems probable that the thorough drying of wax matches accounts for the comparative immunity of the persons engaged in boxing them, and that the hand-cutting and boxing of double-length matches dipped at both ends is additionally dangerous by reason of the incompleteness of the drying which that method permits.
6. Limitation of hours or days of employment in the dangerous processes. Alternation of employment.
7. Avoidance of handling as far as practicable, especially before thorough drying—*e.g.*, in the cutting and boxing referred to above. Handling, and the closer contact which it implies, involves added risk of inhaling fumes, and of carrying phosphorus to the mouth by hand.
8. Selection of workpeople, excluding—
   (*a*) children and young persons, as being less likely to exercise due care, although their dental condition would usually be better than that of adults;
   (*b*) debilitated persons, especially those suffering from phthisis;
   (*c*) persons with unsound teeth.

The attempts at selection hitherto made have been partial and inadequate. Children must not be employed in dipping; and children and young persons under 16 years of age must be examined by the certifying surgeon, and certified as physically fit for the employment before they can be engaged in any factory; but there is no provision for sustained medical supervision by the certifying surgeon. Under the Special Rules, persons who have had a tooth extracted, or who have suffered from necrosis, must not return to work in any of the dangerous processes, without a medical certificate of fitness; but there has often been concealment on the part of the workpeople and lax supervision on the part of the employers.

Far more than this is required, and especially in the direction of ensuring sound teeth. The striking figures given by Dr. Cunningham show the dangerous processes are very largely carried on by persons needlessly exposed to constant danger by reason of the neglected condition of their teeth; and that the condition, as was to be anticipated, grows steadily worse as age advances.

9. It is not enough to secure fitness at the outset. There is need for sustained supervision, and particularly for periodic dental examination of all workers in phosphorus; and for the entry of all necessary particulars in a health register. This system has already been adopted in other countries, and a voluntary beginning has at last been made in certain factories in England.

   Compulsory dentistry, even if provided at the expense of the employer, is not likely to be welcomed by all the persons employed; but the conclusion to be drawn from the evidence now presented is that soundness of teeth is an indispensable condition of fitness for employment in phosphorus processes.

10. Notification of cases of illness due to phosphorus is already provided for by statute, and by Special Rules, but needs to be more clearly defined and far more strictly observed.

    With a properly kept register, and periodic dental examination, it should be impossible for cases to be concealed or overlooked in the future.

11. Suitable and sufficient facilities for washing, to include hot and cold water basins, soap, towels, &c. Also supervision to ensure that they are regularly used.
12. Systematic gargling with a suitable antiseptic mouth wash.
13. Wearing overalls, to prevent the clothing from contact with phosphorus.
14. General cleanliness of premises.

Some of these can hardly be prescribed in detail, by legislation or by special rules, without fettering unduly the choice of alternative methods of attaining safety, but it is clear that, while the use of yellow phosphorus is continued, more stringent conditions must be enforced by revision of the present Special Rules.

The arrangements which promise safety involve expense, and some of them may be difficult of adoption in old and small works. But they are already in use at home and abroad with good results, and can no longer be represented as impracticable or utopian. They will obviate a not inconsiderable cost to the workpeople in suffering, and to the employers in maintenance of injured persons during the years of illness which phosphorus necrosis causes. The effect will be to limit the use of yellow phosphorus, and to lead to the substitution of less dangerous materials and new methods not involving risk to the health of workers; and to stimulate invention generally.

ARTHUR WHITELEGGE.

Home Office, February, 1899.

EXISTING SPECIAL RULES FOR LUCIFER MATCH FACTORIES WHERE WHITE OR YELLOW PHOSPHORUS IS USED.

Duties of Occupiers.

I. It shall not be lawful to carry on a lucifer match factory, where white or yellow phosphorus is used, unless such factory is certified by an Inspector to be in conformity with the following Special Rules.

II. All occupiers of such factories shall provide for the processes of mixing, dipping, and drying an apartment or apartments separate from other portions of the factory.

III. They shall take effectual means to prevent the fumes from the before-mentioned processes and from the boxing department being allowed to enter the rest of the factory.

IV. They shall provide efficient means, both natural and mechanical, for thorough ventilation in the mixing, dipping, drying, and boxing departments.

V. They shall provide washing conveniences, fitted with a sufficient supply of hot and cold water, soap, nail brushes, and towels, and shall take measures to secure that every worker wash his or her hands and face before meals, and before leaving the works. Managers and overlookers shall report immediately to the occupier any instance which comes under their notice where this regulation has been neglected.

VI. Any person employed in the works complaining of toothache, or of swelling of the jaw, shall at once be examined by a medical man at the expense of the occupier; and if any symptoms of necrosis are present the case shall be immediately reported to one of Her Majesty's Inspectors of Factories for the district.

VII. No person having suffered from necrosis shall be permitted to resume work in a lucifer match factory until a certificate of fitness has been obtained from a qualified medical practitioner.

VIII. No person shall be permitted to work in the processes of mixing, dipping, drying, or boxing, after the extraction of a tooth, without the certificate of a duly qualified medical practitioner that the jaw is healed.

As to Persons Employed.

IX. Every person employed in the mixing, dipping, drying, or boxing departments shall carefully wash his or her hands and face before meals and before leaving the works.

X. In all cases where the co-operation of the workers is required for carrying out the foregoing rules, and where such co-operation is not given, the workers shall be held liable in accordance with the Factory and Workshop Act, 1891, section 9, which runs as follows:—

> "If any person who is bound to observe any special rules established for any factory or workshop under this Act acts in contravention of, or fails to comply with, any such Special Rule, he shall be liable on summary conviction to a fine not exceeding two pounds."

REFERENCE.

LETTER ADDRESSED TO DR. T. E. THORPE.*

SIR, Whitehall, 24th June 1898.

I AM directed by Secretary Sir Matthew Ridley to ask you, in co-operation with Dr. Oliver, to undertake on behalf of the Home Office an inquiry into certain important questions which have arisen with regard to the effect of work in lucifer match factories on the health of the workpeople. The inquiry is of the same general character as the inquiry which you and Dr. Oliver have already undertaken with regard to the use of lead glazes in the manufacture of china and earthenware, and he thinks that you will be able to carry on the two inquiries simultaneously.

The questions which have arisen in consequence of recent cases of phosphorus poisoning in lucifer matchworks, and which are now engaging the attention of the Home Office are—

(1.) The nature and extent of the dangers attending the use of yellow and white phosphorus.

(2.) The means whereby these dangers can be lessened.

(3.) The practicability of discontinuing the use of yellow and white phosphorus.

The dangers are understood to arise from inhalation of phosphorus fumes, the carrying of phosphorus to the mouth by hand, and, to some extent, the occurrence of ignition in the process of manufacture.

It is important to ascertain more clearly than has hitherto been done how far the first and second of these causes respectively operate, and chemical analysis may throw light upon this. It may be possible for example to determine the presence and the proportion of phosphorus in the air of rooms in which each of the dangerous processes is carried on, distinguishing in this respect cases where exhaust fans or other safety appliances are or are not used. The extent of the diffusion of the poisonous fumes, and the question whether a given proportion is dangerous to health, might also be investigated.

As regards handling, the question would be examined whether the phosphorus can be readily and effectually removed from the hands by soap and water; and in this connexion it would be of interest to know if it is found in the water in which workers have washed, and if so, in what amount. The question also arises whether the danger increases with the proportion of phosphorus in the paste used and whether limitation in that direction is called for. It is stated by certain manufacturers that the paste used by them does not contain more than five per cent. of yellow or white phosphorus, owing mainly to risk of ignition during the latter stages, such as boxing.

* A letter in identical terms was addressed to Dr. Oliver.

As regards ignition, it seems that a supply of sawdust is found to be a more effective means of rapid extinction than water or wet clothes, which were formerly advocated. Here the further question arises whether the fumes given off by ignited lucifer matches are poisonous in such a degree as to add to the danger incurred by the workpeople.

A most important point is whether preventive measures can be taken, whereby workers themselves may be rendered less susceptible to the effects of phosphorus. Cleanliness, care in avoiding all risk of carrying phosphorus to the mouth, attention to teeth, abstention from work in phosphorus after extraction of tooth—or while unsound teeth remain—are well understood precautions in this direction. It is also important to know whether there are any sufficient reasons for assuming greater susceptibility at early ages, or among females—apart from the consideration that in the former case less care can be expected than among adults.

Many matches are now made in which no white or yellow phosphorus is used. The Secretary of State desires to learn whether the ingredients of these may be regarded as free from materials dangerous to the health of those engaged in the manufacture, and particularly whether the current belief that use of red phosphorus is unattended with risk, either from handling or from inhalation of fumes, may be accepted as an established fact. Is it practicable to make, without white or yellow phosphorus, matches which will strike on ordinary surfaces, not specially prepared?

In all works where white or yellow phosphorus is used, Special Rules (copy of which is enclosed) are in force. In some instances, in the United Kingdom and abroad, it is claimed that the employment of these materials has been rendered practically safe by substituting machinery for manual labour, by complete arrangements for mechanical ventilation (including exhaust fans at the points where the phosphorus is handled), and by periodical examination of the workpeople by medical men and dentists, with temporary exclusion of unfit subjects from work. The Secretary of State will be glad to receive any suggestions upon these or other measures of precaution.

The points which I have mentioned are not intended as exhaustive of the subject, but are given as examples of the questions which have now presented themselves, and upon which the Secretary of State desires your advice. But in the course of your inquiry other points of equal importance will probably arise; and the Secretary of State desires to leave you free to pursue any line of inquiry which may appear to you to be likely to throw light on the question of the effects of phosphorus on health, and to lead to practical results.

The Chief Inspector of Factories will be glad to consult with you at any stage of your inquiries, and will place at your disposal any information or assistance that can be given by the Inspectors of Factories throughout the country.

The experience of foreign countries will also be of importance in this investigation.

The Secretary of State has already commissioned Dr. Oliver to visit certain match factories in France; and if further inquiries in foreign countries should seem to you to be desirable, he will be glad to obtain the sanction of the Treasury to their being carried out.

In view of the number and painful character of the cases of phosphorus poisoning which have recently come to light, the Secretary of State would urge that an inquiry should be prosecuted with all the speed consistent with a thorough investigation on the points at issue, and that an interim report should be made as soon as any definate conclusions are reached, in order to enable him to take further measures for the protection of the life and health of the workpeople.

I am,

Sir,

Your obedient Servant,

(Signed) KENELM E. DIGBY.

REPORT

TO THE SECRETARY OF STATE FOR THE HOME DEPARTMENT

ON THE

USE OF PHOSPHORUS IN THE MANUFACTURE OF LUCIFER MATCHES;

BY

PROFESSOR T. E. THORPE, LL.D., F.R.S.,
PRINCIPAL CHEMIST OF THE GOVERNMENT LABORATORY.

CONTENTS.

TO THE RIGHT HONOURABLE SIR MATTHEW WHITE RIDLEY, BARONET, M.P., HER MAJESTY'S PRINCIPAL SECRETARY OF STATE FOR THE HOME DEPARTMENT.

Government Laboratory,
Clement's Inn Passage, Strand,
London, W.C., 14th January 1899.

SIR,

IN accordance with the instructions of the Under Secretary of State for the Home Department, in his letter of 24th June 1898, I have made inquiry into the conditions under which ordinary, or so-called white or yellow, phosphorus is employed in the manufacture of lucifer matches, with special reference to the dangers incidental to its use, and I have now the honour to forward you a report embodying the results of my observations.

I have thought it desirable, in the first place, to make myself thoroughly familiar with the processes adopted in the manufacture of matches in this country, and for this purpose I have visited all the manufactories, with only two exceptions, in the United Kingdom. I have subsequently visited a number of the leading match factories in Holland, Belgium, Norway, Sweden, Germany, and Austria, and I have paid special attention to the working of the legislative regulations under which the match industry is carried on in these countries. I have further ventured to make a comparison between the general position of the manufacture on the Continent, as a branch of industry, and the state of this manufacture at home. Lastly, I have drawn attention to certain measures which I think may tend to ameliorate the hygienic condition of our match workers.

I believe it will be found that I have considered all the chemical and manufacturing questions raised in the letter from the Under Secretary of State above referred to. My colleague, Dr. Oliver, will no doubt deal fully with the medical aspect of the phosphorus-necrosis question.

I take this opportunity to tender my acknowledgments to Her Majesty's representatives abroad for the manner in which they have facilitated my work. Thanks to their attention and to the courtesy of the various Government Departments in the several countries, I have met with no difficulties in the course of my inquiries. I desire also to express my obligations to the match manufacturers, both at home and abroad, for the readiness with which they have permitted me to view their premises, and for their kindness in giving me such information as I required.

I have the honour to be,

Sir,

Your most obedient humble Servant,

T. E. THORPE.

REPORT.

I.—On Phosphorus as Employed in the Manufacture of Matches.

The phosphorus employed in the manufacture of matches is of two kinds. The first is the ordinary or so-called white or yellow phosphorus, discovered by Brand, of Hamburg, in 1669, and made in this country by Robert Boyle sometime prior to 1678. When pure it is a colourless, transparent, highly refractive crystalline substance, forming regular dodecahedrons, of specific gravity 1·836, melting at 44° C. (111·2° F.), practically insoluble in water, but readily soluble in carbon disulphide, less so in benzene and oil of turpentine. It rapidly becomes yellow when exposed to light, and absorbs oxygen from the air if moist. The absorption under ordinary atmospheric tension is accompanied by a feeble greenish-white light, or phosphorescence, which is at once arrested by traces of many essential oils, such as turpentine, eucalyptus, peppermint, &c. The products of the oxidation are phosphorous oxide and phosphoric oxide. The glow is invariably accompanied by, and is probably dependent on, the formation of ozone. Phosphorus is very inflammable, igniting at a temperature of 34° C. (193.2° F.) and forming, with a plentiful supply of air, phosphoric oxide, P_4O_{10}. If the supply of air is limited, more or less phosphorous oxide P_4O_6 is produced. The so-called white or yellow phosphorus is sensibly volatile at the ordinary temperature of the air, and is readily volatilised in a current of steam. It boils at about 270° C. (518° F.), and is highly poisonous.

As a commercial product, ordinary phosphorus is met with as a more or less opaque or translucent substance of a faint yellow or brownish-yellow colour, and is usually cast into sticks of about half an inch in diameter, or into cheese-shaped masses ("wedges"), for the convenience of the match-maker.

The second kind of phosphorus used by the match-maker is the red or so-called amorphous modification, the existence of which was first definitely established by Schrötter, of Vienna, in 1845. It is a micro-crystalline powder, obtained by heating the ordinary form at a temperature of 230° C. (446° F.) in a closed space or in an atmosphere incapable of acting chemically upon it. It differs in all its physical attributes from the ordinary variety. It has a specific gravity of 2·2 and is insoluble in carbon disulphide, turpentine, &c. It is non-inflammable, and may therefore be handled with impunity. It may be heated to 350° C. (662° F.) without inflaming. It is non-volatile, and absorbs oxygen at ordinary temperatures only with extreme slowness. In hot, damp climates, however, it is more prone to change. It has been alleged that it tends to revert to the ordinary modification, but the statement requires confirmation, and is probably based upon observations made with imperfectly purified material. In any case the process must be extremely slow, and has no practical significance to the manufacturer of matches.

All authorities agree that pure red phosphorus is not acted upon by the solvent fluids of the alimentary canal, and therefore it has no poisonous effects when swallowed.

This was stated to be the case by Liebig (Letters on Chemistry, p. 165), and has since been confirmed by numerous experiments.

M. Bussy and M. de Vrij found that, while from 1 to 3 grains of ordinary phosphorus was poisonous, as much as 30 grammes of the red variety could be given to dogs without any ill effects. Orfila and Regaut gave doses of red phosphorus amounting to several ounces without injurious results.

Neumann, whilst admitting the non-toxic action of red phosphorus when taken into the alimentary canal, finds that it is poisonous when introduced into the system by intra-venal injection.

The injected phosphorus was found to be deposited chiefly on the liver, spleen, and kidneys. Inflammation and fatty degeneration of the tissues were

specially marked in the immediate neighbourhood of small particles of phosphorus. The appearances were similar to those observed in cases of poisoning by ordinary phosphorus.

By comparative experiments made with carbon, sulphur, and arsenic, Neumann proved that the irritation was not due to the presence of solid granular particles.

Experiments made on frogs gave negative results showing that the action is probably dependent upon the relatively high temperature of the blood.

II.—On the Nature of the "Fume" of Phosphorus.

Although ordinary phosphorus boils, under the average pressure of the atmosphere, at so high a temperature as 270° C. (518° F.), it is sensibly volatile at the ordinary temperature. A current of an indifferent gas, like nitrogen or carbon dioxide, led over phosphorus, carries away considerable quantities of the element, as may be proved by passing the gas through carbon disulphide and evaporating the solution. At slightly higher temperatures the amount volatilised is rapidly increased; it is for this reason that in certain continental countries the Special Regulations dealing with match factories stipulate that the temperature of the drying-rooms shall not exceed a certain point.

According to Schönbein the vapour of phosphorus is odourless, the smell actually perceived, and usually associated with the substance, is in reality due to a mixture of ozone and phosphorous oxide.

The vapour of phosphorus disseminated in air is rapidly changed to a mixture of phosphoric oxide P_4O_{10} and phosphorous oxide P_4O_6, and this change is accompanied by the characteristic greenish-white light or *phosphorescence*. The glow is in fact the visible evidence of the oxidation. It is invariably associated with the formation of ozone. It has been found that the best temperature for the production of ozone in air of ordinary tension is 24°–25° C. (75-77° F.); at this temperature the glow of phosphorus is most vigorous.

Analyses of the "fume" of phosphorus have been published by the late Mr. R. Cowper and Professor Vivian B. Lewes, of the Royal Naval College (Journ. Chem. Soc., 1884, 45, 10). Three experiments gave:—

	I.	II.	III.
Phosphoric oxide (P_4O_{10}) - -	71·0	70·1	78·2
Phosphorous oxide (P_4O_6) - - -	9·6	3·2	4·7
Phosphorus - - - -	19·3	26·6	17·0

It will be seen from these numbers that about $\frac{8}{10}$ths of the "fume" consists of the oxides of phosphorus.

It is a singular fact that, although phosphorus is apparently so prone to oxidation, absolutely pure, dry oxygen, is without action upon it. Phosphorus, in fact, does not ignite in dry oxygen, and may be distilled unchanged in an atmosphere of this gas.

If a trace of water be added to the oxygen and its tension be reduced, or if it be mixed with an indifferent gas, like hydrogen, nitrogen, or carbon dioxide in sufficient quantity, the phosphorus at once begins to glow and to become oxidised. The extent of the change is influenced by the temperature and pressure of the oxygen, and by the nature of the indifferent gas; for a given temperature it only occurs between certain definite limits of pressure. For a given pressure, the rate of oxidation, and therefore the glow, rapidly increases with the temperature until, at a certain point, the phosphorus inflames.

The connexion between the glow, the process of oxidation, and the formation of ozone is most intimate. Many circumstances seem to affect the glow; thus it is entirely arrested by the vapours of certain hydrocarbons, such as oil of turpentine, eucalyptus oil, oil of lemons, and many other essential oils. It has been found also that the power of oxygen in air to combine with phosphorus is greatly diminished when the air is charged with these vapours. We have in this fact the explanation of the value of oil of turpentine, and of similar hydrocarbons in preventing phosphorus-necrosis.

It is the "fume" of phosphorus, that is, the mixed oxides of phosphorus, and not the element itself, which is the immediate cause of necrosis. Necrosis

is not due to the action of phosphorus after absorption into the circulation, but to the direct effect of the "fume" upon the bone itself. For it has been found that when the bone of an animal fed with phosphorus is exposed, no carious change takes place; the caries is only produced when the bone is exposed to the action of the "fume." (Lauder Brunton.)

The power possessed by oil of turpentine of retarding the oxidation of phosphorus, and therefore the emission of "fume," has long been known. The following experiments recently made in the Government laboratory may be quoted as illustrating this power:—

1. A sample of air was placed in contact with ordinary phosphorus. All the oxygen (21 per cent.) was absorbed in 18 hours.
2. Two drops of oil of turpentine were diffused through a sample of the same air, which was then exposed to phosphorus. Only 3·4 per cent. of oxygen was absorbed.

3 and 4. Experiment 2 was repeated with still smaller quantities of oil of turpentine, but with greater precautions to obtain a more intimate diffusion of the oil of turpentine vapour through the air. After 18 hours there was practically no diminution in the volume of the air, showing that no oxygen had been absorbed.

5. To obtain an idea of how small a quantity of turpentine oil would suffice to prevent oxidation, about a centigram of the turpentine was diffused through about 1,000 cubic centimetres of air, and a portion of the air containing the vapour was exposed to the action of phosphorus. There was practically no change in the volume after 18 hours; no oxygen had been absorbed, and no "fume" was produced.

The suggestion has frequently been made to employ oil of turpentine in match works as a preventive of necrosis, and it was formerly so used to a limited extent in this country. At the present time, however, I have not met with a single match-works in the United Kingdom, or on the Continent, in which it is so employed.

The Special Regulations in force in Hungary require that a twentieth part of turpentine shall be added to the phosphorus paste, and that rags saturated with turpentine shall be hung in the mixing, dipping, and boxing rooms.

Mr. A. Newlands, H.M. Factory Inspector at Glasgow, has submitted to us plans for making use of the protective action of oil of turpentine.

He proposes to draw the air required for the ventilation of the workshops where ordinary phosphorus is used, over the surface of oil of turpentine, gently heated if necessary to assist vaporisation.

He also proposes that air impregnated with oil of turpentine shall be made to sweep across the dipping table. (*See* Appendix p. 78.)

These suggestions are, I think, well worthy of the attention of match manufacturers.

III.—On the Action of Phosphorus "Fume" and Phosphoric Acid upon Teeth.

At the suggestion of the Chief Inspector, I have made some observations upon the action of the "fume" of phosphorus upon teeth. The experiments, although only two in number, leave no room for doubt as to the result.

Experiment I.—A number of human teeth, all more or less decayed, were carefully cleaned, dried, and weighed. After wetting they were submitted, during about 12 hours, to the action of a stream of the "fumes," obtained by passing a slow current of air over moistened phosphorus. Upon drying and re-weighing, the teeth were found to have lost 0·37 per cent. of their weight.

Experiment II.—A number of cleaned carious teeth were crushed into coarse fragments—so as to expose a large surface—dried and weighed. A dilute solution of phosphoric acid (one per cent.) at a temperature of 40° C. (approximately blood heat) was then passed slowly over the fragments, half a litre being used and the duration of the experiment being about three hours. The teeth lost 8·9 per cent. of their original weight.

There is no question, therefore, that the "fume" of phosphorus, or the product obtained by its solution in saliva, does exert a marked solvent action upon teeth.

IV.—On the amount of Phosphorus "Fume" in the air of the workshops of Match Factories, and on the amount of Phosphorus on the hands of the Box Fillers.

In order to obtain an idea of the amount of "fume" present in the air of a match factory I was directed by Dr. Whitelegge to make analyses of the air of different parts of the factory of Messrs. Bryant & May, Ltd., and also to ascertain how much phosphorus adhered to the hands of the operatives. The results were communicated to the Home Office in a report made in July 1898. It is as follows:—

SIR,

In accordance with your instructions, two visits have been made to the factory of Messrs. Bryant & May, one on 27th June in company with Mr. Seale, the District Inspector, and the other on the 29th June.

Samples of the fume-bearing air from two of the departments—one of the dipping-rooms and two of the boxing-rooms—have been examined, and an estimation has also been made of the quantity of phosphorus removed from the hands of the workpeople by washing. The details and results of these analyses are given below.

Air from Dipping-room.—The room selected was that in which, as stated by the manager, the "dipper" worked whose case terminated fatally a short time ago. The fumes were collected at a point over the dipping table in front of, and a little below, the centre of the fan, the height being about 12 to 14 inches above the surface of the phosphorus paste, *i.e.*, a few inches lower than the level of the dipper's mouth and a little higher than that of his serving boy's.

63 litres of air were aspirated through the apparatus, and ·012 milligram of phosphorus, free and oxidised, was obtained in the analysis, giving ·02 milligram per 100 litres of air.

"Dipping" was in operation as usual during the time of collection, and the fan was said to be working at its normal rate. An excellent draught appeared to be maintained over the greater part of the surface of the table, but the action was naturally much weaker on the part remote from the fan, *i.e.*, on the part most directly under the dipper's nostrils. This defect could, no doubt, be effectually remedied by means of a very moderate blast in front of the dipper and directed from him towards the fan across the surface of the paste. [This addition has since been made, *see* p. 16.]

It must, however, be admitted that so far as visible fumes were concerned none were observed to rise more than a few inches above the surface of the paste on the day in question.

The table at which the air was collected was one at which the deceased dipper was accustomed to work; but on inquiry it was found that the present kind of fan has only been fitted to this table since last Whitsuntide.

Air from the Boxing-rooms.—The sample was taken partly near the middle of one of the more lofty rooms, and partly from a smaller and lower building, the point of collection being in both cases in close proximity to where work was being carried on as usual. Fifty litres were aspirated and yielded ·016 milligram of phosphorus, free and oxidised, or ·12 milligram per 100 litres of air.

The atmosphere in the boxing-rooms was, on account of the frequent "firing" of the matches, obviously more charged with visible fumes than in any of the other departments.

Phosphorus removed from the hands.—A number of workpeople were caused to wash the hands with soap, brush and water, and then after working a certain number of hours to wash again in their usual way; the water in which this last cleansing was done yielded on analysis 37·3 milligrams of phosphorus. The employees in question were 22 in all, including 16 "boxers," 3 "dippers," and 3 boys; and they had worked on an average four hours each. This gives therefore 4·2 milligrams of phosphorus per head per day of ten hours, assuming the accumulation to be proportional to the time employed.

With respect to the mixing-room, there was so much wind on each of the days when the visits were made, and the room is so well exposed to the open

air, that it seemed of little use to attempt the collection of fumes on those occasions. The odour of phosphorus was, of course, very perceptible in the drying-rooms, but as only a few people are concerned with these it seemed desirable to first direct attention to the dipping and boxing departments.

The District Inspector was of opinion that the factory was working under ordinary conditions at the time of our visit; but no doubt during winter many doors and windows would be closed which are at present kept open, and the atmosphere of the rooms would deteriorate accordingly.

I am, Sir, &c.

V.—The Match Works of the United Kingdom.

Match works in Great Britain and Ireland.

There are, or were, prior to the autumn of this year (1898)—for one or two of the smaller works have now disappeared as a result of the operations of the Diamond Match Company at Liverpool—25 match factories in Great Britain and Ireland, giving employment in 1896 to 4,311 workers. These are stated in the Annual Report of the Chief Inspector of Factories and Workshops for 1897 to be distributed as follows:—

	Persons employed.
England and Wales	3,813
Scotland	261
Ireland	237

In London, 2,256 workers.

The 4,311 persons employed are divided into the following groups:—

Half-timers	Males	6
	Females	—
Young persons	Males	390
	Females	1,015
Adults	Males	617
	Females	2,283

In the same report the number of persons who are directly employed in processes involving the use of phosphorus is set down as about 1,700.

The factories are distributed as follows:—

In London and District.

Bryant and May, Limited	Fairfield Road, Bow, E.
R. Bell & Co., Limited	Bell's Road, Bromley-by-Bow.
Palmer and Son	616, Old Ford Road, E.
Wood and Dixon, Limited	Upton Park, E.
B. Daniels	Merton Street, Stratford, E.
J. W. Halsey	Pleasant Grove, York Road, N.
Salvation Army Factory	Lamprell Street, Wick Lane, Bow, E.
W. Salter	Western Road, Merton Abbey.

In the West of England and South Wales.

S. J. Moreland and Sons	Gloucester.
Octavius Hunt	Moor Fields, Bristol.
Crown Match Works	Llandaff Yard, Llandaff.
Swansea Wax Vesta Company	Sketty, near Swansea.

In Lancashire and Yorkshire.

The Diamond Match Company, Limited.	Litherland, near Liverpool.
W. J. Morgan & Co., Limited	Blackley, near Manchester.
Lomas and Collier	Newton Heath, Manchester.
J. Speck & Co.	Macauley Street, Leeds.
Seanor and Sons	Rothwell, near Leeds.
George Myers	Fish Street, Hull.

In Ireland.

Paterson & Co., Limited -	McAuley Street, Belfast.
Irish Match Company, Limited	Ardilea Street, Belfast.
Francis Mussen - -	Lisburn Road, Belfast.
Paterson & Co., Limited -	Hammond Lane, Dublin.
O'Donovan and Sons - -	Dunbar Street, Cork.

In Scotland.

Mitchell & Co. - -	Woodville Street, Govan, Glasgow.
Aberdeen Match Company -	Clayhills, Aberdeen.

Character of matches made.

Only one of the works, the Salvation Army Factory, is exclusively engaged in the manufacture of safety matches. Certain of the works, as those of R. Bell & Co., Wood and Dixon, Palmer and Sons, B. Daniels, are chiefly, and, in one or two cases, exclusively concerned with the manufacture of wax-matches or vestas. But the great majority mainly make the common lucifer, that is, a wooden splint dipped in paraffin wax and tipped with an igniting composition, the exact nature of which varies slightly in different works, but which consists essentially of phosphorus, chlorate of potash, sulphate of lime, whiting, magnesia, powdered glass, sand, &c., made up into a thick paste with glue, and coloured with some dye, usually magenta.

Amount of phosphorus used.

The proportion of phosphorus varies from as low as 5 per cent., calculated on the weight of the dry materials, to as high as 10 per cent. The average amount may be taken as between 6 and 7 per cent.

This phosphorus is almost wholly made at Oldbury, in the neighbourhood of Birmingham, although small parcels of American, Russian, and, latterly, of Belgian manufacture find their way into the country. There is a large manufactory of phosphorus at Lyons, that of MM. Coignet et Fils, but French phosphorus would appear to be little, if at all, imported into England. In any case it is certain that the total quantity imported bears an insignificant proportion to that made at home.

The total quantity of the ordinary phosphorus annually consumed in Great Britain and Ireland in the manufacture of matches probably does not exceed 60 tons. Of this about half is consumed by one firm alone.

The manufacture of safety matches, as compared with their production in Sweden, Germany, Denmark,* and Belgium, is a very small industry in this country, although considerable quantities of such matches are imported.

The total quantity of red phosphorus annually consumed in this country in the manufacture of safety matches probably does not exceed 3½ tons. Of this, nearly three-fourths is consumed by one firm alone.

It will be seen therefore that the red phosphorus employed bears a very small proportion to that of the ordinary variety—only, at most, about 6 per cent.

The great bulk of the lucifer matches produced in this country is made by three firms, viz., Bryant and May, Limited, R. Bell & Co., Limited, of London; and the Diamond Match Company, at Liverpool, employing in all about 2,900 hands. Less important firms are S. J. Moreland and Sons, of Gloucester, Paterson & Co., Limited, in Ireland, and Mitchell & Co., of Glasgow; employing together about 700 to 800 hands. The great majority of the other works employ from 30 to 60 operatives, although some have as few as 8 or 10. The manufacture of matches as a home industry is not carried on in this country.

Method of making matches practised in the United Kingdom.

The British match industry has certain features which are peculiar to it, just as the match itself differs somewhat from that made in other parts of Europe. In the first place the splint is almost invariably made of Canadian pine; on the Continent it is usually made of aspen, which, in Scandinavia and Germany, is imported from Russia; in Bohemia and other parts of Austria it is obtained from Galicia. With us the splints are square in cross

* In Denmark only safety matches are allowed to be made and used. The ordinary phosphorus match has been prohibited since 1874.

section, as a rule much thicker than abroad, and are almost universally double dipped, that is, to begin with, they are twice the length of an ordinary match when inserted in the clamps or frames, and each end is paraffined and dipped in the phosphorus paste. After drying, therefore, the splint requires to be divided in the middle or "halved" or "cross-cut," which is usually done by means of a hinged or pivoted knife.

It may be desirable to describe briefly the mode of manufacture of lucifer matches in this country. The splints are about 4½ inches long, and about one-ninth of an inch thick. These, at the larger works, are received in large cases and are transferred in batches of 20,000 or so on to trays, technically known as "monkeys." They are next filled into "frames" or "clamps," and are so placed that each splint is separated from its neighbour by a space sufficiently large to prevent the tipping composition from cementing the whole together at the ends. The mode of filling the "frames" varies slightly in the different works. In one of the commonest of these a rectangular box at the top of the filling machine is charged with splints lying parallel to each other and at right angles to the face of the machine. The box or "hopper" has given to it a jogging motion by means of machinery, usually worked by steam power, whereby a row of splints is dropped from the box, and by pulling a lever these are pushed over by wires into notches cut in a thin lath placed in the frame; a second lath, the bottom of which is coated with a strip of felt or woollen list, is placed over the row of splints, and another row of splints is immediately brought into the notches by the action of the lever; the operation being repeated until the "clamp" or "frame" has received its complement of 4,000 splints, destined to make twice that number of matches. A skilful hand will deliver to the "dipper" as many as 100 frames a day, that is, 400,000 splints, to be coated at each end with the igniting composition.

Occasionally the splints are slightly charred at the end by being pressed upon a heated iron plate. They are next dipped into a thin layer of melted paraffin wax or crude paraffin scales, or in a mixture of paraffin and stearin, or Japan wax, substances first introduced into the match industry by Letchford in 1861. The paraffin is necessary to insure the ignition of the wood, as probably not 1 match in 50 would take fire without its intervention. Formerly sulphur was exclusively employed for this purpose. Brimstone matches are, however, now rarely seen, although, if procurable, they are preferred by sailors, lamplighters, and cabmen, as, from the low igniting point of sulphur, they are not so readily extinguished by the wind as the ordinary lucifer.

The composition is made by first "melting" the glue in the requisite quantity of water heated by steam, and adding to it, little by little, the phosphorus, weighed out either in the form of sticks, or in segments of the cheese-shaped masses in which it is supplied to the manufacturers. As the phosphorus melts, it is thoroughly incorporated with the glue, with which it forms a thick white emulsion, giving off more or less "fume," mainly of oxides of phosphorus. The colouring matter is then added, and afterwards the mixture of chlorate of potash, whiting, powdered glass, &c., previously intimately mixed in a mill with sufficient water to make the whole thoroughly wet. The entire paste is then once more thoroughly mixed so as to render it of uniform composition.

The pasty mass, which always evolves more or less "fume," is poured, a ladleful or so at a time, on to a horizontal slab, usually of iron, kept at a regulated temperature by means of steam or a water jacket, and is spread out to a layer of uniform depth by means of a gauge or "doctor." The dipper then immerses the ends of the splints on one side of the "frame" or "clamp" into the viscid mass when it is immediately removed to the drying room by an assistant or "carrier-away," who places it with the dipped ends downwards so that the composition gradually sets, forming a well-rounded head. A second "frame" is meanwhile handed to the dipper, and one end of the splints is in like manner dipped into the pasty composition, and is afterwards transferred to the drying room by the "carrier-away." The dipper proceeds in this way until the whole batch of framed splints is dipped at one end only. By the time he has finished, the heads first dipped are usually hard enough to

allow of the clamp being reversed and the other ends dipped; each splint, it being remembered, forming two matches. The dipped "clamps" are allowed to remain in the drying chamber for some hours, the time varying with the humidity and temperature of the air, until the heads are sufficiently set to allow of the splints being cut and the matches filled into the boxes. A clever dipper can dip 1,400 frames in a day of 10 hours, that is, in round numbers, some 11 million matches.

The air of the drying room is always impregnated with more or less of the fumes from the phosphorus and a thin white smoke is usually observed playing about the dipped ends of the matches. The drying rooms, as a rule, are provided with large fans so as to effect a rapid interchange of the air and thus expedite the drying and incidentally to remove the fumes. If all parts of a match factory were as well ventilated as the drying chambers, phosphorus necrosis would happen less frequently.

The next operation consists in dividing the splints and boxing the matches. The dipped and dry splints are removed from the "clamps," or, as it is technically called, are "racked-off" or "laid-out" and taken to benches at which stand a number of girls or women, each provided with a hinged lever-knife and a supply of empty boxes. The boxer throws back the knife, seizes a number of the splints lying beside her—her sense of touch tells her to a match or two whether she has the required number—places them on the wooden support carrying the knife, slings a weighted cord across them to keep them in position, and with a downward stroke of the knife cuts through the 70, 80, or 100 splints. As she again throws back the knife, she takes up one of the half-open boxes before her and drives into it, with a single stroke of the hand, its complement of matches. A very considerable number of matches are necessarily lost in this operation, if they are at all "quick" or tender." The operation of "racking-off" or the friction of the heads against each other in the cutting and boxing not infrequently causes the ignition of the whole batch. Occasionally it happens that the whole of a half day's make will ignite in the drying chamber; a plentiful supply of sawdust in which to bury the inflamed splints will promptly stop the spread of the burning.

The method of making wax vestas differs in many particulars from that of the wooden match. It is, however, unnecessary for the purpose of this Report to describe the mode of making the taper and of filling the "frames." Vestas are only single dipped, and no cutting knife is therefore employed by the box-fillers. The dipping frames are, however, "racked-off" or "stripped" by the box-fillers themselves by rows at a time, and the vestas introduced into the boxes. The composition used for tipping vestas is not sensibly different from that employed on wooden splints.

Splint dipping in "coils."

The above description of the method of making matches holds good for at least 20 of the two dozen works in the United Kingdom. At Bryant and May's the splints are dipped in "coils" according to a plan invented by E. Beecher, of Newhaven, Connecticut, in 1876. The following is a description of this machine (Thorpe's Dictionary of Applied Chemistry, Vol. II., p. 529. Longmans, London.):—"In Beecher's original machine "(Eng. Pat. 4293, 1876, agent, W. R. Lake), the splints were so "delivered from a hopper as to be set at regular intervals between the coils "of a long, flexible tape, band, or bolt of cotton webbing, about the thickness "of a splint, but considerably narrower than its length; this belt was con-"tinuously wound upon a short cylinder or drum adapted to a rotating "mandril or axis, until a coil, or bundle, or frame, of the desired size was "completed. The end of the binding tape was then secured to the preceding "coil by a pin or otherwise, the drum and coil of match-splints thus bound "upon it being now ready for removal from the mandril for dipping. "By this plan of working, the splints are disposed round the drum in a "continuous spiral between the coils of the binder, parallel with each other "and with the axis of the drum. Being separated from each other by the "thickness of the webbing, and by an interval the width of a splint between "every two splints, the splints individually receive the proper proportion of "composition when dipped, and can be conveniently dried in the coil. In "an improved form of the machine (Eng. Pat. 2506, 1877, G. Evans, "patentee), Beecher employs an auxiliary or secondary band in connexion

" with the first, for the purpose of holding the match-splints more securely.
" This form of the machine is shown in section in Fig. 1., A being the coil of

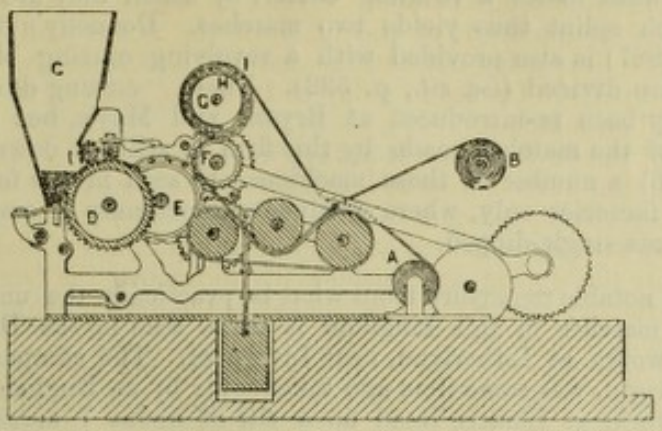


Fig. 1.

" the main belt, B the coil of the secondary belt, C the hopper, D a receiving
" cylinder, E a count wheel, F a setting wheel, and G the mandril or axis
" for the drum H, on which is wound the coil I. Other machines for
" similarly arranging match-splints preparatory to dipping, between coils of
" tape, &c., wound upon revolving spindles, drums, and the like, have been
" invented by W. H. H. Sisum (Eng. Pat. 3524, 1883, agent, W. R. Lake);
" J. Fraser (Eng. Pat. 3554, 1887); C. J. Donnelly (Eng. Pat. 5390, 1887);
" H. C. Zappert (Eng. Pat. 14,813 and 16,353, 1887); and E. Paul (14,111,
" 1889). In Donnelly's machine (Fig. 2) the splints are fed from a

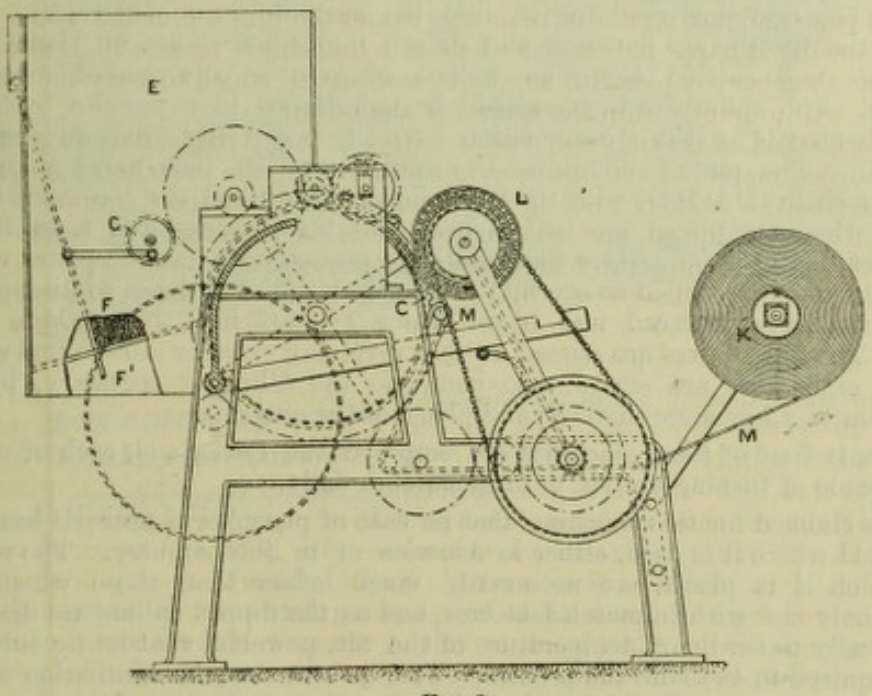


Fig. 2.

" hopper, E, provided with a vibrating feed device, F F', connected with the
" crank wheel G on to a 'pocketed' drum C, from which they are delivered
" on to webs M M', unwound from the reels K K', and wound on to the
" reels L L' in coils."

These coils, which are of the size of a very large cheese, are treated as regards paraffin and dipping very much in the manner already described. The dipped splints are removed from the coils by unwinding, and Beecher (Eng. Pat. 3649, 1877, G. Evans, patentee) has invented a machine which simultaneously performs this operation and the next, namely, "halving," "cutting down," or "cross-cutting." The circular coil of double-headed splints is put on a shaft fixed to the framework of the machine, and the ends of the bands or webs are placed by the operative round two other shafts, on

to which the bands are wound from the coil, the splints being left between endless straps, carried between two revolving discs covered with caoutchouc, and led forward under a rotating cutter, by which they are divided in the centre. Each splint thus yields two matches. Donnelly's machine (Eng. Pat. 5390, 1887) is also provided with a revolving cutting blade, by which the splints are divided (*loc. cit.*, p. 532). These "cutting down" machines have recently been re-introduced at Bryant and May's, but a considerable proportion of the matches made by this firm is still cut down by hand. In Fig. 4 (p. 16) a number of these machines are seen in the foreground. At one or two factories only, where continental machinery is employed, are the wooden splints single-dipped.

The Diamond Match Company's machine.

The most notable departure from what is practically the universal method of making matches in this kingdom is to be seen in the Diamond Match Company's works at Litherland, near Liverpool. The company, which is of American origin, was some time ago taken over by an English syndicate who have built works at Linacre Road on a site of about 7 acres. The factory occupies at present about 1½ acres, and comprises a main building and two wings, each of five floors, giving in all about 200,000 square feet of floor space. The factory is artificially illuminated by the electric light from dynamos driven by two engines of 75 h.-p. each. The match-making machinery is driven by two engines of 350 h.-p. each, and separate engines are provided for the two large ventilating fans, each of which is about 18 feet in diameter, and which are connected with all parts of the building. Self-closing iron doors communicate between the rooms, the ceilings of which are provided with automatic sprinklers as a precaution against fire.

The match-making machinery is placed on the three top floors and is the invention of Mr. E. Beecher. A general view of it is seen in Fig. 3. Small blocks of white pine wood are fed into the machine at one end (A); from these the splints are punched and driven into small holes in plates held together and carried along an endless chain over a series of revolving drums. The splints are successively heated, dipped in a paraffin bath (B), and afterwards in the "composition" fed upon a roller from an enclosed box (C). The plates containing the dipped matches then move along the endless chain (D D D D) with the heads downwards until the "composition" is set, when the plates are turned over and travel backwards towards the front of the machine. Here the splints are pushed out from the plates which are subsequently refilled as originally described. The matches so disengaged are automatically placed into boxes which are fed into the machine from (E). The filled boxes are passed on to a revolving circular table round which six or eight girls are seated, who complete the filling, if necessary, by the addition of a few more matches and place on the outer case.

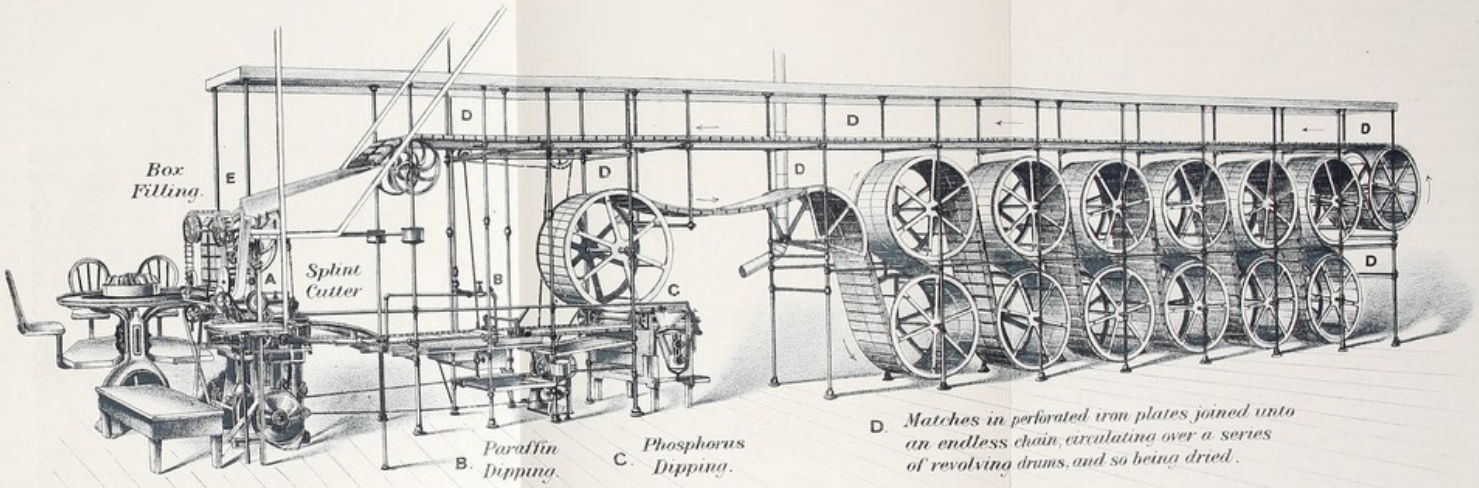
Twenty-four of these machines are employed at Litherland, each of which is capable of turning out six million matches daily.

It is claimed for this machine that no case of phosphorus necrosis has ever occurred where it is used, either in America or in this country. The rooms in which it is placed are necessarily much loftier than those which are commonly met with in match factories, and as the dipped splints are dried at practically the ordinary temperature of the air, powerful ventilating currents are required to expedite the process. This insures that the ventilation of the work-room is very effective; indeed, it is stated that the air throughout the whole of the buildings at Litherland is changed every four minutes. The situation of these buildings is such that fresh air is always available.

I visited the Diamond Company's works on August 23rd, 1898, and was much impressed with their cleanliness and with the order with which they were conducted, and with the arrangements which were provided for the convenience and comfort of the workers. The mixing rooms were unusually large and well-ventilated, and all precautions were taken to minimise the evil arising from the use of ordinary phosphorus, the vessels in which the paste is made being covered with large hoods, through which the fumes of the contents pass into a pipe and are drawn outside by a fan. There was little or no "firing" of the matches, and effective provision was made for the removal of all waste, which was practically burnt in a closed furnace as fast

To face page 14.

MATCH MACHINE
BY
THE DIAMOND MATCH Co
CHICAGO ILL. U.S.A.



B. *Paraffin Dipping.*

C. *Phosphorus Dipping.*

D. *Matches in perforated iron plates joined unto an endless chain, circulating over a series of revolving drums, and so being dried.*

as it was produced. The arrangements for the custody of the operatives' clothes, lavatories, and meal rooms are by far the best to be met with in any English works, and are not surpassed by anything of the kind in even the best equipped factories of the Continent.

It will be seen that one of the great features of the Beecher machine is the comparatively few hands which are needed for the great output of matches of which it is capable. Its main disadvantage is said to be in the character of the splint which it produces. This compares unfavourably with the more neatly cut splints which are generally to be met with in England.

With the exception of the Lagerman machine at Jönköping (*vide infra*, p. 52), which has the advantage of being more compact, and of using any variety of wood and any form of splint, this is the only automatic match-making machine which has had any practical success in Europe.

It is unnecessary to describe in detail the other machinery in use at the Diamond Match Company's works at Litherland. A characteristic feature of the factory, as of the higher class places in Sweden and Germany, is the adoption of labour-saving machinery in place of hand-work, wherever this is practicable.

Comparison of British and Continental modes of manufacture of matches.

As I have had the opportunity of visiting at one time or other, and especially of late in connexion with the present inquiry, every match manufactory in the United Kingdom, with only two exceptions, and as I have personally inspected all the leading factories in Holland, Belgium, Norway, Sweden, Germany and Austria, I may perhaps venture an opinion concerning the position of match making as a manufacturing industry in this country. There can be little doubt, I think, that when this industry is compared with that of the Continent, as seen in such works as those of the Vulcan Factory at Tidaholm; the two factories at Jönköping; the Nitedals Fabrik at Christiania; that of Caussemille, Roche and Co., at Ghent; of Stahl and Nölke at Cassel, and of the various factories belonging to the "Actien-gesellschaft Union" at Habelschwerdt, Augsburg, and elsewhere; and of Bernhard Fürth at Schüttenhofen, the position leaves much to be desired. The significant feature of continental procedure consists in the extraordinary development of mechanical appliances in substitution of manual labour. This of itself has no doubt greatly minimised the evils arising from the use of ordinary phosphorus. In addition there is a relatively greater extension of the safety-match industry in every continental country above-named. British mechanicians have apparently given little attention to the improvement of match-making machinery, and British manufacturers have been slow to adopt the contrivances, the result of the ingenuity of Swedish, German, and Dutch engineers, which are everywhere to be met with on the Continent. The greater number of our manufacturers still use the old hand frame filling machines, invented half a century ago, with here and there modifications introduced by Simlick in 1878. "Halving" or "cross-cutting" by means of the pivoted knife is practised in every match factory in this country where wooden splints are used, with one or two exceptions, notably that of the Diamond Match Company.

On the Continent the pivoted knife has long since become obsolete and is now practically unknown. I am informed by Herr Commerzienrath Buz, whom I visited in Augsburg, that in Germany it is only to be met with in a small factory in the neighbourhood of Darmstadt. I have nowhere seen it in Norway, Sweden, Holland, Belgium or Austria. Anyone familiar with our match manufactories, who visits any of the continental works, must be struck with the very different character of the atmosphere of the box-filling rooms as a consequence of this difference in procedure. It sometimes happens, on account of the frequent "firing" of the matches, due to the friction of the heads under the pressure of the knife, and the consequent formation of oxides of phosphorus, that the air of the boxing-rooms in our factories is laden with a white smoke or fume. The greatest amount of loss in connexion with match making arises from this "firing." It has been stated that this loss is occasionally as high as 10 per cent. (E. G. Clayton, Art. Matches, Dict. of Applied Chemistry, Vol. III., 562). There can be little doubt that

to this fume-laden atmosphere and to the volatilisation of phosphorus in consequence of imperfect combustion, is mainly due the occurrence of necrosis among the box fillers. Contributory causes may be the exhalation of the fumes from the freshly-dried match, when brought into the boxing-room, and to a less extent the adhesion of small quantities of paste from the partially dried heads to the hands of the box fillers.

As regards the exhalation, this is sufficient to reduce nitrate of silver. A piece of paper moistened with a solution of silver nitrate and held in the immediate vicinity of such matches rapidly becomes black, owing to the reducing action of the fumes. This proves that these fumes do not wholly consist of phosphoric oxide. Some idea of the extent to which these fumes are diffused in the air of the rooms, and the amount of paste which may adhere to the hands under ordinary conditions of work is given on p. 8.

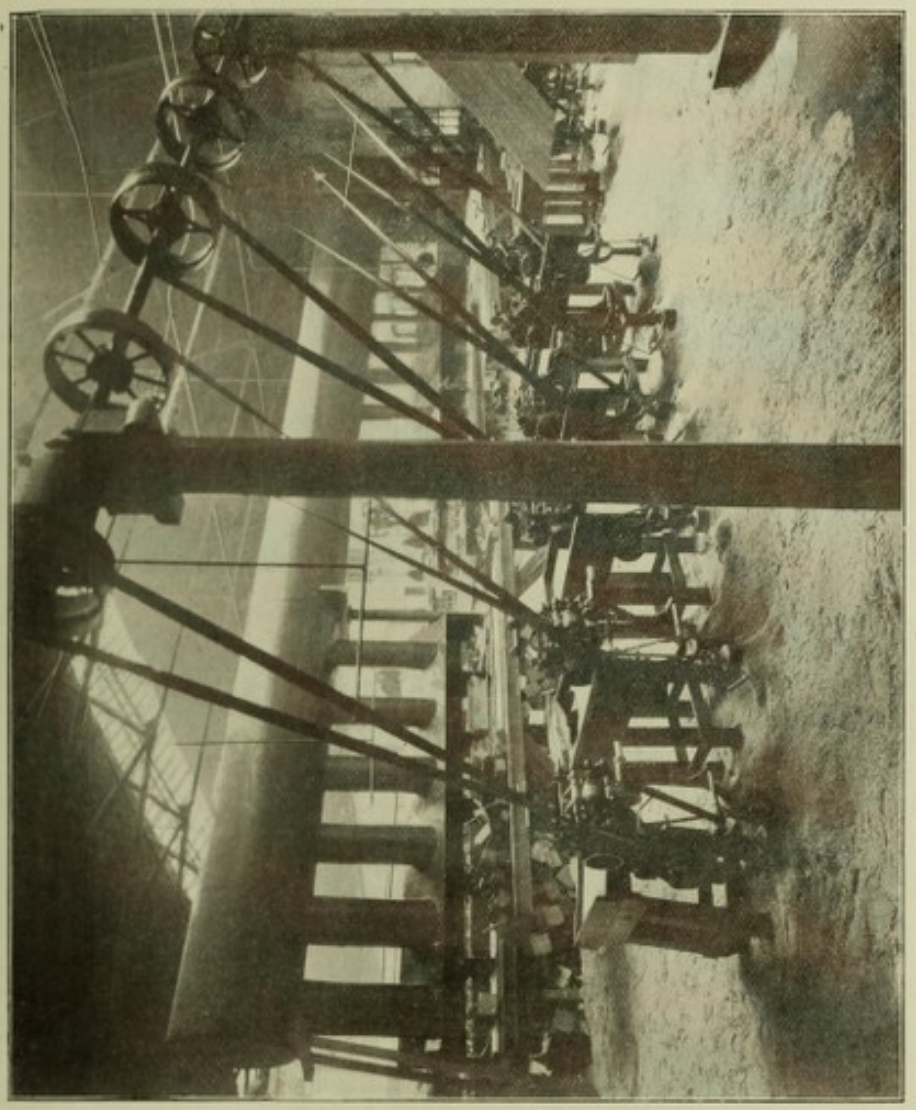
Fig. 4 shows the arrangement recently adopted at Bryant and May's factory to protect the workers from the exhalations of the newly dried matches.

Whilst, therefore, the general condition of the air in these rooms in our factories is much worse than that to be met with abroad, the means of effecting a rapid change of air are seldom so effective as on the Continent. Special ventilation of the boxing tables, apart from the general ventilation of the rooms, such as is to be met with at the Vulcan factory, Tidaholm (*see* pp. 45, 46), or at the factory of Caussemille, Roche and Company at Ghent (p. 29), or at Mariotte and Company at Anderlecht (pp. 32, 33), is nowhere to be found in British factories. Box filling by machinery is nowhere practised in this country except at the Diamond Match Company's works.

In all the larger and better conducted works abroad, where hand-dipping is practised, provision is made for protecting the worker from the fumes evolved from the paste, either by placing the dipping table before a revolving fan as at Caussemille, Roche and Company's factory at Ghent (p. 28), and at the Vulcan factory at Tidaholm (p. 45), or under hoods connected with fans as at Stahl and Nölke's in Cassel (p. 61), or at Bernhard Fürth's at Schüttenhofen (p. 68). The special regulations adopted in every continental country lay stress upon the necessity of thus removing the fumes from the immediate neighbourhood of the dipper. *With the exception of the Diamond Match Company's machine, and of the dipping tables of Bryant and May, who have recently placed them in connexion with fans, and have provided a simple but effective means of causing a current of air to sweep over the paste as spread upon the table* (*see Fig.* 5), *there is really no adequate method for removing the fumes from the immediate proximity of the dipper in any one of the works in the United Kingdom.* But even at Bryant and May's there is, as yet, no sufficient method of protecting the dipper and his assistant from the fumes evolved from the "batch" of composition placed close to the dipping table.

The greater number of the drying rooms in this country are imperfectly arranged. Even in some of the larger works they compare very unfavourably with the systems adopted in Ghent, Anderlecht and elsewhere. An important improvement recently adopted at Bryant and May's factory is indicated in Fig. 5, whereby the coil of freshly dipped splints is more quickly brought into the drying chamber. The mixing rooms in the British factories are, as a rule, small and ill-ventilated. It seems to be generally considered that any odd out-building, which cannot be otherwise used, is good enough to make the composition in. In the greater number of the factories the mixture is made in open vessels, sometimes in an ordinary camp kettle, in which the stirring is effected by hand. Even where the vessel is covered, no proper provision is made for the removal of the fumes. In one or two instances the mixture is made in the open air. But in no single instance, with the exception of that of the Diamond Match Company, are the laboratory arrangements comparable in point of efficiency with those of even a second-class factory abroad. With respect to the lavatory arrangements, again excepting the Diamond Match Company's works, I entirely concur in the remark of Her Majesty's Principal Lady Inspector in the annual report for 1897, "that even "in the best managed match factories I have never found an entirely satis-

(*To face page* 16.)



CUTTING-DOWN MACHINES AT BRYANT AND MAY'S FACTORY, AND METHOD OF REMOVING "FUME" FROM FRESHLY-DRIED DIPPED SPLINTS.

FIG. 4.

(*To face page* 16.)

DIPPING TABLE AT BRYANT AND MAY'S FACTORY.

SHOWING ARRANGEMENT OF BLOW-PIPE AND FAN, AND METHOD OF PRELIMINARY DRYING DIPPED SPLINTS.

FIG. 5.

'factory provision and control of lavatory appliances. Nothing short of 'fittings with taps for hot and cold water supply can possibly be adequate." Indeed, some of the lavatory arrangements I have seen are such that no self-respecting woman would make use of them. In all the match works which I have visited on the Continent provision is made for the employment of some antiseptic solution, in the greater number of cases a dilute solution of permanganate of potash, with which to rinse the mouth before meal times or on leaving the works, and it is the duty of the forewoman in the boxing rooms in many of the larger works to see that this solution is used. No similar provision is to be met with in any of the match works in this country. The Diamond Match Company urge their employees to thoroughly cleanse the mouth, teeth, and gums after meals, using a tooth brush with borax and Castile soap-powder every morning and evening in their homes. Tooth brushes and tooth powder are supplied free.

I give in a subsequent part of this report, and in connexion with each country, the special rules which every Continental Government has found it necessary to frame to protect the match-workers from the evils of phosphorus fumes. These rules are comprehensive, precise and stringent, far more so than is the case in this country, and this circumstance is the more striking when it is remembered that safety matches are made to a relatively greater extent on the Continent than here.

Conclusions.

As the result of my inquiries and observation I conclude—

1. That no satisfactory substitute for phosphorus in either the one form or the other in the manufacture of matches has yet been found.

2. That inasmuch as phosphorus must continue to be employed, the only modification of it which confers complete immunity from phosphorus necrosis is the red or so-called amorphous variety.

3. That, as yet, no method of using this substance in a "strike-anywhere" match is commercially practicable. The risk in the manufacture of a paste in which red phosphorus and chlorate of potash are commingled, and the dangers attending the packing and transport of matches tipped with such a compound would enormously outweigh the evil caused by phosphorus necrosis. The only practicable method of applying red phosphorus at present known is that of Böttger, as worked out by Fürth and Lundström, in the match in which the red phosphorus is placed upon the rubbing surface, that is, the so-called "safety" match.

4. The total prohibition of the use of ordinary phosphorus is probably impossible without international co-operation. "Strike-anywhere" matches are apparently demanded, and will therefore continue to be supplied. Whether, however, all the arguments which are employed in favour of their continued adoption, other than that of price, are valid is open to question. There is no doubt, as regards many of the larger manufacturers abroad, that any general legislative action which compels the use of red phosphorus would be welcomed. It is significant that every Ministerial declaration in Belgium which accompanies any promulgation of the law relating to the conditions under which matches are made in that country, makes reference to a time when red phosphorus will alone be employed.

It is, nevertheless, certain, judging from the experience of other countries in which the special rules have been made sufficiently stringent, and where they are effectively complied with, that the evils attending the use of ordinary phosphorus can be greatly minimised. The remedial measures are comparatively simple. They are:—

1. Proper medical supervision and inspection of the operatives.
2. Periodical inspection of the teeth of all those who in any way come in contact with the fumes of phosphorus.
3. Efficient ventilation of all workshops in which processes involving the use of ordinary phosphorus are carried on.
4. Proper lavatory appliances and vestiary accommodation under efficient control.

As regards medical inspection the special rules of most continental countries require that this shall be at least quarterly. In the case of Holland,

it is two-monthly, whilst, as will be seen from the Report, certain manufacturers require the medical man to attend once a month. The Act of 1895 enjoins that the occurrence of phosphorus necrosis shall be at once notified. Even cases in which the premonitory symptoms are consistent with the existence of but slight necrosis should be brought to the knowledge of the medical department of the Home Office. It will be observed that in the Dutch special rules power is given to the factory inspectors to invoke the assistance, through the central authority, of a medical man paid by the State in all cases in which he has reason to suspect that any collusion exists between the employer and the visiting medical man.

It is clearly established that carious teeth constitute the main channel by means of which the phosphorus fumes are enabled to attack the maxillary bones. This, indeed, seems to be everywhere recognised, and a dental examination is placed among the chief remedial measures which are adopted abroad. Many of the larger firms in this country have now voluntarily adopted this examination, and the dental arrangements at Bryant and May's, and of the Diamond Match Company are excellent.

Greater attention must be paid to the ventilation of workplaces where phosphorus fumes are liable to occur. The "laboratory," or mixing room, should be furnished with efficiently ventilated vessels, provided with mechanical stirrers, and capable of being hermetically closed. Excellent examples of properly contrived vessels of this kind are described and figured on pp. 19, 48, and 67. The room ought to be sufficiently large, and its floor ought to be concreted or asphalted, and it should be provided with an abundant supply of water with which to clean out the mixing vessels, and with a proper system of drainage. Care should be taken that the finished "batches" are kept in properly covered vessels until required for use.

Wherever hand-dipping is carried on, the dipping table should be connected with a fan in the manner already indicated, and provision should be made that the workman is not exposed to the fumes from the "batch" in the bucket or vessel at the side of the table, or from the "waste" which accumulates from the dipping table. The practice of double dipping, if it involves the use of the pivoted knife, should be abolished. The drying chambers should be constructed on a plan similar to that at Ghent or at Anderlecht, whereby the dipper's assistant, or "carrier away," is much less exposed to the fumes than is generally the case here. These arrangements have the further advantage that, if the matches "fire" in drying, which not infrequently happens, the conflagration is localised and more easily dealt with.

The boxing tables should be directly placed in connexion with a fan, as at Ghent (p. 29), and Tidaholm (p. 46). This problem of special ventilation presents fewer difficulties in our climate than in Sweden, where the large volumes of air require in winter to be considerably raised in temperature before they are delivered into the rooms. If single dipping is employed the pivoted knife will no longer be required. Greater comfort to the girls would thereby be secured, as they could sit at their work, as is the case in Sweden and elsewhere, instead of standing all day. Fewer matches would be "fired," and there would be less risk to health.

It is, perhaps, too much to hope that box-filling and packing machinery will become general among the two dozen works in this country. But considering the large saving of manual labour which they effect, the question of their adoption is worthy of more consideration than it has apparently received.

As regards any amendment of the special rules which may be thought desirable, I venture to think that the examples of such regulations to be found in this Report resulting from the experience of other countries will supply all that is necessary upon which to base them. In has been conclusively established that where such rules are vigorously enforced, phosphorus necrosis has almost entirely disappeared.

CONTINENTAL MATCHWORKS AND THE SPECIAL REGULATIONS IN FORCE IN THEM.

HOLLAND.

Match factories in Holland.

The manufacture of matches is a comparatively small industry in Holland. I was informed by Mr. Struve, the chief labour inspector of the Dutch Government, upon whom I waited at the Hague, and who did all in his power to facilitate my inquiries, that there are only three match factories in the country, viz., two at Teteringen, a suburb of Breda, and one at Eindhoven, employing in all about 570 workers. These, on December 1, 1898, were distributed as follows:—

—	Ch. Loyens.	Dijkerman & Co.	Eindhoven.
Males above 16 years	63	48	141
Females above 16 years:			
Married	4	9	5
Unmarried	37	42	72
Under 16 years:			
Girls	22	18	16
Boys	28	30	36

The first-named factory, that of Ch. Loyens, is exclusively engaged in the manufacture of safety matches.

Accompanied by Dr. Kuijper, the district inspector, I visited both the Breda factories. That of Messrs. Dijkerman & Co. makes ordinary matches, as well as safeties, for the home and the English markets.

The composition for lucifers is made in the apparatus seen in the adjoining figure (Fig. 6), of Roller's construction. The mixture of glue and phosphorus

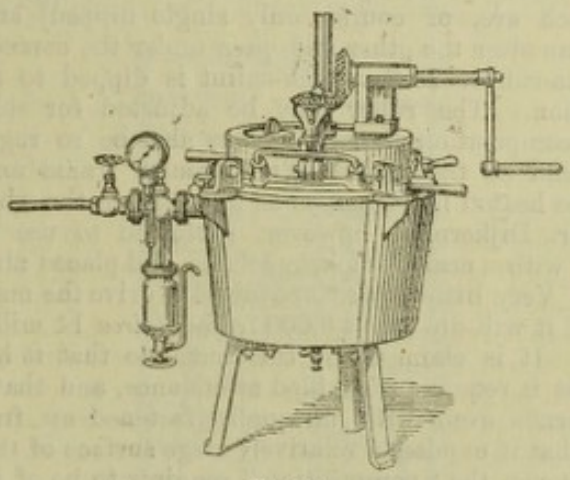


Fig. 6.

is placed in the inner vessel, in which is an agitator, so arranged that it can be worked either by steam-power or by manual labour, the necessary heating being effected by steam delivered into the outer vessel. All the phosphorus required is added at once. The air-tight lid of the vessel containing the composition is fitted with a pipe delivered into the outer air, *i.e.*, above the roof of the mixing room or "laboratory," by means of iron tubing. Mr. Dijkerman, who courteously showed me over the factory, expressed himself as well satisfied with the apparatus, of which he had had about two years' experience. It is economical in use, easy to handle and readily cleaned. It is made in two sizes, capable of dealing with about 25 kilos (55 lbs.) or 50 kilos (110 lbs.) of "composition," respectively.

Mr. Dijkerman's "laboratory" was in excellent order, and fitted with adequate appliances for cleaning the mixing apparatus and other vessels employed in the manufacture of the paste, and for readily and rapidly removing the wash-water.

The dipping was effected by the machine seen in Fig. 7, also of Roller's construction.

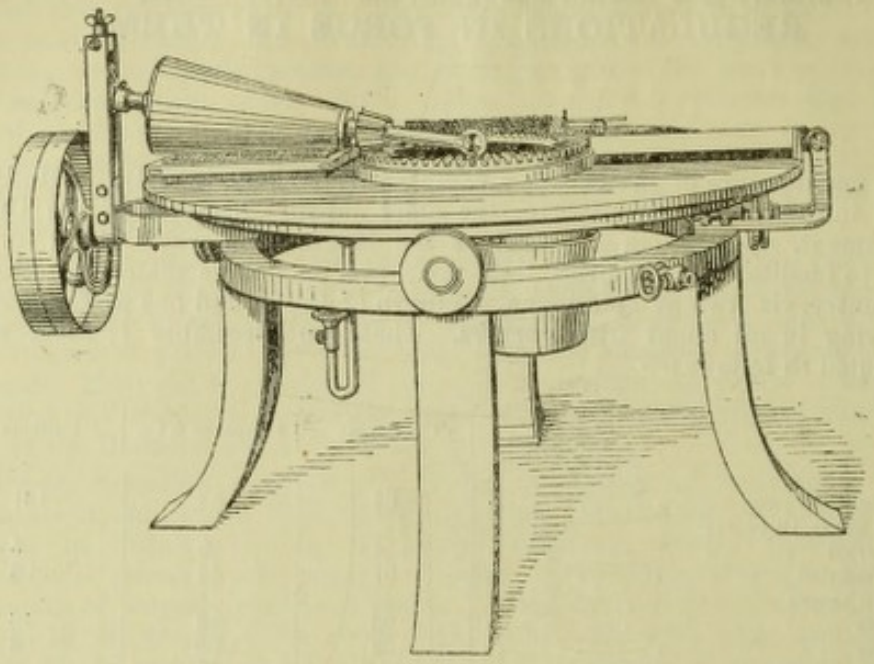


Fig. 7.

As this machine would seem to be unknown in this country, or at least is nowhere employed here, it may be desirable to give a brief description of it. It consists essentially of a horizontal iron table, capable of being slowly turned by friction rollers. It is about 6½ feet long, 5 feet wide, and about 4 feet high. The "composition" is spread evenly over the table by means of the "distributor," seen on the right of the figure and the frames containing the splints (which are, of course, only single dipped) are placed on the revolving table one after the other and pass under the conical roller, which is covered with india-rubber, so that each splint is dipped to an uniform depth in the composition. The roller may be adjusted for splints of different lengths, and the composition-distributor may also be so regulated as to vary the size of the head on the splint. The circular frame under the table is hollow and can be heated by steam, so as to maintain the whole at the desired temperature. Mr. Dijkerman, however, preferred to use a series of small gas jets, burning with a nearly smokeless flame, and placed almost immediately under the roller. Very little power is required to drive the machine (about one-twelfth h.p.), and it will dip about 6,000 frames (*circa* 14 million matches) in a day of 11 hours. It is claimed for this machine that it has not only great capacity, but that it requires no skilled attendance, and that it will turn out evenly dipped heads even with unequally fastened-up frames. Its main disadvantage is that it exposes a relatively large surface of the "composition" to the air. Moreover, the "composition" requires to be of such a nature and consistency that its ingredients do not readily settle. As I saw the machine at work at Teteringen, the dipper and his assistants, three persons in all, were, I thought, too much exposed to the vapours from the paste. There would be no difficulty in so arranging the machine that all fume could be effectually removed from above the exposed surface of the composition, without in any way interfering with the mode of action, or with the convenience of the workers, by placing it under a hood in connexion with the ventilating arrangement of the drying chambers.

The dipping at Messrs. Dijkerman's factory was formerly done entirely by hand, and by means of the apparatus seen in Fig. 8. This arrangement, which is also only adapted to single-dipped splints, and to the comparatively small frames in use on the Continent, is also of Roller's construction, and is to be met with in a number of the smaller works in Germany and Austria. The peculiar feature of the machine is the hinged curved pressure plate, by means of which each splint is forced down upon the table by a single stroke, thus obviating

the hammering down of the splints, as is customary. The composition is maintained at the requisite temperature by means of the hot water cistern, provided with an escape valve, upon which the planed table rests.

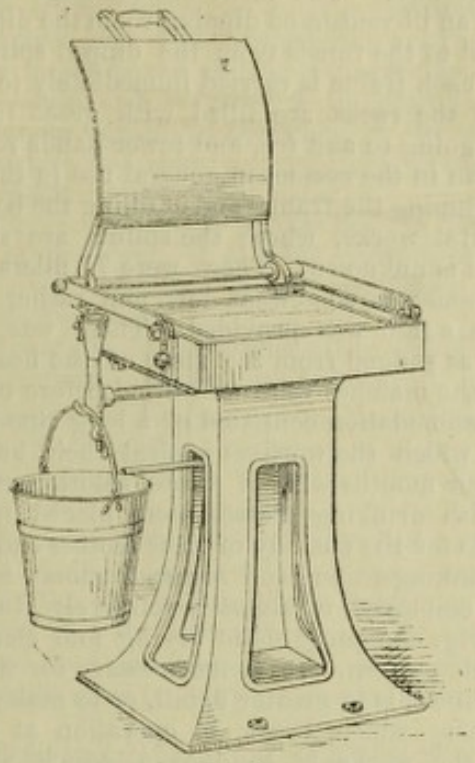


Fig. 8.

The arrangement of the drying chambers calls for no special description. They were conveniently placed with respect to the dipping table, and so constructed that each successive drying rack pushed its predecessor before it in the direction of the filling room. These racks (Fig. 9), which obviate the

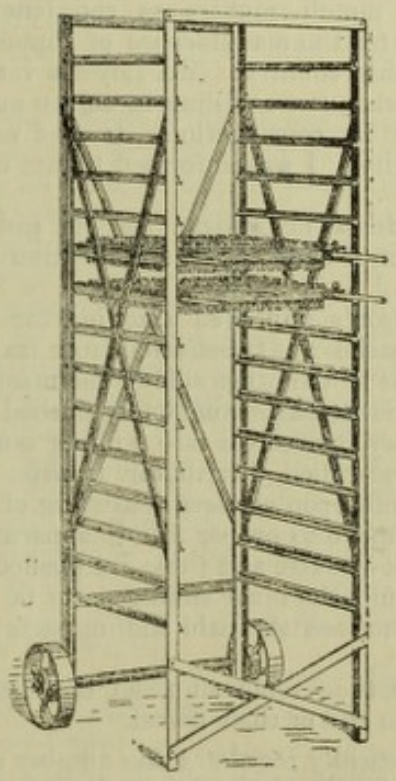


Fig. 9.

necessity of special supports in the drying chambers, are in very general use all over the Continent. They are made of angle iron, and are fitted with

wheels, and can, if need be, be put together in sections; they are light and easily moved. In some works the wheels are grooved so as to run on rails, countersunk with the floor. The main disadvantage of these racks would appear to be that in an ill-ventilated dipping-room the dipper and his assistants are probably exposed to the fumes from the dipped splints for a longer time than they are when each frame is carried immediately to the drying chamber. On the other hand the racks are filled with great rapidity, and there is certainly much less going to and fro, and fewer hands required to go into the drying chambers than in the system in general use in this country.

The method of stripping the frames and of filling the boxes is that commonly adopted in continental works, where the splints are single-dipped and the hinged cutting knife is unknown. There were 71 fillers at work at the time of my visit. The room was somewhat low and rather dark, and no special ventilation, such as a fan, was provided. There was, however, very little "firing," although, as judged from the state of the heads and the condition of the girls' hands, the matches were well dried before being boxed.

The washing accommodation consisted of a long zinc-lined trough provided with 10 taps under which the workers washed their hands. They were also enjoined to rinse their mouths with a dilute solution of potassium chlorate, bottles of which, with drinking glasses, were placed in the lavatory. Provision was also made for the custody of their clothes and overalls. There was a good supply of drinking-water, and separate rooms for meals for the two sexes. The wood employed is almost exclusively Russian aspen, and the machinery for peeling, chopping, splint-drying and cleaning is for the most part of the Durlach pattern. It is unnecessary for the special purposes of this Report to describe this in greater detail, or to make any reference to the box-making machinery which I saw in operation at Breda. Dr. Kuijper informed me that the works at Eindhoven, which also make phosphorus matches, are similar in their general arrangements to those of Teteringen.

The Paulson box-filling machine.

Although the manufacture of safety matches is only indirectly connected with the subject of this inquiry, I waited upon Mr. Loyens at Breda, with a view of seeing a new box-filling machine of which M. Anders Paulson, the engineer attached to his establishment, is the inventor. The firm is well-known to continental match makers as the patentees of a number of ingenious contrivances for the manufacture of match-boxes, some of which, indeed, are in use in this country. Mr. Loyens very kindly showed me the machine in operation, when it was filling-in safety matches, and he explained the general features of its construction. It was running with remarkable smoothness and regularity. I was informed that it may be used equally well for ordinary lucifers.

Thanks to the kindness of Messrs. Loyens and Paulson I have been furnished with a copy of the complete specification relating to the machine, dated October 24, 1898.

In Mr. Anders Paulson's improved machine for filling match-boxes, the prepared or finished matches are transferred from frames filled therewith into the boxes, which are fed to the other side of the machine in a closed condition (*i.e.*, with their inner sliding parts completely pushed into their sheaths).

The said frames empty themselves into a filling box, from which a conveyor or transporter and a so-called distributor transfer a sufficient number of matches for each box into open carriers consisting of different compartments.

These carriers then move to proper filling apparatus which receives, from the other side, the empty boxes, and these are pushed open in the machine.

This apparatus then fills the inner sliding parts of the boxes with matches from the carrier, and pushes the said sliding parts of the boxes partly into their sheaths again.

The filled boxes are then removed from the machine after being again completely closed at the end of their travel.

The machine automatically regulates the number of matches for each box, and permits an efficient supervision as to whether the boxes are sufficiently filled or are overfilled.

The only work of the attendants, therefore, consists in the introduction and removal of the frames filled with matches, and in the feeding of the machine with empty boxes.

The machine, in each revolution of the main shaft, takes three empty match-boxes from the conveyor-band, pushes out the inner parts thereof, fills them with matches, again closes them and finally moves them into the discharge channel or chute, whilst, in nine revolutions of the shaft, the filling box will be supplied once with finished matches from the frame.

The placing of the match-boxes on the conveyor-band in rows of three, and the placing in position and removal of the frame on the filling box is thus the only hand labour which is necessary in filling match-boxes with matches on this machine, and thus a heretofore unknown high grade of mechanical filling of match-boxes is obtained.

The machine will fill from 45,000 to 50,000 boxes a day under the superintendence of a couple of workers. It is thus capable of doing the work of some 16 or 17 skilled boxers, and this without the dipped ends of the matches coming in contact with the hands.

I shall have the opportunity of describing other box-filling machines which I saw in operation in Norway, Sweden, and Germany.

Phosphorus necrosis in Holland.

As all the match factories in Holland are in North Brabant, and under the superintendence of Dr. Kuijper, this gentleman is in an especially favourable position for forming an opinion as to the prevalence of phosphorus necrosis in that country. There is no doubt that it has existed in times past, and to a relatively great extent, considering the comparatively few workers employed. In a recent report, Dr. Kuijper describes seven cases, mainly of women, who had lost more or less of the jaw from necrosis contracted in match factories. He has reason to believe that these do not exhaust the number of instances in which operations have been necessary, whilst it is certain that many less serious cases attended with more or less rapid recovery have escaped notification altogether.

It is, however, no less certain that the condition of the match-workers is being rapidly ameliorated. As an inspector of match factories, Dr. Kuijper enjoys the advantage of having been a pupil of the late Professor Mulder, one of the most distinguished of Dutch chemists, whose assistant he was for some years, and he is therefore a well-trained practical chemist. It is to his knowledge of the chemical principles underlying the manufacture, and to his acquaintance with the properties and modes of action of the materials employed, combined with the influence which he is thereby able to exert among the manufacturers and workers, that much of this improvement is due.

Special regulations in Dutch match factories.

The special regulations affecting the management of match factories in Holland are, under a decree of June 24, 1898, as follows :—

I. No person under 16 years of age or woman shall be allowed to work in a factory or workshop where match paste containing ordinary (white or yellow) phosphorus is prepared.

II. No person under 16 years of age or woman shall be employed in a factory or workshop where matches tipped with a composition containing more than 5 per cent. of ordinary (white or yellow) phosphorus are dipped, dried, boxed, or packed.*

III. No person under 16 years of age or woman shall be employed in a factory or workshop where matches tipped with a composition containing 5 per cent. or less of ordinary (white or yellow) phosphorus are dipped, dried, boxed, or packed unless :—

(*a.*) The head or manager of the factory or workshop is in possession of a written certificate, given by a medical man within the previous two months, stating that the young person or woman can be so employed without danger to his or her health.

(*b.*) This certificate shall be at once exhibited on demand to one of the officials named in Par. 1 of Article 18 of the Labour Law.

* The wording of this regulation is ambiguous. It is not apparent whether the 5 per cent. is calculated on the weight of the dry materials or on that of the actual paste. In answer to an inquiry, Dr. Kuijper informs me: "The per-centage amount of white phosphorus stated in the "regulations (5 per cent.) should be regarded for the paste on the dipping table used, also the *wet* "paste. Approximately this 5 per cent. answers for 4 per cent. in the dry paste, such as used "in our factories."

(*c.*) A medical man may be specially appointed by the Minister of Dykes, Commerce, and Industry, to certify to the fitness for such work of the young persons or women, should the Minister deem this necessary.*

(*d.*) Sufficient opportunity shall be afforded to all workpeople for rinsing the mouth and washing the face and hands with means indicated by the Inspector and provided by the head or manager of the factory or workshop, the Inspector to decide as to the adequacy of the opportunities afforded for making use of these means.

(*e.*) The head or manager of the factory or workshop shall, on the demand of one of the officials mentioned in Par. 1 of Article 18 of the Labour Law, furnish any sample of the paste or matches required by the official, such sample to be duly packed and sealed by the head or manager in the presence of the official.

The object of the last regulation is, of course, to enable the inspector to enforce the limitation as to the amount of ordinary phosphorus which may be present in the paste. At the time of my visit to Breda, Dr. Kuijper was actually engaged in making examinations of such samples, and his assistant, Mr. De Vooijs kindly furnished me with the details of the quantitative methods employed.

As will be seen, it is quite possible in Holland to use paste containing more than 5 per cent. of ordinary phosphorus in the making of matches, provided that all the persons employed in the various operations of dipping, drying, boxing and packing are males of 16 years and upwards. It is, however, hoped that measures intended in the first instance to protect women and young persons under 16, will result in no paste whatever being used which contains more than 5 per cent. of ordinary phosphorus, inasmuch as the matches tipped with such a composition could only be boxed and packed by men, which of course would greatly increase their cost.

On the other hand, it may be pointed out, that the more general introduction of box-filling machinery for packing the boxes when filled may defeat this presumed effect of the clauses.

By the Safety Law (de Veiligheids Wet) (Royal Decree of December 7th, 1896, No. 215) it is enacted that all workshops in use prior to January 1st, 1897, in which ordinary phosphorus is employed must satisfy the following conditions as to height and space.

If the average height between the floor and the ceiling, or the roof where there is no ceiling, is 3 metres or more, there must be a free space of 6 cubic metres for each worker. If the height is between 2·1 and 3 metres the space must not be less than that calculated by the formula,

$$\frac{2 \cdot 40\, h}{h - 180}$$

where h is the average height in centimetres. If the height is less than 2·1 metres the space must not be less than 25 cubic metres for each worker.

If the workshops were not in use before January 1st, 1897, the regulations are 7 cubic metres for each person where the height is 3 metres or more; 25 cubic metres when the height is less than 2·10 metres. Between 2·10 and 3 metres of height the space required is found from the expression,

$$\frac{2 \cdot 80\, h}{h - 180}$$

where h, as before, signifies the average height in centimetres.

* Dr. Kuijper informs me that these regulations mean, "that the manufacturer is obliged *to* "*have* and *to show* a *two-monthly* medical certificate for each person under 16 years of age and "for each woman. Whether the manufacturer is to require the workers to pay for the medical "inspection or must pay it himself is not explicitly stated; but, as a matter of fact, all the Brabant "factories pay the physicians for their two-monthly inspections. When the factory inspector has "reason to believe that there is some understanding between the manufacturer and the physician, "he can ask the Minister of Industry to prescribe a medical inspection by a physician named by "him and paid by the State."

As a matter of fact there is no working-room in any of the Dutch factories with a less average height than 3 metres, but as all were in operation before January 1st, 1897, the law only requires that each worker should have an air-space of 6 cubic metres, which is certainly too small unless accompanied by efficient mechanical ventilation.

BELGIUM.

Measures taken in Belgium to minimise evils arising from use of ordinary phosphorus.

In the Rapport de l'Inspection du Travail" of 1896, addressed to the Belgian Minister of Industry and Labour, M. Henrotte, the late Chief Inspector, gives an account of the various measures taken by his Government to protect from necrosis the workpeople engaged in the manufacture of matches.

In 1880 the "Conseil Superieur d'Hygiene Publique" proposed to prohibit the employment of ordinary phosphorus in the manufacture of matches, in conformity with the advice of the Medical Commission of East Flanders. A careful inquiry into the dangers attending the manufacture, its importance, and the commercial interests to which it had given rise, showed that such a prohibition, however desirable it might be, could not then be decreed without serious consequences to the industry.

Tentative measures, having regard to the interest both of the manufacturers and the workers, were, however, prescribed by the Act of March 25, 1890. The methods of work were so regulated as to ameliorate the hygienic conditions of the shops, and the amount of phosphorus in the composition was limited to 8 or 10 per cent., calculated on the dry materials, depending on whether the dipping was done in warm or cold paste. In order to put the Belgian and foreign manufacturers on the same footing, the Act further stipulated that no depôt or warehouse should store matches containing more than the regulated proportion of ordinary phosphorus.

The immediate result of these regulations fell short of the expectations of the Government. Two manufacturers only declared themselves able to make a composition containing the prescribed amount of phosphorus; the others professed their inability to conform to the decree of March 25, 1890, and to please their customers at the same time. Moreover, quantities of foreign matches containing more than 10 per cent. of phosphorus found their way into the country. Numerous law suits and police prosecutions followed. The entry of illegal foreign matches was largely stopped, and the Belgian manufacturers, under the pressure of circumstances, managed to produce considerable quantities of matches, conformable to law, but of so bad a quality as to be practically unsaleable. The Grammont manufacturers especially, upon whom the loss chiefly fell, began to make matches with more than the prescribed quantity of ordinary phosphorus.

M. Henrotte adds that, in his opinion, the manufacturers, as a rule, were not well disposed towards the hygienic regulations prescribed by the Act of 1890. Desirous of putting an end to this state of things, the Government, towards the end of 1894, instituted a special inquiry with the object of discovering what means were possible to still further restrict the use of ordinary phosphorus, and, in the course of this inquiry, which was entrusted to the newly organised Inspectorate of Labour, it was found that the manufacturers and the workpeople were alike more favourably inclined towards measures tending to limit the use of ordinary phosphorus. The great majority of manufacturers and workmen, especially the dippers, were unanimous in welcoming a law which should forbid the use of ordinary phosphorus matches in Belgium, but all were equally unanimous in requiring that matches destined for exportation should contain it if required. The only objections were that four of the manufacturers employing about one-thirtieth of the workmen, were exclusively engaged in the production of the so-called "stinkstekje," which is the national match of Belgium, and which contains a very high proportion of phosphorus, and these naturally feared that they would be sacrified by a law which prohibited the use of ordinary phosphorus matches in the country. Another objection came from a certain

number of workmen at Grammont, who were afraid that their occupation as fillers of such matches would come to an end. But these objections, M. Henrotte considers, should not outweigh the advantages in regard to protection from phosphorism which would thereby be conferred on the 400 workmen who are at present engaged in the manufacture of the "stinkstekje." The suppression of the "stinkstekje" seemed, therefore, to be the only practicable measure possible at present. Denmark is the only country which has forbidden the manufacture and use of ordinary phosphorus matches within its limits; in Switzerland and France the question is still *sub judice;* in England, Germany, Sweden, and Holland, among which are the great match-producing countries of the world, it has hardly been seriously raised. Until, therefore, some international agreement as to the non-employment of ordinary phosphorus is reached, the total suppression of the manufacture of matches containing ordinary phosphorus in Belgium, is, in view of its large export trade, impracticable.

As regards the partial suppression, in the case of matches made for home consumption, nothing was done, as the Treasury held that such a course would be incompatible with the provisions of existing treaties of commerce. The only course open was to strengthen the requirements relative to the hygienic conditions of the shops, and this was effected by the Act of February 11, 1895.

The new regulations dealt mainly with mechanical ventilation, and difficulties at once arose on the part of the smaller manufacturers who were unable, or disinclined, to incur the expense of the necessary ventilating machinery. Two makers preferred to discontinue wholly the manufacture of ordinary phosphorus matches; a third ceased to make them for home consumption. Only one maker manifested "une réelle mauvaise volonté" towards the improvement of his shops. On the other hand, the efforts of the authorities were cordially seconded by a number of the larger firms, notably by Mariotte & Co., of Anderlecht; by Caussemille, Roche, & Co., at Ghent; by Delannoit; and by Byl-Campen, at Grammont; and by Balthazar Mertens, at Lessines.

I shall describe the methods of ventilation, &c. adopted by certain of these firms when giving an account of my visit to the Belgian factories. The Act of July 12, 1895, prescribed that the match paste, in the dry state, should not contain more than 8 per cent. of ordinary phosphorus. Formerly, only two manufacturers in Belgium, M. Léon Chaubet, the director of the Ghent factory of the company of Caussemille, Roche and Company; and M. François Hoebeke, at Nederbrakel, acknowledged their ability to make good matches containing so small a proportion as 8 per cent. of ordinary phosphorus. At the present time no one contests the possibility or the utility of this reduction with the doubtful exception of M. Balthazar Mertens, who alleges that the 8 per cent. pastes evolve more phosphoric vapours than those containing 30 to 40 per cent., as the former are porous instead of being vitreous as are the latter. The contention is based upon the circumstance that analysis would appear to show that less phosphorus as such is contained in the head of the match than was introduced into the paste, whilst formerly no such discrepancy was observed.

The statement, which is not *a priori* probable, needs confirmation. In any case it does not prove that more phosphoric vapours are disseminated through the air of the workshop, for it is possible that a portion of the phosphorus within the paste may be oxidised at the expense of the oxygenating materials with which it is incorporated.

The Act of February 12, 1895, confirmed the provisions of the former Act prohibiting the storage of matches containing more than 8 per cent. of ordinary phosphorus. Although the inspectors are hardly in a position to enforce compliance with this regulation, the manufacturers as a body make no complaint that illegal matches find their way into Belgium.

Although some of the employers complain of the charges which it has imposed upon them, they generally concede that the best measure introduced by the Government is the monthly medical visit to the workpeople, made at the expense of the manufacturers. M. Henrotte points out that one difficulty in working the regulation arises from the fact that the medical

men are not in accord as to the steps to be taken to prevent necrosis; thus, one man will require that a tooth shall be extracted on the appearance of the least trace of caries, whilst others hesitate to prescribe the operation. It of also pointed out that the provision for change and custody of clothes, and is lavatories, is not always made, and even when made is not satisfactory. Many of the masters assert that the operatives decline to take any personal care of themselves, at least, as regards cleanliness. There may be some truth in this, but M. Henrotte is of opinion that if the washing appliances were more generally satisfactory and better arranged, the workpeople would begin to use them more willingly and, by custom, end by regarding them as indispensable. Their indifference arises from the fact that it has not been sufficiently brought home to them how dependent is the general health upon personal cleanliness.

M. Henrotte concludes his interesting report by stating that 30 years ago hardly a match was made in Belgium of which the paste did not contain 30 per cent. or more of phosphorus. The factories, started by small masters without capital, were worked in defiance of all hygienic rules, and he points to a factory lately existing in Grammont as an example of the old state of things, where the dipping was done in the drying space, itself a part of the boxing room, where no other method of ventilation existed than the doors, and where it could be truly said that every means would seem to have been taken to saturate the air of the shops with phosphoric vapours. How severely Grammont has suffered is well known. The letter addressed to M. Nyssens, the Minister of Labour, by Dr. Brocorens, the director of the Grammont Hospital, giving the particulars of 34 cases, all of men, in which operations have been necessary, from 1860 to 1895, is a sufficiently lugubrious document. Dr. Brocorens states that the malady does not generally declare itself until after 10, 15, or even 20 years of work in the factories. It is remarkable that dippers are the most liable to necrosis of the upper maxillary, whilst necrosis of the lower jaw is the most usual form among the boxers. Death usually follows from cerebral troubles, convulsions, &c., due probably to the extension of the necrosis to the bones at the base of the brain; or even from prolonged hæmorrhage which it is impossible to arrest; or from blood-poisoning, or from the putrid matter which accompanies the spread of the disease. The most fatal period appears to have been from 1860 to 1875. Since the more general introduction of Swedish and so-called "English" matches, and matches made with 8 per cent. of phosphorus, the malady is decreasing, and to such an extent that not a single case of phosphorus necrosis was known in Grammont at the date of Dr. Brocorens's letter (29th July 1895).

Phosphorus necrosis in Belgium.

M. Henrotte is also able to testify to the improvement in the condition of the workers which has followed the operation of the Act of 1890. In 1894 there were two cases, grave, but curable (one at Grammont and one at Anderlecht), and two cases in which the malady was just showing; in 1895, four cases (not serious) were reported.

Excluding four places of small importance, each having less than 10 workers, there are in Belgium at present 13 match factories, employing about 2,600 people. The centre of the industry is at Grammont, where there are six factories, with, in the aggregate, about 1,150 workers. Other factories are at Ghent, Lessines, Denderleuw, Nederbrakel, Anderlecht (Brussels), Oudenarde, and Herenthals. Of these the most important are at Ghent, Grammont, and Anderlecht.

The match industry in Belgium.

About half the employees in the industry come under the protection of the law of 1889 relating to the work of women, youths, and children in industrial establishments. The persons thus protected in the match industry were arranged as follows in M. Henrotte's report:—

Children of from 12 to 14 years -	Boys, 104	
	Girls, 167	
Children of from 14 to 16 - -	Boys, 122	
	Girls, 265	
Girls and women of from 16 to 21 years -		650
		1,308

The matches made in Belgium are of four kinds:—

1. The Belgian match or "stinkstekje."
2. The English match or "crascher."
3. Wax matches or vestas.
4. Swedish matches or "safeties."

The "Belgian" match or "stinkstekje" is, *par excellence*, the national match. The splint is sulphur-coated, and the head contained, prior to the law of 1890, from 30 to 40 per cent. of phosphorus. Nowadays it ought to contain only 8 per cent. Four hundred workpeople, in 11 factories, are employed in the manufacture of these matches which are consumed almost exclusively in Belgium. At the end of 1894 about 200 workpeople were occupied in one factory alone in making these matches for exportation. This, however, was a singular occurrence; in general, no foreign country buys "stinkstekje."

What is known in Belgium as the "English" match is a splint dipped in paraffin and tipped with a composition containing about 5 or 6 per cent., or, in exceptional cases, 7 to 7·5 per cent. of ordinary phosphorus. The name "crascher," commonly given to it by the Flemish workpeople, has reference to the detonation which usually accompanies its ignition. This match is not, as a rule, consumed in Belgium; it is mainly exported to England and abroad. About 650 workers, in seven factories, are employed in its production.

The "composition" for wax matches (vestas) contains up to 8 per cent. of ordinary phosphorus. The manufacture of these matches is carried on in two factories and employs about 400 workers. They are very sparingly consumed in Belgium; the great bulk find their way to England.

The manufacture of Swedish matches is carried on in 10 factories, and employs about 1,100 workers; some of the produce is consumed at home, but the greater proportion is exported.

Visits to certain match factories in Belgium: Ghent.

The largest factory in Belgium is that of La Société Caussemille Jne. & Cie et Roche & Cie, 178, Rue de l'Atelier, Ghent, of which M. Léon Chaubet is the director. By the courtesy of this gentleman I was permitted to visit the factory in company with Mr. Hallet, the son of H.B.M. Vice-Consul at Ghent, whose perfect acquaintance with Flemish was of great assistance to me, and every facility was afforded me to ascertain the methods adopted there to protect the workers. It may be stated that the Society has other manufactories in Algiers, Bona, Turin, and Piobesi, and employs in all about 2,000 workpeople.

The Ghent factory occupies a space of about 16,000 square metres, and is situated on the River Lys, which is used for the transport of the wood, &c. It employs about 450 workers, and manufactures nearly every kind of match, as well as the boxes to contain them. It is a remarkably well-ordered place in an open situation, and justly enjoys a high reputation for the efficiency of its sanitary and hygienic provisions.

The Ghent factory, at the time of my visit, was consuming about 100 kilos of ordinary phosphorus a week. The "composition" is made in closed vessels provided with agitators, and heated by steam, the whole being placed under a capacious draught-hood in connexion with a ventilating fan of Geneste and Herscher's construction. The "laboratory" is unusually large and lofty, and particularly well ventilated. The "batches" of paste when made are preserved in the open air in iron troughs provided with closely fitting lids. The amount of phosphorus in the paste intended for "English" matches is from 6 to 7 per cent.

There are five dipping tables. Each of these is placed immediately before a Geneste and Herscher ventilator, 1 metre in diameter, in such manner that the periphery of the ventilator is tangential to the surface of the paste. I made a number of trials as to the efficiency of the arrangement, and I found it excellent in all respects: the air-current effectually swept away all fumes, no matter from what position of the table. I have nowhere seen a better method of ventilating the dipping tables.

The drying chambers are also noteworthy. They are made of stout black-iron, and the several casements are provided with closely fitting doors also of iron. Each place is separately ventilated, the air current, the temperature of which is under control, entering from below, and leaving the chamber at the top, the whole series being connected with a central channel at the end of

which is a Geneste and Herscher fan. In the separate channels from the chambers is a simple but ingenious arrangement by which the air-current in any one compartment can be immediately stopped should the matches in that compartment take fire. The risk of the fire spreading is thereby greatly minimised. The efficacy of the arrangement was actually demonstrated to me.

The mode of ventilating the boxing-rooms and the work-tables of the fillers is seen in Figs. 10 and 11. The Plates are taken from M. Henrotte's report already referred to. The tables are arranged in series of three, and over each is a sheet-iron tube, about a metre in diameter and 25 metres long, in which is a Blackman propeller of 60 centimetres diameter, running at 1,000 revolutions a minute. Perpendicular to the wide tube, and above each table, is another sheet-iron tube about 20 centimetres wide, connected with a wooden case running nearly the entire length of the table, and provided with openings in immediate juxtaposition to the clamps containing the dried matches. There is, of course, no cutting by the fillers, as in the generality of English works, and the amount of "firing" is comparatively small. Indeed, nowhere on the Continent have I seen the air of the boxing-room so charged with the fumes arising from ignited matches as I have seen in certain English factories.

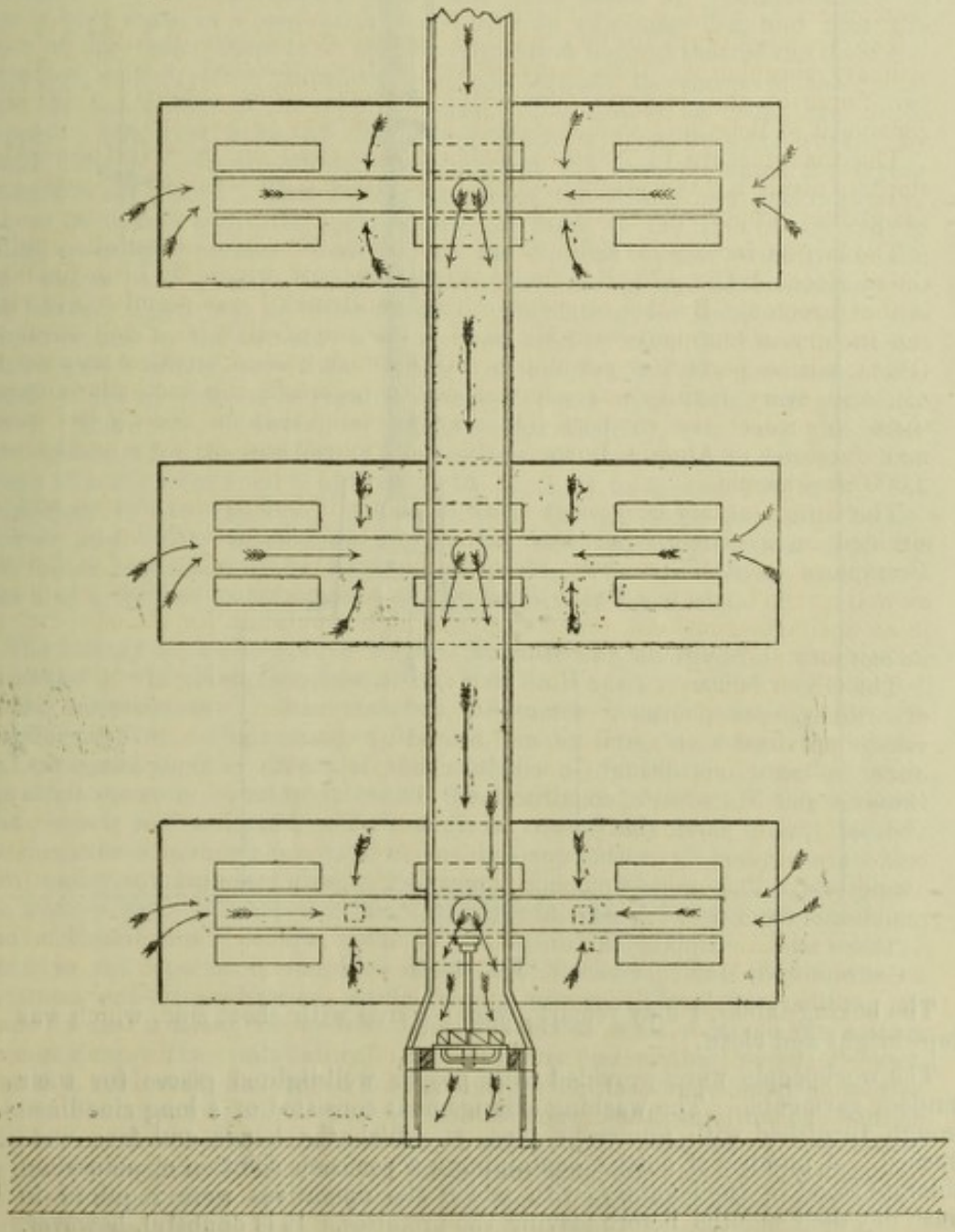


Fig. 10.

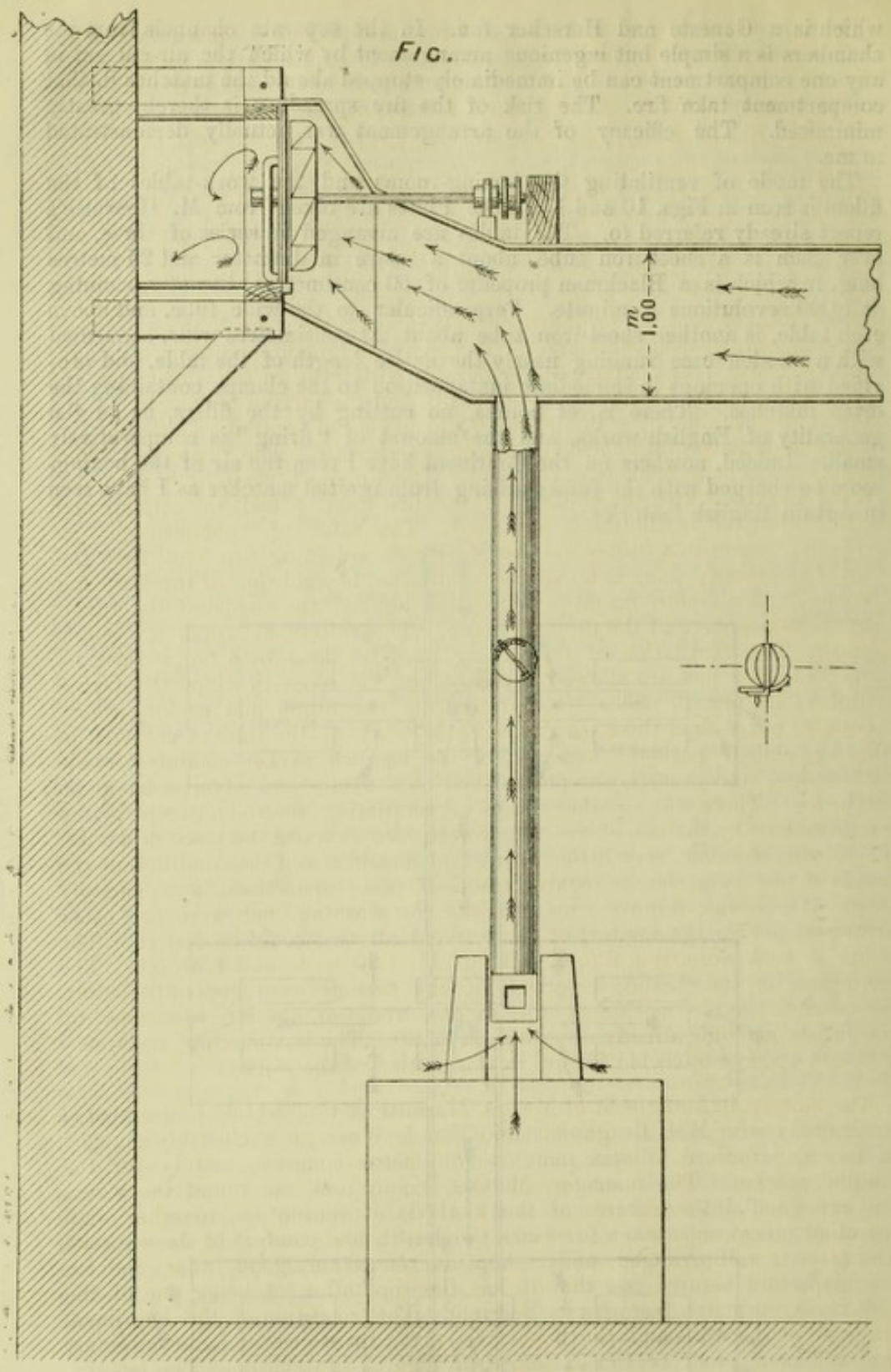


FIG. 11.

The boxing-tables, I may remark, were covered with sheet zinc, which was kept bright and clean.

The workpeople were provided with proper well-lighted places for their outdoor garments. The washing arrangement consisted of a long zinc-lined trough furnished with numerous taps, at which the hands and face were washed. A number of bottles containing a 4 per cent. solution of potassium chlorate stood in the lavatory, with which the operatives were required to wash out their mouths before leaving the premises. It is doubtful, however, whether this is the best antiseptic solution which could be employed for the purpose.

I examined the register of the monthly medical visits. It was well kept, and, to judge from the occasional remarks of the inspector, seemed to be efficient. I was informed that these remarks were not without their influence on the personal cleanliness and general tidiness of the operatives.

Grammont.

The largest factory in Grammont, the centre of the Belgian match industry, is that of M. Mertens, now known as the Belgian Match Co. I visited it in company with M. Joseph Brughmans, Inspecteur du Travail à l'Administration Centrale, and M. Em. Van de Weyer, Assistant Inspector, to both of whom I am under many obligations for their courtesy and for the readiness with which they facilitated my inquiries. This factory employs about 350 workers: 80 per cent. of its production consists of "safeties," and only 20 per cent. of ordinary phosphorus matches; much of its produce is intended for the English market. The general hygienic conditions, although improved of late years, compare unfavourably with those of the Ghent factory. The "composition" is made in a courtyard, and the mixing is done by hand; there is no machinery for the purpose, and no special ventilation either of the apparatus or place in which the operation is performed. The "batches" when finished are kept in buckets in the yard. The dipping is done by hand under a hood connected with the chimney of the fire used to melt the sulphur and paraffin—but the ventilation is not good. The batch of "composition" in use is kept warm in a *bain-marie* placed over an adjoining fire, and near the door of the room; there is no special ventilation beyond that of the door and fireplace, and therefore no proper provision against the escape of the fumes into the atmosphere of the dipping house. The splints, as usual, are single dipped. The ventilation of the drying place is done by a fan worked by hand, but the fumes are allowed to escape into the room in which the drying chambers are placed. This is separate from the filling and packing room. About 30 boxers and three packers were at work at the time of my visit in filling so-called "parlour" matches for the English market—mainly for sale by "stores" and grocers who placed their own names and advertisements on the boxes. There was no other means of ventilating the room except by the windows, and by the two stoves which were used to warm the place in winter. There was, however, very little "firing" of matches, and the condition of the hands of the operatives, as regards traces of paste upon them, was generally good. There was, however, no provision for washing, nor were the other arrangements for the comfort of the workers all that could be desired. The hours of work were from 6 to 8, 8.30 to 11, 1.30 to 4, and 4.30 to 6. The conditions in the "safety" portion of the factory were generally better. Newer and better machinery was in use, and the dipping was done by the Roller machine already described on p. 20. The box-making machinery was also a very noticeable feature in this section of the works.

Anderlecht.

The factory at Anderlecht of Messrs. Mariotte & Co., which I also visited in company with MM. Brughmans and Van de Weyer, is exclusively engaged in the manufacture of wax matches (allumettes-bougies), mainly for the English market. The manager, M. Cos, kindly took me round the works and explained all the features of the methods of ventilation, together with the other precautions taken to ensure the health and comfort of the workers. The place is well arranged, and is kept in remarkably good order; indeed, the inspectors assured me that it has the reputation of being one of the best managed match factories in Belgium. The condition of the buildings, the state of the walls and the floors, the yards, passages, and outbuildings, was sufficient proof of the existence of careful supervision. The factory, when in full operation, employs about 300 workers. The phosphorus is obtained partly from France, partly from America. The "composition" is made under a hood, in a *bain-marie*, connected with a good ventilating arrangement. The "laboratory" contains only one mixing vessel of large capacity, and only one mixer is employed, who has been occupied at the process for upwards of 28 years. Gum only is used, and the agitator is worked by hand. The paste contains 7 per cent. of phosphorus, calculated on the dry materials. The mixing place was light, airy, and well ventilated, and the floor, tables, and walls, and the various mixing vessels were clean and well kept.

There were four dipping tables, and the dippers were women. The tables were much smaller than usual as were the frames or clamps. The method of ventilating the tables, as well as the mode of removing the fumes from the "batch" of composition holding the supply for the tables is seen in Figs. 12 and 13. The table itself is comparatively light and movable, and can be readily run under a tap at the side of the dipping-room and washed down at the close of the day's work, or when it is necessary to change the paste. Attached to the sheet-iron case containing the "batch" is a sloping hood extending half over the table, about 70 centimetres high, and of the width of the table. By this arrangement the second half of the table is left uncovered, and the dipper can readily exercise the requisite pressure on the frames. It will be seen that the hood is in connexion with a case of sheet-iron in which is placed the vessel containing the supply of "paste." The top of the case is furnished with a lid having a counterpoise so that it automatically falls down when the dipper has replenished the table with fresh paste. The case is connected with a tube 20 centimetres in diameter, communicating with the general ventilating system.

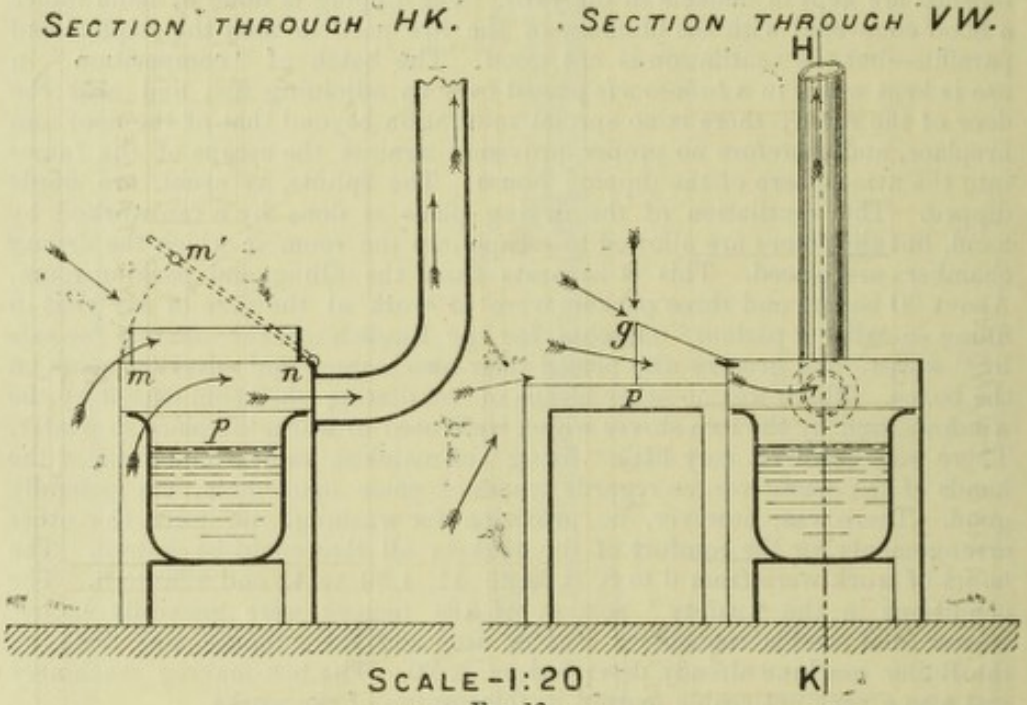


Fig. 12.

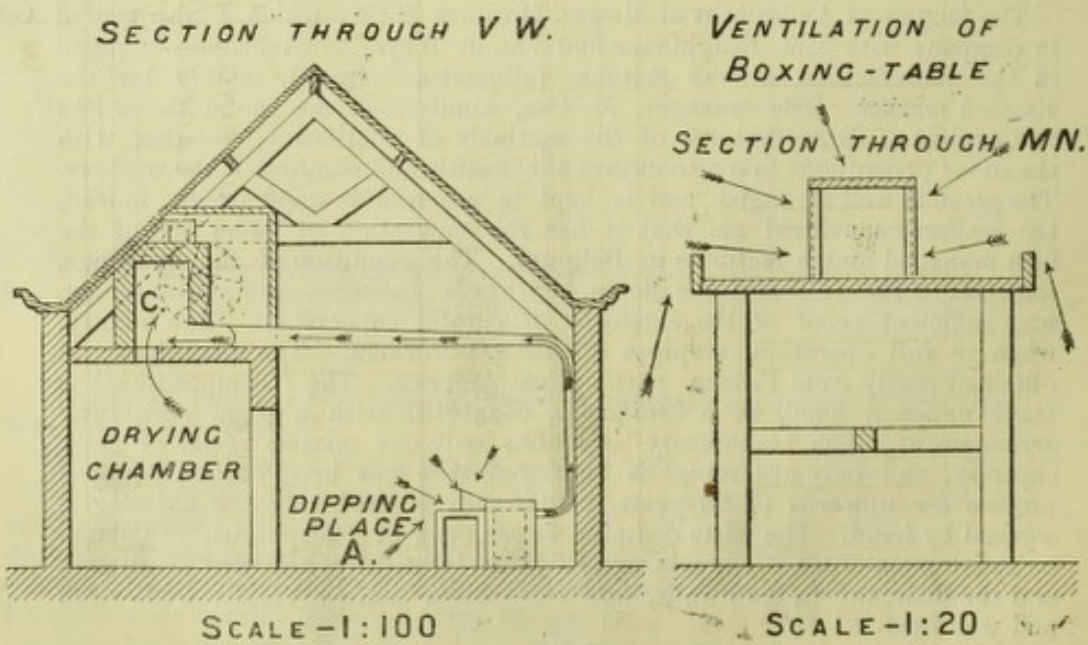


Fig. 13. Fig. 16.

Fig. 15.

ELEVATION. — SECTION THROUGH XYZ

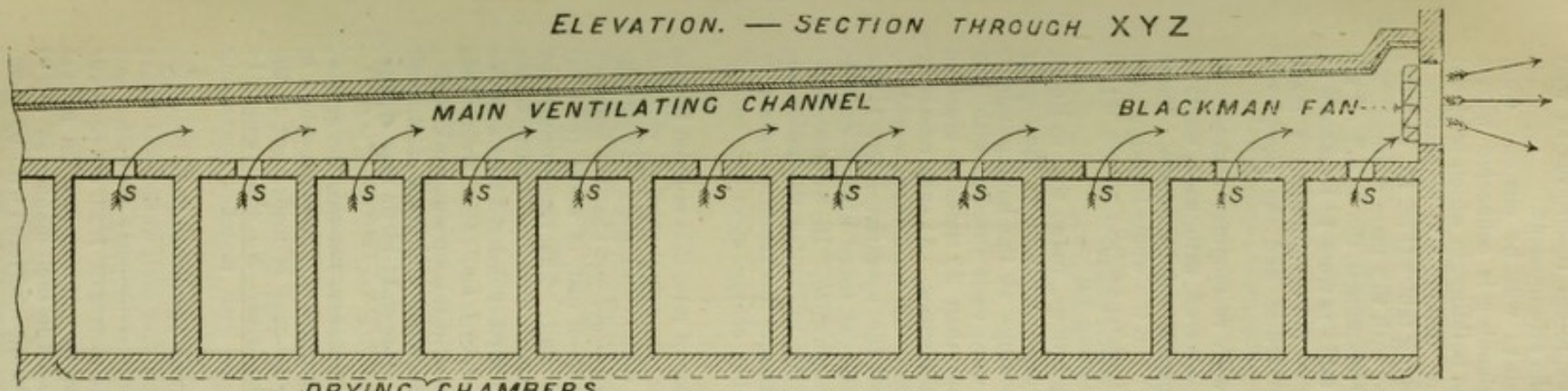


FIG. PLAN.

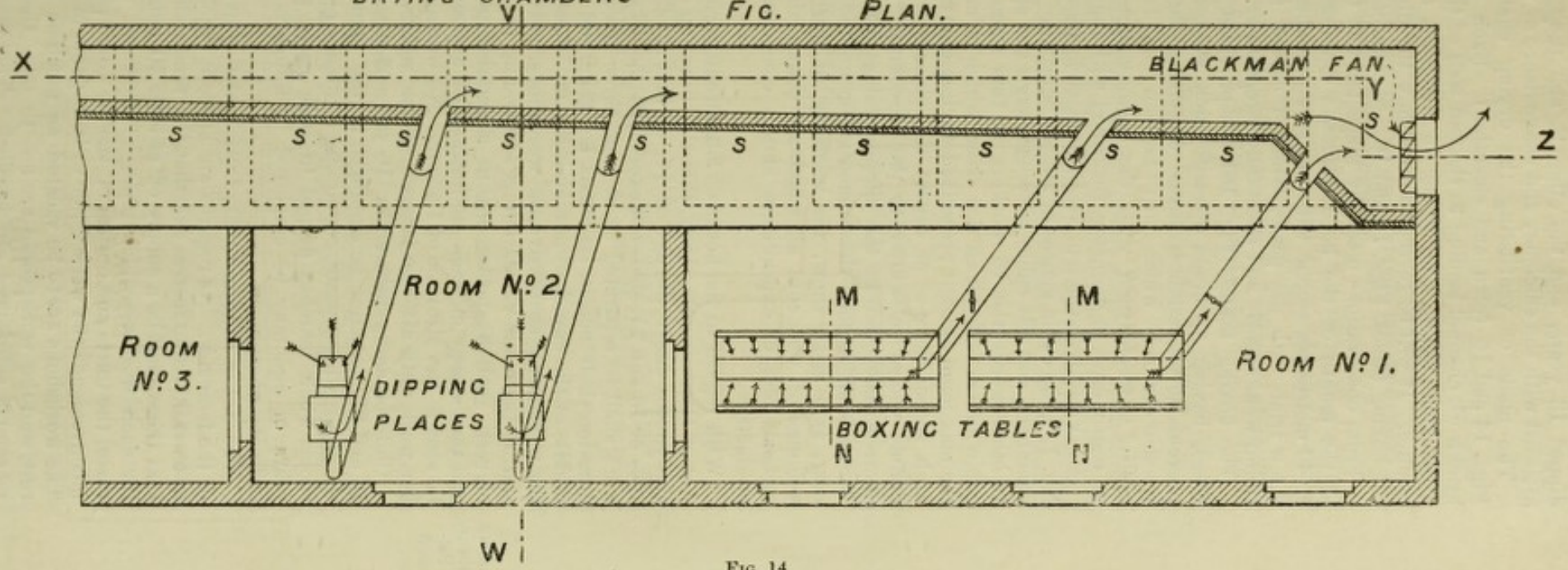


Fig. 14.

At the time of my visit only two dippers were at work; one of these had dipped 13 years, and the other 9, and they expressed themselves as well satisfied with the efficiency and convenience of the arrangement.

The mode of ventilating the drying chambers will be obvious from Figs. 14 and 15 (plan and elevation). Each chamber is connected with a brickwork channel leading to the end wall of the building, in which is placed a Blackman fan of 1 m. 20 cm. in diameter, and making 500 revolutions a minute. It will be further noticed how the dipping tables (Fig. 15) and also the boxing tables, Figs. 14 and 16, are connected with this main channel.

From observations made by Inspector Van Overstraeten, the speed of air at the mouth of the hood over the dipping table is from 1·10 metres to 1·40 metres per second with the given number of fan revolutions. I made a few trials with dry paste, which I caused to ignite, and the phosphoric fumes were rapidly and effectually swept away.

The boxing tables (Fig. 16) are provided with rectangular channels of wood, having openings opposite each worker covered with wire work to prevent burnt matches, boxes, &c. being thrown into the channels. These wooden channels, which it will be seen (Fig. 14) run the whole length of the tables, are connected with the main channel by sheet-iron tubes, 30 to 40 centimetres in diameter, furnished with regulating valves.

M. Van Overstraeten, by anemometric observations, found that in Room No. 1, 1,858 cubic metres of air per hour were aspirated through the drying chambers, and 594 cubic metres through the openings at the boxing tables. In other words the 16 workers in this room were each supplied with 153 cubic metres of fresh air per hour, which is more than 2½ times as much as the maximum amount prescribed by hygienic authorities. At such relatively high speeds there is, of course, the objection that the work-room would be unduly cooled in winter to the discomfort of the operatives, but I was assured that even at the dipping-tables where the speed always exceeds 1 metre per second, the women suffer no inconvenience. In Sweden, however, as I shall show, the necessity of warming in winter the enormous volumes of very cold air which are drawn through the factories is a very serious item of expenditure and a considerable charge upon the cost of production.

Regulations as to labour, &c. in Belgian match factories.

With regard to the hours of labour and periods of rest, it is ordered by the Act of December 26, 1892, that the duration of the actual work of children and youths under the age of 16, as well as of women and girls between the ages of 16 and 21, shall not exceed 10½ hours *per diem*; and that the hours of work shall be separated by at least three intervals of rest, of which the total duration shall not be less than an hour and a half. The rest during the middle of the day shall not be less than of one hour's duration, during which the workpeople shall leave the workshops. It is further ordered that a notice stating the hours of beginning and ending (1) of work and (2) of the periods of rest, shall be posted up, in a suitable place, in the various workshops; and that a copy of such notice, and of any subsequent alteration of it, shall be sent to the Minister of Labour. No woman after child-birth may resume her work until after an interval of four weeks.

Children and youths under 16 years of age, or women between the ages of 16 and 21, may not be employed in the manufacture of phosphorus, nor in the shops where paste containing ordinary phosphorus is made, nor in the rooms where matches dipped in such paste are dried. No child under 14 years of age may be employed in filling boxes with matches containing ordinary phosphorus.

The Act of September 21, 1894, makes provision for the sanitary condition of the factories. As regards air space it enjoins that each worker shall have at least 30 cubic metres and that the rooms shall be properly ventilated and that there shall be a supply of at least 30 cubic metres of fresh air per hour for each worker—which must be increased to 60 cubic metres in special cases, the inlets and outlets of the air to be placed in such manner as not to inconvenience the workers, or to be capable of being interfered with by them. The workshops are to be vacated as much as possible during the periods of rest, and the workpeople are not to take their food in any locality where poisonous substances are handled. The masters are bound to provide a sufficient supply of good drinking water.

The special regulations relating to match factories in Belgium at present in force, as given in the last edition of the "Lois et Règlements, etc.," are as follows:—

Article I.

A. In factories for making matches with ordinary phosphorus each of the operations of making the paste and drying the dipped matches shall take place in premises specially devoted to that purpose.

B. The preparation of the ordinary phosphorus paste shall be effected in an apparatus closed hermetically or at least surmounted by a wide and low hood communicating with a chimney with powerful draught.

It is forbidden to introduce into the paste an amount of ordinary phosphorus exceeding 8 per cent. of the total matter, exclusive of water.

C. Aspirating shafts communicating with a mechanical ventilator must be placed on a level with the tables for dipping matches and vessels containing the paste.

D. Drying rooms to which the workers have access should be mechanically ventilated. The quantity of air necessary for this ventilation shall be fixed in each particular case by the Permanent Deputy on the advice of the Central Department for the Supervision of Labour and Dangerous or Unhealthy Establishments.

Article II.

Exemptions from the preceding regulations, and from those of the Act of 25th March 1890, can be granted by the Permanent Deputies, subject to the approval of the Central Department of Inspection and Supervision of Labour and Dangerous or Unhealthy Establishments.

It was subsequently (April 18, 1898) decreed that:

Article I.

In order to ascertain the proportion of ordinary phosphorus in the paste for matches, the Inspectors of Labour in taking samples of these pastes shall proceed as prescribed in paragraphs A., B., C., D., and E. given below:—

A. Three samples of each paste shall be taken by means of a glass or porcelain spoon, not on the slab where the matches are dipped, but from the vessel containing the paste which must be made homogeneous by careful mixing.

B. These samples are to be enclosed in wide-necked bottles of about 60 grammes capacity, closed with a ground-glass stopper and sealed with the special seal of the inspector.

The manufacturer will be asked to add any mark he may choose, in addition to his seal or his name, beside the seal of the inspector.

C. The bottles shall bear a label the same for samples of the same paste, marked so that it may be possible to distinguish the samples without the chemist entrusted with their analysis knowing their origin.

D. For each sampling, a report shall be prepared in duplicate setting forth the object and circumstances of the case, noting in particular the exact description of the label and the marks or seals placed on the bottle.

E. One of the samples taken shall be left with the manufacturer concerned, who shall receive, within 24 hours at the outside, a copy of the report.

The other two samples shall be sent, with the least possible delay, to the director of the analytical laboratory appointed for this purpose by the Minister of Industry, and to the clerk to the magistrates respectively.

In cases where the inspector has a distance of more than five kilometres to travel to reach the laboratory or the clerk to the magistrates, the samples shall be sent express to their destination by means of the public service, and every care taken that they reach their destination without delay.

The director of the laboratory as well as the clerk to the magistrates or his representative shall deliver or send to the inspector a receipt indicating the date of receipt of the package, describing the label and the marks or seals placed on the bottle as well as the state in which they are found.

The inspector shall transmit without delay to the public prosecutor a copy of the report accompanied by the receipts which have been delivered to him.

Article II.

The director of the laboratory shall immediately proceed to the analysis of the samples.

Article III.

Immediately after completing his analysis, he shall prepare a report notifying the following :—

1. The date of receipt of the sample at the laboratory.
2. The date of the analysis.
3. The description of the bottle, labels, marks, and seals placed thereon, also a note as to the normal or abnormal condition in which they were found when received.
4. A summary of the analytical process followed.
5. A statement of the results obtained.
6. The fee for analysis.

Article IV.

The director of the laboratory must send his report to the public prosecutor, who, after comparing it with the report of the inspector, and the receipts thereto annexed, will decide what course shall be taken.

Article V.

When the results of the report show that the paste analysed contains a larger proportion of ordinary phosphorus than the regulation maximum the director of the laboratory shall forward a copy of the report to the inspector who took the sample.

Article VI.

In case of conviction the costs shall be borne by the party convicted.

Article VII.

Anyone who places any obstacle in the way of the inspector taking samples shall be liable to the penalties provided by Articles 2 and following of the Act of 5th May 1888, relating to the inspection of dangerous and unhealthy establishments and the supervision of machinery and steam boilers, without prejudice to any penalties to which they may be liable under Acts 269–274 of the Penal Code.

Article VIII.

Article 2 of the Act of 12th February 1895 is modified as follows :—

" Exemptions from the preceding regulations and those of the Act of 25th March 1890, except as regards the maximum amount of ordinary phosphorus permitted in the paste, may be granted by the permanent deputies on the approval of the Central Department for the Inspection of Labour, authorised to supervise dangerous and unhealthy establishments."

With a view to the enforcing of Article 3 of the Act of 25th March 1890, above cited, the Inspectors of Labour are required to take samples of suspected matches from the match depôts or stores affected by the regulations relating to dangerous and unhealthy establishments.

The regulations as to sampling, analysis, and report, &c. are similar, *mutatis mutandis*, to those given in the case of the pastes.

Effect of regulations on the Belgian match industry.

Although there can be no doubt that the laws of 1890 and 1895 have greatly improved the hygienic condition of the workers, many manufacturers are of opinion that the limitation of the amount of phosphorus in the paste has reacted prejudicially upon the match industry in Belgium by shutting her out from certain markets. This opinion finds expression in a recent article in "L'Etoile Belge," October 5, 1898. The Belgian matches ("Stinkstekje") containing so low an amount of ordinary phosphorus as 8 per cent. do not keep well, and hence customers decline to stock them, as they are liable to be left on their hands. Pastes containing potassium chlorate do not deteriorate so rapidly, but such matches cost more to produce, and there is probably not the same profit on their sale. In Germany and Austria, and also in Scandinavia, matches containing from 25 to 30 per cent. of ordinary phosphorus may still be made, and hence Belgium is unable to compete with these countries in markets, as in the East Indies, where such matches find a sale. It is also alleged that the Belgian manufacturers are under a disadvantage as regards the incidence of the Customs duties in Belgium. German matches, for example, pay an *ad valorem* duty of 10 per cent. on entry, but as the exporter commonly declares only 70 per cent. of the invoice value, such matches in reality only pay a duty of 7 per cent. The Belgian matches, on the other hand, pay on entering Germany a duty of 12½ francs per 100 kilos. gross, which amounts to 37.50 francs *ad valorem*, or more than five times that paid by the German exporter. Competition is impossible under these conditions. The framers of the Act of 1890 would appear to have been unmindful of the treaty of commerce with Germany, which does not expire till 1902.

It is argued that the only means of saving the match industry in Belgium are (1) the repeal of the prohibition of 1890 as to the limit of phosphorus, or (2) the establishment of a State monopoly, as in France. It is contended that a well-organised monopoly would permit of a better supervision of the workpeople, and of a better scale of wages for their work, whilst the State could make a net profit of from 8 to 10 millions of francs a year without any sensible hardship to the consumer. This estimate is based upon the assumption that the actual consumption of matches in Belgium is eight matches per head *per diem;* this, with a population of six millions, corresponds to a consumption of about one million boxes (one box = 50 matches). Assuming that the actual net cost of a box is now 0·6 of a centime, and that the increased wage to the workpeople and the costs of administering the State monopoly increases the cost to 0·8 of a centime, the million boxes would cost 8,000 francs. In France, where the match monopoly has existed for a quarter of a century to the satisfaction of the working classes, as well as of the Government to whom it brings in from 25 to 30 millions a year, a box of 50 matches sells for 10 centimes. If the Belgian Government sells it at the rate of 3 centimes, a trifling increase which would not lead to any diminution in consumption (the Belgian public pays 2 centimes a box for Swedish matches), the receipts would be 30,000 francs a day, that is, a profit of 22,000, or, in round numbers, eight millions a year.

DENMARK.

Manufacture and sale of ordinary phosphorus matches prohibited in Denmark.

The case of Denmark is especially interesting from the circumstance that it is the only country in which the manufacture and sale of matches containing ordinary phosphorus is prohibited. A Bill, absolutely forbidding their manufacture or sale, was passed without amendment by the Landsting on 17th December 1873 and by the Folketing on 20th January 1874, and received the Royal assent on February 14, 1874.

Its provisions are as follows:—

S. 1. After January 1, 1875, the manufacture of matches containing ordinary phosphorus, or of any other matches, except such as are intended to strike on surfaces specially prepared for that purpose, is forbidden.

The importation into the country of matches made with ordinary phosphorus is also prohibited from the same date, and the sale of them is prohibited after July 1, 1875.

S. 2. In match manufactories, where red phosphorus and potassium chlorate are used, the room where the work with red phosphorus goes on shall be well separated from the places where the work with potassium chlorate takes place.

S. 3. Violation of this law shall be punished by fines from 20–200 kroners (1*l.* 2*s.* 3*d.*–11*l.* 2*s.* 6*d.*), and confiscation of the prohibited matches. The offences to be treated as ordinary police cases.

S. 4. The law can, by Royal decree, be made to extend to the Faröe Islands.

The circumstances which induced the Danish Government to introduce the Bill of 1874 were :—

(1.) The recognised danger to the health of the workers from the use of ordinary phosphorus, (2) the danger from fires in houses and buildings, and (3) the fact that a ready means of poisoning was placed in the hands of everyone.

At that time (1874) a large number of children and young persons were employed in the manufacture of the sulphur matches tipped with phosphorus paste, and the Health Commission (17th November 1866) drew up regulations to be observed in the factories. These regulations proved ineffective; and in consequence of the reports from the Health Commission of Frederiksberg with regard to the dangers attaching to the manufacture, the Ministry of Justice felt bound to make searching inquiry into the matter. At one factory in Frederiksberg, especially, cases of phosphorus poisoning occurred out of all proportion to those in the other factories, and yet it satisfied the regulations in all respects. The Health Commission therefore recommended the prohibition of the manufacture of matches with ordinary phosphorus.

The conclusion arrived at as to the excessive occurrence of phosphorus poisoning in this particular factory was that the proportion of phosphorus in the paste used was greater than in the others.

The prohibition of the use of matches made with ordinary phosphorus was considered possible, as matches were in use both at home and abroad which satisfied all the requirements of a lighting material without any of the dangers associated with those in question.

In the seven factories where ordinary phosphorus was used there were employed 76 adults and 180 children. At the hospitals of Frederiksberg and Copenhagen in the last five years 11 patients were treated for phosphorus poisoning; 9 of these came from the factory in Frederiksberg, of whom 2 died, 4 underwent resection of larger or smaller portions of the lower jaw, and 3 recovered without resection after the removal of teeth, &c., in the affected jaw bones. Several other cases of phosphorus necrosis came to light, which had not been treated in hospital. Of the remaining 2 cases where the place of employment was not recorded, 1 died after operation, and the other recovered.

The Ministry of Justice appointed a Committee of the Polytechnic School to report on the Frederiksberg factory (at which 83 were employed out of the total 256), and the conclusion arrived at was that it was not necessary to prohibit entirely the manufacture of phosphorus matches, but that by stringent regulations the employment could be made as safe as, for instance, the manufacture of china, white lead, or glass.

The Committee recommended—

(1.) That the amount of phosphorus in the paste should not exceed 10 per cent.

(2.) That dextrin or gum should be used in place of glue in the paste.

(3.) That the dipping should be done on a plate on which the paste was spread out in a thin sheet; that round the plate there should be oil of turpentine to "neutralise" the phosphorus fumes, and that by suitable ventilation at the level of the plate the fumes should be drawn away.

(4.) That the drying room should not be continuously occupied while the drying process was in operation.

(5.) That all the rooms should be well ventilated.

(6.) That turpentine be sprinkled on the floors.
(7.) That the hours of work should be shortened so that no adult should work in the factory for more than 12 hours.
(8.) That every factory should appoint a medical man to examine the new hands, and at intervals all the work-people.
(9.) That meals should not be taken in any of the work-rooms, and that the work-people should wash before meals and after ceasing work.
(10.) That the master should be bound to contribute to the maintenance of a workman who, by reason of necrosis contracted in the factory, is incapacitated wholly or partially from work.

The Committee reported that on several of these points the arrangements at the factory at Frederiksberg were very defective.

The Royal College of Health, when requested to express an opinion on the question, stated that as no regulations had ever sufficed to prevent the danger to health from the manufacture of matches with ordinary phosphorus, and, in view of the carelessness of the children and adults employed, its use should be prohibited.

The Government was of opinion that it would be impossible to carry out, with any degree of success, the recommendations suggested by the Committee of the Polytechnic School, as it was afraid that they would be regarded as burdensome by the employers, who might in consequence reduce the wages of the workpeople. By entire prohibition, on the other hand, the owner would merely have to resort to the manufacture of safety matches on the same premises.

On the second point, namely, the danger from fire, the Government pointed out that out of 5,041 fires which occurred in the 10 years of 1862–72, no less than 291 could be set down to phosphorus matches. Of these, 198 were caused by children under 10 years of age.

As regards the third point, the placing of a ready means of poisoning in the hands of everyone, it was to be noted that of 32 cases of poisoning between the years 1857–72, in Denmark, 18 were due to phosphorus matches.

In view of the fact that matches made with red phosphorus are entirely without danger to the workers, are not poisonous, and are less likely to cause fires than the other kind, the Ministry of Justice thought the simplest measure to adopt was the entire prohibition of the manufacture of matches made with ordinary phosphorus.

Match factories in Denmark.

I am informed by Professor Stein, the Danish Government chemist, that at the present time there are six match factories in Denmark, employing 447 workers, of whom 339 are adults, and 108 youths and children. Since the passing of the law of 1874, not a single case of phosphorus necrosis has been known in Denmark.

In answer to my inquiries as to whether there was any evidence that ordinary phosphorus matches were ever clandestinely made in Denmark, Dr. Stein reports that it is certain that such matches are nowhere manufactured in the country. A few cases of smuggling have occurred, which is not surprising considering the proximity of Germany and of Norway and Sweden, but these cases have been promptly followed by legal proceedings. Travellers, especially from Sweden, occasionally bring over a few ordinary phosphorus matches, but there is certainly no illicit trade in the articles. During the 25 years the Act has been in force the people have become wholly accustomed to the use of safety matches, and practically neither know of, or have any desire for, any other form.

Considering that the population of Denmark is very largely agricultural and maritime this testimony is very significant.

During the year 1897, 268,000 kilos. of safety matches were exported from Denmark.

NORWAY and SWEDEN.

Norway.

Match factories in Norway.

At the present time there are six match factories in Norway, viz. :—

(1.) The Nitedals Tändstikfabrik, Christiania.
(2.) Agnaes Tändstikfabrik, Fredriksvaern.
(3.) Bryns Fyrstikfabrik, Bryn.
(4.) Haldens Tändstikfabrik, Fredrikshald.
(5.) Oddernacs Tändstikfabrik, Christianssand.
(6.) Elvebakkers Fyrstikfabrik, Molde.

The total number of workers is about 600, of whom 400 are employed in the manufacture of ordinary phosphorus matches. Certain of these works employ only from 8 to 10 workers, and supply only a local demand. The most important factories in Norway are the two works of the Nitedals Company, the larger of which is at Grönvold, near Christiania, and employs about 380 workers. The other, the Agnaes Works at Fredriksvaern, employs about 100 hands. The hours of work at Grönvold are from 7 to 9.30; 10 to 1; 2 to 6; on Saturdays from 7 to 9.30 and 10 to 2. At Fredriksvaern the hours are from 6 to 9, 9.30 to 1, 2 to 6; on Saturdays they stop at 2. The annual output of the Grönvold factory is about 8,000 cases of 50 gross of safeties, and 12,000 cases of 50 gross of ordinary phosphorus matches. At Fredriksvaern no safeties are made; the yearly production is about 5,000 cases of 50 gross. "English" or "parlour-matches" (with paraffined splints) are no longer made by the Nitedals Company. The total amount of ordinary phosphorus consumed by the company is about 140 kilos. a week; the paste used contains about a third of its weight of ordinary phosphorus.

"Dippers" earn, on the average, from 23 to 25 kroner (25*s.* 5*d.* to 27*s.* 7*d.*), clamp fillers about 22 kroner (24*s.* 5*d.*), box fillers and packers from 10 to 13 kroner (11*s.* 1*d.* to 14*s.* 5*d.*), and box makers about 8 kroner (8*s.* 11*d.*) a week.

I visited the Grönvold factory on October 12, 1898, and was taken over the works by Mr. Adolf Andersen, and Mr. Gustav Piene, the engineer, who explained to me all the details connected with the manufacture of the phosphorus paste, the methods of dipping, drying, and boxing the matches, and the precautions taken to ensure the health of the workers. The works, which were started in their present position (the old Nitedals factory no longer exists) about 25 years ago, are situated in an open position, on high ground to the rear of Christiania, and occupy a site of 250 maal. The buildings were specially designed for the manufacture, and are well arranged in themselves and with respect to one another.

The "composition" is made in a separate building, situated in the middle of the yard, and altogether removed from the other premises. Four mixing vessels are used. These are heated by steam, and are placed under a well ventilated hood. Fig. 17 shows the internal arrangement of the vessels

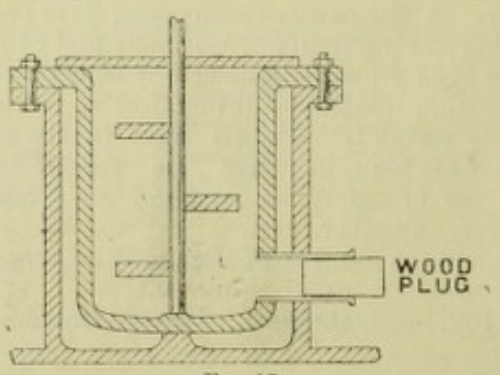


Fig. 17.

and the mode of withdrawing the paste. Each vessel holds 3 pailfuls of paste, containing in all about 4 pounds of ordinary phosphorus, sufficient to dip 330 gross. The "batches" when finished are placed in a separate iron building specially ventilated. One man only was employed in the "laboratory," and he had been engaged in the work for about 2½ years; he seemed to be unhealthy, and was stated to be suffering from tuberculosis.

The "ramme" or clamps are dipped over a roller, revolving in the paste in the manner seen in Fig. 18. Both the roller and the pail containing the

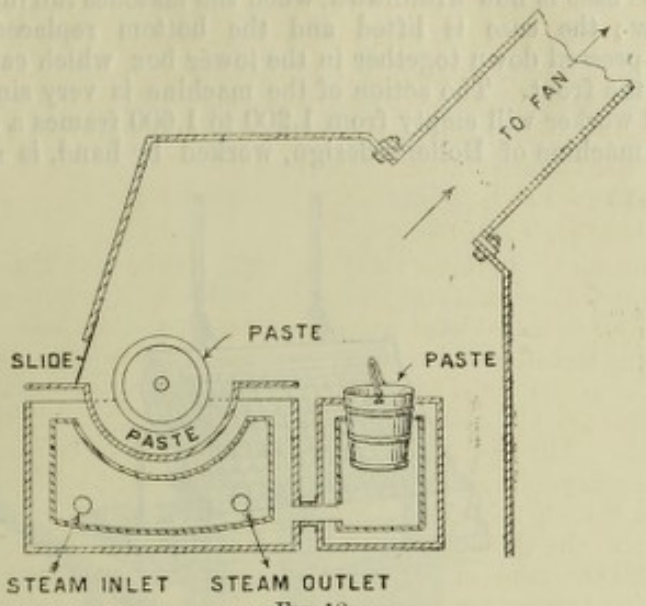


FIG. 18.

supply of "composition" are placed under a hood connected with a ventilating fan. Three dippers were at work. One, whose operations I watched for some time, stated that he had been dipping with this machine for 12 years and had suffered no inconvenience. The drying room adjoins the dipping place, from which it is separated by a partition of corrugated iron. The "tralle" or waggons containing the "clamps", each waggon holding 160 clamps, run on rails through the drying room in which they remain at least two hours. There is excellent general ventilation in the drying rooms as well as in the dipping house.

The dried matches (the splints as usual are only single dipped) are shaken out of the frames, sorted, placed under ventilating hoods, hand picked and boxed by the Arehn filling machine (Lundgren's patent).

As emptying machines, and box-filling machines, other than that of the Diamond Match Company, are not to be met with in this country it may be desirable to give some description of them here. Those most commonly seen on the Continent are made by Roller, of Berlin, and by the Sebold Company at Durlach. The Schnetzer machine made by both these firms is seen in Fig. 19. The filled frames containing the dried matches are placed

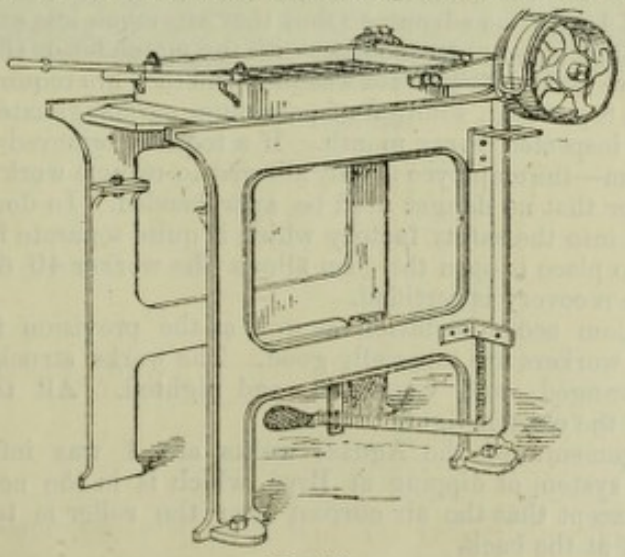


FIG. 19.

over the trough, and unclamped; when the matches drop into the receptacles, head downwards. A second and third frame are then similarly treated and the case receiving the matches is set in motion by slipping the band over the fast and loose pulley, whereby the splints are shaken closely together in

such manner that their heads all lie in the same direction. A fourth, and when the splints are thin, even a fifth frame can be similarly emptied. The bottom of the case is now withdrawn, when the matches fall into a second box placed below; the case is lifted and the bottom replaced, whereby the matches are pressed down together in the lower box which can then be withdrawn from the front. The action of the machine is very simple and rapid, and a skilful worker will empty from 1,200 to 1,600 frames a day.

A simple machine of Roller's design, worked by hand, is seen in Fig. 20,

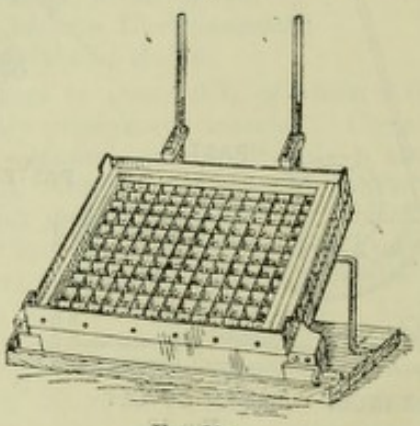


Fig. 20.

and is thus described by him. The frame is placed head downwards on the apparatus, and, by means of two levers, the couplings are removed so as to allow the matches to fall into the reception-case. When four frames have been so emptied, the case is shaken so as to bring the matches closely together; for this purpose, the case is fitted with rollers. The apparatus is then placed in a slanting position, as shown in the figure; the reception-case is lifted at the back and the matches, together with the front part of the filling-frames are shifted into the filling-case which forms the bottom of the apparatus. The machine, like that of Schnetzer, is equally suitable for safety and for phosphorus matches. One girl can empty 800 frames a day by means of it.

These machines not only save labour, but they have the great advantage of diminishing the necessity of bringing the hands in contact with the heads of the matches.

Seventy women and girls are engaged at Grönvold in boxing and packing. This comparatively small number is due to the circumstance that the boxing is entirely done by the Lundgren machine, whereby one machine with two attendants, who require no special experience, can do as much work as five skilled girls, and with the advantage that they are much less exposed to fumes, and that their hands are not in contact with the match heads (Fig. 20A.). The workpeople have good provision for washing, and they are required to rinse their mouths with a 8 per cent. solution of potassium permanganate. The workers are medically inspected every month. If a tooth is removed—the dentist is paid by the firm—the employee is only allowed to resume work on a certificate from the doctor that no danger need be apprehended. In doubtful cases the worker is sent into the safety factory which is quite separate from the lucifer factory. If no place is open the firm allows the worker 40 öre ($5\frac{1}{4}d.$) a day until complete recovery is certified.

The meal-room accommodation as well as the provision for keeping the clothes of the workers are especially good. The works struck me as particularly well arranged, well ventilated, and lighted. All the rooms were provided with the electric light.

The arrangements of the Agnaes works are, I was informed, exactly similar. The system of dipping at Bryn, which is in the neighbourhood, is also similar, except that the air current over the roller is taken out at the side instead of at the back.

Phosphorus necrosis in Norway.

Mr. Dundas, the Consul-General at Christiania, informs me, as the result of special inquiries which he was good enough to make at my request, that cases of phosphorus necrosis are not altogether unknown in Norway. They are, however, much less frequent than formerly.

(*To face page* 42.)

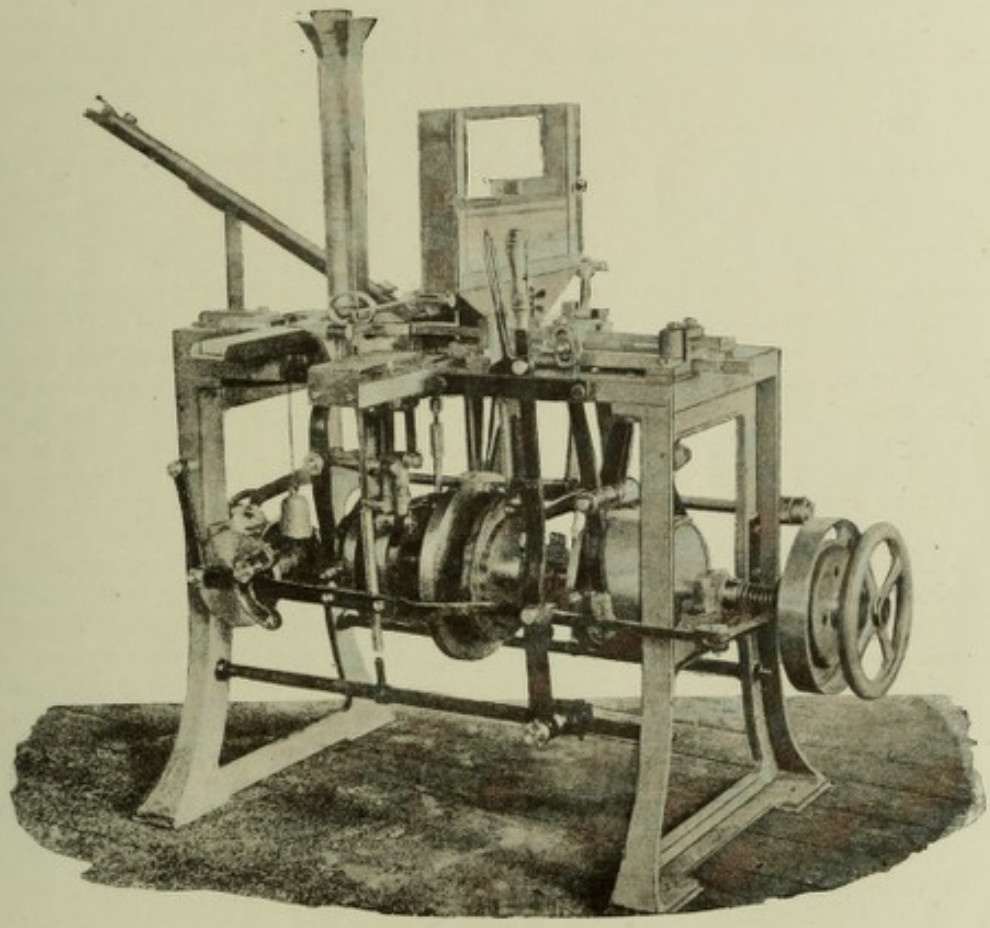


FIG. 20A.

Through the kindness of Dr. Egeberg, I have received through the Consul-General the following report from the director of the Norwegian Civil Medical Board on cases of phosphorus necrosis in Norway during the years 1880 to 1893 (inclusive).

The printed health reports as far back as 1866 have been gone through, and the following information is extracted therefrom.

According to the statistics of operations the number of cases of phosphorus necrosis treated in the year 1880–93 has been as follows :—

Year.	No. of Cases.	Year.	No. of Cases.	Year.	No. of Cases.
1880	1	1887	6	1890	1
1882	1	1888	9	1891	2
1883	3	1889	4	1893	1

The majority of the above cases are stated to have been treated in the infirmary.

The following extracts are added from the health reports dealing with the subject :—

1885, *Akershus District.*

Mr. Bennecke, graduate in medicine, and doctor at the Jolsen Match Factory, Enebak, states that in his experience phosphorus necrosis occurs but seldom in proportion to the number of workpeople who are exposed to this danger. He knows workpeople who have been employed at the factory for several years and whose teeth have been unimpaired and in excellent condition. Fistula in the gum, and small instances of necrosis among the workpeople have several times had to be treated, but have been completely cured by the extraction of the teeth attacked. He therefore utters a warning against too much haste in connexion with treatment of this illness, as if the workman returns to his work directly after the operation, and with the bone still exposed, he is very liable to the danger which it is the object of the operation to guard against.

1887, *Akershus District.*

Three cases of phosphorus necrosis occurred at the Christiania Match Factory at Heggedal, in Asker. The patients were sent to the State hospital. The sanitary arrangements of the factory were later subjected to a more vigilant control.

Buskerud District.

Two girls working at a match factory in Drammen were treated for phosphorus necrosis.

1888, *Akershus District.*

Three cases of phosphorus necrosis occurred at the Christiania Match Factory at Heggedal, in Asker.

1889, *Akershus District.*

Two fresh cases of phosphorus necrosis from the Christiania Match Factory at Heggedal were sent to the State hospital for treatment. One relapse also occurred. At the instance of the Public Health Officer a lavatory was arranged in the spring of 1889 with appliances for washing and rinsing the mouth. This is compulsory, before each meal and before leaving the factory in the evening, for all employed in the dipping room, packing room, and warehouse, and its observance is strictly enforced.

The match trade of Norway.

From the last report on the trade and commerce of Christiania, published by direction of the Exchange Committee, it would appear that the match trade of Norway has not fully participated in the commercial improvement of the country which set in in 1895. The export of matches during the years 1895–97 has amounted to—

	Total.	From Christiania.
1895	4,231,630 kilos.	3,897,390 kilos.
1896	3,020,482 ,,	2,511,982 ,,
1897	3,329,825 ,,	2,127,450 ,,

The falling off in the last two years has been caused by the Japanese, who have flooded the East Indies, Norway's largest market, with phosphorus matches. Unlike Sweden, Norway mainly produces the phosphorus matches for exportation, the home consumption being comparatively small. Unfortunately too, Norway's chief market for safety matches, viz., South America, was, at about the same time, closed against her by the high rates of duty. On the other hand, India, by several concurrent circumstances, has been regained as a market; but, in the opinion of the Committee, Norway's ability to hold her own in the general competition is weakened by the difficulties which the industry has to contend against at home, and which have not been alleviated by the import duty on matches imposed in 1896.

Sweden.

The match industry in Sweden.

The match industry in Sweden, excluding those working at home in box making, &c., employs about one-twentieth of the artizan population, and represents about a thirtieth of the total value of the Swedish industrial production.

According to Dr. Key-Åberg's "Sveriges Industri" for 1898 (Stockholm: Norstedt and Söner) there are at the present time in Sweden 27 match factories, employing in all about 5,500 workers, about half of whom are females. The following is the list:—

Name of Place.	Character of Matches.	Workers.
Södertelge	Safeties	123
Enköping	„	51
Barnarp	„	53
Hvetlanda	„	11
Jönköping (Gemla)	Lucifers, safeties	736
Jönköping Västra	„ „	666
Anneberg	Lucifers, paraffin, safeties	319
Junebro	„ „ „	234
Vexiö	Lucifers, safeties	263
Axebo	„ „	12
Emmaboda	Lucifers	7
Grönskåra (2)	„	17
Kalmar	Lucifers, paraffin, safeties	251
Lovers	Lucifers	51
Mönsterås	Parffin	88
Nybroköping	Lucifers, safeties, paraffin	79
Nyverk	„ „ „	10
Vesterviks	Safeties	290
Malmö	Lucifers, safeties	170
Ystad	—	—
Uddevalla	Safeties	258
Venersborg	Lucifers, safeties	193
Lidköping	Lucifers, paraffin, safeties	365
Vulcan, Tidaholm	Lucifers, safeties, &c.	1,330
Haganäs	Lucifers	20
Krokom	„	12

Of these, by far the most important are the Vulcan Factory at Tidaholm, and the two large factories at Jönköping, viz., the well-known Jönköping's (or Gemla) fabrik, and the Jönköping's Västra fabrik established in 1882.

The Vulcan Factory at Tidaholm.

By the courtesy of Mr. George Murray, the managing director, I was permitted to visit the Vulcan Factory. I am under great obligations to that gentleman and to Mr. Hans Gustafsson, the manager, for the readiness with which they aided my inquiry by every means in their power, and for the kind hospitality offered me at Tidaholm. The Vulcan Factory is probably one of the largest, and is certainly one of the best equipped match works in the world. It was established in 1868 by Baron Essen, the chief landowner of the district, and is the principal manufactory in the place, giving employment, directly or indirectly, to about 2,500 persons. At the time of my visit

1,450 workers were employed in the factories, which are distributed over about 12 hectares of land.

The ratio of men to women may be gleaned from the following figures which are the official returns at the end of 1897.

Males	Over 18	465	Total, 678.
	Under 18	213	
Females	Over 18	483	Total, 712.
	Under 18	229	

At that time 498 persons were concerned in the manufacture of ordinary phosphorus matches. The hours of labour are from 6 to 8, 8.30 to 12, 1 to 4.30, 5 to 7.

The works are at the outskirts of the small town, in a park-like country, surrounded by trees and fields, and intersected by the River Tidan. The production is about half safeties and half phosphorus matches. Of the phosphorus matches, about one-third are sulphur-tipped and two-thirds paraffin or "parlour" matches. The tendency, however, is toward a greater production of safety matches. At Tidaholm there are four separate and distinct factories. I shall confine myself to a description of those in which processes involving the use of ordinary phosphorus are carried on.

In these there are four dippers who are permitted to dip only for a month at a time. During the intervening month they are kept outside the factory on jobbing work. They are examined every month by the medical attendant of the works, Dr. Schwieler, as are the "compo" makers and workers in the drying rooms. The dipping room is a comparatively large and lofty room, and is excellently ventilated.

The mode of effecting the change of air will be obvious from the plan and section given in Figs. 21, 22, 23, from a drawing which I owe to the kindness

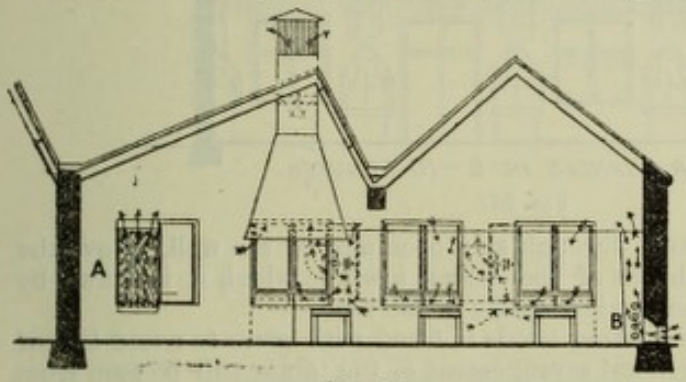


Fig. 21.

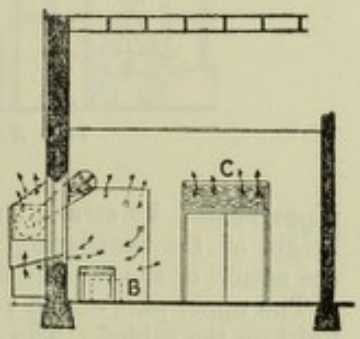


Fig. 22.

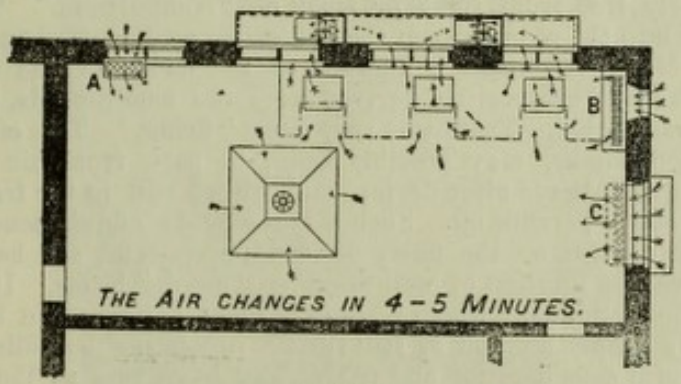


Fig. 23.

of Mr. Gustafsson. The air, which enters at A and C, and which in winter is warmed by passing over the pipes at B, is extracted from behind the dipping tables by a couple of fans on the outer wall, as shown. The action of these fans is sufficiently powerful to cause a constant and rapid current of air over the face of the dipping stone. There is also a shaft in which is a third fan, for the general ventilation of the room. The volume of air thus drawn into the dipping room is such that a complete change occurs in every four or five minutes. The place is kept very clean. The floors are of concrete and the walls are lime-washed at frequent intervals.

The "laboratory" adjoins the dipping room. It is provided with two mixing vessels of the usual type, fitted with mechanical stirrers, and capable of being hermetically sealed. The "paste" employed for the sulphur-coated splints contains about one-third of its weight of ordinary phosphorus; that used for the "paraffin" or "parlour" ("English") matches contains 4½ per cent. of ordinary phosphorus. The floor is at present flagged, but Mr. Gustafsson considers that it would be better if concreted.

The method of ventilating the boxing room and work tables will be evident from Figs. 24 and 25. The air, which in winter is warmed by passing over

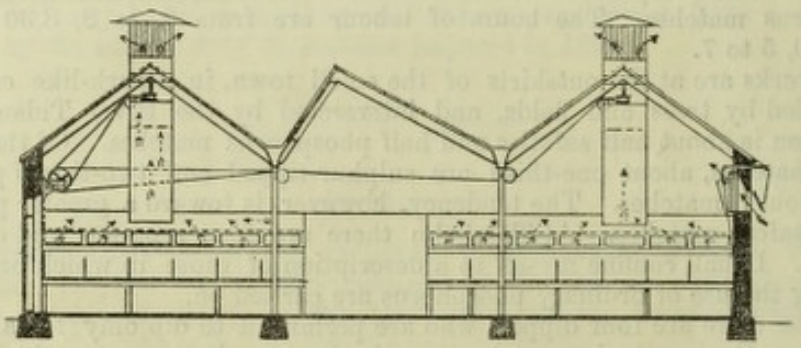


FIG. 24.

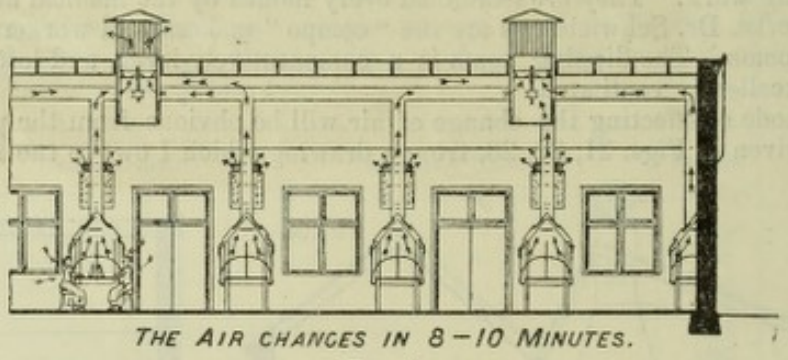


FIG. 25.

pipes heated by steam, enters through side openings in the wall, above the height of the ventilating hoods of the tables, towards which it is drawn by the action of the fans in the vertical shafts in the roof.

The upper part of the ventilating hoods is fitted with glass to avoid loss of light on the tables. The general arrangement of the tables will be seen from Figs. 26 and 27. The whole room was in excellent order, and the atmosphere singularly free from fume or smell of "composition." The volume of air passing into the room is such that its entire content is changed in from 8 to 10 minutes. I examined a number of the hands of the workers for evidence of traces of composition derived from the match-heads, but nothing of the kind was visible. There was very little "firing." This circumstance, Mr. Gustafsson thinks, may possibly arise, in part, from his practice of brushing the match-heads after drying, and whilst still in the frames with a thin film of heavy paraffin oil. Such a film would no doubt tend to prevent the action of oxygen on the finely divided phosphorus, and hence tend to diminish the risk of ignition of well-dried or "quick" heads. It would also certainly diminish "fume," which is caused by oxidation. We have here a possibility of a simple method of still further protecting box-fillers, which is worthy of careful consideration and trial. The box-fillers at Tidaholm, who as a class are a remarkably clean and tidy set of girls, are examined once a month by the medical man attached to the establishment.

Mechanical box-fillers are being tried at the Vulcan factory, and Mr. Gustafsson spoke very favourably of the one I saw in operation, which was turning out filled boxes at the rate of 52 a minute. Some idea of the production at Tidaholm may be gleaned from the fact that about 200 cases, each of 50 gross of boxes, are daily sent out from the works, or, in other words, about 160,000 matches are made per minute.

The arrangement for washing, which was conveniently placed with respect to the boxing-rooms, consisted of a long copper-lined trough over which were

(*To face page* 46.)

BOX-FILLING TABLES AT VULCAN FACTORY, TIDAHOLM.

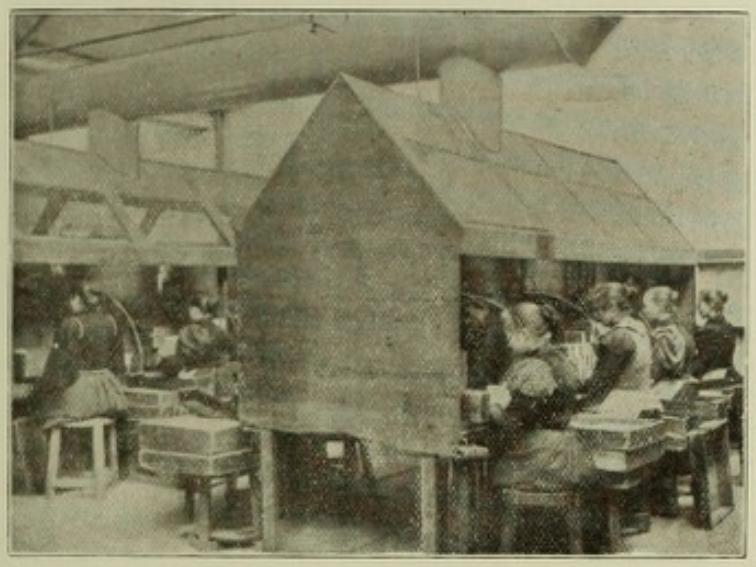


Fig. 26.

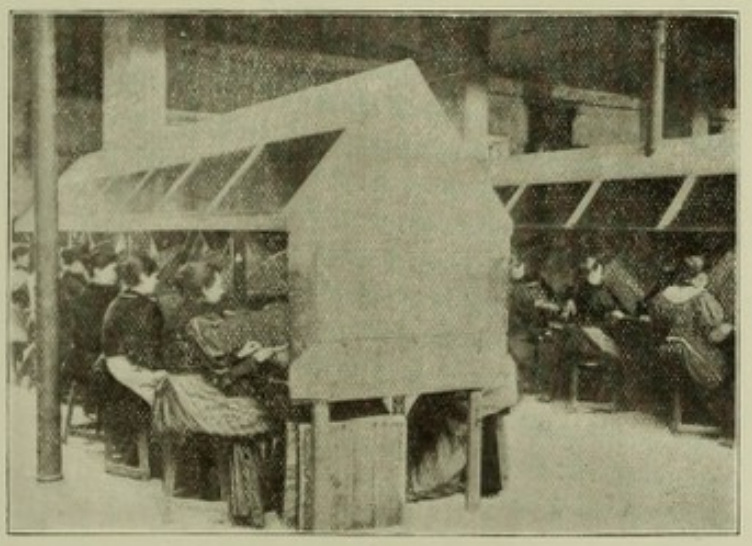


Fig. 27.

a number of taps. Soft-soap, or so-called "green" soap was provided and was placed over the trough in a stout box (Fig. 28), through which ran a

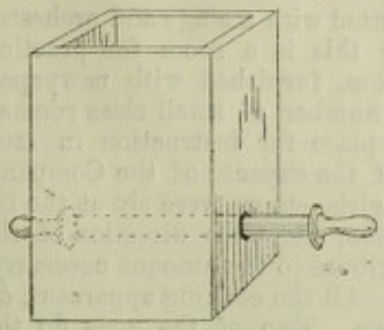


FIG. 28.

thick wooden rod, capable of being moved backwards and forwards, so that the finger could withdraw a small portion of the thick lining of soap which covered it. This method of providing a constant supply of soap is frequently to be met with in continental factories; it does not seem to be known, or at least is not to be seen, in British match factories, where the complaint is frequently made that pieces of ordinary hard washing-soap are apt to disappear much too quickly, to the annoyance of both managers and work-people. The lavatory is also provided with a supply of drinking-water and the workers are required to rinse their mouths with a dilute solution of potassium permanganate at least once a day. The place is well kept and clean.

No food is allowed to be eaten in the workrooms. Girls earn from 1 kroner (1*s.* 1½*d.*) to 2·25 kroner (2*s.* 6*d.*) a day. Dippers from 3 (3*s.* 4*d.*) to 3·50 kroner (3*s.* 10½*d.*), and splint cutters from 1·75 (1*s.* 11*d.*) to 3 kroner (3*s.* 4*d.*).

As regards phosphorus necrosis, the Vulcan works have had three cases during the last five years, two of which were mild and soon cured. In the third case a portion of the lower jaw had to be removed. There has been no recent case. Mr. Gustafsson shares the general opinion of all who have studied the phosphorus necrosis question, that personal cleanliness and attention to the teeth and mouth on the part of the workers, combined with efficient ventilation and proper appliances for washing in the works, will ensure freedom from the complaint. At the same time there would seem to be little doubt that certain persons are constitutionally liable to attack, especially such as are scrofulous or suffering from tuberculosis. Hence the necessity for a medical examination of all applicants for work in a factory in which ordinary phosphorus is used. In cases of doubt, such applicants should only be permitted to work at box making, or in the yard, or in the safety department.

As regards the possibility of red phosphorus ultimately displacing the ordinary variety, Mr. Gustafsson thinks that it is very improbable that a "strike-anywhere" match containing red phosphorus will be commercially possible. Such matches can, no doubt, be made on the small scale, as has frequently been shown, but they would be highly dangerous to make, as a manufacturing operation, and dangerous also to handle in transit. Safeties made on the present principle might with very little disturbance be made to displace the paraffin or "parlour" match having the 5 per cent. phosphorus paste, and indeed there is a gradual tendency in the direction of such replacement; but it would seem to be illogical to insist on such a change when matches coated with a 30-40 per cent. paste may still be made. Although Sweden may be said to be the main seat of the manufacture of safeties, 75 per cent. of the matches used in Sweden are tipped with these highly phosphoretted pastes; they are only half the price of other matches, keep better in a damp atmosphere, and are less easily extinguished by wind—all circumstances which lead them to be preferred in Scandinavia, as well as in many countries abroad. (*Cf.* Denmark, p. 39).

No description of the Vulcan factory would be complete without some reference to the Hall of Recreation and Educational Institute, which is

situated in the grounds belonging to the works. This place, a handsome structure of red sandstone and brick, is a veritable "People's Palace." It contains a lecture hall fitted with a stage and orchestra, and capable of seating 950 persons; adjoining this is a room for practice, rehearsals, and small concerts; a reading room, furnished with newpapers; a lending library of 1,400 volumes; and a number of small class rooms. In the basement is a cookery school, and a place for instruction in laundry work. Competent teachers are provided at the expense of the Company. At the beginning of each week a number of girls—there were six at the time of my visit—are told off, in rotation, to provide, under the direction of the teacher, dinners for as many as choose to contribute to the amount necessary for the purchase of the materials to be cooked. All the cooking apparatus, &c. and fuel and lighting are provided by the firm. Two of the girls do the marketing, whilst the others make the necessary preparations. The total cost is then divided by the number of contributors; in this way each gets a well-cooked and excellent dinner for a few öre.

The Jönköping factory.

The Jönköpings Tändstikfabrik Aktie Bolag, originally established in 1845 by the brothers Lundström, was made a company on its present basis in 1858. It occupies a site of about 9 hectares (22 acres), and is situated close to the southern shore of Lake Wettern. It employs about 450 men and 240 women and children. The output is about 250 million boxes a year. About one-eighth of its production consists of common phosphorus matches, the remainder being the well-known "safeties," usually associated with Lundström's name.

Baron Fock, Mr. Berndt Hay, and Mr. Alex. Lagerman were present on the occasion of my visit, and readily gave me all the information I desired, Baron Fock, the managing director, courteously conducting me over the factory.

The phosphorus composition, which contains upwards of 30 per cent. of ordinary phosphorus, is mixed in an arrangement similar to that seen in Fig. 29, and which can be heated, as it revolves, by a jet of steam or hot

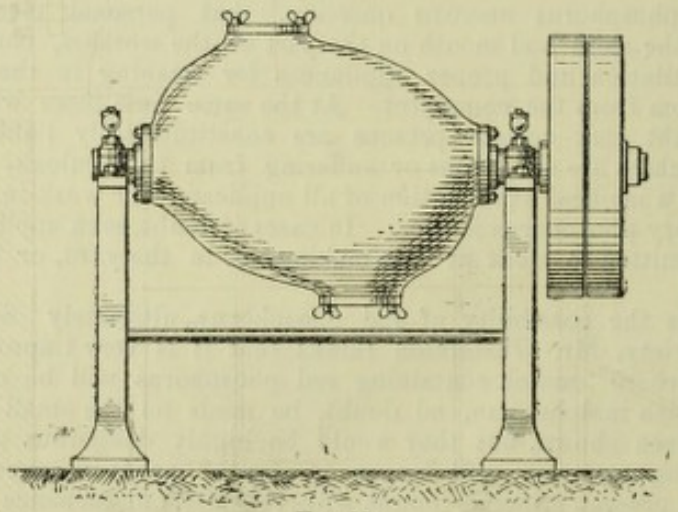


FIG. 29.

water. In the "laboratory," which contains two of such machines, there are two "compo" mixers, who work during alternate weeks. The man I saw actually employed had been making "composition" for 14 years. The "laboratory" appeared to be well ventilated, and was in good order; the fact that the floor was kept wet, and that there was at times a considerable amount of steam in the place, would tend to withdraw from the air any phosphoric fumes that might be present.

The dipping arrangement employed for this character of paste is seen in Figs. 30, 31, 32, from a drawing which I owe to the kindness of Baron Fock. It is similar in principle to that already described in connexion with the Nitedals Fabrik (p. 41).

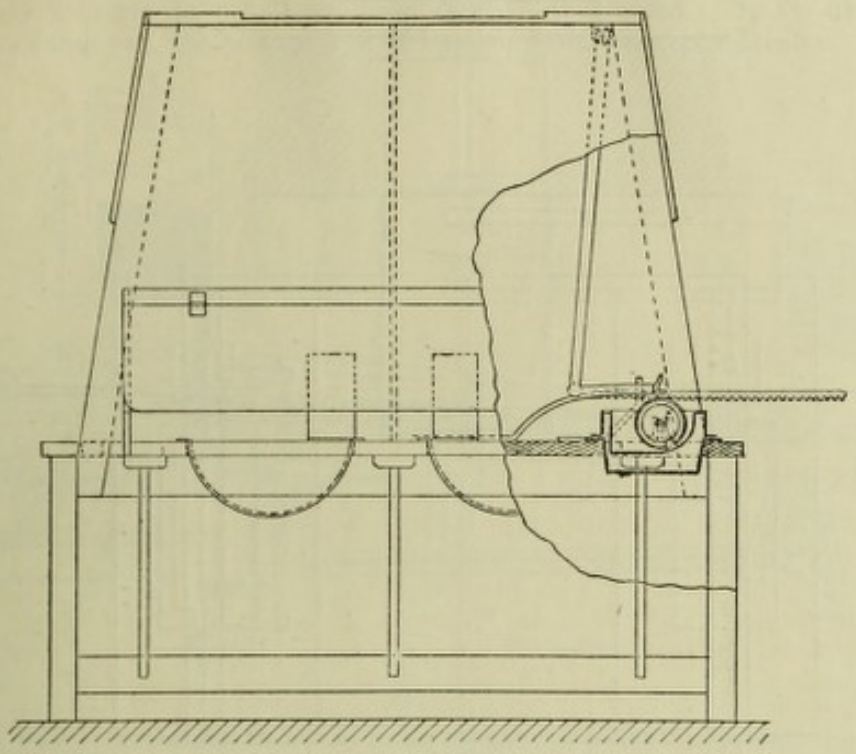


FIG. 30.

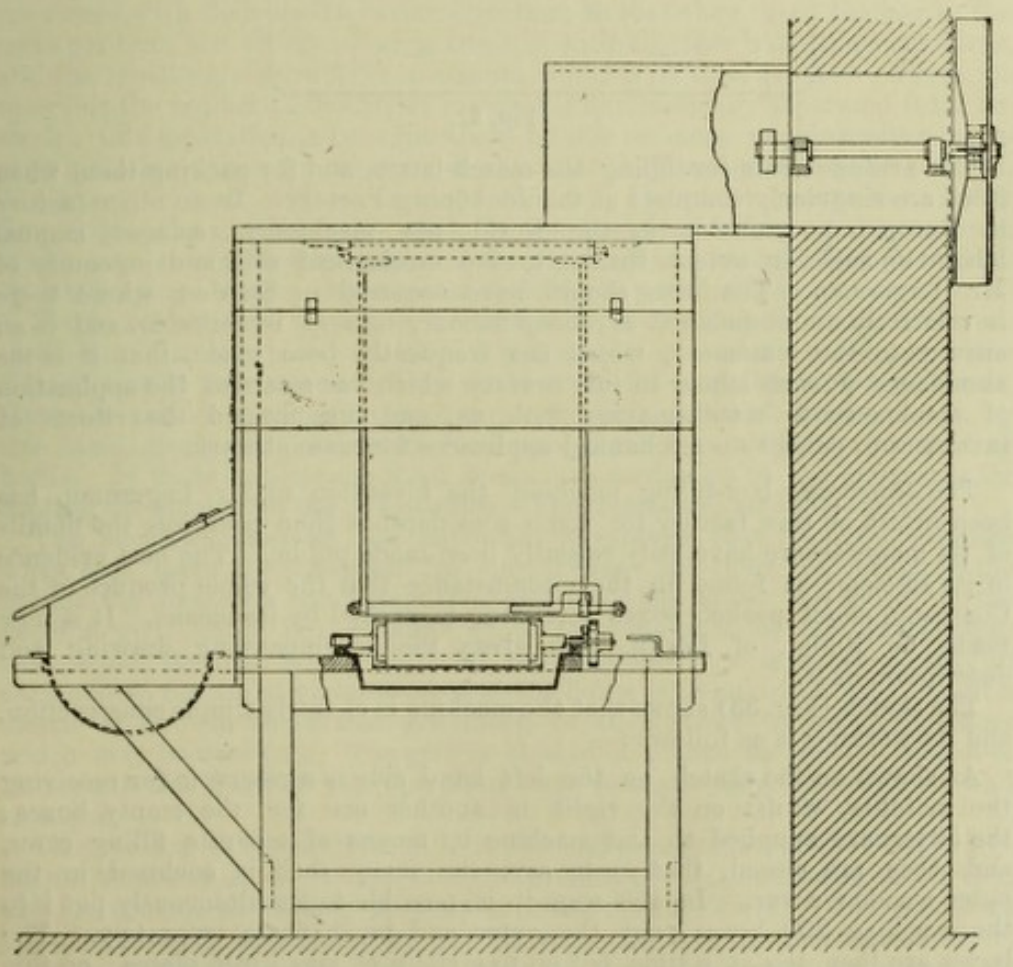


FIG. 31.

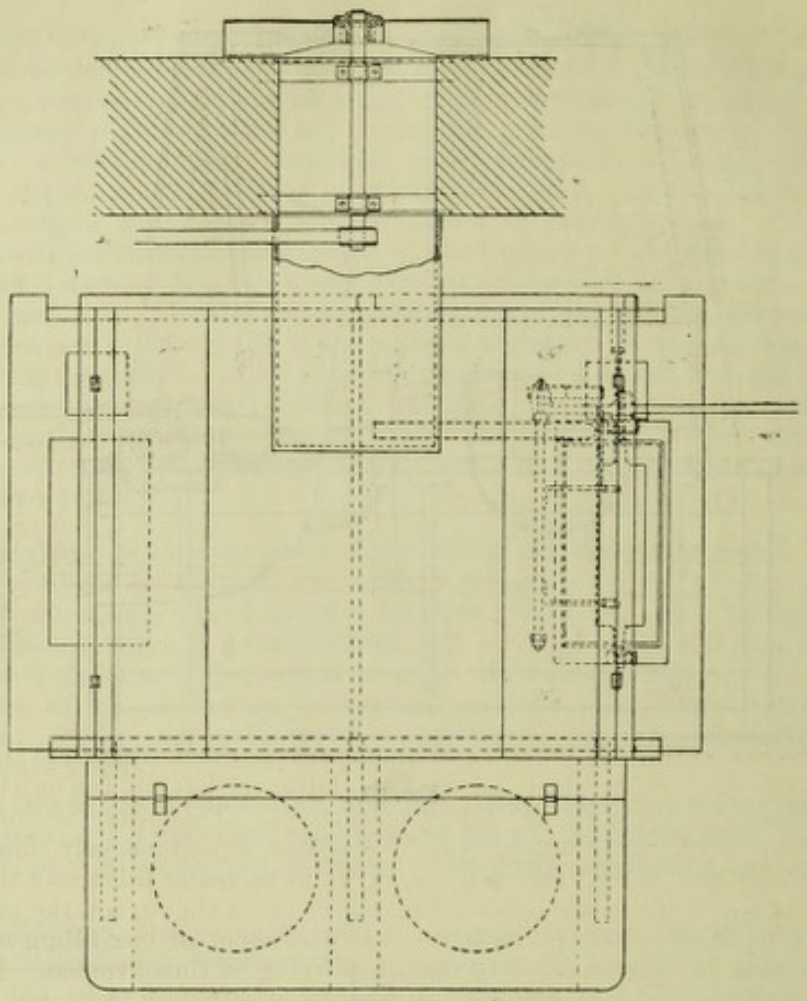


FIG. 32.

The arrangements for filling the match-boxes, and for packing them when filled are singularly complete at the Jönköping Factory. In no other factory in Europe, or probably in the world, has machinery replaced manual labour to such an extent, thanks to the mechanical skill and ingenuity of Mr. Lagerman. That this should have occurred in Sweden, where there is relatively an abundance of cheap labour, is very remarkable, and is an answer to the statement, which has frequently been made, that it is the abundance of such labour in this country which has retarded the application of machinery to match-making with us, and discouraged the efforts of inventors to substitute mechanical appliances for manual work.

The Jönköping box-filling machine.

The Jönköping box-filling machine, the invention of Mr. Lagerman, has been in use at this factory for some considerable time past, but the details of its manufacture have only recently been made public. The best evidence of its efficiency is found in the circumstance that the whole produce of the Company, small pocket boxes included, is packed by its means. It is now made by Roller, of Berlin, who gives the accompanying drawing and description of it.

The sketch (Fig. 33) shows that the machine is of fairly simple construction, and its working is as follows :—

As shown on the sketch, on the left hand side is a reservoir for receiving the matches, whilst on the right is another one for the empty boxes; the latter are supplied to the machine by means of separate filling cases, and they are closed, that is to say, the inner shell is enclosed in the outer wooden cover. In this way it is possible to simultaneously put into the machine 200 boxes—not the outer and inner parts separately. The boxes are then, ten at a time, fed on to a chain of small iron plates; on this chain the boxes remain loose till they are filled and closed together. There is no forcible guiding of the boxes, and in this way the breakage and consequent interference with work, which were inherent in all the box-filling

machines hitherto in use, have been completely avoided. By the systems hitherto employed, the per-centage of breakage was very considerable.

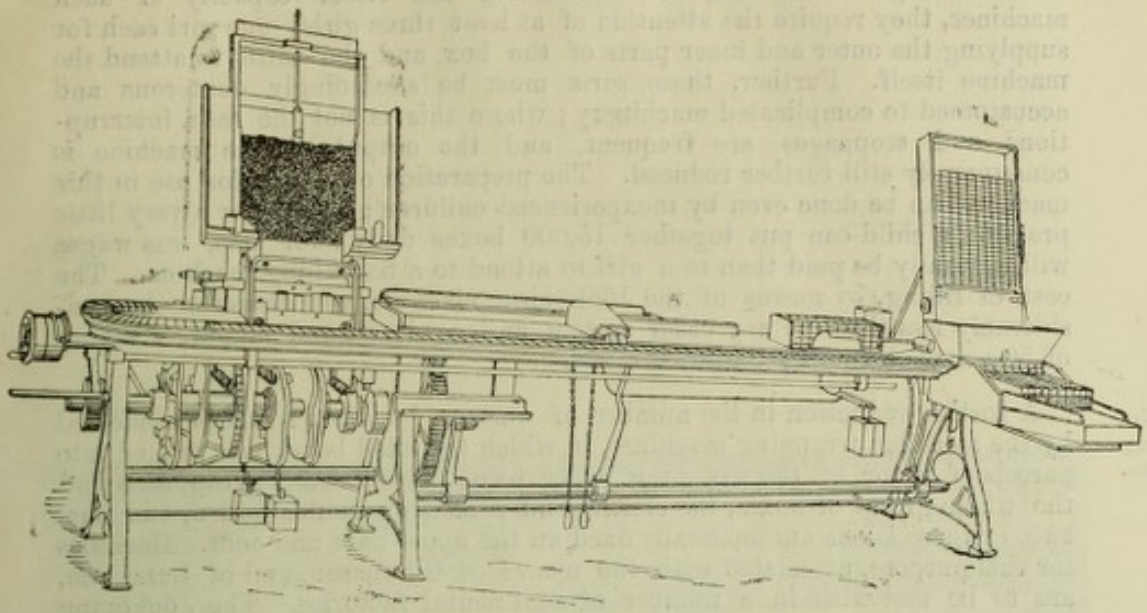


FIG. 33.

The chain moves the boxes on to an apparatus which draws out the inner shell so far that only a small part of the latter is left in the outer casing; thence the boxes go on to the filling mechanism. This latter is constructed for double working; that is, two boxes are simultaneously filled. The arrangement is such that the matches, previous to being filled into the boxes, are stored with their heads in one direction, so that they reach the box in the same position, not crosswise as is the case with all other box-filling machines, and the resulting interruption to smooth working is thus avoided. From the reservoir the required quantity of matches is automatically separated from the stock; this separation is brought about by one or more matches adhering to the separating apparatus in such a way that they are not apt to be crushed. The reservoir itself is fixed and not shaken. In order to secure the regular dropping of the matches, the stock in the reservoir is arranged by a brush which acts on the headless ends in the same way as when this work is done by hand; this has the advantage of avoiding any risk of fire.

The boxes are then passed on to another apparatus where they are either entirely closed, or only partly so, when it is desired to control the regularity of the filling; thence they are carried by the chain to the reservoir for empty boxes. Here, as each 10 boxes are passed on, a similar number of filled boxes is, by the same mechanism, delivered from the chain into a basket for holding boxes. In these baskets the filled boxes are carried on to the apparatus for coating the sides with the composition which forms the striking surface.

This machine possesses the important advantage, that from the moment when they leave the reservoir for empty boxes till their delivery into the basket the boxes lie completely free, and are thus under the control of the machine girl. Each box remains about four minutes on the transporting chain—half the time empty and half the time filled; it is, consequently, an easy matter for the attendant to see if the boxes be regularly filled; to add a match or two to those that are short, or to abstract a few from those which may be over-full. The girl is able at a glance to control dozens of boxes, and this part of the operation only demands very limited time and attention.

The working of the machine is so simple and so easy that, at the Jönköpings Tändstiksfabriks-Aktie Bolag, one girl attends to two machines, and is thus able to control the filling of 40,000 boxes in ten hours. This enormous capacity is easily understood by anyone who may see the machine at work; it arises mainly from the large number of boxes which are simultaneously being treated, and from the safety in working, whereby any interruption is rendered impossible. The capacity of the machine is also largely due to the fact that the boxes are placed on it in their closed state—not with the two

parts separate. The crushing, inevitable with other machines on the separate principle, is completely avoided; with these machines the boxes require fixed mechanical guidance, and, notwithstanding the lesser capacity of such machines, they require the attention of at least three girls—one girl each for supplying the outer and inner parts of the box, and the third to attend the machine itself. Further, these girls must be exceedingly dexterous and accustomed to complicated machinery; where this is not the case, interruptions and stoppages are frequent, and the output of the machine is consequently still further reduced. The preparation of boxes for use in this machine can be done even by inexperienced children; and, after a very little practice, a child can put together 15,000 boxes daily; for this, less wages will naturally be paid than to a girl to attend to a box-filling machine. The cost of filling, by means of the Jönköping machine, will therefore be considerably less than by any other system, and, against hand labour, a saving of 50 per cent. to 66 per cent. is effected.

Swedish wrapping machines.

A further reduction in the number of workers handling matches is effected by the so-called wrapping machines, in which the filled boxes are packed into parcels of 10 or 12, the wrapping paper being mechanically wrapped round the whole group of boxes, the closing-end pasted or double-folded, and one, two, or three labels automatically fixed on the upper part and ends. Machines for this purpose, associated with the names of Göransson, and of Lundgren, are to be met with in a number of continental factories. The Jönköping factory employs a machine of Mr. Lagerman's invention. This machine will pack, *per diem*, 250,000 boxes into wrapped, pasted, and labelled parcels of 10 or 12, under the superintendence of a couple of girls. It will do the work therefore of some 16 or 17 ordinary hand-packers.

"Sanding" machines.

The Jönköping factory, like most of the larger continental factories, applies the striking surfaces to the sides of the box by machinery. Such machines differ somewhat, depending upon whether they are used to apply the composition containing red phosphorus, as in safety matches, or simply to affix the powdered glass, sand or emery, as in ordinary sulphur or paraffin matches. These machines, which effect a great saving in work and wages, will "sand" or coat with red phosphorus from 100,000 to 150,000 boxes a day.

The packing of the sulphur matches for the home trade, as at Tidaholm and elsewhere, is done by hand. These are contained, to the number of about 70, in paper capsules unprovided with any striking surface. When intended for export they are packed in boxes and by machines. At the time of my visit about 50 girls were employed in placing these matches in the capsules. The room in which they were at work was provided with two large fans of such power that the air was changed every five minutes. There was very little "firing"; indeed, the atmosphere was almost as clear and as free from smell as that of the safety department, and the condition of the girls' hands was very good. The shops were lighted by the electric light.

The Jönköping match-making machine.

One of the most notable features of the Jönköping factory is a match-making machine of a kind somewhat similar in general character to that of the Diamond Match Company, but of very different construction (Fig. 33A.) It is the invention of Mr. Lagerman, and has been in use for about seven years. I saw three of the machines in operation, two making "safeties," and a third, somewhat smaller, making phosphorus matches. It possesses the great advantages that it uses any form of splint of any kind of wood suitable for match-making; it takes up much less room than the Diamond machine, and requires the superintendence of only two persons. One foreman attended to the three machines. Splints in sufficient quantity to fill 200 boxes, together with this number of empty boxes, are simultaneously supplied to the machine in a single operation. From the reservoir of splints, between 6,000 and 7,000 are seized each minute by the machine and placed in holes in wooden plates. The splints are heated, sulphured or paraffined, dipped in the phosphorus or safety composition, as the case may be, the heads dried, the dipped splints discharged from the plates and put into receptacles by portions at a time, these, adjusted to the proper height, transferred to the empty boxes as these are automatically pushed from the reservoirs, trade mark labels or slips placed in the boxes to protect the ends, and 200 filled boxes removed at a single

(*To face page 52.*)

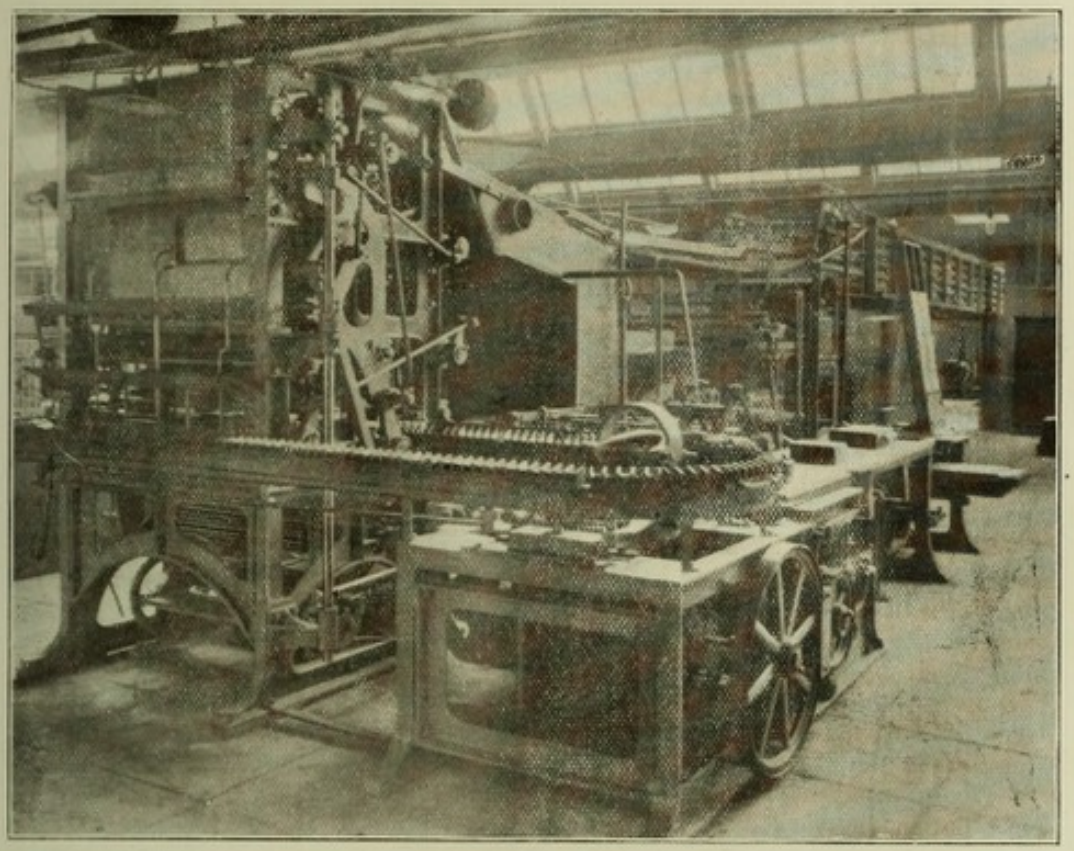


FIG. 33A.

stroke. The action of the machine is continuous, and it could, if necessary, be worked day and night.

It is claimed for this machine that it not only produces matches at a relatively low cost by replacing machine for manual labour, but that it is directly economical, as it wastes less material and occasions far less "firing" than the ordinary hand methods. There is, therefore, less risk to the premises in which the operations are carried on.

The machines I saw in use were each turning out 40,000 filled boxes during a working day of 11 hours. There is no structural feature connected with the machine which would make it difficult to remove, by mechanical ventilation, the fumes which may arise in dipping and drying.

The box-making department at Jönköping is a most important and interesting section of the work. There is probably no factory in the world in which this branch of the industry is better organised and developed.

The lavatories are immediately outside the workshops. Their arrangement is similar to that already described (p. 47). It is part of the forewoman's duty to see that the girls wash their hands before taking food and on leaving the factory. All the persons who in any way work with matches containing ordinary phosphorus, or with the paste, are examined quarterly by a medical man. Special attention is given to the teeth. Baron Fock was especially emphatic on the necessity of a proper dental examination. He was convinced that phosphorus necrosis was not a necessary concomitant of lucifer match-making, and he pointed, in proof of his statement, to the fact that not a single case of phosphorus necrosis had occurred in the Jönköping factory during the last 17 years.

The dining accommodation is in a building separate from the rest of the works and is altogether excellent.

As regards wages, men earn from 2·25 kr. to 3 kr. (2*s.* 6*d.* to 3*s.* 4*d.*) a day; women from 1·25 kr. to 1·75 kr. (1*s.* 4½*d.* to 1*s.* 11*d.*) a day (11 hours). Nine hours are worked on a Saturday.

The Jönköping Västra fabrik.

The Jönköping Västra fabrik was established in 1882. It is situated to the rear of the town on a space of about 20 acres, of which the buildings and their appurtenances occupy about 6 acres. These buildings were specially designed for the purpose, and are lofty, airy, and particularly well-lighted and well-ventilated. At the time of my visit about 650 people were at work, of whom 250 were males and 400 females. Mr. Roemke, the manager, who was so good as to show me over the factory, informed me that, at present, their output of the so-called sulphur match, containing the highly phosphated paste, was only about six or seven per cent. of their total production, and that the firm was inclined to drop their manufacture. He is disposed to think that the safety match will, for many reasons, be the match of the future—partly by the growth of public preference for it, and partly by reason of legislative enactments, which in some countries are somewhat ahead of public opinion, and in others are closely on the heels of it. At the same time he thinks that the example of Denmark cannot be universally followed; special circumstances, as of price and climate, will always necessitate the employment of ordinary phosphorus. For this reason he would maintain the manufacture of such matches at Anneberg—a comparatively new factory associated with the Västra fabrik, and employing about 300 hands.

The regulations at present in force in Sweden, and which are based on the practice of the Jönköping factories, are, in Mr. Roemke's opinion, sufficient, if properly observed, to obviate the danger of phosphorus necrosis. As evidence of this he stated that only one case of necrosis had occurred at the Västra fabrik during the 16 years of its existence. This was that of a boy who had had a tooth withdrawn, and who came back to work immediately after the operation.

There are many features of general interest at the Västra fabrik relating to the hygienic and sanitary condition of the workpeople. There is a bathing-house arranged for men and women, and in which soap, hot water, and a towel are provided with each bath at a charge of 10 öre. The dining room is remarkably clean and comfortable, and a well-cooked dinner of meat, vegetables and potatoes is provided by the firm at a cost of 20 öre for the men, and 16 öre for the women, which it is calculated just about covers the average cost of the food materials.

The hours are from 6 to 8.30, 9 to 1, 2 to 7, with a short break for tea. On Saturdays work stops at 6. The average earnings of men are from 2 kr. (2*s*. 3*d*.) to, in a few exceptional cases, 4 kr. (4*s*. 5*d*.) per diem; of young girls, from 1 kr. to 1·25 kr. (1*s*. 1½*d*. to 1*s*. 4½*d*.); of older girls and women, 1·50 to 2 kr. (1*s*. 8*d*. to 2*s*. 3*d*.).

No coal is used in the factory, the sawdust and waste wood being sufficient to fire all the boilers employed in connexion with the machinery of the splint-cutting, frame-filling, box-making, label-printing shops, &c., as well as for electric lighting and power. Hence there is a complete absence of black smoke. As at the older Jönköping factory, the most significant general feature is the application of labour-saving machinery in every department of the works.

There is no Trades Union among the match workers in Sweden. The relations between the employers and their workpeople are generally good, and labour disturbances are not very frequent. Although the hours of labour are much longer than with us and the holidays fewer, the general appearance and condition of the operatives is good. Whilst the standard of comfort is not so high as in England, the people are well clothed, well housed, and at Jönköping and Tidaholm, at least, they live under far healthier conditions than in the poorer districts of our large cities.

The factory inspectors of Sweden are educated in the Polytechnic Schools. They are mainly mechanical engineers with a good all-round scientific training.

The "phosphorus question" in Sweden.

The "phosphorus question" has been frequently raised in the Swedish Parliament during the last 30 years. Indeed, scarcely a session passes without the matter being discussed in one form or other by persons who contend that the only solution possible is the complete prohibition of the use of ordinary phosphorus. Whilst it is generally admitted that the measures at present in force have resulted in much improvement, it is argued that these are merely palliative. Of late the advocates of total prohibition have somewhat shifted their ground, and necrosis is very rarely heard of as an argument. Attention is rather drawn to the comparatively frequent occurrence of poisoning as the result of using ordinary phosphorus, extracted from match paste, for procuring abortion and for the purposes of suicide; and it is contended that the wide-spread diffusion of matches containing so large an amount of ordinary phosphorus affords a ready means of committing these classes of crime.

The fact is that, as regards the existence of phosphorus necrosis in the past, it is not easy to obtain trustworthy information. It would appear that the official statistics, collected by means of printed papers of questions, cannot be altogether relied upon. The manufacturer is not obliged to report cases of phosphorus disease, and, with a view of averting the dreaded prohibition of ordinary phosphorus, there is little doubt that many instances in the past have not been notified.

In 1892, Mr. Larsson, the deputy from Upsala, brought in a Bill to forbid the use of ordinary phosphorus in the manufacture of matches, which gave rise to a heated debate in the Riksdag, and considerable discussion in the Press. The matter was eventually remitted to a committee.

In their preliminary report, the committee discussed the various measures that had from time to time been proposed in the Riksdag for the improvement of the conditions of work in the phosphorus match industry, and criticised the most weighty of the points brought forward by the proposer of the motion, namely, the danger from fire and poisoning, and (owing to the facility with which it could be obtained) its frequent abuse for purposes of murder, suicide and abortion.

In their discussion of the dangers to the health of the workers in match factories from phosphorus poisoning very different statistics were obtained for the year 1891 from those obtained from other sources. The Commission laid stress on the importance to the country of the match industry, as only 26 per cent. of the produce was used in the country itself, the remaining 74 per cent. being exported. In wages this represents a total of 3 to 4 million kroner, or about 40 per cent. of the value of the produce. About 80 per cent. of the matches produced were made from ordinary phosphorus.

It is worth while to compare these figures with those obtained from other sources. From the returns of the manufacturers sent to the Committee for the revision of the Order of 1881, the value of the *phosphorus* matches produced in 1890 was, in round figures, 1,700,000 kroner, whilst, according to the Commission appointed in connexion with Mr. Larsson's motion, the value of the total matches produced in the same year was 7,800,000 kroner. If we accept the statement, therefore, that 80 per cent. of the total matches are made from ordinary phosphorus, and the cost of the latter to be 1,700,000 kroner, it follows that the remaining 20 per cent. of safety matches must amount to 6,100,000 kroner, and consequently that the safety matches must be about 15 times dearer than phosphorus matches. This is, of course, not the fact. The relative price is not as 1 to 15 but as 1 to 2.

This, again, proves that where there is a desire to minimise the danger of the phosphorus match industry, the figures supplied are lower, and, to say the least of it, inaccurate.

The Commission finally decided that a veto on the use of phosphorus would injure the manufacturers in numerous ways, and would seriously affect the balance of trade, and, indirectly, the burdens on the State, and must increase the number of the unemployed. They therefore rejected the motion, which decision was confirmed by a majority in the Parliament.

In the debates of April 8th, and May 3rd, 1897, one of the speakers in the Riksdag spoke of 743 cases of suicide within a time he did not specify, as due to ordinary phosphorus; and another speaker stated that 80 per cent. of the cases of suicide at the present time are caused by this substance obtained from the paste of the common form of lucifer matches. The accuracy of these figures was contested, but that ordinary phosphorus is being used to an increasing extent for criminal purposes in Sweden was not questioned.

The Lower Chamber was so much impressed with these statements that it passed a Bill prohibiting the importation, exportation, and sale of phosphorus matches in every part of Sweden, but the proposed measure met with strong opposition in the country. Petitions were sent in, especially from the northern provinces, from the mining, fishing, and hunting populations; from the manufacturers; from the retail dealers, protesting against the restriction. It was argued that there is no adequate substitute for ordinary phosphorus; that everybody knows that common lucifer matches are poisonous, and that a nation must not be legislated for like children; that the change would destroy one of the largest industries of the country, and would deliver the consumer into the hands of the Japanese.

It was urged that safety matches cannot be made cheap enough to compete with the common phosphorus matches, and that even if they could they would be useless at sea, in rainy places, in the wet woods, everywhere where a poor and sparse population (such at that of Northern Sweden) lives out of doors. Several speakers deprecated the agitation as "thoughtless," and as "cowardly" and "short-sighted." If successful, it would extinguish the small factories and turn thousands out of work. Some speakers thought that phosphorus matches might continue to be exported ("foreign women may poison themselves if they like"), but should no longer be made for home consumption. The majority of speakers in the Upper Chamber were averse to any change.

The question of the danger to the workmen was first seriously raised about 30 years ago. A Royal decree of February 18th, 1890, was the earliest to deal with the protection of workers in match factories where ordinary phosphorus is used. This was the result of an active agitation produced by the startling increase of cases of phosphorus necrosis. The law of May 10th, 1889, embraced this subject, and the result was a Code of Regulations still more strict and minute in its protective clauses. This was so effective that phosphorus necrosis has been practically stamped out of Sweden. By the law of December 9th, 1896, which came into force on July 1st, 1898, the medical inspection was made more stringent and complete, and it is now well-nigh impossible that any serious case of necrosis can escape detection and notification.

There can be no question that the entire prohibition of the use of ordinary phosphorus would, in the absence of any international agreement, seriously cripple the match industry of Sweden. There is little doubt that it is the knowledge of this fact which has prevented the Swedish legislature from

following the example of Denmark. If phosphorus matches are to be supplied, the climatic conditions of Sweden and Norway are favourable to their production. It is practically impossible to make ordinary phosphorus matches in the districts which largely consume them, and it is questionable whether the safety match will ever altogether replace these matches in these countries, of which the atmosphere is both hot and humid.

Special regulations in Swedish match factories.

The general conclusion is then that so long as the world demands the ordinary lucifer match, means must be found to supply it, but that in Sweden the demand can only be met by the application of regulations, which will obviate, or, at least, greatly minimise the danger attending the manufacture.

The regulations at present in force in Sweden as to match factories date from 1870, and are the direct results of a motion in the Riksdag as far back as 1863, which aimed at the introduction of measures for averting the frequent cases of necrosis which at that time occurred in match factories.

These Regulations are as follows :—

S. 1. Matches the paste of which contains ordinary phosphorus shall be made only in factories specially arranged for the purpose.

S. 2. Such manufacture shall be carried on only by one authorised to possess a factory, who (if he superintends the manufacture himself) shall give satisfactory evidence of his knowledge of the raw materials used, or (in case he employs a manager) of the manager possessing the necessary certificate that he has the requisite knowledge.

Such a certificate may be given by a professor in any of the universities of the kingdom, by the Caroline Institute of Medicine and Surgery, by the Pharmaceutical Institute, or by one of the higher technical institutes.

S. 3. When such factory passes by inheritance, sale, or other lawful manner to another owner, who is entitled to carry on a manufacturing business in general; or when the manager leaves his situation, the owner shall immediately or within a month at latest, notify in the form prescribed, whether in accordance with s. 2. he will superintend the manufacture himself, after proof of his ability to do so, or whether another competent person has been engaged as manager.

S. 4. Factories referred to in this order must be situated in an open and dry position. The following processes shall each be carried on in a separate room: (*a*.) preparation of the paste and dipping of matches, (*b*) drying; (*c*) packing. These rooms shall be separated from the remaining work-rooms, but shall communicate with each other by tightly fitting doors, closing by means of springs, weights, or similar means. In each of the rooms above-mentioned there must be a thorough change of air, either by means of mechanical ventilation, or else by a sufficiently high draught chimney under which a fire shall be kept up on a special hearth during work time. The said rooms must be at least 10 feet high, and a floor space of at least 30 square feet be allowed for each worker engaged therein. The walls must be coated with oil paint, and the floor covered with asphalt, cement, or with closely-fitting flagstones. In rooms used for the preparation of the paste and dipping the matches, these operations must take place only under flues connected with the ventilating apparatus.

The stock of phosphorus shall be kept in a special closed room of which the manager shall keep the key.

S. 5. The manufacture may commence only after the factory has been inspected, and certified as conforming to the above requirements of s. 4. This inspection shall be carried out, on the request of the proprietor and at his expense, by the magistrate in towns and country districts, or, where there is no magistrate, by the town authorities, and in the country or in country places not connected with any particular town, by the magistrate of the district.

S. 6. No worker under 15 years of age shall be employed in the operations of preparing the paste or in dipping the matches, and no one may be engaged for more than six months at a time in these operations. He may not return to this kind of work until the expiration of at least two months during which no detrimental effects of the work have been shown in regard to his health. In order to enforce the strict observance of these regulations there shall be a special register in the factory in which shall be entered the christian name, surname, and age of every worker, as well as the date on

which he commences or ceases to work in any particular department of the factory.

S. 7. The manager of the factory shall see that every worker engaged in the operations mentioned in s. 4 wears the proper working dress which is to be put aside in a special room on leaving off work, that clean water is available in a convenient part of the factory for the purpose of rinsing the mouth on the conclusion of work, and that soap is provided by the proprietor so that the employés may wash their hands and face before leaving the factory or at meal-times. The manager shall also see that the employés do not remain longer in the rooms referred to than is necessary for the work, that no eatables shall be consumed therein, and that these rooms shall not be used for dwelling rooms, sleeping places, or for keeping eatables or clothes.

S. 8. The doctor appointed by the owner of the factory shall carefully examine the employés at least once a quarter. The result of this inspection and advice with respect to the removal or the transference of the workpeople to other branches of the work shall be entered in the register provided under s. 6. Observations made during any occasional visits of the doctor to the factory as to the general state of health should be entered in the same register.

S. 9. The rooms mentioned in s. 4 and the tables and working places therein shall be cleaned at least once a day. The floors and walls shall be washed down at least once a fortnight. Refuse must immediately be burnt. The water used for washing and rinsing the mouth must not be poured into a sink or open place, but only into a specially constructed drain.

S. 10. The manager is required to exercise great vigilance in seeing that the regulations and protective measures are carried out, and to watch carefully the state of health of the employés, especially those who suffer from decayed teeth or unhealthy gums. When such present themselves he shall send immediately for medical assistance.

S, 11. In every workroom the manager shall have this Order posted up in a convenient place as well as any other regulations which may be arranged between the manager and the doctor.

S. 12. For any infringement of ss. 2, 3, or 5, the proprietor of the factory shall be liable to a fine of from 50 to 500 kr. If the owner or manager fail to carry out any other provisions of this order, or if the workpeople neglect the above-mentioned precautionary measures, a fine of from 5 to 200 kr. will be imposed.

S. 13. Of the fines mentioned in the last section two thirds will be paid to the State, and one third to the complainant, When the person convicted is without means, the punishment shall be in accordance with the general Penal Code.

S. 15. What has been said with regard to matches in which ordinary phosphorus is employed for making the paste, applies equally to the manufacture of other combustibles which require such phosphorus for their production.

S. 16. Factories in which the manufacture is already carried on must after this order be adapted to meet the requirements of these regulations. Should, however, it be impossible to carry into effect the changes necessary to conform strictly to s. 4, as to the site of the factory, the separate working rooms, and the fitting up of ventilating apparatus, without too great a cost and inconvenience, such relaxation of the regulations may be granted as the circumstances may allow of, consistent with the health of the employés.

The magistrate, or the town authorities, or (when the factory is situated in the country) the Government representative in the district, shall see that the factory is inspected as soon as possible by two experienced men in accordance with s. 5, and shall thereupon frame the necessary orders, fixing a time within which the orders must be carried out in case the proprietor intends to proceed with the work.

When a certificate under s. 2, of another kind than that herein prescribed has been given to anyone who is in charge of a factory already in operation, such certificate shall be valid so long as he manages the factory.

With respect to these regulations I concur with Mr. Rauschenbach (*vide infra*) as the result of my own inquiries that section 2 of the Regulations which requires that the manufacture of matches, as being a dangerous trade, can only be carried on by persons who can prove to the satisfaction of the authorities named that they have an adequate knowledge of the properties of the substances employed, has undoubtedly greatly contributed to the diminution of cases of phosphorus necrosis. Similarly in accordance with section 3, everybody who comes into possession of a factory, whether by inheritance or purchase, must show that either he himself or his manager possesses the requisite knowledge.

Although no very great knowledge is required for the manufacture of matches it can hardly be doubted that such a regulation, requiring in the manufacture certain specific knowledge, which itself pre-supposes a certain amount of general education, has had a great influence on the general character of the industry in Sweden.

As regards the other regulations it would appear that the rule as to the separation of the various premises is, on the whole, rigidly carried out. Renewal of air is everywhere effected by mechanical means, and in the dipping rooms and mixing rooms the vapours produced are invariably removed by ventilators.

According to Mr. Rauschenbach the provision against overcrowding is less frequently observed. In the larger and better conducted factories which I visited I certainly observed no breaches of this regulation.

With respect to the admission of children, the regulations do not go further than to forbid workers under 18 years of age to be employed in the dipping-rooms or in the preparation of the paste. Beyond this there is no limitation to the employment of children in the match industry, and the consequence is that about one third of the workers are below 18 years of age, and of these a great number are from 12 to 14 years old.

An order of November 18th, 1881, fixes the working time for children under 18 years of age from 6 to 10 hours a day according to age. Adults work 11 to 12 hours a day.

The preparation of the paste takes place everywhere in closed apparatus provided with stirrers worked by machinery, and so arranged as to prevent, as far as possible, the escape of fumes into the air of the room. The provision that no worker shall be employed continuously for more than six months in the preparation of paste or in dipping, and that, if he subsequently returns to the same work, there must be an interval of two months, is not everywhere scrupulously observed ; nor is the rule as to overalls strictly enforced.

As regards the value of oil of turpentine, which I have nowhere seen used, Mr. Rauschenbach mentions one factory in which the floors are daily sprinkled with it, and in which vessels containing it are placed under the tables where the box fillers are at work, whilst the dipping table is surrounded by a trough or groove for its reception. The monthly consumption of oil of turpentine for these purposes is stated to be 150–160 litres. In this establishment no case of necrosis has occurred for the last 10 years.

The reports of the Swedish Factory Inspectors indicate that the worst works are to be found at the South and East of Sweden. Dr. Nordström, in his Report for 1890, states that the inspector for the southern district reports that out of the seven phosphorus match factories visited by him, only two could be said to have satisfied the requirements of the regulations ; all the rest were in a deplorable state.

Mr. Ångström, in his Report for 1891, complained that while certain improvements had been made in these factories many irregularities still remained, and he came to the conclusion that it is only in the larger factories that it is possible to make the arrangements which appear absolutely necessary for the prevention of necrosis. Experience has shown that not only those workpeople employed in the rooms for making paste, dipping and filling, suffer from phosphorus necrosis, but that also those who are exclusively engaged in packing may be effected by it. Mr. Ångström is of opinion that the packers should also be subject to the same regulations as to washing and rinsing the mouth, as the "phosphorus workers," strictly so-called, and that packing should be carried on in special rooms, mechanically ventilated. He considers that the proper removal of phosphorus vapours without mechanical

ventilation, as by means of a draught chimney, is impossible, and he also comments on the inadequacy of the means employed in many cases for warming the air in winter whereby the provision already made for ventilation is at times rendered purposely inoperative. Lastly, he thinks that the medical examination of the workers should be independent of the control of the manufacturer.

At the same time, all inquiry goes to show that the medical examination, at present made at the expense of the employers, is fairly well carried out.

The Swedish match factories have already been made the subject of a special Report to the Industrial Department of Switzerland, by the Factory Inspector Rauschenbach, as a result of a visit paid to Sweden in 1893.

I extract the following from this Report:—

As a result of the Berlin Congress of 1890, a Commission was appointed by the Swedish Parliament to consider the revision of the Order of 18th November 1891, concerning the employment of minors in factories and other works.

This Committee considered, amongst other things, the match question, and took in chronological order the various measures that had been brought before the two Houses. A motion of 1863 and of 1874 also had for their object the total abolition of the use of ordinary phosphorus. This motion was rejected by the Committee appointed to consider it, and consequently also by the Chamber. A Bill was brought in the First Chamber, in 1882, for the prohibition of the sale of phosphorus matches, on the ground that the number of cases of phosphorus poisoning and suicides by the use of ordinary phosphorus in the preceding year had reached 22, and the Committee agreed that, although no great danger to the workers resulted from the use of ordinary phosphorus when the Regulations were carefully observed, yet it was necessary to restrict the sale of phosphorus matches, and formulate effective regulations for the protection of life and property, owing to the loss which had occurred through poisoning and fire.

The Commission considered the veto on the sale of ordinary phosphorus matches as insufficient so long as their manufacture and importation into Sweden was allowed, and unanimously advised the Chamber to forbid the manufacture, sale, or importation of matches made with ordinary phosphorus under pain of fine and confiscation, and to make regulations for carrying this into effect.

In spite of the unanimous recommendation of the Commission, the Chamber rejected the proposal, on the ground that the Order of 1870 and the Regulations of the Medical Department (concerning the sale of poisons), 1877, ought to suffice to meet the dangers referred to in the proposed motion.

The Committee, on the revision of the Order of 1881, finally gave the result of their inquiry in connexion with Larsson's motion into the condition of the phosphorus match manufacture and the number of workpeople engaged in it. Information was obtained from the manufacturers, by means of question sheets, as to the extent to which they manufactured phosphorus matches and the number of workers employed.

The Commission then requested the Supreme Medical Department to require from the doctors of the districts in which there were match factories reports as to the state of the health of the employés.

The medical reports contained, besides the required particulars as to the sanitary condition of the factories, statements as to the number of workers engaged in the phosphorus match manufacture.

From the statistics obtained from the manufacturers, in 1891 there were 13 factories, with 1,218 employés (of whom 606 were under 18 years of age), engaged in making phosphorus matches. According to the reports of the city, provincial and factory doctors, the number of people in these factories working with ordinary phosphorus was 2,174—a difference of 956, which the Commission ascribe to the fact that the doctors included in their reports workers who were not exclusively engaged in working with phosphorus.

Even in the case of a very important factory, producing for years about 40,000 to 50,000 boxes a day, the statistics obtained from the doctors and manufacturers disagreed.

The doctors also gave different accounts of the state of the health of the match-workers.

The diseases occurring amongst the operatives reported by the Medical Department of the Commission were stated to be decay of the teeth, catarrh of the windpipe, lung diseases, disordered stomach, inflammation of the jaw, and, particularly amongst the female workers, chlorosis, without, however, ascribing them to the influence of phosphorus. The special necrosis caused by phosphorus fumes also occurred. The number of cases of the latter was, however, inconsiderable. In four of the factories no case of necrosis was reported, and in the remainder from 1 to 6 cases per factory during the years 1889–91.

There were in all 19 cases of necrosis in the year (1891) in the 13 factories. It is agreed by different authorities that this disease may appear a long time, often 10 to 17 years after the operatives have been working with phosphorus. In one case the disease broke out two years after the woman had ceased to work in the factory. It is generally the workers engaged in preparing the paste and dipping the matches who are affected with the disease.

The reports agreed that the patients were cured after an operation and proper treatment, and that no fatal case had been proved.

A diseased tooth was always and directly the exciting cause of necrosis. No one with sound teeth had fallen a victim to this disease (?)

Another authority expressed the opinion that the placing of the matches in boxes was very injurious to health.

One doctor who had had 15 years experience as factory doctor stated that many cases occurred through the carelessness of the workers themselves, and that they were averse to the use of the ventilating apparatus provided, as well as to the observance of the necessary precautionary measures. The ventilating arrangements should, therefore, be so arranged that the workers cannot interfere with the current of air. He thought there was no means of absolutely avoiding phosphorus necrosis other than a complete veto on phosphorus match factories.

The final conclusion of the Commission on the Revision of the Order of 1881 was that the prohibition of the use of ordinary phosphorus was not indispensably necessary, but that it would suffice to amend the Order of 1870. The modified regulations correspond fairly closely with the recommendations of Mr. Ångström. They require that the filling of the boxes shall be entrusted to young people only when over 15 years of age; that the doctor superintending shall no longer be freely chosen by the manufacturer, but shall be nominated by the "*Statthalter*," who shall have power to suspend partially or wholly the working of the factory, on the report of the medical officer that there is any failure in carrying out the preventive measures prescribed.

The Commission did not feel justified, therefore, in view of the statistics collected, in recommending such a sweeping change as the veto on ordinary phosphorus would have entailed.

GERMANY.

The Match Industry in Germany.

At the present time there are some 90 match factories in Germany, of which about one-third are exclusively engaged in the manufacture of phosphorus-sulphur matches. Many of these are only small works, and mainly supply a local demand. Comparatively few factories make only safety matches, although among these are some of the largest and most important in the country, such as the "Union" factories at Augsburg, Aalen, Habelschwerdt, and the "Vereinigte-fabriken Zanow-Hannover," at Hanover.

The so-called "English" match is rarely seen in Germany, and vestas have only a very limited sale. The matches mainly consumed by the upper and middle classes are "safeties," and these are also in very general use in the towns, whilst the phosphorus-sulphur matches mainly find their way into the agricultural and mining districts.

The use of the safety match is, however, steadily increasing in Germany; the greater number of the new works and the extensions of the older ones are concerned with the manufacture of this kind of match.

As types of German factories, I selected the works of Stahl and Nölke at Cassel, of Carl Grübel and C. Tietze's successor at Habelschwerdt, and the two "Union" factories of Habelschwerdt and Augsburg.

The factory of Stahl and Nölke at Cassel.

The first-named works was visited on October 6th, 1898, in company with my friend, Professor Debus, late of the Royal Naval College, Greenwich, now residing in Cassel, who introduced me to Mr. Carl Nölke. This gentleman kindly conducted me over his works and gave me much general information concerning the position of the match industry in Germany. I was specially desirous of seeing this factory, as it has been already favourably reported upon by the Swiss Inspectors, Dr. Schuler and Herr Rauschenbach, in the report to the Industrie-Department of Switzerland, already referred to on page 59.

The firm of Stahl and Nölke possesses two factories, one at Cassel and the other at Kosteim, both making phosphorus-sulphur matches, paraffin matches, and safeties. In the Cassel works, which employs about 200 workers, 70 persons only are engaged in processes involving the use of ordinary phosphorus; at Kosteim there are also about the same number so engaged. At Cassel, about 30 kilos. of ordinary phosphorus are used daily; at Kosteim, about 25 kilos.

Three dippers in phosphorus paste are employed in each factory, who dip for a couple of weeks only at a time.

The "laboratory" at Cassel is a remarkably well-arranged place, lofty and well ventilated, with a good asphalted floor, which can be readily and thoroughly washed. It contains seven mixing vessels capable of being hermetically closed, and provided with stirrers worked by steam power.

The ordinary phosphorus matches, which contain about 5 per cent. of phosphorus, calculated on the dry material, are all cold-dipped. The dipping arrangement is peculiar to this factory, and is so contrived that the splints are subjected to pressure by a descending plate as the frames pass over the table. There was very little fume, but this little was effectually removed by mechanical ventillation. The room was particularly clean and well ventilated.

The drying-room was a large, well-lighted place with concrete floor, into which the iron racks (see p. 21) were run. The drying was done at the ordinary temperature, and in a strong current of air. All the openings between the several rooms were provided with closely-fitting iron doors. The walls were evidently frequently lime-washed.

The boxing-room was also clean, well lighted, and airy. There was practically no smell or appearance of phosphoric fumes, and the hands of the workers were free from any evidence of paste.

The washing arrangements consisted of a long trough provided with flowing water and proper supply of soap and towels. The men and women are not permitted to wash in the same room. There are also separate places for keeping the clothes of the workers, and separate eating-rooms for men and women. All these places are remarkably clean and airy, and the floors and tables were washed down once a day.

The Cassel factory is one of the cleanest, best appointed factories I have seen. Mr. Nölke, whose house is practically part of the establishment, evidently takes a pride in the place. The factory is being largely extended, to manufacture a new kind of safety match.

As regards the operatives, Mr. Nölke stated that they were only engaged after an examination by a medical man employed by the firm, and it was a necessity that they must have sound, healthy teeth. In addition, they are subjected to a monthly medical examination, Mr. Nölke being of opinion that the quarterly examination required by the law is insufficient. If the teeth are found to show signs of caries, they must either be taken out or stopped, as the dentist may determine. Only persons whose teeth continue sound, or are kept in good order, are permitted to continue at work as dippers or boxers of phosphorus matches. Mr. Nölke is strongly of the opinion that faulty teeth have much to do with phosphorus necrosis. The operatives are further required to wash before every meal, and to rinse their mouths with water and a dilute solution of potassium permanganate. It is the duty of the forewoman to see that this regulation is complied with. They are also required to wear overalls when at work.

From the report of the Swiss Inspectors I gather that there had been no case of necrosis in this factory for 12 years prior to their visit in 1893.

The match works at Habelschwerdt.

Thanks to the good offices of my friend Geheimrath Professor Ladenburg, Professor of Chemistry in the University of Breslau, who introduced us to Prince Hatzfeldt, the Governor of the province of Silesia, Dr. Oliver, who had been able to join me in Berlin, and I were given every facility to see over the Habelschwerdt works. We were accompanied by Regierungs u. Gewerberath Schuler and Kgl. Gewerbe Inspector Tobias, to whom we are under obligations for the manner in which they caused everything to be shown to us, and for the readiness with which they gave us all the information at their disposal.

At Mr. Carl Grübels's factory we met the son of the proprietor, who was so good as to conduct us over the works. The establishment is about 20 years old, and has been subjected to a number of structural alterations to enable it to comply with the regulations. It employs about 140 hands, of whom 40 are adult males. Its production is about one-third of the common phosphorus-sulphur matches, and two-thirds safeties. The manufacture of the former kind of matches is very intermittent, occurring on the aggregate on not more than 100 days in the year.

The total annual consumption of ordinary phosphorus (English) is about 600 lbs., *i.e.*, at most 6 lbs. a day. The "composition" consists of glue, zinc oxide, and phosphorus—the latter to the extent of one-third of the dry materials. A common form of such highly phosphoretted paste is as follows:—

Glue	14 parts.
Water	18 ,,
Phosphorus	9 ,,
Zinc White	7 ,,
Powdered glass	3 ,,

It is usually coloured with magenta paste or some other aniline dye.

It is first mixed by hand in the shop and afterwards stirred by an agitator, driven by power, in the open air. No special precautions are taken as regards "fumes."

The dipping was done by the machine figured on page 21. We were told that no case of necrosis had occurred in the place.

Roller's machinery is used for splint cutting, &c., and Russian aspen is employed exclusively. The boxes are made outside, in the homes of the worker.

Twenty persons only are concerned with the manufacture and packing of phosphorus matches. The boxing is done by hand, and in rooms of about 5 metres high; the women employed are, as, a class older than is usually found in match works. The washing arrangements were somewhat primitive; opportunities were afforded to the operatives to rinse their mouths with permanganate solution.

The hours of work are from 6 to 11.30, 1 to 4,4. 30 to 6.30.

C. Tietze's Nachfolger's Factory at Habelschwerdt is a type of works which, happily, is gradually becoming extinct in Germany. It mainly makes phosphorus-sulphur matches, and these under very insanitary conditions. It employs about 100 workers, 40 of whom are men. About 30 persons are concerned in the manufacture and handling of phosphorus matches. The apparatus is old-fashioned, and of a type, indeed, which is almost obsolete. There is no steam-power in the place, and the ventilation is bad, partly owing to structural defects and partly to the situation of the building against the face of a high rock.

About 5 lbs. of phosphorus are consumed daily. The mixing is effected in a small room with no mechanical ventilation, or indeed, any other means of removing the vapours beyond the occasional opening of a door.

The dipping is done by hand on a machine similar to that shown in Fig. 18, p. 41, which the Inspectors have caused to be placed under a hood connected with a chimney. The smell of phosphorus was very evident in the place.

The drying rooms were not ventilated, and their general condition was bad.

The filling was done into the old-fashioned round chip boxes. There was practically no "firing," and the hands of the boxers were not stained with composition.

The washing arrangement consisted of a long trough, provided with hot and cold water, but having no means for drawing off the waste. A solution of potassium permanganate was provided. The hours of labour are from 6 to 8; 8.15 to 11.30; 1 to 4; 4.15 to 7 (11 hours). On Saturday work ceases at 5.30. The box-fillers earn from 7 to 10 marks a week.

The most commendable feature of the factory was the meal room. This place was comfortably arranged, the workers were provided with lockers for their clothes, and had the opportunity of getting their dinner cooked for 15 pfennig a week, or two together for 25 pfennig.

Phosphorus necrosis is well known in Habelschwerdt, although cases are much less frequent than formerly, thanks to the action of the Inspectors in enforcing the regulations.

We saw several cases of malformation in the works last mentioned, due to the removal of more or less of the maxillary bones.

In striking contrast with the works just mentioned are the two factories of the Actiengesellschaft "Union" at Habelschwerdt and at Augsburg. As these, however, are exclusively engaged in the manufacture of safety-matches, it is unnecessary to describe them in detail. The Habelschwerdt factory is quite new, and has been specially designed for its purpose. It occupies a spacious and airy site, has large and lofty rooms, comfortably warmed and ventilated, and is provided with the electric light. The machinery is of the most modern and most approved type, and hence the power of production in the factory is altogether incommensurate with the number of its workers (140), judged from the standpoint of the practice in English works. The factory, indeed, is one of the best equipped and best arranged of its kind I have seen anywhere.

The Augsburg "Union" Factory, at the Untere Jakobermauer, also occupies a good airy site near the Moat, and on the outskirts of the city. It is remarkably clean and well kept, and its arrangements, although not so modern, are generally similar to those at Habelschwerdt. Herr Commerzienrath C. A. Buz, the General Director, informed me that the company was created by the union of his own business at Augburg and Deggendorf with the firms of Krauss-Glinz and Gebr. Seydelmann at Alaen, of Eiberle and Molfenter at Ulm, of John Schnetzer at Kempten, and of Müller and Erbe at Göppingen. The company owns factories at all these places with the exception of Ulm; it has also factories at Linz, together with the one at Habelschwerdt above mentioned. Phosphorus matches are made only at Kempten and Deggendorf. The company makes more than twice as many safeties as ordinary phosphorus matches. As regards the future of the match manufacture, Her Buz is of opinion that legislation and public opinion together will gradually bring about the general adoption of the safety-match, at least in Germany, where its use is rapidly extending. He pointed, in fact, to the newly erected Habelschwerdt factory as an indication of his opinion as to the direction in which the public taste was tending. At the same time he thought there would always be a demand for ordinary phosphorus matches, as these were preferable under certain conditions, but in view of their eventual comparatively limited production, the regulations at present in force as to ventilation and attention to teeth and washing ought, if properly carried out by employers and employed, to minimise, and, indeed, he thought, altogether avert the mischief arising from the action of phosphoric fumes.

Special Regulations in Germany.

For the purpose of carrying out the requirements of the Act of 13th May 1884, relating to the manufacture of and duty upon matches, the Bundesrath has issued the following provisions, based on s. 120(*e*) of the Trade Regulations as to the suitable arrangements to be adopted in factories where matches are made with ordinary phosphorus.

S. 1. A special room must be set apart for the following operations:—

(*a.*) Preparation of the paste.
(*b.*) Dipping the matches.
(*c.*) Drying the dipped matches.
(*d.*) Filling and preliminary packing.

These rooms should be placed under one another only, but not in immediate connexion with other workrooms, nor with dwelling or business rooms. Immediate connexion is, however, allowed between the dipping room and the receiving-room, and between the rooms for filling and wrapping and the store-room for finished matches. Each kind of work must be carried on exclusively in the room appointed for that purpose, but it is permitted to treat the splints with paraffin and sulphur in the dipping rooms (*b.*).

S. 2. The rooms in which the operations mentioned under s. 1, (*a.*), (*b.*), and (*d.*) are carried on must be at least 5 metres high; the rooms under (*b.*) and (*d.*) must have fireproof ceilings, and the drying room (*c.*) must be made fireproof all over. The walls of the rooms under (*a.*), (*b.*), and (*d.*) are to be covered with a coating of limewash, which is to be renewed at least once every half year, after the previous coating has been rubbed off.

S. 3. The rooms in which the paste is prepared must be so arranged that a continual change of air takes place sufficient to dispel any phosphorus vapours that may have been evolved.

The preparation of the paste must take place only in vessels closed airtight, the charging orifice of which must be so contrived as to act simultaneously as a safety valve.

Vessels containing paste must always be kept well closed.

S. 4. The dipping of matches must be carried out by means of such contrivances as will prevent phosphorus vapours penetrating the workrooms.

If the paste is used warm, apparatus for dipping may only be used which has been specially sanctioned for this purpose by the authorities.

S. 5. Rooms in which matches are placed for drying must be properly ventilated.

In drying rooms warmed artificially the temperature must not exceed 33° C. (95° F.). Every drying room must be provided with a thermometer, on which the highest permissible temperature is conspicuously marked, so as to be visible from outside.

The rooms may not be entered or emptied unless the doors and windows have been kept open for at least half an hour, or unless complete change of air has been effected by a special ventilating apparatus.

S. 6. The filling room, and, if there is a special room for the preliminary packing, this also, must be of such dimensions that an air-space of at least 10 cubic metres is allowed for every worker therein. The said rooms must be provided with windows which can be opened, and with effective ventilating apparatus.

S. 7. The rooms under s. 1 (*a.*), (*b.*), (*d.*), must be cleaned daily when work is finished. The refuse then collected is to be immediately burned after the cleaning is finished.

S. 8. The employer is to see that the workers in rooms under (*a.*) to (*d.*) wear an "overall" or an apron covering the upper part of the body. These are to be taken off and kept in a special room apart from the workrooms every time the workrooms are vacated. In these dressing rooms special receptacles must be provided for hanging the working clothes and the ordinary clothes taken off before beginning work.

S. 9. The employer is not to allow food to be brought into or consumed in the workrooms. He must, therefore, provide for the meals being taken only in rooms completely separated from the working and dressing rooms. Apparatus for warming food must also be provided outside the workrooms.

S. 10. A sufficient supply of washing utensils and vessels for the purpose of washing out the mouth must be provided outside the workrooms, but in close proximity thereto.

S. 11. The employer must see that the workpeople before meals and on leaving off work thoroughly wash their hands, rinse their mouths, and put away the overalls or aprons used during work.

S. 12. Employers are to allow only those persons to work in the rooms referred to under (*a.*) to (*d.*) who bring a certificate from an approved physician that they do not suffer from phosphorus necrosis, and that their bodily health is such that they are not in any special degree liable to contract this disease.

The certificates are to be collected and kept, and shown on demand to the inspector.

S. 13. The employer is to commission an approved physician, to be named to the inspector, to superintend the health of the employés. The doctor is to make an examination of the workpeople at least quarterly, and is to acquaint the employer with any ascertained case of illness from phosphorus necrosis.

As soon as the employer learns, either from the factory doctor or otherwise, that any of his workpeople suffer from phosphorus necrosis he shall send notice to the inspector in writing. He must no longer employ any such worker in the rooms under (*a.*) to (*d.*).

S. 14. The employer is required to keep a register in which must be stated the christian name, surname, age, address, and date of entrance and leaving of each of his employés. In this register the factory doctor must enter the date and the results of his examinations. This is to be submitted to the Inspector when required.

S. 15. A copy of s. 2 of the Act of 13th May 1884, and ss. 1 to 14 of these Regulations, must be hung up in a conspicuous position in every room, as well as instructions for the workpeople in each special room. A copy of these instructions shall be handed to every worker employed in rooms under (*a*). to (*d.*).

S. 16. New premises intended for the manufacture of matches with ordinary phosphorus must, after their erection and before working, be notified to the proper Inspector. The latter is to ascertain as quickly as possible after this notice whether the arrangements of the premises conform to the prescribed regulations.

S. 17. In case of contravention of s. 1 of the Act of 13th May 1884, or ss. 1 to 16 of these Regulations, the police authorities are empowered to prohibit the work being carried on until the required conditions are complied with.

S. 18. The foregoing provisions come into force from the date of their publication in the place of the Regulations published in the Order issued by the Chancellor on 11th July 1884 (Centralblatt fur das Deutsche Reich 8.195).

The exceptions allowed in s. 18, par. 2, of the latter to the Regulations in s. 1, and s. 2, par. 1, remain in force until repealed.

As a result of the regulations, it is asserted that no cases of phosphorus necrosis occurred in the next few years, but it is probable that this was accidental. The carrying out of such severe regulations at once throughout the Empire was impossible, and thus, even as late as 1896, it had not been found possible to stop in the smallest states, such as Meiningen, Schwarzburg-Sondershausen, &c., the prosecution of the industry in the homes of the workpeople.

On the whole, however, the effect of the regulations has been very good, especially in the way of putting a stop to the small match factories.*

Phosphorus necrosis in Germany. Official Reports of the Factory Inspectors, 1893–96.

Although contraventions of the special rules as to factories in which ordinary phosphorus is used were frequently noted, only isolated cases of phosphorus necrosis came to the knowledge of the Inspectors in the districts of Cologne, Brunswick, Lorraine, and Mittelfranken.

The Inspector in Cassel, who had heard of no case during 1896, reported one dating from 1895, which had been concealed by the manufacturer, the poor law medical officer, and the patient herself. He remarks, "Seeing "the way in which such cases are concealed, the fact that none are notified "does not exclude the possibility of their occurrence. If workpeople "become affected it is only by chance that they are discovered."

The defective condition of the match factories, reported on by almost all the inspectors, led in several instances to the closing (on a police order) of the factories. It is accounted for by the depressed condition of the industry.

The Inspector in Hesse states that during the last few years the number employed in the match industry has not experienced any perceptible increase.

* Weyl's Handbuch der Hygiene, Vol. VIII., Article Phosphor und Zündwaren, by Dr. Helbig.

They were 157 in 1896, 167 in 1895, 160 in 1894, 167 in 1892, and 203 in 1890. At one factory at Pfungstadt, in Hesse, belonging to J. Siepermann, efforts have been made for years to replace ordinary phosphorus by some other chemical. This year they have succeeded in manufacturing, without any phosphorus at all, good matches which will strike upon any surface.

1895. The health conditions in the match factories are reported to have much improved. One case occurred in the district of Würtemberg, and one in Hanover, through neglect of the special rules, and isolated cases occurred in Cassel, Breslau, and Anneberg through neglect on the part of the workers themselves.

In reporting on the death from necrosis of a workman the Inspector in Schleswig states that the medical inspection on the part of the visiting physician must have been done in a very indifferent manner.

1894. Eleven workpeople were affected with phosphorus necrosis, five in the district of Meiningen, two in Pfalz, and one each in Liegnitz, Schleswig, Hildesheim, and Schwarzburg-Sondershausen. The Inspector in Meiningen states that the five cases occurred in three match factories. The majority of the workpeople have carious teeth; in one factory, of the 30 workers, 23 had atrociously bad teeth. The case in Schwarzburg-Sondershausen was that of a woman who, besides working at the factory, carried on the manufacture at her own home. He says that the suppression of this kind of home industry seems almost impossible, from the way in which the people practising it hold together. While one factory is being inspected the others are informed and only empty or closed rooms are subsequently found. Competition, however, is driving it out of the field.

In six factories in Hesse breaches of the special rules were observed. In three the medical inspection was not carried out every three months, in three the whitewashing was not done every six months, and in one the vessels for washing out the mouth were not supplied.

The general condition of the workpeople was exceedingly good.

The Inspector in Cassel considers that the medical examination and the removal of carious teeth has been very beneficial. The employers have thereby the power of enforcing, through threat of dismissal, the observance on the part of the workers of the regulations. One workman preferred to lose 23 teeth in the course of a short time, rather than give up his employment.

1893. Only one case of necrosis was reported, although the Inspector in Meiningen believed that in his district the manufacture of matches with ordinary phosphorus was still carried on as a home industry.

AUSTRIA-HUNGARY.

The manufacture of matches is an important industry in Bohemia, Galicia, and Hungary; according to Jettel's "Adress-Buch" upwards of 90 firms are engaged either in their production or distribution in Austria-Hungary, and large quantities are exported to Servia, Bulgaria, Roumania, Turkey, and other parts of South-Eastern Europe.

The factory of Bernard Fürth at Schüttenhofen.

One of the oldest, most important, and best known of these firms is that of Bernard Fürth, at Schüttenhofen and Bergreichenstein in Bohemia, founded in 1838. To Mr. Bernard Fürth is due the credit of having first attempted to use red phosphorus, discovered by Schrötter, of Vienna, in 1845, as a substitute for the ordinary variety, and matches with a rubbing surface of red phosphorus on the box, as suggested by Böttger, were actually placed on the market by the Bohemian firm in 1854–55 without, however, any great commercial success.

I visited the Schüttenhofen works on November 1, 1898, and was courteously taken over the factory by Dr. Ernest Fürth, the grandson of the original proprietor, and now one of the chief partners. The factory employs about 850 workers, of whom about 60 per cent. are women and about 5 per cent. children between the ages of 14 and 16. The firm makes every variety of match with the exception of vestas. About three-fourths of the output consists of phosphorus matches, dipped on sulphur, stearin or paraffined splints; the remaining fourth consists mainly of safety-matches. The phosphorus employed is wholly of English manufacture; in fact, the firm is

the largest consumer of English phosphorus in Austria. The amount of ordinary phosphorus used is about ten times that of red phosphorus.

The "laboratory" is one of the best arranged places of the kind I have seen anywhere. It is a large and lofty room, excellently ventilated, and between 6 and 7 metres high, with asphalt floor, and good arrangements for washing out the mixing vessels. These, six in number, are arranged as shown in Fig. 34. Each vessel D (Figs. 35, 36) is steam jacketted and provided

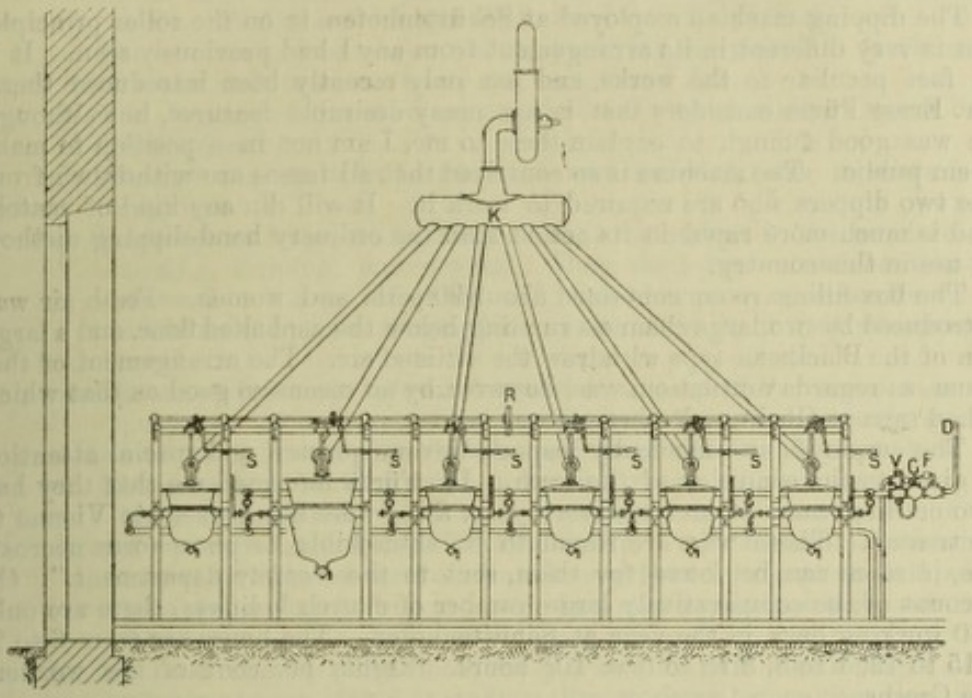


Fig. 34.

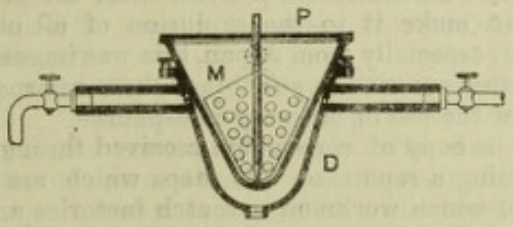


Fig. 35.

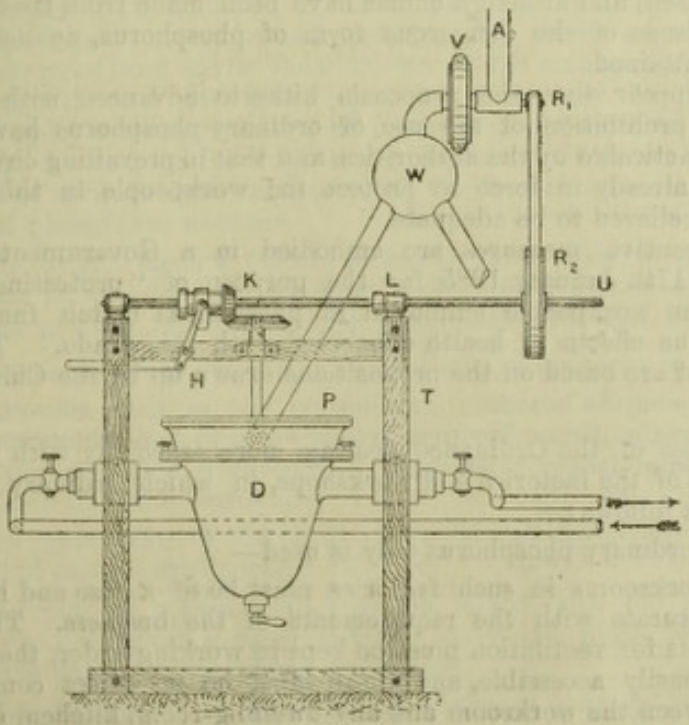


Fig. 36.

with an agitator M, geared as shown in Fig. 36, and connected with an exhaustor V, worked from the shaft U. After the glue and phosphorus have been introduced, the lid is hermetically closed, steam introduced into the outer jacket and the agitator, and, at the same time, the ventilator, set in motion whereby the phosphoric fumes are effectually withdrawn. When the phosphorus has been thoroughly admixed, the steam is cut off, and the agitator stopped, and after cooling the lid is removed and the mass poured out by inclining the vessel.

The dipping machine employed at Schüttenhofen is on the roller principle, but is very different in its arrangement from any I had previously seen. It is in fact peculiar to the works, and has only recently been introduced there. Dr. Ernst Fürth considers that it has many desirable features, but although he was good enough to explain these to me, I am not in a position to make them public. The machine is so contrived that all fumes are withdrawn from the two dippers who are required to work it. It will dip any kind of match, and is much more rapid in its action than the ordinary hand-dipping method in use in this country.

The box-filling room contained about 90 girls and women. Fresh air was introduced by two large channels running below the asphalted floor, and a large fan of the Blackman type withdrew the vitiated air. The arrangement of this room, as regards ventilation, was, however, by no means so good as that which I had seen at Ghent and other places.

The employés are medically inspected every quarter, and special attention is given to the condition of the teeth. Dr. Fürth informed me that they had two or three cases of necrosis every year, these were usually sent to Vienna to be treated. Those who are found to be susceptible to phosphorus necrosis are, if room can be found for them, sent to the "safety department." On account of the comparatively large number of church holidays, there are only 280 working days in the year at Schüttenhofen. The hours are from 6 to 9, 9.15 to 12, 1 to 3, 3.15 to 6 = 10½ hours. Eighty per cent. of the workers are Czechs.

Dr. Fürth expressed his individual preference for the safety match, and said he should prefer to make it to the exclusion of all others, but in face of foreign competition, especially from Japan, this was impossible. No complete solution of the necrosis question is possible without international agreement as to the prohibition of the use of ordinary phosphorus.

The following is a copy of a despatch received through the Foreign Office from Vienna, enclosing a report on the steps which are taken in Austria to meet the dangers to which workmen in match factories are exposed.

In Austria the use of both varieties of phosphorus in match-making is legally permitted, and although efforts have been made from time to time to secure the disuse of the dangerous form of phosphorus, no definite result has yet been attained.

It would appear that the proposals hitherto advanced with a view to securing the prohibition of the use of ordinary phosphorus have not been considered practicable by the authorities, and that in prevailing circumstances, the measures already in force to protect the workpeople in this branch of industry are believed to be adequate.

These preventive measures are embodied in a Government Ordinance issued on the 17th January 1885 for the purpose of "protecting, so far as "possible, the workpeople employed in phosphorus match factories from "the injurious effects to health connected with this trade." The various clauses thereof are based on the propositions drawn up by the Chief Sanitary Council.

Special regulations in Austria.

Those clauses of the Ordinance dealing more especially with the internal arrangements of the factories and workshops, in which ordinary phosphorus is used, are as follows;—

A. Where ordinary phosphorus only is used—

1. All workrooms in such factories must be of a size and height commensurate with the requirements of the business. The arrangements for ventilation must be kept in working order, the exits must be easily accessible, and there must be no direct communication between the workroom and any dwelling-room, kitchen, or bedroom.

2. The rooms in which the processes of mixing, dipping, drying, and sulphuring are carried on must be well ventilated and distinct from one another.
3. Doors and windows shall be kept open before the commencement of work, during the midday interval and after the close of work so as to flush out thoroughly the rooms with fresh air. Rooms in which there is a possibility of phosphorus material being scattered on the floor must always be cleaned carefully after the close of the day's work. Walls shall be limewashed once a year at least.
4. The sweepings from these rooms must not be placed in dustbins or ashpits, but be burnt every day in a closed fire.
5. The drying rooms shall be emptied only when all the fumes have disappeared.
6. The matches shall be stored in a cool and airy room separate from any other.
7. Perfectly healthy persons shall alone be employed in the processes of mixing, dipping, and drying. They shall from time to time be allowed a change of work, and such change must immediately be made should the least symptom of toothache or jaw disease present itself.
8. The employer must provide special clothes for those engaged in the processes of mixing, dipping, drying, and the removal of the matches. The clothes shall be well aired after the work is done.
9. The employer shall provide a special room for the workpeople to leave their ordinary clothes, and shall not allow them to be left in the workrooms. He shall further provide the necessary number of basins and glasses for enabling the workers before meals and before leaving the factory to wash their face and hands and wash out their mouths.
10. No food may be taken into the workrooms, and the employer must use his utmost efforts to induce the workers before changing their clothes to wash their hands and faces and rinse out their mouths. The workpeople must not remain in the workrooms during the midday interval.
11. The employer must appoint a surgeon to look after the health of the workpeople. The latter must certify them before their employment, and at stated intervals afterwards. He shall certify such as are tuberculous or have defective teeth as unfit for work in the processes mentioned in paragraph 7. He must enter the details of his examination in a special register, which must be shown to the inspector on demand. He shall also satisfy himself that the precautionary measures adopted for the preservation of health are observed, and advise the employer or his manager of defects in this respect, and the way in which they may be remedied. The employer must exclude such persons as are notified to him as unfit by the surgeon for work in the processes mentioned in paragraph 7. The surgeon must at once notify the factory inspector of every case of phosphorus necrosis.
12. The district medical officers of health must from time to time visit the factories to see whether the sanitary arrangements are satisfactory, and if their previous recommendations have been carried out.

B. Factories in which only red or amorphous phosphorus is used—

1. Materials such as red phosphorus, chlorate of potash, sulphide of antimony, &c., must be kept in fireproof rooms, separate and distinct from the other workrooms. Chlorate of potash must be kept apart from the other materials.
2. The preparation of the paste must be entrusted only to trustworthy and careful workpeople.
3. Chlorate of potash shall only be mixed with the other materials when all are in a finely divided state and moist, and with careful avoidance of jars, blows, or friction.
4. The preparation of the striking surfaces must be carried out in a separate room.

A copy of the above regulations must be posted up in a prominent place in every match factory.

Necrosis in Austria.

Austria-Hungary is divided up for the purposes of factory inspection into 17 districts, each with two, three, or more inspectors. The following are the numbers of cases of phosphorus necrosis mentioned in the inspectors' reports since 1881. They make no pretension to be complete, as some inspectors use the words "several" or "numerous" in their reports, no account of which can be taken—

	Cases.		Cases.
1881–84	12	1891	3
1884	2	1892	2
1885	15	1893	5
1886	15	1894	5
1887	6	1895	7
1888	47	1896	5
1889	4	1897	10
1890	2		

The large number of cases 47, in 1888, is attributable to the fact that, at that time, the manufacture of matches with ordinary phosphorus was carried on extensively as a home industry. This practice has now almost entirely disappeared.

The General Report for 1895 says, "It must be acknowledged that the "Orders of 1885, as regards the manufacture of matches with ordinary "phosphorus, are not strictly observed everywhere."

In the report for 1896 on District XVII. (Galicia), the inspector writes: "The workpeople in the 10 match factories have to work under most in- "sanitary conditions, owing to the inefficient manner in which the regulation "of 1885 is carried out. Cases of phosphorus necrosis are comparatively "frequent. Since 1888 over 30 cases have been treated surgically in the "local hospitals. An exact estimate of the number attacked cannot be given "as some prefer to be treated by private practitioners and others in outside "hospitals."

One case of necrosis in a dipper was notified to the same inspector in 1897, who attributes it to the faulty condition of the factory, and neglect on the part of the employer to observe the regulations.

In the Report on District XVI. (Silesia) in 1896, the inspector writes: "Despite the efforts of the inspectors to enforce the strict carrying out of the "Order of 1885, cases of necrosis still occur. During the last 9 years, 12 "cases, all from one factory, have been treated in the hospitals of Cracow "and Biala."

In 1895 there were three cases (women) resulting in the death of one, and entire loss of the lower jaw in the other two.

In District XI. (Bohemia), where the match industry is more extensive than in any other part of the kingdom, no case was reported to the inspector in 1895. He attributes this to increased manufacture of safety matches, and to greater attention being paid to the regulations than was the case formerly. But in this district, in 1896, five or six cases came to the inspector's knowledge, and in 1897, two or three.

In District X. (Bohemia), where there are six match factories, employing only 105 workpeople, one visiting surgeon states that in 24 years he has not treated more than four cases. Others, however, believe that phosphorus necrosis would be an almost everyday occurrence were it not for the immediate suspension of workers showing the first symptoms of the disease.

During the three years 1895–97 one or more cases occurred, also in Districts II. (Austria below the Enns), III. (Austria above the Enns), IV. (Gray, &c.), XII. and XIII. (Bohemia).

Special regulations in Hungary.

As regards Hungary, the regulations are as follows:—

Art. 1. In all factories where ordinary phosphorus is used in the manufacture of lucifer matches, the rooms in which the operations mentioned below are carried on must be specially constructed, viz.:—

(*a.*) Preparing the paste.
(*b.*) Dipping the splints.
(*c.*) Drying.
(*d.*) Boxing.

All these workrooms must be situated in buildings separate from each other, and be provided with ventilating shafts for the effective ventilation of the premises. The buildings shall consist of only one—the ground—floor, and be so constructed as to prevent the spread of fire. The various workrooms of this description may be in communication with one another, but must not stand in direct communication with other workrooms, dwellings, or business premises. The dipping room and the place in which boxing is carried on may communicate with the storerooms where the finished goods are kept. In all these rooms only the operations can be carried on for which they have been fitted up, but the sulphuring or paraffining of the splints may be done in the dipping-room.

Art. 2. All shops in which work is carried on, as described in Art. 1. under (*a.*), (*b.*), and (*d.*), must be limewashed at least once every six months; prior to this the walls must be well scrubbed down.

Art. 3. The mixing rooms, where the paste is prepared, must be so constructed as to allow of the phosphorus fumes being carried off by means of separate ventilating arrangements.

Only covered vessels can be used for mixing and preparing the paste, which must be fitted with ventilating pipes to carry the phosphorus vapour off into the atmosphere. All vessels containing paste must be kept constantly covered up. Turpentine (one-twentieth part) must be added to the paste, and in all localities where work is carried on, as mentioned under (*a.*), (*b.*), and (*d.*), linen cloths saturated with turpentine must be suspended.

Art. 4. For the dipping operation such apparatus only shall be used which thoroughly prevents the spread of the phosphorus vapours through the work-rooms, and which effectually protects the workpeople against the inhalation of the noxious vapours.

Art. 5. In drying rooms, which are artificially heated, the temperature must not be allowed to rise above 35° C. In all such places thermometers are to be kept, upon which the maximum temperature allowed shall be clearly marked, so as to be easily noticed from within and without the room. If workmen have to enter these premises for the purpose of bringing in matches to dry, or for taking the dried ones out, the doors and windows of the drying room must be kept open for at least half an hour, or some other appropriate method of ventilation must be employed in order to bring about a total change of air, and render the place safe. For this purpose the ventilators and windows of the drying rooms shall be so constructed as to allow of their being opened and set into operation, even from outside the premises.

Art. 6. All workshops used for fitting and packing operations must be of such dimensions as to give to every workman employed therein not less than 10 cubic metres of air space.

Art. 7. Factories where the wood for matches is cut and planed must be provided for this purpose with separate well ventilated workrooms.

Art. 8. The rooms mentioned in Art. 1., under (*a.*), (*b.*), and (*d.*) must be constantly ventilated during the intervals from work, and must be thoroughly swept daily after the close of the day's work; the sweepings shall be burnt immediately afterwards.

Art. 9. The employer shall see that all workers employed in localities wherein work is carried on, as described under (*a.*), (*b.*), (*c.*), (*d.*), are provided with overalls, to be used for that purpose during working, and, when not in use, to be kept in a special dressing room separate from the workrooms. This dressing room shall be fitted with lockers for the keeping of the ordinary clothes, which the workers must take off before commencing work.

Art. 10. The employer shall not allow the workpeople to take food or drink to the workrooms. He shall provide a proper place in which the workers can take their meals, and where they may deposit such provisions as they may happen to bring with them; such place to be separate from the workshops and the dressing room.

Art. 11. Outside the workshops, but in close proximity, special facilities for washing must be provided, such washing arrangements to be of such size and so numerous, that at least one-fifth of the total number of the workers may be

accommodated at a time. On the working premises a glass or cup for each worker is to be kept, and a sufficient quantity of rinsing liquid, composed of permanganate of potash, must be provided.

Art. 12. The employer shall see that the workmen thoroughly wash their hands, rinse their mouths, and take off the dress worn during work time before taking their meals, and before leaving the factory premises.

Art. 13. In the rooms mentioned under (*a*), (*b*), and (*d*) of Art. 1, only such workmen shall be employed who prove their fitness for the work in question, by a certificate from a medical practitioner, stating that the person does not suffer from phosphorus necrosis or caries of the teeth, is not tuberculous, and, judging from his or her bodily constitution, is not specially liable to such diseases.

These medical certificates are to be kept for inspection by the controlling authorities.

Art. 14. The employer shall employ a qualified medical officer to superintend the sanitary condition of his workpeople. The medical officer shall examine each worker as to diseases attributable to phosphorus poisoning at least once every quarter, and must report to the employer every case of such disease. The name and residence of the medical officer shall be communicated to the Sanitary Authority in the first instance, and to the factory inspector of the district. The employer shall report at once to the Sanitary Authority, and to the factory inspector, every case of disease attributable to phosphorus poisoning of which he may become cognisant by report or otherwise.

It is strictly prohibited to continue to employ, on the premises described in Art. 1, under (*a*), (*b*), (*c*), and (*d*), persons found suffering from such diseases.

Art. 15. The employer shall keep a register of all his workpeople. This register must contain, besides the columns prescribed by the Statute Laws XVII., 1884, special columns for inserting data with regard to the medical certificate, the employment upon which the worker has been engaged, by whom and when it was given, when he was last examined, and also on the state of the workman's health at the time of examination, this last column to be signed by the examining medical officer.

Art. 16. On the premises stated in Art. 1, under (*a*), (*b*), (*c*), and (*d*), no person under 16 years of age shall be employed.

Art. 17. The employer shall provide, and always keep on the premises, the necessary medical dressings and bandages for the treatment of poisoning or burns.

Art. 18. The employer must arrange that strangers or friends of the workpeople who are not employed on the premises shall not be able to gain access to the factory premises.

Art. 19. The owner of the factory shall have all the necessary alterations ordered by this present regulation carried out within six months after its publication.

Factory owners, to whom compliance with this regulation would be a too onerous task, may within three months after its publication petition the Minister of Commerce, who, after consulting the Minister of the Interior, may grant such modifications or facilities as the case may admit of having regard to the place and the special circumstances.

In newly erected factories, however, the above rules must be strictly complied with. In such cases the workshops and rooms must be at least five metres high, well lighted, and effectively ventilated. In granting the building license, the authorities shall take this point into special consideration, as also the public exigencies, fire-police regulations, and the rights of those living near. The selection of the site upon which the factory is to be erected must largely depend upon all these conditions.

Art. 20. The license to use localities for such factory purposes can only be issued after the Sanitary Authorities have, conjointly with the factory inspector, examined the localities, and have thereupon granted a preliminary permit.

Art. 21. This order of regulation, together with the "observations" given below, must be exhibited in every workshop or room in some easily accessible place.

"OBSERVATIONS."

"The phosphorus used in the manufacture of lucifer matches acts injuriously upon human health, and causes diseases. The first symptoms of disease are—Swelling of the gums accompanied by pain and an inclination to bleeding; the gums afterwards become sore and ulcerated. The teeth are loosened, and dull persistent pain follows. In other instances coughing and pains in the chest manifest themselves.

"Those persons in whom such symptoms develop are requested, for their own sakes, to report themselves to the Medical Officer, to leave off work, and to submit to a regular course of medical treatment, if they desire to avoid more serious consequences.

"For those who have wounds on the body, suppuration in the mouth, or whose gums begin to bleed, or whose teeth have only recently become decayed, to work in the mixing, dipping, or packing rooms is especially fraught with danger.

"Workmen engaged in these operations are enjoined to leave these places at once, the more so because they are sure to be dismissed from them at the next quarterly medical examination.

"To avoid the noxious action of the phosphorus every workman must well wash his hands, rinse his mouth with the violet coloured lotion kept for this purpose in the washing rooms, or at least thoroughly wash his hands and rinse his mouth with clean water before taking his meals. The overalls worn during working hours must also be taken off before washing and before meals are taken. Persons employed can obtain gratuitously a copy of these regulations from the factory inspector of the district."

Art. 22. The Sanitary Authorities and their experts shall inspect the lucifer match factories at least once in every three months, and satisfy themselves that the preventive arrangements ordered by these regulations are effectively carried out.

The expert of the Sanitary Authority shall assist in the examination of such factories when called upon to do so by the factory inspector.

Art. 23. The Order, No. 5,089, issued by the Minister of the Interior, on March 15th, 1869, referring to the protection of the health of workmen engaged in the manufacture of lucifer matches is hereby revoked and declared null and void.

Art. 24. Those infringing the administrative rules or the prohibitions of this order commit a misdemeanour at common law, provided that their acts do not come under the Criminal Statutes XVII., 1884, or XVIII., 1893. In accordance with the orders issued by the Minister of the Interior, in conformity with Art. 42 of the Statute Laws XXXVIII., 1880, such misdemeanour can be punished by a fine, not exceeding 100 florins.

Special regulations relating to the manufacture of matches in various countries, in addition to those already given, have also been collected by the Home Office, with the assistance of the Foreign and Colonial Offices. They are as follows:—

SWITZERLAND.

Recent legislation on the subject of phosphorus poisoning in Switzerland dates from March 1870, when the attention of the Federal Assembly, at that time considering a new Factory Act, was directed, by the Medical Society of Berne, to the injurious effects of phosphorus on the health of the workers.

In June 1878 the Federal Chambers approved of a motion that special attention should be devoted to the manufacture of phosphorus matches, in connexion with the execution of the Factory Act then coming into force, and that a report be made to the Federal Assembly of the measures taken and the results obtained.

In May 1879 a special report of the factory Inspectors was presented, in which they stated it as their opinion that the use of ordinary (yellow) phosphorus should be prohibited, and in November of the same year a Bill was brought forward, and approved by the Federal Assembly, for prohibiting the manufacture, importation, and sale of matches in which ordinary (yellow) phosphorus was used, the law to come into force in January 1881.

Shortly after the passing of the Act complaint became loud as to the bad quality of the matches made under its terms, and to the fact that the manufacture of matches with ordinary phosphorus was carried out clandestinely under conditions very injurious to the health of the workers.

The Federal Chamber in June 1882, recognising that the Law of 1879 failed of its purpose, passed the "loi federale concernant la fabrication et la "vente d'allumettes chimiques," repealing the Act of 1879 in so far as the prohibition of the use of ordinary phosphorus was concerned, but at the same time giving full power to the Government to draw up and enforce regulations, chiefly with a view to prevent necrosis.

Such regulations were made, but they were observed in a very lax manner, so much so, indeed that the factory inspectors stated in October 1886 their conviction that the prohibition of the use of ordinary phosphorus by the Law of 1879 should be reimposed. Failing that, they recommended that the manufacture of matches with ordinary phosphorus should become a monopoly of the State, as the only means promising a reduction in the number of cases of necrosis and a chance of pecuniary compensation to those attacked.

The President of the Federal Council, while explaining that the object of the State in obtaining the monopoly of the sale of matches made from ordinary phosphorus was to safeguard the health of the workers, pointed out the advantages which would at the same time be obtained by the centralisation of such a business, and the guarantee which could be given of the quality of the article produced.

Before introducing the Bill information was collected by the Inspectors as to :—

1. The extent to which matches were used in Switzerland :—
   (*a*) containing ordinary phosphorus ;
   (*b*) without ordinary phosphorus.
2. The number of factories which would be required to furnish the necessary supply of matches.
3. The amount of compensation it would be necessary to pay to the owners of existing factories.

As regards :—

(1.) The estimation was 122,879 cases, each containing 50,000 matches. Of this number 101,984 were made of ordinary phosphorus, and 20,895 of red phosphorus.

(2.) Three or four large factories ; and

(3.) 1,021,462 francs (400,358*l.*)

The Bill of March 1895, introduced with a view to the securing by the State of a monopoly in the manufacture of dangerous matches, was rejected in September of the same year by a popular referendum owing to its centralising tendency.

The Government was, therefore, considering the question of imposing fresh regulations, which should be more stringent than those adopted in 1882, when further action in this direction was stopped by the consideration in the National Council of a motion dealing with the manufacture of matches by M. Haberlin, in December 1895, and the request by the National Council that the Federal Council would take steps in the matter without delay.

The motion of M. Haberlain was: "The Federal Council is asked to "reimpose the prohibitory clauses as regards the manufacture, importation, "and sale of matches and wax vestas made with yellow phosphorus, "scheduled in the Law of December 23rd, 1879, and to present a new Bill "on the matter, containing, if necessary, the prohibition of the use of "matches made with yellow phosphorus."

The following are the terms of the projected law on the subject which has been approved by the National Council (Chamber of Deputies), 15th June, 1898, but which cannot be taken into consideration by the State Council till after the expiration of three months. No effect can be given, therefore, to the proposed law before 1899.

Federal Law concerning the Manufacture and Sale of Matches.

1. The manufacture of matches of every kind is subject to the regulations of the Federal Law concerning work in factories, whatever be the number of the workpeople and the importance of the business.

The sale of matches similarly is subject to Federal legislation in conformity with the following provisions of Articles 4, 5, and 6.

2. The manufacture of matches cannot be undertaken except with the authority of the Government of the Canton, which again cannot grant the permission unless authorised to do so by the Federal Department of Industry or the Federal Council. The Federal Council will draw up the conditions necessary for the health and safety of the workers and of the public.

3. To obtain permission to start a match factory, it it is necessary to lay before the Government of the Canton, which shall transmit them to the Federal Department of Industry :—

(*a.*) Detailed plans of the proposed buildings, the buildings to be used exclusively for the manufacture of matches.

(*b.*) The intended method of manufacture, and the composition of the paste.

(*c.*) The fittings.

(*d.*) The method of packing.

4. The manufacture, importation, exportation, and sale of matches made with ordinary (yellow) phosphorus are forbidden.

5. The importation of ordinary (yellow) phosphorus is only authorised for scientific or pharmaceutical purposes, and notice of every such importation shall be sent by the Customs to the Government of the Canton.

6. The sale of matches shall only take place in boxes or packages bearing the name of the maker or his trade mark.

This shall hold good for all matches imported or exported.

7. The officials charged with the superintendence of factories shall have powers of entry, subject to the regulations, at any time into any place where there is a suspicion that it is being used for the manufacture of matches illegally.

8. The Federal Council is authorised to obtain and communicate to manufacturers processes of manufacture presenting the least danger to the health of the workpeople.

9. Infraction of (*a*) Articles 1 and 2 shall be punishable by a fine of 100–1,000 francs : (*b*) Articles 3, 5 and 6, by a fine of 50–500 francs: (*c*) of regulations issued by the Federal Council, and instructions drawn up by authorised persons, 50–500 francs.

Further, infraction of Articles 1 and 2 may be punished : (1) in case of a second offence by imprisonment for not more than three months : or, (2) withdrawal of the permit from the manufacturer.

All goods manufactured, transported, offered for sale, or imported contrary to these regulations shall be confiscated. Penalties shall be imposed by the judicial courts (tribunaux) of the Canton except in the case of the withdrawal of the permit from the manufacturer and of punishments connected with the infraction of the rules upon and exportation of matches, which are to be dealt with by the Federal Department of Industry.

The judgments delivered by the courts, together with the notes of the proceedings shall be sent by the various Cantons to the office of the Inspector of Factories.

10. The Cantons are charged with the execution of the present law. The Federal Council shall draw up the regulations necessary for the carrying out of the said law, and shall cause such measures of safety to be taken as are necessary in the manufacture, packing, carriage, sale, importation and exportation of the matches.

11. The law of June 22nd, 1882, is repealed.

12. The Federal Council shall publish the present law, and fix a time when it shall come into force in conformity with the requirements of the Federal Law of June, 1874, concerning the referendum.

ITALY.

No rules or regulations have been issued by the Government.

RUSSIA.

In accordance with the despatch of the 27th June this year, sub-No. 6022, the Department of Trade and Manufactura has the honour to supply the information sought in reply to the queries presented by the British Ambassador at the Imperial Court as to the steps taken to avert the dangers to which workmen employed in match factories are exposed.

The Ministry of Finances has striven to limit as far as possible the manufacture in Russia of ordinary phosphorus matches, dangerous in respect of fire and injurious in their preparation to workmen, and this endeavour was also sustained when elaborating excise regulations for matches.

On the establishment, however, in 1888, of an excise tax on matches, the Ministry of Finances could not avoid taking into account the fact that the great majority of the factories (about 85 per cent.) then produced the cheaper matches of ordinary phosphorus, which were used by the masses of the population; to have restricted this industry and encouraged the manufacture of safety matches was considered premature and might have placed the match industry at a serious disadvantage.

It was, moreover, anticipated that the establishment of a tax, and the manner of its collection, combined with the measures adopted for concentrating the production of matches in properly organised factories, subject to Government supervision, as also the rules projected for the sale of matches, would result in a gradual attainment of the desired object, and would indirectly effect the improvement and perfection in the methods of much production, and it was expected that the new measures adopted would result in the reduction of the number of ordinary phosphorus match factories.

In 1892, when the question respecting the limitation of the number of match factories was again under consideration, the Government had to recognise the fact that of the whole number of match factories then in existence, only 82 produced safety or Swedish matches, while 246 manufactured ordinary matches of phosphorus or of sulphur; of the latter kind nearly 107 milliards were produced, while the production of Swedish matches amounted only to 37·8 milliards.

In view of this the entire prohibition of the manufacture of ordinary phosphorus matches would have prevented the match factories satisfying the demands of the population for matches, and would at the same time have considerably raised their price. By prohibiting the construction of new factories for the manufacture of phosphorus matches, as proposed by the Medical Council of the Ministry of the Interior, the desired object would not have been gained. With the adoption of such a prohibition the old factories of phosphorus matches would not only have remained and continued their operations, but would have been placed in an absolutely privileged position, and a monopoly for a whole branch of the match industry would have been thus created.

The Ministry of Finances, however, seeing that a reduction of the production of ordinary phosphorus matches was absolutely necessary, proceeded to attain its object in another and more gradual manner, namely, by doubling the excise duty on such phosphorus matches.

A law to this effect was passed on the 10th November 1892, and the effect of it was the gradual diminution in the number of ordinary phosphorus match factories and the gradual development of safety match factories, as seen from the following table:—

Year.	No. of Match Factories.				Quantity of Matches in Thousands.		
	Phosphorus.	Safety.	Both.	Total.	Phosphorus (Ordinary).	Safety.	Total.
1889 - -	240	20	52	312	111,719,366	27,984,361	139,703,727
1890 - -	200	20	70	290	108,258,303	34,590,970	142,849,273
1891 - -	189	25	57	271	106,902,912	37,844,413	104,747,325
1892 - -	160	27	68	255	104,656,282	111,939,190	146,595,472
1893 - -	76	29	115	221	62,575,750	74,366,387	136,942,137
1894 - -	74	32	106	212	70,315,973	87,125,998	157,441,971
1895 - -	72	39	101	212	64,140,637	102,930,484	167,071,126
1896 - -	53	39	95	187	46,369,330	120,520,660	166,889,990

Although the Ministers of Finances and of the Interior have at various times projected rules regulating the arrangement of certain workshops, the observation of certain rules in regard to the handling of phosphorus, &c., &c., those rules have not as yet been finally sanctioned.

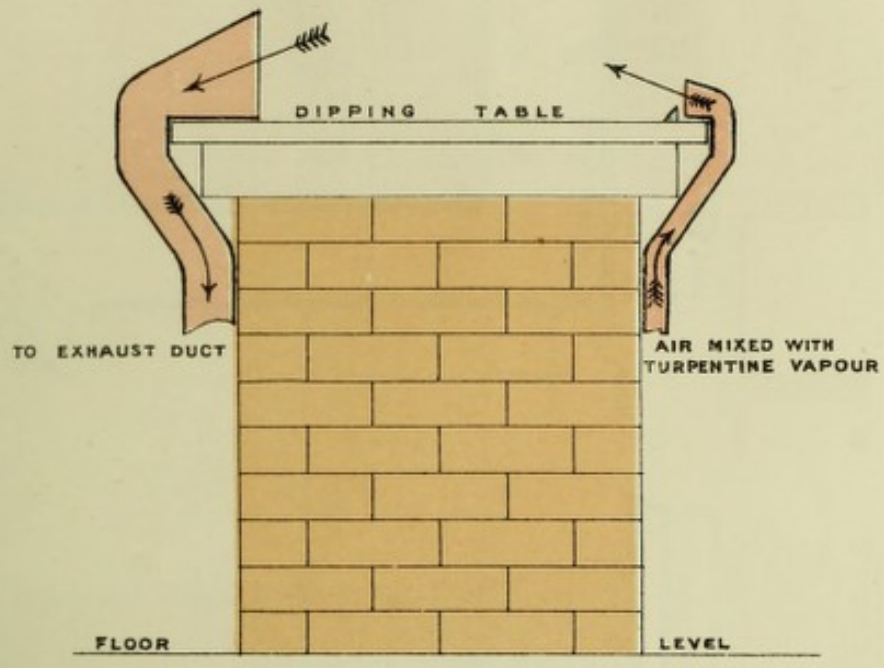
The law in existence is confined to the following provisions: the work of minors under the age of 15 years in ordinary phosphorus match factories is absolutely prohibited in the workshops where the melting of phosphorus, the dipping, drying, and packing of phosphorus matches is conducted.

Notwithstanding the measures taken to protect the workpeople against the injurious effects of phosphorus at the match factories, they do not seem to be safeguarded to any great extent, and the only efficacious measures of protection for the workmen consists in the total prohibition of the use of ordinary (white or yellow) phosphorus, and its substitution by the red (amorphous) variety.

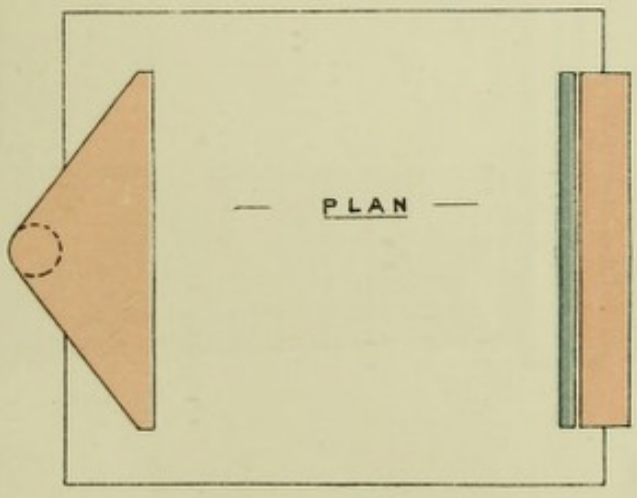
There are no Government match factories in Russia.

UNITED STATES OF AMERICA.

No rules or regulations have been issued by either the State or municipal governments.



ELEVATION.



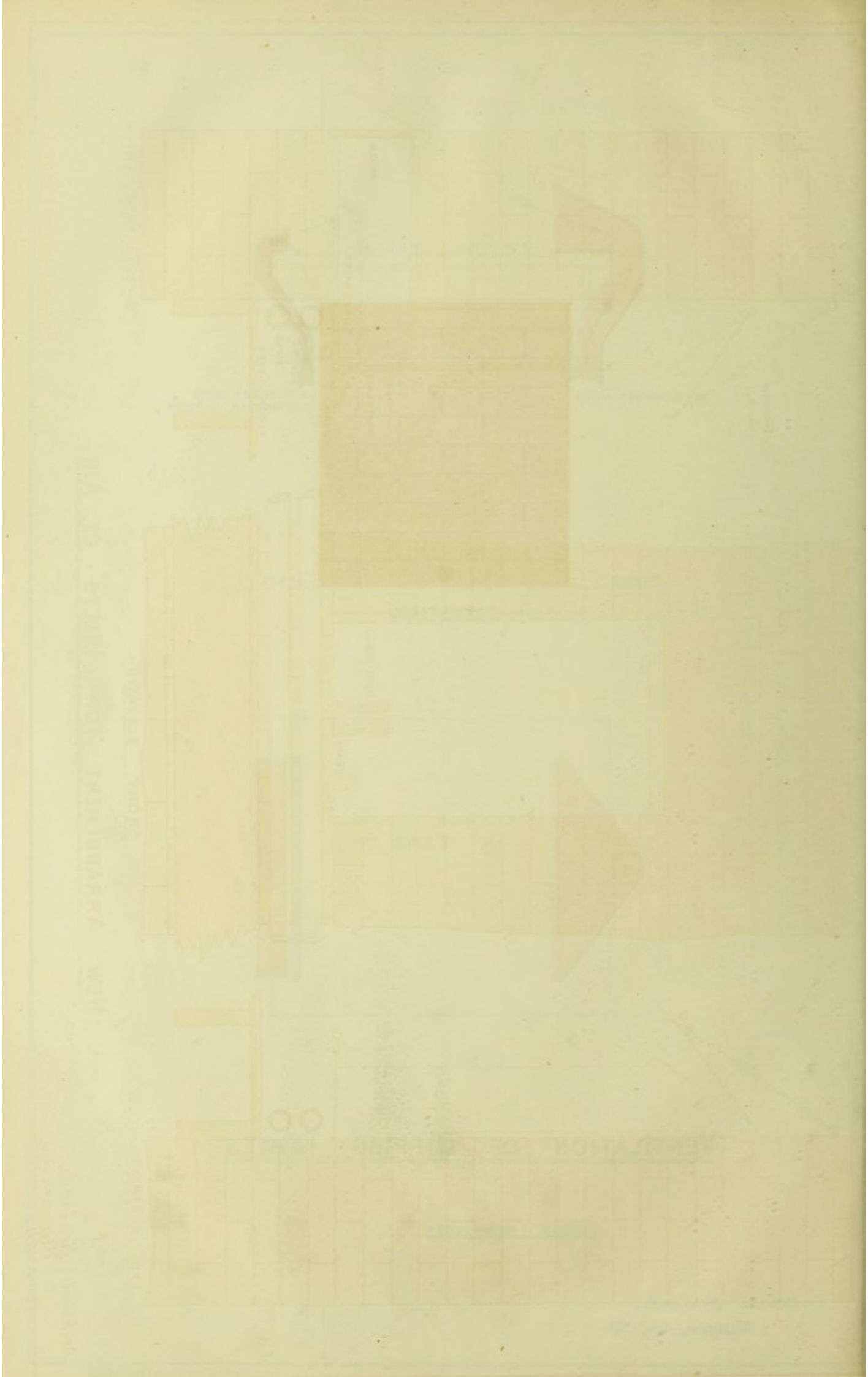
PLAN

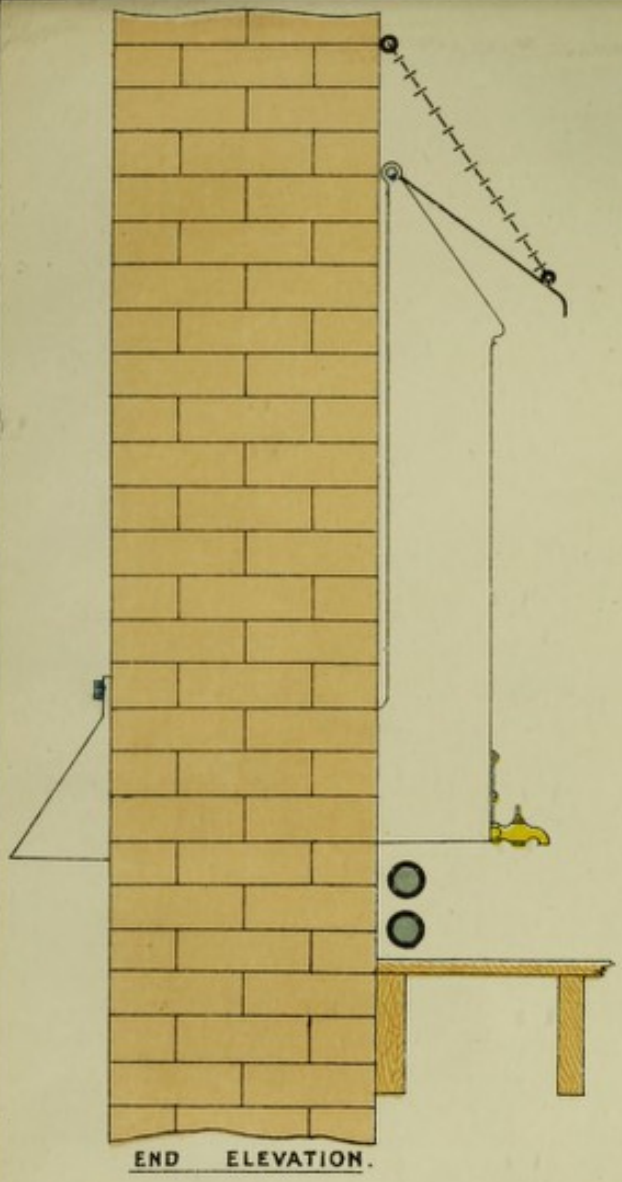
VENTILATION OF DIPPING TABLES

SCALE 1 INCH = 1 FOOT

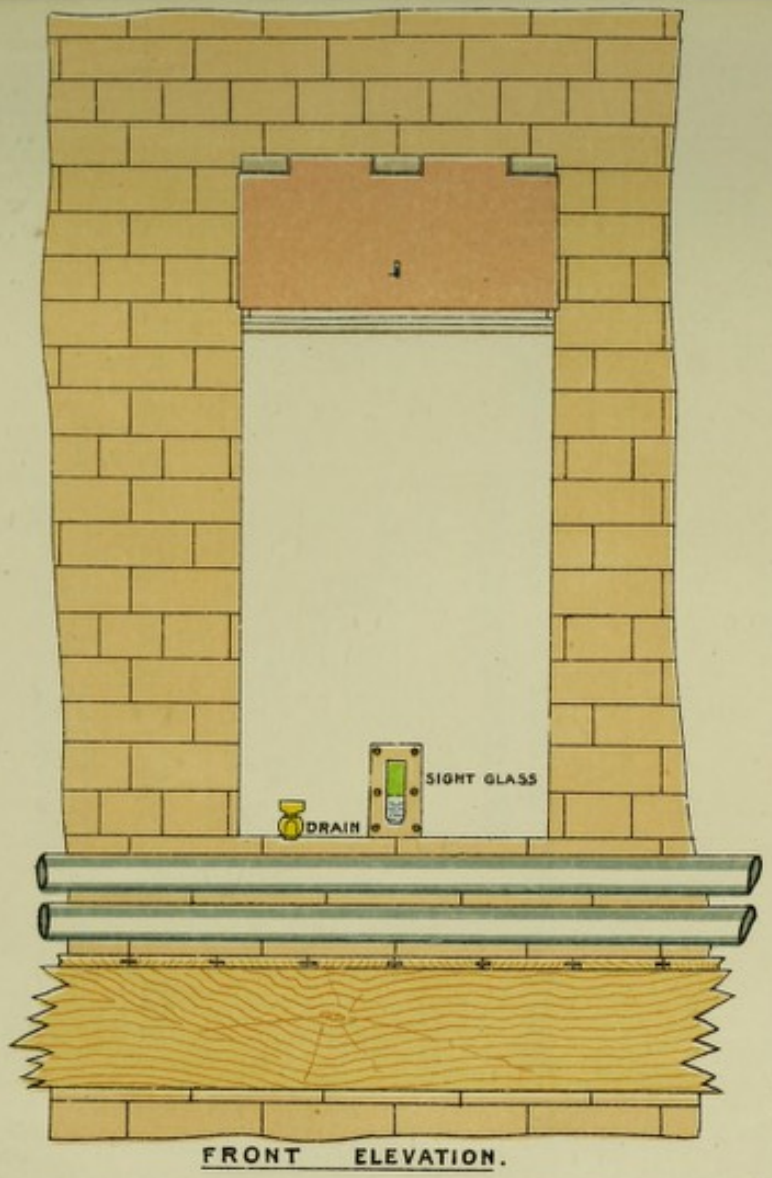
Archibald Newlands,
Glasgow, Aug, 98.

Wyman & Sons Ltd. Lith. 3280 - 1 - 99

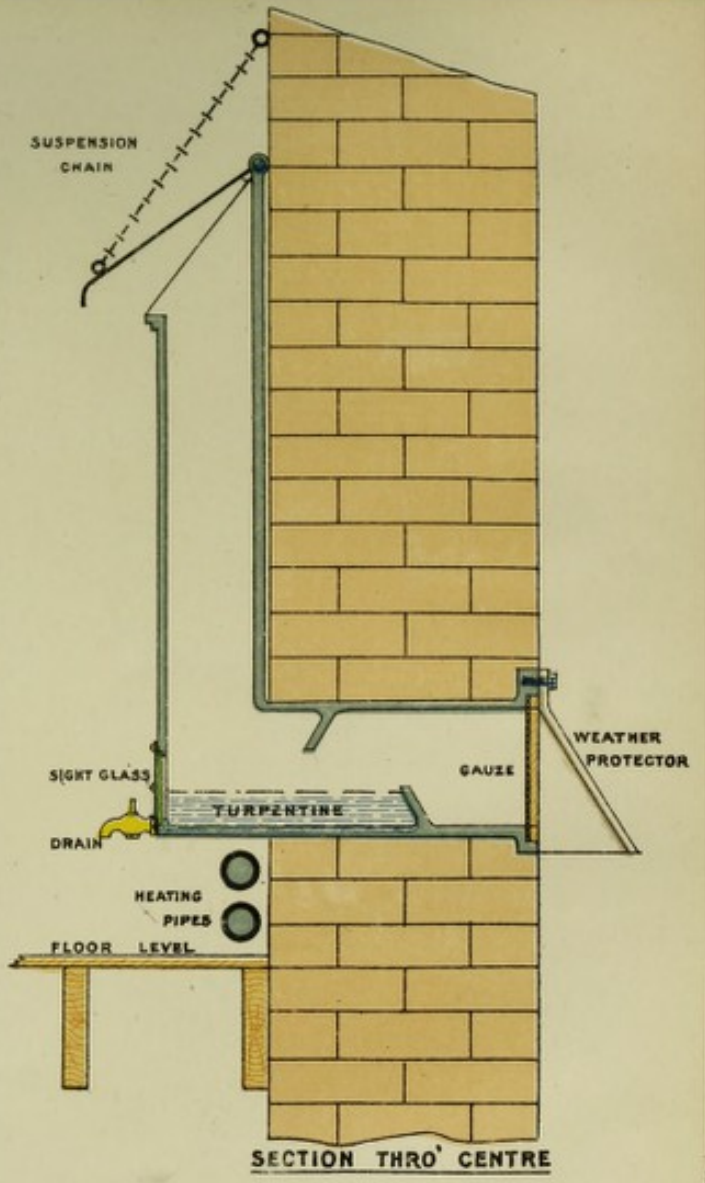




END ELEVATION.



FRONT ELEVATION.



SECTION THRO' CENTRE

NEW ARRANGEMENT FOR INLETS OF AIR.

Archibald Newlands,
Glasgow, Aug, '98.

SCALE 1 INCH = 1 FOOT

Wyman & Sons, Ltd. Lith. 3280 . 1 . 99

REPORT

TO THE SECRETARY OF STATE FOR THE HOME DEPARTMENT

ON THE

USE OF PHOSPHORUS IN THE MANUFACTURE OF LUCIFER MATCHES;

BY

THOMAS OLIVER, M.D., F.R.C.P.,

PHYSICIAN TO THE ROYAL INFIRMARY,
NEWCASTLE-UPON-TYNE.

TO THE RIGHT HONOURABLE SIR MATTHEW WHITE RIDLEY, BART.,
HOME SECRETARY.

7, Ellison Place, Newcastle-on-Tyne,
16th January 1899.

SIR,

I HAVE the honour to transmit to you my Report upon Lucifer Matches, the Dangers Incidental to the Health of Workpeople employed in their Manufacture, and the Medical Aspects of the subject generally.

To the Government officials of the various countries that I visited, the Foreign Office for papers received, and to Dr. T. Morrison Legge, Her Majesty's Medical Inspector of Factories, for translations of several reports, I acknowledge my sense of indebtedness, and beg to return my thanks.

I have the honour to remain,
Sir,
Your obedient Servant,

THOMAS OLIVER.

REPORT.

To the Secretary of State for the Home Department on the use of White and Yellow Phosphorus.

It is only within the last few years that public attention in this country has been to any great extent directed to the dangers incidental to health in lucifer match-making. The terms "phosphorus necrosis" and "phossy jaw" have come to be associated, not only in the medical, but also in the public mind, with workers in this particular industry. The prefix phosphorus of itself suggests that in some way or other it is responsible for the malady in question. Although discovered as far back as 1669 by Brandt, it was not until the thirties of this century that phosphorus came to be employed in the manufacture of matches. Oldbury, near Birmingham, is the principal seat of the manufacture of phosphorus, for although this substance is also manufactured at Lyons and in Germany, the Worcestershire town produces the largest amount, and supplies not only the British, but several of the Continental, markets.

Two kinds of phosphorus are employed in making lucifer matches—(*a*) the yellow or white, the fumes from which are known to be dangerous, and (*b*) the red, or amorphous, used in the production of safety matches, and generally regarded as in no way detrimental to health. In the manufacture of yellow phosphorus only very few men are required, and it is interesting to know that the men who follow this avocation run, comparatively speaking, little risk to health. All through the years that the manufacture has been carried on the industry has been remarkably free from danger, there having been recorded only two or three cases of serious injury to the health of workmen so employed.

For the first account of phosphorus necrosis or disease of the jaw bone arising in workers in match factories we are indebted to Lorinser of Vienna, who, in 1845, or about 11 years after the establishment of the match industry in Austria, drew the attention of the medical profession to the occurrence of disease of the jaw, arising in matchmakers. Between 1839 and 1845 he had seen nine cases of phosphorus necrosis. In 1847 Dr. Wilks (now Sir Samuel Wilks, Bart., President of the College of Physicians), then holding an appointment in Guy's Hospital, similar to the present Surgical Registrarship, reported upon the occurrence of disease of the lower jaw in a matchmaker, which was attended by suppuration and followed by exfoliation of the bone, remarking at the same time that this disease had previously been noticed to be not uncommon in those working in phosphorus. This carries us back to a period 50 years ago.

Since then the malady has from time to time received literary treatment in this country at the hands of Drs. Bristowe, Salter, Harrison, and others.

No country in which the manufacture of matches is carried on to any great extent has been free from phosphorus necrosis. Our neighbours on the Continent have suffered as much as, if not more than, we have. In France the excessive amount of sickness among matchmakers was very largely the reason why the Government took over match-making into its own hands and made the industry a monopoly. Within the last year France has proceeded to manufacture matches without white phosphorus. The wisdom and the utility of this step can only be settled after a sufficiently lengthened lapse of time, for as the matches are made from sesquisulphide of phosphorus, which is said to be rather an unstable body, time will be required to test their keeping powers with retention of their combustible properties. In Belgium match-making was found to be attended by such injury to health that measures have been repeatedly adopted with the object of diminishing the dangers of the industry, the latest step on the part of the Government being

the offer of 2,000*l.* to the inventor of a "strike anywhere" match free from white phosphorus and unattended with risk to the health of operatives in its manufacture. The Government of Switzerland has been much exercised as to whether it should not, so far as match-making is concerned, follow upon lines similar to France. Twenty-one years ago (1876) Denmark not only prohibited the manufacture, but the importation into the country, of matches made with white phosphorus. In Sweden the dangers incidental to the use of phosphorus lately received the careful consideration of Parliament, but it is interesting to know that this was not on account of any large amount of ill-health on the part of the workers in match factories so much as in consequence of the large number of cases of acute phosphorus poisoning that occurred in the country, 62 in one year, and due to the taking of phosphorus by women with the view of producing abortion. It was felt necessary to pass stringent rules in regard to the sale of phosphorus. In Great Britain phosphorus poisoning during the ten years ending 1892 caused 55 deaths by accident or negligence, viz., 22 males and 33 females, and suicidally 92 deaths, viz., 28 males and 44 females. In England and Wales the number of deaths attributed to poisoning, homicidal and accidental, by phosphorus during the first five years of the present decade is as follows: for 1891, 19; for 1892, 11; for 1893, 12; 1894, 14; and for 1895, 11; or a total of 67 in five years. In our own country phosphorus is resorted to as a means of suicide, and also for inducing abortion, but if it were only more widely known among the lower classes how very painful is the illness which it causes, it would not be so rashly taken for either purpose. Phosphorus poisoning may be acute or chronic. It is not so much, however, as a cause of death by poisoning in this country generally, as of ill-health or of death slowly supervening in matchmakers, that I am dealing with phosphorus in this report. It is estimated that in Great Britain and Ireland about 4,500 people are employed in making matches, and of these 1,908 are engaged in the phosphorus or dangerous processes. From 1893 until the end of June 1898 there were known to have occurred at least 31 cases of necrosis, and since that date other 6 have been reported to the Home Office in July and August, making up till the end of last December 37 cases in six years. The largest number of these has occurred, as might reasonably be expected, in London, for the metropolis is the largest producer of lucifer matches, although Gloucester, Liverpool, Belfast, and Glasgow have contributed their share of necrosis.

As to the relation between the inhalation of the fumes of phosphorus in the manufacture of matches, and necrosis or disease of the jaw bone, there is now no longer any doubt. The freedom of workers in all other industries from bone disease, with the exception, perhaps, of arsenic makers, and the occurrence of necrosis in those who are engaged in the manufacture of matches made *only* from yellow phosphorus, and in these again *only* in those who are employed in processes where fumes are given off, viz., the mixing, dipping, drying, and boxing departments, also the fact that the disease in question was not known to have existed until match-making became a large industry, employing scores or hundreds of people in a particular factory, leave in our mind no doubt whatever as to the association of jaw bone disease and lucifer match-making. Statistics, too, show that the amount of ill-health among operatives is proportional to the absence of ventilation, or to the want of means for the removal of the phosphorus fumes. Under these circumstances it might naturally be thought that the larger the per-centage of phosphorus in the paste for heading the matches, the greater would be the risk to health, but on this point it is only right to add there is a difference of opinion, although the medical testimony, particularly in Belgium, rathers favours the association.

FORMS OF POISONING, AND MODE OF ENTRY OF PHOSPHORUS INTO THE SYSTEM.

Dr. Garman, who has had considerable experience of phosphorus necrosis during the 20 years he has acted as medical officer to Messrs. Bryant and May, informs me that he has never known a case of acute phosphorus poisoning occur in a matchmaker. That too is my experience. It is the chronic form of poisoning that develops, and of the chronic form that in

which the effect of the poison is located in the jaw bone, giving rise to phosphorus necrosis, or what is more vulgarly called "phossy jaw." The late Dr. Magitot, of Paris, and Dr. Arnaud, who at present is in medical charge of the match works in Marseilles, both of whom, therefore, have had considerable experience of disease arising in match makers, have drawn attention to a peculiar constitutional state arising in these operatives, and to which they apply the term *phosphorisme*. In France, as far back as 1840, the graver accidents dependent upon working in lucifer match factories had attracted medical attention. It was only natural that the severer forms of disease, *e.g.*, necrosis of the maxillary bones, should throw into obscurity the minor. The general health of the French match maker appeared also to suffer. In 1856 a Committee of Hygiene inquired into this subject, and Professor Tardieu, the distinguished medical jurist, on behalf of his colleagues, reported that many of the operatives had complained of loss of appetite, and had suffered from deranged digestion and muscular pains, especially the females.

In the hospitals in Paris at this particular period many of the patients who were suffering from pulmonary consumption were found to be match makers. Magitot had shown that, in consequence of breathing the irritating fumes arising from handling the matches, and the frequent fires arising during the boxing of the same, several of the workers suffered from bronchitis.

It was he who drew the attention of the medical profession to the ease with which, in the absence of any recognised cause such as an injury, the long bones of match makers became easily broken. Since 1890, the date upon which the French Government took over the match factories in Marseilles, Dr. Arnaud has had medical charge of the workers. About one-half of the operatives, he says, are anæmic, especially young females from 18 years upwards, also that 28 per cent. of all the hands suffer from bronchitis. He is strongly of opinion, however, that work in a match factory *per se* in no way predisposes to tubercular disease of the lungs. Dyspepsia is a common complaint. In a very large number of the operatives he finds albuminuria, but he admits that this seldom proceeds to Bright's disease of the kidneys.

Fifty years ago it was the current opinion that pregnant female match makers were extremely prone to miscarry, an accident which was assigned to the nature of their employment. Arnaud has given this part of the subject his careful attention, and, as the result of his experience, extending over several years, he maintains that there is not the slightest evidence to show that female match makers abort more frequently than their sisters engaged in other industries.

He draws attention to one very important fact, that is, that match makers may still develop symptoms of bone disease as late as two years after leaving their employment.

In our own country we do not meet to any extent, if at all, with this particular form of constitutional phosphorus poisoning that I have just described. Match makers, if healthy to start with, and well fed, remain on the whole a healthy class, although, in some instances, it would appear as if lengthened exposure in the dangerous departments, quite apart from the risk of developing necrosis, did predispose to illness by a gradual deterioration of health and reduction of vital resistance. Girls born and bred in the slums of our large cities, reared upon improper and insufficient food, anæmic, undergrown, and ill-clad, do not form a desirable class from which workers for such a dangerous industry should be drawn, and yet, unfortunately, it is too often such that one sees in large numbers in the boxing and other departments of match factories. The dread of the match maker and of the employer alike is the occurrence of the affection of the jaw bone known as phosphorus necrosis. The fact that the disease is confined to the jaw bones is at once suggestive of the manner in which the illness is caused. In a word, it is by the fumes which arise from the phosphorus finding their way through a decayed tooth to its pulp, and setting up an inflammation of the covering of the bone, or periostitis, followed by an abscess.

Experience has shown that people with sound healthy teeth can be exposed to these fumes, and no harm arises unless the constitution is by nature scrofulous or tubercular, or has become enfeebled through the intemperate use of alcohol. Experiments upon animals support this opinion. In animals it is not until teeth have been extracted, thereby exposing a raw surface, or a

compound fracture of the jaw bone has been caused, that inhalation of phosphorus fumes is followed by a localised inflammation and subsequent necrosis, or death of the bone. As to what that something in the fumes is that causes necrosis opinion until recently has been, and is still, divided, but present chemical and medical opinion rather leans to the view that it is not *phosphorus* as *phosphorus* that causes the disease, but some of its lower oxides, either alone or combined. Phosphorus at once becomes oxidised the moment it is exposed to the air. Ozone is invariably present. The fumes which are observed rising from phosphorus alone, or from phosphorus paste, and likewise the glow that is seen, are caused by the presence of one of the lower oxides of phosphorus or of phosphorus in the act of oxidising, and it is this which has been regarded as the source of danger.

It is sufficient here to state that *phosphorous oxide, i.e.*, the product formed by the oxidation of phosphorus, rapidly passes into a higher form of oxide, the *phosphoric*, which is not considered dangerous. In the presence of moisture this phosphoric oxide becomes converted into phosphoric acid. In match factories there is proportionally a greater amount of necrosis in dippers than in box-fillers, owing to the fact that the fumes from the paste spread on the dipping table are in a fresher condition, that is to say, they exist in the form of the lower oxide first mentioned. It is known that an incompletely oxidised or only partially saturated compound is almost invariably more active and potent in its chemical effects and action than a completely oxidised or fully saturated body. In the boxing room of a match factory there frequently occur fires. The smoke that arises is thick; the fumes are penetrating and doubtless irritating to the lining membrane of the respiratory passages of those who breathe them. They are, however, much less dangerous than the fumes from a dipping table, owing to the phosphorus being present mostly in the form of the higher oxide. I have, for example, submitted a rabbit to the influence of clouds of smoke and fume arising two or three times a day from the burning of several boxes of ordinary matches, and although this has gone on for months the animal remains just as healthy as before the experiment was commenced. Recognising the fact that women do suffer from phosphorus necrosis who have never done anything in the factory but fill boxes with matches, it is clear that in the fumes which are given off from the silent matches the phosphorus must be present in the form of the lower oxide. It is when phosphorus exists in this form that it gives rise to its characteristic garlic odour, and one has only to smell the hands of a girl filling match boxes to feel how intense may be this odour. Hence the necessity for washing the hands well before eating.

In stating the subject of phosphorus necrosis thus it would appear as if "phossy jaw" was simply and purely the result of the chemical effects of the lower oxide of phosphorus upon the jaw bone of a match maker, the fume having found its way thereto through a decayed tooth. It is more than likely that other factors are in operation. In examining microscopically and bacteriologically pus taken from an abscess at the root of a tooth of a match maker suffering from commencing necrosis, and sent to me by Dr. Garman, I find evidence of the presence of numerous micro-organisms, *e.g.*, putrefactive bacteria, streptococci, and staphylococci pyogenes. No tubercle bacilli were found, though carefully searched for. How far these microbes are to be regarded as accidental, or as playing an essential part in the production of phosphorus necrosis, has not yet been determined. The mouth, under any circumstances, swarms with micro-organisms. Since Professor Stockman, of Glasgow, found in the pus obtained from necrotising match makers' jaws tubercle bacilli, along with the other microbes I have mentioned, he is disposed to regard the death of the bone as due to the action of the tubercle bacilli. I am not prepared to say that the morbid process may not be tubercular, but the mode of onset of the illness, and the severity of the local symptoms in the early stage, are rather against the theory elaborated by Dr. Stockman. It is more than probable that, as the result of working in the dangerous departments of a match factory, the vital resistance of the individual is reduced, and that micro-organisms gaining access through a carious tooth to the jaw bone induce those changes which end in necrosis. But with such a powerful irritant as phosphorus, the smallest speck of which is sufficient, if swallowed, to cause extremely severe local inflammation of the lining membrane of the stomach, with necrosis of the same, I am at this stage of the

inquiry not prepared to entirely ignore the direct chemical or irritating influence exerted by the fumes of phosphorus. These may cause a localised diminished resistance of the jaw bone, and thus prepare the soil for the operation of one or several forms of micro-organisms. This, however, is a part of the inquiry which I have not yet completed.* Research is being continued.

How long it takes for a match maker, be he dipper or box filler, to be brought under the influence of phosphorus while following his employment it is impossible to say. Match making was an industry in Vienna for seven or eight years before necrosis of the jaw was recognised as one of its consequences. The opinion is entertained that it requires several years' exposure to the fumes before the constitutional resistance becomes lowered, and for local symptoms to arise. In some of the match factories that I visited I certainly found that the victims of necrosis had worked many years, 7, 10, 12, or 15, before suffering, and yet in other instances in London, Glasgow, and Marseilles the illness developed within two or three years after entering the works. Phossy jaw is known to have arisen within a twelve-month. It is only within the last few years that statistics of phosphorus necrosis have been kept in this country. Dr. Garman, of Bow Road, has a record of all the cases of this disease that have occurred in Bryant and May's works during the last 20 years. This register I have had the opportunity of consulting. During this period there have occurred in Bryant and May's 51 cases of phosphorus necrosis, 31 females and 20 males; 22 major cases and 9 minor among women; 17 major and 3 minor among men. The upper jaw was affected 15 times, and the lower 16 times in the women, while in men the numbers corresponding were 11 and 9. The major type of necrosis formed 70 per cent. of the illness among females, and 85 per cent. among males; the men being dippers, have been more exposed to the purer fumes of phosphorus. Of these 51 cases of phosphorus necrosis, 9 ended fatally; in other words, 83 per cent. recovered and were able to return to work. The ages at which death occurred in the 9 fatal cases shows that it is not necessary to have a lengthened exposure in order that the fumes may cause a fatal illness. Dr. Garman's patients were aged respectively 19, 23, 21, 27, 22, 27, 19, 22, and 22 years. The patients did not all die from uncomplicated necrosis and its consequences, inflammation of the membranes of the brain, or disease of the kidneys. Two at least died from a co-existing consumption. One of these died at the age of 21, was ill for four years, and is said to have developed simultaneously signs of phthisis and necrosis. It is only right to remember that from the diseased jaw bone of the match worker there is continually passing off into the mouth a very offensive discharge, rich in microbes, the trickling of which into the respiratory passages would of itself tend to induce disease of the lungs, which may or may not become tubercular.

The fact that phosphorus necrosis is confined to the jaw is strongly suggestive, as already stated, of the phosphorus fumes acting locally. Lorinser, who first wrote upon this disease, believed that the blood of the worker was primarily surcharged by phosphorus, and that this had an affinity for the bony tissues, but at the same time he admitted that the fumes acted locally. It is the local action of the vapours that is now almost universally believed in. If there is no decayed tooth in the mouth of a match maker there is little or no risk of phosphorus necrosis. Dental caries is a pre-requisite. In his report to the Privy Council, the late Dr. Bristowe, of St. Thomas's Hospital, questioned this statement, basing his argument not so much upon any personal knowledge that he had of the pre-existing condition of the teeth of the workers as upon information supplied by the workpeople themselves, that their teeth had been previously good. The source from which he obtained his information can scarcely be regarded as absolutely reliable, for caries may proceed a certain length without attracting attention. I am not in a position to say what per-centage of the working classes between the ages of 15 and 40 years have good teeth, but presumably it must be small. The soft food that is eaten and the tea drinking that is indulged in would tend rather to make the teeth bad than to keep them sound.

* Since writing the above other tubes containing pus that had escaped from the necrotising jaw bones of four match makers have been examined bacteriologically. In not one of them were any tubercle bacilli found, although every means was adopted to detect them. There were, however, putrefactive bacilli, streptococci, and staphylococci.

On my visit to Bryant and May's I had the opportunity of inspecting the dental department recently established in the factory, of seeing some of the workpeople have their teeth stopped, and of discussing this subject with Mr. C. Laurence Gill, the qualified dentist in charge. In a letter subsequently received from him, he says, "I find on the female side of Messrs. Bryant and "May's works the worst teeth prevail amongst the older hands, and that there "is also an intense desire to smother any existence of toothache symptoms. "No doubt this arises from fear of having them removed. In fact, in some "mouths the teeth are almost all unsound. This is unfortunately the condi- "tion of vast numbers of the East End women of the lower classes. I do "not think that the Bryant and May women have worse teeth than women "employed in other trades, but certainly they are much more trouble to remove "after a few years amongst the phosphorus. Perhaps one might find 5 per "cent. of sound mouths, but not more, certainly." Mr. Gill is of opinion that there is never phosphorus necrosis without there having being a previously exposed nerve in a decayed tooth; also that in people in whom there are no decayed teeth a lengthened contact with the phosphorus fumes induces an adhesive inflammation around the root of the tooth, whereby this becomes firmly incorporated with the bone, rendering the tooth as he has said, extremely difficult of extraction. It is the recognition of the dependence of phosphorus necrosis upon pre-existing decay of the teeth, that is the reason why Messrs. Bryant and May, also the Diamond Match Company at Litherland, Liverpool, have established in their factory a dental department where all the workers can be treated free of charge, and in this matter, they are the pioneers of what ought to be a boon to the match maker. By the systematic oral examination of the workers by the dentist, not only will dental caries be detected and treated, but the early detection of the caries and notification of the fact to the managers will result in the removal of the individual to a healthier department of the factory, or to temporary suspension, and thus phosphorus necrosis will be largely prevented.

England is the first to have taken this important preventive step. It is to be hoped that other employers will follow Messrs. Bryant and May's and the Diamond Company's example. In the Belgian match works an inspection of the teeth forms an essential part of the doctors' visits, but it is neither systematic nor thorough. There may be a racial element in this question of early decay of the teeth. The teeth of townspeople for example are not so durable as those of people living in the country. Food has something to do with this, and probably the air we breathe. It is believed, for example, that there are certain populations living along the shores of the Mediterranean whose teeth decay with great rapidity and at an early age. These are regarded in France as bad subjects for working in a match factory. This circumstance, the other facts already alluded to, and the knowledge that bad teeth run in families are points not above being borne in mind when employers are taking on fresh hands for the first time into a match factory.

Since writing the above, and almost at the last moment of sending in my Report, I have received a note from Messrs. Bryant and May bringing this question up to 31st December 1898. I am informed that the firm has passed through the dental surgery 451 of the workpeople, of whom the larger half were men and boys. Of this number a great many were only examined, but 104 had been treated and subsequently certified as having sound mouths; 120 of the 451 examined had already left the works, some before treatment, some after partial, and several after complete, treatment. At the present time it appears there is a difficulty with the women. They will not submit to the extraction of their teeth when, in the dentist's opinion, this has been considered necessary. Meanwhile the filling of carious teeth is being proceeded with. The Managing Director of Messrs. Bryant and May's says that he hopes that the attitude assumed by the women is temporary, for since it has become known outside that the workers are expected to pass through a dental examination, this circumstance has deterred women from offering themselves, and it has been found difficult to obtain their required number of workpeople. I can only express the hope that workpeople who are taking up match-making as an employment for a shorter or longer period will recognise that the dental examination is for their good, and that they are better to be told that they are disqualified for the work at an early stage than when too late.

In my Report* upon the Belgian match works I allude to the fact that, in Grammont, which is one of the principal seats of the match industry of the country, Dr. Brocoorens met with and treated in 25 years 30 *cases of spontaneous fracture of the long bones*, caused by muscular effort, affecting exclusively the lower limbs of workmen who had been employed for years in the dangerous departments, and who had also suffered from necrosis of the jaw.

This number, 30, is too large for the circumstance to be simply a coincidence. It points, therefore, to some peculiar effect of phosphorus and its compounds upon osseous tissues other than the maxilla, whereby the bones become extremely fragile.

This accident is not unknown in our own country. Dr. Garman, of Bow Road, informs me that he knows of nine cases in which the long bones of the arm or the leg became broken in match makers.

There is no question as to phosphorus necrosis being in the early stages of its development an extremely painful affection. For the first few days during which the inflammation has attacked the covering of the jaw bone and induced periostitis, and when an abscess or a collection of pus is forming under this membrane, the pain is excruciating, but once the pus has found a vent by surgical incision or otherwise the suffering greatly abates. Too often, unfortunately, this is only the early stage of what becomes a lingering local affection. Pus keeps oozing out around the exposed fang of a tooth, and this tooth is perhaps extracted. For months or years there goes on a slow but gradually progressive death of the bone until a dead portion or sequestrun of the jaw bone is expelled, or the patient, in order to facilitate matters, submits to a surgical operation. As regards "phossy jaw" neither sex is spared, nor is there any difference in the severity or location of the malady. Men who dip, girls who cut down and those who fill the boxes suffer all alike, and equally, once the disease has obtained a hold.

All of them do not daily run the same risk, but once phosphorus necrosis commences, male and female workers alike may loose a portion of their upper or lower jaw and recover, and after a term of months or years may return to their employment with, in some instances much, in others comparatively speaking, very little disfigurement to the face; or death terminates a lingering illness, the fatal event being induced either by a purulent inflammation of the membranes of the brain, pyaemic inflammation of the lungs, tubercular consumption, or lardaceous disease of the kidneys. Still, the fact remains that 83 per cent. of the patients recover.

STATISTICS OF PHOSPHORUS NECROSIS IN CONTINENTAL COUNTRIES, AND THE ATTITUDE OF EACH STATE IN REGARD THERETO.

Switzerland began to legislate upon the subject of phosphorus poisoning in March 1876, the attention of the Federal Assembly having been directed to the injurious effects of phosphorus on the health of the workers by the Medical Society of Berne. Two years later the Factory Inspectors having reported that the use of yellow phosphorus should be prohibited, the Federal Assembly passed a Bill in May 1879 prohibiting the manufacture, importation, and sale of matches in which yellow phosphorus was used, the law to come into force in 1881. Shortly after the Bill became law, many were the complaints heard as to the bad quality of the matches made under its terms; besides, it soon became known that the manufacture of matches with yellow phosphorus was being carried on clandestinely under conditions even more injurious to the workers. It was recognised that the law had failed. The Federal Chamber therefore repealed that part of the Act that dealt with the prohibition of yellow phosphorus, but issued regulations with the view of preventing necrosis. So little attended to were these regulations that in October 1886 the Factory Inspectors again recommended that the interdiction of the use of yellow phosphorus by the law of 1879 should be reimposed. Failing that they suggested that the *manufacture of matches with yellow phosphorus should become a monopoly of the State as the only means promising a reduction in the number of cases of necrosis and a chance of pecuniary compensation to those attacked.* Information, however, was first asked from the Inspectors as to (1) the extent to which matches were used in Switzerland:

* *See* Appendix, page 106.

(*a*) made with yellow phosphorus and (*b*) without it; (2) the number of factories required to furnish the necessary supply of matches; (3) the amount of compensation necessary to pay the owners of existing factories.

To these questions the following answers were returned :—(1) 122,879 large boxes each containing 50,000 matches; of this number 101,984 were made with yellow phosphorus and 20,895 of red phosphorus. (2) three or four large factories. (3) 1,021,462 francs (400,858*l.*).

In March 1895 a Bill was introduced with the object of allowing the State to secure the monopoly of the manufacture of matches, but in September it was rejected by a popular referendum on account of its centralising tendency. A Bill is now before the Federal Council, the principal terms of which are the reimposition of the prohibitory clauses as regards the manufacture, importation, and sale of matches and vestas made with yellow phosphorus; no manufacture of matches to be undertaken without the authority of the Government of the Canton, permission to the Canton itself having been previously obtained from the Federal Council, which will also state the conditions necessary for the health and safety of the workers and of the public, the Federal Council in addition undertaking to obtain and communicate to employers new processes of manufacture presenting the least danger to the health of the workpeople.

Number of Cases of Phosphorus Necrosis.—The statistics in regard to this are not complete. In the Valley of Frutigen there are nine match factories. Between the year 1880–89 there were 20 cases of necrosis in these works; the illness was distributed equally between the sexes. In the Berne district, 1884–96, there were 10 cases of phosphorus necrosis reported to the factory inspectors.

Dr. Kocher, Professor of Surgery, Berne, in a report to the Department of Industry and Agriculture, deals with 55 cases of phosphorus necrosis that occurred in Switzerland. The cases were limited principally to the Frutigan Valley, in the Canton of Berne, in which match factories have existed since 1840, and have continued to produce lucifers from then till now, with the exception of two years, viz., January 1st, 1881, to the end of December 1882, during which the manufacture was prohibited.

During these two years the works were closed the people themselves made matches clandestinely. Lucifer match making is not an industry that can be carried on in the homes of the people without the greatest risk to health. Wherever it has been attempted it has ended in producing some of the severest forms of necrosis.

The Swiss Government does not believe that its nationality has been severely scourged with phosphorus necrosis, but we should remember that in Switzerland the manufacture of matches is comparatively speaking a small industry; it only produces for home consumption and not for exportation. There are only 300 match makers in Switzerland altogether, and as 5 to 10 cases of phosphorus necrosis are known to occur every year, this makes it 1·6 to 3 per cent. annually. In Britain it is probably not more than 1 per cent. Dr. Kocher's 55 cases extended over a period of 25 years. His observations are interesting from a medical point of view, *e.g.*, he never found necrosis of bone apart from that occurring in the jaw, and yet, as showing how phosphorus induces fragility of the bones, he mentions the case of a match maker under his care who broke the long bone of his thigh five times. Kocher believes that phthisis and disordered digestion are likely to arise in the course of phosphorus necrosis owing to the swallowing of pus. Nine out of his 55 cases terminated fatally, or in other words 83·7 per cent. recovered, an interesting fact compared with Dr. Garman's 83 per cent. of recoveries at Bryant and May's.

Denmark.—In 1875 a Bill was introduced and passed, whereby since 1876 the use of yellow phosphorus in the country has been prohibited; only safety matches are allowed to be made. It may be interesting to state here why the Danish Government took this important step. The reasons assigned are (1) the dangers to the health of the workers, (2) the danger from fires in houses and buildings, (3) the fact that a ready means of poisoning was placed in the hands of the people. It appears that at that period (1875) a large number of children and young persons were employed in match making, and although regulations had been framed for such they proved ineffective. The

Ministry of Justice, therefore, made a searching inquiry into the subject. It had been struck, for example, by this peculiar fact, that in one place, in Frederiksburg especially, cases of phosphorus necrosis had occurred out of all proportion to those in other factories, a circumstance which was subsequently attributed to the larger amount of phosphorus used in the paste here than elsewhere. In the seven factories in Denmark where yellow phosphorus was used there were employed 76 adults and 180 children. At the hospitals of Frederiksburg and Copenhagen during the previous five years 11 patients had been treated for phosphorus poisoning; nine of these came from the factory in Frederiksburg, of whom two died; four were operated upon, and three recovered. Other cases of phosphorus necrosis were subsequently brought to light.

A committee of the Polytechnic School was appointed by the Ministry of Justice to inquire into the conditions of labour in the Frederiskburg Factory in which were employed 83 out of the total 256 engaged in the match industry. This committee reported that it was not necessary to prohibit entirely the manufacture of phosphorus matches, for by stringent regulations the employment could be made safe. It recommended, for example, a reduction of the phosphorus in the paste to 10 per cent.; better ventilation of the dipping tables, and these to be surrounded by turpentine; all through the factory better ventilation and repeated medical inspection. Subsequently this subject was dealt with by the Royal College of Health whose opinion was that, as no regulations had ever sufficed to prevent the dangers to health from the manufacture of matches with yellow phosphorus, and in view of the recklessness of the children and adults employed its use should be prohibited. The Government recognised the difficulty in which it was placed by these conflicting recommendations, but it at once saw that if it prohibited the use of white phosphorus employers would simply have to resort to the manufacture of safety matches in the factories they occupied. The Government drew attention to the following facts, viz.: that of 5,041 fires during the years from 1862 to 1872 no less than 291 were due to phosphorus matches; of these 198 were caused by children under 10 years of age; also that as regards the 32 cases of poisoning that had occurred in Denmark between the years 1857–72, of these 18 were due to the use of phosphorus matches. In view of the fact that matches made with red or amorphous phosphorus are entirely without danger to the workers, are not poisonous and are less likely to cause fire than ordinary matches, the Ministry of Justice thought the simplest measure to adopt was the entire prohibition of the manufacture of matches made with yellow phosphorus.

Sweden is one of the largest producers of matches and has some of the best factories for the manufacture of "safeties" and ordinary lucifers. In 1870 Sweden began to legislate for ordinary phosphorus matches. The Government entrusts the manufacture of these to such persons as possess a certificate from a University, Medico-chemical, and Pharmaceutical Institute, or a Higher Technical School, showing that they are quite familiar with the processes of manufacture and dangers of the industry. Although not strictly enforced it is one of the provisions of the regulations that no person shall work in the mixing or dipping room longer than six months without a break of two months. Gargles of permanganate of potash are provided for, and are used by the workmen, and in some of the factories the floors are sprinkled with turpentine. In the south of Sweden there are 10 factories which use yellow phosphorus, and in 1891 there were 6 cases of necrosis (0·56 per cent. of the number employed), but as there is no compulsory notification of this illness it is more than likely that the number stated is less than it should be. It is the opinion of most of the Swedish employers that were the use of yellow phosphorus prohibited it would spell ruin to the match-making industry in their country. In all the Swedish match factories where yellow phosphorus is used there occurred in two years, 1890–91, 19 cases of necrosis. One of the cases is interesting from the fact that the symptoms did not develop until two years after leaving the factory.

Germany.—Dr. J. Kuipers, in a paper on *phosphorus necrosis*, gives an analysis of 18 cases treated at the Jena Hospital between 1890 and 1895. Regulations were framed by the Government in 1884 which dealt with the subject of phosphorus necrosis, but in spite of the regulations it would

appear that the illness occupies an important place in the returns "diseases of occupations" in the Thuringian district. In the 33 years, between 1857 and 1890, there were 56 cases of phosphorus necrosis, or 1·7 per cent. annually, and in the five years, 1890 to 1895, there were 18 cases or 3·6 per cent. annually.

It was in the years between 1830–40 that phosphorus matches were for the first time made in Germany. At this period similar factories were established in Vienna, Nuremburg, and Paris. Kuipers holds, and is therefore of the opinion which I have stated in an earlier part of this Report, that phosphorus necrosis is, in the first instance, a purely local affection, and that many of the other symptoms that arise are entirely secondary, and due to a general weakening of the system induced by the local affection. The disease can only arise through defective teeth or inflamed gums. In the hospital at Jena both sexes suffered equally. Billroth, a well-known German surgeon, is reported to have treated 23 cases of phosphorus necrosis; of these 7, or 30·5 per cent., related to the upper jaw, and 16, or 69·5 per cent., to the lower. Haëckel treated 46 cases at Jena, of which 33, or 58·9, were lower jaw, and 20, or 25·7 per cent, upper, there being 3, or 5·7 per cent., both upper and lower. In Kuipers' 18 cases the disease, in 10, or 59 per cent., involved the upper, and in 8, or 41 per cent., the lower jaw: in none of the patients did the illness prove fatal; 15, or 89 per cent., recovered, while 2, or 11 per cent., had relapses.

It is extremely difficult to estimate the extent to which phosphorus necrosis has occurred in *Germany*, but from the Reports of Factory Inspectors 1893–96, it would appear (1) that isolated cases had been reported to the Inspectors of Cologne, Brunswick, Lorraine, and Mittelfranken. One case of concealed necrosis had been found by the Inspector at Cassel. (2.) That at Pfungerstadt in Hesse, attempts have been made for years to replace yellow phosphorus by other chemical substances, and that this year manufacturers had succeeded in producing a strike-anywhere match free from yellow phosphorus.

There has been no fresh legislation for match factories in Germany since 1893. In the report for 1895 it is stated that the health conditions of the industry have much improved. One case of phosphorus necrosis had occurred in the district of Wurtemburg, one in Hanover through neglect of the Special Rules, and isolated cases in Cassel, Breslau, and Annaberg. One man had died in Schleswig under circumstances which showed that the medical inspection had been anything but thorough.

During 1894, 11 workpeople were affected with phosphorus necrosis, 5 in the district of Meiningen, 2 in Pfaly, and 1 each in Liegnitz, Schleswig, Hildesheim and Schwazburg-Sonderhausen. The five cases in Meiningen occurred in three factories; the majority of the workpeople had carious teeth. In one factory containing 30 workpeople, 23 had notoriously bad teeth. The case in Schwazburg-Sonderhausen was that of a woman, who, besides working in a match factory, carried on the manufacture at her own home. The Inspector adds that it is extremely difficult to suppress this kind of home industry. The people will not inform upon each other. In regard to the Cassel district, the Inspector states that the medical inspection of the workpeople and the removal of their carious teeth have already been followed by beneficial results. During 1893 only one case of phosphorus necrosis was reported as having occurred in Meiningen, but the manufacture of matches from yellow phosphorus was still being carried on as a home industry.

Belgium and France.—I have dealt with the Belgian match factories and phosphorus necrosis in a special report (see Appendix), that it is unnecessary to reproduce the question here. The same remark applies to *France*.

As regards *Holland*, Dr. Kuyper of Breda, one of the Government Inspectors, informs me that in his country there are only three match factories, two in Breda and one in Eindhoven. In one of the works in Breda only Swedish or safety matches are now made. The two other factories while making safeties also make matches from white phosphorus, the paste for which contains 3·5 to 5 per cent. of phosphorus. In Breda, in the dangerous processes about 90 hands altogether out of 120 are employed (men, women, and young persons) during the two to three days a week they work, and in Eindhoven there are 95 persons thus employed in the yellow phosphorus processes out of about 200 engaged in the factory. Before the year 1895

Dr. Kuyper tells me that phosphorus necrosis was unknown to him. It was concealed from him on purpose. A careful search, however, unearthed 10 cases of phosphorus necrosis as having occurred in Breda within the last eight years, the last case occurred in January, 1898. The disease is not unknown in Eindhoven, but steps have been taken to conceal the facts.

Austria.—Although efforts have repeatedly been made in Austria to prohibit the use of yellow phosphorus no definite result has yet been attained. Any recommendations hitherto advanced have not been considered practicable by the authorities who believe that the measures already in force for the protection of the workpeople are adequate if they are only attended to. These measures are embodied in a Government Ordinance of 17th January 1885 for "protecting as far as possible the workpeople employed in phosphorus match-"works from the injurious effects to health connected with their trade." Provision is made for thorough ventilation and cleansing of the rooms, for frequent change of employment of the workpeople who must report the earliest development of such symptoms as toothache, &c., the wearing of special clothing, provision of washing and gargling appliances. There is a medical examination of the workers when they first enter the factory, the doctor rejecting all scrofulous persons or those with decayed teeth. There are periodical medical inspections of the workers. A statement as to the conditions of health of each worker is kept in a register, and the doctor must report each case of phosphorus necrosis to the authorities. A Government Medical Inspector, over and above, visits from time to time match factories and has to satisfy himself that sanitary prescriptions are being followed.

Notwithstanding the stringency of the regulations, cases of phosphorus necrosis are said to be of "lamentable frequency in Austria," and that trustworthy statistics relative to this disease are extremely difficult to obtain. In many instances the workpeople evade the medical inspection, and employers are said to display a reluctance to imparting information fearing compulsory improvement of the workshops or more vigorous official intervention. Several of the factory inspectors complain of the obstacles placed in their way alike by employers and employed. Many cases of "phossy jaw," therefore, do not come within the cognisance of the Government.

During the past three years the following cases of phosphorus necrosis have been returned by the factory inspectors, but, although official, they are only approximate :—

——	1895.	1896.	1897.
Brunn district, cases	3	—	—
Budweis „ „	—	6	3
Gratz „ „	—	—	1
Koniggratz district, cases	1	—	—
Lemberg district, cases	3	30 (since 1888).	—
Lensz „ „	1	2	—
Olmütz „ „	—	2	—
Troppau „ „	—	12 (since 1887).	—
Wiener Neustadt district, cases	—	1	1

It is noteworthy that the cases of phosphorus necrosis that have become known to the inspectors have almost invariably occurred in small factories unprovided with modern machinery and appliances, or in factories where, despite all precautions, the workpeople have neglected the regulations. On the other hand, it is stated by the inspectors that "in factories arranged on "modern lines, and where the spirit as well as the letter of the regulations "is observed, cases of phosphorus necrosis are rarely recorded."

In *Austria-Hungary* the regulations for match factories are stringent enough, if they were only attended to. Provision is made for ventilation; the people employed must be healthy, change their particular work from time to time in the factory, and report the earliest symptoms of toothache, &c. Special clothes are provided by the employer for workers engaged in the mixing, dipping, and drying departments; also cloakrooms, washing

appliances, &c. Medical inspection is also paid for by the employer. The surgeon has to certify as to the health and fitness of each applicant for employment. Tubercular persons, or those with defective teeth, are disqualified. The doctor must keep a register, and satisfy himself that all precautionary measures have been adopted for the health of the workpeople; if there are any defects he must point them out and see that they are remedied. Every case of phosphorus necrosis must be reported by him to the employer, and the employer reports to the factory inspector. In addition, the sanitary arrangements of the match factories are periodically examined by the district Medical Officer of Health.

There is one very exemplary regulation in Austria-Hungarian match factories which might well be adopted by British employers. In the factories there are hung up on the walls not only the printed regulations, but a series of *Observations* which are meant to show the workpeople themselves the dangers of the trade they are following. They are told, for example, that phosphorus is dangerous to health, and may cause disease; that the symptoms of poisoning usually show themselvss at first as toothache, loosening of the teeth, aching jaw, and swelling of the gums, and the workers are advised for their own good, on the supervention of these symptoms, at once to see the factory doctor and to discontinue temporarily the employment. It would be well if similar observations were made to young hands entering a match factory in our own country for the first time, also if they were printed and hung up on the walls, and read to all the workers on several occasions during the year.

From the reports of the factory inspectors for the years 1895, 1896, and 1997, I find that Austria-Hungary is divided into 17 districts for factory inspection, and that each district is provided with two or more factory inspectors. The following are the number of cases of phosphorus necrosis mentioned in the inspectors reports since 1881, but they are not to be regarded as complete, since some inspectors use the words "several" or "numerous" in their reports, and of these no account has been taken :—

Between 1881–84	12 cases.	1891	3 cases.
1884	2 „	1892	2 „
1885	15 „	1893	5 „
1886	15 „	1894	5 „
1887	6 „	1895	7 „
1888	47 „	1896	5 „
1889	4 „	1897	10 „
1890	2 „		

In all 140 cases of phosphorus necrosis have come within the cognisance of the factory inspectors of Austria-Hungary since 1881. The large number of cases, 47 in 1888, is attributed by them to the fact that at that time the manufacture of matches with yellow phosphorus was extensively carried on as a home industry. This practice, it is stated, has now almost ceased.

The General Report for 1895 states "it must be acknowledged that the "orders of 1895 as regards the manufacture of matches with yellow "phosphorus are not strictly observed anywhere." In the report for 1896 regarding Galicia the Inspector says, "The workpeople in the 10 match "factories have to work under most insalubrious conditions owing to the "inefficient manner in which the Regulation of 1885 is carried out. Cases "of phosphorus necrosis are comparatively frequent. Since 1888 over 30 "cases have been treated surgically in the local hospitals. An exact "estimate of the numbers attacked cannot be given, as some people prefer "to be treated by private practitioners, and others in outside hospitals." One case of phosphorus necrosis in a dipper was notified to this Inspector in 1897, and attributed by him to the faulty condition of the factory, and non-compliance by the employer with the regulations.

In the Report upon Silesia 1896 the Inspector says: "Despite the efforts of "the Inspectors to enforce the strict carrying out of the Order of 1885 cases "of necrosis still occur. During the last nine years 12 cases, all from one "factory, have been treated in the hospitals of Cracow and Biala." In 1895 there were three cases (women), resulting in the death of one, and entire loss of the lower jaw in the other two.

In the district of Bohemia where the match industry is more extensive than in any other part of the kingdom no case of phosphorus necrosis was reported to the Inspector in 1895. He attributes this to the increased manufacture of safety matches, and to greater attention being paid to Regulations than was the case formerly. During 1896, however, five or six cases came within the Inspector's knowledge, and two or three in 1897.

In another district of Bohemia (district X) there are six match factories giving employment to 105 workpeople. The visiting surgeon states that he has not treated more than four cases of phosphorus necrosis in 24 years. Other medical men state that phosphorus necrosis would be an almost every day occurrence were it not for the immediate suspension of the workers on their showing the first symptoms of illness.

Russia.—The Ministry of Finance has striven as far as possible to limit in Russia the manufacture of phosphorus matches by imposing certain excise regulations. In 1888 an excise tax was placed upon matches. As at this period 85 per cent. of the factories were producing the cheaper matches made with white phosphorus, it was considered premature to restrict this industry and encourage the manufacture only of safeties. It was anticipated that the establishment of a tax, and of rules for concentrating the production of matches in properly organised factories under Government supervision, also a stipulation of the conditions under which the sale of matches was to be carried on, would result in a gradual attainment of the desired object, and indirectly effect the improvement and perfection in the methods of match production. It was also believed that there would follow a reduction in the number of white phosphorus match factories. In 1892 the question of limiting the number of match factories was again under the consideration of the Government, but it was recognised that of the total number of match factories then in existence only 82 produced safety matches whereas 246 manufactured ordinary matches, 107 milliards of ordinary matches being made annually as against 37·8 milliard pieces of safeties. To have prohibited all at once the manufacture of phosphorus matches would for the time being have prevented the factories satisfying the public demand, and would have increased the price of the matches, and on the other hand to have prohibited the construction of new factories for phosphorus matches as recommended by the Medical Council of the Ministry of the Interior would have given the old factories the monopoly and a privileged position. The Ministry of Finance therefore simply doubled the excise duty on phosphorus matches, and since effect was given to this law in November 1892 there has been a gradual increase in the number of safety match factories throughout the country, and a corresponding diminution in the number of factories making ordinary matches. In 1891 there were 189 factories making white phosphorus matches; in 1896 only 83; in 1891 there were 25 factories making safeties, in 1896 there were 39. In 1891 the number, in thousands, of white phosphorus matches made was 106,902,912, and of safeties 37,844,413, whereas in 1896 the numbers respectively were 46,369,330 and 120,520,610. Very little has been done in Russia by legislation for match works. No person under 15 years of age is allowed to work in the mixing, dipping, drying, and boxing departments of an ordinary match factory. In spite of measures introduced to protect the people against the injurious effects of phosphorus the workers do not seem to be safeguarded to any great extent. The officials of that department of the Ministry of Finance which is connected with trade and manufacture state that the only efficacious measures of protection for the workpeople lie in the total abolition of the use of white phosphorus. There are no Government match factories in Russia.

Italy.—The Italian Government has never framed any rules or regulations for the protection of workpeople engaged in the manufacture of matches made with yellow phosphorus.

What Provision is made for Necrosed Workpeople during their Illness.

In France since the match industry became a Government monopoly, the State naturally contributes to the maintenance of the workers who have been obliged to give up their employment on account of illness connected

with their trade, and in Belgium there exist insurance societies from which incapacitated workpeople draw an allowance. In our own country necrosed workpeople are not dealt with uniformly as witness examples taken from Scotland, the Midlands, and London. Last October in Glasgow I saw a young woman suffering from necrosis of the left lower jaw. She was 25 years of age, and had worked as a box filler for 12 years. Her wages had run on an average from 11*s.* to 12*s.* a week. When I saw her she had been off work for five months. During that period she had received 7*s.* a week, but although this was paid to her by the firm, it really came out of a fund to which every work man and woman in the factory contributed at the rate of 1*d.* per week. Medical advice was provided.

At the match factory of Messrs. Moreland & Co., Gloucester, when cases of necrosis occur, the firm gives half-pay during the time the illness lasts. After recovery the operative is put to work again in some part of the factory unconnected with phosphorus. A medical man is employed and paid for by the firm to whom all workers are sent on first complaining. The doctor certifies as to the fitness of the individual to return to work. In this factory there is no insurance fund for the workers thus incapacitated. At Bryant and May's, when a worker becomes the subject of phosphorus necrosis, he is sent to Dr. Garman who reports to the Company as to the fact, and advises what sum per week should be allowed. As a rule, the firm gives at first 15*s.* a week in the case of women, and 24*s.* in the case of men. The allowance to women is rather in excess of their earnings, while the amount given to men closely corresponds to what they have been making. As a rule, this allowance is increased as times goes on by 5*s.* for the women, making it 20*s.* a week, and the men receive an additional 4*s.* raising it to 29*s.* Some of the cases of phosphorus necrosis have been in Dr. Garman's hands for several years, as many as 14, and during that period the firm has continued the allowance and paid for medical services. When an operation has been performed an extra allowance has been given for the nursing, &c. There is no general insurance fund at Bryant and May's for the workpeople, either men or women, but there is a mutual insurance fund to which the men may belong, and which is controlled by the office staff. On the death of a worker the surviving members contribute each 1*s.*, and the amount thus raised is supplemented by a grant of half the total amount by the firm, the whole being handed over to the representatives of the deceased member. The treatment by British employers of matchworkers who suffer from phosphorus necrosis contrasts most favourably with that observed in some of the Continental countries where the industry is not a State monopoly. A few weeks ago, in a match factory in Silesia, I found a woman, aged 38, working in the safeties department, the whole of whose lower jaw had been removed for phosphorus necrosis. She had worked as a box-filler from 1887 to 1894 when she became ill, her wages are at present, and have never been higher than 7*s.* a week, the working hours are from 6 a.m. to 7 p.m., with two hours off for meals. She has never received from first to last the slightest compensation from her employer.

GENERAL REVIEW OF THE SUBJECT.

I have visited matchworks in England, Scotland, France, Belgium, Sweden, and Silesia, and have thus had numerous opportunities of discussing not only the subject of the manufacture of matches generally with employers and employed, but also of examining several of the workpeople who have suffered from phosphorus necrosis. The ill-health of the workpeople and the accidents that occur in this industry are circumstances that have from time to time attracted the attention of almost every European Government. Each country has tried to solve the problem in the manner that seemed most compatible with its own economic and industrial conditions. Denmark, for example, settled the question as far back as 1876 by totally prohibiting the manufacture and importation of matches made with white phosphorus. Russia has imposed a tax upon the manufacture of ordinary phosphorus matches. France has striven, and in her own belief successfully, to replace the ordinary white phosphorus match by one capable of striking anywhere yet free from white phosphorus. By these and other means, such for

example as better ventilation and improved methods of manufacture carried on under stringent regulations, most Governments have tried to deal with this important question. There is no doubt that so long as ordinary white phosphorus is used in matchworks, even with all known precautions, absolute freedom from risk cannot be guaranteed to the workers. Total prohibition of the use of white phosphorus is therefore the simplest and readiest way to obviate danger. Two or three countries have adopted this procedure with complete success, of course, so far as the health of the workers is concerned. To-day England is brought face to face with this question in such a manner as she has probably never been before, and how is she going to solve it? Is total prohibition called for in her case? is it the only or best solution of the problem, and is it possible to produce a "strike anywhere" match without white phosphorus?

The fact that workpeople in Continental countries have suffered from phosphorus necrosis even more than those in Britain, is a proof that no matter where match-making is carried on, under different climates, and varying hygienic and legislative conditions, it is an industry fraught with danger. Phosphorus necrosis occurs more frequently in small factories with defective plant and imperfect methods of production, or in old buildings that cannot be properly ventilated, and where the workpeople themselves are not cleanly. There is a very general opinion, both at home and abroad, that if the manufacture is carried on in modern and lofty buildings, with the newest methods, with machinery replacing hand labour wherever possible, with complete ventilation of the mixing, dipping, drying, and boxing rooms, personal cleanliness on the part of the workpeople, and repeated medical inspection, necrosis of the jaw is practically unknown. Whether an excessive per-centage of phosphorus in the paste itself constitutes a danger is a question in regard to which there is considerable difference of opinion. In some pastes there is as much as 30 to 40 per cent. of phosphorus, but as in most of the English pastes there is seldom more than 4 to 5 per cent. on an average, this question scarcely arises for discussion, so far as our own country is concerned. Besides, in regard to it expert opinion is divided. It has been a simple matter for Denmark, just as it would be for Switzerland, to prohibit the use of white phosphorus altogether. The same remark applies very largely to France. Wherever matches are consumed in the country in which they have been produced there is comparatively speaking little difficulty. In such, abolition of the white phosphorus match simply causes personal inconvenience to the consumer, but in manufacturing countries, whose exporting trade is greater than that providing for home consumption, the question of abolishing the use of white phosphorus assumes a commercial and social aspect, which does not arise in other countries. It is this side of the question that concerns such countries as Belgium, Sweden, and England. These not only manufacture for home consumption, they produce for exportation, and have to run the gauntlet of competition with for example such a new power as Japan, a country where labour is cheap, and factory legislation non-existent. In Britain there is a growing demand for safety matches. Each year the consumption is steadily increasing. Safeties are now so largely produced that they can be bought almost as cheaply as matches made from white phosphorus. The gradual education of the working classes in regard to the use of safeties will of itself help to settle the question of prohibition, so far as home consumption is concerned, but ordinary phosphorus matches will still require to be produced if Britain is to continue an exporting country, until such a period at any rate as it can be shown by experience and length of time that our manufacturers have succeeded in, and are capable of, producing a strike anywhere match, free from white phosphorus, and which under all sorts of conditions, heat, cold, transportation, &c., will respond to the same tests that are applied to the ordinary phosphorus match. France is extremely sanguine on this point. She maintains that she has succeeded in manufacturing matches from the non-dangerous sesqui-sulphide of phosphorus, but it is too early yet to pronounce an opinion upon the keeping qualities of these matches. The whole problem is one that has considerable interest, and a financial value for manufacturers and chemists both at home and abroad. Invention has been of late so stimulated that the future gives promise of success. To some extent the solution of the problem

rests with the public. Employers while they may lead the way yet only make to satisfy the public demand. Under the circumstances therefore of experience having shown that methods of manufacture exist which are capable of practically excluding phosphorus necrosis from the industry, of the "new strike-anywhere" sesquisulphide match of the French Government still passing through its period of probation, and inventors busy at work, it is premature to recommend the total abolition of white phosphorus in Great Britain and Ireland. If total prohibition were alone the order of the day, and the importation of matches made with white phosphorus allowed, we would simply transfer the risk of phosphorus necrosis in our own workpeople to those of other countries where factory legislation and Government supervision are not so strict as here. The problem under these circumstances would become complicated, and have to be settled by some international agreement.

RECOMMENDATIONS.

If white phosphorus is to continue to be used in this country it is absolutely necessary that such structural alterations should be made in factories which will separate the mixing, dipping, drying and boxing rooms from each other, and that each should be thoroughly ventilated by fans; that each dipping table should be so thoroughly ventilated by a fan that the fumes cannot rise upwards towards the worker beyond an inch or two from the slab, but must be drawn towards the fan; that the boxing rooms should be lofty, and ventilated by fans; that ventilating hoods or shafts should be placed above each bench so that the fumes are drawn away from the worker as she fills the boxes. As one of the most frequent causes of fires in boxing rooms is the cutting of the splints by a hand knife, this is a practice that should cease. I have seen more fires from this cause in a boxing room than from any other. Provision should be made for washing; soap and towels should be provided by the firm and facilities for washing should be offered to the workpeople, not in the open yard of the factory exposed to all kinds of weather, but in a room or shed. Gargles should be provided and each worker should have his own mug. Overalls should be worn, and there should be dental and medical inspection of the workpeople on entering the factory and at stated intervals afterwards. There should be a change of occupation for the workers; men and women should not be allowed to remain more than a few weeks at a time in any one department. The mixing of the phosphorus paste should be done in closed vessels and the paste kept until required in covered iron tanks. Plans of new match factories and of proposed structural alterations in old factories should be submitted to the Home Office. A medical and dental register should be kept in the factory.

THOMAS OLIVER.

APPENDIX TO DR. OLIVER'S REPORT.

REPORTS ON FRENCH AND BELGIAN MATCHWORKS.

(1.) REPORT OF A VISIT OF INSPECTION TO FRENCH MATCHWORKS AT AUBERVILLIERS, PANTIN, AND MARSEILLES, IN JUNE 1898.

7, Ellison Place, Newcastle-on-Tyne,
1st July 1898.

To the Right Hon. Sir Matthew White Ridley, Bart., M.P.,
Secretary of State for the Home Department.

SIR,

I HAVE the honour to present to you the accompanying Report of my official visit of inspection of French Matchworks.

On arrival in Paris I proceeded, as requested by the Foreign Office, to the British Embassy, where, as on the occasion of my previous visit to Pantin, I found that Sir Edmond Monson and Mr. Lee had secured for me from the Minister of Finance, M. Cochery, an entrée to the various match factories. I should like, therefore, to take this opportunity of thanking the various officials of the French Government for their prompt assistance, always most generously rendered; the British Ambassador in Paris, also Mr. Lee and Mr. Boothby of the Embassy, for the help they so courteously extended to me, whereby all difficulties of visiting the factories were removed.

I have, &c.

THOMAS OLIVER.

REPORT.

In accordance with instructions received from the Secretary of State I visited on 21st June, 1898, the matchworks (1) at Aubervilliers, and (2) Pantin, both of which are situated outside the fortifications of Paris.

The manufacture of matches is in France a State monopoly: it is under the direction of the Minister of Finance, and is the source of a considerable revenue to the Government.

AUBERVILLIERS.

The works at Aubervilliers are old and do not fulfil modern requirements. I was conducted over the factory by M. Buisson, the director. Two hundred people find employment here, 105 women, and 95 men. At the time of my visit several of the workpeople were sitting about in the yard disengaged, owing to some experiments which were being made with a new paste for match heads. In the office of the works I observed a notice board: "Tableau des ouvriers en interruption de Service pour causes dentaires," and on it I found the names of 15 of the employees, 2 men and 13 women. Although the illnesses were those that might be properly called minor ailments, yet several of the workers had been suspended as long ago as June 1897, and had not yet been allowed to return to work. Only the ordinary wooden or splint matches are manufactured at Aubervilliers, and these are made from the so-called white or yellow phosphorus.

Processes of Manufacture.

Formerly the mixing of white phosphorus was done by hand, but at present it is accomplished in a series of three closed iron vases by means of machinery. These cylinders communicate with, and can be emptied into, each other by means of connecting iron pipes. Into the second of these cylinders there flows from cylinder (1) in due course the molten glue, and at the proper time the sticks of white phosphorus are added by the hand of the workman. After properly mixing, the paste, composed simply of glue and phosphorus, is drawn off into cylinder No. 3, into which are poured the other necessary ingredients, powdered glass, colouring matter, &c. The whole mass is intimately mixed for one hour. No fumes escape into the mixing shed—they are carried off high up into the outer air by a small iron shaft from cylinders Nos. 2 and 3.

Once the composition is made it is removed to an adjacent room and stored until required in iron tanks which are again enclosed in iron chambers; from each of these a shaft arises to allow of the free escape of fumes.

The "tipping" of the matches is carried on in a room adjacent to that where the mixing is done. Here the matches are first tipped in molten sulphur and subsequently in the phosphorus paste, the latter being accomplished by machine rollers which are hooded. From this particular part of the machine the air is withdrawn by suction pipes, so that no fumes ought to reach either the feeder or receiver of the matches. The phosphorus paste feeds the rollers mechanically. The ventilation of the dipping machine seemed to me to be quite sufficient, the down-draught was strong and I could detect no odour of phosphorus. When the matches have been tipped both in sulphur and in the phosphorus paste they are transferred to adjoining drying chambers made of iron and with iron doors closely fitting.

Into these are run on iron chariots trays of tipped matches, the principle being similar to that observed in large laundries, only the chambers are air-tight and have a column of air circulating through them, the vitiated air being removed by a special exit tube. The mixing, tipping, and drying of the matches are conducted in a building detached from the other parts of the works, and these functions are delegated to men only.

In the boxing department ("mise en boite") the work of filling the match boxes with lucifers is carried on by women, and is all done by hand. This takes place at one end of a long room, while at the other the labelling and packing are conducted. The separation of these two departments into different rooms seemed to me to be very desirable, for the odour of phosphorus was extremely strong in the boxing department, and was readily detected where the women were labelling in spite of ventilation of the workroom by means of open windows.

Pantin.

From Aubervilliers I proceeded to Pantin along with Mons. Buisson, who is also in charge here.

In the month of April of this year I visited these works and had the pleasure then of reporting upon them. To that report I have little or nothing to add.

At Pantin three kinds of matches are made:—

(1.) The ordinary wooden strike-anywhere match.

(2.) *Tison*, a kind of safety vesuvian, which only strikes upon paper prepared from red phosphorus.

(3.) Safety matches which also only light upon the box.

The works at Pantin are better than those at Aubervilliers; they are not so old, they are kept better, and are justly regarded as one of, if not the, most important of the State factories. They give employment to 600 people, 400 women and 200 men. Since the methods of manufacture are practically the same at Pantin as at Aubervilliers it is unnecessary to reproduce them. The boxing of the matches is here all done by hand.

Marseilles.

On the 22nd June I visited the Matchworks, Prado, Marseilles, where I was received and conducted over the factory by M. Desbrosses. This is the most modern of the three works that I inspected, having been built only two years ago on the site of previous works destroyed by fire. It is built in a series of long detached blocks separated from each other by a considerable carriageway. Smaller works are at Aix. In the factory Prado 540 people are employed, 460 women and 80 men. Here are made all the wax matches that are sold in France; but although Marseilles is the seat of the manufacture of vestas, it still makes—and this is a point of considerable importance from a health point of view—a larger number of ordinary wooden than wax matches, the daily average being something like 20 millions of ordinary matches as against five millions of vestas. No safety matches are made in Marseilles.

Processes of Manufacture.

The processes of mixing, tipping, and drying are carried on in a building detached from the rest. Only men are engaged in this work; those whom I saw were healthy. In the mixing house I found pastes of various kinds. One of these contained red oxide of lead. It is this ingredient which makes matches strike softly without any noise. The sharp noise or explosion heard when a match is struck is due to the presence of potassium chlorate. On an average there are made at the Prado every year 300 millions of wax matches tipped with phosphorus and the oxide of lead, and 750 millions of matches containing chlorate of potassium. No symptoms of lead poisoning are said to have occurred in the workpeople.

The tipping of the vestas is done by one man upon a marble slab, and although both along the front of this slab and at the left side there existed aspirating arrangements

for drawing down the fumes, the odour of phosphorus at the time of my visit was extremely strong, and on testing the aspirating funnel I found it was not drawing. The man engaged in this operation was 52 years of age; he had worked at it for 36 years and had only once been off ill from some minor dental affection. The drying chambers I found well ventilated and with free circulation of air. The boxing of the vestas is done by women and by hand. These women are seated at a long counter divided off into places like trays or open desks—one for each, and in front of each space is an open grating through which are supposed to be removed the fumes arising during the boxing of the matches. The boxing rooms are large, lofty, and ventilated in the ceiling. The women whom I found here were much older (30–40 years) than those whom I saw either at Aubervilliers or Pantin. The departments where the wax thread is made, where the wood for the splints is cut, and where the splints are collected "*mise en presse*" were all satisfactory. In the sulphur dipping department, where the matches are tipped preparatory to being headed by the phosphorus paste, there was a considerable odour of sulphur, and this I found due to imperfect aspiration at the sides of the rollers, the openings of which were too small and the draught not powerful enough. In the "*mise en boite*" department for ordinary wood matches, and where the boxing is all done by hand by women, and by younger girls than in the similar departments for wax matches, several small conflagrations kept breaking out at the various trays. These were readily extinguished by means of a sponge wetted with water, but only with the evolution of dense clouds of rather an irritating smoke. In front of the trays was a grating for the removal of the fumes.

In a building quite apart from the other blocks is a dining-room, excellent in its way. Outside of the dining-room, in a covered way, are hung up on the wall large bottles filled with turpentine gargle, which, I am informed, there is no difficulty in getting the workpeople to use. A room is set aside as the women's wardrobe; it is a well-appointed room, clean, and well kept. Each woman has a separate numbered apartment for her overclothing, and above it a little cupboard which contains a tin mug bearing the same number as the compartment. All the mugs that I examined were perfectly clean and free from odour. Each worker is supplied with a mug, which she uses for drinking purposes and for gargling.

On examining the health register at the Prado I found that on an average 22 to 23 workpeople are absent every month, having been suspended on account of illness.

The numbers for May 1898 were 22, for April, 24, and for January, 24. All of these were women with the exception of one man. This seems a large number of suspensions, but the illnesses are tedious and so the names of the workpeople are carried forward from month to month. It is the opinion of Mons. Desbrosses that women are much more easily fatigued at the work than men, and are more susceptible to the poisonous fumes.

Phosphorus Necrosis.

One case of *phosphorus necrosis* has been on the list since 9th November 1896. I had the opportunity of examining this woman, Maria Ruquet, aged 23 years, a strong healthy looking blonde, who had worked eight years in the factory before becoming necrosed. Eighteen months ago she became ill, and, without describing in detail her illness, it is sufficient to state that she has lost a few teeth and a portion of her lower jaw bone, that the bone, as seen from the inside of the mouth, is exposed and ulcerating, and that fistulous openings communicate with the skin underneath the jaw. This woman is, of course, not allowed to enter a match factory. Two other women who are working in the factory were also brought to me for examination. One, aged 41 years, had at the age of 19 necrosis of the jaw which lasted for 2½ years. She lost several of her teeth and a piece of jaw bone. Since then she has been regularly employed in the "*mise en presse*" department, even although at the present time one of the glands behind the jaw is enlarged and painful, and a portion of her superior maxillary bone is bare.

The other woman is 52 years of age; when 21 she had necrosis of the upper jaw bone, and, after losing several teeth and a piece of necrosed bone, she has followed her employment in the matchworks regularly in the "*mise en presse*" department.

Dangerous Processes.

The dangerous processes in match-making are the mixing, dipping, drying, and boxing. While, theoretically, the mixing of the composition and the tipping of the matches should be the most dangerous, yet, as a matter of experience, the boxing when done by hand causes more ill-health than the others. More hands, for one thing, are employed, and these are women, and, although in the works in Marseilles the rooms are large, airy, and well-ventilated, and a grating is placed in front of each woman where she manipulates the matches, yet the odour of phosphorus was particularly strong, owing to the artificial means for removing the fumes that day not being in perfect working order. This, it is

needless to say, is one of the principal sources of danger, for, as reliance is placed upon these, there is a tendency to disregard the methods to secure ordinary ventilation, and so work is carried on in an atmosphere more polluted than otherwise would be the case.

General Rules of State Factories.

Printed instructions are hung up in proper places in the works, and can be easily read by all the employées. Of these I shall give only such extracts as apply principally to the health of the workpeople and the conditions of labour.

Hygienic Regulations.

It is forbidden to take food or drink into the workshops. Such should be deposited in the dining-room. Those who wish to partake of a light meal during the interruption of work can resort to the dining-room during the hour fixed for this purpose, performing first the following:—

(1.) Leaving their working clothes in the cloak-room.
(2.) Washing their hands with soft soap and water.
(3.) Gargling the mouth with a gargle provided by the Administration.

The same precautions are to be observed on leaving work.

The heads of departments and those in charge must see that these regulations are carried out; they must see that the vessels for receiving the gargles are clean, and are kept filled, that the gargles are properly made and that the workpeople have their teeth examined on the prescribed days. The Order, from which these extracts have been taken, is affixed in the workshops, and has to be read out aloud on the first Saturday of every month, those in charge inscribing in a memorandum book the date upon which this monthly reading took place.

Rules for Internal Discipline (Extract).

Applicants for employment must not be under 16 years of age and must not be beyond 32 years of age for men and 28 for women, must show a certificate of birth, and one also of good moral behaviour. Each applicant must subsequently be examined by the doctor, who is required to find him free from bodily infirmity and contagious disease, that he has been vaccinated or had small-pox, that the state of the teeth is good, and that without risk to health he can be employed in lucifer match-making.

The normal duration of a working day is 10 hours; a deduction is made for the time allowed for going to and coming from meals. The hours of entering and leaving the works are fixed as follows:—Morning: enter 6.30 a.m., depart 11.30 a.m.; afternoon enter 1 p.m., depart 6 p.m.

Five minutes before the time of leaving off work a bell announces that it is time to clean up; at the hour fixed for leaving a second bell announces the fact.

When the necessities of the service require it, the duration of the working day may be either diminished or lengthened beyond 10 hours.

Any worker absent through ill-health or on account of treatment for a mouth affection cannot resume work without a certificate from the doctor to the factory stating that work can be resumed without risk to health.

Smoking in the works is not allowed; neither must a pipe nor tobacco be taken into the factory.

Medical Precautions.

In further elaboration of the above regulations, I learn from M. Buisson that at Pantin-Aubervilliers the workpeople are examined by Dr. Courtois-Suffit, physician to the Paris hospitals, and physician employed by the State for these matchworks, twice a year at intervals of six months. Any man or woman who has a carious tooth is suspended should the doctor consider it advisable, and if such an individual is working in a department where chemical matches are made, total exclusion from work is the rule, but the individual is allowed to work in such other departments as are considered harmless, *e.g.*, where the wooden splints are cut and gathered together, match boxes made, &c. When a worker who has been suspended by order of the doctor presents signs of phosphorus intoxication, but without necrosis, such symptoms, for example, as anæmia, malnutrition, loss of flesh, and albuminuria, the doctor, in addition to prescribing medicine, is allowed to order 1 litre of milk daily. M. Buisson informs me that during the last 18 months Dr. Courtois has not had to order milk for any of the workpeople. All workers suspended by the doctor receive three-fourths of the wages they were making at the time. Where a workman has had teeth extracted on account of the supposed effect of the industry he is seldom allowed to return to work before 2-6 months, not until the doctor is satisfied that the gums are quite healthy and healed over.

When Dr. Courtois made his first visit to Pantin-Aubervilliers, in August 1897, he found 15 men and 35 women suffering from simple dental caries, but without any other ailment; in his visit in February 1898 he found only 4 men and 12 women.

I had hoped to have met Dr. Courtois-Suffit, but our expected meeting fell through.

M. Buisson was good enough to give me a copy of a short paper prepared by Dr. Courtois for the Academy of Medicine, Paris, 7th December 1897, upon the Sanitary Condition of the match works at Pantin-Aubervilliers. I may mention that, owing to the ravages caused by white phosphorus among match makers a few years ago, the Minister of Finance invited the Academy of Medicine to nominate a small Commission to investigate into the state of health of 226 workpeople, men and women, and into the insalubrity of the making of matches. In October 1896 the Commission met, viz.:—M.M. Vallin, Magitot, Roussel, Hanriot, and Monod. These gentlemen visited the factories at Pantin, Aubervilliers, Aix, and Marseilles, and also some of the principal matchworks in Belgium.

So far, I have not yet succeeded in obtaining a copy of this report, but as the French Government attributes considerable importance to the note of Dr. Courtois I am privileged to reproduce it. Dr. Courtois says: "Entrusted for the last year with the duty " of medically supervising the Matchworks at Pantin-Aubervilliers, I beg to present to " the Academy a short note upon the Sanitary Condition of these factories. The Academy " of Medicine justly moved a year ago by the increasing and constant ill-health caused " by the use of white phosphorus nominated a Committee with the object of studying the " progress of the evil and the means of remedying it. We have vivid recollections of the " relatively large percentage of cases of necrosis, and of the general accidents due to " chronic phosphorus poisoning, in the report of M. Vallin.

"It is this circumstance which makes me think it of some interest to bring forward the results of my own personal observation.

"There has not been within the last year (1st December 1896–1st December 1897) a single fresh case of phosphorus necrosis, nor a single example of general illness logically and seriously attributable to chronic phosphorus intoxication, and this too in workshops which justly pass as the most unhealthy of all, and in a population of 575 men and women.

"The fact deserves attention since the methods of manufacture have remained the same, and the installation of the factories has not been sensibly modified. A methodical selection of the workers, constant and rigorous supervision of them, and a closer attention to hygienic regulations have sufficed to lead to this result during the year.

"We cannot deny for a single moment the existence of phosphorus necrosis during previous years, and it would be rash to affirm that the illness can be no longer produced, but we believe that we can see it diminish in distinctly sensible proportions by the application of certain principles which appear to me to be well thought out and to which I shall allude later on. If in the manufacture of matches we could replace white phosphorus by substances altogether innocuous the best remedy would thus be immediately found, but the situation does not thus present itself at the present moment."

Medical Testimony.—Marseilles.

During my visit to Marseilles I had the opportunity of meeting and conversing with Dr. François Arnaud, who is the doctor to the matchworks, and the author of one of the best works on industrial phosphorus poisoning. Arnaud believes that the poisoning arises through absorption by the respiratory channels, and probably, too, by the skin, of the vapours given off from white phosphorus, and their elimination by the various emunctories, after a more or less lengthened sojourn in the organism. This induces either chronic industrial phosphorism, or the more acute accident known as phosphor necrosis. It is interesting to remark, says Arnaud, that in a certain number of people, greater perhaps than we would *a priori* suppose, match-making does not sensibly alter the general health. He knows of several people who have been exposed to phosphorus for 10, 20, and 30 years, and who not only have remained free from grave phosphorus accidents on the side of their jaw bones, in spite even of bad teeth, but have preserved all the appearance of good health. There are certain types of individuals who seem to be specially liable to become affected, *e.g.*, those who are the subjects of glandular enlargement, who are ill-developed, scrofulous, of weak constitution and tending to tubercular disease, rickety, those suffering from cough, heart disease, and indigestion, also those whose elimination is imperfect, *e.g.*, anæmics, alcoholics, and those suffering from albuminuria.

Arnaud has been for 12 years the medical adviser to the matchworks; he has, therefore, had numerous opportunities of watching the effects of phosphorus upon the workpeople. From 1884–89 his observations were based upon the Prado factory. In 1890 the French Government took over these works. During the year 1895 there were engaged in the works at Prado and Amphoux 503 people; in the dangerous departments, 25 men and 196 women. From 1884 to 1896, *i.e.*, in 12 years, there were four cases of confirmed necrosis, three of which occurred during 1890–95. Of these four cases of necrosis, two died. There were 13 cases of commencing necrosis, which, however, stopped short of sequestration of the bone, and 57 cases (1890–95) of inflamed gums, dental abscesses, penetrating dental caries and fistulous openings. It appears that 30 kilos of phosphorus (66 lbs.) are used daily in the works at Marseilles; 600 kilos per month (1,320 lbs.) and 6,084 (13,385 lbs.) during the year. The total number of matches

made annually is six milliards 150 millions. The per-centage of white phosphorus in these matches usually runs, for ordinary wooden splints 11, and for vestas, 5 to 7. What makes the ordinary wooden match more dangerous in its manufacture than the vesta is the higher temperature at which the match is tipped, and the larger per-centage of phosphorus in the paste. Wax matches are tipped cold. In the boxing room for wax matches there is distinctly less odour of phosphorus, the women look healthier and they do not suffer to the same extent as their sisters employed in the similar departments for wooden matches.

Non-Poisonous Matches.

The works at Pantin-Aubervilliers are evidently regarded as the most important of the State factories. At my visit to Aubervilliers I was struck by the large number of workpeople who were idle. A strong odour of amylene pervaded the atmosphere. I ascertained that experiments were being made with some new paste in which amyl acetate largely predominated. Free, comparatively speaking, as the match makers of Pantin-Aubervilliers are to-day from the worse forms of phosphorus poisoning, they were not always so. At the close of the year 1894 there were 32 cases of phosphorus poisoning; in December 1895 the number had risen to 125, and the year later, 223 cases, or about one-third of the effective force of the factory. Since this severe scourge of industrial phosphorism, the French Government has left no stone unturned to introduce new methods of manufacture, and to replace white phosphorus by harmless substances. Experiments with this object in view have been encouraged, and invention stimulated by financial aid from the National purse.

It was therefore one of numerous experiments that I saw being made to-day. M. Buisson showed me a large number of formulæ which he had tried, and several kinds of matches he had made without phosphorus, but, practically speaking, all of them had been failures. To some extent, however, the Government has solved the problem of making a match free from white phosphorus and capable of striking anywhere. This match, the so called "sans phosphore," is not absolutely free from phosphorus. M. Buisson informed me that it contains a modified form of the harmless red phosphorus. The manufacture of this match, or of a similar kind, is carried on at Trélazé, Bègles, and Saintimes, but it is not yet an industry in the ordinary sense of the word. It has only been in existence since March 1898, and, owing to the delicacy of the manipulations required in its production, the unreliability of the chemical composition, and the fact that it has not yet been possible to make the paste in large quantities, this match, although apparently successful, has not yet been placed within the reach of the people. I had the opportunity of discussing the prospects of the manufacture of these "sans phosphore" matches with one of the inventors, M. Ponteau. Both he and M. Buisson, the director of the works, are hopeful and confident, and as the Government is doing all it can to stimulate enterprise, the manufacture of matches that are capable of striking on any surface, and yet free from white or any form of phosphorus, would seem to be within the range of early possibility.

Personal Impressions and Deductions.

(1.) Until recently the match makers in certain of the French factories suffered severely from phosphorus poisoning; that at the present time there is apparently a reduction in the severer forms of the illness.

(2.) That the reduction in the amount of illness is attributable to greater care exercised in the selection of the workpeople; raising the age of their admission into the factory; medical examination on entrance; subsequent close supervision; repeated dental examination; personal cleanliness on the part of the workers; early suspension on the appearance of symptoms of ill-health; improved methods of manufacture.

(3.) That the French Government, aware of the dangers of match making, is furthering by all possible means new methods of manufacture, and, with this object in view, retains in its service chemists and inventors who are continually making experiments.

(4.) That the Government has to some extent already succeeded in manufacturing a match capable of striking anywhere, yet free from white phosphorus, but that until now the manufacture of this match is not an industry.

THOMAS OLIVER.

Postscript.—23rd January 1899.

At the time I wrote the foregoing I had not seen the Report of the Commission of the Academy of Medicine alluded to on the preceding page *re* "The Employment of Phosphorus in the Manufacture of Matches." A perusal of the document within the last few days in no way obliges me to alter any of the opinions I have expressed, nor to detract from any of the statements I have made. Several facts, however, may with advantage be mentioned.

From 1st January to 31st December 1896, the State paid 400.000 francs as allowances to sick workers, men and women, employed in the Match Factories of Pantin-Aubervilliers, or on an average 650 francs per head of the workers employed. During 1888 to 1896 there occurred among the workpeople eight cases of deforming necrosis, 12 of necrosis either cured or not requiring surgical treatment, 21 probable cases of phosphor necrosis and 18 doubtful cases of *phosphorisme* making in all 59 cases. It was believed that necrosis occurred in match workers in France to the extent of 2 to 3 per cent.

Speaking generally, and quite apart from phosphorus, the pastes used for heading the matches were not satisfactory. Some of them contained as much as from 55 to 64 per cent. of lead oxide, the use of such was risky for, when women were in the act of either emptying the presses or filling the boxes, the slightest friction often caused the matches to ignite, especially when the paste contained chlorate of potassium. The danger lay in the fact that as the temperature was raised the lead volatilised to such an extent that, as M. Schloesing, Director of the School of Explosives showed, the fumes thus evolved contained 25 to 98 per cent. of the metallic lead employed, the remainder being found in the charred head of the matches.

For several years past the Administration has not felt comfortable in regard to the health conditions of the match industry in France. Ever since 1856, the year in which Professor Tardieu reported on behalf of the Commission of Public Health in favour of the total abolition of the use of white phosphorus, this aspect of the question has been kept dangling before successive Governments. The year 1898 has witnessed the change so that at present the "sans phosphore" match is alone made in France.

(2.) NOTE UPON THE SEVÈNE AND CAHEN, OR "SANS PHOSPHORE" MATCH OF FRENCH MANUFACTURE.

7, Ellison Place, Newcastle-upon-Tyne,
20th January 1899.

To the Right Hon. Sir Matthew White Ridley, Bart.,
Home Secretary.

SIR,

I HAVE the honour to send you the accompanying *Note* upon the so-called "Sans phosphore" match of French manufacture and which may be regarded as a Supplement to my Report of a visit of inspection of the match factories of France.

I have, &c.
THOMAS OLIVER.

In June of last year, I had the honour of presenting a Report upon the French Match Works of Aubervilliers, Pantin, and Marseilles. At that date the manufacture of a "strike anywhere" match free from phosphorus, otherwise called the "sans phosphore" match, was still in the experimental stage. Six months have elapsed since then, and as the manufacture of the new matches has proceeded at such a rapid pace as now not only to be considered an industry, but to be spoken of as the *only match industry* of France, it may be well to review the subject of the non-poisonous French matches generally, and to state the estimation in which they are held by the Government officials who are concerned in their production. France has lately replaced the old white phosphorus match, which was known to be dangerous, by one made from sesquisulphide of phosphorus which is believed to be non-poisonous. This substance was proposed by Messrs. Sevène and Cahen, and adopted by the State after many experiments as the best substitute for white phosphorus, hence the initials S. C. on the matches after the inventors.

In my former report I make mention of a communication to the Academy of Medicine on 7th December 1897 by Dr. Courtois-Suffit who drew attention therein to the health of the workpeople in the match factories of Pantin-Aubervilliers during 1897. He showed that daily supervision, a methodical selection of the workers and the enforcement of regulations drawn out by a Commission of the Academy of Medicine had created a healthy condition of the factories that had even exceeded the expectation of the most sanguine. A year previously the works had been regarded as the most insalubrious in France, but by rigid attention to hygienic rules not only had phosphorus necrosis been completely suppressed among the 700 workpeople, men and women, but even the minor ailments, rightly or wrongly attributed to chronic phosphorus poisoning, had also disappeared. This satisfactory condition of things was secured in rather old buildings, structurally deficient for the purposes to which they were put, and without in any way interfering with the use of white phosphorus in the production of the matches.

The manufacture of the old matches continued until August 1898.

It was in 1897 that the Administration, dissatisfied with the match industry on account of the large amount of sickness among the workpeople, offered inducements to chemists and inventors to find a substitute for white phosphorus that would be harmless to the workers, and that would offer to the consumer the same advantages as matches made from white phosphorus. Among the numerous samples presented there were two that seemed likely to fulfil these requirements, and these were :

(1.) The matches of Mons. Ponteau which contained in the paste acetate of amyl. Matches were being made with this substance, and experiments were being conducted with it the day upon which I visited the works at Aubervilliers, but the amyl acetate simply saturated the atmosphere that inhalation of it tended to cause headache and created unpleasant effects upon the cerebral circulation. It was quite clear that in amyl acetate a substance was being used, the prolonged respiration of which would become harmful to the operatives.

(2.) The matches of M. Otto Miram which contained lead in such quantities as to threaten to substitute one form of poisoning for another. Rather than adopt either of these two, it was considered safer to continue the manufacture of the old phosphorus match, still adhering closely to rigid hygienic regulations, until such a time as a harmless match could be made.

The French Government believes that to-day it has solved the problem by using the sesquisulphide of phosphorus in the manufacture of matches. The chemical and experimental grounds upon which the belief is based that sesquisulphide of phosphorus is harmless form the subject of a paper recently read (27th December 1898) to the Academy of Medicine by Dr. Courtois-Suffit who is the medical officer in charge of the match factories of Pantin-Aubervilliers.

White phosphorus is so volatile that at the ordinary temperature even its unpleasant odour can be detected throughout the factory. Its fumes are composed of certain oxidation products with probably some phosphureted hydrogen and other gaseous compounds. French physicians are of opinion that the phosphorus vapours may cause necrosis of the jaw or gain entrance into the system through the respiratory organs, become fixed in the blood and tissues, and induce the constitutional state known as phosphorisme. White phosphorus melts at a temperature of 44° C. (111° · 2 F.); its poisoning power or toxicity is considerable, for 15 to 30 centigrammes (2 · 3 to 4 · 6 grains) are sufficient to cause the death of an adult. The sesquisulphide of phosphorus, on the contrary, owing to its method of preparation can only contain as impurities in addition to water small quantities of red phosphorus, which is not dangerous.

It is said to possess the special odour characteristic of many sulphides, but present as it is to the extent of 6 per cent. in the paste, the odour is not at all unpleasant, either to the worker or the consumer. The sesquisulphide of phosphorus melts at a temperature of 142° C. (320° · 6 F.). It is, therefore, rather a fixed body, and gives off no fume, and when pieces of it are rubbed together there is none of the phosphorescence which is exhibited by sticks of white phosphorus similarly treated.

The glow exhibited by phosphorus is due to oxidation, and this is continually taking place so long as it is exposed to the air. Lemoine states that he has exposed samples of the sesquisulphide of phosphorus to the air for several years without any alteration taking place. The sesquisulphide is obtained by combining red or amorphous phosphorus and sulphur. It cannot be obtained in the first instance from white phosphorus, certainly not by a direct combination of white phosphorus and sulphur, for thus would be formed either a subsulphide or hydrosulphide, which has no relation to the sesquisulphide in question. The toxicity of the sesquisulphide when absorbed directly into the system is stated to be small. Messrs. Sevène and Cahen gave repeated doses of 3 centigrammes (2/5th grain) of the substance daily to guinea pigs, without these animals appearing to suffer, although the ingestion of 3 millegrammes (1/25th grain) of white phosphorus caused rapid death. The dose of 3 centigrammes (2/5th grain) to a guinea pig would correspond to 3 · 5 grammes (54 grains) for a human adult, that is to say, to the amount of sesquisulphide of phosphorus present in 6,000 matches. For these reasons, therefore, the inventors maintain that sesquisulphide matches are harmless.

The following is the composition of the paste employed :—

Sesquisulphide of phosphorus	6
Chlorate of potass	24
Zinc, white	6
Red ocre	6
Powdered glass	6
Glue	18
Water	34

The composition is altered accordingly as the paste is required for sulphur tipped and paraffined matches, or for vestas. It is said that the introduction of the new match has not modified to any great extent the processes of manufacture generally. Any alterations that have taken place have been advantageous. In certain factories it has been found better to give up the mechanical stripping of the matches on account of a certain loss arising from the working of the machines than from any material impossibility connected with the matches themselves. Other mechanical methods

which were believed to be causing undue fatigue to the workers have also been abandoned. As was to be expected, experiments made in the early periods of the manufacture with the new S. C. matches did not prove altogether satisfactory; there were many failures, but to-day it is maintained that the sesquisulphide match is irreproachable, and that in all the match factories of France such alterations have taken place that they are now made in Trélazé, Bègles, Saintimes, Aubervilliers, Pantin, Aix, and Marseilles. For the last three months only the S. C. match and no other has been produced. Sufficient time has not elapsed for any change to be observed or any effect to have been produced upon the health of the workers, so that for the present at any rate it is not proposed to make any change in the rules, or reduce the stringency of the regulations in the factories. Only healthy people with sound teeth are taken on as operatives; there is to be the same medical inspection of the workers, because it is known that even after a lengthened discontinuance of exposure to the fumes of white phosphorus ill-health may still ensue.

As on the two occasions upon which I visited the matchworks at Pantin I had lengthened conversations with M. Buisson, the Director of the Pantin-Aubervilliers factories, it seemed to me desirable to obtain from him a statement as to how the manufacture of the new matches was proceeding generally. From his letter, which is dated 29th December 1898, I abstract the following:—

The sesquisulphide matches give us complete satisfaction, and their manufacture is now an industry in all the factories of France.

They can be made more or less sensitive, or in other words can be so made that they will ignite too readily when rubbed, rendering it therefore necessary for great care to be exercised, otherwise their manufacture becomes extremely delicate requiring on the part of the workmen the adoption of precautions so as to obviate the risks of accidental ignition. There has been little change in our processes of manufacture. Certain stripping machines and others that automatically filled the boxes with matches have been done away with, but more with the object of improving the production. At Aix, where the workmen and women are extremely careful, it has not been found necessary to make any alteration at all. Taking the factories generally M. Buisson tells me that it has been found necessary to employ a few more workwomen who fill the boxes, about one-fifth more, that is to say 20 more at Aubervilliers, and 30 more at Pantin. The number of men required has been on the contrary diminished by one-tenth in three of the factories.

The Administration has not reduced the rate of wages since introducing the new method of manufacture. The mean salary remains about the same with the exception of certain modifications that have for their object the return to a normal rate of 10 francs a day instead of 15 as the daily earnings of the dippers, in order to distribute the difference among other branches of the industry in which the men were not so well paid.

Mons. Buisson says that he experienced some difficulty in manufacturing the new matches during the great heat of last summer. The matches then made were too explosive. This inconvenience is now said to have been completely overcome, that the quality of the manufacture is independent of variations of the external temperature.

As regards the keeping qualities of the matches, the director states that he believes them to be capable of unlimited duration, at least as long as the limits of industrial requirements are concerned. It is now nearly a year since he exposed some of the S. C. matches to alternations of heat, moisture, and dryness, and these have lost nothing of their primitive qualities. They are even stated to be less sensitive to humidity than matches prepared from ordinary phosphorus. Accidental ignition of the matches is now rare in the factories, and when it occurs the fire is just as easily extinguished by the throwing on of sawdust as that caused by ordinary phosphorus.

General Review of the Question.

The sesquisulphide match is now launched upon the market, and awaits the verdict of experience. It is too soon to express an opinion one way or the other. The ordinary phosphorus match and wax vesta of British manufacture are bad to beat. French matches, especially the wooden splints, have never commended themselves to our countrymen. It may be that a new era commences. Hitherto when efforts have been made to produce a safe "strike anywhere" match, inventors have begun by substituting the red or amorphous phosphorus for the white, but when red phosphorus is mixed with potassium chlorate, which is so necessary as an oxygen supplier, the compound becomes more explosive than the ordinary phosphorus, and there is considerable danger therefore in mixing the paste, owing to accidental ignition. The difficulty has been to retain the red or non-poisonous form of phosphorus, and at the same time to find a substitute for potassium chlorate. Permanganate of potassium has been tried, but it decomposes too readily, and it oxidises organic substances, such for example as the glue in the paste. Recourse has been had, as stated in an early part of this Report, to oxides of lead, but no satisfactory result was thereby obtained, because these are not sufficiently combustible for the phosphorus. Potassium chlorate had to be added with the result that the

matches exploded too much. Besides, if lead is to be used in the manufacture of matches there is always a risk of saturnine poisoning taking place.

Several boxes of non-poisonous "strike anywhere" matches have been forwarded to me by inventors in this country, but not one of them is capable of taking the place of the ordinary white phosphorus match. Some of these matches do not strike at all; others are so explosive as to be extremely dangerous. In expressing this opinion, I do not stand alone.

The sesquisulphide is much less poisonous than the ordinary white phosphorus. Prepared, as it is said to be, by the French chemists, from red phosphorus, it may possess the stable qualities which they claim for it. On our side of the Channel there is some doubt upon this point. Sulphides are unstable bodies. It is therefore believed that in the presence of moisture the sesquisulphide of phosphorus will give off sulphureted hydrogen, a gas which is harmful to animal life. This is a chemical objection, which in the case of the new matches may or may not be found to hold good. The match is on its trial, and time will show whether the French manufacturers have successfully solved the problem of producing a "strike anywhere" match free from poisonous phosphorus.

THOMAS OLIVER.

(3.) REPORT OF A VISIT OF INSPECTION TO BELGIAN MATCHWORKS.

To Sir Matthew White Ridley, Bart., M.P,
Secretary of State for the Home Department.

7, Ellison Place, Newcastle-npon-Tyne,
30th September 1898.

SIR,

I HAVE the honour to present to you my Report upon the match factories of Belgium, the hygienic conditions under which the industry generally is conducted, and the effects of the trade upon the health of the workers.

In Belgium, which for its area and population, ranks as the largest match producer, it is inevitable that there should be all kinds of factories, good and bad. With these inequalities the Government is grappling, and successfully.

I should like to take this opportunity of thanking Her Majesty's Minister in Brussels, Sir Francis Plunkett. G.C.M.G., and George E. Welby, Esq., of the British Legation, for the prompt and very helpful assistance they rendered me in my visit to the country; the Belgian Minister of Labour, for extending to me the permission asked for through the Foreign Office, and M. Brughmans, Inspector Principal, Central Administration, Brussels, not only for the valuable information he gave me, but for his personal kindness, and companionship, in our visits to the factories.

I have, &c.
THOMAS OLIVER.

REPORT.

Belgium is an important and large producer of matches. Compared with the United Kingdom which has 24 match factories giving employment to 4,300 people, Belgium, if we set aside four small works which employ only a few hands, has 13 match factories in which 2,600 persons are employed. Belgian matches are largely exported to England and her colonies, and to America. It is estimated that less than one-sixth of the matches produced is consumed at home. The matches made are the ordinary wooden splints, sulphur or paraffined; safeties and vestas. The principal factories are in West Flanders, in Gramont, and neighbourhood, but works are also found in Ghent, Lessines, Anderiicht, Herenthals, Audernarde.

Of the 2,600 match makers, it is estimated that 1,100 are employed in the manufacture of safety matches, and 1,500 in those made from white phosphorus.

GHENT.

In July 1897, Mr. Edward Gould, Her Majesty's Superintendent Inspector of Factories and myself visited the large match works of Messrs. Caussemille, Roche, and Company at Ghent. In the Annual Report of the Chief Inspector of Factories, 1897, Mr. Gould gives an account of our visit, and has described in detail the structural arrangements of the factory. To what he has written in this respect I have nothing to add. I quite confirm the statement he has made as to the excellence of the works as a whole, and their satisfactory management. In visiting Belgium anew for the purpose of inspecting and reporting upon its match industry, it seemed to me desirable on account of the extreme care with which Messrs. Caussemille, Roche, and Company conduct their works, and the excellent system of ventilation which they have adopted, to refresh my memory upon some of these important facts, to again acquaint myself with their methods of manufacture, and to examine the workpeople from the medical point of view especially

in regard to phosphorus poisoning. Accordingly on August 11th, 1898, I reached Ghent for this purpose. The works were established in 1875, 500 hands are employed, of whom 350 are women and girls. Only one case of phosphorus necrosis has occurred and that was 18 years ago. About 150 kilos (330 lbs.) of white phosphorus are used every week. The paste for the match heads contains 5 to 6 per cent. of white phosphorus, although the Belgian laws allow the use of 8 per cent. Messrs. Causemille, Roche, and Company make ordinary splint matches, safeties, and vestas. Of safety matches only few are made; their principal manufacture is ordinary splints and vestas, and these are made in about equal quantity.

Processes.

Mixing Room.—The paste is mixed by means of machinery in copper vases placed within an iron chamber which can be completely closed by means of an iron shutter.

During the process there is therefore no exposure, and no fumes are detected, for these are withdrawn, from the interior of the iron closet, by means of ventilating pipes. When thoroughly prepared the phosphorus paste is removed and taken to another part of the same room to be mixed with chlorate of potassium. As this is done before a fan in motion, the mixer never inhales any of the fumes. Once the mixing is completed the paste is removed and kept until wanted in hermetically sealed iron boxes placed on the floor of a shed, part of which only is roofed in. The mixing house communicates directly with the boxing room by means of a door.

Dipping Room.—The phosphorus paste is smeared on an iron plate kept at a temperature of 50° C. (122° F.) by means of hot water pipes underneath. Thick white fumes can be seen rising from the paste to the level of 1 to 2 inches, but these do not rise higher. They can be observed floating to the distal side of the dipping plate, drawn thither by the suction influence of a revolving fan placed in a recess in the wall, and running parallel with it. This fan made by Geneste and Herscher performs 300 revolutions per minute, and so completely does it remove the fumes that, although I stood directly over the paste, and made several deep inhalations, I could not detect any odour of phosphorus. The paste while waiting to be used is kept in basins in hot water in a trough close at hand, and the fumes arising from the paste are carried away through a wide hood and pipe, the air of which is aspirated by a fan. The dipper was a healthy looking man, he had worked at this table for eight years and never been ill, and his companion who had been similarly employed for five years had never suffered.

Boxing Department.—The boxing room is large, airy, well lit, and extremely well ventilated. There are seven large ventilating pipes. The boxing of the matches is all done by hand by women and girls. Immediately in front of the table at which each woman is seated is a ventilator, the air through which is aspirated upwards away from the worker into one of the large ventilating pipes already mentioned, the air of which is kept in motion by a Blackman's fan going at the rate of 1,000 revolutions a minute. The trays which contain the dried matches are set up on end facing each worker, and are so placed that in the event of matches becoming accidentally ignited during handling, the dense fumes arising from the burning matches are also drawn upwards into the ventilators, and therefore away from the worker. Nothing could be more satisfactory than the ventilation of this room generally, and of the tables particularly. Although all the women were busy at the time of my visit, and the day was extremely hot, there were no indications of discomfort, and no air of lassitude apparent in the workers, and no odour of phosphorus detectable in the room. I tested several of the ventilating openings on the tables, and felt that, while there was strong aspiration, the draught was not such as to be felt unpleasantly by the women when working. I was particularly struck, too, by the care with which the firm deal with badly-dipped and broken matches. These are not allowed to lie loosely upon the table, or to be thrown upon the floor emitting fumes, but are dropped into a receptacle placed immediately beneath the mouth of the ventilator. In addition, on the tables in front of each woman there lies a large wet sponge ready for use to extinguish the small conflagrations that continually arise during boxing. For more serious fires, pails of water are placed all over the room. In winter the boxing room is heated by large iron pipes.

All the women look healthy. There was less pallor among them than is observed in women and girls who are employed in factories, the work in which is not regarded as dangerous. During the interval, which corresponds to the workmen's dinner-hour in our country, a woman is employed by the firm to sweep away all the refuse on the floor.

Drying Chambers.—These are made of iron, and form a double set of chambers, separated by a passage way floored with iron plates, in several of which are gratings, down which air is aspirated. This air passes into the drying stoves, and after circulating through them escapes from the top of the chamber by means of iron pipes into the open.

Lavatories, Washing Appliances, and Vestiary.

The lavatory for the women is immediately entered from the boxing room. A long zinc trough runs along one side of the room. Above this trough is an iron pipe perforated at successive distances. Through these openings water escapes for washing. Soft soap is supplied by the firm, but no towels; the women dry their hands on their aprons. Overalls are worn by the women when at work, but these are not provided by the firm. In a cupboard in the lavatory are rows of small tumblers, each one occupying a numbered recess and filled with a solution of potassium chlorate. With this liquid every woman is obliged to gargle and to rinse her mouth before leaving work. One woman is told off to keep the tumblers filled. In the lavatory is also the vestiary, where, under her own number, each worker deposits on entrance her outer garment. At 10 minutes before the time for ceasing work a bell rings, so that each worker has 10 minutes to wash and gargle before leaving the factory. The foreman tells me that it is his duty to see that the women gargle and wash; that he has no difficulty in this respect; that if the gargle is not used, he imposes a fine of 5 or 10 centimes.

A dining room is provided for the women, away from the factory, but as nearly all the workers prefer going home for their mid-day meal, the refectory is only resorted to at 8 a.m. and at 4 p.m. for light refreshments, *i.e.*, during the 15 minutes work ceases for this purpose. This is a well-appointed room, and thoroughly clean. Copies of the rules of the factory are hung upon its walls.

Hours of Work.

Girls begin to work in those departments wherein white phosphorus is used at the age of 16 years; in the non-dangerous processes, however, they may commence work at the age of 12 years. Women under the age of 21 work 10½ hours daily; above 21 years, 11½ hours daily. The hours are from 6 a.m. to 12 mid-day. At 8 a.m., interval of 15 minutes. Commence again 1.30 p.m. to 7.30 p.m. At 4 p.m. interval of 15 minutes, The duration of effective work is for those under 16 years of age, as well as for girls and women aged more than 16, but under 21 years, from 6 a.m. to 11.50 a.m., and 1.30 p.m. to 6.40 p.m.

Medical Supervision.

A medical inspection of the workpeople engaged in the dangerous processes is made every month by Dr. Van Meeren, of Ghent, who is paid by the employers. He examines them individually, special attention being paid to the state of their teeth, and he enters the result in a book kept for this purpose. It is his duty, if he finds evidence of inflammation of the gums, or penetrating caries of the teeth, to suspend the worker. I examined the Medical Register for some years back, and found everything satisfactory. Each medical visit is entered and numbered, the numbers going on successively. Subjoined are copies of some of these entries taken at random, *e.g.*, June 1893, "No "phenomena of poisoning, sanitary condition excellent."—Signed Claus. July 1895, "I, the undersigned doctor in medicine, certify that I have examined seriatim the mouth "of each worker in the factory of Messrs. Caussemille and Company, and that I have "not found any trace of poisoning. Having inspected the factory generally, I can add "that all hygienic precautions are attended to, and that the danger to the workpeople "is nil."—Signed Eug. Van Meeren. March 1896, "I have found the health of the "workpeople excellent."—E. Van Meeren. April 1897, "All is in order, not a single "case of poisoning."—E. Van Meeren. July 1897, "Nothing could be better."—E. Van Meeren. August 1898, "All the workers enjoy perfect health."—E. Van Meeren.

I had the opportunity of meeting Dr. Van Meeren, and of discussing with him the hygienic conditions of the factory generally, and the health of the workpeople. He informed me that since his appointment, three years ago, as medical adviser, he has not had one case of necrosis in the works. He has only had two cases of slight gingivitis (inflammation of gums), and these were so mild that it was not necessary to suspend the workpeople, but to transfer them into other departments wherein there was no danger. Toothache was not more frequent among the matchmakers than among the working classes generally.

Since his appointment he has not had to extract 10 teeth from the workers altogether. It is a rule that any worker complaining of toothache is sent to the doctor. A medicine cupboard is kept in the factory, from which Dr. Van Meeren supplies such antidotal remedies as turpentine perles in case of need.

Discipline.—Regulations special to Messrs. Caussemille's factory are hung up in various parts of the building. Out of 15 rules I extract the following:—It is forbidden to any person to enter in a state of drunkenness, to sing, or smoke in any part of the factory. No newspapers are allowed. Workers must leave the factory each time it is closed. It is severely prohibited to introduce alcoholic drinks. A vestiary is provided where women, before beginning work, must deposit their outer garments, and put on working clothes. All persons working in the mixing, dipping, drying, and boxing departments—in a word, wherever matches made from white phosphorus are handled—

are obliged to wash their hands before each meal and before leaving the factory; they must also, in addition, carefully rinse the mouth mid-day and evening. The firm places gratuitously at the disposal of the workpeople a potassium chlorate gargle, and workpeople wishing to repeat its use can have more by simply asking for it. All the workers, on entering the factory for the first time, make a declaration that they have knowledge of, and have accepted, the conditions stated in the regulations affixed therein.

LESSINES.

On the 12th August 1898, along with M. Brughmans, Principal Inspector, Central Administration, whom the Belgian Government kindly placed at my disposal, I visited the match works of M. Balthazar Mertens situated at Lessines. M. Mertens, tth present owner of the works is the son of the gentleman who introduced matches into Belgium. Ordinary matches were made by his family as far back as 1837, and safeties were commenced in 1857.

Processes.

Mixing Room.—The mixing of the white phosphorus paste is done in iron vases covered with iron lids, but as these are not hermetically sealed the odour of phosphorus could be detected in the room. Eight per cent. of white phosphorus is used in the paste. The man who was mixing the paste was 64 years of age; he had worked with the Merten's family for 46 years, he had never been ill, but he had lost all his teeth.

Dipping.—The matches are dipped by machinery by means of rollers covered with paste and fed by hand from a pail lying close beside the machine. The roller is hooded; a strong aspirating draught carries the fumes of phosphorus upwards away from the dipper. The feeding of the rollers with white phosphorus paste is done by girls above 16 years of age. The two girls at one of the machines I examined were healthy, one had worked for two years. The man who receives the trays of tipped matches passes them at once into the drying chambers leading out of this room.

Drying Chamber.—This is built of brick and closed by iron doors. It is ventilated in the roof, air enters through a grating in the iron floor just outside, circulates through the chamber, and leaves it by the roof. In the event of a fire occurring inside the drying chamber the air entering by the grating is at once cut off.

Boxing Room.—This, although old, is lofty and well ventilated. In front of the table at which each woman works are ventilators which I found aspirating well. The women are healthy. A special form of the ordinary "Belgian" match is made in this factory which contains the maximum of white phosphorus allowed by law, and which is packed in round boxes. As this requires a good deal of handling, and the process is regarded as dangerous, the work is done by men only. The men and women occupy different sides of the same room. It is found that the men who do this kind of work best are Flemish, while the women and girls are Walloons. In the process of boxing the "Belgian" matches frequently take fire or smoulder, and this the men extinguish by the naked hand, not a safe procedure, but one which I was informed had not been followed by any bad effects.

Safety Matches.

These matches are first tipped in paraffin kept in a molten state in a heated tank. Men do the dipping. Subsequently the matches are dipped in chlorate of potassium paste, the mixing of which is done in an iron vase in a well ventilated room.

The red phosphorus paste is applied to the sides of the match box by machinery. One girl places the boxes on end seriatim, in a long iron canal with moveable floor, and as these boxes travel onwards they reach a part of the machine where they receive a coating of amorphous phosphorus paste and again pass onwards. Underneath the floor of the canal is an iron pipe which is heated in winter so that the match boxes as they are taken off by the receiver are perfectly dry. 150,000 boxes of safeties are thus coated daily.

The safeties are packed in this room. In the boxing room for safety matches, 40 women and girls are employed; 25 millions of matches are made daily in the factory, of these 10 millions are safeties, and 15 millions are made from white phosphorus. 130 kilos (286 lbs.) of white phosphorus are used every month, and about an equal quantity of amorphous. No gargle is provided for the workers, and although washing appliances are provided M. Mertens states that he has considerable difficulty in getting the workpeople to wash before leaving the factory. There is the usual monthly medical visit to the works by the doctor. I examined the Medical Register and found that two women in July were obliged to have some teeth extracted. Turning over the pages of the register I found no notice of even any minor ailment until November 1897, when one case of carious teeth and toothache is reported, another in September, one in August, and none in July 1897, so that five cases of painful carious teeth were recorded during a year. No case of necrosis. M. Mertens employs 300 hands, of these 200 are women

and girls. During the last 10 years two cases of necrosis have occurred, neither of which was fatal, both were women 25 to 30 years of age. This was four years ago, and they are still on the sick list, and are drawing an allowance from the proprietor of 10 francs a fortnight.

Grammont.

On the 13th August 1898, along with M. Brughmans I visited Grammont, the principal seat of the match industry in Belgium. In this town there are six factories giving employment to upwards of 1,100 persons.

The Belgian Match Company.

In this factory, one of the oldest, for it was built in 1847, there are 320 people employed, of whom 180 are women and girls; 86 of these women make safety matches, and 28 make ordinary lucifers. Formerly, when ordinary lucifers were made, 25 per cent. of white phosphorus was used in the paste. In 1850 four of the men who dipped suffered rather severely from necrosis of the jaw bones. These men are still employed in the works, although 40 years have elapsed since the date of their illness. Twenty years ago the firm began to use only eight per cent. of phosphorus and subsequently 6·5 per cent., and during these two decades there has been no case of phosphorus necrosis. Dr. Van Heghe of Grammont visits the works once a month, examines all persons employed in the dangerous processes, and enters the visit in a register. Three kinds of matches were formerly made: (1) safeties; (2) paraffin tipped and containing 8 or 6·5 per cent. of white phosphorus; (3) the ordinary "Belgian" match dipped in paste containing 22 to 25 per cent. of white phosphorus. They have discontinued the manufacture of the "Belgian" match. No vestas are made. 100 kilos (220 lbs.) of white phosphorus are used every month, and 150 kilos (330 lbs.) of red or amorphous phosphorus. Of the paraffined white phosphorus match, 80,000 boxes are made daily, and of safeties 260,000 boxes daily. No gargle is provided by the firm, but water, soap, and towels are. I did not see the lavatory owing to structural alterations which were taking place. The women and girls in the boxing department can make as wages 2½ francs daily.

Safety Matches.

Dipping.—This is done on a revolving table. After being dipped the trays of matches are run into the drying chamber at the other end of the room.

Boxing.—Only women and girls, 86 in number, are employed in this room; each can fill about 4,000 boxes a day, and is paid at the rate of 20 centimes for every 400 boxes. A statement as to the rate of wages for work done is posted up in every room. The wages are paid fortnightly. The room in which the boxing was done was the uppermost in the building; it was extremely hot, and its atmosphere was polluted by the ascent of air from the working room beneath through wide open gratings in the floor. The lower room ventilated into the upper—rather an objectionable proceeding.

The red phosphorus paste is applied to the sides of the boxes by means of machinery similar to that mentioned under Lessines, only successions of match boxes three abreast, instead of two, keep moving along the canal. A boy feeds the machine at one end and another boy receives the match boxes at the other end, each paid 10 centimes for 1,000 boxes pasted.

Paraffined and White Phosphorus Matches.

These matches are dipped in paste containing 6·5 per cent of white phosphorus. They are dipped on an iron slab, above which is a ventilator going up through the roof. Two men were thus engaged, one had worked 20 years and had never been ill, the other two years and had always been healthy.

The boxing is done by women and girls in a good room, clean and cool. Twenty-eight women were working; there was no girl under 16 years of age. The wages are 30 centimes for 400 boxes filled. All the women and girls looked healthy. I examined a few taken at random, *e.g.*, Amandan Van Den Neucker, 28 years of age, single; has worked 10 years in the boxing room, is healthy. She has, however, several decayed teeth in the lower jaw, but these have never caused her pain. Her teeth are brittle, they break readily and fall off. By chance the next girl I examined was the sister of the above. She was healthy-looking, 19 years of age, had worked in the factory for six years, had excellent teeth. A married woman, age 22 years, Adolphine Mertens, has worked two years in the boxing department and seven years among the safeties. Three of her teeth had been extracted, those that remained were good.

The *boxing* room is ventilated solely by open windows; no means are adopted to remove the fumes from the tables where the boxes are filled, and there are neither wet cloths nor pails of water in the room to extinguish matches that have become ignited. I examined the hands of several of the women; they smelt strongly of phosphorus, and were deeply stained from the dye off the match heads.

The mixing of both forms of phosphorus paste is done by one man by hand in iron vessels in an open shed. The white phosphorus paste is subsequently poured into iron basins and kept there, exposed, until required. The man who mixes has done the work for 11 years; he looks healthy; the teeth in his upper jaw are good, two of those in the lower are carious.

I had the opportunity of examining two of the four men who 40 years ago suffered from necrosis of the jaw bones. Joseph Surdiacourt, aged 64 years, was formerly a dipper, but for several years past has been a wood cutter in the factory. In 1857 he had necrosis of the jaw. Several of this teeth fell out, and with these a piece of dead bone came away. Twice he went into the hospital in Brussels with a view to being operated upon for his necrosis, but the surgeons declined to interfere. Subsequently the diseased piece of bone came away itself. He was ill for 14 months. He looks thin, but is otherwise a tough healthy old man, with only five teeth left in his mouth, both jaw bones having been affected.

Joseph Ritsman, 72 years of age, formerly a dipper, suffered from phosphor necrosis in 1859; he was ill for 14 months. He lost a large portion of his left upper jaw, in which there can still be observed a deep hollow; he has only two teeth left; is now a wood cutter. I did not examine the other two old men who were also employed as wood cutters in the factory, but the above confirms what we know of these cases that phosphor necrosis is often only a local affection, and not the localised expression of a generalised diseased state or phosphorisme, and that once the illness is recovered from, individuals may return apparently with safety to work in the non-dangerous departments of a match factory and with prospects of longevity equal to those of other healthy people of their own age.

Match Works of M. Antoine Hoebeke.

This factory gives employment to 400 persons; of these 300 are women and girls. The works were built in 1870. There has never been a case of necrosis, and no minor ailments of any moment among the workpeople. There have been no suspensions except for accidents. The freedom from illness is attributed to the fact that on the slightest complaint of toothache the worker is at once seen by the doctor, and sent to some other department in the factory rather than suspended.

No vestas are made, only the ordinary splints and safeties. 300 kilos (660 lbs.) of white phosphorus are used every month, and 150 kilos (330 lbs.) of red. No gargles are provided, the lavatory is undergoing repair.

I examined the medical register, scanned the Doctor's entries for several months, and found all satisfactory.

Grammont Hospital and Local Medical Testimony.

Along with Dr. De Cooman and M. Brughmans I visited the Grammont Hospital, a large institution with 300 beds, but we found no case of necrosis in the building.

We called upon Dr. Brocoorens, principal physician to the hospital. I considered it very desirable that this gentleman should be visited as he has had a larger experience of phosphorus necrosis than perhaps any one in Belgium. Besides he gave very important evidence before the Commission appointed by the French Government in 1896, to inquire into the dangers of match making. Dr. Brocoorens kindly gave me all the assistance possible. He informed me that during 1897 there had only been one fatal case of necrosis, and that while the death occurred in Grammont Hospital the man who was a dipper came from Nederbrackel. With this exception there has been no case of phosphor is necrosis in Grammont since 1895. Between 1860 and 1895, there were 34 cases of phosphor necrosis, 11 of which ended fatally. The deaths occurred between 1860 and 1875, at a period when hygienic methods had not been introduced into the factories. Since the Royal Decree, 25th March 1890, making ventilation obligatory, and reducing to 10 per cent. the amount of phosphorus in the paste, and insisting upon regular and systematic factory inspection, necrosis has become rare. During 25 years Dr. Brocoorens treated 30 cases of spontaneous fracture of bone, caused by muscular effort, affecting exclusively the lower limbs in workmen employed for many years either as dippers, or in the dangerous departments, and who had also suffered from necrosis of the jaw.

Anderlicht.

The match factory of Messrs. Mariotte and Company. Here only vestas are made. About 100 kilos (220 lbs.) of white phosphorus are used every month. The firm employs 200 women and girls and 13 men.

The factory was built in 1869. There has only been one case of necrosis, that of a woman in 1890, who systematically avoided the medical inspection.

Mixing Room.—One man mixes the paste in open vases which are covered with a hood. The fumes of phosphorus are thus removed, and do not reach the workmen. The room is well ventilated. Formerly the firm used 7 per cent. of white phosphorus in the paste, at the present time only 3 to 4 per cent.

Dipping Room.—Six women perform the dipping of the vestas, but they only do this work for a very short period. They keep changing into other departments. The matches are dipped on an iron slab, the distal end of which extends under a hood up through which the air is aspirated, and escapes by a ventilating pipe in the roof. The one case of necrosis alluded to occurred in a woman, who dipped, and who was in the habit of bringing her meals into this room, keeping them on the edge of the slab and eating while working.

The drying chambers lead out of the dipping room. They are built of brick, closed by means of iron doors and are well ventilated, the circulating air escapes by the roof.

The boxing of the matches is done in the far end of the mixing room. In front of the table of each woman is a ventilator with good draught.

Since the occurrence of the crse of necrosis in 1890, no food is allowed to be taken into the workrooms. A dining room has been provided which is very clean, well kept, very accessible, and heated by a stove in winter.

This room also serves as the vestiary. All the women seemed healthy. The floors of the various rooms are cleansed and sanded every day by one woman kept for the purpose.

I examined the medical register and found everything satisfactory.

State Medical Inspection of Factories.

In addition to the local doctor, who once a month visits the match factories, and who is paid by the employer, medical men are appointed as factory inspectors. Of these, there are five. They are in the employment of the State, and are not allowed to practice their profession. The medical inspectors are distributed thus—(*a*) for East and West Flanders: (*b*) Brabant, Antwerp, and Limbourg; (*c*) Liege, Verviers, and Luxembourg; (*d*) Hainault and Namur; (*e*) Central administration. The principal Medical Factory Inspector lives in Brussels, and is connected with the Central Administration.

Some of the Duties of Medical Factory Inspectors.

Should an ordinary factory inspector in the course of his visits observe any flaw either in the processes of manufacture, or a defect in the machinery, the continuance of which he regards as prejudicial to health, it is his duty to communicate his opinion to the medical factory inspector for the district who is expected to make an early visit to the works notified. If the medical factory inspector detects nothing wrong, no report is made, but if the defects alluded to by the factory inspector are such as to be considered serious by his medical colleague, the latter reports to the chief inspector of the district and suggests certain alterations. This entails a visit by this gentleman to the factory, and, if his opinion corroborates that of the other inspectors, a report is sent to the Governor of the province, usually the Prefect, who submits the facts to a permanent board composed of six members nominated by the Council of the province. An injunction is taken out against the employer, and the inspector is authorised to carry out the suggested improvements, the employer's wishes in the matter practically never being consulted at all.

All the matchworks in Belgium are under State supervision. The same laws apply to all, but each factory can in addition frame its own special regulations. Cases of phosphor necrosis are not reported as in England to the factory department. They are simply entered by the local visiting doctor in the monthly medical register kept in the factory. The Ministry of Labour, therefore, has no immediate knowledge of the amount of phosphorus poisoning, or of necrosis, that may be present at any particular time in the match factories. All accidents in matchworks are reported, except those where the patient recovers within eight days.

Assurance of Matchworkers.

In one of the match factories which I visited, there is an accident fund, part of a large insurance society in Brussels, to which the workpeople are compelled to contribute, not by law, but at the request of the employer. The workpeople contribute 1 per cent. of their salary. In the event of death, an amount of money is paid to the dependants equal to 600 times the daily wages the individual was receiving at the date of the accident. For *permanent* incapacity the workman receives 800 times the amount of his wages; for incapacity for a short period one-half of his wages for 200 days. After this period, if the workmen is not better, he has to decide whether he will accept the terms offered under permanent incapacity.

In addition to the above, the workers themselves have instituted a Mutual Benefit Fund, part of a larger benefit society in the country generally, to which each worker

contributes 110 centimes every four weeks, receiving in the event of illness 110 centimes daily, besides medical attendance, so long as he is off work. During the first three months of his illness he receives 110 centimes daily, for the second three months 80 centimes daily, and for the next three months 50 centimes daily. He thus receives an income for nine months. After this period he receives 1 franc every Sunday, and this he gets whether he is being treated at home, in hospital, or in an asylum. In the event of death, the Mutual Benefit Fund pays the funeral expenses. Workers are received into the society any time between the ages of 16 and 42 years. It is an entirely voluntary association, but it is encouraged by the State, which occasionally gives a grant.

In another match factory the employers insure the workers against accidents: the firm pays 1 centime per franc of the wages, and the workers pay the same. The insurance is effected through the Zurich Assurance Society (Swiss). Necrosis occurring in a match worker is regarded as an accident.

There is no insurance against ordinary illness, except by the workers themselves.

The subject of workmen's assurances generally in Belgium, however, is not in such a settled condition as readers may at first suppose. Opinion is divided as to the advantages conferred. It formed the subject of a very important discussion in the Chamber of Representatives as recently as 25th February 1898. According to the law of 1897 on the payment of wages, employers are empowered to make certain deductions from the wages of workers for the purpose of assurance.

It appears that in several instances employers have made two different contracts with insurance societies. By one contract the employer assures in a collective manner the whole of his workpeople against the accidents of the industry in an insurance company which undertakes to pay the indemnity stipulated in the policy for a certain specified premium. This premium becomes a charge upon the wages of the workpeople, the levy being made once a fortnight. In the event of an accident, the insurance company hands over to the employer the indemnity, and this is remitted to the workmen. So far, the Belgian workman has no complaint. But there is a second contract which he maintains is not legitimate. By the side of the contract of "Collective Assurance," many employers are said to have made with the insurance company a second contract, called "Civil responsibility," by which the same insurance company with which has been made the first contract guarantees the employers against all risks of lawsuits which may be directed against them by injured workmen. It was stated in the Belgian Parliament that in this second contract no premium is paid, and that the premium paid for "collective assurance" is sufficient to cover the risks of both contracts. But as the premiums paid for "collective assurance" are derived from the wages of the workpeople, it is claimed by these that the employer has no right to utilise this money other than for the object it was intended. The law of 1887 does not allow the employer to deduct anything from the wages of his workpeople in order to assure himself, and in cases where this is done clearly the workmen should either have some control of the fund or some knowledge of the company with which the insurance has been effected. That information is withheld. The working men, therefore, favour collective assurance only, and do not hesitate to say that the weak point in the law of 16th August 1887 is that, while it allowed deductions to be made from their wages for assurance, it did not give them authority to control the disposal of the money. In his reply to the interpellation the Minister of Labour clearly stated that the only deduction which could be legally made from the wages of a workman by an employer was that represented by the premium paid to the insurance society to guarantee the workman against the risk of accident, and that no deduction could be made from a workman's wages in order to cover the risk of the responsibility of the employer. It was true that the terms of the law had not always been fully complied with, and it was the knowledge of this fact that had obliged him to impose upon factory inspectors the additional duty of seeing that Article VII. of the law of 16th August 1887, which prohibits every kind of deduction other than those which are authorised for objects strictly defined, is rigidly observed. The Minister of Labour had learned that in three establishments the deduction taken from the wages of the workpeople for assurance against accidents was greater than the total premium necessary to pay the insurance society covering "civil responsibility" of employers, and guaranteeing the "collective assurance" of the workpeople against accidents. Legal proceedings were taken against these employers and certain fines were imposed. An Order of 10th June 1896 gives to the factory inspector the right to be made acquainted with all the conditions of the payment of insurance premiums and to exact all necessary information, so that he may be thoroughly convinced that all is done in accordance with law; he is then in a position to state whether the deductions made by the employers exceed the amount of the premium paid for the assurance of the workpeople. I have dwelt thus at length upon this question of workmen's insurance, because there is considerable ignorance of this subject, even in Belgium, as is indicated by the words of the Minister of Labour in closing the debate in the Chamber of Representatives, "It is desirable that these conditions of assurance should be better known among the workpeople themselves."

Review of the Match Industry in Belgium generally.

It was in 1837, exactly 61 years ago, that the manufacture of matches was introduced into Belgium by M. Mertens. Why Belgium has become such an important manufacturer it is impossible to say. Probably the wood grown in the country lent itself at first specially to the making of matches; if so, the wood has long gone, for nearly all the manufacturers now obtain their supply from Russia. An industry so large and so dangerous to health could scarcely have continued without from time to time attracting the attention of the Government. In a report on match factories using white phosphorus by M. J. Henrotte, Principal Inspector, and published in the "Rapports Annuels de l'Inspection du Travail," 1896, the subject of the match industry generally is dealt with. From it I learn that in 1880 the Superior Council of Hygiene proposed to proscribe absolutely the employment of white phosphorus, but on inquiry it was demonstrated that, however desirable this interdiction might be, it could not be carried out immediately without inflicting grave injury upon the manufacture of matches. Temporary measures, therefore, were adopted, in the hope of reducing to a minimum the dangers incurred by workpeople, as witness the Royal Decree 26th March 1890. These measures consisted in so conducting the manufacture as to insure proper internal hygienic conditions in the factories, and to limit to 8 or 10 per cent., according as the dipping was done hot or cold, the amount of white phosphorus in the paste. In view of placing Belgian makers and foreign manufacturers on the same footing, it also stipulated, that no matches should be allowed into the country that contained more than the regulation quantity of phosphorus. The results were not satisfactory. Matches containing more than 10 per cent of phosphorus did find their way into the country, and the home manufacturers did not always find it easy to comply with requirements; besides the matches made were not so good. As the hygienic regulations stated in the Order of March 1890 were also not favourably received by the manufacturers, it was considered desirable to put an end to a state of things which after all had not worked satisfactorily. The Minister in 1894 instituted an inquiry as to how and what measures should be taken in order to restrain employment of white phosphorus in large proportions. The Factory Department at this period had been re-organised and to it was entrusted this inquiry, in the course of which it was ascertained that both employers and workpeople were favourable to regulations restraining the quantity of white phosphorus. The question of the complete suppression of this substance, which so many hygienists regard as the only remedy for phosphorism, was again studied, and in a fresh manner.

Scheme for the Radical Suppression of White Phosphorus.

If we except four factories of little importance, there are 13 match works in full activity, which were giving two years ago occupation to 2,600 workpeople of all ages. The centre of the industry is Grammont, in which 1,150 workpeople find employment in six match factories. About one half of the total workpeople employed throughout the country in the industry, viz., 1,308, is protected by the law of 1889, which regulates the labour of women, young people, and children. The distribution of these protected persons is as follows:—

Children of 12–14 years	boys, 104 girls, 167
„ 14–16 „	boys, 122 girls, 265
Girls and women 16–21	650
	1,308

Four kinds of matches are made:—

(1.) The "Belgian," sometimes called the phosphorus match.
(2.) "English."
(3.) "Vestas."
(4.) "Swedish" or "safeties."

The "Belgian" match is truly the national match. Its end is first tipped with sulphur, and while the head formerly contained 30 to 40 per cent. of white phosphorus, to-day the paste ought according to law to contain only 8 to 10 per cent. About 400 people, divided over 11 factories, are employed in making this match. At the end of 1894, nearly 200 workers were occupied in one factory alone in making this type of match for consumption abroad, but its exportation was only a temporary matter, for, as a rule, no foreign country buys the "Belgian" match.

The "English" match is also made from white phosphorus; instead of being dipped first in sulphur it is paraffined; it crepitates strongly when struck. In the dry state the paste of these matches contains from 5 to 6 per cent. of white phosphorus, very exceptionally 7 to 7½ per cent.

The "English" match is not consumed in Belgium: it is exported in large quantities to England and her colonies. About 650 workpeople, spread over seven factories, are employed in the manufacture of this match for exportation.

The paste for "Vestas" contains as the maximum 8 per cent. of white phosphorus. This match gives employment to nearly 400 workpeople, spread over two factories, and is not consumed in Belgium except in very small quantities. It is exported to England and other foreign countries.

The number of workers of all ages and of both sexes occupied in the manufacture of white phosphorus matches is 1,550, of whom only 500 are engaged in making matches for home consumption. About 1,100 makers of all ages are employed in 10 factories making "Swedish" matches, a manufacture generally admitted to be healthy, since it is the red, and not the white phosphorus that is used therein. More than one-half of the Swedish matches made in Belgium are exported.

When the question of the suppression of the three kinds of matches that contain white phosphorus was submitted to the consideration of the manufacturers, they were unanimous in regard to the retention of those matches destined for exportation. The fear, too, was felt that a large portion of the trade would be expropriated by such an interdiction. The Grammont workers who are employed in filling boxes with "Belgian" matches were afraid of being deprived of their situation if Swedish matches were to replace the "Belgians" for safety matches are boxed by children and young girls. The suppression of the manufacture of "English" matches would have deprived of their daily bread fully 1,000 workers of all ages, and of both sexes; besides, in the absence of an international agreement as to the employment of white phosphorus, other countries would have benefited by the interdiction. The question of the partial suppression of matches consumed at home was also considered, but the Department of Finance was not favourable to the scheme. It remained, therefore, for the Government simply to enforce the regulations bearing upon the hygiene of factories, the terms of which appear in the Royal Decree of 11th February 1895, and which are mainly 8 per cent. of white phosphorus in the paste, obligatory medical visits, and the exercise of cleanliness on the part of the workpeople. The monthly medical visit to the workpeople by a doctor paid by the employer has been satisfactory. Some employers, it is true, complained of the expense thus imposed upon them, but in my visits to the various factories I heard nothing but approval of this medical inspection. Some of the factories which I visited had arranged dining-room, vestiary, and suitable washing places; in others the lavatories either did not exist or were undergoing repair. In Belgium as elsewhere, certain employers maintain that the workpeople themselves are unwilling to take the proper precautions, and there is at times doubtless some truth in the statement. If manufacturers, however, would only make lavatories more comfortable, workpeople would wash themselves more readily, and would probably never leave the factory without complying with this requirement.

What is Belgium doing still to improve the Industry.

We have seen that Belgium has reduced to 8 per cent. the amount of white phosphorus in the paste, has introduced certain hygienic regulations, and an obligatory monthly medical examination of the workers.

To give practical proof of her desire to make match making a healthy industry the Government has offered a prize of 50,000 francs for a satisfactory "sans phosphore" match, to be awarded any time after 1st January, 1899.

Belgium Prize.

The conditions under which this prize is to be awarded have already been published in the Annual Report of the Chief Inspector of Factories, 1897, but for the sake of reference and applicability they are briefly reproduced here.

The paste must present such resistance to shock or friction as is necessary to avoid dangerous explosions during manufacture. It must contain no substance which either by its fumes or otherwise can be dangerous, during manufacture, to the health of the workpeople. The matches made from it must be capable of striking upon any surface, even upon cloth, and when submitted to alternations of moisture and dryness, heat and cold, within limits, shall sufficiently preserve their inflammability, and not be liable to spontaneous decomposition. During the act of ignition the matches must not throw off anything capable of burning any person or of setting fire to anything, nor must they evolve poisonous fumes. Preference will be given to matches the paste of which does not contain any poisonous substance. The matches must also be so insensitive to friction that they cannot under ordinary conditions become ignited when carried in the pocket—must be capable of transport, and of being stored, without danger. The inventors are to send in before 1st January 1899, under seal, their name and residence as well as their motto, which is also to appear on the boxes. They are to furnish 250 grammes of paste in the moist state in a proper receptacle as ordained, and 10,000 matches packed in boxes, each box to contain 500 matches. The communications are to be sent to

M. Woeste, President of the Commission, the Ministry of Labour, Brussels. The inventor must give proof that the matches can become an industrial article, and that he is willing to stay in Belgium and manufacture at least 1,000,000 matches in the presence of the Commission or of its delegates. The Commission reserves to itself the right to extend the time of the competition.

The origin of the prize is interesting. At the commencement of the year 1897 a Bill was introduced into the Legislature which dealt among other things, with the tabulation of Dangerous Trades. Each worker in a trade regarded as dangerous was to be supplied with a copy of the regulations of that industry, and with information bearing upon the dangers of the trade and how they might be avoided. As the Bill did not pass these trades have not been scheduled, but it is currently believed that before another Parliamentary Session is over this Bill will have become law. It was when this matter was before the Chamber of Representatives that the member for Lessines raised the question of the necessity for improving the hygienic conditions under which matches are made. One of the members for Brussels supported him and proposed an amendment to the Budget, the outcome of which was that the Minister of Labour was obliged to institute the Competitive Prize. The Government was opposed to the procedure, but the measure was carried in both chambers. It is only right to add that the objection of the Government to the scheme was not so much upon principle as upon the improbability of anything like useful results being obtained. The match makers generally throughout Belgium have viewed the matter with indifference. The Commission appointed to adjudicate and award the prize is composed of:—

M. Woeste, Minister of State, President of the Commission.
„ Thienpoint, Member of Chamber of Representatives.
„ Depaire, Professor of Chemistry.
„ Blaes.
„ Gody, a Military Officer and Professor of Explosives at the Military College.
„ Spring, Professor of Chemistry.
„ B. Mertens, match manufacturer, Lessines.
„ Van Overstraete,
„ Henrotte,
„ Keyser,
} Government Officials in the Labour Department.

With M. Mertens, of Lessines, who is the only practical match maker on this Commission, I had a lengthened conversation as to the prospects of a suitable match being produced without the use of white phosphorus. He has given me his views in writing but beyond stating that he is extremely hopeful, and believes that already one paste, at any rate, has been invented that meets all requirements, I do not feel that I am at liberty either to anticipate the decision of the Commission or to compromise any of its members by giving the information I have received. It may be stated here that the Belgian prize of 50,000 francs is not the first occasion upon which a Government has offered a gift of money to inventors for this purpose. The French Government, some time ago, offered 50,000 francs as a subsidy—not to the inventor simply to be pocketed, but to be applied to researches that gave promise of the production of a "sans phosphore" match.

Decline of Phosphorus Necrosis.

On looking back over the history of the manufacture of matches in Belgium it will be observed that 30 or 40 years ago employers were under no State supervision, and that the paste frequently contained 30 per cent. of white phosphorus. It was a period when men embarked upon the industry, often without adequate capital, so that buildings were erected or transformed that were totally unfitted for the purpose of the trade, and which it was impossible to render sanitary. It is with match making, as with other trades: if money is not sunk in good plant and well-constructed factories, the employées suffer proportionally. This has been the case in Belgium. Since the introduction of hygienic measures, and a legal maximum of 8 per cent. of white phosphorus in the paste, there has been a gradual disappearance of necrosis. M. Mertens has questioned the relationship between the decline of necrosis and the reduction of white phosphorus in the paste. In his opinion a paste containing 8 per cent. of white phosphorus gives off as much fume as the older pastes owing to its more porous consistence compared to the vitreous character of the latter. In this opinion he is not supported by other manufacturers, such as the Belgian Match Company, Caussemille, Roche, and Company, nor does medical experience confirm it. The testimony of Dr. Brocoorens, of Grammont, is on this point suggestive. It was in the period between 1860 and 1875 that phosphorus necrosis played sad havoc with the Belgian match workers. Since then the manufacture in larger quantities of Swedish or safety matches, improvement in the hygienic surroundings, a reduction in the amount of white phosphorus in the paste, and an obligatory medical inspection, have together contributed to such a marked declension in the amount of phosphor necrosis, that in Grammont, for example, where a few years ago there were always cases of necrosis, none at present exists. With the disappearance of necrosis there has also been a declension in the number of cases of the milder forms of

phosphorus poisoning. Owing to the monthly medical examinations, workers who are beginning to suffer are at once treated, and either suspended or transferred to another department in the factory where there is no danger. This has been attended by the happiest results.

The gradual disappearance of necrosis, and the good health of the employed, bear testimony to the beneficial influence of factory legislation in Belgium. The Government attributes these good results to improved methods of manufacture, reduced per-centage of phosphorus in the paste, removal of the air of workrooms by aspiration and cleanliness on the part of workpeople, the provision of means whereby this can be secured, and a monthly medical inspection. In some of the factories all these precautions have been so thoroughly developed that they indicate how the dangers of an unhealthy industry may, practically speaking, be abolished.

THOMAS OLIVER.

REPORT

TO THE SECRETARY OF STATE FOR THE HOME DEPARTMENT

ON THE

USE OF PHOSPHORUS IN THE MANUFACTURE OF LUCIFER MATCHES, WITH SPECIAL REFERENCE TO THE DENTAL ASPECT OF THE QUESTION;

BY

GEORGE CUNNINGHAM,

M.A. (CANTAB.), L.D.S. (ENG.), D.M.D. (HARVARD),

SENIOR DENTAL SURGEON TO THE LONDON HOSPITAL.

TABLE OF CONTENTS.

APPENDICES.

To the Right Honourable Sir Mathew White Ridley, Bart., M.P.,
Secretary of State for the Home Department.

Sir, 23rd January 1899.

I have the honour to present to you the accompanying Report on the present condition of the Yellow Phosphorus Match-Making Industry with Special Reference to the Dental Aspect of the Question, which has never yet received, except in France and America, the attention which its importance demands.

It is gratfying to know that most of the recommendations I make have already been adopted by the Diamond Match Company, and Messrs. Bryant and May, Limited, which leads me to hope that any steps you may take to give them effect will be equally well received by other manufacturers.

I cannot conclude without thanking the workpeople at the various factories, who voluntarily underwent the necessary dental examinations. This readiness inspires the hope that they will realise the importance of the care of the teeth in regard to their general health, as well as to the subject of the present inquiry.

I am, Sir,

Your obedient servant,

2, King's Parade, Cambridge. Geo. Cunningham.
(30, Harley Street, London.)

REPORT.

I.—HISTORY OF THE PHOSPHORUS MATCH INDUSTRY AND THE ORIGIN OF PHOSPHORUS NECROSIS.

Before I proceed to deal with the dental aspect of phosphorus necrosis, it is, I think, necessary to call attention to some of the literature upon the subject, especially to certain reports in connexion with public health.

The manufacture of lucifer matches is not an industry of very long standing. The first friction matches, called "Congreves," and invented by Walker, about 1827, contained no phosphorus, and consisted of strips of stout cardboard or thin wooden splints, coated at one end with sulphur, and tipped with a mixture of antimony sulphide, potassium chlorate, and gum. "Promethians," which followed, also contained no phosphorus, and it appears that yellow phosphorus did not come into use for match-making till about the year 1833, in consequence chiefly of the discovery of Preschel. At first the chief seat of the trade was Austria and Southern Germany.

Safety matches appear to have been invented by Lundström in 1845. They were first made practicable in this country about the year 1855, by Messrs. Bryant & May, who have continued to make them, but the patents having expired, they are now also made by others.

Their main peculiarity consists in the separation of the phosphorus from the other ingredients by painting it upon the outside of the box, and as, for this purpose, the amorphous red or harmless phosphorus is equally efficient with yellow phosphorus and has no smell, the red sort only is employed. Thus they are safety matches in more senses than one; for they are safe to make as well as to use. It is unfortunate, however, that the public do not like them. Most people seem to prefer to carry loose matches about with them in their pockets, and ignite them on the walls of rooms, or their trousers, or on the furniture; and, though no available statistics exist on the subject, it is certain that the number of strike-anywhere matches which are sold very largely exceeds that of safety matches. In France only 8 out of the 28 milliards of matches made annually are safety matches; and so far as I have been able to gather from manufacturers, the matches consumed in this country are in about the same proportion.

Besides the manufacture of matches for home consumption, they are also made for exportation. I am informed that "safety matches" do not stand well in moist climates. This, therefore, gives an additional stimulus to the manufacture of non-safety matches with yellow phosphorus.

It may be inquired why, if red phosphorus is of the same chemical composition as yellow, it cannot be used in the heads of the ordinary strike-anywhere match. The answer, I believe, is, that it is practically impossible to mix red phosphorus with chlorate of potash in bulk, and that, though many attempts have been made, no one has yet succeeded in producing a combination of these indispensible ingredients with safety.

The record of phosphorus necrosis only seems to date back to 1839, when the first-recorded case occurred in Germany.

I am unable to say at what date the manufacture of phosphorus matches commenced in England, but it appears that the first-recorded case of phosphorus necrosis was in December 1846.

Therefore the continental experience of this disease dates back about 60 years, while our English experience of it extends over about half a century.

As it occurred earliest and in its most severe forms on the Continent, it is natural to find that the first medical notices of it occur in German works.

such as those of Lorinser, Heyfelder, and that of Von Bibra and Geist in 1847. In later years the subject has been exhaustively treated by such eminent authorities in France as Roussel, Trélat, Magitot, and Arnaud, and very many others.

In English there appeared several monographs at various dates, but all of them are summarised in and superseded by the admirable report prepared in 1862 by Bristowe, and published in the fifth report of the Medical Officer of the Privy Council.

This report is so exhaustive and complete that it leaves little to be said upon the medical aspect of the question in those times. As, however, there are certain very important parts of it upon which modern opinion differs, and which I shall have to submit are not well founded, it seems desirable that in the course of my remarks I should give some quotations from it and refer to some of the conclusions put forward, especially as it is now out of print and not very easily procurable.

The trades which deal with phosphorus remain much as they were in Bristowe's time, except as regards those improvements which have been brought about by the progress of inventions.

They are (A.) production of phosphorus; (B.) the manufacture of matches; and (C.) the preparation of certain vermin-killing pastes.

(A.) The Production of Phosphorus.

In 1862 the making of phosphorus was only carried on by two firms, Albright and Wilson, of Oldbury, and Eden, Jones, and Company, of Bristol. I believe the former of these firms is the only one now remaining by which phosphorus is made in this country. The phosphorus used to be prepared from bones, the inorganic basis of which is phosphate of lime, but is now made from apatite, a pure form of mineral phosphate of lime, combined with either calcium fluoride or calcium chloride. Originally the stick shape in which phosphorus was and still is sold was produced by sucking with the breath the melted yellow phosphorus into glass tubes! This process has long been abandoned. I shall presently give some statistics relative to the health of the workers in Messrs. Albright and Wilson's factory, which has presented in recent years a remarkable freedom from disease. I may add, however, that the trade of phosphorus making is not under the special rules affecting the match-making trades, and it may become a question whether this omission should not be rectified.

Both yellow and amorphous phosphorus, besides other chemicals, are made at these works. The yellow is made by two processes—one, the old plan, of which a pretty full account is given in standard works on applied chemistry, and the other an electrical process; but the principles involved are practically the same.

After milling the mineral phosphates and their treatment by sulphuric acid, the concentrated phosphoric acid liquor is mixed with carbon, and placed in earthenware retorts in a furnace heated by gas to an intense heat. An earthenware pipe connects the mouth of each pot to a receiver, which runs the length of the furnace, and is filled with water, under which the mouth of the pipe opens. The crude phosphorus distils over and is condensed in the water in the receiver.

During the operation phosphorus fumes escape through the joints, but they take fire immediately through the heat of the furnace; part of the furnaceman's duty is to stop up these joints. The rooms are very hot, it being essential that a certain temperature should be maintained.

The crude phosphorus is syphoned off from the receiver into pans and allowed to cool under water. It is next taken to be bleached. For this purpose it is put into large pans and stirred round by machinery, always under water—there appear to be three stages in the bleaching process; in the final one it is broken up in the pan by means of an iron hook and washed under a stream of running water. In this process it continually fires as

pieces are exposed to the air, and a considerable amount of unburnt fumes rise. These pans are very efficiently ventilated, they are half covered in on the side furthest from the attendant, and connected with this cover is a pipe which goes through the roof, a constant draught being maintained by means of a steam jet, so that while some of the fumes come near the man, the greater part are carried out away from him up the ventilating shaft. There is very little smell of phosphorus in this department, except close up to the tanks where a little firing takes place at the stirring. After the phosphorus is bleached it is melted, and while in this state it is drawn by hand through tubes into sticks, which are cut off into the required lengths with scissors. The whole of this latter operation is done under water, the benches are in a large room entirely separated from the bleaching room, and ventilated by three fans in the roof. Three men, who act alternatively drawing and cutting, supply sufficient material to keep one weigher at work. As the latter removes the beautifully clear transparent sticks, as innocent looking and as pretty as so many sticks of barley sugar rock, they fume visibly as they are passed into the open tin can full of water on the weighing machine. After the sticks are thus packed in tins they are sealed up, in water, ready for delivery.

Phosphorus in large quantities is supplied in a different form, being moulded into what are termed and looked like "cheeses," divided into wedge-shaped sections.

A new development is a strong exhaust draught stand-pipe which sucks in the rising fumes. This is an undoubted improvement in what seems the most dangerous part of these works. Naturally the hands of all these finishers smell very strongly of phosphorus.

The weigher, whom I interviewed, told me that he began as a lad at 7*s*. a week fully 21 years ago, he had been 14 years in the finishing shop; he was now 35 years of age, and was earning about 40*s*. per week, and had always enjoyed excellent health.

Some new furnaces, in which electricity is employed as the fusing agent, have been fitted up. I did not notice any fumes coming from them.

Amorphous phosphorus is also made by this firm, by exposing the ordinary yellow phosphorus to continuous heat. By this means the colour changes, becomes red, and the chemical and physical properties of the phosphorus are altered. It acquires also the peculiarity of not being volatile, and thus fumes do not escape from it, and it is probably from this quality that workers with red phosphorus appear not to be subject to necrosis.

Amorphous phosphorus is made from yellow phosphorus by heating it in closed pots. As the gas escapes it ignites and produces fumes. The amorphous phosphorus thus obtained is in hard, compact reddish-brown lumps, somewhat resembling in appearance hematite iron ore. These somewhat brittle lumps are broken up in a mill, and ground into a fine powder, and freed from ordinary phosphorus. It is sent out in the dry state in tin boxes. For ignition, it is said to require a temperature of at least 240° C.

I had an interview with Mr. Wilson, the chairman of the board of directors, in which he dwelt on the long and persistent efforts of Mr. Albright, senior, to introduce amorphous phosphorus as the proper material from which to make matches. He devoted many years to experiment and trial in association with Lundström about 40 years ago, yet to this day the consumption of red phosphorus is comparatively small.

(B.) The Manufacture of Matches.

The largest consumers of phosphorus are the makers of lucifer matches.

Great alterations and numerous improvements have been made since Bristowe's time, notably by the introduction of machinery. As far as I have seen, there are three different systems in use in this country:—

(1.) The coil system of long splints (double matches).
(2.) The frame system of short splints (single matches).
(3.) The continuous match-making machine system.

But the process of mixing, dipping, drying, and boxing are still essentially the same, and therefore the work-people continue to be exposed to the fumes of phosphorus though in a less degree than formerly.

The matches made are of two sorts, (1) what is termed the strike-anywhere match, and (2) the safety match.

I shall leave to those more capable than I am of dealing with the chemical aspects of the question, the task of describing the various compositions used, and the chemical character of the fumes disengaged during the working.

(1.) All I need here say is, that ordinary matches made to strike anywhere are composed of a paste of yellow phosphorus, binoxide of manganese, chlorate of potash, plaster of Paris, or other ingredients, made into a paste with glue, and coloured pink, blue, brown, or yellow, to suit the taste of the purchaser.

The old formulæ, from sheer routine, long contained an exaggerated proportion of yellow phosphorus, even as much as 30 to 40 per cent. (Vallin). Nowadays the per-centage of phosphorus varies from 4 per cent., perhaps, up to 15 per cent. Each manufacturer has his own recipes, but I believe I am correct in saying that the proportions used on the Continent generally are larger than those used in Great Britain, which may be taken as never exceeding 5 per cent., while they are often less. The so-called English matches ("Anglaises") made in Belgium are said to contain 3 per cent. in summer and 5 to 6 in winter or damp weather. In France the proportion varies from 6·5 to 10 per cent. The question of the amount is important, because, as the per-centage of phosphorus increases so also does the danger of necrosis.

The process of making the matches consists—(1) in "mixing" the glue and phosphorus and other ingredients; (2) in spreading the mixture upon warm plates of iron, and then dipping the wood splints into the layer of paste to form the heads, called "dipping"; (3) in "drying," or putting the bundles into a warm room to dry; (4) "boxing," or packing the matches into boxes.

In all these operations the workmen employed come in contact with the fumes, and hence all are dangerous; but the most exposed to risk are the dippers, who are always men.

It may be said that probably more than half the operatives engaged in the match-making trade come within the sphere of the influence of phosphorus fumes, and thus incur a liability to necrosis.

The process is begun by the mixing of the ingredients. The ingredients are mixed in kettles, which are heated by steam, closed with covers, and provided with tubes to carry off the fumes. From these kettles the melted matter is drawn off by a tap, or ladled into copper pails and carried by hand to the place where it is wanted. The men handle the phosphorus in filling the kettles, but the contact is hardly more than momentary.

The dipping is performed by a man opposite whom a large fan is working to carry off the fumes (*see* illustration A, p. 138), or at a table with efficient cross-ventilation.

In some cases a hood is placed opposite the worker, with a fan in the neck of it. The effect of the hood is to direct the draught so as to cause the air to be drawn past the workman and over the phosphorus paste, so as to blow or, rather, suck it away from before him.

The Coil and Frame Systems of Match Making.

The splints of wood are first put into an ingenious machine which rolls them up with a strap,* or places them in rows in a square iron frame,† so that they are all isolated from one another, and kept firmly fixed about one eighth of an inch apart, as it were like pins in a pin-cushion. Some of the hot mixture of glue and phosphorus is then poured upon an iron slab, and a workman passes a straight-edge over the surface, so as to leave an even coating of sticky paste upon the slab. The coils or frames of splints are then brought to him by boys, and he takes them, dabs them down upon the flat surface of the paste, into which they penetrate. Then they are raised up, with a drop of paste adhering to each of the heads, and the coil is

* Coil system of *long* splints or double matches, therefore requiring "cutting down."

† System of shaking *short* splints or single matches into frames, hence there is no necessity for "cutting down."

suspended on a peg or the frame placed in a rack. Thence it is removed by a boy, who takes it into the drying room.

The paste during the operation is warm, and there can be no doubt that fumes are given off in large quantities. Most of those which arise from the dipping table are swept away by the fan, but there must be in the room a considerable quantity arising from the bundles of dipped matches. The drying room must also be full of fumes. One can smell the phosphorus there very distinctly, and the fumes can be also seen in the dark.

The boxing rooms at well-arranged factories, such as those of Bryant and May, or of Bell & Co., are large and well-lighted rooms, and are ventilated by means of fans. The work here consists in releasing the dry matches from the coils or frames in which they had been made and putting them into boxes. If in coils the splints as they come from the dipper are dipped at both ends, so as to produce a long two-headed match. These have to be cut in two, and then the single matches are put into boxes. The cutting is done by a sort of guillotine, worked by hand, and the boxing is hand-work also.

As the matches are nearly dry when in this room, the fumes coming from them must be much less. But, on the other hand, very many of the matches catch fire, and whole bundles of them burn, so that there escapes into the room a considerable quantity of the fumes of ignited phosphorus, principally the pentoxide. I am not able to say in what chemical condition all the phosphorus is. It is probably in the form of some other lower oxides, the nature of which could perhaps be discovered by analysis. Nor am I able, with confidence, to say whether in this shape the phosphorus is less likely to produce necrosis. Probably it is not, but I do not know that any data exist from which the question could be determined, and the subject is not one which can well be investigated by experimental methods.

In any case, it is certain that boxers are attacked by necrosis, although the strength of the phosphorus fumes may only be half, or even less, as much as that in the dipping and drying rooms.

Wax Vestas.—The wax taper is made by passing a large number of strands of cotton through a steam-jacketed tank containing melted stearine, in which is inserted a perforated steel plate. The strands of cotton thread are drawn through the holes in the plate in the tank and wound on huge revolving drums. This operation is repeated some six or seven times until the cotton has received a sufficient coating of wax, the gauge being determined by the size of the holes in the plate. The wax taper is made by the mile, and the process is illustrated at p. 136.

A row of certain lengths of this wax taper is fed into a machine, and cut into the requisite lengths for the size of match required by a travelling knife. These lengths are caught and held in successive rows at the requisite distance from one another in a square iron frame by transverse wooden bars. Each frame contains over 7,000 matches, and is now ready for transport to the "dipping" room. The dipping and drying processes are exactly similar to those employed in "frame" wood match-making.

Whether the coil system of long or the frame system of short plints is adopted, there is absolutely no difference in the exposure to the fumes of phosphorus so far as mixing, dipping, and drying processes are concerned. With regard to the final operation of boxing, however, there is a decided, and in my opinion, a capital difference. Any long splint or double dipped match-making method necessarily involves "cutting down" or halving. In order that this may be done without undue waste to the producer, the matches have had to be manipulated in a relatively moist condition. Whereas, wax vestas can only be boxed when they are thoroughly dried, otherwise their heads would come off in the process of stripping them from the frames.

Wood matches made on the "frame" system must be "bone dry," as they say in the trade, or practically so; that is to say as dry as wax vestas. They are manipulated in the same fashion by stripping the dipped matches from

the frame by the thumb and forefinger and so boxed, the palm of the hand playing little part in the process.

Wood matches made on the "coil" system have hitherto been "cut down" by hand, and have had to be treated in a relatively moist and therefore fuming condition, otherwise there would be much "firing" in the process. Not only so, but in the releasing of the splints from the coils, the amount of firing must increase with the dryness of the dipped splints.

I do not attach so much importance to the further difference that the "frame" made matches are stripped with the thumb and forefingers, while the "coil" made matches have to be boxed, mainly by the palm of the hand, yet there are good grounds for asserting that, so far as manipulation is concerned, there is more danger of absorption through the skin in the case of moist "coil" made matches than by dry "frame" made matches, whether made of wood or wax taper. But I do attach much importance to the difference in exposure to the fumes of phosphorus.

With the "coil" system, there is greater exposure to the fumes, probably the lower oxides of phosphorus, since the matches are not so dry; and there is also a greater amount of "firing" than in the case of either "frame" wood or wax matches, hence a greater exposure to fumes of the higher oxide.

In support of this view, I submit the fact that I have not come across a single case of necrosis amongst the boxers of wax vestas, while there have been several cases amongst the boxers of wood matches.

I have carefully examined the recent improvements of the old "coil" system which will enable the "cutting down" to be done by machinery, and which will allow of long splints or double-ended matches being dried harder, as in the case of wax vestas before being handled by the box fillers. I think this must prove to be of enormous importance in the prevention of necrosis. (Vide Messrs. Bryant and May revisited, p. 139, par. 4.)

A word as to the colour of match heads. It is not without significance. The colours do vary considerably, but they are all equally safe or unsafe, according to the point of view taken on the subject. It is purely a question of dye. The colour must be something like a trade mark, or brand, otherwise how can we explain that in England one town in a county will only buy blue-tipped matches, while the rest of the shire will do with red; that one small part of Ireland will only buy blue, while the rest must have red; that each colony in Australia has a predilection for some special colour of the wax vestas. Even the style of box in which they are put up is forced upon the manufacturer. The same matches sold in this country in the well-known square metal boxes can only find a good market in the colonies if put up in round cardboard boxes. Fashion and local habit and custom are more dominant factors than would at first sight appear, in controlling the character of the matches manufactured, as to shape, size, number, colour, character, and even packing.

I have found that claims for burns are often made by the consumer against the producer. I have seen the detailed evidence in some of these cases, and I can vouch for the fact, that in every one of them only safety matches were the cause; most of them of cheap foreign manufacture.

(2.) The process of making safety matches is very similar, except that instead of putting powdered glass upon the boxes, their sides are painted with a composition of red phosphorus and antimony sulphide. This is done by girls, whose fingers become somewhat dirtied with the phosphorus paste, but I have not heard that any of them have suffered, nor is there any proof that red phosphorus is dangerous at all.

Although the innocuousness of red phosphorus has been long claimed, it ought to be said that, in the opinion of some, it is not absolute. Kobert* asserts that red phosphorus if kept a long time in the damp is gradually changed into yellow phosphorus, and resumes its poisonous character. He quotes a case reported by Lancarstein of a workman who was boxing safety matches for 17 years, and who was attacked by phosphorus necrosis of the

* Handbuch der practischer Gewerbehygiene, Von Dr. H. Albrecht, Berlin, 1896, p. 108.

jaw. I agree in thinking with M. Vallin that this unique case is almost inadmissible; and it is extremely probable that the workman must have had some indirect contact with yellow phosphorus. The danger I believe to be questionable, and this case seems too exceptional to deserve serious attention, but it ought to be mentioned, more especially as it is generally believed that commercial red phosphorus does contain a minute amount of the yellow variety.

The boxing in the case of safety matches is free from fumes, and the matches very rarely ignite. When, however, they do take fire they inflict very nasty burns, for all match-heads that do not contain yellow phosphorus appear to be very violent in their action.

The Continuous Match-making System.

The illustration annexed* shows one of the machines which starts by having wood put in at one end, and almost without the intervention of anyone, turns out the matches filled into boxes at the other.

This process is not quite automatic, for the machine requires tending and looking after, and helping over its difficulties. But it is almost automatic.

The machine consists of five principal parts (as will readily be seen from the accompanying illustration):—

A. Of an apparatus for cutting wood into match splints;
B. „ „ paraffin dipping;
C. „ „ phosphorus dipping;
D. „ „ drying;
E. „ „ filling.

The working process, which is continuous, is as follows:—

Blocks of wood without knots and cut with the grain, 2 inches thick of any length, and suitable for the average length of matches, are fed into the machine, seized and led automatically into the cutting apparatus. The latter cuts out, at every revolution, 48 matches, which are automatically arranged in rows, in series of perforated iron plates which are joined up into a movable endless chain, running the whole length of the machine. The iron plates in this endless chain, which, in the making of these matches, take the place of the ordinary dipping frames, are carried forward with the splints projecting underneath their surfaces. The splints then pass over hot iron plates in order to prepare them for properly absorbing the paraffin, thence through a bath of melted paraffin, and, last, over a roller running in a trough containing the warm phosphorus composition, where they are provided with heads. The matches are now ready to be dried. This is achieved by the chain moving on slowly over a number of large drums, thus bringing them in contact with drafts of dry air, and then returning to the front of the machine, having been 1 hour and 20 minutes in transit. The filling apparatus then pushes the matches out of the endless chain, and they drop automatically into boxes, which move forward in a continuous stream on a revolving table.

One youth attends to the feeding the machine with wood, and one or two boys are sufficient to keep up the feed of boxes.

Attached to each machine is a revolving table on to which the machine delivers the boxes filled with matches, and those other matches which have missed their aim and do not fall into the boxes. The table has usually three sitting and three standing places on a raised platform. As a rule six girls, changing from sitting to standing from time to time, are busy round the table receiving the boxes and putting on the outer cover or slide. Occasionally the matches fire, but are promptly and easily extinguished, and thrust into waste buckets attached to each place at the table. There is, however, much less firing than in the ordinary cutting down process. The matches too are drier, nearly if not quite as dry as wax vestas, and hence there is less fuming and less transference of phosphorus to the hands of the workers. The whole machine might fire, but it is of extremely rare occurrence. I looked in vain for such an accident during my six visits. Even if it did

* This is the illustration facing p. 14.

occur, the persistence of the white fumes must be of short duration, as the air is driven into the room from the ventilating shafts at such a pressure that the atmosphere is said to be completely changed every four and a half minutes. The danger from fire in such a case is minimal, and the automatic sprinklers and the fire hose are ready should they be necessary. Indeed, Mr. George Paton, the local director, offered to give me a practical demonstration by intentionally firing a machine, which offer I refused as a needless waste, as from experience in the relatively harmless flare up of even a large body of ordinary matches, so far as danger from fire is concerned, I was quite prepared to accept his statement of facts.

It is claimed for these continuous machines that they produce matches of excellent quality, at the rate of over 5,000,000 in 10 hours, and that they work independently of the length of the match produced.

The machines for making outside covers of boxes produce from 250–480 coverings per minute, viz., 150,000 to 288,000 pieces in 10 hours. The boxes are printed and sanded, and they leave the machine almost dry.

By means of this machinery, each workman can produce four times as many matches as he could by hand processes, and it is claimed that the waste is much less.

Statistics of those employed.

There are 25 match factories in Great Britain, which employed, in 1896, 617 men, 2,283 women, 390 boys under 18, 1,015 girls under 18, and 6 boys under 14, making a total of 4,311 hands. In 1862 there were about 57 match-making establishments, employing among them upwards of 2,500 hands.

The following tables give the statistics of persons employed as nearly as they can be ascertained :—

Persons Employed.

According to the first, second, and third annual returns of persons employed, the number of workpeople engaged in lucifer match work in 1895, 1896, and 1897 was as follows :—

	1895.	1896.	1897.
Men	589	617	643
Women	2,015	2,283	2,015
	2,604	2,900	2,658
Young Persons, *i.e.*, Persons between the ages of 14 and 18 :			
Male	318	390	425
Female	686	1,015	1,067
	1,004	1,405	1,492
Children, *i.e.*, those under 14 years :			
Male	2	6	2
Female	0	0	0
	2	6	2
Male	909	1,013	1,070
Females	2,701	3,298	3,082
Total	3,610	4,311	4,152
Factories	25	26	25

Many of these, however, are employed in processes which entail on exposure to phosphorus, and in one of the 25 factories no yellow phosphorus is used. According to the figures for 1896, obtained in the course of the recent special inquiry, 1,701 persons were engaged in mixing, dipping, drying, and boxing in 24 factories, that is to say, in the dangerous part of the manufacture. Thus:—

	Mixing, Dipping, and Drying.	Boxing.	All Phosphorus Processes.	All Processes.
Male - - - - -	283	17	300	—
Female - - - - -	247	1,154	1,401	—
Total - - -	530	1,171	1,701	3,770

(C.) The Manufacture of Vermin Pastes.

Among the trades employing yellow phosphorus enumerated by Bristowe, is that of making vermin pastes.

He failed to get permission to see the process of manufacture, or to obtain any trustworthy information concerning it. One manufacturer told him that his firm employed from six to eight persons, who were little, if at all, exposed to the vapours of phosphorus, although they used from 30 to 40 lbs. of phosphorus per week. Bristowe published certain French formulæ which seemed to prove that these pastes usually contained 5 per cent. of phosphorus. From inquiries I have made, it seems that phosphorus is rarely if ever used in vermin pastes now, even when the name of "Phosphor paste" has been retained.

The modern vermin pastes consist of starch or other similar substance, containing small quantities of strychnine and arsenic as the active ingredients, and are coloured with mythelene blue.

II.—NOTES OF VISITS TO VARIOUS MATCH FACTORIES IN ENGLAND.

In order to obtain practical information so as to test the theory that, with the teeth in proper order, necrosis of the jaw cannot take place, and with the further view of endeavouring to discover how far in fact the operatives were exposed to the danger of necrosis, I made a great many visits to various match factories, as well as the only phosphorus works in this country. This took some time, because I deemed it necessary not only to inspect the factories and their general arrangements, but also, in conjunction with my assistants, to make a detailed examination of the teeth of a considerable number of the workpeople.

I was accompanied in some of the visits by Mr. F. M. Farmer, L.D.S.Eng., my principal assistant and *locum tenens* at the London Hospital, and my former pupil, Mr. P. S. Campkin, L.D.S.Eng., and more especially Mr. S. J. Stewart, D.D.S., to whom I wish to make public acknowledgment of the valuable assistance they have afforded me in this inquiry.

Messrs. Albright & Wilson's Yellow and Amorphous Phosphorus Works, Oldbury.

In this section of the works there are four departments in all, and the total number of hands employed is about 100. They work in 10 hour shifts of 5½ days per week for the most part, but where continuous running is required, 8 hour shifts are arranged.

Only adult males are employed in the phosphorus departments.

Mr. Wilson, the chairman of the company, in conjunction with Mr. Gatheral, the manager, conducted me over the whole works, which cover an enormous amount of ground. The phosphorus plant, as a whole, does not occupy one half of the area, as the firm is engaged in the manufacture of other chemicals besides phosphorus.

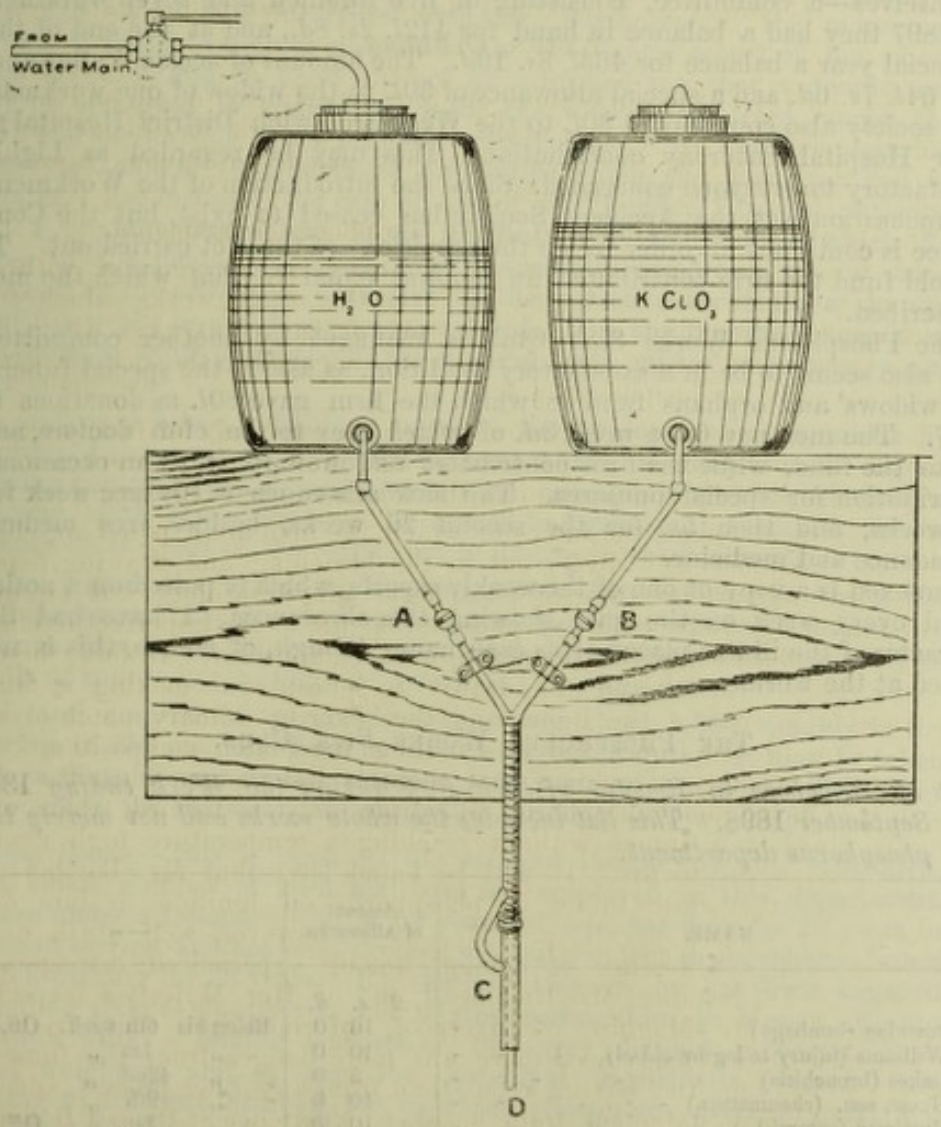
The firm, which was formed into a limited company only for family reasons, takes the keenest interest in the comfort and welfare of its workmen, and many evidences of its popularity with the workmen occurred during my visit.

In the furnace rooms, the fumes to which the men are exposed are chiefly those of phosphoric anhydride, but in the bleaching and drawing departments the fumes are not those of phosphoric anhydride alone, but are made up largely of the lower oxides of phosphorus, due to the imperfect oxidation which takes place below the temperature of combustion. In fact, the condition of the bleacher and the drawer in phosphorus making is almost comparable to that of the dipper and the boxer in ordinary match-making in exposure to the fumes and in handling the match composition. Mr. Gatheral is strongly of opinion that there is less danger when the phosphorus is burnt and phosphoric anhydride only is formed, than when it only glows and fumes without reaching a temperature high enough for the phosphorus to fire. It will be found later that Mr. Bartholomew also regards the white fumes of phosphorus on ignition as innocuous, or relatively so (*see* par. 1, p. 137). It is, however, well worth noting that there is a difference of opinion among experienced managers on this point. For instance, Mr. Richmond, one of Her Majesty's inspectors, reported that Mr. Maguire, of Liverpool, informed him that, from long experience, he was convinced there was more danger from the fumes of ignited matches in the boxing room than from any other process, and that he confirmed that statement from his own experience at the old Boundary Street works of Collard and Kendall. Monsieur Buisson, director of the Paris-Pantin factories, if I remember rightly, and certainly other match-makers, incline to the former view of the comparative innocuity of the fumes of ignited phosphorus.

A study of the returns of the necrosis cases from these works, seems to prove that the dangers from the fumes of ignited phosphorus, are real, and should not be overlooked.

An ingenious apparatus, of which I give a sketch below, has been devised and made in the works laboratory for the use of the mouth-wash by many persons without undue waste, and yet reducing to a minimum any risk of contamination of one worker by another. It consists of two glass barrels, one containing pure water, and the other the chlorate of potash solution. A tube with a stop cork runs from each to join in a single but two-way mouth-piece of glass (C). Before use, the water is turned on at A, and washes the glass tube mouth-piece D; the workman places it in his mouth, turns the mouth-wash tap B, and takes just enough to fill his mouth. The tap is turned, the Y-shaped connexion is hung on a hook, and the ablution of the mouth is completed.

The rubber tubing with which the glass tubing is jointed facilitates handling the mouth-piece with comfort. I tried it, and found it extremely convenient and practical. Such an apparatus is provided in the hut or cabin which is attached to each furnace-room, and is constantly and regularly used by the men. These huts are comfortable, one might almost say cosy. There are eight men to each hut, and the accommodation is commodious. There are two tilt-up basins, with separate supply of hot and cold water, soap, towels, &c. in each hut. The men eat their dinners there, and only, as far as I could see, after very thorough washing. The dinners, which they bring in, I found excellent and nourishing, and in quality far



above any of the workmen's dinners I saw in the match factories. Many of them had beer with their meals. The men are all big and strong, quite above the usual standard, and seem very healthy.

With respect to the precautions taken, anyone who complains of illness is at once temporarily suspended from work; respirators are not used, but in going through the works one occasionally meets a workman (when employed in handling the carbon mixture, which is a state of fine black dust) with a handkerchief tied over his mouth.

There is no special medical examination, but I am informed that many years ago an examination of the teeth was instituted, but as the men objected and gave up coming forward for examination these dental precautions lapsed. A mouth wash made of dilute solution of chlorate of potash is provided by the firm and used by the men.

I am enabled to supply a complete list of the cases of *necrosis* occurring during the last 32 years at this factory which will be cited later on.

I found also an excellent installation of baths, each with a separate dressing room, which the men are encouraged to use, although there are no rules relating thereto, and I could not obtain any statistics showing how much this excellent provision is made use of by the workmen. There was good evidence, however, that the weekly bath is popular with many of them, and that Sunday morning from 6 to 9 a.m. is usually the busy time.

The firm also took a great interest in the Oldbury Phosphorus Works Accident Insurance Society which, from its balance sheet, appears to have been in a very satisfactory and improving condition.

The management of the fund was entirely in the hands of the workmen themselves—a committee, consisting of five foremen and seven workmen. In 1897 they had a balance in hand for 412*l*. 2*s*. 8*d*., and at the end of this financial year a balance for 463*l*. 8*s*. 10*d*. The amount of accident allowance was 54*l*. 7*s*. 6*d*. and a special allowance of 30*l*. to the widow of one workman. The society also contributed 30*l*. to the West Bromwich District Hospital as their Hospital Saturday contribution. This may be regarded as highly satisfactory to everyone concerned. Since the introduction of the Workmen's Compensation Act, the Accident Society has ceased to exist, but the Committee is continued in order to see the provisions of the Act carried out. To the old fund the firm contributed an amount equal to that which the men subscribed.

The Phosphorus Works Sick Club is managed by another committee. This also seems to be in a satisfactory condition, as also is the special funeral and widows' and orphans' fund to which the firm gave 80*l*. as donations in 1897. The men pay 6*d*. a week, 3*d*. of which goes to the club doctors, and 3*d*. to the fund, while the firm contributes 50*l*. annually, with an occasional contribution for special purposes. The sick allowance is 10*s*. per week for 26 weeks, and then 5*s*. for the second 26 weeks, besides free medical attendance and medicine.

Annexed is a copy of one of the weekly reports, which is posted on a notice board every week on the gate, showing the allowances. I have had the character of the illness placed after each name, though, of course, this is not posted at the works:—

THE PHOSPHORUS WORKS SICK CLUB.

List of Members in Receipt of Sick Pay during the Week ending 13*th September* 1898. *This list includes the whole works and not merely the phosphorus department.*

NAME.	Amount of Allowance.				
	£	*s.*	*d.*		
J. Downing (lumbago)		16	0	Being his 6th week.	Off.
T. Williams (injury to leg by chisel)		10	0	„ 1st „	
T. Oakes (bronchitis)		5	0	„ 42nd „	
T. Guest, sen. (rheumatism)		10	0	„ 9th „	
J. Mortimer (catarrh)		10	0	„ 1st „	Off.
W. Haycock (conjunctivitis)		10	0	„ 1st „	
B. Sherwood (cold)	1	0	0	„ 1st & 2nd „	Off.
T. Knott, jun. (catarrh)		11	8	„ 1st	Off.

NAME.	Amount of Allowance.	—
	£ s. d.	
E. Baker (locomotor ataxy) - - - -	5 0	Being his 30th week.
J. Harris (debility) - - - -	5 0	„ 44th „
C. Green (hepatitis) - - - - -	10 0	„ 15th „
G. Skidmore (mitral regurgitation) - -	10 0	„ 5th „
Total - - £	6 2 6	
DECLARED ON.		
J. Chance, Oldbury Road, Spon Lane (injured back).		
C. Parkes, Joining Banks (vertigo).		

JAMES SMALLWOOD,
S. PARTRIDGE,
For the Phosphorus Works Sick Club.

September 14th, 1898.

MESSRS. BRYANT AND MAY.

On Monday, 27th June 1898, I attended at Messrs. Bryant and May's works, and had a long interview with Mr. Bartholomew, the managing director. I found him quite appreciative of the dental aspect of the phosphorus question, and in proof thereof he informed me that a dentist was regularly employed in connexion with the works, but acted under the control and supervision of the regular medical officer. He also took occasion to point out some of the undoubted difficulties which the employer had to encounter. For instance, the case of one of our London Hospital patients, which I brought before him as an illustration of the cases in which the services of the dental practitioner were specially indicated, was at once prejudiced by the erroneous character of the patient's testimony as to the part of the works in which she was employed. She had described herself at the hospital as being employed in the dipping room, where no woman or girl is ever employed.

He indicated other difficulties in which the employer was prejudiced by the action of the employee in directions over which he could see no way of exercising control. I explained the kind of examination which I desired to make, and after some discussion, he agreed to facilitate it, though he feared resistance on the part of the employees to its inquisitorial character.

I also visited the works on Thursday, 30th June 1898. It was a hot close forenoon, and therefore as bad a day as possible. There consequently was more than usual "firing" of the boxes in packing, and especially of the coils of splints in "rolling-off" previous to cutting down.

The total number of workers employed are about 1,300, roughly in the proportion of 250 men and boys to 1,050 women and girls. It may be taken that from 60 to 65 per cent. are engaged in parts of the works where they are exposed to the fumes of, or engaged in handling, yellow phosphorus.

Mixing Room.—This is open to the air, and thoroughly well ventilated. Only a small number of men and boys are employed in this department. They are under a foreman, who is 52 years of age, has been for 13 years in his present service, and has been exposed without accident to phosphorus fumes in match-making for 33 years. For the last 12 years he has been engaged in handling yellow phosphorus and mixing composition in Messrs. Bryant and May's works. Mixing consists of two very distinct processes; first, that of weighing and mixing the principal ingredients, which vary according to different formulæ, but in which phosphorus plays no part; and second, that of mixing the glue and the yellow phosphorus, which has been weighed under water, after being taken direct from the iron drums in which it comes from the manufacturer. The requisite amount of yellow phosphorus and glue is finally added to the first composition. The latter

process alone is that in which danger is possible. The mixing is made in a closed chamber from which the fumes are carried by a ventilating shaft, and from which the phosphorus glue mixture is drawn off as required into a copper pail placed under a hood, also provided with a powerful ventilating shaft. The final addition of this mixture (which contains from 4 to 5 per cent. phosphorus) into the composition is also made under another ventilated hood.

I assisted at a complete operation, and noted the visible withdrawal of the phosphorus fumes from the workman, even from the spindle of the opening valve, into the shafts in the process of drawing off, and also that what little fumes occurred in the mixing were carried up into the capacious hood under which they were mixed. The whole process of drawing off and mixing did not occupy more than three minutes, and owing to the retentive power of the glue, only an occasional bubble indicated the presence of any gaseous product.

It is interesting to note that in this part of the work, which might seem to be one of the most dangerous, it is stated that no case of necrosis had ever occurred amongst the workers.

Dipping and Drying Rooms.—Twenty-five to twenty-six dippers are employed in distributing the phosphorus composition on a heated steel plate called the dipping stone, and dipping the wood coils or wax frames therein. Behind the dipping stone is a strong ventilating fan, which draws the fumes from the large surface of "compo." into the ventilating shaft.

The proportion of wax to wood dippers is as 5 to 20, hence it is not surprising that there are fewer cases of "phossy jaw" among the wax dippers.

Three cases of phosphorus necrosis, now under treatment, have occurred amongst dippers, but it would be incorrect to assume that as an average of 12 per cent. in the absence of information as to the time over which these cases have extended, and the total number of different men employed during that time. The dippers have two days of duty in this department, where they are exposed to the fumes of phosphorus, and one day in which they are occupied by other duties in an innocuous department of the works.

The work of these 25 dippers gives employment to 75 lads, who are occupied in bringing in the "compo." bowls, supplying the dippers with material, and arranging the coils or frames for drying. They are constantly occupied, and exposed day after day to the fumes without any relief in an innocuous department. No case of necrosis has occurred amongst these lads, except in the case of one, aged 20, who had just qualified to be transformed into a dipper.

Washing-places, with soap and a nail brush, are provided; but as the ablutions are performed in two ordinary sinks, in which several persons wash in the same water, better provision to this end might easily be made, though it is not of prime importance.

It is extremely interesting to note in connexion with the special aspect of the present inquiry that, although there is no requirement of the kind under the "Special Rules of the Home Department," Condy's fluid was constantly kept at hand, with which these operatives might wash their mouths. The provision was inadequate, for a single bottle of the fluid was provided for the common use of the dippers and the boys, without any glass or other vessel from which to take it, and defective, because it was so strong as to be extremely nauseous, thus defeating the purpose of the employer.

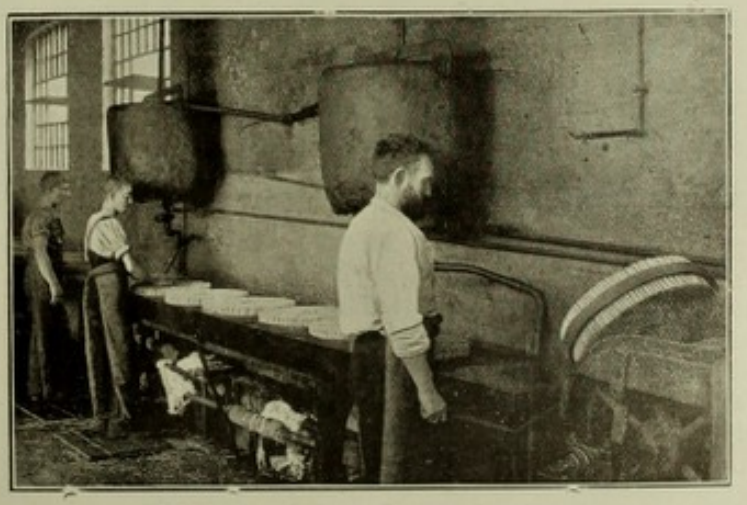
A better and more effective mouth-wash might easily be provided at a comparatively small cost. The presence of this provision is, however, a clear proof of the readiness of the employers to go beyond the provisions of the Special Rules, and also of their recognition of the importance of the dental aspect of the disease and its origin.

In passing from this department to the next, the boxing room, it was noticed that the cleansing (effected by heat) of the bowls used to contain "compo." is usually conducted in the open air; but it is also occasionally carried out in wet weather under cover of a shed open to the air, and in either

(*To face page* 136.)

WAX VESTAS.—TAPER MAKING.

WOOD MATCHES.—EMPTYING THE LEATHER COILS.



WOOD MATCHES.—PARAFFIN DIPPING.

WOOD MATCHES.—BOXING ROOM, CENTRE FACTORY, FAIRFIELD WORKS.

(*To face page* 136.)

case it gives rise to the dense pentoxide fumes which come from the ignition of phosphorus. Mr. Bartholomew himself drew attention to the difference between these fumes and those less visible, but apparently more noxious fumes from the glue phosphorus compound and the finished "compo." itself, stating his belief that the former were non-injurious or relatively so. The chemical report will doubtless throw some light on this question.

Boxing Room.—As already stated the weather was such as to lead to an unusual amount of "firing" as the coils of match splints, coming from the drying room, were being rolled off. This gave rise to an exceptional development of clouds of phosphorus in ignition which, however, were promptly cleared off by the ventilating fans. Phosphorus is sensibly volatile at ordinary temperatures, so that apart from the proximity of the drying room the prolongation of the drying process after the splints are cut down, and the process of packing and storing may still render the atmosphere of the boxing room dangerous. Seven out of the eleven cases at present under treatment, are from this department. Lads are employed to do the rolling off from the machines, while women are exclusively employed in cutting down the double "compo." ended splints into matches. Further on in the same large room women and girls are actively engaged in packing; one boy at the machine providing work for from ten to eleven boxers. They work for five hours at a time, twice a day, with one hour for dinner. All women and girls manipulating the matches get their hands soiled with phosphorus composition, but they are most particular in complying with the rule as to washing their hands before meals and before leaving their works. The question naturally arises, is there any danger from this soiling of the hands? The stains, noticeable on the hands, even after vigorous washing, and even re-washing, as I tested on a subsequent visit, are due entirely to the smoke of burnt matches (brown stain) or to the aniline colour in certain match compositions; and are probably of no real importance. I also examined their finger nails, which are all short from the nature of their work, and are naturally more or less dirty.

I was told that considerable difficulty had occurred at first in inculcating the habit of washing the hands, but that it had now been thoroughly acquired. I am sure that a similiar habit of washing the mouth, equally forcibly inculcated, would be as certainly acquired, and prove, quite apart from its specific value as a "phossy jaw" preventative, of incalculable benefit to the teeth and general health.

In concluding this part of the report I must express my appreciation o the facilities afforded me by Mr. Bartholomew, the manager of the Fairfield Works. He made a point of conducting me personally over the works, and assisted me with all information and such facts and figures as I desired.

Opposite the entrance to the Fairfield Works are four small houses joined into one, bearing the prominent title of "Clifden House Institute and Restaurant for Working Girls. Established 1889." This Institute was founded by Lady Clifden in 1889, with the help of Messrs. Bryant and May and others. Owing to some difficulties in management in its earlier years, it was deemed advisable in 1893 to form a committee representing, first Lady Clifden, second the Union, and third Messrs. Bryant and May; and the work of this joint committee, assisted by Miss Nash, the superintendent, and an efficient staff of workers, has been very successful.

At the Institute girls can have full board and lodging for 6*s*. a week. There are classes in needlework, cookery, reading and writing, arithmetic. drilling, and other subjects, but the chief interest seems centred in the, singing class, which is considered somewhat famous from its successful rivalry in competition with similar classes from other clubs and institutes in London and district.

In the large dining-hall behind the Institute, we found about 100 girls enjoying an excellent meal, well served, amidst pleasant surroundings, It seems a pity that more of the girls do not avail themselves of the advantages offered by this admirable institution, if only for their meals.

Messrs. Bryant and May's Works Revisited.

Since the beginning of this Inquiry I have revisited these works many times, sometimes by appointment, but often not; so that I have seen both the works and the operatives at all hours, in sunshine and in rain, in daylight and at night.

Every facility for independent inquiry has been placed in my way, and any suggestion that I have been able to make has been adopted, so far as practicable.

With regard to the washing of the hands, I can answer for the fact that it is carried out by all the girls in a thorough manner, as I have examined hundreds, both at noon and at night, without discovering a single defaulter. A foreman is always in charge to supervise this matter. The only improvement one could desire would be cleaner nails on the part of some of the girls.

The men set them an excellent example. I have always found the dippers clean to their finger tips. I made special inquiry as to this, as I was informed from a good source that, no matter how perfectly they cleaned their hands and nails, their finger nails were luminous in the dark. I examined several in the dark without stating my purpose, but I could not see any light, and on mentioning that subsequently, the men laughed at the statement.

I also examined the urine of several men, but failed to find any luminosity, nor was I able to come across a single undoubted case of phorescence of the urine.

Some of the out of door wash places have been roofed over, and further protection from inclement weather at other places is being prepared.

Extensive alterations are also in progress in connection with the large dining hall, which will enable the operatives to have their dinners heated up for them, and to be supplied with coffee and soup should they desire either.

In the following description of the alterations, and the improvements made in the present year up to the time of my last visit, 10th November 1898, so far as these parts of the works are concerned, I would especially call attention to two very great improvements: (1) what I may call the new air screen over the dipping stone, and (2) the new method of dealing with the long splints, so that the matches can be boxed dry.

Dipping and Dipping Rooms, &c.

The custom of constantly washing down the floors of dipping rooms with water has been discontinued, and the floors are now strewn with sawdust. This change has produced a distinct improvement in the atmosphere of the dipping rooms.

Blow pipes have been fixed to all dipping stones. The pipe is about 2 inches in diameter and is fixed along the front of the stone and pierced with holes through which air is driven, so that a current passes over the stones from the front. (*See* Illustration A.)

This is considered to be the greatest improvement yet made, and the dippers are enthusiastic as to it. The air, being warm, does not cool the surface of the composition, which would be detrimental. It is found that the air being blown along the surface from the front and attracted up the air shaft by the fan at the back, the fumes cannot possibly rise into the dippers' faces.

The iron racks or trees which stood in the dipping rooms in order that coils might be placed upon them between the periods of first and second dippings have been enclosed, a ventilated air shaft carrying any fumes arising from the coils in the enclosed racks direct into the air. (*See* Illustration B.)

Overalls have been provided for all men and boys who work in the dipping rooms, composition-making rooms, drying rooms, racking-out machines, &c., &c. Clogs have also been provided for all men and boys.

Formerly dippers worked two days on the stone and one day off, but under the fresh arrangements all dippers will work one day on and one day off. This arrangement will work admirably provided the men keep good time, but it is obvious that even with a sufficiently large staff, it may occasionally happen that because of men stopping out, others may have to take a second day on the stone.

(*To face page* 138.)

MESSRS. BRYANT AND MAY'S WORKS REVISITED.

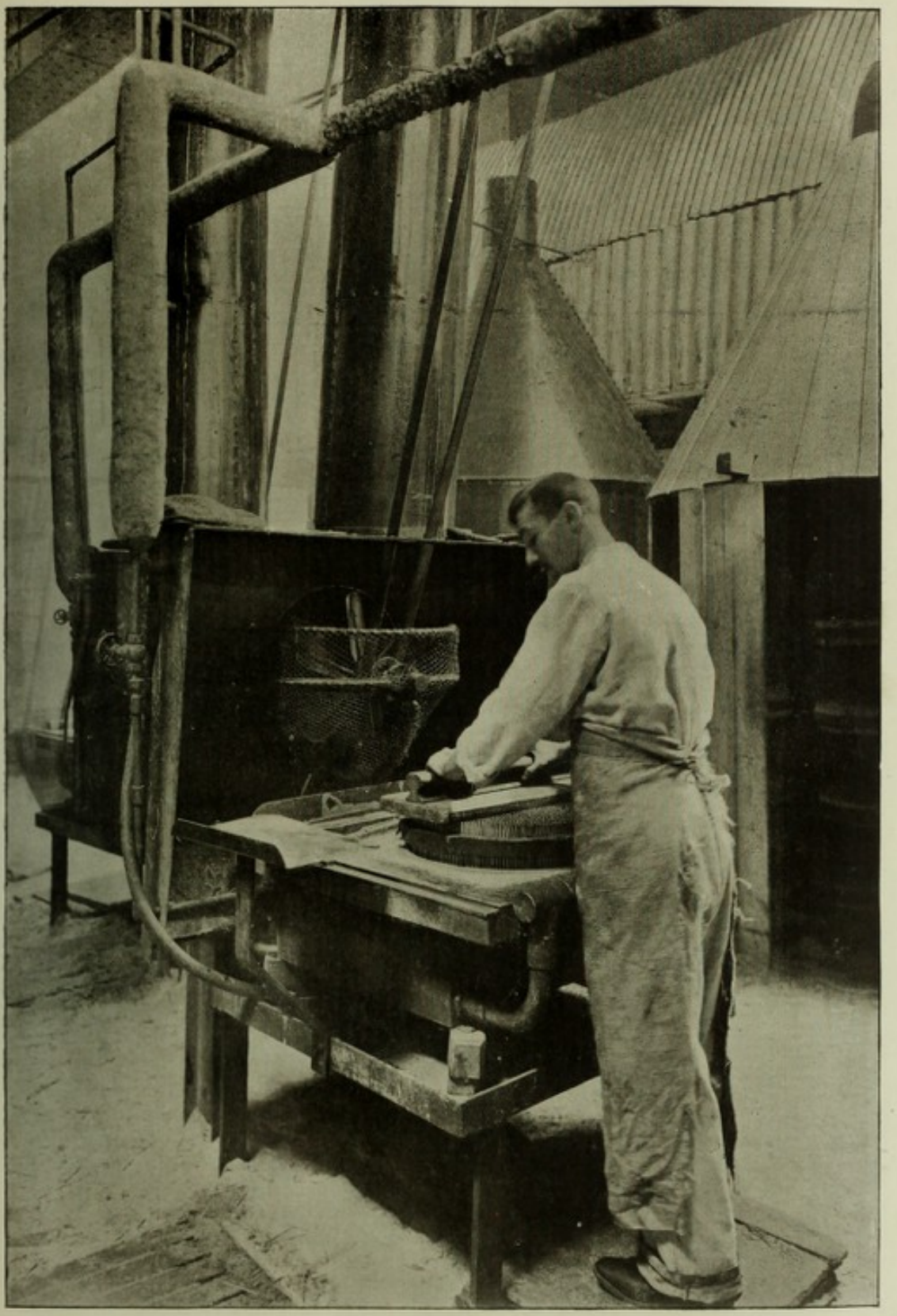
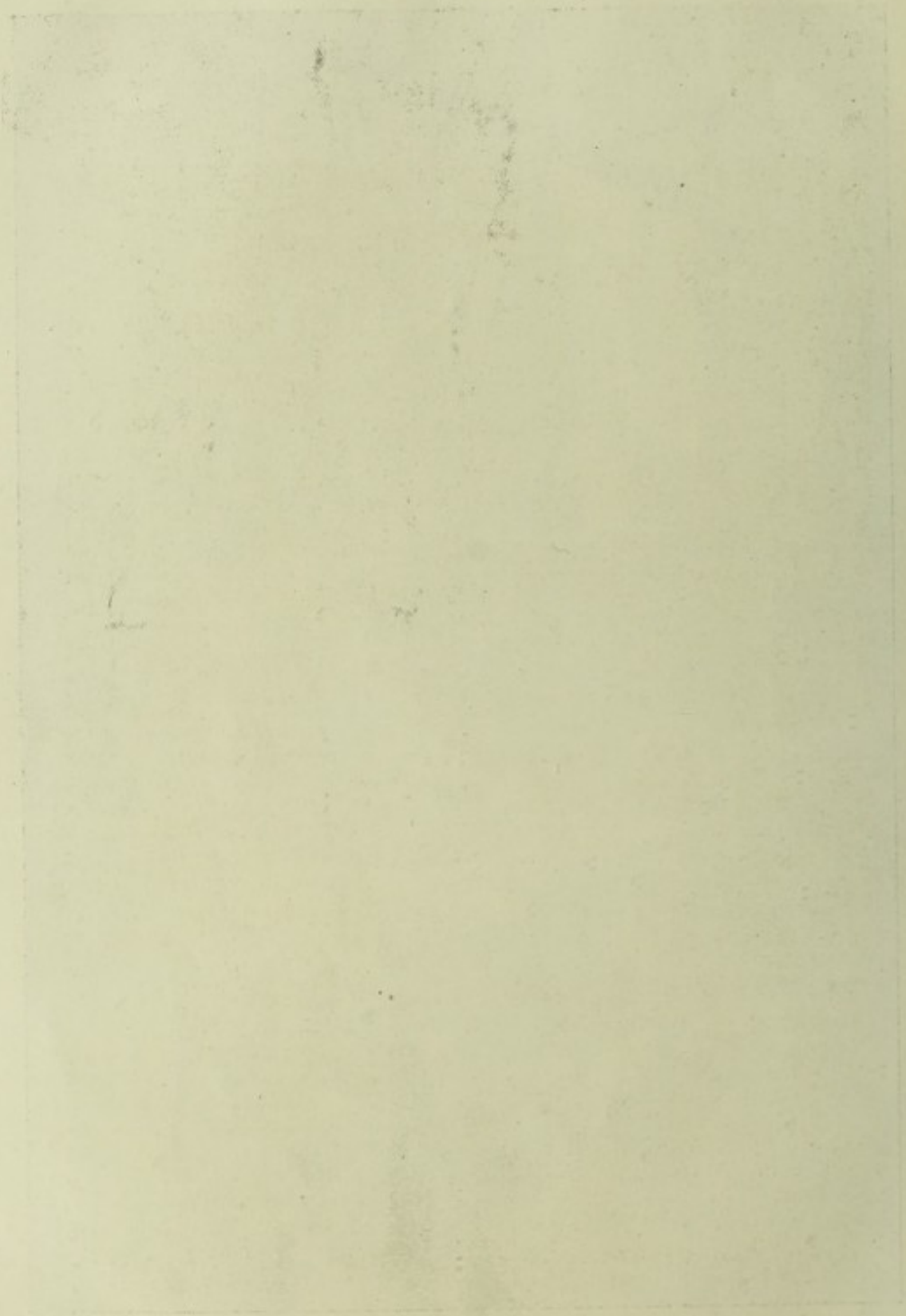
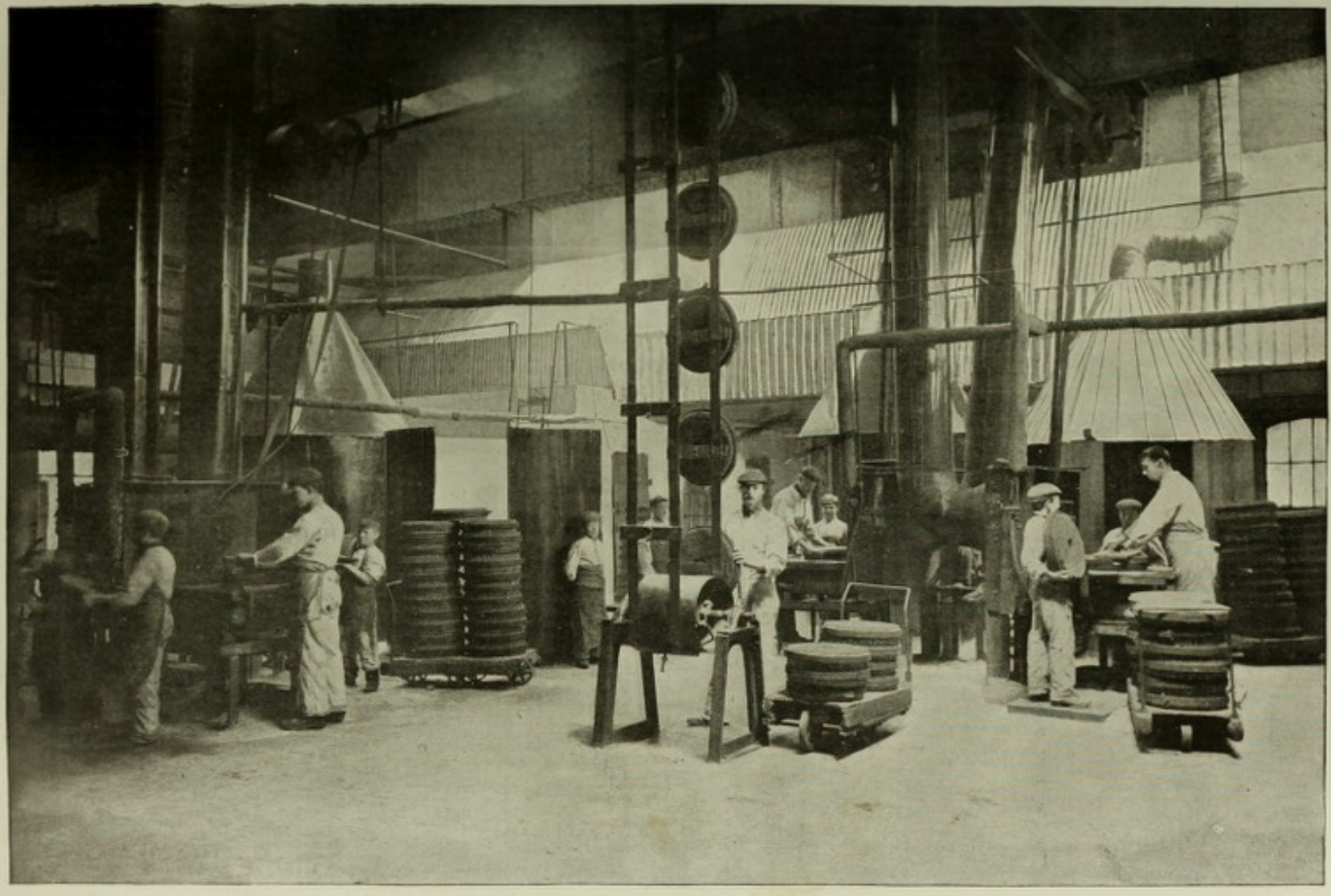


Illustration A., showing a phosphorus dipper at work. The air screen separating him from the fumes from the paste on the slab is produced by a current of air issuing from a series of holes in the tube in front of the dipping stone and streaming towards the exhaust fan at the back.





Ventilated Hood in which are stored Once Dipped Coils till ready for the Second Dipping.

Dipper.

Dipper. *Creeper bringing Undipped Coils from Upper Floor.* *Carrier.*

Illustration B.—DIPPING ROOM.

(*To face page* 138.)

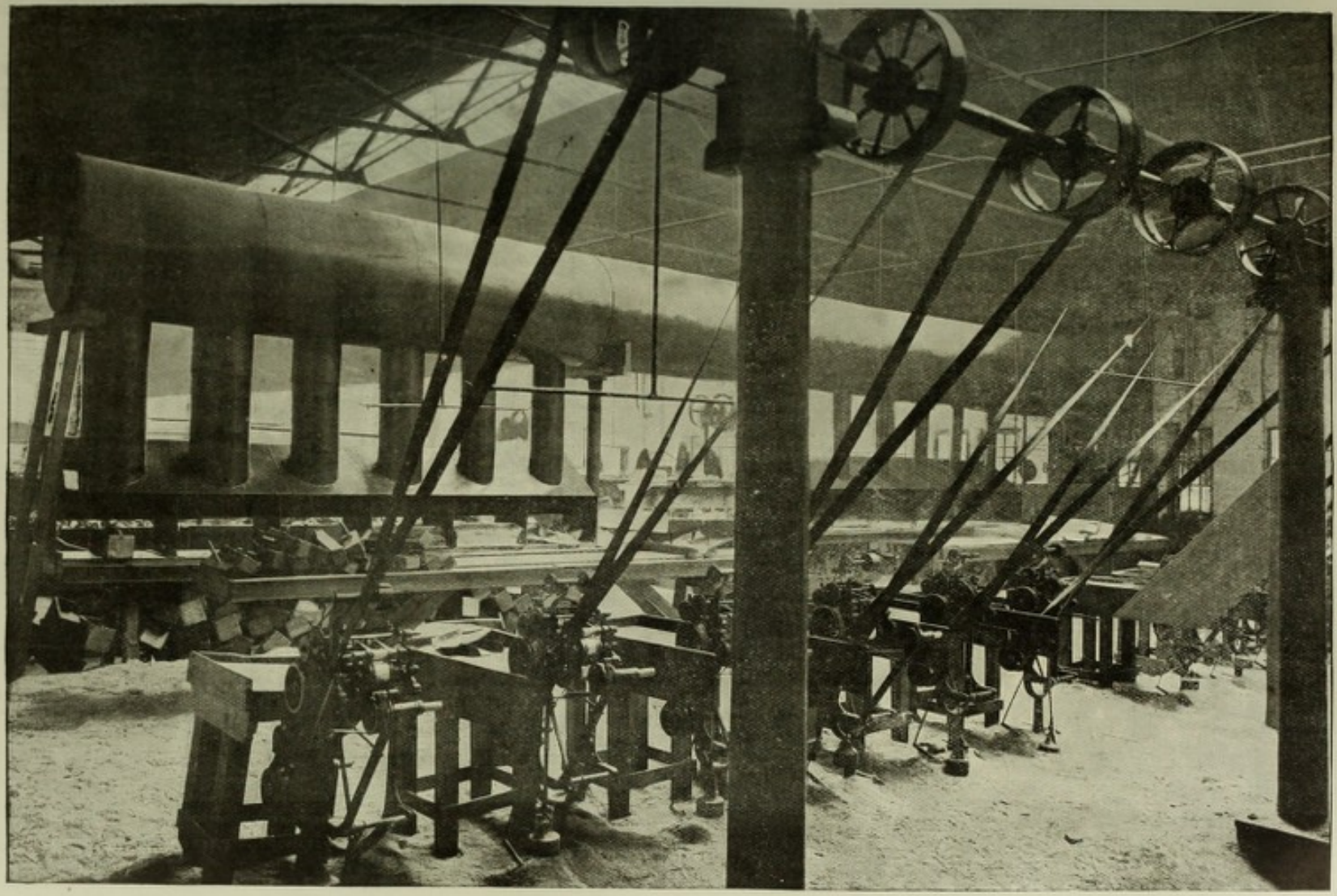


Illustration C., showing in the foreground the new coil-releasing machines which "cut down" or halve the splints by machinery, and in the background, ventilating hoods over the benches of the boxing hands.

(To face page 138.)

All dippers now employed, and henceforth to be employed, will first be certified by a qualified dental surgeon that their teeth are quite sound.

Drying Rooms.—The ventilation of the drying rooms has been in many cases considerably improved, and further improvements in this direction are in hand.

Boxing Rooms.—Additional fans, producing more efficient ventilation, have been put in here and there, wherever considered necessary.

A new process, intended to remove the danger attaching to the boxing of damp matches, has been instituted, and is now in full work in one factory, the Albert. Under this arrangement, the cutting down by the girls is done away with; the box fillers receive the matches dry, and practically free from fume. It is proposed to extend the new process to the other factories when practicable. (*See* illustration C.)

I found that the new rules for the preservation of the teeth (*see* Appendix) had been freely posted throughout the various departments, and small hand copies distributed to the workpeople.

The certifying surgeon, too, continues to reject fresh applicants if their teeth are not good, and if they can be seen to be addicted to biting their nails.

Cloak rooms have been provided for the women workers away from the factories.

Not the least improvement is the installation of a complete and well-equipped dental surgery and a system of dental examinations of all new hands, and to which I must refer later. There are two operators and two chairs, but the accommodation is rather small. The intention, however, is to regard this installation as a mere temporary expedient, and, if the system works well, to build larger and more commodious premises.*

Messrs. S. J. Moreland and Sons' Match Factory, Gloucester.

On the 20th and 21st September I visited the old-established works of Messrs. S. J. Moreland and Sons. The number of hands employed was 415; of these 163 were working in departments where no phosphorus is used, thus leaving 252 exposed, more or less according to the occupation, to the fumes of or contact with yellow phosphorus. The numbers are, of course, subject to fluctuations, but the total number, I am informed, never exceeds 450. A considerable number (99 girls and women) of the 163 hands are occupied in the manufacture of cardboard and wooden boxes, and in the sanding and labelling room. Boxes are made by special machines, each machine costing about 90*l.*, and one girl sufficing to work it. She can earn from 10*s.* to 12*s.* per week, according to her skill. In the mill, veneering, and web-board rooms, male labour is employed, viz., 64 men and lads. These works are quite separate from the match factory.

We first visited the small wax vesta factory, employing about 30 hands. The dipping shed contained the usual dipping stone, and there was no ventilating fan attached to it, but the ventilation was good, as it is practically quite in the open air. The dipper I found here was occupied for about two hours, and then had about two hours off at some other kind of work away from phosphorus, each morning and afternoon.

The drying room is of the usual old-fashioned style, and hence open to great improvement.

In the boxing room the work was conducted in the usual way; the only noticeable feature was the absence of the mechanical ventilator, although there was plenty of fresh air during the fine summer day on which I visited it. It is obvious that such a condition must depend very much upon the direction of the wind and the state of the weather. About 25 to 35 hands are employed in this department, under a manager who is now 61 years of age, and has been 35 years in the match trade, always working in the midst of phosphorus.

* On Monday, 16th January 1899, I found that a change had been already made. There is now a commodious waiting-room, and the two chairs placed in a larger, well-lighted room on the first floor; and arrangements are already in progress for the installation of four chairs, and the employment of a third dentist.

We then passed on to the wood match department. In the frame filling department the short or single splints are shaken by a machine into regular rows, as in wax vesta making. The frames pass through the paraffin dipping and are ready for the phosphorus "compo" dipping.

In the dipping room I found five dippers at work, assisted by five boys. I was given to understand that all the men chewed tobacco. Here, again, the ventilation was fair, although there was no mechanical ventilation. The washing accommodation was good, and here again I had ocular demonstration that the dippers are extremely careful in this matter of washing both their face and their hands. A bottle of mouth wash was provided, but, as at Bryant and May's, it consisted of an extremely strong solution of permanganate of potash. I instructed the foreman as to the proper strength.

The drying rooms were of the usual old-fashioned style and are capable of great improvement.

In the boxing room I found that the wood matches are better dried than with the ordinary methods. It is now six or seven years ago since the "cutting down" process was done away with, the single or half splints being used in frames, a method somewhat similar to that used in the wax vesta factory, and also to that in use abroad. In the frame filling department about 45 men and boys were at work tending the machines by which the metal frames are filled automatically with the match splints. From this department, the filled frames are put on trolleys and run into the dipping room, thence into the drying room, and finally into the boxing room. The frame filling department has hitherto been regarded as an innocuous one, as there is, of course, no phosphorus used in it or even near it. From it we get the curious return in the report of D. R., aged 30, as not having been exposed to any kind of phosphorus, and yet having had an attack of slight necrosis. I saw him and have reported on his condition. It was an undoubted case of necrosis. The explanation of the apparent mystery seems simple, that though there is absolutely no smell of phosphorus in that department, the frame fillers are handling all day long these frames and must get some contact with the phosphorus composition. Mr. Philip Moreland assured me that in the future this department would no longer be regarded as "safe," and in his return to me of the hands employed it is entered as part of the phosphorus section.

The frames, as they are brought in on trolleys into the boxing room, are quite as dry as the wax matches, which of course is a very great advantage, inasmuch as there is far less fuming and less handling of the phosphorus, and hence less danger of necrosis. There were about 140 boxers at work, and I was informed by the forewoman that they earn from 7*s*. to 13*s* a week. An extra shilling a day is allowed as a bonus to those who work up to a certain quantity and conduct themselves according to the rules of the establishment.

It is important to point out how fixed rules rigorously applied may occasionally frustrate the object of them. Owing to the structural position and relation of the drying room to the boxing room in this establishment, what was originally an open passage had to be blocked up with a swing door in order to conform to the rules. With the door open the ventilation was much better than with the door shut, as it interfered with the action of the mechanical ventilating fan.

In the mixing room I found that the process was again different from any other that I had seen, and I further took the opportunity of assisting at a complete operation, so as to determine how far the workmen are exposed to the fumes during its process. The glue and zinc white are melted in a pot, enclosed in a steam jacket, which also contains a mechanical mixer. The weighed phosphorus is brought in in a pail of water, and is quickly dropped into the pot by hand, and the cover put on. Almost immediately dense fumes are given off, and are distinctly visible as they pass into the air from the chimney connected with the pot. No fumes, however, escape into the room where the men are working. In the next room a greater part of the composition is prepared by melting the chlorate of potash and glue and other ingredients into a paste. When all is ready the phosphorus glue composition in the pot, which has taken about half an hour in cooking, is carried to the next room, and is

mixed with the paste, which process is conducted by a mechanical mixer. During the process of removing the lid and the mechanical mixer, fumes rise, as they also do from the pot, but the exposure is an extremely short one. After the phosphorus part of the composition is added to the paste, another half hour stirring with the mechanical mixer takes place, under such conditions that no fumes arise until the operation is over, and it is emptied into the pails. These pails are kept covered under a hood until required.

The refectory is in the first room of that part of the establishment where wood is sawn up and prepared for use, either as boxes or splints. It has only been occupied since the 2nd May. It was bright and cheerful on the sunny day of my visit, but it must be a cheerless room in winter, and I do not remember seeing any provision made for heating. Nothing was provided except forms for the girls to sit upon, not even tables being provided. Only girls are allowed the use of this room. The meals they brought in with them were of the usual character, and decidedly of a poor kind. Most of them drank tea which they prepared for themselves on the premises. A few of them, however, but not so many as I should like to see, had soup; this they procured from a coffee house just outside the works, at the cost of a penny a bowl. A penny deposit has to be made for the return of the bowl. Some of the girls on both days were good enough to let me taste the soup. I must say I found it very good, and excellent at the price. Many of the girls expressed a desire to have some means of heating up the dinner which they brought with them. The girls enjoy good health, seem happy, and certainly were frolicsome. I found out that many of them had been in previous employments, but prefer match-making. Several of them told me that they could manage very well on 8*s*. to 10*s*. a week. It was pointed out to me by Mr. Moreland that an examination of his books containing the wages returns proves that the wage earned by the girls is always distinctly greater immediately before the regulation holidays. This indicates that the amount of piece-work done by the girls varies with either the desire of or the necessity for earning extra money.

No final judgment should be passed on any of the criticisms which I have made with regard to the present arrangements in these works as a large new building is in course of erection, in which it is proposed to employ a number of machines, such as are employed in Belgium. The dipping, drying, and boxing will be done in one large room, amply provided with mechanical ventilators. Naturally, with so much building going on, and so many extra hands about, the ordinary running of the match factory is somewhat upset for the time being.

I found that there is no sick club for the employees in connexion with these works, and this is a matter of some importance, as I was informed that the usual workmen's sick clubs in the town refuse them as members, because of their working in a match factory. Something might well be done to rectify this matter, either by convincing those outside that the match-making industry, as a rule, is not the unhealthy occupation which it is taken to be, or that some special local effort should be made to assist the match-workers in having their own sick fund, as has been done in other places.

Visit to Messrs. R. Bell and Co., Limited, Match Factory, Bow.

Before proceeding to conduct me over the works, Mr. Bell, senior, the managing director, gave me a brief history of the firm, which he claimed to be the oldest match makers in the country, having been established in 1832. He informed me that he had only known of one case of phosphorus necrosis, which had occurred in the case of a dipper, about 15 to 17 years ago, when the case was a slight one, and he was soon able to resume his occupation. Our conversation naturally centred upon the reasons why Messrs. Bell and Co. had thus escaped this fearful scourge of necrosis. He attached a great deal of importance to the construction of the works, especially in the complete separation of the dipping and drying rooms and the boxing room from one another. In the case of their present building, as will be shortly seen, the dipping and drying rooms are on the roof, and the boxing room is

situated on the second floor below. He did not deem it absolutely essential that the dipping and drying room should occupy this position, but it had proved to be a good one. In designing the two new factories which he had recently built in Australia and New Zealand, all the buildings were on the ground level, but he had kept the dipping and drying rooms quite separated from the boxing room by a distance of about 30 to 40 feet. He placed the dipping slab in the open, but under cover. He also attached great importance to the fact that their principal manufacture is wax vestas, and the number of wood matches they make extremely small. With the system of "cutting down," the composition on the splints must be of a damp or moist character, whereas the composition of the wax vesta must be almost bone dry before boxing, otherwise the heads would come off. He considered that the fumes arising from the damp or wet phosphorus are very serious in their effect, but not those rising from the dry composition, otherwise he thinks they would have suffered just as others had done. This of course applies only to the boxing hands, and not to the immunity of the dippers and driers. He ascribed that to the open character of the dipping shed on the roof, where there was almost constantly a breeze, which kept the atmosphere relatively free from fumes. He spoke strongly against any prohibition of the use of yellow phosphorus. Their main trade was in the Colonies, and prohibition would mean the immediate closing of their works, the effect of which would be that the trade, which they now shared mainly with the Belgian and Italian manufacturers, would entirely be left in the hands of the latter. He also pointed out that the practice of paying the dippers for anything over one thousand frames per day is an incentive to overwork the employee, and that the excess thus earned was too often spent on drink, resulting perhaps from the over fatigue which the extra work had produced.

As we passed through the office to the works the first thing which struck my attention was a large tank labelled—

"MOUTH WASH,

For Use of the Wax Room Girls Only."

To this tank two iron mugs are attached by chains, and the foreman or forewoman watches to see that use is made of it by the hands. It had been in use for about a month previous to my visit. The wash consists of permanganate of potash, but in this instance was rather too weak, as I afterwards found out. Although the habit of using the mouth wash is not so completely acquired as that of washing the hands, it is gradually and certainly being acquired. I advocated the extension of the use of the mouth wash to all the hands, which was readily granted, as also a suggested improvement in its preparation.

We now ascended to the roof, and found there a light structure mainly of galvanised iron, in which are the mixing, dipping, and drying rooms. The foreman or chief mixer has under his direction three dippers, all of whom have been in constant employment at these works from 8 to 14 years. He himself has been dipping and mixing for 16 years. He always puts the phosphorus into the composition himself, and he has never been 16 minutes away from his work for illness of any kind. The dippers work constantly day after day at their work, putting in usually about nine hours actual work. They are all strict teetotalers, and enjoy exceedingly good health. There is no rule with regard to this question of temperance, but Mr. Lomax, the foreman, has himself always been a teetotaler and recommends the other men to follow his example. They are all members of the Phœnix Order. He himself does not chew nor smoke, but the others do. The boys who assist in this department are from 14 to 15 years of age, and are about 17 in number, on the average. The men and boys all wear overalls. The boys are only in the phosphorus department on alternate days, being one day in the dipping and drying rooms, and the other days working on open work such as emptying racks, carrying frames, &c.

The men have a sick benefit society of their own, and I was informed that there is so little call upon it that they share out the greater part of the money at the end of every year.

The mixing I found to be conducted in a way quite different from anything else I had seen, quite in the open, without any cover at all. The iron melting pot was placed in the usual steam jacket, and in it the glue is first melted, and then the usual coloured composition is added, and the whole remixed under cover by the mechanical mixer, something like a large oval egg switch. When the composition has been thoroughly mixed the wedges of phosphorus are brought in a pail, and quickly put by hand into the melting pot and the lid again closed. Some fumes arise during the few seconds this operation takes, and the mixer carefully places himself on the windward sides of these fumes. There is no stirring in with the wood baton, and the mixer is in no way at all exposed to any fumes that arise. The whole of the work at the cauldron does not take up more than from four to five minutes of the workman's time in the whole operation, which is repeated about six or seven times a day.

In the dipping room here, there are two dipping tables of the usual character, but there is no mechanical ventilation. This has not been considered necessary, as the room is so freely open to the air.

The drying rooms are also situated in the roof, and have nothing peculiar about them worth calling for a remark, except that the smell of phosphorus was much less than in most others I examined.

At the other end of the roof there is another dipping stone, also open to the air, and a small installation for making wood matches on the double splint method. There is also a room in which the process of making Vesuvian matches with wire braiding is conducted. There was no smell of phosphorus at the time of my visit.

The floor immediately below this, which forms the third storey, is entirely devoted to wood and cardboard box-making, while the principal or second floor is entirely occupied by the wax-boxing hands. The ground floor is devoted to two departments, viz., the manufacture of tin boxes, and the wax preparation department. In this room there are the usual large drums, on which are rolled miles and miles of wax taper. The wax taper is then fed into a machine, and cut into appropriate lengths, and set up and held in square iron frames by transverse wooden bars, ready for dipping. Hitherto the creeper (a kind of endless belt with hooks) has been employed for carrying the material for dipping to the roof, but now the frames are loaded on trolleys, which are sent up in a lift. Although the roofs are not very high, the building in which these different floors are situated is well ventilated by windows, some of which cannot be closed, on each side facing east and west. This arrangement ensures good cross ventilation. In the boxing-room one or two mechanical fans have been placed, in order to comply with the special rules, but they are said to be really unnecessary.

The boxing hands may be said to resemble very closely the employees at the Fairfield Works, both as to age, health, and general character. As far as I could see, they were equally attentive to the washing of the hands. A great number of them used the mouth wash, both at the dinner hour and evening exits. I made also, on different occasions, different visits to the refectory, which consists of a large hall, well lighted, airy, and quite outside the works. Ample provision seemed to be made for heating the room in winter, but not for heating meals. The forms, and tables, and floors were always very clean. The food of the girls was very much the same as at the Fairfield Works, and would permit of very considerable improvement. The favourite mustard pickle, which is obtained at a shop outside the works, was again too much in evidence. Tea seemed to be the only beverage, and I did not see a single girl having soup or coffee. The girls mess at the table very much according to their position at the works, and it seemed to me that if they could be encouraged to take a little more interest in their own welfare the quality of their diet might be easily improved.

At one of my later visits, I found that the annual outing had taken place during the interval, and they all seemed to have enjoyed themselves very much. There is a kind of rivalry on these occasions to compete with the

workers at the Fairfield Works. Some also talked very kindly of a veteran old lady who had just been pensioned off by the firm, after 50 years' service as a match maker.

During two of my visits to the factory of Messrs. Bell I assisted at the attendance of the medical practitioner who is in charge of the workpeople's sick fund associated with these works, and had the opportunity of seeing the character of cases that wait upon him at his little office in the works, and also to confer both with him and one of the workmen who is secretary to the fund. The cases for which the doctor was consulted were of quite a simple character, and his report as to the general health of the employees will be found on p. 155. He also acts as their dentist, but naturally his operations are confined to extraction.

I was informed that owing to the Truck Acts the firm's contribution to the employees' sick fund has been discontinued for some three or four years.

The greater part of my time at the many visits I made to this factory was devoted to a very close and detailed examination of the teeth of the match-making hands, and the results of which are included in the dental section of this Report. Every one, without exception, submitted to this voluntary inspection. I desire, therefore, to express my thanks to all of them, and also the directors of their staff for their help.

Diamond Match Company's Works at Liverpool.

The American Diamond Match Company founded the British Company. I had the opportunity of meeting Mr. Barber, the President; Mr. J. K. Robinson, the Treasurer; and Dr. Stewart, who is their inspector and adviser on all matters applying to hygiene, but especially dentistry. The following notes embody the main facts which I gathered in the course of several long and interesting interwiews with these gentlemen, but especially the two latter.

The American Company commenced business about 1881 by buying up 28 factories. These, however, they have abandoned because the premises were unsuitable, and the four that they now possess are all new buildings, specially designed for the manufacture of machine-made matches. They are probably the most complete which exist.

They employ in America about 2,000 hands, of whom about 800 are men and the rest are boys and women, most of whom are young.

This company is said to do quite 85 per cent. of the American match trade.

The peculiarity which distinguishes this company from those in Europe is the extensive use of machinery, by which the output, in proportion to the number of workpeople employed, is enormously increased, and the exposure of the employees to phosphorus fumes is reduced to a minimum.

I have already given a description (p. 129) of these machines. A natural conclusion from a study of these machines is, why should the process not be made absolutely perfect by enclosing the machine in a closed glass casing, as suggested in M. Vallin's Report (Appendix II., p. 218), and so isolate the workpeople from the fumes? This involves a practical point. Steady gradual evaporation is essential to putting a good head or tip on a match—the draught in a series of closed chambers cannot be regulated with that nicety possible in a large hall. A closed chamber would lead to a chilling of the outer surface of the match head.

Practical experience has proved that it is better to leave the machine open and not enclosed since a breath of cold air is sufficient to so chill the surface that the whole batch of matches would be spoilt.

It is, however, with regard to health that these machines are chiefly to be regarded from the point of view of my inquiry. Although the magnificent installation of mechanical ventilation is regarded as an essential part of the equipment, I am still unable to say that the work is so safe that no precautions are requisite; but there seems to me no reasonable doubt that it is far less dangerous than the old hand processes.

In former days under the old system there were many and severe cases of necrosis. It was so great a source of continuous anxiety that the directors resolved that they must definitely and absolutely prevent the disease or give up the industry.

In order to comprehend the magnanimity of this resolution, it must be stated that in the United States there are no special rules, as in this country, for the conduct of match factories. They are only subject to the variable rules of each particular State, affecting all factories in which machinery is employed.

About 1881 an attempt was made to cope with the evil by employing Dr. Stewart, who had previously worked occasionally for the principal promoters, to take charge of the health of the workers. Since the year 1890, Dr. Stewart has devoted his whole time to systematically and periodically inspecting all the persons employed. He is a dental surgeon. If the teeth of the workers are out of order they have to be put right, but at the worker's expense. To enable them to get good dental attendance, dental practitioners are nominated who will do the work at reasonable fees: the workers may go elsewhere if they like, but Dr. Stewart has to be satisfied that the dental work has been properly done.

The company pays wages during the time the worker may be incapacitated from work through medical or dental treatment by Dr. Stewart's directions. The workers are also on many occasions provided with artificial teeth at the employers' expense. In fact, when the workers are poor, they are assisted by the employers to have their teeth put in order. This is not a matter of absolute right, but of arrangement.

The wages of workers in America are considerably higher than in this country. Girls earn from $1 to $2 per day, and as they are paid by piecework they are often dismissed if they cannot earn a minimum of $1 per day, but the skill required is greater than in the ordinary English factory with hand work.

The workers are also taken more care of in America than in most factories in England.

A dining-room is attached to each factory, with tables at which each worker has his or her own place. They bring their own provisions and consume them there, but in addition to their meals, soup, coffee, milk, and biscuits are served out to them at the expense of the company.

Mr. Robinson, the treasurer, considers that this system works well, for the company can supply these things when made in quantity at a low cost. No charge is made to the workers for the use of the room or the food, but the firm considers that it more than gets its money back by the improved worth of the operatives.

The Diamond Match Company established a factory on the American principle in Liverpool about two years ago, with American machinery.

The Company purchased the works and business of the old Liverpool firm of Collard and Collard from Messrs. Kendall and Maguire, in 1895, and ran the old Boundary Street Works till the new works were complete, when all the old machinery was destroyed as worthless.

The new factory is situated at Litherland, a suburb of Liverpool, near Seaforth, and therefore is in a most healthy and breezy district, where there is plenty of fresh air and sunlight, and consists of a large central block and two lateral wings, with an annex in the centre containing the engines, furnaces, and ventilating machinery, in a large open space of nearly seven acres, and without any neighbouring high buildings.

The buildings are entirely new and cover about 1½ to 2 acres of ground. The central block consists of four storeys and a basement, while the lateral wings consist of three storeys and a basement. Over the central block are two high towers for the storage of water at adequate pressure. Pipes are laid all over the building, provided with automatic sprinklers in case of fire. Two local watchmen and connexion with the neighbouring fire station, at Bootle, constitute a further protection to life and property from fire. The works are lighted throughout by electricity generated in the works.

All dangerous chemicals and explosive materials are stored in a separate building, completely isolated, and at some distance from the main building.

The factory has now been occupied for about two years.

It was a raw, cold, rainy day, immediately after the long heat spell in August, so that I first saw the works and the workpeople under rather gloomy conditions.

Mr. Maguire, the manager, conducted me personally over such parts of the works as I desired to inspect.

The lower part of the buildings are entirely devoted to innocuous work, such as preparing the timber for splints, wood boxes, packing, &c., and in machine box-making. The upper floors alone are devoted to match-making.

On our way to the mixing-room, we passed through an innocuous department, where both cardboard and wood boxes were being made by special machinery. The inside boxes are made from a long reel of cardboard fed into the machine, which cuts out the blank, folds it, pastes the edges together, and delivers it dried at the rate of 68 per minute. Another machine makes the slide or cover for the inside box; the continuous strip of cardboard being cut into blanks, folded, gummed, printed on three sides, glass-papered, partially dried, and delivered at the rate of 480 per minute.

The mixing of the phosphorus composition is carried on in a large top room at the end of one of the lateral wings, and is therefore quite isolated from the rest of the factory. The composition is of the usual character, and contains from 4 to 5 per cent. of yellow phosphorus. The glue and dye are first melted in steam chests, after which the phosphorus is added, and the mixture is then poured into large copper kettles surrounded with a steam jacket. A mechanical stirrer, something like a long narrow egg-whisp, is attached to the running gear, and covered with a galvanised iron hood connecting with a strong exhaust and ventilating shaft. After the phosphorus is thoroughly melted, the remaining part of the "compo," containing the usual chlorate of potash mixture, previously ground in a machine mill to a consistency of very soft putty, is added to the phosphorus glue mixture. The mixer does this with a long wood bâton, or spatula, over the open kettle, and during this time is exposed to the fumes. Owing to the semi-solidity of the added mass, the workman is longer exposed than in the mixing as described by me at some other works. The mechanical stirrer is now attached, and the hood readjusted till the operation is complete.

On making the mixture with the bâton, in affixing the mechanical gear, and still more in cleaning the kettles and gear, the mixer is exposed to the phosphorus fumes, but only for relatively short periods in his day's work. Directly over the kettle there is naturally a strong smell of phosphorus, but the ventilation is so thorough that there is no smell of phosphorus in the mixing-room, the only prevailing smell being that of melted glue.

This department is carried on by a foreman mixer with the aid of three assistants, who are always more than 18 years of age. I examined the mouths of these men, and found them in fair condition, and one of them almost perfection itself but for a little tartar. They all chewed, which is not a bad protective, since we know that tobacco juice is even a stronger germicide than tobacco smoke.

The foreman has been a matchmaker from youth upwards, and a mixer for five years, and has always enjoyed excellent health. He thought that only those of weak constitution or dissipated habits could catch the "Phoss." In the old works he could remember three cases in 25 years, but there had not been the slightest trace of necrosis in the new works.

In the large and lofty hall at the top of the principal block, running the whole length of the building, are installed some 17 of the continuous machines making wood matches. In a smaller but similar room in one of the wings are six similar machines turning out wax vestas. On the other side of the building are installed the machines for making paper or cardboard matches, which are mainly used for advertising purposes; these, however, are safety matches, having no phosphorus in their composition.

In these halls, despite the number of machines, very efficient ventilation renders the smell of phosphorus wonderfully small; in fact, many visitors have failed to detect it. In the neighbourhood of the mechanical roller dipping apparatus, however, it is more perceptible, but none of the work-people are in its vicinity except the composition-supply men. Curiously enough, these men still call themselves "dippers," presumably, I suppose, because that was their function in the past. Their duty, however, is completely different to that of the dipper in any of the other factories I have described. In the centre of the large hall there is a tank of the composition, which should be kept covered up except when portions of it are being removed for use. The composition-supply man or dipper first ladles out a small pail full, and then proceeds to the dipping portion of each machine, by the side of which is a funnel-shaped reservoir which feeds the machine with the liquid composition. He uncovers the reservoir, fills it nearly full, and immediately covers it up again. One man can attend to about a dozen or more machines, but during the process he is naturally much more exposed to the fumes of phosphorus than is any other operative in the room, but not nearly so much, nor so continuously, as is the case with the dipper under the ordinary methods. I was careful to inquire about the process of cleaning up. Every night the roller is cleaned by means of a sponge and hot water, a process which takes about five or six minutes for each machine. Every Saturday both the trough and the roller are removed and thoroughly cleansed; this takes about a quarter of an hour for each machine. In consequence of what I was told as to the danger of cleaning the roller-dipping machine in the French factory, I made a point of assisting at one of these weekly cleansings. Absolutely no firing occurs, but naturally there is a much stronger smell of phosphorus in that part of the works where the operation is being carried out. All the men whom I interrogated on the subject, and who had been dippers in the past, gave it as their impression that they were much less exposed to the fumes than had formerly been the case. Their employment, however, is not without danger, and great watchfulness is necessary.

Of the 600 workers, about 320 are women and girls. From Monday to Friday they work 10 hours, from 7 till 12, and 1 till 6; Saturdays, five hours, 7 to 12. They breakfast before coming to the works. Some go home to dinner, some stay. For those who stay, there is a special dining-room, and tea and coffee, with milk and sugar, and biscuits are supplied free. In the winter, soup is given free, and draughts and other games will be provided.

They are mostly on piece-work, and earn from 8*s.* to 16*s.* per week. There are no fines for any offence. If a girl is late, she loses her place at the machine, and is put on to some slower and less remunerative work.

In settling in a new district like Litherland and Seaforth, it was found better to train entirely new hands, more especially as a better type of female workers was obtainable, and now only three of the old staff are left.

Lavatories are provided on each floor, and on the bottom floor are wash-basins, with plenty of water and frequently changed towels. One rule is that all workers must wash their hands before meals, and before leaving the works in the evening, using the brushes provided for their finger nails.

The women are obliged to leave their hats, shawls, coats, &c., and their lunch in charge of the cloak-room officials, and no food is allowed to be taken upstairs. But, notwithstanding all this vigilance for their good, silly girls will sometimes take biscuits and sweets in their pockets. If found out they are severely reprimanded.

The following notice has been for some years posted up in the works :—

NOTICE.

To the Employees of the Diamond Match Company, Limited, Liverpool.

I.—All employees on entering the works shall receive a check ticket bearing their number, which must be delivered up at meal hours and on leaving off work.

II.—All coats, shawls, hats, lunches, food, &c. must be delivered up to the official in charge of the cloak room, the employee giving number of check ticket, so that they may be kept apart. These will be returned at meal hours and at stopping time on production of check ticket.

III.—All employees must carefully wash their hands, using the brushes provided for their finger nails, before lunching or dining, and before leaving the works.

IV.—Employees are urged to thoroughly cleanse the mouth, teeth, and gums after meals, using a tooth brush to the teeth with borax and castile soap powder every morning and evening in their homes. Tooth brushes and tooth powder will be supplied free.

V.—Employees requiring attention to their teeth will be received by Mr. Westerton, in the dental surgery on the second floor, between the hours of 9.30 a.m. and 1 p.m. each Saturday, unless otherwise specially arranged.

By Order.

A circular, issued by the American company to all their employees, will be found in Appendix XI., p. 234.

At the request of the company, I drew up a series of instructions to be observed by workers. They are very nearly identical with those which I prepared for the Irish school children, and which were adopted by the National Board of Education. These rules of course are not intended as a sample of such rules as the Home Office may prescribe, but are rather as a series of hints to the workpeople on the care of their teeth. I append them to my report (Appendix IX., p. 233), and recommend that copies of them, or some modification of them, should be posted up in phosphorus and match factories, in addition to any special rules that the Secretary of State may prescribe.

I have called attention (p. 134, par. 4) to the arrangements made for a Sunday bath at the Oldbury Phosphorus Works. This is an excellent plan, and well worthy of adoption in all dangerous employments. On each occasion of my visits I noticed towards the end of the dinner interval that the men were playing football in the field adjoining the works.

The Dental Department has been under the care of Mr. Westerton, L.D.S., who is in practice in the neighbouring town of Bootle. He attends once a month for purposes of inspection, at the same time as the certifying surgeon, who is also surgeon to the works. All the new hands are examined by the doctor and the dentist, and the names of those requiring attention are entered in a register setting forth the work necessary to be done. A record is kept of those whose teeth are perfect; these are, however, extremely exceptional instances. Some minor cases are attended to at the time in the operating room, which at the time of my visit adjoined the consulting room in the factory.

The dentist spends about four hours at the works every Saturday, for the purpose of extracting, under nitrous oxide, or performing other operations for the batch of patients selected for the day. When extractions have been made, the patients immediately leave the factory, and do not resume work until they can produce a certificate of fitness from the doctor. Newcomers who are passed by the doctor as otherwise physically fit are employed in parts of the works where no phosphorus is used, until they have had their teeth put in order. Mr. Westerton reported that the working class in Liverpool have extremely bad teeth, and present a very large per-centage of cases in which nothing short of a complete clearance of the whole of the teeth, or nearly all, is of any use. In extensive operations nitrous oxide gas alone would not be sufficient for painless extraction. The Company, therefore, allow an extra fee to the doctor for the administration of ether. Mr. Westerton reports that he has met with little or no opposition from the workpeople since he has been enabled to extract under an anæsthetic.

I was pleased to find that the workpeople are being supplied with tooth brushes and tooth powder at the expense of the Company, but it was obvious

to me that their employment must remain ineffective, unless a large number of the operatives had their teeth thoroughly scaled and cleansed in order to give them a proper start.

At a subsequent visit, I had the opportunity of reporting to the directors as to the difficulty, and even danger, of administering an anæsthetic, even so safe an one as nitrous oxide, in a room where the noise of running machinery overhead was distinctly overpowering. On my reporting this and other matters, I was immediately asked what provisions I would propose to make, and I may say that nothing could exceed the promptitude and thoroughness with which every suggested reform has been or is being carried out. The directors have taken a small house opposite the works in which they have installed a dental surgery provided with all the resources of modern dentistry. In addition, they have engaged a matron, who is also a certificated and experienced nurse, whose sole business is to attend to the general health and social well-being, as well as especially to the hygienic condition of the mouths of the workwomen and girls. She also assists the dental surgeon in his work. It is worth while noting that several candidates for this post were at once rejected because they themselves had either bad teeth or were careless as to the cleanliness of them.

The directors are thoroughly convinced as to the necessity of their work-people's teeth being in thorough order. It is a work, however, of enormous magnitude, as will be gathered from a calculation made by Dr. Stewart and myself, that at the rate, under the old arrangement of dental service, of half a day weekly, it might take an expert operator something like 24 years to put the teeth of all the present employees into order. They have, therefore, engaged a fully qualified dentist, Mr. J. S. Farnfield, L.D.S., who will attend daily, under the supervision of Mr. Westerton, until the task is completed.

IV.—PHOSPHORUS NECROSIS, ITS CAUSES AND ITS INCIDENCE.

A.—Its Causes.

I next pass to consider the disease produced by phosphorus.

From what has been said it will be seen that the workpeople are liable to get the phosphorus into their system in one of three ways, viz., by inhaling it, by getting it on their hands and then transferring it to their mouths, either in the act of wiping their lips or in eating, or by absorption through the skin, but more particularly by the scalp, axilla, &c.

Dr. Stewart, who has had some 25 years' experience in the treatment of phosphorus necrosis in America, asserts that he has never seen any evidence of bad effects due to inhalation.

It must not be imagined that phosphorus is nothing but a poison. It is sometimes prescribed either as an alterative or as a nerve-tonic. It is therefore not impossible that, under favourable conditions and where very little was taken into the system, it might be beneficial. Whence it may follow that in a well-conducted factory, with every precaution taken and plenty of ventilation, no ill results to health might follow. In fact, there is reliable evidence that apart from necrosis the general condition of health of match-makers is not unsatisfactory. On the other hand, French testimony, to which I will presently refer, seems to point to the fact that the general health may somewhat suffer in some directions while it gains in others, when compared with that in other employments. In other words, phosphorus may act in two ways on the human organism, either as a poison, or as antagonistic to certain affections. It will be seen later, as a matter of fact, that the general health of operatives exposed to phosphorus fumes compares very favourably with that of those employed in other factories under similar conditions in the same district.

The description of the disease given by Bristowe is as follows :—

"*Necrosis of the maxillary bones.*—It was observed that amongst those who were employed in the making of matches, and especially among those of them who were most exposed to the fumes arising from the composition employed, some, sooner or later, became attacked with the disease in question; and it was soon established that the proclivity to this disease, through varying in intensity in different manufactories, was a special evil common to them all. The disease, it was noticed, began usually with aching in one of the teeth. At first this was probably mistaken for an ordinary toothache, and would, indeed, at times intermit. Sooner or later, however, recurrence of pain necessitated the extraction of the tooth, and the pain and annoyance for a time probably ceased. The wound in the gum, however, was found not to heal; offensive matter began to ooze from it, and ere long a portion of the alveolus became exposed. Occasionally, the portion of bone thus denuded came away, bringing with it, perhaps, one or two of the neighbouring teeth, and the disease made no further progress. More frequently, however, the disease continued to spread; and, sometimes slowly, sometimes rapidly, more and more of the jaw-bones became denuded, the gums grew spongy, and retreated from the alveoli, the teeth got loose and fell out, the fetid suppuration became more and more copious, the soft parts around grew swollen, tender, and infiltrated, and often the seat of sinuses. And thus the disease continued to progress, till in the course of six months, a year, two years,—it might be even five or six years,—the patient sank from debility, or from phthisis, or from some other consequence of the local affection; or, having lost piecemeal, or in the mass, large portions—one half, or even the whole—of the upper or lower jaw, returned to his original state of good health, but the victim of a shocking and permanent deformity. During the earlier, and more acute, stages of the disease, constitutional disturbance, as might be expected, generally showed itself indicated by febrile symptoms, loss of appetite, thirst, constipation, a sallow, pasty condition of the skin; and these were often associated with intense pain, in the affected parts, and consequent sleeplessness. After a while, however (especially in cases that were tending to a favourable issue), pain and constitutional symptoms diminished, and the patient sometimes recovered the aspect of health, even while necrosis of the jaw was still progressing.

"As regards the relative frequency with which the jaws were affected, it was observed that, on the whole, the lower jaw was more frequently the seat of disease than the upper; and this difference (notwithstanding that it was so little, in the cases collected by Von Bibra and Geist, that out of 68 there were 21 in which the superior maxilla alone was affected, and only 25 in which the lower maxilla alone was involved) seems to have been noted by almost all observers. Occasionally both jaws were affected, either simultaneously or successively.

"A pathological difference was observed in the progress of the disease in the two jaws. Thus, in the case of the upper jaw it was, I believe, invariably noted that the sequestrum was bare, and that no new bone was developed around it; that the process of necrosis was unattended by any, the slightest, attempt at repair. In the case of the lower jaw, on the other hand, it was with equal invariability observed that, after the removal of the bone, a framework of new bone was left behind—small and imperfect, it is true, but still replacing, and to a certain extent fulfilling the functions of the original organ; and it was further observed that the dead jaw itself was clothed, especially below, with an imperfect layer of slightly adherent new bone; this latter appearance was considered, by Dr. Geist, to indicate that the disease was essentially, and in the first instance, periostitis; and that the disease and death of the bone were merely a secondary occurrence,—a view which has, I believe, been generally accepted."

The description of the disease given by Salter in his work on "Dental Pathology and Surgery," London, 1874, at p. 289, is as follows:—

"The influence of the phosphorus fumes upon the jaw is undoubtedly local.

"Lorinser, who has the merit of discovering this disease, held a modification of this view. He considered that the blood is first surcharged with phosphorus, which has an affinity for the osseous tissues, and that the immediate action of the poison is localised in the jaws by their direct exposure to its application.

"Dr. Ebel holds the same view, in a very interesting memoir published by him in Casper's 'Wochenschrift.'* However, Roussel, Geist, and indeed subsequent writers generally, have adopted the opinion, which all the evidence upon this point seems clearly to establish, that the disease is local in its causation.† I have not space here to enter upon the argument of the question; I may, however, mention one telling fact; it is, the necessity of dental caries in the individual before the disease can be produced. It has never been known to occur, excepting where the sufferer has had carious teeth; and many persons have worked in the manufactories for a long series of years with perfect impunity, who, upon the supervention of dental caries, have been attacked with the malady. Dental caries, by opening the central chamber of the tooth and exposing the pulp, seems to offer a direct channel for the poison to be communicated to the subjacent periosteum, and this, no doubt, is why tooth-destruction is a necessary pre-existing condition.

"Dr. Bristowe, in his collection of evidence on phosphorus disease, laid before the Privy Council, disputes the fact that the local application of oxidised phosphorus to the exposed tooth-pulp is the primary and essential cause of the malady; and he bases his opposition to the generally received opinion upon the circumstance that some of those who have been afflicted with the disease, have told him that they had not previously been the subjects of dental caries. If, however, Dr. Bristowe were, as a dental surgeon, practically acquainted with the neglected condition of the mouths of the poorer classes, and their ignorance, and utter indifference as to the state of their teeth, he could not, I am sure, have adduced the mere assertions of these people as of the slightest value in discussing the question. A large majority of the poor, between the ages of 15 and 40, have carious teeth, and very many of them remain entirely ignorant of the circumstance till the fact asserts itself by the occurrence of toothache. I would go further:—I am confident that, of any given number of the poor artisan class, who, upon being asked, asserted that their teeth were sound, a considerable proportion would be found to have dental caries. No such assertion therefore by the patient, unless endorsed by the careful scrutiny of a surgeon *skilled in tooth-disease*, would be of the slightest value as a matter of evidence. Indeed it requires a particular and special knowledge and habit of search to discover many of the points of dental caries, which would be overlooked by an ordinary practitioner of medicine or surgery.

"What the precise nature of the action of phosphorus oxide thus absorbed may be upon the bone is a matter of speculation; but the particular nature of the poison, entering as it does so largely into the composition of the skeleton, is a suggestive circumstance: perhaps, if accumulated by the periosteum, it may generate on the bone's surface a condition of chemical *superphosphate* inconsistent with osteal vitality.

"The *symptoms* of phosphorus necrosis do not differ essentially from other forms of necrosis in the same parts; they are, however, not infrequently accompanied by bronchial and pulmonary irritation from inhalation of the fumes; this has been especially pointed out by Sédillot, Gendrin, and Dupasquier.‡ And one of the patients whom I have seen, affected with this malady, has detailed to me symptoms of *spasmodic asthma* which occasionally supervened, when he was employed for many continuous hours '*dipping*,' while suffering from a common 'cold' in winter weather. Barring this occasional manifestation of pulmonary irritation, the general health of these workpeople seems to be remarkably good.

---

* "Ueber den Einfluss der Phosphorzündholzfabrication auf die Gesundheit der Arbeiter," Mitgetheilt von Dr. Ebel, in Casper's *Wochenschrift*. 15 Mars. 1851.

† The arguments bearing upon this question, and the conclusive inference to which they lead, are stated with cogent force in an admirable clinical lecture on this subject by Mr. Simon, in the *Lancet* for 1856, p. 41.

‡ *Gaz. Méd. de Paris*, 1846, No. 49.

"The symptoms of the jaw-disease usually commence with what is supposed to be toothache, the pain being at first pretty much localised to some one tooth that is carious, and which is probably the channel by which the poison is introduced. The advance of the disease is generally slow at first, and, as it were, undecided—indeed, indefinitely chronic: the pain is inconstant, and not early attended with more serious symptoms; presently, however, it becomes more severe and erratic, extending vaguely about the side of the head and down towards the shoulder, and with this severer pain, swelling, and extreme tenderness occur; the integument near the affected region becomes red, tense, and distended, while the teeth feel elongated and extremely painful when brought in contact with their fellows of the opposite jaw, and they become loose. The gums are swollen and livid, and this condition extends to the mucous membrane of the cheeks. All these symptoms increase till suppuration is established, and with them, more or less symptomatic fever is developed in proportion to the severity and extent of the disease: the patient has rigours and pyrexia, and is often thoroughly ill. The point at which the pus finds its discharge varies a good deal: the soft parts become very boggy, especially the gums, and matter often escapes early around the necks of the loose dead teeth; when pointing externally, its approach is accompanied by intense, glistening erysipelas-like redness of the integument. The discharge of the pus is attended with great mitigation of the patient's suffering. The pus itself is often sanious at first, and always very fetid, having the odour characteristic of the presence of necrosed bone. The orifice of discharge frequently leads to long burrowing sinuses, especially where the lower jaw is affected; and through these the dead bone may be detected by a probe. The swelling which attends the disease is often very great, particularly when the lower jaw is necrosed: it is diffuse and widespread, encasing the external and under surface of the bone in a prodigious, dense, plastic exudation. In very severe cases, previous to the discharge of pus, while the inflammatory symptoms are at their extreme height, the whole head, except the summit of the scalp, is involved—the eyes are closed, the nose, and even the forehead, swollen; the cheeks, lips, neck, and throat, are one continuous area of florid intumescence.

"It is a curious circumstance, that in the lower jaw the necrosis is attended with a very large and complete development of ossifying callus, whereas none is formed when the upper jaw is affected. The large plastic exudation which surrounds the base of the lower jaw becomes converted into a mass of supplemental bone, supporting the sequestrum, which is, for the most part, naked and bare within and behind, and connecting sound portions of bone at its extremities when the whole of the maxillary arch is not involved. Geist assumes that the particular region occupied by the osteophytic incrustation about the lower jaw is the result of gravitation—an idea altogether too mechanical: it is rather to be looked upon as a physiological manifestation, and one element in that marvellous exhibition of the *vis medicatrix naturæ* which this lower jaw-repair displays: the supplemental bone thus placed forms the best support for the sequestrum and the least interferes with the functions of the mouth; while the absence of an ossifying callus at the upper and inner region of the maxillary arch offers the readiest escape of the dead bone through the thin mucous membrane which there alone covers it, and this without damaging the integument of the face.

"As the bone becomes laid bare by alteration of the soft parts, it is observed bathed in ichorous pus, ragged and irregular on its surface, and of a dirty, blackish grey colour. Heyfelder has pointed out this latter as a characteristic element of the disease: but it is certainly not so, though very general. I have seen specimens of phosphorus necrosis white and clean, and with the compact external layer of bone intact. And I have seen syphilitic necrosis of the lower jaw in which the sequestrum was much coated with this particular black-grey incrustations.

"To return to the symptoms of the disease. When the extent of necrosis is very great, the constitutional disturbance is correspondingly severe; and in the early stages of the malady the patient may have intense fever, with delirium and agonising local sufferings, the more distressing from the region which the affection occupies—interfering with or altogether suspending the action of the mouth, and, by the secretion of foul and fetid pus, producing nausea, ructus, vomiting. The looseness and projection of the dead teeth is another source of annoyance and distress; as the sequestra containing them emerge from the surrounding parts, their elongation and angularity much irritate the gums and cheek in contact with them. In the severest cases, general sphacelus of the soft parts about the jaw, with œdema of the face and neck, may supervene, accompanied, or not, by erysipelas; and death may then close a scene of terrible suffering. In other instances with a fatal issue, life is drawn out through many months of tedious illness, varied by different degrees of local irritation; till at length the patient, with vital endurance inadequate to the requirements of the disease, sinks, tabid and exhausted, under continuous hectic, and not infrequently with tubercular complications.

"But the pathological changes may be even more terrible than those already mentioned. Dr. Ebel describes a case, which occurred in the practice of Dr. Hervieux at the Hospital *Necker*, in which the patient, a lucifer-match maker, had first necrosis

of the lower jaw, then of the upper, afterwards of the palate bones, and the orbits and lastly, of the os frontis. He died with brain symptoms. Pus was found between the dura-mater and the brain.

"When the malady progresses to a favourable issue, which it does in the majority of cases, the dead bone gradually loosens and becomes detached; and this is generally anticipated by the falling out of some of the necrosed teeth. In the upper jaw the sequestra are usually more broken up and smaller than in the lower, and they are shed easier, not being held in and detained by ossifying callus, which is always wanting in the upper jaw. In the lower jaw the sequestra are usually more extensive, often including large portions of the body of the bone, not infrequently the ascending rami, and sometimes the coronoid processes, and even the articular condyles. The shedding of these sequestra is often hindered by the large surrounding ossifying callus which always forms when the lower jaw is the subject of this disease."

Mr. Christopher Heath, F.R.C.S., &c., in his work on "Diseases of the Jaws" (London, 1894), Chapter VIII., after enumerating the various causes of necrosis of the jaw, such as syphilis, poisoning by mercury, phosphorus, &c., goes on to say that—

"The phosphorus fumes produce no injurious effects so long as the teeth and gums of the workers are sound, but as soon as the teeth become carious, or if a tooth is extracted so as to leave an open socket, the disease rapidly develops itself. The experiments upon animals by Geist and Von Bibra are amply confirmatory of this view, since they found that rabbits exposed to phosphoric fumes suffered no injury so long as the teeth and jaws were uninjured, but that if the teeth were extracted or the jaw broken, periostitis and necrosis rapidly resulted. On the other hand, it may be mentioned that a case has been reported by Grandidier ('Journal für Kinder Krankheiten,' 1861) of necrosis of the upper jaw from phosphorus fumes in a child but six weeks old, and in whom therefore the teeth were not developed."

This must certainly have been a very curious case. Looking to the fact that other causes besides phosphorus can produce necrosis, and that the child was but an infant, I cannot think that one isolated report of this kind should be allowed to stand against the unanimous opinions of our greatest surgeons. I may add that my own experience, as dental surgeon at the London Hospital, confirms me in the opinion that in the absence of any specific disease any ulcerative or suppurative conditions of the mouth may set up general periostitis of the bone, terminating in necrosis, but that I cannot see how it is possible for necrosis to be contracted by match workers unless either the teeth or gums are defective or the maxilla or the mandible has been injured. Nor have I ever seen such a case.

Upon a question of this nature, in which experiment upon human beings is impossible, and the disease fortunately comparatively rare, it is impossible to pronounce with absolute certainty, but I believe it may be safely said that no case of necrosis has ever been reported in which the teeth were positively known to be in a sound condition when the disease was contracted; and that the weight of modern scientific opinion in the light of the wider experience of the present day is unanimously in favour of the view that if the teeth and gums are sound, or if all decayed teeth are properly stopped, it is not possible to contract phosphorus necrosis. And I shall presently show that in other countries, notably France and America, this view has been adopted as the basis of the preventive measures taken against the disease. In the existing special rules the danger from decayed teeth has been recognised, but I think that the stringency of these rules as regards the inspection and care of the workpeople's teeth, requires considerable increase.

As a result of Bristowe's observations, he says that, though he found ample proof of the occurrence of necrosis of the jaw, yet he did not find any proof of the prevalence of other forms of disease.

My own observations of the workpeople in the factories which I visited bear out this view. They do not appear to me to be worse in general health than those engaged in other occupations classed as healthy; indeed, there are good grounds for saying that their health is even better than the average. Of the condition of their teeth I shall speak presently.

Bristowe goes on to say:—

"What is the predisposing cause of the jaw disease:—

"In answer to this question, I may repeat, that I have entirely failed to detect the existence of any constitutional cachexia, or disorder, attributable to phosphorus fumes, in those most exposed to their influence; and may affirm that I have met with no evidence that any kind of idiopathic ill-health had preceded the outbreak of the local

disease. Nevertheless, I may mention here a somewhat curious fact, which may seem to throw doubt on the accuracy of the latter observation, viz., that out of the cases which I have collected, there were eight instances in which two brothers or sisters had become attacked. In the absence, however, of any constitutional disturbance, some local determining cause must exist; and since (as Mr. Simon has pointed out) no similar disease takes place primarily in the bones of the nose, although the schneiderian membrane is exposed equally with the mucous membrane of the mouth to the deleterious fumes, it is naturally to some peculiarities in the teeth and gums that attention becomes directed.

"Ever since the appearance of Von Bibra and Geist's work it has been generally admitted that the presence of carious teeth is necessary to the production of the disease; that exposure of the tooth-pulp, and through its agency, of the periosteum, is a *sine quâ non* in its causation, and that those with quite sound teeth enjoy perfect immunity. This view, however, I am not disposed altogether to accept; for, in the first place, I have obtained abundant evidence that the existence of even very carious teeth, among those who have been dippers for years, does not ensure for them an attack of jaw disease; and in the second place (if the testimony of the sufferers themselves goes for anything), two or three of those I have conversed with, assert that their teeth, prior to the occurrence of the disease, were excellent—an assertion which is in accordance with that which I have already quoted from Dr. Bilroth of Zurich. It is certainly a fact that the disease does not select, in any special degree, those whose teeth are in a *peculiarly* unsound condition. Of 102 persons, who were acting as dippers or mixers, or who had acted in one or other of these capacities, I found that 63 had, at the time of my examination, carious teeth, and that 39 had sound teeth; but that, among the latter, were several who had had teeth extracted, more than one who had had a tooth or two accidentally broken, and several who had worn away the crown of one or two front teeth by the constant habit of tobacco-pipe smoking. Now, most of these had worked for many years at match-making, and many of them had been exposed for some years habitually to the concentrated fumes of phosphorus, and yet their jaws remained healthy. In regard to those, again, who had had the disease, I found certainly that, in the majority of cases in which I was able to make personal inquiries, they had had carious teeth prior to the occurrence of the disease; but they had not had, as a rule, any peculiar degree of caries, nor were they, so far as I could ascertain, those in whom, at the time of the supervention of jaw disease, the teeth were in the worst condition. It must be borne in mind too, in considering this question, how difficult it is to prove the pre-existence of perfectly sound teeth. The persons affected belong to a class that habitually pays little regard to the condition of these organs.

"As a corollary to the above, I may state that I found no reason whatever to suppose that the teeth themselves suffer from the phosphorus fumes. And although numbers of those engaged have, as I have shown, bad teeth, their proportion is probably not larger than would be found among any equal number of persons of the same age. In corroboration of this statement, I may point out that many in whom I found the teeth carious, had had them in this condition before they had commenced matchmaking; and that the great majority of them themselves attributed the caries to natural causes; that, among the sufferers from bad teeth, the decay was almost universally confined to the back teeth, which, under ordinary circumstances, are most commonly affected, and which are least exposed to the action of external influences; and that the front teeth, even in cases where they had been accidentally damaged, continued, although chiefly exposed, almost invariably sound and good; and, lastly, that of the dippers and mixers with sound teeth, many had been engaged for years in their employment."

It must be admitted that on the Continent most writers still hold to the belief that "phosphorism" exists, but in this I think that they are wrong. The lack of any constitutional cachexia or disorder attributable to phosphorus fumes in those most exposed to their influence, and the absence of any kind of idiopathic ill-health preceding the outbreak of the local disease, noticed by Bristowe, also characterised the more recent medical evidence which I have obtained in this country. With regard to the one fact he mentions as possibly seeming to throw doubt on the accuracy of the above observation, viz., the occurrence of instances in which two brothers or sisters had become attacked, I, too, have collected a few other similar instances, which, however, have not in the least shaken my judgment in the soundness of his conclusion as to the absence of any general systematic disorder from the fumes of phosphorus, termed "phosphorism," as distinct from the local disease of phosphorus necrosis, which, alas! is not so extinct as some modern text books would lead us to believe.

By "phosphorism" most continental observers mean a special form of intoxication from continually breathing or being exposed to an atmosphere charged with phosphorus fumes, similar to that produced by alcoholism,

saturnism, and mercurialism, and which puts these individuals in such a cachectic condition that the resistance of the individual to the attack of the numerous diseases which constantly threaten all factory operatives is lowered. Many fallacies have hence arisen. For instance, it has been asserted that miscarriage arises from this intoxication, yet from a modified believer in "phosphorism" we learn that there is absolutely no evidence of exposure to phosphorus fumes procuring abortion, since during the year 1896 at the Paris-Pantin match factory there was a total of 109 births amongst a *personnel* of 500 workwomen.

Again, with regard to the frequency of fractures of bone, the ease with which fractures occur, and the slowness of the formation of the callus, noted by Magitot and others as peculiar to match-workers, Dr. Mahu could find no evidence.

Dr. Arnaud,* who has long been doctor to the large match works at Marseilles, had only met in 12 years with one case of fracture in a woman, and she had been working for five years in the factory. That fracture consolidated quite regularly in the usual space of time with no defective callus nor shortening.

Dr. Toland, in association with his senior partner, Dr. Alexander, has the care of several works in the east end of London, and is, therefore, able to compare the diseases and accidents in several different occupations. In Messrs. Bell & Co.'s Match Factory he considers they enjoy marvellous health, and only suffer from common ailments. The accidents, too, are slight, as only three cases in two years have come to him for treatment of burns. Of course there are many very slight burns which occur, but these are mostly treated by the forewoman or the girls themselves. The most frequent accidents in these works are crushed fingers under the press. These occur, of course, in the tin-box manufacture, and not amongst the match operatives. Anæmia is probably the most common trouble with which he has to deal, but it is no more frequent than in girls working in the rubber factory; indeed, he was inclined to think rather less. He had never seen a case of phosphorus necrosis, and he had never seen the slightest evidence of any general or constitutional effects, toxic or otherwise, from exposure to ordinary phosphorus. Neither did they suffer more than other girls from toothache. If a girl comes with bad toothache, she visits him at his own surgery, and he takes the tooth out at once, and does not treat her any differently from an ordinary patient, except that she is directed not to go back to work until the gum is thoroughly healed. No certificate of fitness to return to work after extraction is usual, nor in his opinion required. No registration of the cases treated is kept. Dr. Toland was kind enough to write me a report, with a few statistics. Owing to pressure of time, as can well be imagined in an East End practice, where the duties are heavy and the fees are small, the statistical information he has been able to give is not as great as he would have liked, but it is sufficient as another proof of the healthiness of match industry as compared with others in the same class and district:—

We have been surgeons to Messrs. R. Bell & Co.'s match factory for the past three and a half years.

During that time we have not had a case of phosphorus necrosis, nor have we met with any disorder attributable to the action of phosphorus.

The general health of the employees compares favourably with that of workers in other factories under our charge.

The common ailments among the girls and women are anæmia and dyspepsia. Burns are rare. Injuries to the hands among the workers in the tin-box department are common, *e.g.*, bruised fingers.

The men and boys do not trouble us much.

Carious teeth are present in nearly all the employees, but toothache and gum-boils are not more prevalent than in the workers in our other charges.

* Etude sur le phosphor et le phosphorisme professionnels, par le docteur Fr. Arnaud, à Paris, chez Baillière, 1897.

We are of the opinion that with care and cleanliness the risk, to the match-worker, of phosphorus necrosis is almost *nil*.

TABLE I.

—	Number employed.	Applied for Advice during one Week.	Per-centage of those Ill.
Match works - - - - -	650	20	3·07
Rubber works - - - - -	550	13	2·36
Soap works - - - - -	200	11	5·5

TABLE II.

—	Number applying for Advice as above.	Teeth Trouble.	General.
Match works - - - - -	20	3	17
Rubber works - - - - -	13	2	11
Soap works - - - - -	11	1	10

Table I. shows (1) the number of employees in three factories under our charge (those employed in the soap works are males only, in the other two works males and females); (2) the number which came under our treatment during one week; and (3) the per cent. of those ill to the total employed.

Table II. divides those under treatment into two classes: (1.) Teeth troubles; (2.) General ailments; and (3) gives the per cent. of teeth trouble to the number under treatment.

Two of the three teeth cases amongst the *match workers* were *toothache* due to carious teeth. The treatment was palliative. The other case was *extraction* of a tooth for some cause.

The two cases of teeth troubles in the *rubber workers* were, one of *extraction* for caries, and one of *toothache from carious* teeth.

The one case in the *soap works* employee was *extraction for caries.*

Under the head of *General ailments* are included gastric trouble, mainly errors of digestion, anæmia, bronchitis, rheumatism, tonsilitis, and laryngitis.

The above report gives a fair average of the illness met with in the three classes of work mentioned.

Our experience leads us to believe that match-workers do not suffer from their teeth any more than do those employed at other trades.

SAMUEL ALEXANDER, L.R.C.P. and S. Ed., L.S.A.Lond.
C. K. TOLAND, M.B., C.M (Glasgow Univ.).

Morley House, Bruce Road, Bow, E.
13th October 1898.

Dr. Young and his partner, who are the medical attendants to several large factories in the neighbourhood of the Diamond Match Factory near Liverpool, corroborate the foregoing view as to the health of the match-workers there, as compared with other industrial occupations in the vicinity.

In France, Dr. Mahu, to whose investigations I shall allude later, may be taken as favouring this view.

A careful perusal of the able and lucid report of Bristowe on the manufactures in which phosphorus seems to be produced or employed, and on the health of the persons engaged in them together is essential to the formation of any intelligent opinion on this question; but after an interval of 36 years it is evident that any consideration of the question must be approached on somewhat new lines. The science of bacteriology has been created since that report was written, and the progress of the science and art of dentistry, both theoretical and applied, has been enormous.

In the light of these scientific developments it seems difficult to understand Bristowe's opposition to the special dental aspect of the question; especially as the condition of the teeth plays so prominent a part in his history of cases, and as the majority of investigators were practically agreed in conceding that defects in the teeth were potent in producing this particular form of necrosis. The views of Salter, his contemporary, have prevailed, and have been embodied in their works by most British and American surgeons who have since written on the subject. The great French authority Magitot, in the "Comptes rendues de l'Académie des Sciences, 1875," insists emphatically that the sole cause, the invariable and exclusive point of attack, is that variety of dental caries known as penetrating caries (la carie pénétrante). This simply means that stage of decay in a tooth which has progressed so far that the pulp, or so-called nerve, has become involved.

It certainly seems strange that doubt should still exist on this point, and surely the time has come, owing to this apparent recrudescence of the disease, for its being cleared up. It may be that advanced caries of the teeth is not the sole origin of the disease, but it is absolutely certain that bad teeth necessitate resort to the forceps and an operation which almost certainly leads to an attack if neglected or ignored. Accepting Bristowe's statement that the disease is essentially "periostitis leading to necrosis," it is surely evident that a putrid pulp, which usually causes, sooner or later, an inflammation of the dental periosteum (periodontitis, pericementitis) and which in its turn may extend to the periosteum of the bone with which it is continuous, and the formation of an abscess which invades the substance of the bone itself, must be a source of danger. Such a condition of the teeth can be remedied and often absolutely prevented by treatment in the early stages of caries.

In support of this view I am glad to be able to add the following notes which have been specially prepared for this report by my friend, Dr. Joseph Griffiths, Reader in Surgery to the University of Cambridge, after a full discussion of the matter with me, and which may be taken as typical of the modern surgical view of the disease and its causation :—

"Although the bones of the skull are but rarely affected with the diseases of suppuration, yet the maxilla and mandible are very commonly affected. In these two bones, however, the suppurative disease is usually limited, whether by nature or by prompt and effective surgical measures, and it does with few exceptions follow upon acute infective disease of the pulp of the tooth, infection of socket after extraction, or abscess at the apex of the root. Occasionally a localised suppurative periostitis of the lower jaw may be met with after fractures of or blows upon the jaw. In a greater number of cases the infection by means of the organisms of suppuration—staphylococcus aureus and albus and streptococcus—can be traced from the tooth through the substance of the bone at and beyond the root outwards to the under surface of the periosteum, which is raised from the bone by the collection of pus. Occasionally, it happens both in the upper and lower jaw bones that the process of suppuration extends beyond the immediate zone of the diseased tooth until a considerable portion, if not the greater part of the bone, becomes involved and necrosis follows. I have seen three cases : one in a boy (4–5 years) in whom the left half of the mandible became necrosed, and from whom I subsequently removed it ; the other in a lad in whom, after an ordinary acute abscess following upon disease of the root of the right upper lateral incisor, the greater part of the maxilla became dead ; and the third in an old man in whom the greater part of the horizontal portion of the right half of the mandible was affected with acute osteo-myelitis and necrosis, following upon the extraction of a tooth.

"Although the lower jaw, for example, is affected with localised suppurative periostitis and osteo-myelitis more frequently than any other bone in the body from its becoming infected through the teeth, yet extensive osteo-myelitis with necrosis in the mandible (or in the maxilla) is rare except among persons who work in phosphorus fumes—match-makers—and owing to the frequency of this disease among the workmen it has received the name of phosphorus necrosis, the so-called 'phossy jaw.' But there is nothing peculiar about phosphorus necrosis, for it begins like acute necrosis of any

other bone, runs a definite course and then subsides, and it is caused in the same way as acute necrosis of the tibia, viz., by the entrance into the bone of the organisms of suppuration, which in the case of the jaws usually gain entrance through diseased teeth. At times the organisms that cause the suppuration gain entrance into the general circulation, and induce one of the varieties of septic disease, which are liable to lead to the death of the person. What part the phosphorus fumes play in making this common disease so much worse in match-makers than it is under ordinary circumstances is a question that still remains to be solved. Whether the phosphorus lowers the vitality and consequently the resisting power of the teeth and jaw-bones, or increases the virulence of the staphylococci in the diseased teeth, are questions that are still open.

"The treatment of this suppurative disease when localised, and in connexion with a morbid state of the pulp of a tooth, resolves itself into early and free incisions through the gum and periosteum to the bone. This should be done even before there is any evidence of the accumulation of pus under the periosteum, because the relief of tension thus afforded by the escape of pent up lymph, and by the excessive bleeding, as a rule, suffices to stop the progress of the malady. When infection follows upon the extraction of a tooth, then it is necessary to scoop out the socket, and to soak it well with some substance such as pure carbolic acid, in order to get rid of the infected cancelli of the surrounding bone. When, however, the disease is found to be more extensive, the suppuration extending in the interior as well as on the exterior of the bone, then it becomes necessary to establish free drainage from the interior of the bone, as well as from the under surface of the periosteum, by making one or many apertures for the exit of the inflammatory products. The lower jaw should be dealt with just as the tibia, but in the upper the cavity of the antrum should be well drained. The upper jaw can only be drained into the mouth, but in the lower, drainage should always be established along the inferior border just below the margin of the face. In dealing with these suppurative diseases it is essential to act promptly, and to make extensive incisions, even if they ultimately prove to be too large. Doubtless in the case of 'phosphorus necrosis' the same plan of treatment will be followed by results similar to those seen in ordinary cases."

Such features as are peculiar to the process of necrosis in the jaw bones are clearly indicated in Appendix VI., p. 225, which embodies the views of Professor Kocher of Berne; also in it the infective nature of the disease, and the dependence of infection upon the presence of some morbid state of the teeth are strongly emphasised.

Further corroboration of the view that this disease is entirely due to infection by means of the miro-organisms of suppuration occurs in a recent article by Professor Stockman* "On the Cause of so-called Phosphorus "Necrosis of the Jaw in Match-workers." With regard to pathology he says:—

"As regards the bone, the condition is one of cario-necrosis, there is chronic ostitis and periostitis, and it differs in no respect from the same lesion as seen in other bones and from various causes.

"It has long been held that this necrosis, or cario-necrosis as it should rather be termed, is due to a specific action of phosphorus fumes on the bone, these being supposed to cause a peculiar and specific kind of inflammation. If one considers, however, the whole circumstances and the clinical histories of individual cases, the conclusion must inevitably be drawn that the process is due to infection from a micro-organism. Phosphorus fumes consist of phosphorus anhydride (P_4O_6) chiefly, with some phosphoric anhydride (P_2O_5), and during the oxidation either ozone or hydrogen peroxide is also formed in small amount. From what we know of suppurative processes, it is inconceivable that any of these bodies can cause a chronic purulent inflammation of bone such as has just been described as occurring in 'phossy jaw.'"

Professor Stockman made cultivations of the pus from six cases, which revealed the presence of staphylococcus albus, streptococcus, and numerous

* British Medical Journal, No. 1984 (Saturday, January 7, 1899), page 9.

other organisms, none of which, in spite of other observations to the contrary, he thinks could reasonably be regarded as the cause of cario-necrosis. He also found the presence of tubercle bacilli in every case, which he seems to regard as proof positive of the tuberculous origin of the disease.

"The part which the phosphorus plays in the process is not far to seek. The acid fumes (phosphorus and phosphoric acids) produced by its oxidation in the air have no effect on bone covered by gum or mucous membrane; but when they can penetrate to the bone directly through the aperture left by a decayed or extracted tooth or any injury, they erode the bone, weaken its nutrition and resisting power at this small spot, and make it susceptible to infection by tubercle bacilli. The bacilli having made good their foothold, spread slowly in some cases and with disastrous rapidity in others. I think I am correct in saying that the great majority of workers in match factories have carious teeth, and yet only a very small proportion of them become affected with cario-necrosis of the jaw—namely, those of them who, owing to their home surroundings or to individual predisposition, become readily infected by the tubercle bacillus."

His statement that in most cases death occurs from tuberculosis of the lungs is not in accord with the views of other observers. His view that phosphor necrosis is essentially a tubercular disease will meet with many dissentients both amongst medical practitioners of experience in such cases, and amongst bacteriologists.

However that may be, his remarks as to prophylaxis are pertinent to other organisms as well as to tubercle, and will therefore meet with general approval.

"As regards prophylaxis, there is absolutely no risk so long as the bone remains protected by gum, and even when carious teeth are present the entrance of the bacilli can be prevented by careful stopping. Efficient ventilation of the workshops will dilute the acid fumes arising from the phosphorus, and make them less active in injuring exposed bone. The infection with the tubercle bacilli is a matter quite apart from the factories, and cannot be controlled either by State regulations or workshop rules. It is acquired—as other tuberculous affections are acquired—by certain persons and not by others, and owing to the present all-pervading frequency of the organism persons with exposed bone eroded by acid fumes, and living under bad hygienic conditions, are very apt to become infected.

"It is just possible that actinomyces or other organisms may also occasionally lodge in the weakened bone, and lead to caries and necrosis, but in those cases which I have hitherto examined I have only found the tubercle bacillus."

With regard to Professor Stockman's particular view, I would submit two statements in answer to his own inquiry "whether the fumes also weaken "the mucous membrane of the lung alveoli and predispose to pulmonary "phthisis among persons employed in match factories, I have no information "which will enable me to decide."

Firstly, Dr. Lauder Brunton, in his lectures on the Action of Medicines,* calls attention to the fact that "the fatty degeneration which is observed after the administration of phosphorus is a toxic action, but the same thing may be utilised in its lesser grades for its therapeutic action; for fatty degeneration is one of the means by which solid exudations are absorbed in the body, and we find that the administration of phosphorus or of arsenic in various forms tends to help the absorption of certain exudations."

Secondly, Dr. Mahu,† in his able thesis, "Le Phosphorisme dans les manufactures d'allumettes, Hygiène-Prophylaxie," after detailed statistics to which I allude later on, p. 194, states that tuberculosis affects the tobacco operatives to a greater degree than the match-workers. In 1896 of 11 deaths in the tobacco factory, there were seven from tuberculosis, while in the match factory there only five in 15 deaths. In order to give greater weight to this statement, he investigated the records up to the 1st January 1891, and found that the deaths from tuberculosis were 30 in the

* Macmillan & Co., Ltd., 1897, p. 500. † Jouve, Paris, 1898, p. 38.

tobacco factory, as against 20 in the match factory. Hence he concludes that the mortality from tuberculosis is considerably less in the latter than in the former occupation.

By the courtesy of Dr. Stewart I am able to give here some of his opinions upon the subject of phosphorus poisoning. They are particularly valuable, as probably no one has a wider experience. Besides, the free hand given to him, not merely to inspect the teeth, but to look after the general health, and even to act as the company's almoner among the workpeople, has given him great insight into their habits and ways of thinking. It must, however, be remembered that his experience has been exclusively gained in America, with the exception of his recent visit to the Liverpool factory in England.

Dr. Stewart considers that there is absolutely no doubt as to the dental origin of phosphorus necrosis. He believes, and our experience here seems to bear him out, that the operation of mixing the phosphorus is less dangerous than subsequent operations. For although the heating of the phosphorus gives rise to great fumes, yet they are directly under a hood, and are not finely distributed as is the case, to a certain extent, in the other operations. The ordinary dippers he considers most exposed to danger.

It appears that the diamond match machine operatives do not change their employment, but work their whole time at their own respective branches.

There is no means of knowing exactly when disease commences, but Dr. Stewart's system is this—If he observes the general health to be in any way affected, he at once causes the urine to be examined. If this discloses an exceptional quantity of phosphates, or any exceptional condition, he then observes the case until the urine is again normal.

Although the phosphorus shows itself in the urine, there does not appear to be any unusual tendency on the part of the operatives to kidney disease.

The best remedies he thinks are not drugs, but rather physiological than therapeutic. He recommends baths and exercise. This becomes possible, because, in connexion with the works, there is always some outdoor or semi-outdoor work to be done, such as packing or assisting to load vans. This point is worth observation. It would probably be a good thing that dippers in England should periodically be put upon some employment in the fresh air while at the same time they took a few baths to open the pores of the skin and promote perspiration.

In America Dr. Stewart estimates that not one in a thousand of the operatives is "phosphorised."

He thinks that though the teeth may be undecayed, yet if they are surrounded with masses of tartar which force the gums away from the bone of the jaw, that necrosis might result, hence he considers that the decayed condition of the teeth has been too exclusively regarded as the cause of the disease.

He therefore thinks that the first point of importance is the removal of tartar from the teeth, and then thorough cleansing. In this, his view will be seen to agree with that I have taken in this Report.

B.—Incidence of the Disease.

The following table gives the cases of phosphorus poisoning reported to the Factory Department as having occurred in lucifer match factories in the years 1894 to 1898 inclusive:—

Year.	Mixing.		Dipping.		Drying.		Boxing.		Total.		Fatal.	
	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.	M.	F.
1894	—	—	—	—	1	—	—	1	1	1	—	—
1895	—	—	1	—	—	—	—	3	1	3	1	—
1896	—	—	3	—	—	—	1	3	4	3	1	—
1897	—	—	4	—	—	—	1	2	5	2	—	—
1898	—	—	4	—	—	—	1	5	5	5	1	—
Total	—	—	12	—	1	—	3	14	16	14	3	—

Some of the cases marked here as belonging to 1897 and 1898 had really occurred earlier, but were not reported till those years. In strictness, therefore, they should be placed under the columns for the previous years.

It appears that several firms have for years continued the use of yellow phosphorus without the occurrence of ascertained cases of necrosis, and that the recorded incidence of attack of the disease upon workers in phosphorus during five years was about 1·7 per cent., and the number of fatal cases about 0·17 per cent.

Among boxers the per-centage attacked was very much lower, but among dippers it was very much higher.

These figures represent the average for the last five years on a *personnel* of 1,700 workers,* therefore assuming the latter as a fair average for these years, the number of cases of necrosis is 0·34 per cent. per annum, and the number of fatal cases is 0·034 per cent. per annum.

These figures must be mere approximative, for it is or will be evident that the "population" is extremely variable from employees coming and going; and therefore the results are under rather than overstated, since no allowance has been made for inevitable changes in the *personnel*.†

Notes on visits to Match-workers suffering from Necrosis.

Through the kindness of Dr. Garman, I was enabled to examine all his patients at present suffering from necrosis. Some of them I saw in his surgery, but most I visited in their own homes. Only one case was not visited as the patient was too ill to be disturbed.

The notes taken will illustrate the descriptions already given.

These visits were doubly interesting as most of them had been already reported on by Dr. Paddock Bate, in May 1898, and I was thus able to contrast their condition in the end of the following September.

All the cases must be regarded as severe, but all the patients were comfortable and one might almost say reasonably happy in their affliction. As a rule, once the acute stage has been passed, there is little pain and no fear of any fatal result, except from complication by some other disease from which these match-workers are no freer than ordinary mortals. The one patient I was unable to see was suffering from pneumonia. All the patients are well cared for and all seemed on excellent terms with the doctor, and grateful to their employers, who have spared no expense in their treatment, or during their convalescence.

It is worth noting that one of the men had got married to a nice, healthy-looking, young woman two years after being attacked, and has two children, and that others had had children born since the commencement of the disease.

It will be noticed that all these cases invariably started with some dental trouble, either a decayed tooth giving pain, or one causing an abscess.

The family history was good in eight of the cases, fair in four, and bad in none.

The personal history was more difficult to ascertain. The majority, especially the women, were known to be careful livers. Two of the male cases are reputed to be addicted to alcohol.

The condition of the mouth is always very bad, usually foul with very large deposits of tartar, and sweltering in pus. It must be extremely difficult to keep the parts clean, but some dental attention and the frequent use of more efficient antiseptic mouth-washes would greatly improve their condition.

All the cases had been treated under the old expectant method. For this method it may be said that the fatality is low and the end results are good. We saw cases proving that even after the loss of the entire lower jaw, a new bone had been formed affording an excellent base for an artificial denture. Indeed, in one case of long standing which was announced cured, and with excellent results, the patient did not at all seem to like having to resume working for his daily bread.

* *Vide* page 131, First Section.

† In Bryant and May's factory the number of admissions in a year often greatly exceeds the average number of all the employees.

The length of time during which they had worked at match-making prior to the commencement of the disease varied considerably: from nine to 26 years in the case of the men, and from four to 27 years in the case of the women. The total average was 13½ years. The age when attacked varied from 22 to 39 for the men, and from 19 to 39 for the women.

The duration of the disease is equally variable, some of the more severe cases having been under treatment for six and seven years.

The modern treatment of this condition is anything but expectant, and its results will be found in Professor Kocher's and Dr. Kuiper's monographs, abstracts of which are given in Appendices VI. and VII., pp. 225–229. It will be seen that its advantages must be summarised thus:—(1) Lowered mortality; (2) curtailed duration of the illness; and (3) absence of relapse.

The occupations in which these patients were engaged at the time of their attack were, in the case of the six men, dipping in all except one, who was a drying room assistant, and in the case of the seven women, boxing and cutting down wood matches. As the number of female operatives is about six or seven times that of the male hands, the dipping and drying rooms seem to be about six times more dangerous than the boxing room. By doing away with the cutting down by hand, wood boxing might be made as safe as wax boxing.

Details of Cases.

Men.

(1.) W.C., aged 35 years.—(Case not reported, having occurred before notification was required), has been a match-worker since 14 or 15, and was a dipper for 15 or 16 years.

History.—Seven years ago he suffered from toothache; Mr. Gill extracted a lower tooth, and then the others loosened and dropped out.

The whole lower jaw up to the condyles came away about a year ago. A complete new lower jaw has been formed. It is very broad and thick, giving great fulness to the lower part of the face, and will form an excellent support for an artificial denture. The strongly marked cicatricial scars do not show very much.

His upper teeth are good, but foul and covered with tartar.

Family History, good. He has five children, between the ages of 1 and 12, all healthy. He himself is healthy and strong.

(2.) T.W., aged 25 years.—Five years in drying-room, and five years handing out.

History.—Symptoms commenced February 14th 1894, with toothache followed by spongy gums. The whole of the lower jaw, including the rami, became necrosed.

*Present condition.—Sequestrum on left side has been removed, but that on the right is still *in situ*. There are still some external sinuses discharging, but the man's health appears good.

Re-examined September 29th.—A large sequestrum representing the right ramus was removed this morning. The repair of the lower jaw is remarkably good.

Teeth foul, with much tartar. Upper teeth very good.

Family History, good. One sister employed at Bryant & May's died at 30 years of age in her confinement; one brother died at 50 years. Father, 66 years, alive, two elder sisters, one elder and one younger brother alive and well.

(3.) C.P., 41 years of age.—Fifteen years a dipper, previous to that a carrier boy, 26 years in works.

History.—Abscess formed about root of carious molar in left upper jaw. Came under treatment 8th March 1896, gums became spongy, abscesses formed, and nearly the whole of both upper maxillary bones became necrosed.

*Present Condition.—The sequestrum is still *in situ*, but is loose.

---

* Dr. Bate's Report, May, 1898.

There is a large wound under the left eye through which the nasal process of the maxillary bone protrudes. The man's general health appears to be good. He is comfortable, and well looked after.

Note by Dr. Bate.—This man states that on one or two occasions he had teeth extracted previously to his illness. He was away from work on each occasion for about a fortnight. This period is much too short, and should be extended to at least four weeks.

September, 1898.—Condition much the same. Teeth foul with much tartar. Teeth very good. He has always led a careful life.

Family History.—Father died at 56 years; mother at 40, in childbirth; his only brother died at 21 years from consumption; five sisters died very young, two sisters survive, one, 38 years, now in Bryant & May's, the other, 40 years, living in the country.

(4.) E. G., 27½ years.—Five years a dipper, six years previously as a boy.

History.—Has been under treatment since December 2nd 1896.

Symptoms commenced in the usual way with toothache, followed by spongy gums and formation of small abscesses at the side of the nose.

*Present Condition.—Now about two-thirds of the right upper maxillary bone and the whole of the malar bone are necrosed. Sequestrum is loose but is still *in situ*. There is a large opening over the right malar bone under the right eye.

The man acknowledges having had teeth extracted, and going back to work before gums were completely healed over.

Later Condition.—With regard to the above admission, he stated that he had a tooth extracted on a Saturday and returned to work on the following Monday without giving notice. He asserts that the tooth was the lower left first molar, and that a year later he suffered much toothache from badly decayed teeth, but did not seek advice till he had a swelling on the right side of his nose. He was under treatment twelve months before the teeth loosened and came out. The case has developed rapidly, and the left upper maxillary bone is now necrosed.

The remaining teeth are of excellent quality, but very dirty, and with a little tartar.

He has gained 20 lbs. in weight since last Christmas, and weighs over 11 stone.

Family History, fair.—He says that his father was a heavy drinker.

(5.) J. M., 24 years.—Nine years match-working, a dipper for 1½ years, previously a hander-out.

History.—Had a decayed stump in left side of lower jaw. About August 31st 1897, an abscess formed and now the right side of the lower jaw as far as the canine tooth on the left side is necrosed.

*Present Condition.—Fresh abscesses keep forming, the dead bone is not loose. The man's general health is fair.

Later Condition.—Much the same, all the teeth on the right side of the sequestrum have been lost, but the left lower incisors and canine are free from decay but quite loose in their sockets. The rest of the lower teeth are firm and sound, the upper teeth strong, well formed teeth of excellent quality, but very foul and five have been lost. The acute stage lasted about one month when he was confined to bed and was in much pain.

He continues to increase in weight, being now fully 3 lbs. more than he ever reached before his illness. He used to earn 29*s.* a week, and is now allowed 33*s.* a week, being 24*s.* for himself and 9*s.* for his wife, a former box-hand who attends him. He has always lead a careful life.

Family History, good.—Father 60 years alive, two brothers and four sisters all alive and well. He has one child.

New case since Dr. Bate's inspection.

(6.) J. M., 34 years.—Dipper for 14 years, and assisted as a boy, carrying, etc., since about 10 years old.

History.—This patient had had the right upper second bicuspid extracted by Mr. Gill under the direction of Dr. Garman, who had the case under observation for some time about the end of July 1898.

* Dr. Bate's Report, May, 1898.

The extent of the necrosis is still uncertain, but the prognosis is favourable.

Present Condition.—There is considerable inflammation of the gums, with some ulceration and puffiness in the neighbourhood of the extracted tooth.

The teeth are of good quality and condition, except that they are foul and very much covered with tartar.

Family History.—The father died at 48 in a hospital, the mother is alive and nearly 80 years of age; there were six sisters, all match-workers, of whom one died from necrosis, four married and left the works, and one, a widow, is still employed at Bryant and May's. They are all older than himself except one. His wife had also worked in the same factory for over 10 years. They have had four children, respectively seven, four, and two years, and one buried at 13 months.

Women.

(7.) M. A. D., aged 30 years.—Twelve years a box-filler (wood) and cutter down.

History.—About six years ago she had a carious wisdom tooth, which was extracted. An abscess formed inside the mouth over the palate bone. This discharged and a small piece of bone came away.

*Present Condition.—She has now a purulent discharge from the left nostril, but no other symptom of necrosis.

Later Condition.—No marked change.

Her teeth are poor in quality. She has lost two molars on each side of the upper jaw, in addition to the extracted upper left third molar, and the second bicuspids and all the molars in the lower jaw except the left third molar. Three teeth are at present so badly decayed as to need extraction, and as many, if not more, require filling.

The teeth are very dirty and stained, and there is a little tartar, and general inflammation of the gums.

Family History, fair. Father died at 59, mother at 46; two brothers alive at 32 and 27 years. She has had three children. Her first child is alive and healthy, aged seven, and of the others born since her own illness, one lived two years and died from infantile diarrhœa, and another baby at Christmas 1896 was stillborn, said to have been strangled in its membranes.

(8.) E. S., 44 years.—Seventeen years a box-filler (wood); 10 years before a machine-filler.

History.—Owing to toothache and abscess in face she first came under treatment about December 1893. Gums became spongy and other abscesses formed. The whole of the right upper maxillary bone became necrosed.

*Present Condition.—The sequestrum is loose, but is still *in situ*. The woman's general health appears good.

Later Condition.—The disease has extended, and the left upper maxillary bone is involved as far as the region of the left upper first molar. She has lost all her upper, and three of her lower teeth. Her remaining teeth are poor in quality, and some six teeth require extracting, and others filling. They are naturally dirty, and there is a little tartar.

She had hitherto been allowed 15*s.* a week, but as husband who earned 30*s.* to 40*s.* a week hawking sawdust was now dead, the firm, per Dr. Garman, agreed to refund all the funeral expenses, and increase her allowance to 30*s.* a week.

Family History, good. She had always led a careful life, and has been well conducted. Her general health is very good.

(9.) L. D., 29½ years.—Box-filler (wood) and cutter down for nine years. 4½ years previously in box store.

History.—In June 1895 a decayed molar in right lower jaw gave trouble, an abscess formed, followed by others, and the gums became spongy. She was in bed for seven months.

*Present Condition.—The whole of the lower jaw, including the rami on both sides, is necrosed. The new bone beneath is pushing up the sequestrum,

* Dr. Bate's Report, May, 1898.

but there are a number of sinuses discharging externally from ear to ear. The general health appears good.

Later Condition.—Much about the same. She suffered much pain in the acute stage and dwindled to a shadow. On liquid food, stews, &c., she has been gaining in weight for the last two years.

She had had bad teeth and suffered much. She had a tooth extracted and about four weeks later had an abscess, when she consulted a doctor at the Mile End Dispensary, who said that there was diseased bone there and that he could do nothing for her. She then applied at the factory for the first time, and got an order to consult Dr. Garman. She used to earn 14*s.* to 16*s.* a week, and now draws 20*s.* a week as sick pay allowance. Her teeth in the upper jaw are foul and deeply covered with tartar.

Family history, remarkably good.

(10.) J. R., 21 years.—Box-filler (wood) and cutter down.

History.—Commenced with pain in a carious tooth.

An abscess formed, followed by spongy gums and other abscesses. Patient had very severe periostitis and was in bed for six months.

*Present Condition.—Necrosis affects right upper jaw from canine to molars.

The sequestrum has not yet been removed, but is almost sufficiently loose. She has been under treatment since November 1895.

Later condition.—Much the same condition.

This is evidently a limited case. This has, however, been great pain, especially in the acute stage, when very free use of morphia had to be made. She has now been nearly three years away from duty, and had been "cutting down" for five years. She did not complain of toothache, but there was a sudden swelling (gumboil), and the right upper second bicuspid and first molar in the sequestrum were not extracted but fell out. The root of the first bicuspid still remains. The other teeth are remarkably good, but in a foul condition, with exceptionally large accumulations of tartar.

Family History, good.

(11.) E. T., 33 years.

Box-filler (wood) and cutter down for 15 years.

History.—Nearly three years ago she had face-ache and a decayed tooth. She had the tooth extracted and stayed from work for eight days, and did not report this to the authorities.

On November 26th 1895, abscesses formed, severe periostitis followed, and she was confined to bed for three months.

*Present Condition.—The whole of the lower jaw has necrosed, but the sequestrum has not been removed. There are external abscesses and fistulæ all round from ear to ear, but the general health appears fairly good.

Later Condition.—Condition much the same. She is strong and healthy, and continues to make weight. She has seven discharging sinuses. Her upper teeth are bad, seven or eight so bad as to require extraction and others filling.

She never earned more than 13*s.* 7*d.* per week, and now has an allowance of 25*s.* per week.

Family History, good. Father died at 77 years, mother about 50, when she was only about one year old. She has an older sister, aged 36, whom she describes "very simple" and engaged at Bryant and May's.

(12.) E. C., 21 years.

Box-filler (wood) and cutter down for four years.

History.—In August 1897 some decayed teeth in the right lower jaw gave trouble. These were removed, and she appeared to be getting better. Six months afterwards her face began to swell, the gums became spongy, and external abscesses formed.

* Dr. Bate's Report, May, 1898.

*Present condition.—There are several sinuses with exuberant granulations. The ascending ramus and body on right side of lower jaw are probably necrosed, but no bare bone is visible inside the mouth, though dead bone can be felt with the probe.

September 1898.—Case not seen, too ill to be disturbed.

(13.) C. H., 19 years.—Box-filler (wood) and cutter down seven years.

History.—Symptoms commenced in January 1896. She had a decayed tooth on the left side of lower jaw.

*Present Condition.—The gums are spongy and swollen and the teeth on the left side are loose and pus is exuding at the sides. The jaw is exquisitely tender. There is an abscess at the left side of the chin which is discharging. The girl is anæmic and feeble, and a likely subject for septic trouble.

Later Condition, September 29th.—The general health has improved, she has put on weight (half a stone), the jaw is not so tender. This case seems to show great neglect upon the part of the patient; she had bad teeth, and suffering from toothache she remained away for three months, she returned to the works and was sent to the doctor. After three days a left lower second molar tooth was extracted, which was followed by a discharge of pus. The necrosis extends from the left lower canine to the position of the extracted tooth, and in the sequestrum the first lower molar is so decayed as to warrant extraction.

Her other teeth are badly decayed, five of them being in such a condition that in an ordinary case some four or five would be better extracted and as many filled.

The state of the teeth generally is very foul, and the amount of tartar present is exceptional.

Family History, good. Father 50, mother alive, and nine brothers and sisters alive, and one dead when a baby.

With regard to the making of phosphorus the cases of necrosis seem to have been about 17 during a period of about 50 years, 9 of them being very slight, 4 bad, and 4 very bad, but none fatal. Patients receive 25*s.* per week during their absence from the works. Further details are given in the annexed memorandum, for which I am indebted to the directors of the Oldbury Works.

It must be remembered that the trade of phosphorus making is not included in the special rules, which apply only to the manufacture of matches. The directors have, however, taken practically the same precautions as if they had been included. To this must be attributed the small number of the cases of necrosis that have occurred.

Cases of Necrosis since establishment of the Works in 1844.

†1. 1866. Not very acute—prolonged. Finishing house, about 6 to 7 years.
2. 1870. Not very acute. Finishing house, about 6 to 7 years.
3. 1870. Acute—still working here. Furnaceman about 20 years.
4. 1870. Not very acute. Furnaceman about 15 years.
5. 1871. Bad case. Furnaceman about 15 years.
6. 1871. Slight. Labourer about 10 years.
7. 1880. Away two months—still working here. Furnaceman about 18 years.
8. 1881. Away eleven months—still working here. Furnaceman about 12 years.
9. 1883. Slight—did not return to work here. Blacksmith about 1 year.
10. 1884. Away five months—still working here. Furnaceman about 15 years.
11. 1888. Away two months—worked here until pensioned off when 71 years of age in 1896. Labourer, had been a furnaceman for many years, but not for 6 or 7 years past.
12. 1891. Away three months—still working here. Furnaceman about 29 years.
13. 1891. Away two and a half months—still working here. Furnaceman about 10 years.
14. 1893. Away eleven weeks—still working here. Furnaceman about 10 years.
15. 1895. Rather severe case—12 months off—still working here. Finishing house, about 20 years.

* Dr. Bate's Report, May, 1898.

† Finishing house includes both bleachers and drawers, because the duties are interchangeable.

16. 1895. Messenger. Had been a furnaceman. On getting too old, shifted into time office. Had not worked in a phosphorus department for two years. Began slight; cancer developed, and of this he died. Off 12 months.

*17. 1898. Slight—off work about three weeks—still working here. Furnaceman about 15 years.

Nine of the above cases were slight, the remaining eight were more or less acute, involving loss of several teeth and some discharge. Four of the above eight were decidedly acute, losing more or less of the jaw.

They occurred—

1 case in	1871.
1 case in	1881, still working here.
1 case in	1884, still working here.
1 case in	1895, still working here.

The four less acute occurred—

1 case in	1866.
2 cases in	1870, one man still working here.
1 case in	1895.

The following account of the four phosphorus necrosis cases reported from Messrs. Moreland's factory is likely to be interesting:—

(1.) A. E. W.—Taken ill about January 1895, after having worked here two years (one year as dipper). *Died* on *26th June* 1896 after 18 months' illness, most of the time in the Gloucester Infirmary. Age at death, 22.

(2.) D. R.—Now 31 years of age. Worked here 17 years as frame-filler, and took necrosis in August 1896. He was absent from work six weeks, of which he passed one week in the infirmary, and returned to work in the wood mill (innocuous), with doctor's certificate, cured. He is at present all right, and works in the filling room.

The early history of this case is somewhat obscure, but it is probably a case of the workman returning prematurely to a dangerous occupation after tooth extraction. Only one tooth was extracted at the infirmary, and he admitted having others extracted previously, about two years ago.

All the teeth are gone between the canine and wisdom tooth on the left upper jaw. Some three portions of necrosed bone, about the size of hazel-nuts, were removed at the infirmary, but the parts are completely healed. The left upper canine is loose, and the root completely denuded of gum and bone to the very apex of the tooth. There is acute inflammation of the gums, and the condition of the mouth generally is bad, not to say foul.

At my suggestion he was removed from the filling room, which the occupier will regard as "dangerous" in future.

It is worth noting that he is the brother of the subject of the next case.

(3.) L. R.—Now 22½ years of age. Worked eight years in filling room.

His statement is that before Christmas 1897 he had face-ache for some weeks. Some time in November he went to the chemist and had a tooth extracted and returned to work. He left work one Saturday in December, and was operated on on the following Wednesday, and was nine days an in-patient, and the rest of the 12 weeks an out-patient. He came back with doctor's certificate, but had a relapse in July last. He underwent another operation, being three weeks under treatment, and was absent a further 11 weeks, and started lately to work in mill with doctor's certificate.

The teeth and a considerable part of the bone between the right upper lateral incisor and the third molar are gone. A considerable opening into the central cavity persists. The teeth were dirty, several in early stages of caries and only one in an advanced stage. The teeth are good in quality and the gums fairly healthy.

As a frame-filler he was considered quite removed from any phosphorus fumes, and this case seems entirely due to contact by handling the iron frames, afterwards used by the dippers and boxing girls. Other makers, even in France, treat this department as innocuous.

(4.) O. S.—A Swede, aged 37 years. Worked here nine years as a dipper. Has been 25 years in the match trade, was attacked by necrosis in August

1897. He was operated on by Dr. Bower in the Gloucester Infirmary, where he remained for 10 days, and then returned to work as splint-shaker with doctor's certificate, and is now working in the veneering department.

It is a slight case affecting the anterior part of the right upper maxilla. Another small piece of bone separated about a year after the operation. The parts are well covered with fresh tissue, but there is still some evidence of necrosed bone. I took the case to Dr. Ancrum, who confirms my diagnosis.

He has several badly decayed teeth which require extraction, and some others that might be filled. The teeth are foul, heavily coated with tartar, and the mouth generally in such a condition that necrosis might be anticipated irrespective of occupation.

He states that in May 1897 he noticed a swelling under his *left* eye, but he did not consider it very bad, as, though it was sore, there was no great pain, and the swelling rose and fell. On the August Bank Holiday following he went to a doctor, who sent him at once to the infirmary. After being about one week in the hospital he was operated on under ether, and was dismissed six days later. About six weeks later he returned to work, with the doctor's certificate. He worked in the timber yard for a time, but is now working in the veneering department, but not quite regularly. In September 1897 he was suffering from a cold, and was ordered back to the infirmary, where he remained for a fortnight. He used to earn 25*s*. a week as a dipper, but now he can only earn 18*s*. His family history, which is bad, is worth noting. His father died at 39 years from inflammation of the lungs; his mother died at 49 from dropsy; his elder sister died at the age of 33, illness unknown; and his youngest sister at 22, from consumption. None of them were match-workers. His brother Auguste had worked from a boy in an ordinary phosphorus sulphur match factory, and was foreman of the boxing department. He got necrosis, and after a short illness of 7 weeks he died at the age of 34 years. He himself has been married for 7 years to an Englishwoman. They have had 4 children, of whom 2 died at the age of 5 months, and 1 at 15 months, while the other is 2 years and 8 months, and delicate.

With regard to the last case, in 1898, a detailed account is necessary, as will be seen from the result. It is that of C—— R——, a big, strong, healthy-looking man, of 37 years of age, and who had been 15 years making phosphorus. On the 16th June 1898 he had toothache, and went to a medical practitioner; who, according to his account, took out the wrong tooth, a molar, and broke off a bicuspid tooth. This was on the Thursday night, and he returned to the works on the Friday and worked till the Monday following without notifying to the manager what he had done. He stayed away all Tuesday, as he said his leg hurt him, and returned on the Wednesday, when he complained of toothache. He was not allowed to start work, but was sent by the manager to report himself to the certifying surgeon, who then referred him to a dental practitioner who removed the fractured root left in the jaw. The case was then reported as one of slight necrosis. On the 18th July the patient was certified as being fit to return to work in the yard, and on the 6th of August as fit to return to phosphorus work. On examination I found the upper first and second bicuspid and first molar had been extracted, and the gum had perfectly healed with almost unusually little absorption. There was no trace of any loss of bone, and no signs whatever of necrosis; all the other teeth we found to be free from decay, strong, greatly worn from mastication, incrusted with a good deal of tartar, and in a dirty condition. In reply to numerous questions, he admitted that he slept well, that his appetite was good, and that he only felt "queerish." Mr. Leedham Green, F.R.C.S., surgeon to the Queen's Hospital, Birmingham, kindly examined this case with me, and agreed in saying that it was not one of necrosis, and, therefore, should be deleted from the list. This case seems to indicate the necessity for some provision being made by which some preliminary notification should be made of a doubtful case, to be afterwards confirmed at a subsequent period, say at a month's interval, or whatever time further experience may suggest as advisable.

V.—DENTAL ASPECT OF THE NECROSIS QUESTION.

In considering the dental aspect of the necrosis question, it must be remembered, as Professor Miller has observed, that myriads of micro-organisms are constantly present in the human mouth. These micro-organisms are responsible for the vast majority of the diseases of the teeth and contiguous parts which the dental surgeon is called upon to treat; they also give rise to other local and general disorders. As Professor Miller says, there exists a most excellent nursery for bacteria at the very portal of the human body. And, again, in speaking of the invasion of pathogenic mouth bacteria following mechanical injuries, he says* :—

"Many facts favour the supposition that a considerable number of pathogenic micro-organisms may thrive in the juices of the mouth without showing in their vital manifestations any distinction from the common parasites of the oral cavity, as long as the mucous membrane remains intact. If, however, the soft tissues have been wounded, as in extraction, or if the resistance of the mucous membrane has been impaired, these organisms may gain a point of entrance, and thus become able to manifest their special actions.

"The severe injuries of the soft tissues and the bone caused by difficult extractions, as well as the open wound left by every extraction, furnish a convenient point of entrance for bacteria. Whoever has examined an unclean mouth, with its broken-down teeth, inflamed gums, thick, smeary deposits with which some of the teeth are wholly covered, will not wonder that inflammation, swelling, suppuration, necrosis, caries of the bone, or even septicemia, and pyæmia may follow upon operations in the mouth.

"Infections through gangrenous tooth-pulps are to be ranked among the most frequent pyogenic infections of the human body; they by no means always have the harmless character commonly ascribed to them. The fact that the point of infection is so deep-seated, and is inclosed by hard, bony tissue, of itself anticipates results of a serious nature.

"The infection of the periapical tissue is usually occasioned either by the micro-organisms working their way into it independently from the pulp, or by the mechanical forcing of infected material (remains of pulp, &c.) through the apical foramen.

"If, on the other hand, living pathogenic bacteria are present in the pulp, an infection will take place whose intensity depends upon the number and virulence of the same.

"Where the typically pyogenic micro-organisms, Staphylococcus pyogenes aureus, &c., are present we must expect severe suppurative inflammation, and formation of abscesses.

"Infections with various pathogenic micro-organisms (mixed infections) will provoke divers phenomena. The progress of the infection will in all cases materially depend upon the general predisposition of the patient to infections, and upon his momentary state of health. Consequently, apical infections exhibit all transitions from a hardly perceptible reaction to the most dangerous phlegmonous inflammations, accompanied by general symptoms, such as high fever, chills, &c., which, as many instances show, may lead to meningitis, as well as to pyæmic and septicæmic processes, with fatal termination.

"It is well-known that the mucous membrane of the mouth, under certain conditions, loses its normal resistance to parasitical influences.

"Wherever, by any possible cause, mechanical, chemical, or thermal, local or general, external or internal, the nature of the tissue is so changed as to furnish a suitable culture-medium for certain microbes, a colonization of one or more of the various species in the mouth will take place. Some of the diseases induced in this manner are:

(*a*.) Limited suppurative processes at the margin of the gums.

(*b*.) Formation of abscesses in consequence of impeded eruption of wisdom teeth.

(*c*.) The affection termed pyorrhœa alveolaris.

* The Micro-organisms of the Mouth, S. S. White Dental Manufacturing Co., Philadelphia.

"(a.) *Limited Suppurative Processes at the Margin of the Gums.*

"The dentist daily meets with such cases. Accumulations of tartar, sharp edges of decayed or filled teeth, pledgets of cotton, protuding fillings, &c., irritate or inflame the gums, thus facilitating or making possible the colonization of pyogenic bacteria. A small degree of suppuration will always be found in such cases; it may, under certain circumstances, extend to the pericementum and lead to abscess formation.

"(b.) *Abscess Formation resulting from Impeded Eruption of Wisdom Teeth.*

"The infection by pyogenic microbes, so often accompanying impeded eruption, occasions not only profuse suppuration and abscess formation in the region of the lower jaw, which are accompanied by pronounced general symptoms, but also often leads to general infection (septicæmia, pyæmia), with fatal results.

"Various fatal cases of blood-poisoning occasioned by the impeded eruption of lower wisdom teeth have been cited.

"(c.) *Pyorrhœa alveolaris.*

"A disease of probably parasitic nature, which, next to decay of the teeth, has attracted more attention among dental surgeons than perhaps any other disease of the human mouth, and which every dentist has abundant opportunity of observing in his practice, is the so-called Rigg's disease, pyorrhœa alveolaris, a chronic suppurative inflammation of the periosteum, with more or less severe inflammation of the gums and necrosis of the alveolar process of the diseased teeth."

Woodhead furnishes evidence of the greatest value to the same effect*:—

"It will thus be seen that in certain cases injury of the mouth, of the periosteum of the jaw, or the soft tissues of the pharynx, may lead to infections of very different kinds; but it may be laid down as a general rule that septic infection is frequently the result of invasion from these regions, and very numerous are the cases recorded in which death has resulted, even from the most trifling operations in the mouth and naso-pharynx. I have seen several cases where death has ensued, with all the symptoms of most acute septicæmia, or with symptoms of more chronic poisoning, as in pyæmia, from the extraction of a tooth or the lancing of the gums in patients with imperfectly cleansed mouths, or in persons who have been engaged in attendance on patients suffering from certain infectious diseases; the organisms in such cases finding their way from positions in which they were comparatively harmless into the wounds that were unavoidably made, whence they invaded the lymphatics or passed directly into the blood stream and set up septic or other mischief.

"It is scarcely necessary here to enter into the different forms of septic tooth disease, or to consider the points at which the different kinds of poison may enter, but it should be mentioned in the interests both of antiseptic purity and suffering humanity, that a good, stout tooth-brush, plenty of water and some antiseptic dentrifice, applied morning and night, afford a greater safeguard against many diseases than most people are aware."

In other words, the opinions held on the dental aspect of phosphorus necrosis are entirely different from those prevailing in the days of Bristowe and of Salter.

Diseases of the Teeth.

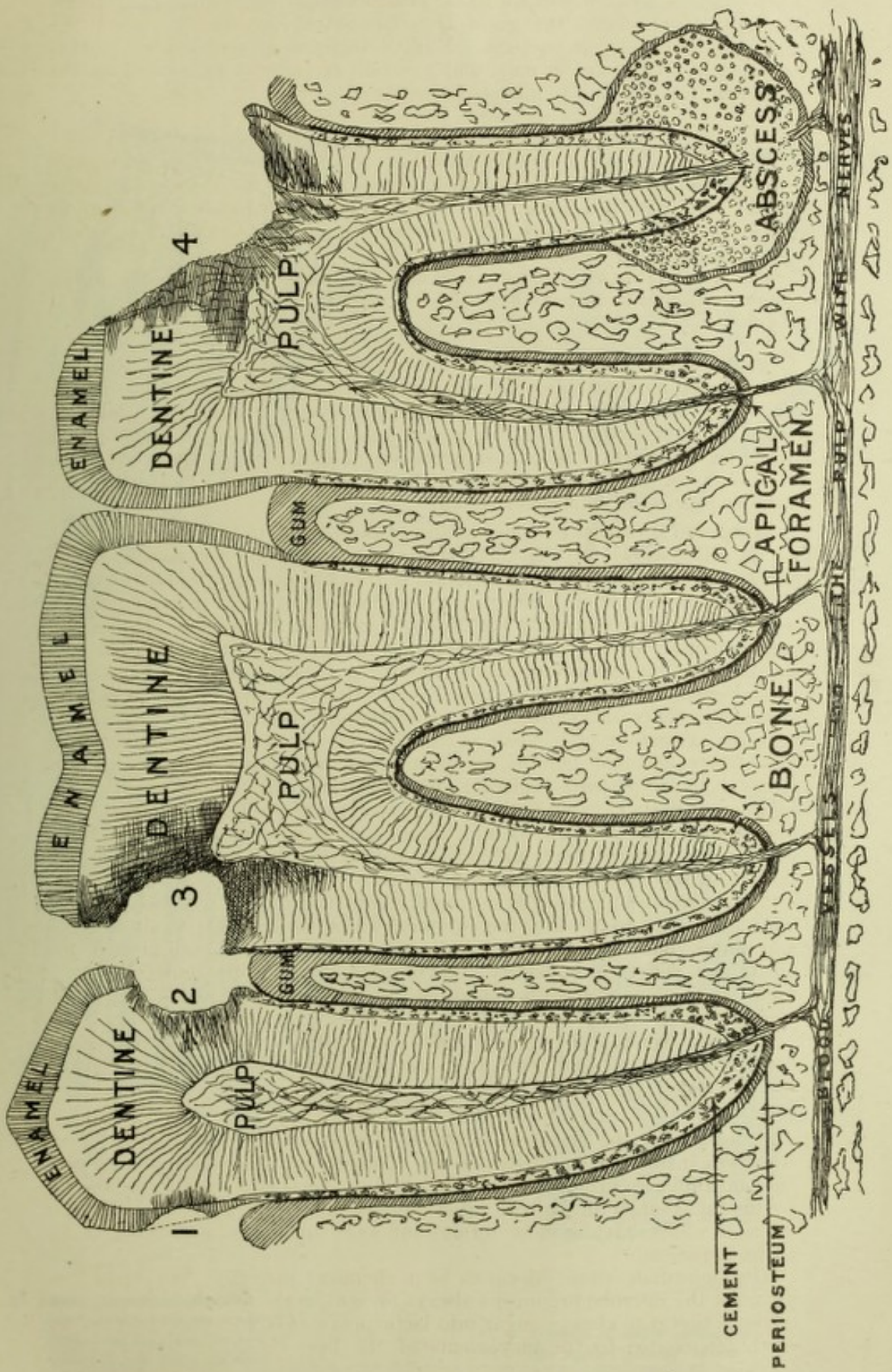
"Caries" is the scientific name of the disease which results in the wholesale disintegration of the tissues of the teeth, the hardest structures entering into man's composition. Its injurious effects are enormously increased by the fact that, if neglected, caries almost inevitably leads to a train of diseases which have a most serious influence upon the well-being of the entire organism.

The immediate cause of caries is a chemical parasite. We know that amongst the microbe-organisms always present in the mouth, there are some whose action is to change sugar into lactic acid; that in every part of the teeth not scoured by the movements of the lips, cheek, or tongue, starch

* On Micro-organisms: Contemporaneous Science Series, W. Scott & Co., London.

(To face page 170)

Diagram A of a lower bicuspid & two molar teeth,
Showing the four degrees of Caries.



1 & 2, Early stages of decay; 3 & 4, More advanced or penetrating Caries. (Carie Penetrante)

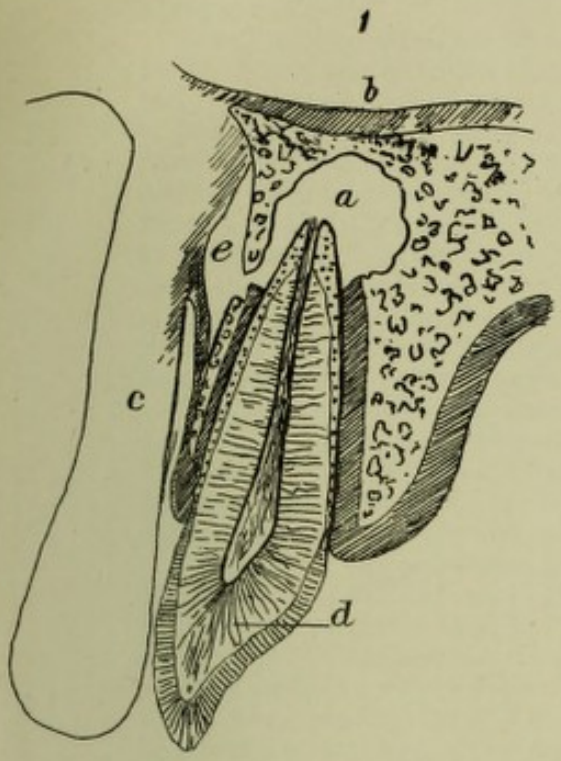
Wyman and Sons Ltd Litn 3280.11.58.

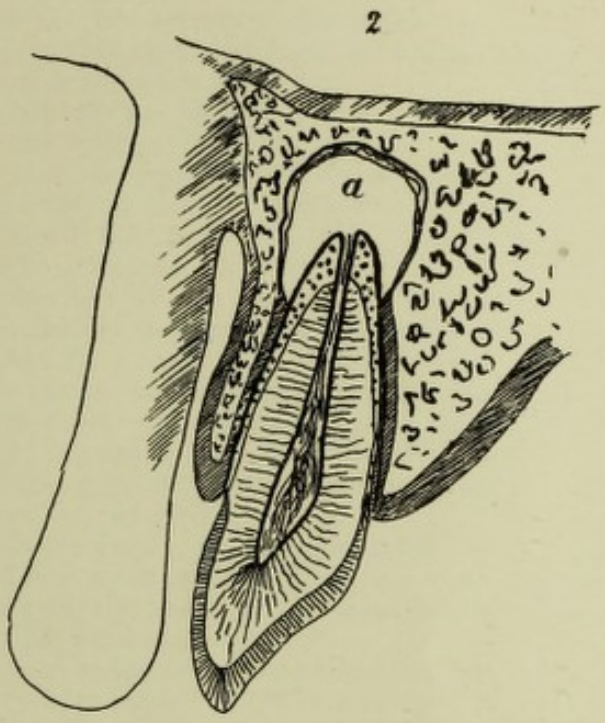
Diagram B

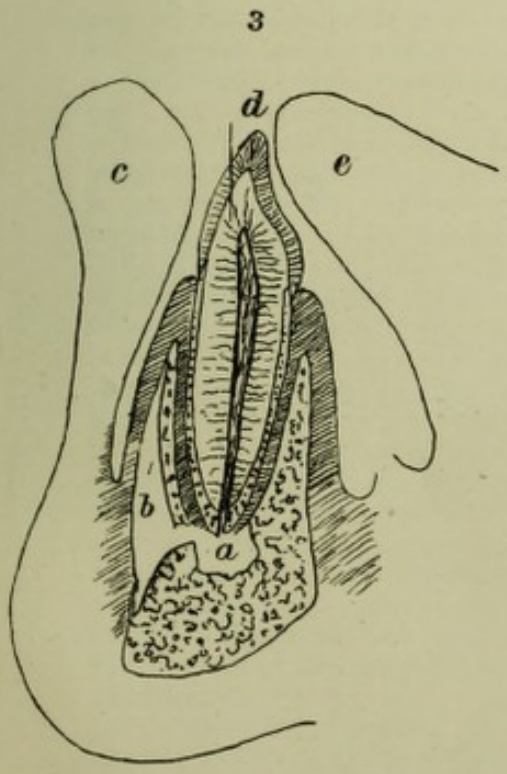
(To face page 170)

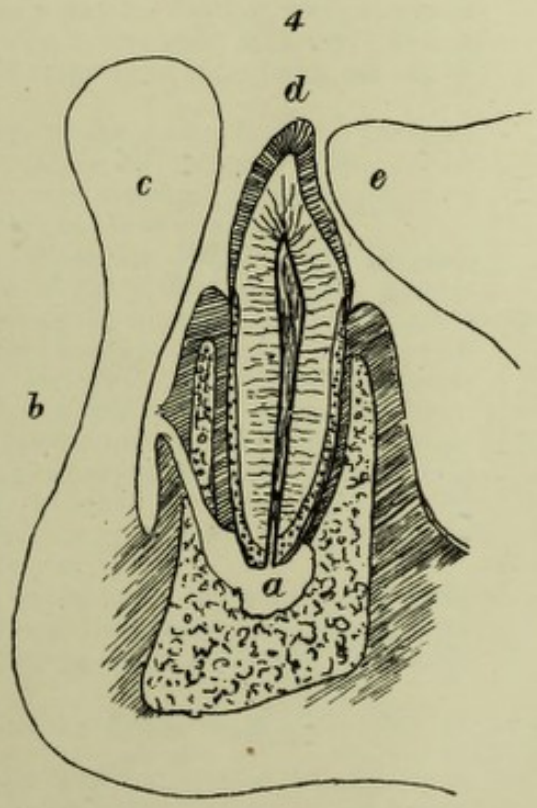
1. Acute alveolar abscess with pocket and pus between the periosteum and the bone. (a.) abscess cavity in the bone. (b.) floor of the nostril. (c.) lip. (d.) tooth. (e.) pus cavity beneath the periosteum.

2 Blind abscess at the root of an upper incisor. (a.) abscess cavity in bone.









3 Acute alveolar abscess of lower incisor with pus cavity between the bone and the periosteum. (a.) pus cavity in the bone. (b.) pus between the periosteum and bone. (c.) lip. (d.) tooth. (e) tongue.

4 Chronic alveolar abscess at the root of a lower incisor. (a.) abscess cavity in the bone. (b) fistula discharging in the gum. (c.) lip. (d.) tooth. (e) tongue.

Wyman and Sons Ltd Lith 3280. 11. 98.

and sugar containing food remnants lodge in which these acid-forming bacteria germinate and exercise their destructive activity.

The tooth substance becomes softened, more or less discoloured, and finally breaks up; if unchecked, this process goes on until the central "nerve" or pulp is reached, and then severe toothache generally, but not always, ensues.

It will thus be seen how favourable to the occurrence of decay are any nooks or crannies in which particles of food may lie undisturbed for a time, and how the want of cleanliness will work in the same direction.

Dental caries is a disease which, without any exception, commences from the outside of the tooth; therefore the enamel is first attacked. The dentine when once reached is attacked with far greater rapidity than the enamel, so that there comes to be a comparatively large mass of soft dentine to which access is given through only a small hole in the enamel. At this stage the patient is usually not aware of the existence of any mischief, and it is in order to ensure the detection of cavities at this early stage that a periodical inspection of the teeth by a competent dentist is so necessary for their preservation. (*See* Diagram A, 1 and 2.)

Then as the softening proceeds, the pulp, or "nerve," begins to be sensitive to changes of temperature, and finally commences to ache. (*See* Diagram A, 3.) It cannot be too strongly impressed upon those who wish to preserve their teeth that, when a tooth has once really seriously ached, the most favourable time for filling it has gone by, never to return.

When decay has penetrated somewhat more deeply, the nerve may become absolutely exposed, or it may inflame without actual visible exposure. Then it generally aches severely, but not continuously, and often, after an attack of the most violent throbbing toothache, dies somewhat abruptly.

Then there is a rather sudden and quite complete relief from all pain; but it is a false security, for it is usually only a pause before the oncoming of a new series of troubles. The dead pulp decomposes, finds its way out at the end of the root, and a violent inflammation is set up. This runs on to the formation of matter (*see* Diagram A, 4), which has got to escape; it is confined between the root of the tooth and the bone of the socket, and until it can get out through the root, or by boring a way for itself through the bone and the gum, there is a state of tension which causes great suffering. This is a "gum-boil," such abscesses in the vast majority of cases being caused by teeth with dead nerves.

Penetrating caries is only a further stage of the disease in which the pulp is involved (3), and soon or later necroses (4), or, in other words, dies. This is usually quickly followed by swelling and suppuration, terminating in an abscess at the root of the tooth, as shown in the diagram.

Necrosis, in its incipient stage, is very difficult to diagnose. In Diagram B, I have graphically represented some of the conditions which usually follow the formation of an abscess resulting from caries as shown in the previous diagram. Any of these conditions occurring in an ordinary person would be regarded as a mere "gum-boil," but if the practitioner had ascertained that the occupation of the patient was that of a phosphorus worker, he might at once diagnose it as a case of phosphorus necrosis, except possibly in the case of Diagram No. 2, which only a very experienced dentist could recognise, and then not with certainty, as what is termed a blind cold abscess. On the other hand, he might regard a gum-boil as a case of purely dental disease, and not necrosis; and rightly so.

Two cases came under my observation in the present inquiry; in one, the medical practitioner had reported as a case of necrosis a purely dental case, and the other he regarded as dental proved to be a case, as he himself admitted, of necrosis.

The necessity, therefore, of requiring the notification of "doubtful or uncertain cases" is of great importance.

The next most frequent source of danger is suppuration of the alveolus or socket of the tooth. This usually arises from the deposits of calcareous matter, commonly known as tartar, round the necks of the teeth. The amount and the character of the deposit varies very much, but in many cases it is accompanied by the formation of matter or pus. It may be easily

and painlessly removed and the gums restored to health, if treated in an early stage. It is more particularly a disease of advancing years, and after a certain age more teeth are lost by tartar than by caries.

From Diagram C, representing the detachment of the gum from the tooth by the intrusion of tartar, its onward course by addition to its lower surface, and the final loss of the tooth, can be easily imagined.

To my late and much lamented friend Dubois belongs the credit of making the first statistical inquiry as to the condition of the teeth of match-workers, though the importance of that had been debated almost from the day of the discovery of what then seemed a new disease. As he well said in 1886:—

"After half a century of research by the most eminent authorities, the pathogenesis of phosphorus necrosis is still uncertain, and no one knows exactly the reason of the penetration, or why it locates itself in the maxillary bones only."

He was evidently impatient of the attitude of authorities on the subject as to the rôle which the teeth play in the production of the disease; and given the opportunity, he promptly proceeded to examine the state of the teeth of the match-makers at the Pantin-Aubervilliers factory.

In publishing the results, he made no claim to have solved the complicated problem as to the origin of the disease, but only to have furnished certain data which he had had the opportunity of proving.

Dubois published the results of an examination of 418 workers, 228 of whom were exposed to phosphorus. His classification was somewhat different from that adopted by me, and his results seemed to require verification, as will be seen from the following quotation:—

"The presence or absence of penetrating caries has been employed to establish a classification. The different degrees as to the condition of the mouth, good or bad, were classified according to the following rules:—

"No. 1, Good.—Healthy mouths without caries (many of them only because many teeth had been extracted) or with superficial caries, the dental pulp not being attacked by a single penetrating caries, a single root sufficed to place the individual in the second class.

"No. 2, Doubtful 'Good.'—Mouths containing one or few teeth with exposed or dead pulps, roots which have not caused much disorder, simple inflammation of the gums.

"No. 3, Doubtful 'Bad.'—Mouths with penetrating caries, roots in considerable number, gingivitis, accumulation of tartar.

"No. 4, Bad.—Mouths in a very bad state, purulent ulcerations, loosening of the teeth, and especially fistulæ opening on the gum or skin.

"418 workers were examined, of whom 228 were employed in work suspected of determining phosphorus necrosis (129 boxing, 76 degarnissage, 20 dipping and drying, and 3 mixing), of the total number of 418, there were 149 good, 114 doubtfully 'good,' 109 doubtfully 'bad,' 51 bad."

He confessed that his surprise was great in meeting in such environment so great a number of individuals having the mouth in so good a state.

Dubois' method of classification no doubt served his purpose and may be excellent from the particular point of view as to necrosis, but it has most serious defects from that of general application as the following instances prove.

A boy of 14½ years (see Chart VII.) has nine fissure cavities of decay affecting seven teeth, and is therefore classified by me as "Bad"; but as the dental pulp is not yet attacked in any of these teeth, in accordance with Rule No. 1, the case must be registered as "Good."

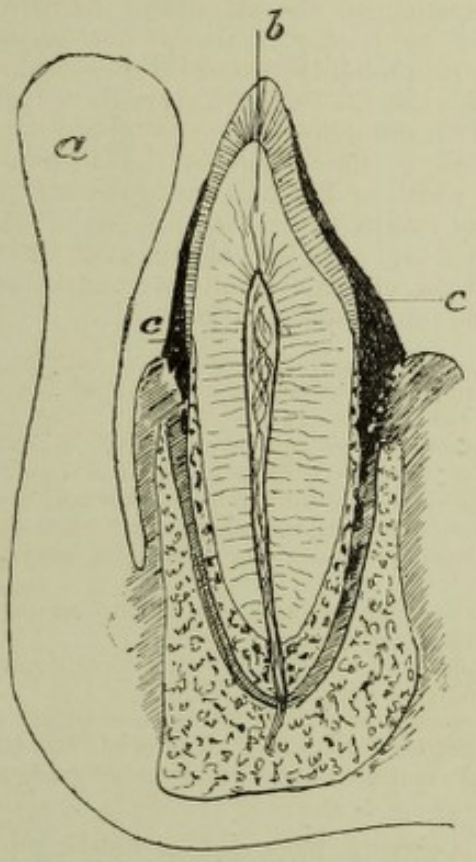
A boy of 14½ years (see Chart IV.) has ten defective permanent teeth, and is classified by my method as "Very bad"; but as there is only one decayed tooth which has reached the stage of penetrating caries affecting the pulp, by Rule No. 2 the case must be registered as doubtful "Good."

Further comparisons will be found in the other six cases which are illustrated with charts, but the last case is certainly the most convincing of all.

A young man of 18 years (see Chart VIII.), who had very bad teeth, and therefore had a large number of teeth extracted recently, would be classified by me as "Very bad," since he had lost 23 teeth and had only

(*To face page* 172.)

Diagram C. of a Lower Incisor Tooth, showing the formation of Tartar, and the consequent displacement of Gum and the absorption of the Bony Socket.



(*a*) Lip. (*b*) Tooth. (*c*) Tartar.

(*To face page* 173).

Diagram graphically representing the Relative Liability to Dental Caries of Match Workers in the Phosphorus and Non-phosphorus Departments.—(*Cunningham's Classification, for definition see p.* 173.)

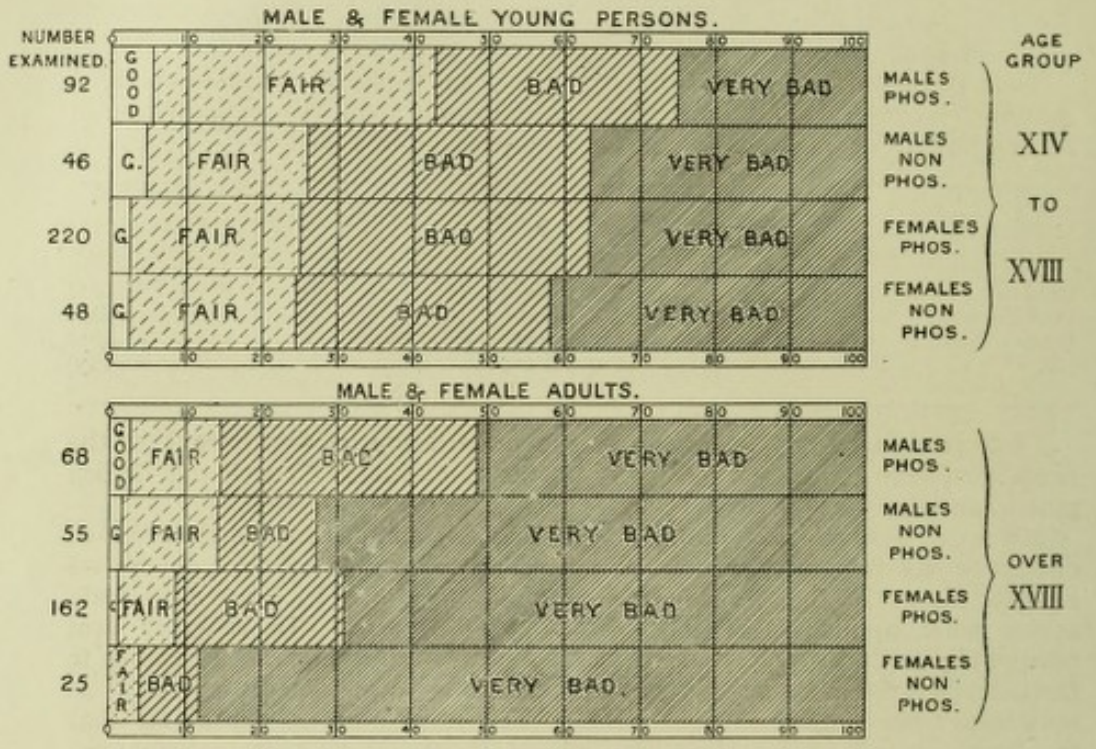
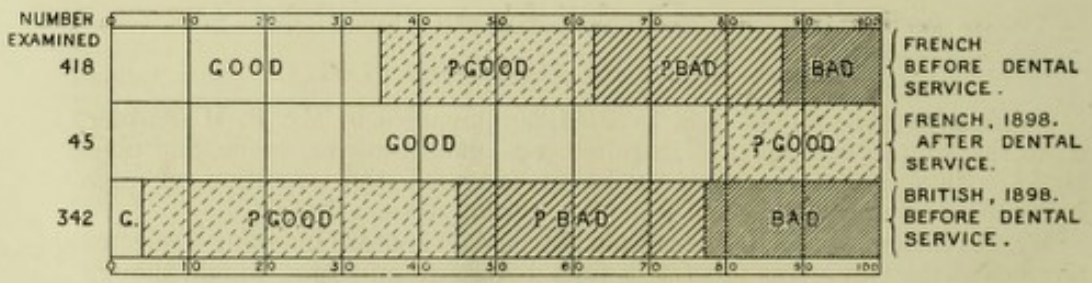


Diagram to illustrate Table C. (*page* 181) *showing the Comparative Results of Examinations of French and British Match Workers' Teeth; and the Effect of Selections and Dental Treatment on the Condition of the French Employés.*—(*Dubois Classification, for definition see p.* 172.)



9 remaining; but because these 9 teeth are free from decay, by Rule No. 1 (Dubois classification) even this extreme case must be registered as "Good."

By this method it is obvious that extracted or lost teeth are as effectual for statistical purposes as sound teeth.

The classification which I have adopted is based upon the soundness of the denture as a whole, and includes four classes.

"Good," where all the permanent teeth are sound.

"Fair," where 1, 2, 3, or 4 permanent teeth are decayed or lost.

"Bad," where 5, 6, 7, or 8 permanent teeth are decayed or lost.

"Very bad," where 9 or more permanent teeth are decayed or lost.

The two methods give very different statistical views of the same facts, as may be seen from the following examples, based upon the examination of 630 employees of the Diamond Match Company at Liverpool:—

Dubois.		Cunningham.	
Good	7·5	Good	2·7
Doubtful good	43·3	Fair	21·0
Doubtful bad	33·2	Bad	30·3
Bad	16·0	Very bad	46·0

I have employed both methods in the present inquiry, but except for the purpose of comparing the results of the examination of French and British match-workers' teeth, I do not purpose using the Dubois system.

My own method was specially devised for analysing the statistics of children's teeth. It must be admitted that the standard which we rightly expect in the examination of children under 14 years may seem severe when applied to adults from 21 to 60 years. In order to deal adequately with the question of adult dentures, it would be advisable to further distinguish another group, with four more defective teeth, as something worse than "Very bad." There is ground for thinking that the Broca scale,* or some modification of it, would be more satisfactory. He writes as follows under the title "Good or Bad Denture, Loss of Teeth":—"When all the teeth are intact the denture is *very good;* if only "one or two teeth are carious it is *good; mediocre*, if three to six teeth are "carious; *bad*, if more than six; *very bad*, if more than half the number of "teeth. The state of the denture is measured especially by the *loss of teeth;* "for, if the teeth may sometimes be lost in consequence of an accident, or "from disease of the gums, it is nearly always caries which is the cause of "their loss."

The annexed Charts show the method adopted for recording the results obtained from each dental examination.

Details of Dental Examinations.

Messrs. Bryant and May's (First Visit).

On Tuesday, 28th June 1898, I visited, accompanied by Mr. F. M. Farmer, with the simple equipments I required, viz., mouth-mirror, probe, and case-books with appropriate charts on which to record the condition of each individual tooth, as well as the general condition of each mouth.

Mr. Bartholomew then informed me that he had hopes of inducing a selected number of the employees to submit to a dental examination, which, though not nearly so numerous as I had requested, would be typical. They consisted of batches of three or six from different departments. He introduced me personally to these employees, who came from the dipping and drying rooms in the case of the men and from the boxing room in that of the women and girls. No employee refused to be examined. No really sound per-centage conclusions could be based on so small a number of examinations, but the condition of the teeth was much worse than anticipated.

* "Instructions générales pour les Recherches anthropologiques à faire sur le Vivant," published by the Anthropological Society of Paris (Masson, Libraire de l'Académie de Médecine, p. 246).

I examined 18 young persons with the following results :—

Two of them had no teeth decayed or lost, one had from one to four teeth decayed, seven had from five to eight teeth decayed or lost, and eight had nine or more teeth decayed or lost.

It is clear, therefore, that the teeth of these young people were extremely bad. Those of the boys were not nearly so much so as those of the girls, as is clear from a further analysis of the extent and degree of the dental caries present. In order to make them artificially sound as to their dentures, I estimated that 41 ordinary stoppings, 9 stoppings with pulp treatment, 1 stopping with pulp canal treatment, and 13 extractions (8 temporary and 5 permanent teeth) would be required for the 8 boys, as against 60 ordinary stoppings, 14 with pulp treatment, 4 with pulp canal treatment, and 16 extractions (6 temporary and 10 permanent teeth) in the case of the 10 girls.

Of the 8 men examined, all were between the ages of 23 to 27 except two, one 40 and the other 52 years. The results were 1 good, none fair, 1 bad, and 6 very bad. In order to make them artificially sound as to their dentures, 31 ordinary stoppings, 5 stopping with pulp treatment, and 1 extraction would be required.

Of the 14 women examined, the ages varied from 20 to 47 years; none good, 1 fair, 5 bad, and 8 very bad. In order to make them artificially sound as to their dentures, 66 ordinary stoppings, 5 stoppings with pulp treatment, 8 stopping with pulp canal treatment, and 24 extractions would be required.

We have no statistics as to the average condition of the teeth of people in the East end of London with which we can compare these results.

It may be taken that of the 16 men and boys from the dipping department, 7 had teeth so bad that either an abscess might result at any moment or extraction be rendered imperative; and of the 24 women and girls, 23 were in a similar condition of possible danger.

The condition of the gums was also carefully noted in each case with the following results. Of the 16 men and boys, 5 had much tartar on the teeth, 7 had fairly clean, 5 very dirty, and 4 positively foul teeth; and of the 24 women and girls, 6 had fairly clean, 13 very dirty, and 5 positively foul teeth. In the worst cases there was the usual local inflammatory conditions, which accompany filthy teeth and deposits of tartar, but as a rule the gums were fairly healthy, though some half a dozen cases were very bad. In many cases, half an hour's, and in most, an hour's work would suffice to place every one of them in a condition so that the teeth might be easily kept clean and the gums healthy in the future.

None of the women and girls, and only two of the men and boys, cleaned their teeth regularly; the two who did so comprised one aged 27 years with a perfect set of teeth, and the other aged 40 years who had been working with phosphorus for 25 years.

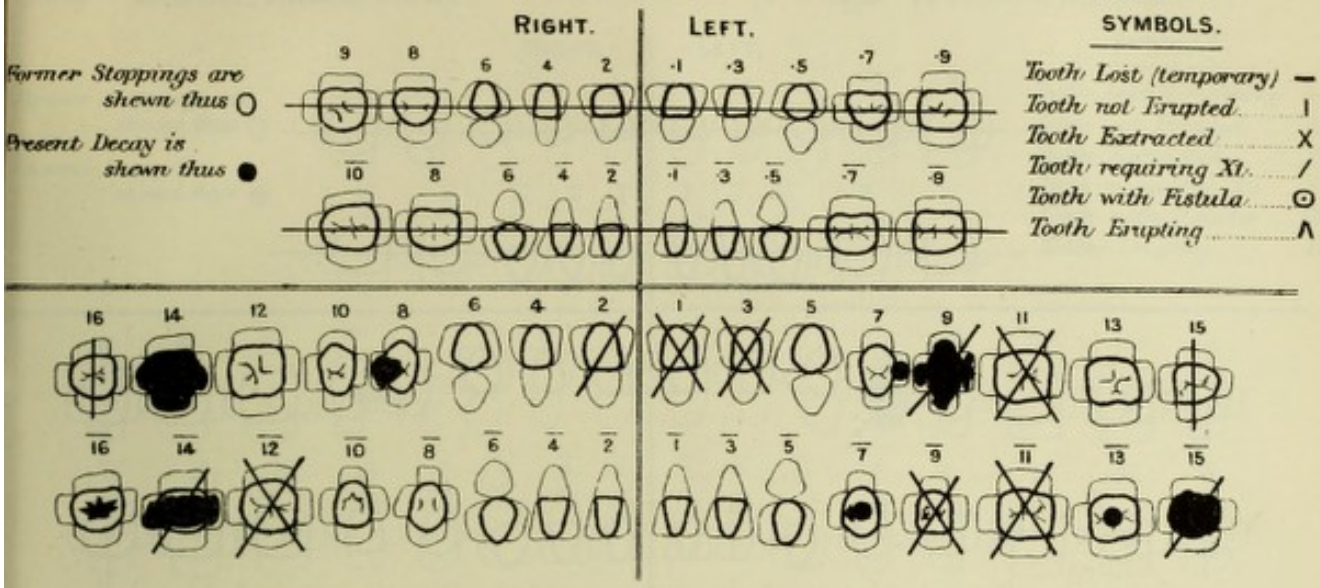
Some remarks on special cases must be made, more especially as they may serve to throw light on some of the obscure features of this insidious form of necrosis. The danger of exposure to the fumes of phosphorus after tooth extraction has been fully and universally recognised, but it is possible that in the case of some of the younger workers the undue retention of the temporary or milk teeth is a source of danger, since such teeth may be exfoliated without resort to the forceps, and a wounded surface thus exposed to the fumes. This exceptional condition is far more common than one would suppose, as is proved by the fact that in the present examination it was found that 4 out of 8 boys had unduly retained milk teeth; one of 16 years having 2 teeth, and three of 14½, respectively 1, 1, and 4 teeth; and also in 3 out of 10 girls, one of 16 years having 3 teeth, another of the same age 2, and one at 15¼ years 1 tooth of that kind. The healing of the wound in such cases would be very much more rapid than in the case of the extraction of a permanent tooth. The advisability of efficient dental supervision is further indicated, since the retention of such teeth is a distinct disadvantage to the individual in any circumstances, and the operation of removal is as a rule quite trivial.

It was pointed out to me that one of the chief difficulties of the employer was that the employees, when suffering from their teeth, sometimes went to a hospital or to a private practitioner, and had the tooth or teeth extracted during the dinner hour or on a Sunday or holiday, returning at once to the

(To face page 174.)

CHART I.

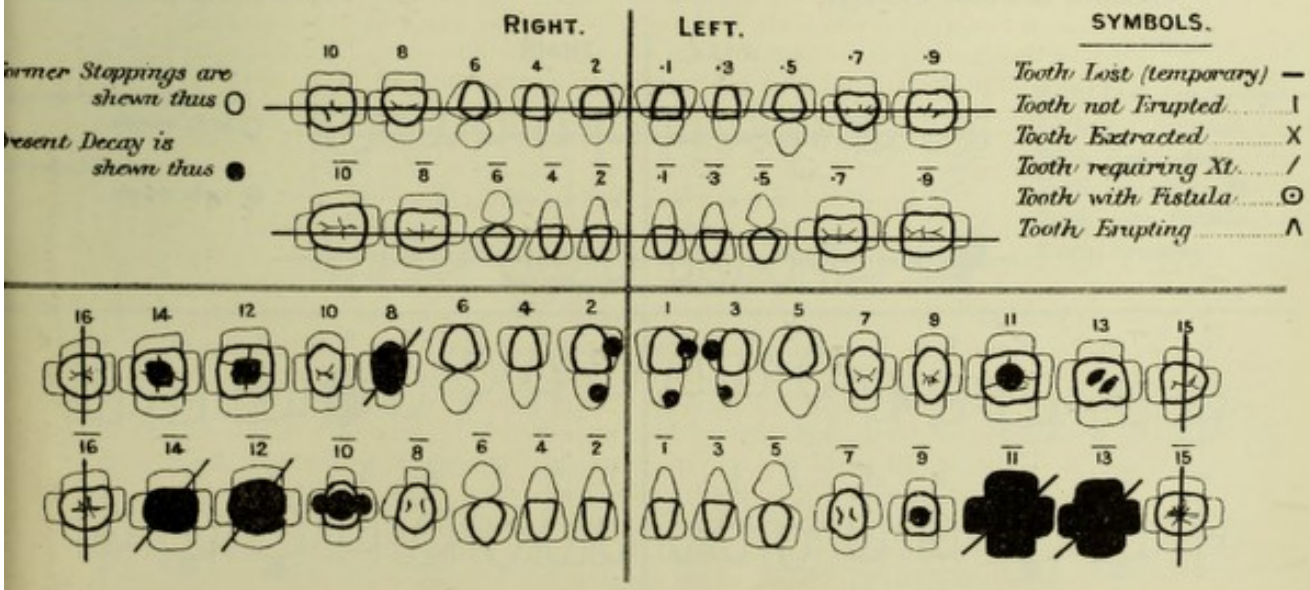
Name Osborne, Emily (131·12) Age 29.



Has been 16 years "boxing wood" dentally treated 9 years ago, absent 3 months after extraction of 5 teeth; teeth foul, gums acutely inflamed, some pyorrhœa, and absorption of alveolus, upper right central incisor extremely loose & out of position. Type of dangerous case - & removed since the examination.
Dubois Classification = Bad.
Cunningham ,, = Very Bad.

CHART II.

Name Harper, Annie (131·18). Age 15 years 4 months.



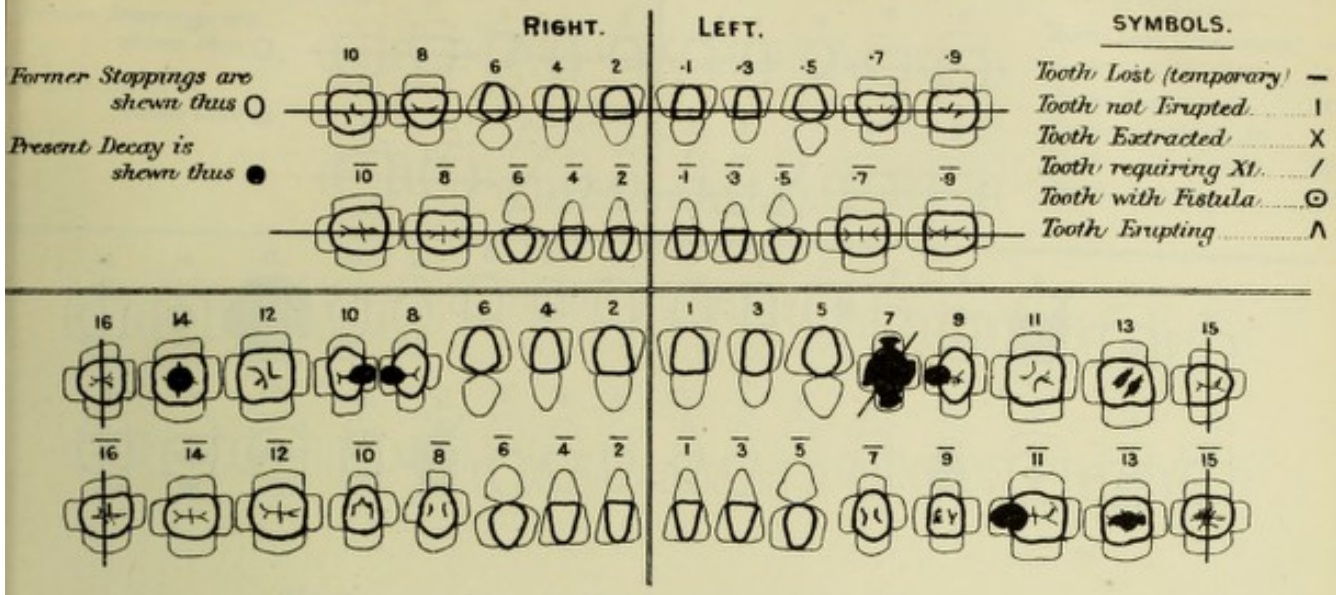
Has worked at wax packing for 10 months
Large polypus of the pulp in $\bar{1}1$.
Typical case of possible danger.
Dubois Classification = Doubtful, Bad'.
Cunningham ,, = Very Bad.

Wyman & Sons, Ltd. Lith. 63, Carter Lane 3250-10-98

(To face page 174.)

CHART III.

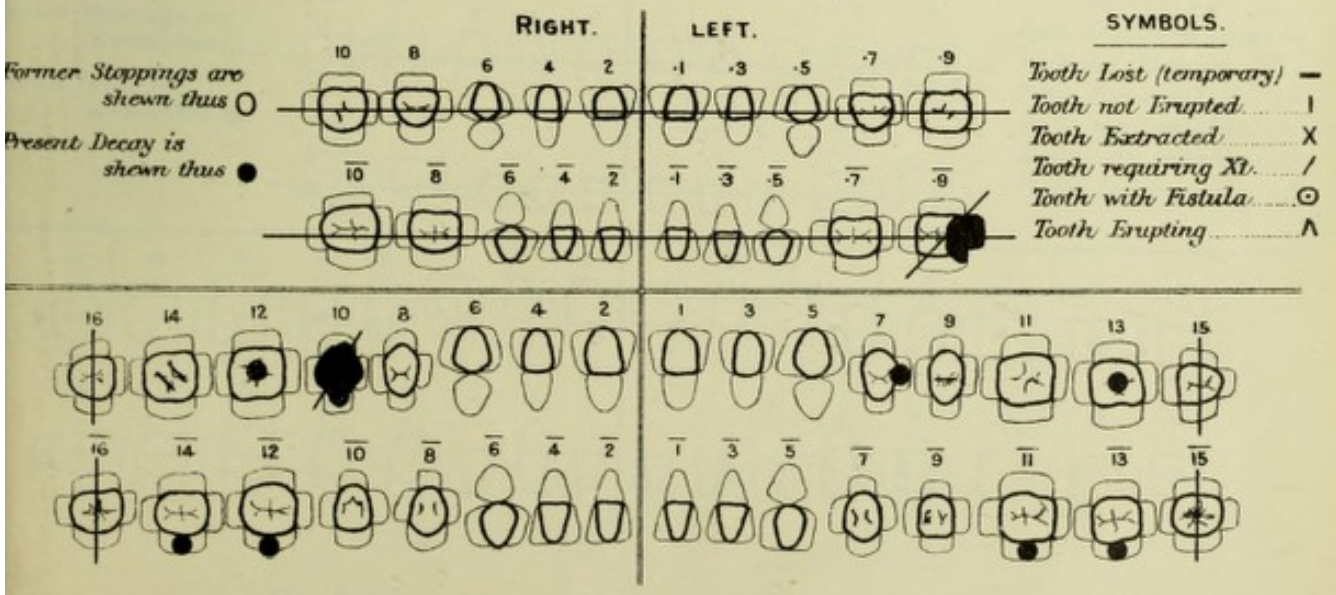
Name Lawrence, Thomas. (87·8). *Age* 14 years 6 months.



Has been at work one week assisting in dipping room.
Typical case passed as "fit" by the Certifying Surgeon
Dubois classification = Doubtful 'Good'.
Cunningham ,, = Very Bad.

CHART IV.

Name Thomas, Joseph (87·11) *Age* 14 years 6 months.

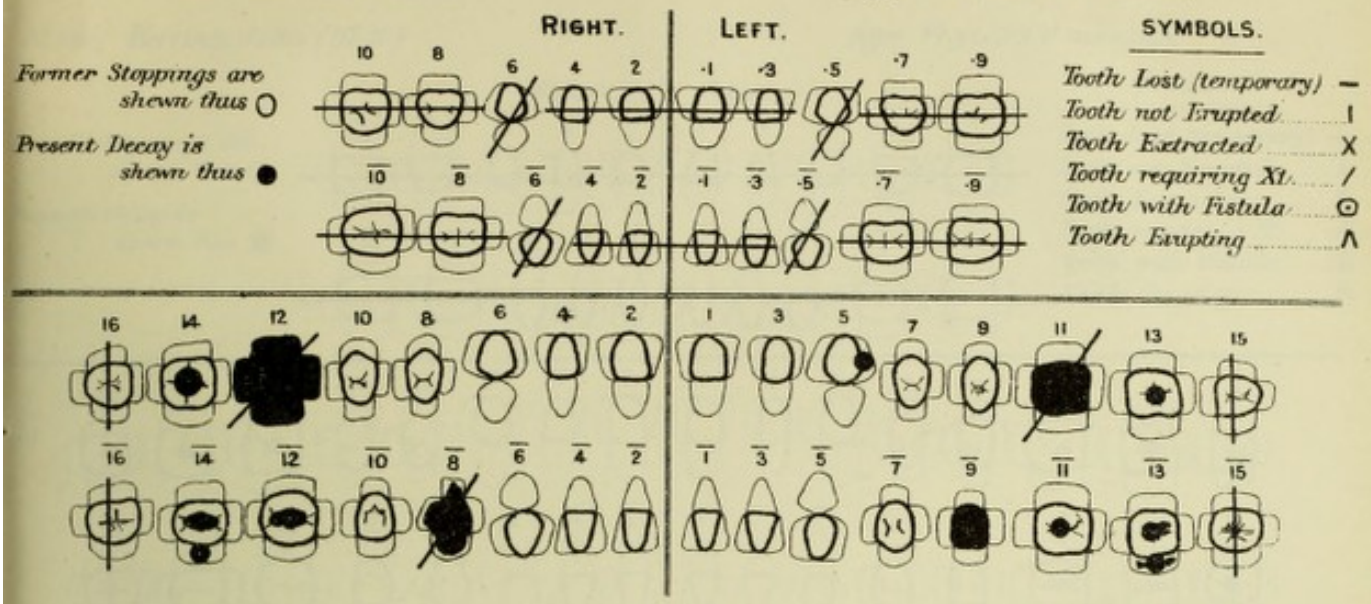


Has been assisting in dipping room about 6 weeks.
Typical case recently passed as "fit" by the Certifying Surgeon
Dubois Classification = Doubtful 'Good'.
Cunningham ,, = Very Bad.

Wyman & Sons, Ltd. Lith. 63, Carter Lane 3280·10·38

CHART V.

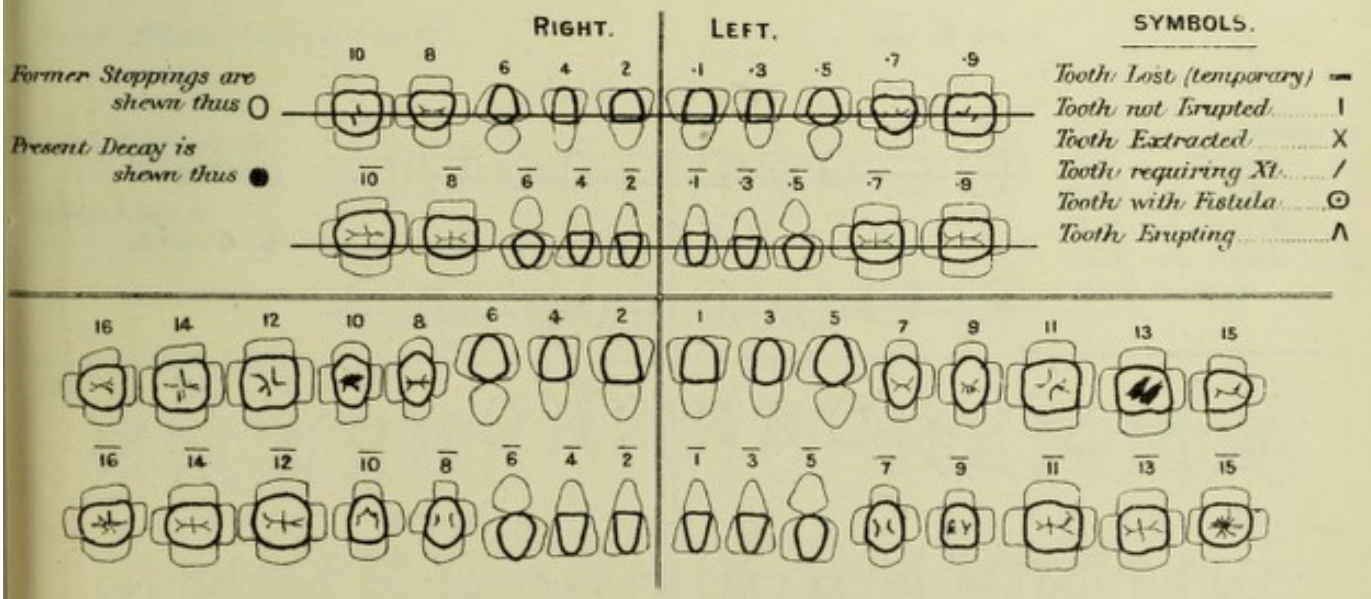
Name Wright, Frederick (87·12). *Age* 14 years 6 months.



Has been working in the dipping room for 10 weeks.
is suffering from toothache.
Typical case passed as "fit" by Certifying Surgeon.
Dubois Classification = Doubtful 'Bad'.
Cunningham ,, = Very Bad.

CHART VI.

Name Cooke, William. (87·9) *Age* 15 years.



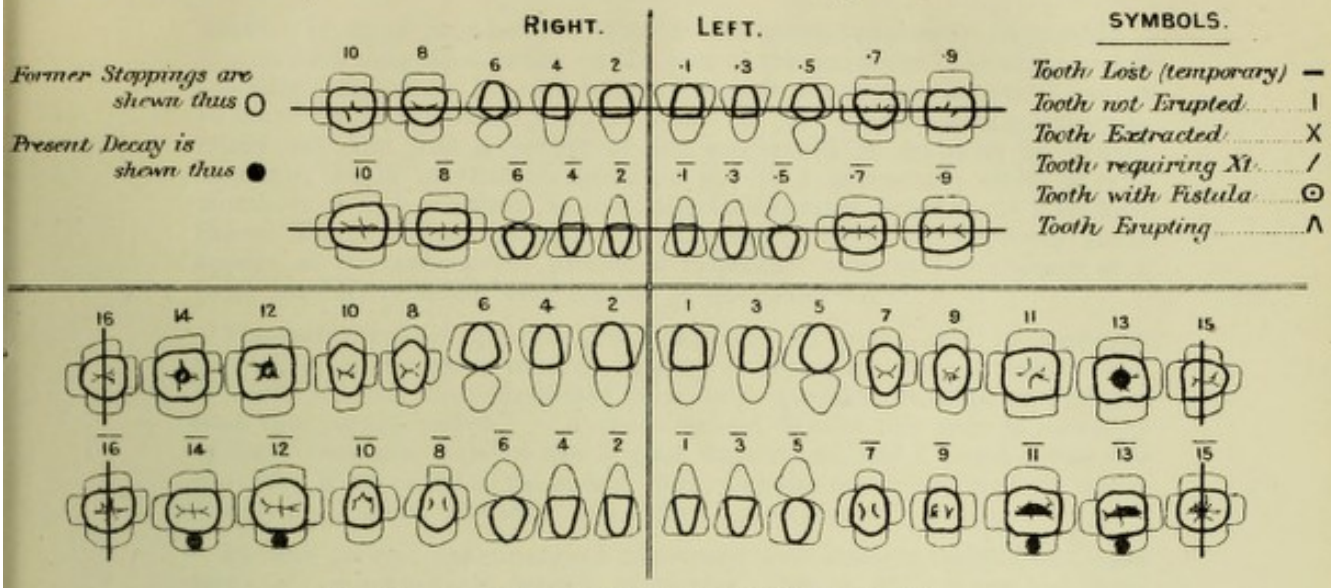
Has been working in dipping room for 14 months.
Type of case easily made "artificially sound."
Dubois Classification = Good.
Cunningham ,, = Fair.

Wyman & Sons, Ltd. Lith. 63, Carter Lane. 3280·10·98

(To face page 174.)

CHART VII.

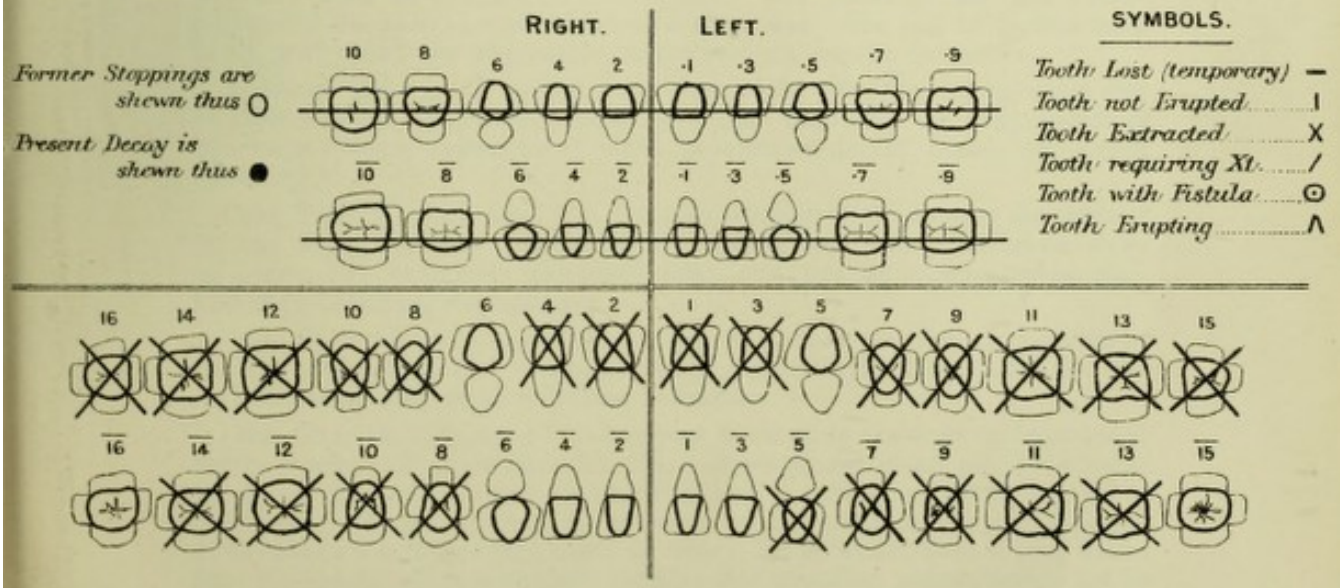
Name Herring, John (87·10) *Age* 14 years 6 months.



Has been working in dipping room for 6 weeks. Typical case of what the medical practitioner might regard as "dentally fit," fine looking Teeth, beautiful arches, but with numerous cavities in early stage of caries, which if neglected will entail inevitable suffering, and extractions in a few years.
Dubois Classification - Good.
Cunningham ,, - Very Bad.

CHART VIII.

Name Ellison, George. (40·12). *Age* 18 years.



Had been allowed to return to work prematurely, gums not healed, therefore suspended by the dental inspector.
Type of case requiring artificially dentures.
Dubois Classification - Good.
Cunningham ,, - Very Bad.

Wyman & Sons, Ltd. Lith. 63, Carter Lane. 3350-10-98

works. It must be admitted that it does seem apparently impossible to control such misguided action on the part of the employee in evading a rule specially designed for his own benefit, when it seems certain that it cannot be found out. A knowledge on the worker's part that he must certainly be found out, and that a breach of the rule would be followed by instant dismissal, would prevent his breaking it. If a permanent chart of each mouth, such as is required by the Local Government Board in all Poor Law School Dental Appointments, were accurately kept, no employee could appear at the subsequent periodical inspection without the absence of a tooth not duly certified being noticed by the examiner.

The special rule in question provides, that "No person shall be permitted to work in the process of mixing, dipping, or drying after the extraction of a a tooth without the certificate of a duly qualified medical practitioner that the jaw is healed." In the Fairfield Works this rule is extended to the women and girls in the boxing department, and I would advise this provision being added to the special rules, and also the insertion of the words "or dental" after "medical" and before "practitioner."

In this present examination I discovered two cases in which there were signs of comparatively recent extraction, though the gums had been perfectly healed for several weeks, and on a little cross-examination both women acknowledged that they had broken the rule of the works by returning immediately to work without giving notice of the extractions.

It is worth noting that one case of duly certified tooth extraction, that of a dipper, involved the expense to the employer of seven weeks' sick-leave.

The importance of periodical dentally skilled inspection is apparent from the following cases, which I selected as typical:—

Case, *see* Chart I. A woman aged 29, who has worked for 16 years at "boxing," had five teeth extracted about nine years ago, and was absent on sick-leave for three months. Owing to the teeth not being replaced by an artificial denture, the right upper central incisor with its bony attachment had become separated and displaced diagonally into the space formed by the loss of the two left upper incisors. The gums were actually inflamed with considerable pyorrhœa and absorption of the bone, while the incisor tooth was very loose. Due note was made by the manager of what seemed a very dangerous case.

Case, Chart II. Another case was that of a girl aged 15 years and 4 months, who had been 11 months in the factory "wax packing," and had a large polypus of the pulp in a very carious lower molar. She had 14 carious teeth in all, 3 of which are unsaveable, and, therefore, require extraction.

Although there is no special rule demanding this, the management rely on their medical officer's certificate of fitness including an examination of the teeth. Some instances of what constitutes dental fitness are worth recording.

Case, Chart III., boy, aged 14½, has been working in the dipping department for one week, and has 5 teeth in an early or moderately advanced stage of caries, two extremely advanced stage, and one quite unsaveable, and, therefore, requiring extraction.

Case, Chart IV., boy, aged 14½, has been working in the dipping department for six weeks, and has 9 carious teeth and one quite unsaveable, and the root of a temporary tooth requiring extraction.

Case, Chart V., boy, aged 14½, has been working in the dipping department for ten weeks, and has 8 carious teeth, 3 of which are in an advanced stage involving the pulp, 3 quite unsaveable and 4 temporary teeth requiring extraction. On sitting down in the chair to be examined, the lad appealed to me not to touch a certain tooth as otherwise he would have raging toothache for hours. Boys with their teeth in this condition should surely not be allowed to be exposed in so dangerous an environment.

The notes of two other cases are interesting from quite another point of view.

Case, Chart VI., aged 15 years, has a perfect set of teeth but for two slight fissure cavities, and could be made "artificially sound" by little more than half an hour's work.

Case, Chart VII., aged 14½ years, has an apparently sound set of teeth arranged in beautiful broad arches. Any medical examiner might easily be excused passing such a case as sound, but not a dental examiner, for with mirror and probe in hand no dentist could overlook the numerous fissure cavities, 9 in number, but all in that early stage of caries when treatment is most effective, but which if neglected mean almost inevitable suffering and extractions in some years' time.

It may be instructive if I append the charts of the mouths of these seven cases. The form of these charts, as already explained, shows the method adopted of registering and classifying the state of the teeth. I am of opinion that such charts should be regularly kept for every employé. The result would be to show at once any alteration in the state of the mouth, and if an operative had teeth extracted without properly reporting it, the fact would be immediately discovered at the next periodical examination.

The general reader will understand that it is not necessary for the examining dental surgeon to draw a picture of each tooth. Blank lithographed forms, of which I append specimens, would be provided, and the dental surgeon could then make on each tooth a mark indicating its condition. By this easy shorthand system, it is possible not only to keep an exact record of the state of the mouth, and every change in it, but of every operation performed. Charts such as these, in some form or other, are now generally used by the most careful dental practitioners, &c.

Messrs. Moreland's Factory.

I made no extensive examination of the teeth of the people at this factory, owing to lack of time, but, at the request of Mr. Moreland, I examined one of the dippers and the mixer, and some special cases upon which he asked my opinion.

My report as to the first two cases, which are of purely dental interest, is as follows :—

(1.) G. B., 28, dipper 2½ years, previously in army. Teeth dirty, with some tartar. Never had a tooth extracted yet. Five gone from decay and subsequent exfoliation. Six carious saveable teeth, and seven unsaveable, requiring extraction. Eighteen carious or lost, therefore "very bad" (Cunningham classification).

This man had served for seven years in the Army, and had been a bugler. He ascribed the bad condition of his front teeth to the action of the plain brass mouthpiece he had to use, but the condition was entirely due to natural causes, neglected caries.

(2.) J. M., 31½ years, mixer. From 16 to 18 worked in "Phoss" as a lad; then worked in the celebrated Gloucester Wagon Factory for seven years, and returned to Messrs. Moreland as a paraffin dipper, and has been working as first assistant and then chief mixer for seven years.

Teeth dirty, stained with much tatar, four carious, saveable, one already extracted, and eight requiring extraction. Thirteen carious or lost teeth, therefore "very bad" (Cunningham classification).

Messrs. Albright and Wilson's Phosphorus Factory.

I am informed that efforts are being made at this factory to secure that the teeth of the workmen are put in proper condition.

The manager kindly arranged for me to examine a small number of the workmen's mouths, and I shall now give a brief summary of the conditions I found :—

A. H., 21 years, yardman for 10 months. Teeth strong but very much neglected, being foul and stained with very large deposits of tartar. He had nine teeth in a very advanced stage of decay, and one left lower

molar with an abscess in an active state of suppuration. He had been put on the list for treatment, but with this pus formation I strongly recommended his immediate removal as a dangerous case. 9 defective or lost permanent teeth = very bad.

W. H., age 22, yardman 1¼ years. Teeth fairly clean, with a little tartar. He uses the mouth-wash regularly. He had 6 carious saveable teeth, 1 already extracted and 1 much decayed therefore requiring extraction. 8 defective or lost permanent teeth = bad.

W. E., age 27, yardman for 6 years. Teeth strong but dirty, stained with large deposits of tartar. He had 2 carious saveable teeth and 3 badly decayed, requiring extraction. 5 defective or lost permanent teeth = bad.

J. W., age 29, yardman for 6 years. Teeth strong but positively foul, with large deposits of tartar, and therefore the gums in a very bad condition. He had 1 carious saveable tooth, 3 already extracted, and 7 so badly decayed as to require extraction. He was on the list for treatment. 11 defective or lost permanent teeth = very bad.

M. H., age 29, yardman for 1½ years. Teeth, fair quality, but dirty and with large deposits of tartar. He had two carious saveable teeth, 3 already extracted, and 7 so badly decayed as to require extraction. 12 defective or lost permanent teeth = very bad.

R. G., age 32, yardman for one year, had been formerly working at the precipitating pans in the copper works. He had good strong teeth, but in a filthy condition, and badly stained with much tartar. He had lost 2 teeth and 1 required removal, but in one tooth there was spontaneous arrest of caries for which his past occupation might be responsible. He passed the dental examination recently. 4 defective or lost permanent teeth = fair.

J. D., age 37 years, had only been a furnaceman for about 4 months. Only the eight front lower teeth and two lower wisdom teeth were free from decay, all the others were very badly decayed or already lost. Some 20 extractions were necessary. The gums were, of course, badly diseased. He was on the list for treatment. 22 defective or lost permanent teeth = very bad.

Such conditions speak for themselves, and it is evident that some strenuous effort should at once be made to remedy this sad state of affairs. I should recommend thorough cleansing of the teeth as more important than extraction and stopping, which must follow.

Although the ventilation is good, and although there had been no case of necrosis since 1895, I am inclined to think that it would be wise to adopt in the factory the same precautions which I shall recommend for match factories in general.

The results of the investigations undertaken at the factory of Messrs. Bell and Company, where every one of the operatives concerned voluntarily submitted to a detailed examination, will be found embodied in the general report. It has not been found advisable to present these results in detail. The same remark applies to the statistics of the workers at the Diamond Match Factory. I should like to express my obligation to Dr. Stewart, Dr. Young, and Mr. Westerton, the medical and dental officers to the Diamond Match Company, and also to the Directors for allowing me every facility and assistance.

Classification of Results.

During my researches into the question, I have examined or procured records of over 1,200 workpeople, and a summary of the results obtained will be found classified in the Tables which follow.

Table A.—Results of Examination of Teeth of 965 Workpeople employed in Five English Factories.*

Age.	Sex.	In Phosphorus Processes.					In Non-phosphorus Processes.				
		Number of Persons examined.	Number of Persons whose Teeth were found to be				Number of Persons examined.	Number of Persons whose Teeth were found to be			
			Good.	Fair.	Bad.	Very Bad.		Good.	Fair.	Bad.	Very Bad.
Under 18	M.	159	23	79	65	32	46	2	10	17	17
	F.	318	9	77	114	118	48	1	11	16	20
18 to 21	M.	22	1	4	12	5	22	—	4	3	15
	F.	103	1	11	28	63	14	—	1	1	12
21 to 30	M.	52	4	14	15	19	19	1	1	3	14
	F.	50	1	1	11	37	5	—	—	1	4
30 to 40	M.	19	1	5	3	10	13	—	2	1	10
	F.	20	—	1	2	17	3	—	—	—	3
Over 40	M.	—	—	—	—	—	5	—	3	—	2
	F.	—	—	—	—	—	7	—	—	—	7
All ages	M.	292	29	102	95	66	105	3	20	24	58
	F.	491	11	90	155	235	77	1	12	18	46
Total	M. & F.	783	40	192	250	301	182	4	32	42	104

Table B. — Results of Examination of Teeth of 965 Workpeople employed in Five English Factories. Summary showing Per-centages.

Age.	Employment.	Sex.	Persons.	Per-centage in whom the condition of Teeth was found to be			
				Good.	Fair.	Bad.	Very Bad.
Under 18	In phosphorus processes	M.	199	11·6	39·7	32·6	16·1
		F.	318	2·8	24·2	35·9	37·1
	In other processes	M.	46	4·3	21·7	37·0	37·0
		F.	48	2·1	22·9	33·3	41·7
Over 18	In phosphorus processes	M.	93	6·5	24·7	32·3	36·5
		F.	173	1·2	7·5	23·7	67·6
	In other processes	M.	59	1·7	16·9	11·9	69·5
		F.	29	—	3·5	6·9	89·6
All ages	In phosphorus processes	M.	292	9·9	34·9	32·6	22·6
		F.	491	2·2	18·3	31·6	47·9
	In other processes	M.	105	2·9	19·0	22·9	55·2
		F.	77	1·3	15·6	23·4	59·7

* The Diamond Match Company, Limited, Messrs. Bryant and May, Messrs. R. Bell & Co., Messrs. Moreland, Messrs. Albright and Wilson.

From these tables the following facts appear :—

As age advances the condition of the teeth very rapidly deteriorates.

The teeth of those manipulating phosphorus were found to be decidedly better than those of workers not brought in contact with it in any way, and this held true in each subdivision according to sex and age. If would be rash to assume that the fumes of phosphorus have any protective action on the teeth, but the tables seem to show that they have no specific corrosive action on the hard dental tissues, and, therefore, are not injurious to the teeth. The tables also serve to throw light on Dubois' surprise on finding the teeth of Paris match-workers under the old Cie. Fermière so very much better than he anticipated, although many of them had been 25 years or more exposed to the effects of phosphorus. It may seem more obvious to explain this state of affairs by ascribing it to "selection of the worker." If so, it must be unconscious selection, for the same thing occurs where there has been no examination whatever as to their dental fitness.

Both in young persons and in adults the teeth of the males are decidedly better than those of the females.

Paris-Pantin Factory.

M. Buisson, while ready to do all he could to help me, confessed that as neither he nor anyone else had the power to compel the employees to submit to an investigation of their teeth, I should in all probability get on much better if left to my own devices.

Accordingly, with the help of the department, I improvised an inspection room in a corner of the works, but next day both factories commenced structural alterations. I was, therefore, only able to examine 45 mouths in all, but I think that these afforded a fair average of the whole. I must not omit to mention that M. Godon, Directeur de l'Ecole, Dentaire de Paris, kindly arranged for me to have the services of M. Bourrat, one of his senior students, who ably assisted me in recording the results of my examination.

These results are embodied in the two following tables :—

TABLE A.—SHOWING THE RATIO PER 100 FRENCH MATCH-WORKERS (MEN AND WOMEN) HAVING SOUND AND DEFECTIVE PERMANENT TEETH.

Pantin, Paris.

Age Group.	25 and under.	Per cent.	Over 25.	Per cent.	Total.	Per cent.	Quality.
No. examined - -	19	—	26	—	45	—	——
Sound permanent teeth -	3	15·8	4	15·4	7	15·6	Good.
Defective permanent teeth—							
1—4 - -	8	42·1	11	42·3	19	42·2	Fair.
5—8 - -	5	26·3	4	15·4	9	20·0	Bad.
9 and more - -	3	15·8	7	26·9	10	22·2	Very bad.
	19	100	26	100	45	100	

This table shows the condition of the teeth of those under 25 years of age, of those above that age, and the total average condition. On comparing this table (A.) with table (B.), p. 178, it will be seen that the teeth of French match-workers are in a far better condition than those of the work men and women in our own country.

TABLE B.—SHOWING THE RATIO PER 100 OF FRENCH MATCH-WORKERS HAVING SOUND AND DEFECTIVE PERMANENT TEETH, ARRANGED IN DECENNIAL AGE GROUPS PERIODS.

Males.

Age Group.	21–30.	30–40.	40–50.	Total.	Per cent.	Quality.
No. examined	11	7	4	22	100	——
Sound permanent	3	—	1	4	18·2	Good.
Defective permanent teeth—						
1—4	6	3	1	10	45·5	Fair.
5—8	1	2	—	3	13·6	Bad.
9 or more	1	2	2	5	22·7	Very bad.

Females.

Age Group.	17–20.	21–30.	30–40.	Total.	Per cent.	Quality.
No. examined	6	15	2	23	100	——
Sound permanent	1	2	—	3	13·0	Good.
Defective permanent teeth—						
1—4	3	6	—	9	39·1	Fair.
5—8	2	2	2	6	26·1	Bad.
9 or more	—	5	—	5	21·8	Very bad.

The second table contrasts the difference in the state in the teeth as to sex. The number examined is small, but the sexes are practically equally represented, and though the women, being younger, have the advantage over the men as to age, yet the general proposition that men have better teeth than women is maintained.

The difference, however, is not so marked as in the British tables.

The results of these tables may be summed up.

MALES.

Out of 22 males examined—

9 had mouths with no caries (1 artificially sound; 3 fillings).
5 with teeth in first stage of decay.
5 „ second „ „ ; 1 with one and 1 with two fillings.
3 „ third and fourth stages of decay.
11 had inflammation of the gums, due to tartar and neglect, and of these 3 had their teeth in a foul condition.
1 had a lower wisdom tooth erupting, which might give rise to inflammation and suppuration.
1 had 3 teeth filled.
1 had 2 teeth filled.
1 had 1 tooth filled.

FEMALES.

Out of 23 females examined—

6 had mouths with no caries.
3 with teeth in first stage of decay.
10 „ second „ 2 with one filling each.
4 „ third and fourth stages of decay.
7 had inflammation of the gums, due to tartar and neglect.
2 had one tooth each filled.

From the point of view of modern dentistry, such a state of affairs as shown in this table, though far better than anything we could show at that time, is still far from satisfactory. Of the total 45 workers, 7 required extraction

of teeth in a very advanced stage of caries, 15 required fillings urgently, and 8 within a reasonable time, otherwise the teeth would soon be in a hopeless condition, and consequently capable of no other treatment than extraction. I was surprised to find, in spite of the doctor's disinclination to admit people with filled teeth, that five workers had had teeth filled, all, I believe, by their private dentist. One was a gold filling.

With regard to the condition of the teeth as to tartar and of the gums, there were 18 cases in which scaling and gum treatment was necessary.

The consequent inflammation of the gums was not, as a rule, great, but in three cases (all men) the teeth were positively foul, and the inflammation suppurative. The women were better in this respect than the men.

Only eight women and five men owned tooth brushes, and even of these many confessed that they were used occasionally only, while four women and five men used a rag for cleaning—in many instances with good effect—and the majority confessed to not using the mouth wash provided at the works.

TABLE C. — RESULTS OF EXAMINATION OF TEETH IN FRENCH AND ENGLISH MATCH-WORKERS, SHOWING EFFECT OF DENTAL SUPERVISION IN THE FORMER CASE. (DUBOIS CLASSIFICATION.)

Country and Date.	Persons examined.	Per-centage in whom the Condition of the Teeth was found to be			
		Good.	Doubtful (Good).	Doubtful (Bad).	Bad.
France, 1875 - -	418	35	27	26	12
„ 1898 - -	45	78	22	—	—
England, 1898 -	342	4·4	42·1	33·9	19·6

On page 180, I have given the results of the examination of a number of French operatives, which shows that their teeth are in a better condition than those of the match-worker in England. This, no doubt, is due to the elaborate system of inspection in force in France, which I have described.

In the above table I have been obliged to adopt the Dubois classification. They show the comparative results of three series of examinations, the first made by Dubois, and the other two by myself. It is clear that some system of selection had been at work, for it is impossible to believe that the teeth of all French operatives are so infinitely superior to those of our own working class. I am strongly of opinion, however, that the teeth of the French are decidedly better, though that opinion is not based on any other statistical data than that here represented. On working out the second and the third series on my own classification, the difference in favour of the French is even more convincing.

The difference between the first and second French series is very striking, showing an enormous change, which is solely due to selection of the worker and to dental treatment. It is not surprising that under these improved conditions, which only date back two years, there is no phosphorus necrosis now, though there had been up to 1896, when a thorough revolution took place.

PREVENTIVE MEANS ADOPTED SINCE INQUIRY BEGAN AND ADVISABLE TO BE EXTENDED.

Messrs. Bryant and May's.

Dental Department.—A dental surgery has been established in the works, and two properly qualified dentists are at work there for 3 hours every working day.

The present surgery is well situated, with a good light, and is furnished with two good dental chairs, dental engine, saliva ejector, &c.; indeed, all the essential appliances of modern dentistry, including a nitrous oxide gas apparatus. It is rather small, however, and a larger and more commodious one is about to be built.

Up to this date 361 workers' mouths have been examined. It is reported that a large number of the workers have left upon being informed they must have teeth extracted, stopped, &c. A small proportion have submitted to treatment, and of these part have returned to their work, and part have left, provided with sound teeth. Very many hands, especially the older ones, have objected to have their teeth treated; and applicants for employment are fewer, the reason being that they are trying to find work elsewhere, in order that they may not have to submit to extraction, stopping, &c., of the teeth.

The arrangements for providing tooth brushes and tooth powder are not completed, but up to the present all those employees who have been under treatment have been supplied with tooth powder.

Complete records are kept on charts of the examinations made and operations done. I have had 201 of the earlier cases copied into case books similar to those used by me in the examination of other factories.

I have therefore been enabled to analyse and tabulate the different cases according to age, condition of the teeth, number of fillings, &c., as shown in Table A. Of the 121 cases (males), two charts could not be tabulated, as the condition of the teeth was not indicated on the diagram. One was the case of a dippers' boy, who had been nearly 2 years in the works, and was rejected as unsuitable (syphilitic); and the other was that of another dippers' boy who had a very large number of badly decayed teeth, and was consequently rejected. The value of skilled dental treatment is further well shown in many other cases; the working notes of two will serve as illustrations.

"Hander-out," age 18, in works 2 years (phos.), 3 fillings required; glandular enlargements on both sides of neck; will go on safety side only—"Left."

"Dippers' boy," age 13, new hand, 4 fillings required; extraction, 26th August 1898; suspicious case, suspended temporarily; 2nd September 1898, improving rapidly—"Left."

The number of "male young persons" is 90, while that of the male adults is only 29, hence the total average per-centage as to quality seems unusually high. This is mainly accounted for by two factors—the bulk of the "young persons" are boys between 13 and 15, and the adults are selected men having teeth far above the average in quality.

Of the 90 lads, 17 had sound teeth and required no attention; 16 were made "artificially" sound, by means of 50 fillings; 3 were made sound for all practical purposes by means of 3, 2, and 8 fillings respectively, in conjunction with other treatment; and 32 had left or were discharged.

Of the 29 adults, 4 had sound teeth and required no attention; 11 were made "artificially" sound, by means of 25 fillings; 2 were made sound for all practical purposes by means of 6 fillings, and other operations. I append to Table A a detailed return of the number of men who had teeth filled and the number of the fillings per individual.

Of the 80 cases (females) there were 3 special cases in which no details were entered on the chart, and therefore could not be tabulated. They are interesting as further proving the value of intelligent dental service as a precautionary measure. The working notes are as follows:—

A. G., aged 30, box hand, 17 years in works; she complains of sore gums; special report sent in.

M. A. R., aged 17, box hand, in works 9 months, has a buried and abscessed molar. She refuses to have it extracted, hence she must not work in the phos.

M. H., aged 15, coil carrier, in works 1 year; she complains of toothache. To be seen at surgery outside the works for further consideration.

The number of "female young persons" is 33, while that of the female adults is 44, and the number between the ages of 19 and 21 greater than in the males, hence the total average per-centage as to quality is much nearer the normal condition as shown in the special dental section of the report.

Of the 33 girls, 4 had sound teeth, and therefore required no attention; 3 were made "artificially" sound for all practical purposes by means of 8 fillings: and 4 had left or were discharged.

Of the 44 adults none were sound, and therefore all required attention, but only 1 had been made "artificially" sound for all practical purposes by means of 1 filling; and 3 had left or were discharged.

None of these 201 cases have been tabulated in my own returns, as the examinations have been made under different conditions, and not for the immediate purposes of this report.

TABLE D.

Result of Recent Examinations at Messrs. Bryant and May's Factory.

Out of 90 male young persons, 32 left or were discharged.

Of these:—
8 with sound teeth.
15 new hands with unsound teeth.
8 after 3–12 months service.
3 under 2 years' service.
2 „ 3 „ „

Of these:—
2 left after dental treatment.
1 with 1 filling—new hand.
1 „ 5 „ —8 months service.

Out of 29 adult males:—
1 left after 7 months service, requiring 4 extractions and 2 fillings.

Out of 52 male young persons:—
9 had sound teeth; but
4 „ temporary teeth persisting.

Out of 43 requiring fillings:—

No.	3	Fillings	1	3	Total.
„	5	„	2	10	„
„	2	„	3	6	„
„	3	„	4	12	„
„	3	„	5	15	„
„	1	„	6	6	„
„	1	„	8	8	„
	18 cases	Completed with		60	fillings.

Out of 29 adult males:—
4 had sound teeth.

Out of 25 requiring fillings:—

No.	2	Fillings	1	2	Total.
„	5	„	2	10	„
„	5	„	3	15	„
„	1	„	4	4	„
„	1	„	5	5	„
	14	Completed with		36	fillings.

Out of 33 female young persons:—
4 left or were discharged.
1 in works 8 months; treatment for toothache begun, *i.e.*, dressing.
1 „ 12 months; very unhealthy mouth.
1 „ 5 days; after one tooth extracted.
1 1 day; bad mouth, requiring much attention

Out of 25 requiring fillings:—

No.	1	Fillings	1	1	Total.
„	1	„	2	2	„
„	1	„	5	5	„
	3 cases	Completed with		8	fillings.

Out of 44 adult females:—
3 left or were discharged.
1 in works, 12 months (boxer); in pain; extractions, bites her nails; suspicious case.
1 in works 2 days (boxer); abscess.
1 ,, 7 years (cutter down); nothing done.

Out of 41 requiring fillings:—
No. 1 case - Fillings 1 Completed 1 Total.

Males.

Messrs. Bryant and May's Employees.

Age Group.	13–18.	Per cent.	19–21.	Per cent.	22–30.	Per cent.	31–41.	Per cent.	41 and over.	Per cent.	Quality.
No. examined - -	90	—	4	—	14	—	8	—	3	—	119 Total.
Sound, permanent -	9	10·0	1	25·0	2	14·3	1	12·5	—	—	13 } (17·6 %). Good.
Sound, transitional -	8	8·9	—	—	—	—	—	—	—	—	8 }
Defective, permanent, teeth—											
1–4 - -	43	47·8	1	25·0	10	71·4	4	50·0	3	100	61 (51·3%). Fair.
5–8 - -	27	30·0	2	50·0	2	14·3	2	25·0	—	—	33 (27·7%). Bad.
9 and more -	3	3·3	—	—	—	—	1	12·5	—	—	4 (3·4%). Very bad.
	90	100	4	100	14	100	8	100	3	100	119 (100 %).

——	Number examined.	Good.	Per cent.	Fair.	Per cent.	Bad.	Per cent.	Very bad.	Per cent.	——
21 and under - -	94	18	19·1	44	46·8	29	30·9	3	3·2	100 %.
22 and over - -	25	3	12·0	17	68·0	4	16·0	1	4·0	100 %.
	119	21	17·6	61	51·3	33	27·7	4	3·4	100 %.

Fillings, No. of - -	1.	2.	3.	4.	5.	6.	7.	8.	Total.
No. of men with fillings	3	10	6	4	5	1	—	1	30
Total No. of fillings	3	20	18	16	25	6	—	8	96

Females.

Age Group.	14–17.	19–21.	22–30.	31–40.	Over 40.	Quality.
Number examined - -	33	18	19	5	2	77.
Sound, permanent - - -	2	—	—	—	—	2 } 4 (5·2 %). Good.
,, transitional - -	2	—	—	—	—	2 }
Defective, permanent, teeth:						
1–4 - - - -	16	5	6	—	1	28 (36·3 %). Fair.
5–8 - - - -	9	5	7	3	—	24 (31·2 %). Bad.
9 or more - - -	4	8	6	2	1	21 (37·3 %). Very bad.
	33	18	19	5	2	77 (100).

Age Group.	Number examined.	Sound.	Left or discharged.	No. of Fillings.					Total Fillings.
				1.	2.	3.	4.	5.	
14–18 - -	33	4	4	1	1	—	—	1	=8
Over 18 -	44	—	3	1	—	—	—	—	=1
Total -	77	4	7	2	1	—	—	1	=9

It is obvious, if only from the number with sound teeth, and, therefore, the most desirable workpeople, who have left, that the question of compulsory dentistry is not the cause of so many hands leaving as might at first sight appear; and that the number leaving after having dental treatment is small. It is also clear that the manufacturer has got rid of a number of undesirable employees.

It is but fair to call attention to the fact that since the above tables were compiled a later report from this factory shows a larger per-centage of workers who have left after dental treatment.

From an examination of their dental register, it appears that up to November 22nd, 1898, 397 of the workers had been examined by their dentists; of these 55 were men and 253 boys, 26 women, and 63 girls. Operations (fillings and extractions) have amounted to 309. In all, 87 cases are reported as "artificially sound," and have obtained certificates of dental fitness.

Out of 397 workpeople examined, 116 have left their work; of these 26 had been treated and finished, and therefore certified as fit for work, while 90 had left either without or after treatment.

A later report has reached me, showing that up to the end of the past year 451 workers had passed the dentist's examination. The number of operations were 535, comprising 420 fillings and 115 extractions.

I regard these figures as a great deal more than creditable to the new regime; as, if anyone will take the trouble to compare the relativity of the number of fillings to those of extractions, at even the best of our dental hospitals, he will be enabled to appreciate the difference and the truly conservative character of the first steps in the promotion of industrial dentistry.

The main contention of this Report concerns the connexion between phosphorus necrosis and the state of the teeth. That the possibility of an attack of the disease depends largely on the condition of the teeth has, it will be seen from the Appendix, been recognised for many years in various countries; but hitherto very few effective precautions have been taken. It has been thought well in consequence to insist here on a few simple rules and suggestions which will, it is believed, serve to minimise to a very great extent the danger, and even to render it non-existent.

Means Advocated and some of the Difficulties.

The preservation of the teeth depends very largely upon systematic attention to cleanliness, and the principal means to this end are constant cleansing by tooth-brush, floss-silk, &c., and the use of a suitable mouth wash.

The proper time for the performance of the principal act of this personal hygiene is obviously after the last meal. To brush the teeth in the morning only is to lock the stable door after the steed is stolen. To do so after each meal must obviously be salutary, and, in the long run, so economical a proceeding that the time necessarily involved is far from being wasted.

To those who have never acquired the habit, it may seem irksome and unnecessary, but to those who have done so, comfort is not complete without even these supplementary cleansings.

Many persons, even belonging to the highest classes of society, believe in all good faith that they clean their teeth perfectly when they do not. The thorough cleansing of the mouth exacts much application, for even in a perfect denture there are between the teeth, both on the external as on the internal surfaces at the border of the gum, numerous intervening spaces where the food, strongly compressed during mastication, becomes lodged, and where it is retained more or less securely. Thoroughness in cleansing is essential in order to have a mouth sufficiently, not to say irreproachably, clean.

Parkes, in his excellent little manual on "The Personal Care of Health," strongly recommends perfect cleanliness of the teeth as the best preservative against decay. As he well says: "The avocations of many working men, "which take them from their homes, may not allow them to brush their "teeth after meals, but everyone could wash the mouth out thoroughly "with water, and thus remove most of the food, which would otherwise "adhere."

The following suggestions and rules for the preservation of the teeth, specially prepared at the request of the employers for the employees

in match factories, might well be adopted in all factories throughout the land :—

THE PRESERVATION OF THE TEETH.

Without good teeth there cannot be thorough mastication.

Without thorough mastication there cannot be perfect digestion, and without perfect digestion one cannot have good health.

Hence the paramount importance of sound teeth.

CLEAN TEETH DO NOT DECAY.

Food left on the teeth ferments, and the acid formed produces decay.

Decay leads to pain and the total destruction of the tooth.

When decay occurs it should be attended to, whether giving pain or not.

The immediate stopping of a small cavity is of the greatest service in preventing the necessity for extraction.

The following rules should therefore be closely observed :—

1. The teeth should be cleansed at least once *daily*, with tooth-brush and powder.
2. The best time to clean the teeth is *after* the last meal.
3. A small tooth-brush with stiff bristles should be used, brushing up and down, and across ; inside and outside, and in between the teeth.
4. A simple tooth-powder, or a little soap and some precipitated chalk, taken up on the brush should be used. If the teeth are dirty or stained, a little fine pumice powder may be used ; but very occasionally.
5. It is a good practice to rinse the mouth out after every meal.
6. All rough usage of the teeth, such as cracking nuts, biting thread, &c., should be avoided ; but the proper use of the teeth in chewing is good for them.
7. **All persons engaged in these works should rinse their mouths thoroughly before meals and before leaving the works.**

Dr. Stewart, who has had wide experience in America, says that without thorough removal of the tartar it is almost impossible to keep the teeth clean, and without steady care and the use of a tooth brush decay is always likely.

This constant care he thinks of more importance than extractions.

His system of dental examination in America is as follows :—

He examines each of the 1,800 people engaged in the rooms where there is phosphorus once in every 6 weeks or 2 months, and a record is kept of the conditions of each. Whatever dental operations are deemed necessary are indicated in a special case-book, and at the end of each day's examination a report is drawn up and handed to the proper officer for his guidance. There is no special dentist attached to the works. The expense of setting the teeth right is borne by the operatives, but means are taken to recommend them to good dentists, by whom they will be fairly treated. The charges made are not uniform, but are graduated in accordance with his position and wages of each worker at the factory.

The introduction of this strict rule caused many complaints at first, but the workpeople are now satisfied, and are practically finding the general improvement to their health so considerable, by reason of their improved powers of mastication, that they, in many cases, insist on the best work, such as gold stoppings and even crown and bridge-work.

Dr. Stewart has a discretion to assist those who are poor.

At the same time, I must say that the examinations I paid here convinced me of the great necessity of obliging the working classes in match factories to attend to this matter. For this I think the aid of the State in some way is requisite. It is most difficult for an employer to compel a large number of factory hands, especially boys and girls, to submit to dental examination, especially when the operation of having a tooth extracted, or stopped, will be the probable or certain result of the inspection.

Having regard to the bacteriological aspect of the subject, already referred to, the question of an effective mouth wash becomes of great importance.

A mouth wash should be antiseptic, antacid, pleasant to taste, and inexpensive. The following formulæ are preferable to any I have found in use in match factories :—

(1)	Carbolic acid - - -	100 grains.
	Oil of gaultheria - - - -	5 minims.
	Oil of peppermint - - - -	5 minims.
	Saturated solution of benzoic acid to - -	1 pint.
(2)	Soluble saccharin - - - -	10 grains.
	Saturated aqueous solution of thymol to -	1 pint.

Or equal parts of these may be used, with the addition of 10 grains of bicarbonate of soda per ounce to make the solution alkaline.

The problem of providing efficient dental treatment is difficult enough to solve in schools, but it is obviously very much greater when we come to deal, as in the case of match factories, with a much larger number of persons, and with teeth in a very much worse condition.*

As an example, I will take one factory, and give an estimate of the dental work required to place the teeth and mouths of the employees in a sound state of health.

Of 630 persons examined, it was found that 2,610 teeth required fillings, 241 required root canal fillings, 3,036 teeth or roots required extraction, and 290 persons required tartar to be removed and the teeth thoroughly cleansed.

I have made a very careful calculation as to the total time necessary for this large number of operations required, and I came to the conclusion that it would take a good operator two years to complete the work. At the time of my visit the dentist was devoting one half-day per week to dental treatment, and at this rate it would take 24 years to complete the task. If two operators are appointed, the same work could be completed in a year.

To this must be added the attention required by new hands coming into the factory.†

When once, however, the work has been finished, it would not be difficult for one operator to keep all the teeth in order, and do all that is necessary for new hands. It is satisfactory to be able to state that the directors of the Diamond Match Factory have adopted the recommendations made by Dr. Stewart and myself. A dental surgery completely equipped outside the works with the matron as the sister in charge is already installed under the care of a dentist, assisted by another who will now devote his whole time to the care of the employees' teeth.

* The following remarks come from an important firm engaged in the manufacture of matches :—

"We have given a great deal of consideration to the dental aspect of the phosphorus necrosis question, and have recognised for a long time that it is a very important, the most important, aspect of the question, and we have tried to deal with it in a satisfactory manner; but many serious and insuperable difficulties have presented themselves. We believe, however, that the public attention which has recently been drawn to the subject has simplified matters somewhat, and probably our workpeople will to-day submit to treatment they would have resented even a few months ago. We have, therefore, decided to institute immediately a dental surgery inside these works, and a temporary room is already fitted, and we are expecting to arrange that the dentists may commence their work on Monday next. We are not in a position as yet to say how much we shall accomplish, and we may not get on so well as we hope."

* * * * *

"We are sure you will appreciate many of the difficulties we have to encounter. Our workpeople object to having their mouths treated, many will prefer to try and find work elsewhere rather than submit, many others will probably submit to the treatment only to leave our employment immediately they have been provided with sound teeth, and it would be quite easy for us to so deplete the works that we could not keep our business going. We ought, perhaps, to refer to the probable attitude of the smaller manufacturers in the country. Although the number of workpeople employed by those manufacturers is much smaller than the number we employ, it is of course a matter of proportion, and although they may object to the heavy expense which such special rules as we are here recommending will entail upon them, yet we think if *we* are prepared to undertake the work, notwithstanding our very large numbers, they should not hesitate to do the same, and we should use our influence with them, for what it is worth, to induce them to accept the resolutions."

† The following is a sample of dental work done during a morning's attendance of a match factory dentist abroad, from 8 a.m. to 1 p.m., as entered in the official register :—18 examinations; 33 dressings to carious teeth; 1 filling; 15 dressings of inflamed gums; 1 case of scaling teeth; 1 tooth disked; 1 case requiring extraction, but at the patient's request left to be done by another practitioner; 1 examination and certificate of cicatrisation after extraction; total number of patients seen, 71. The total of curative effects is summed up in one filling and one cleansing. Dental appointments carried out in such a manner are simply a snare and a delusion, as they would merely serve to give a false sense of security.

VI.—VISIT OF INSPECTION TO THE FRENCH MATCH WORKS.

In accordance with the instructions received from the Secretary of State I proceeded to Paris.

Nothing could exceed the courtesy extended to me by the director and officials of the Department of State Manufactures during my stay.

Instructions were at once sent to M. Buisson, the director, and Dr. Courtois-Suffit, the Medical Officer of the Paris Factories, to meet me the following morning at the Office of the Administration at Pantin, which is situated some little way outside the fortifications of Paris.

Before proceeding to describe the results of that visit, I place here a brief summary of the history of the industry in France which will explain some of the extraordinary vicissitudes which have occurred in connexion with the provision of dental service.

Being obliged to find a new source of income after the disastrous Franco-German war, the National Assembly created different taxes by the law of 4th September 1871, amongst which figured one on matches. All matches made in France, or imported, had to bear a Government stamp.

The receipts, which were expected to reach about 15 millions annually, never passed 4,800,000 francs, owing to various frauds which it was found impossible to prevent.

The State, therefore, assumed control over the purchase, manufacture, and sale of matches. On October 1872 the monopoly was conveyed for 20 years, with the faculty of annullment every five years, to a company which agreed to pay the State:—(1.) A fixed revenue of 16,030,000 francs per annum. (2.) A proportional revenue should the annual consumption exceed 40 milliards of matches. (3.) A duty of 10 per cent. on revenue derived from exportation.

The cost of the compulsory purchase of the several factories was—30,500,000 francs for goowdill, and 2,000,000 francs for machinery, stock, raw products, &c.

The farming company, "Cie. Générale des Allumettes," having obtained the monopoly of manufacture, also acquired that of exclusive sale. In the first quinquennial period, the State received an annual average of 16,238,000 francs. The contract was continued for a second term of five years.

The revenue declined, and therefore, in 1883, the Government proposed to modify the financial stipulations. The new agreement was passed by the Chamber of Deputies, June 1884.

Two counter proposals—one tending to abolish the tax and the other to re-establish freedom of manufacture, with a slightly increased tax—were rejected by the Chamber. The first attempt to sell the exclusive rights of manufacture and sale was unsuccessful.

Finally, however, the "Cie. Générale des Allumettes pour la France et l'Étranger" obtained a concession of the monopoly from 1st January 1885.

It agreed to pay the State a fixed annual revenue of 17,010,000 francs, and an excess sum for all matches made for consumption in France above 35 milliards of matches.

The special revenue for exportation was suppressed. The company was forbidden to import foreign matches. The length of the new concession was fixed for 20 years, from 1st January 1885; but by giving a year's notice the contract could be annulled by either party.

About the year 1885 or 1886 M. Dubois was appointed dentist to the factory at Pantin and Aubervilliers. At that time he made an important collective examination of the mouths of all the workers in the factory, to which I shall refer later on in the special dental part of this report.

In a series of articles, which he then wrote on industrial hygiene, from a dental point of view, he anticipated that the periodical inspection and care of the teeth by dentists would result in a very great diminution of the disease, both as to amount and intensity; and it is regrettable that, as he was the first to proceed and make a statistical inquiry as to the dental aspect of the question, he did not live to make the further communications which he had promised.

At the time of his appointment, I remarked to him that the fee proposed to be paid would barely make good his out-of-pocket expenses for travelling, and could not possibly cover expenses of stopping, but he said that he proposed to have the fillings done by the students of the dental school.

The employment of a dental school or hospital for such a purpose, whether it be by the State or by a rich employer like the Compagnie Fermière, is, I think, inexpedient.

From some of the former employees of the company I learned that M. Dubois used to attend at the works accompanied by some of his pupils; that the only treatment was by extraction, and that no teeth had ever been filled. On this account I found that there was some prejudice still existing against the memory of my friend Dubois, which I could not understand, as he was one of the most earnest workers in our profession whom I have ever known, and moreover was an ardent advocate of any measure which tended to the promotion of the welfare of the working-classes.

In 1890 the Government cancelled the contract, and has since itself conducted the six national match factories of Pantin-Aubervilliers, Bégles (Bordeaux), Saintines (Oise), Trélazé (Angers), Marseilles, and Aix-en-Provence. I did not visit any of the latter places, but I prepared returns as to the health and dental condition of the operatives at Aix and at Marseilles, which will be found in Appendix VIII., page 233.

I have been unable to gather much information as to the dental service, which seems to have been continued more or less regularly by Dr. Brochard and Dr. Richer and others.

Dr. Moiraud was appointed in 1892. At that time the dental service was organised as follows:—The dentist attended once a fortnight to those workers who were referred to him by the doctor as attacked by some dental disease, or some disease of dental origin. In September 1892 a rule was made that all dippers and dryers must be examined once a month by the dentist.

In June 1893 the duties of the dentist were further increased by his having to give one forenoon per week attending at Pantin and Aubervilliers alternately.

Finally, a new director adopted the recommendations of Dr. Moiraud that the periodical examination of the teeth and mouth of all workpeople should be made compulsory, and that all new hands should present a certificate of fitness, signed by both the doctor and the dentist.

Dr. Moiraud must be congratulated on the great improvements he was enabled to effect, but they were not appreciated by those for whose benefit they were intended. The workers started active opposition, and finally went out on strike.

Dr. Moiraud failed to get professional support where he had most reason to expect it, and was obliged to send in his resignation.

A summary of his report will be found in Appendix No. I., and I shall allude again to his experiences later on (p. 194).

In 1896, however, the state of health of the operatives was still very serious, and public attention became attracted to the matter. The cause of its coming into notice was that in the two factories of Pantin and Aubervilliers, the workpeople when certified as ill were excluded from the works, but continued on the pay list, the wages were sometimes diminished, but more frequently paid in full or even increased, until a complete cure was effected. Many hundreds of workpeople thus received during a period varying from 6 to 18 months, sick-pay allowance, varying from 5 to 10 francs per day, according to the average earnings of the operative. The returns of the pay were published. When it became known in 1896 throughout Paris that over 200 workpeople out of an average total of 600 were on the sick list, a violent Press campaign ensued, and public opinion was thoroughly aroused against the administration.

In October 1896, the Minister of Finance invited the Academy of Medicine to appoint a Commission to ascertain how far the manufacture of matches could be made healthy, and a summary of this report will be found in Appendix II.

The most astonishing fact, however, was the result of the investigation into the state of health of the large number of workpeople on the sick list at

that time, namely, 225 out of an average total of 620. Were it not the result of a careful individual examination by such medical experts as Vallin, Magitot, and Manod, one could scarcely believe that 189 were found to be in good health, general and local, and capable of resuming work at once. Of these 124 had one or many carious teeth, and as this is recognised as conducive to phosphorus necrosis, they were advised to seek other employment, their wages being continued for a certain period in order to give them time to find work. Only 36 were passed as really entitled to be on the sick list, and 20 of these were suffering in some degree or other from symptoms attributable to phosphorus. Some necrosis cases were slight, some recent, and others of long standing, going back to a time before 1890, but actually cured. Many of them, who were disabled or infirm were pensioned off as well as some others on account of old age and long service in the factories. Finally, a certain number were put under treatment, or for observation at their own homes, or in an hospital.

From 1st January to the 31st December 1896 a sum of 16,000*l.* was expended by the Administration in sick pay to the match-workers who were sick or reputed such in the two factories, or an average of about 26*l.* for each of the 620 employed. In one case it was proved that 80*l.* had been paid to a workman in consequence of one decayed tooth which had not occasioned necrosis.

This state of affairs is in the report ascribed to the following causes :—" The " excessive fear of overlooking the first sign of any indisposition attributable " to phosphorus, the extreme benevolence of the administration and the " doctors, perhaps also to the tendency of the operative to get exemption " from work while continuing to draw wages ; all these causes had singularly " raised the apparent number of the sick. Moreover, it must be confessed " that the manifestations of slow chronic phosphorus poisoning are still little " known, and that it is difficult to measure by the apparent health of the " workpeople the unhealthiness of the sole industry which makes use of this " dangerous substance."

The conclusions of the report were—

1. It is urgent to put an end to the unhealthiness which persists in a great number of match factories in France.
2. The suppression of the yellow phosphorus is the only means of definitely assuring the salubrity of that industry.
3. The general use of improved automatic machinery is a valuable expedient, but on condition that the harmful processes are carried out within glazed compartments where the workman does not remain.
4. While awaiting the complete success of the experiments now in progress, the present unhealthiness might be diminished by the following means: better ventilation, shorter hours of work, and alternation of workpeople in the dangerous workshops; initial selection and periodical medical visits, with temporary or definitive suspension of workpeople having the mouth in a bad state ; better installation and rigorous supervision of refectories, wash-places, cloak-rooms, &c.

Magitot dissented strongly from the above conclusions. He endeavoured to show that the suppression of yellow phosphorus was both needless and impractical ; that the Academy had not to determine whether yellow phosphorus should be suppressed in order to adopt red phosphorus ; that such questions are industrial and technical, and did not concern the Academy in any degree ; that its attitude should only be to reply to the one single question : is it possible, yes or no, by hygienic precautions to make the present industry of matches healthy, and, if so, to formulate proper hygienic rules. He, therefore, proposed to replace the conclusions of the majority of the Commission by the following amendment :—

1. Our present knowledge of hygiene is such that match factories may be made perfectly healthy without making any change in the technique of the industry.

2. That healthiness depends upon putting in application the two following processes :—(A) Forced ventilation of the workshops (general ventilation, isolated or individual, and by means at the command of the engineer). (B) Selection of the workpeople ; permitting neither the admission nor the retention of any workman attacked with the initial lesion affording an entrance to the periosteum.

After a long discussion the amendments of Dr. Magitot were rejected, and the recommendations of the report adopted.

In spite of the recommendation of the report, it was decided not to abolish yellow phosphorus, and, instead, a Commission of Reform was appointed, which resulted in the medical and dental services being placed on an entirely new basis.

However draconian the measures taken, they have been effective. This is evident from the note on the Sanitary Condition of the Paris Match Factories, by Dr. Courtois-Suffit, read at the Academy of Medicine, 7th December 1897, by Dr. Vallin, and announcing an entire absence of phosphorus necrosis, and even phosphorism amongst the workers.

Thus the methods recommended in the amendments of Dr. Magitot and rejected by the Academy seem to have prevailed in the long run.

At my first interview with M. Buisson, the director, and Dr. Courtois-Suffit, the subject of phosphorus necrosis and the special dental precautions taken in the French factories naturally formed the main subject of discussion. Dr. Courtois-Suffit informed me that immediate surgical operations for the treatment of phosphorus necrosis had been usual up to 1894, when they ceased, mainly owing to the influence of Dr. Magitot. He mentioned six cases which had been operated on. Five of these cases occurred before 1890 and one after. In 1892 there was one patient who died under chloroform. He himself has now been acting for two years as medical attendant, and he had not had a single case of necrosis. He gave me a copy of a communication which he had made sometime ago to the Academy of Medicine, adding, " I have nothing further to add to the report, except to say that what was " true at that time is happily equally true up to the present time " (July 1898).

The communication is as follows :—

" Entrusted for the last year with the duty of medically supervising the matchworks at Pantin-Aubervilliers, I beg to present to the Academy a short note upon the sanitary condition of these factories.

" Last year the Academy of Medicine, justly moved by the increasing and constant havoc caused by the use of yellow phosphorus amongst the workers in match factories, nominated a Commission with the object of studying the progress of the evil and the means of remedying it. And no one can forget the relatively large number of cases of necrosis and of general ill-health due to chronic phosphorus poisoning described in the report of M. Vallin.

" It is this circumstance which makes me think it of some interest to bring forward the results of my own personal observations.

" There has not been within the last year (1st December 1896–1st December 1897) a single new case of phosphorus necrosis, nor a single example of general illness, logically and seriously attributable to chronic phosphorus poisoning, and that, too, in workshops which justly pass as the most unhealthy of all, and in a population of 575 working men and women.

" The fact deserves attention since the methods of manufacture have remained the same, and the installation of the factories has not been sensibly modified.

" A methodical selection of the workers, constant and rigorous, hygienic regulations more strictly followed, have sufficed to produce this result this year.

" One cannot think for a single moment of denying the existence of phosphorus necrosis during previous years, and it would perhaps be rash to affirm that the disease will never occur again, but one can at any rate claim that it is visibly diminishing in distinctly sensible proportions by the application of certain principles which appear to me to be now well determined, and to which I shall return later.

" If in the manufacture of matches we succeed in replacing yellow phosphorus by completely innocuous substances, the best remedy will have immediately been found, but such substitution has not occurred up to the present time. Substances, distinctly injurious on various grounds enter into the composition of the different kinds proposed ; on the one hand, amylene acetate, the influence of which on the cerebral circulation is obvious, and renders its use impossible and dangerous ; on the other hand, lead salts, which, manipulated in large quantities and continuously, will almost certainly entail chronic lead poisoning, the pernicious effects of which have been long recognised.

" It has seemed to me advantageous in the interests of the workpeople themselves to draw attention to these different points.

Since Dr. Courtois-Suffit's appointment, a thorough medical examination twice a year is compulsory for every worker in the factories. Any workman or workwoman who has a carious tooth, or whose mouth is unhealthy, is suspended until reinspected and certified by the dentist, unless working in a department where yellow phosphorus is not employed. The following table shows the number to be reinspected by the dentist after the first general examination held under the new rules:—

Number examined.*	Phosphorus Departments.	Non-phosphorus Departments.	Total.
224 men - - -	12	12	24
352 women - - -	45	20	65
	57	32	89

* Of these 16 men and 35 women were finally suspended.

The difference between the number reinspected and those finally suspended is due to the fact that the teeth were not carious, or that they were regarded as fit to work in the non-phosphorus or harmless departments, such as frame filling, box-making, and "tisons"—a kind of safety vesuvian match. A complete register of the teeth of all the employees is not kept, but charts are made of all those cases referred to the dentist. After being certified as "Bon," *i.e.*, with no carious teeth, by the dentist, the workman is reinspected by the doctor, as he can only resume duty on this certificate being duly signed by both doctor and dentist.

At the second general examination, in February 1898, the number suspended from duty was much less, viz., 3 men and 11 women.

It is worth noting that the "lait des nécrosés," of which the newspapers and the workpeople made so much, is now practically extinct. Whenever a worker presents any signs of phosphorism, such as anæmia, malnutrition, loss of flesh, and albuminuria, the doctor may grant an allowance of 1 litre of milk daily. In former times, as much as 3 litres daily was allowed as the best medicine to employ. In the year of the phosphorus scare, as much as 22,000 francs was thus spent for milk. Dr. Courtois-Suffit has not had any occasion to order milk for any of the workers since his appointment about two years ago.

Decayed teeth and diseased gums are practically the only disqualifying conditions.

There is a dental surgery at both the factories, but Dr. Courtois-Suffit regards that as bad, because the dentist would naturally be tempted to operate on employees while still at work. He said that, as a matter of fact, the dentist did nothing beyond conducting inspections, giving advice, and when possible, a little gum treatment. The only dental treatment that is allowed is extraction, as he did not think that the filling of teeth was advisable for such patients. When extractions have to be done for the operatives, they are sent to the Hospital Larisboisière. The extraction, however, is not performed immediately, as he considers that would be dangerous, and it is only after they have been removed from the fumes of phosphorus by being secluded for two months that the operation is performed. The patient is not allowed to return until the gums are completely healed over. A worker thus suspended by the doctor receives half-pay for the first 21 days, and then three-fourths of the average wages they happen to have been making at the time until they are able to re-enter the works. The period of seclusion, therefore, for a simple extraction may extend from $2\frac{1}{2}$ to 6 months, or even longer.

He attaches a great deal of importance to the washing of the mouth before beginning work, before dinner, and after work is over. The mouth wash which is used is as follows:—

Chlorate of potash - - - -	300 grammes.
Bicarbonate of soda - - - -	300 ,,
Salicylate of soda - - - -	075 ,,
Carmine - - - - -	001 ,,

Dissolved in 20 litres of water.

On my inquiring (since extraction is the only form of treatment) what the attitude of the workpeople was, he said that after the Vallin investigation of 1896 a Commission de Reforme had been appointed to act as a committee of reference in the event of any complaint on the part of the workpeople, but that the services of this committee had never been asked. He said, however, that owing to the opposition of the workpeople, the first great inspection was only carried out by the administration calling to their aid the gens d'armes, but that the situation was now entirely altered, and they all apparently willingly submitted to the examination except in rare cases. It can be well imagined that there is a considerable demand for employment in the State Match Factory, and recently provisions have been made by taking on auxiliaries, that is to say, a number of workpeople who are only accepted temporarily, and not placed permanently upon the staff. This period has been fixed at two months, and there was, at the time of my visit, 40 such in the Pantin factory and 20 at Aubervilliers. These operatives sometimes have the period of trial extended to a further period of two months at a time. Out of all this auxiliary staff, only one had so far refused reinspection.

Dr. Courtois-Suffit attaches great importance to their method of recruiting the personnel. All candidates have to submit themselves to a rigid dental examination. They then bring their chart of examination marked either good or bad, and are finally accepted or rejected by the doctor, who is required to certify that they are free from bodily infirmity and contagious disease, that they have been vaccinated or had small-pox, that the state of their teeth is good, and that without risk to health they can be employed in phosphorus match making.

On another day I had an opportunity of attending the visit of the dentist, Dr. Rousseau, but unfortunately the works were closed except for cleaning. He attends one day a week alternately, at Pantin and Aubervilliers. The dental surgery is in a building overlooking the factory, where a good many of the workpeople also live. The duty of the dentist is mainly confined to that of inspecting and certifying as to the condition of the teeth. He also attends to anyone who may require his advice, but he has obviously very little demand for his services. He occasionally does some fillings for the higher members of the staff, the departmental manager, book-keepers, &c. He had only known of one case of clandestine or secret extraction on the part of the workers. He also reported that there was a great deal of malingering on the part of the workpeople, who being well paid for any interruption in their services, tried all sorts of pretexts to get on the sick list; pricking the gums with pins, &c. to procure a little inflammation in the gums is one of the methods he specially mentioned.

The following case, taken at hazard from the register of cases, is typical of the thorough character of the examination imposed on all candidates for admission to a French Government Match Factory:—

H—— M——.

29.3.1898	- Doctor	- One carious molar (may work in non-phosphorus parts of the works).
12.4.1898	- Doctor	- Result of voluntary extractions not healed, to be seen again on Tuesday.
18.4.1898	- Dentist	- Do. do. do.
19.4.1898	- Doctor	- Result of voluntary extractions not healed, to be seen again in eight days.
25.4.1898	- Dentist	- Do. do. do.
26.4.1898	- Doctor	- Do. do. do.
2.5.1898	- Dentist	- Do. do. do.
3.5.1898	- Doctor	- Good (result of voluntary extraction cured).

Note.—All extractions are entered as "extractions voluntaires."

The rules in force in the French match factories will be found in Appendix V., p. 221.

Great importance is attached to the age limits of employees. The limit of age is set at from 16 to 32 years of age for the men, and 16 to 28 for the

women, but as a matter of fact, they rarely, if ever, take anyone under 18. The tendency also is to reduce the number of women in certain departments, such as press filling, which formerly was all done by women, replacing them by adult male workers.

Interview with Dr. Mahu.—Dr. Mahu has been engaged in connexion with the match industry since 1890, and since being at the Central Administration he has taken his degree as doctor of medicine. He took "phosphorism" as the subject of his graduation thesis. He is therefore doubly qualified to discuss this question.

There are two state factories in Pantin, one devoted to the manufacture of matches, and the other to that of tobacco, the former being classed under the French laws as "unhealthy" (insalubre) and the latter not. The personnel is practically equal, and the medical attendant at that time (1896) was one and the same person.

Dr. Mahu, as I think, had the happy inspiration to examine and compare the diseases occurring in these two factories. I have carefully examined his statistics which were carefully compiled and were sufficiently detailed.

Briefly, his conclusions were: (1) that there had been no alarming number of cases of "phosphorism," since in eight years there were only 15 serious cases of phosphorus necrosis, of which four were fatal in a changing personnel of on the average 700 workpeople; (2) that accidents and wounds were more frequent amongst matchworkers, and are only exceptionally of a serious character; (3) that general diseases are slightly more numerous, but that the mortality is not greater; and (4) that certain diseases, such as anæmia, chlorosis, and especially tuberculosis, are on the contrary less numerous.

According to Dr. Mahu the French workpeople complain much of salivation, but their complaints are greatly exaggerated. In this country we have had no evidence of complaints of this kind. He thinks that the saliva becomes impregnated with phosphorus, but that this does no harm unless there is some channel, such as a tooth with penetrating caries or suppurative inflammation of the gums.

The objection of the old workpeople to dental treatment is still the cause of great difficulty which does not exist with a new personnel like that at Aix. He thinks that the more oxidised the phosphorus fumes are, the less is the danger. He entertains a strong opinion as to the danger of absorption of the phosphorus through the hands, by the handling of damp matches. He is convinced that it is possible to manufacture matches from yellow phosphorus without danger from necrosis. Turpentine had long been used as a precaution in France, but it was absolutely of no value. He holds that the fumes in some way alter power of resistance of the individual, but there is no special phosphorus idiosyncrasy. He stated that it was very easy, from a medical point of view, to decide the question of precautions, while it was extremely difficult for the manufacturer to put them into practice, mainly from the indifference or wilful neglect of the workpeople themselves.

Interview with Dr. Moiraud.—In a long interview, Dr. Moiraud gave me an account of his experience as dentist to the Paris Match Factories for three years. He is quite of the opinion that if a workman has perfect teeth, or no teeth at all, he cannot possibly be attacked by phosphorus necrosis. He is confident that provided proper and efficient care of the teeth is added to the beneficial effects already produced by effective ventilation and strict attention to personal cleanliness, all danger of phosphorus necrosis may be avoided without the prohibition of yellow phosphorus. Before necrosis can occur the micro-organisms must have gained access to the bone through the medium of the alveolodental periosteum.

A young woman having presented herself for voluntary examination and advice, he found that she had two teeth with penetrating caries, a right and a left bicuspid, and he proposed extraction as preferable to filling. She consented to let him extract the tooth which was giving her the most pain, which was the one on the right side. As to the bi-cuspid on the left side, despite his remarks as to the danger of filling, and that if not removed it was even better to leave it unfilled, she went and had the tooth filled by a dentist outside the works. All went well on the right side where the tooth was extracted, and the healing of the gum took place quite naturally. After

a few months of constant pain in the tooth filled outside the factory, she again sought his advice. The tooth was extracted, but already the bone was attacked. Under careful antiseptic treatment the amount of bone lost was not very great.

The period of healing after extraction he found usually extended from 15 to 25 days. During his period of office there were six cases of necrosis, all of which arose from defective teeth, or diseased gums; most of these patients had entered the works in that condition, and had never availed themselves of the voluntary dental service. From his experience he was quite confident that the immediate extraction of the teeth was quite feasible, but it ought to be undertaken with more than usual care, and followed by appropriate antiseptic treatment. He did not find the teeth of phosphorus match-workers any more brittle in extraction than those of ordinary people, but he said that he saw some change as to colour, and there was certainly less soft caries and more dry caries than in the teeth of workers in other industries. He was of opinion that the suppuration of the wisdom teeth, or third molars, which frequently occurs in the course of their eruption, would be a source of great danger. He advocated very strongly that some innocuous department of the works should be used as a sanatorium for patients who were undergoing dental treatment, as he considered that the leisure of between 14 or 15 days after a simple extraction was pernicious. This idleness often led them to drink, and thus to aggravate rather than improve their condition.

The recommendations and improvements which he had introduced in the dental service excited great opposition on the part of the workpeople, who ascribed all the phosphorus necrosis cases to the result of the extractions, they protested therefore against his retaining his appointment, and finally went on strike, and ultimately he determined to retire and sent in his resignation.

I also had interviews with Dr. Galippe, who introduced me to Dr. Moiraud and furnished me with various communications which are summarised in Appendix III., p. 219; and with Dr. Michaels, the eminent dental prosthetist, who collaborated with the late Dr. Péan in his work on "Phosphorus Necrosis."

Matches without Phosphorus.

I find that a good deal of confusion has arisen as to the so-called "sans phosphore" match as made in France. The only match which has been introduced under this name was that invented by M. Poutaux, and this was the match so strongly advocated by the Syndicate of French Match Workers as solving all difficulties and doing away with the necessity of using yellow phosphorus. The composition certainly contained no phosphorus, either yellow or red, and consisted mainly of permanganate of potash and collodion. It was therefore extremely dear to make. The matches when placed on sale were an utter failure, and therefore the manufacture of them was entirely given up.

In one of the large warehouses adjoining the office of the administration at Pantin I was arrested by a strong odour of amyline, which pervaded the whole warehouse. On inquiry I found this was due to the presence of a considerable quantity of these matches, which were only awaiting orders from headquarters to be burned up. I was told that this strong odour was even greater in the first match manufactured, and that M. Poutaux endeavoured to suppress the etherised sulphur smell by varnishing the heads of the matches, but without success. M. Buisson gave me an interesting account of the various attempts that had been made to make several kinds of matches without phosphorus (red or yellow), but all of them had failed. The match which is now being made and sold by the French Government under the initials "S. C." is not really a non-phosphorus (sans phosphore) match, for the characteristic component of the composition is the sesquisulphide of phosphorus, a preparation of phosphorus which has not hitherto been used in match making. It is a yellow powder, as manufactured by Messrs. Quesnier, of Lyons. It has a low point of ignition, and may be readily mixed with chlorate of potash. In these respects it resembles white phosphorus, and neither in their manufacture nor in their transport do the matches made from it readily catch fire. It has a strong odour. This new match

will strike anywhere. I was present at the first big mix they were making at the Pantin factory. The mixing takes place in an open mill, and necessitates much careful attention and watching. It is a much more delicate and prolonged operation than making the ordinary composition. It takes about five hours to make a mix of 50 kilograms. It is said that the sesquisulphide contains only small traces of red and yellow phosphorus.

From other sources of a trustworthy nature I learn that changes do take place, and that in the course of time a certain proportion of yellow phosphorus is formed. However that may be, it would not do away with the advantages of this new composition to the workman, though it may possibly interfere with the success of the match as a practical one. The principal objection to it at present seems to be the odour. As matches are often stored in private houses in cupboards, where food is kept, the disagreeableness of the smell on opening the cupboard door must be an obstacle to it as a practical match. Meanwhile, it is certainly the best and most promising of all the new matches which have been lately introduced. It should not be forgotten that many matches which can be sold under a monopoly would never be saleable in this country. Although in France the "S. C." matches are sulphur dipped, the sesquisulphide is quite capable of being applied with equal success to a paraffin dipped match.

This match is the invention of M. Sevine and M. Cahen, experts associated with the Government match administration, and hence the name of it, the "S. C." match. "The toxicity of the sesquisulphide of phosphorus, too, has "been determined by Messrs. Sevine and Cahen, and shown by them to be "practically nil. They gave three centigrammes daily to guinea-pigs for a "period without any bad results, although the ingestion of three milli-"grammes of white phosphorus in a control experiment caused rapid death; "and when we remember that the three centigrammes given to guinea-pigs "correspond to 3·5 grammes given to man—that is to say, the amount of "sesqui-sulphide of phosphorus contained in 6,000 matches—some idea may "be gained of its harmlessness compared to white phosphorus."

These experiments, however, have not any bearing on the question of the effects of the fumes, and do not definitely settle the question of the toxicity.

"It is claimed that the new match will strike anywhere. If the practice of the future confirms the expectation of the present, Messrs. Sevine and Cahen will deserve the congratulations and support of the public."

Visit to the Factories.

I went over the works both at Pantin and at Aubervilliers.

At Pantin I found that the mode of manufacture of phosphorus matches in France varied very much from anything I had thus seen in this country.

The single match splints (allumnettes blanches), as the French term the matches before they have been dipped in the phosphorus paste, are set up by machine, and disposed in such a way that each match is kept free from contact with its neighbours, and so as to form a flat square surface in the following manner:—The square iron frame (technically termed "étrier") is of such a thickness that it is a little less than the length of a match. Let us imagine a series of these short splints, laid flat, parallel with one another, and separated by a slight interval until the first line is complete; and then applied on the top of the first row of splints a bar of wood covered with cloth so as to hold the whole row, each in its place. On the top of this bar is now placed another row of splints, or undipped matches, as was done in the first row, and then another bar is similarly placed upon it in its turn. Continuing the operation in the same fashion by alternately placing a row of splints and the wooden bar covered with cloth on two sides, we shall have, when we have reached the top of the frame, built up a rectangular parallelepiped of the height of a match, and of which the bases will present the extremities of the splints placed at an equal distance from each other, and in the same plane. This constitutes what is termed a "presse garnie," or filled press. The filled presses are then carried to the sulphur dipping bath, and then to the phosphorus dipping machine, where one of the large surfaces is plunged successively into the fused sulphur and then into the phosphorus composition. The dipped frames are then placed on a trolley, and conveyed to the

drying room or tunnel. When dry they pass to the "dégarnissage," which corresponds to our releasing and boxing department, and where the finished matches are subjected to a process exactly the reverse of that which we have described for the filling of the frames. Thereafter follows a series of other operations, such as picking out, "piquage," "triage," and "mise en bâteaux" somewhat equivalent to filling "ducks" in this country and finally boxing (emboitage).

It will be necessary to describe the processes a little more in detail later on.

With the exception of the frame filling, it is evident that throughout the whole course of manipulation just described the workmen are constantly manipulating the dipped matches, and in consequence are exposed to phosphorus fumes.

The workshop in which I will commence this brief description is the laboratory where the phosphorus composition is prepared, in which the workmen are less exposed than one would at first suppose.

1. *Preparation of the Composition.*

La pâte, as the phosphorus composition is termed, is composed as follows:—Yellow phosphorus, 10 per cent.; glue, 19 per cent.; powdered glass, 11·4 per cent.; peroxide of iron, 11 per cent.; zinc, white, 5 per cent.; Bismark brown, 0·5 per cent.; water, 43·1 per cent.

The preparation of the composition is conducted exclusively at the factory in Aubervilliers, the quantity required for the factory at Pantin being transported thither. It is prepared in a special apparatus (which remains very much as it was when invented by M. Germot, the director of the old Compagnie, Fermière), by which the pattissiers, or mixers, are completely protected from phosphorus fumes, at least during the actual making, since it is wholly effected by machinery in closed vessels. The apparatus consists of three distinct compartments, placed at different heights, and communicating with one another by connecting pipes. A portion of the molten glue in the upper closed chamber is run into the second chamber; and the phosphorus is introduced into the melted glue by a self-closing valve, so that no fumes escape. By means of a mechanical mixer or turbine, the intimate mixture of the phosphorus with the glue is completed. The result of this first mixture in the second chamber is drawn off into the third chamber, where it is mixed with the remainder of the molten glue from the first chamber, and the other necessary ingredients, powdered glass, colouring matter, &c. The third chamber of the apparatus is larger than the other two, and in it the mixture of the phosphorus composition is completed by means of a mechanical mixer. When finished the composition is drawn off into a moveable kettle, and immediately covered by a lid. The whole operation takes about three-quarters of an hour. No fumes escape into the mixing shed, as they are carried off into the outer air by iron shafts.

It will thus be seen that the worker is exposed to the vapours of phosphorus when he is weighing it and introducing the moist phosphorus into the machine, and again at the termination of the operation, when he is removing the hot composition. The vessel in which he receives the finished paste is immediately carried to a refrigerating chamber, consisting of a sort of hood which conducts the fumes to the open air, while the composition is constantly stirred by a mechanical mixer, with the view of maintaining its homogeneity. The paste thus cooled is carried to the dipping rooms, during which transport the workmen are still exposed to the inhalation of phosphorus fumes. In the cleaning up of the machine, also, the mixer must be more or less exposed, but to what extent I had not the opportunity of judging. The features characterising this process are, first, the large amount of phosphorus employed—fully twice as much as in this country; and, secondly, the absence of chlorate of potash from the composition. There can be little doubt that by adding chlorate of potash to the composition the amount of phosphorus might be reduced even to one half, but it would be extremely dangerous, if not absolutely impossible, to prepare a chlorate of potash phosphorus composition in a system of closed metal vessels, such as is used in the French factory.

2. *Sulphur and Phosphorus Dipping.*

These operations are conducted in a new building on the ground level, which is lofty and well ventilated.

Two tanks containing the sulphur are placed opposite the door in this workshop. The frames brought from the filling-room, which is entirely separated, are placed one by one upon a heated iron table upon which they are made to slide up to the tank. There each press is seized by the sulphur dipper, who plunges one of its surfaces, that is to say, one series of the ends of the splints, a certain depth into the molten sulphur, and then places the press upon a trolley, which transports it to the dipping apparatus.

The phosphorus dipping in the Pantin factory is carried out by means of an apparatus known as the "rouleau trempeur" (roller dipper). It consists of a horizontal roller rotating in a trough containing the phosphorus composition, and upon which the dipper places the press which has just been sulphured. A hood ought to cover the roller and the press be passed through a slot in the hood. The men prefer to work without the hood, which prevents them seeing their work so well. The phosphorus composition of course has to be heated to a proper temperature, and the points of the matches are impregnated with the phosphorus composition as they touch the surface of the roller. The two columns supporting the roller and trough are hollow, and where they terminate at the upper end and at the level of the trough they are in communication with a mechanical ventilator which carries off the fumes. It must be admitted that the atmosphere of the room did not smell strongly of phosphorus, but this I ascribed to the more dominant smell of the molten sulphur. On standing close up to one of these roller dippers it seemed to me that the smell was quite as strong as with the ordinary dipping stone, and stronger where the dipping stone is provided with a powerful ventilating fan. Personally I should prefer to work over a well-ventilated open dipping stone than over a machine of this character; and I have reason to believe that on the removal of some of the old French match-makers to other countries on the institution of the State manufacture, the roller dipper has been almost entirely abandoned. The roller dippers at Pantin are two in number, and necessitate, for their proper working, the presence of two men, one who acts as the dipper who acts as feeder, and the other as assistant dipper, who acts as receiver of the frames. Each sulphuring bath is managed by one man, and three porters for each group of sulphuring and dipping machines, who undertake the transport of the frames as they enter and are taken away from this department. There is thus in all an equipment of 12 men, who take alternately between them the dipping, the assistant dipping, and the transport, in such a way that one man is only employed one day out of three at the roller dipper, which is regarded as the most dangerous post in the factory. The most dangerous time in the dipping is that when the workman raises from the roller the frame which he has just dipped and holds it in the air at the proper visual distance in order to verify the proper execution of his work.

In addition to that, it should be noted that the dippers have to undertake the duty of cleaning the machine thoroughly at least once a week. This is regarded as the most dangerous duty of all, since they are then most of all exposed to the fumes of phosphorus. I was unable to assist at this operation, but the character of it is well indicated by the fact that the men are paid an extra high price for performing this duty.

3. *Drying.*

From the dipping room the trolleys, containing each 16 frames of matches placed one above the other, are run into the drying room.

The drying rooms have undergone a complete transformation since the manufacture has been undertaken by the Government. They now consist of a rectangular block of brickwork in the middle of the workshop, which is divided up by horizontal walls into a certain number of tunnels, of which the two extremities are closed by sliding doors of sheet-iron, one at the entrance, and the other at the exit. Each tunnel has a double roof, but the partition forming that does not run the whole length. Hence, in each tunnel the hot air required to keep up the temperature necessary for drying purposes

passes along the chamber in the roof of the tunnel and is admitted near the far end. In the front part of each tunnel on the ground level is a tube, communicating with a mechanical aspirator. In this way warm air passes in at the roof at the back and goes out by the aid of a ventilating tube situated on the floor level in front, and thus passes through each tunnel from behind forward and from above downwards.

The workman on introducing the trolley containing the 16 frames of sulphur-phosphorus dipped matches, only passes it far enough that the door of entry can be shut. It is easy to see that the lower frames only on the trolley will be met by the current of hot air. Shortly after that, without anyone entering into the tunnel, the second trolley introduced pushes the first one forward by exactly its own length. It therefore follows that it will now be the lower frames of the second trolley that will be most exposed to the hot air, while the series of frames higher up on the first trolley will be exposed in their turn to the hot air as a third trolley is introduced. In this way, the one pushing the other at different intervals of time, the frames on the whole series of trolleys, which the tunnel will admit, will be gradually and methodically dried. All the frames on each of the trolleys will be successively exposed to the hot stream of air, beginning with the lower frames and finishing with those above, and by the time the last of these are dried the trolley will have arrived at the end of the tunnel, and it is only necessary to open the door of exit and take it out.

Therefore, when the drying tunnel is in full working, just as a trolley containing the freshly-dipped frames is pushed into the tunnel a trolley, of fully-dried frames is expelled at the exit. Hot air coming from the opening is drawn away by a mechanical ventilator, and is carried off to the centre chimney, which also increases the draught, and extracts a quantity of waste matches, &c. Not only is this system deemed sufficiently perfect to place the workmen absolutely out of reach of the fumes of phosphorus, but it also considerably reduces complications which were frequent with the old system of drying, and which it was impossible to arrest by isolating the series of matches from one another.

Should a fire take place in one of these tunnels, it is promptly extinguished by closing the chimney by which the warm air is introduced and the tube which communicates with the ventilating shaft. The sheet-iron doors at the entrance and the exit are so closely fitted by means of asbestos packing that each tunnel is absolutely air proof. Besides preventing the spread of fire, this system has the further and even greater, from a hygienic point of view, the greater advantage of absolutely preventing the phosphoric and sulphurous fumes which would arise from combustion of the matches from spreading into the atmosphere of the workshop. I believe a similar system has been adopted in the new match factories in Belgium.

I have described the installation and action of the new drying chambers at length, as I believe they constitute, from the hygienic standpoint, a great advance upon any drying rooms existing in this country.

4. *Dégarnissage.*

The frames of matches thus dried are carried to the ends of the workshop for dégarnissage, that is to say, for the removal of the matches held by the transverse bars in the iron frame and placing them in masses to be handled and have all the ends set in the proper direction. This undoing of the matches, as it were, from the frames is executed by means of a machine which shakes the matches into a series of small rectangular compartments, whose greatest dimension is less than the length of a match. A to-and-forward motion is given to the series of these compartments, with the final result that by this shaking process the matches fall finally into a receptacle with masses of holes turned in the same direction. The matches are then collected on a duck (bâteau) or tray of wood or iron, on which they are transported to the next stage of the process. The machine is ingenious, it is true, but extremely noisy and fatiguing. The machine is altogether out of proportion to what it has to do. Its working of this machine exposes the workmen very much to the fumes of the phosphorus, and also to the dust, which can readily be seen with the naked eye while the machine is working.

An attempt has been made to lessen this by means of a mechanical ventilator, but owing to the smallness of the holes, which of course cannot be greater than the narrowest dimension of a match, they are liable to be blocked by dust and splinters. The mechanical ventilator in such a case must be illusive. Dr. Mahu regards both the men and women occupied in this part of the work as amongst those most exposed to the fumes of phosphorus, as the process of handling is altogether longer, and the impregnation of the hands with phosphorus is greater.

In the middle of the workshop is a long table, to which are carried these trays containing the matches from this machine. The matches are now arranged on larger "ducks" or trays, still keeping the heads of the matches pointing upwards. These larger trays are then carried to a table running parallel to the former, at which the *piqueuse* proceeds to pick out all the bad matches; also those with the heads turned in the wrong direction. This work requires very close attention. The workwoman is continually close to her work, which requires very good eyesight. It is considered both very trying and dangerous, and it is not surprising, therefore, that these workwomen earn higher wages than the others—six to seven francs a day. A provision is made for ventilating these tables, but it did not seem to me to be sufficiently strong, many of the apertures being completely blocked up.

Each of these Schemzer machines requires the employment of three persons —one man and two women. The workshop contains eight machines, of which seven are constantly working. In summer the atmosphere in these rooms is almost unbearable, and the elevation of the temperature causes the ignition of the matches, which are submitted by this machine to rather rough treatment. Such fumings are promptly extinguished by suffocating the flaming matches with sawdust, and of course are of very slight consequence, except for the vapours of phosphorus and sulphur which they occasion. It is, in fact, of these vapours that the workmen most complain as causing coughing, spitting, and an unquenchable thirst.

From what I have since seen of other factories, where the frames are not emptied as a whole, but stripped gradually by hand, in the same way as in wax vesta boxing, there would be no advantage to the worker from the use of such machines in this country.

5. *Mechanical Boxing, Stamping and Packing.*

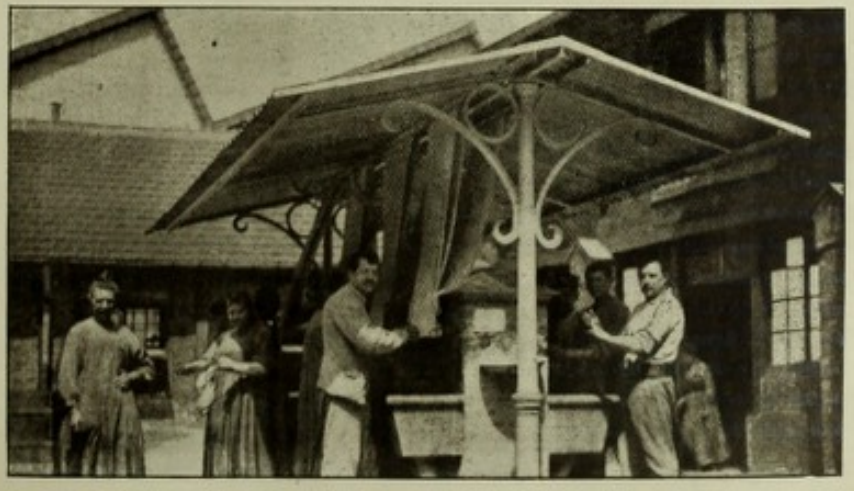
The boxing at Pantin is done by a special machine. The matches, previously selected and arranged (triés), are placed in a receiver, and when so placed, are separated from the work girl by a sheet of glass through which they are visible. It would take too long to describe all the details of the mechanism; suffice it to say that the receiver of the machine is provided in its lower part at the centre with an opening which brings the matches into a kind of spout immediately in front of the work girl. She has only to present a match box to the end of the spout in order to receive a quantity of matches, which amount is measured by the successive opening and closing of the lower orifice in the receiver. This alternate movement is brought about by a pedal lever worked by the boxer. The work executed by the work girl consisting, as it does, in the active and constant movement both of the arms and hands, as well as the feet, is extremely fatiguing. She comes in close contact with the fumes of the phosphorus. Two other girls assist in closing the boxes after they are filled, and one of them alternates duties with the first, but all three are necessarily exposed to, and in contact with, the phosphorus fumes. Some 10 or more of these machines were at work, and the deafening noise produced by them must add very considerably to the trying nature of the work.

The pasting of the State stamps on the closed boxes is also conducted in the same room, as also is the packing of the matches. The number of these workpeople are about 50, including carriers and porters. The number seemed very large for the size of the workshop. I also notices that trays were suspended in this room for the purpose of holding turpentine, but all I examined were empty. If turpentine is of no use, why keep the trays in position and the rule as to refilling posted on the walls?

(*To face page* 200.)

BRITISH MATCH GIRLS.
(Messrs. Bell & Co.'s Factory.)
"THE DINNER HOUR OUTSIDE THE REFECTORY."

FRENCH MATCH GIRLS.
"A CASUAL GROUP AT THE PANTIN FACTORY."



"WASHING UP BEFORE THE DINNER HOUR."
(At the Pantin Factory.)

I also visited the works at Aubervilliers, which are far from being as good from a sanitary point of view as the Pantin factory, which leaves much to be desired. Indeed at the time of my visit, these works were being connected with the sewerage for the first time.

In going over the works at Pantin I found the ventilation in some parts very defective. M. Buisson pointed out to me with regret that the extensive improvements which had been in progress for promoting the better ventilation had been stopped as the administration was about to alter the process of manufacture by the introduction of the new match composition (sesqui-sulphide of phosphorus). But, surely, even the doing away with the fumes of yellow phosphorus should not be a reason for depriving the workpeople of the very best ventilation possible.

With regard to the habits of the workpeople as to personal cleanliness, they all seem to be very careful in conforming to the regulations. The washing places are in the centre of the court, open to the air, but protected by a permanent canopy. Cold water only is supplied, and the operative washes his or her hands in a running stream of water which flows by pressure of a pedal lever. The towels were of a better quality than those I have seen in any British match factory, except at Liverpool.

In Paris, every worker is entitled to free tickets for a bath once a month, and mixers and dippers twice a month. In some of the newer provincial factories, a bathing establishment forms part of the works.

The men are allowed three blouses yearly, while the women are provided with pieces of material sufficient to make the same number. Each worker is allowed 1½ metres of material every two months for repairing these garments. It seems a pity that the match girls in this country have not adopted the hygienic and economical habit of wearing a blouse at work. The word blouse is not used in the same sense that it has in this country. In France it means a smock frock. Dippers and all who are doing heavy work are provided with broad gymnastic belts, and the engineers and stokers are supplied with 4 metres of flannel for waist belts, and all those whose work exposes them to wet feet are provided with goloshes. A huge tank of black coffee is kept going from morning till night from which the workpeople can help themselves. They are gratuitously supplied with a good tooth powder, but for which I was informed there was little demand. The mouth wash is in a small glass barrel on a block attached to the wall in the court of the factory, there was little evidence of its being used to a great extent. The workpeople complain of its taste, and that it is not renewed sufficiently often, and that it gets acrid by being exposed to the sun and weather. The acrid taste was simply that of chlorate of potash and I did not sympathise with the complaint of the workmen in this respect. I pointed out, however, to M. Buisson that the mouth wash had no antiseptic effect, and he said he would only be too glad to adopt one of greater efficiency.

I visited both the cloak-rooms occupied both by the men and the women. The arrangements are of a rudimentary character. A new refectory was just being completed and the tables were covered with oilcloth. The room is very small, but the majority of the employees live in the neighbourhood and therefore go home to dinner. The old refectory was very dirty and very badly lighted, being simply an old shop transformed and the shutters being kept permanently up. There was, however, a stove on which they could prepare their meals. The dinners, which both the men and women brought in with them for consumption in the refectory, were of a much better quality than anything I have ever seen in this country. They always had meat or fish, or sometimes an excellent haricot and wine. I never saw even one of the women indulging in the usual stereotyped British can of tea. It is not surprising, therefore, that both the men, and more especially the women, have a much healthier appearance than the match-workers in this country. It must be remembered, of course, that the wages are very much higher, especially for the women.

I visited the rooms of the concierge (M. Gobin). I was interested in noticing that he had a framed diploma which announced that he had been

awarded the medal of honour given by the State as a recompense for long and devoted service in the same establishment. He was then 50 years of age. From the age of 12 he had worked in the phosphorus departments of this match factory. His idea was that there should be no distinction made between the different parts of the works. He had no fear of suffering from the fumes of phosphorus. Protection was simply a question of exceptional personal cleanliness and abstention from all excess as to drink and otherwise.

French Provincial Factories.

On making inquiries at the Central Bureau in Paris, as to the existence of phosphorus necrosis in the provincial factories, I was informed that there was now only one case on the list, viz., at the Marseilles factory. In order to satisfy me on this point I was allowed to inspect the whole series of monthly reports from Marseilles. In running through these I found the following in red ink: "No. 221, Ouvrière atteinte de necrose, 9 aout 1897." On inquiry I found this related to the case reported by Dr. Oliver, one Marie Ruquet, aged 23 years, who had been on the list since the 9th of November 1896. She was occupied in the "dégarnissage," releasing frames of wood matches, and was allowed 4·44 francs per day as "nécrosée."

I also obtained access to similar reports from Aix-en-Provence. I could find no trace of any case of necrosis; but I saw the reports were not detailed as to the number of medical, surgical, and dental cases. No tabulations of these returns are made, so I proceeded to make them for myself, and having done so, concluded that, from a dental point of view, there was nothing to be gained by going there, especially under uncertain conditions and at an unsatisfactory time of year.

Some of the results I obtained seem very instructive as to the comparative worthlessness of statistics without some standard of comparison and a knowledge as to the difference which exists in the dental service and the calls upon it in the several factories.

The documents at my disposal consisted of the monthly reports which every third month is marked as quarterly. The following table prepared therefrom again shows that dental disease is the most common ailment. The character of the dental service is well shown from the treatment being mainly conservative and from there being only one case of extraction in the whole year. I think, however, this cannot be quite correct, for I found evidence of more extractions in other returns. The entries of the men not fit to work in the phosphorus departments are a little difficult to understand but may possibly explain this discrepancy. From a list of names and the operations done for them, I found that seven men had teeth filled and seven teeth extracted; while 60 women had teeth filled and seven had teeth extracted. Most had one filling done, many two, 11 three, 3 four, and 1 five fillings; in all some 120 fillings.

Marseilles.

On the site of the old works, which were destroyed by fire, the match factory, at Prado, Marseilles, was rebuilt some two years ago. The State had taken over the old works and the personnel, as a "going concern" from the farming company, and consequently a number of the "old hands" remain and the old traditions still hold sway.

All I could compile from the Marseilles returns was: (1) That the following were the numbers for the year in the factory:—

—	Men.	Females.	Total.
1897, September	77	442	519
„ December	77	442	519
1898, March	77	437	514
„ June	75	434	509

(2.) The returns of the facultative consultations for the care of the teeth which must be made monthly.

	Men.	Females.		Men.	Females.
1897.3.29	2	2	1898.1.26	7	2
„ 4.28	4	4	„ 2.25	3	4
„ 8.2	4	5*	„ 4.25	5	3
„ 10.6	4	8	„ 5.25	4	7
„ 11.30	2	5	„ 6.25	7	5
„ 12.17	5	2			
			Total	49	47

* In the temporary absence of Dr. Arnaud, it is preferable to defer the application of the rules as to the extraction of the teeth.

On examining the last monthly report just quoted and carefully headed as above, as to the facultative and periodical character of the dental inspection, I learned that, of the 12 presenting themselves, seven were men and five women; that four men and one woman were "Bon" and, therefore, not requiring attention; that amongst the men one tooth required filling and one extracting, whilst amongst the women 13 teeth required filling and three extracting, and that one man required scaling.

The returns were so differently compiled, that I found it impossible to make any table for comparison with the Aix factory.

Aix and Marseilles compared.

The monthly returns of the workpeople who have been suspended from duty in consequence of dental disease and injuries, giving the number of days off and the amount of sick pay allowed from both factories, are on such lines that I have been able to compile a table giving the comparative results, which are not only striking but of a most instructive nature from more points than one. The summary I have prepared is so surprising that I feel bound to publish in Appendix VIII., pp. 230–233, Tables A., B., and C., the full detailed returns compiled from the monthly returns of both factories.

In one or two instances there was a complication, where the case was included under both heads, "Dental" and "Surgical," and in the Aix returns a separate column was added, viz., that of "Malades," or medical cases, in addition to that of "Blessés," or surgical cases.

But the amount of the difference is so small as not to be worth while regarding, for the returns would not be more than infinitesimally altered.

I asked for similar returns as to Paris and other factories, but was informed that they were not forwarded to the central administration, but kept at the local centres. From what I saw I should say that similar records, on parallel lines, are kept of the sick pay allowances for dental and surgical cases in all factories, as shown in the tables I publish as to the number, date of suspension, and weekly allowance, in the Pantin-Aubervilliers part of my report. The wages there are much larger than in the provinces, therefore, the sick pay allowances and the total average amount expended must be much greater still than those I now publish.

The value of a uniform system of records, however, both on economic as well as scientific grounds, is obvious.

I have, however, been able to prepare two tables (see Appendix VIII., B., and C., pp. 230–233), from which I desire to present the following summaries:—

TABLE A.—SUMMARY SHOWING THE RELATIVE NUMBER OF WORKPEOPLE SUSPENDED FROM DUTY IN CONSEQUENCE OF (A.) DENTAL AND (B.) SURGICAL CASES IN THE STATE MATCH FACTORIES OF AIX-EN-PROVENCE AND MARSEILLES FOR THE YEAR ENDING 25TH JUNE 1898.

Marseilles.			Aix-en-Provence.		
Average Number in Factory.	Number Suspended.		Average Number in Factory.	Number Suspended.	
	Dental.	Surgical.		Dental.	Surgical.
517	263	101	156	6	11
100	50·9	19·5	100	3·8	7

TABLE B.—SHOWING THE RELATIVE NUMBER OF DENTAL AND SURGICAL PATIENTS HAVING RESUMED DUTY AFTER SUSPENSION, AND THE AMOUNT OF SICK PAY ALLOWED IN THE STATE MATCH FACTORIES OF MARSEILLES AND AIX-EN-PROVENCE FOR THE YEAR ENDING 25TH JUNE 1898.

Total Staff of State Match Factory.	Dental Cases.			Surgical Cases.	
	No. of Cases.	No. of Days Off.	Amount of Sick Pay Allowed.	No. of Cases.	Amount of Sick Pay Allowed.
			Frs. Cts.		Frs. Cts.
Marseilles: Average No. 517	75	5346·6	14,002 10	160	4,780 11
Aix-en-Provence: Average No. 156	10	110	221 09	53	529 62
∴ Average per case { Marseilles	1	71·3	186 70	1	29 87
∴ Average per case { Aix	1	11	22 10	1	10 00
∴ Per 100 employed { Marseilles	14·4	70	2,248 48	30·9	922 98
∴ Per 100 employed { Aix	6·4	10	141 44	33·9	339 00

In Table A. the difference of nearly 51 per cent. disabled from dental cause seems almost beyond comprehension, at Marseilles, when compared with nearly 4 per cent. at Aix. A higher age would make some difference, greater vigilance on the part of the dentist also, but the main cause is, no doubt, indicative of the advantages of the initial selection of workpeople with good teeth.

Differences in wage and treatment, pretended illness, or the benevolence of the officials, separately or combined, seem the main reasons for the enormous difference in the amount of sick pay to those who have resumed duty (Table B.), for the per-centage of dental cases are only 14·4 to 6·4, yet the time off duty is nearly seven times as great, and the cost about 90*l.* to less than 6*l.* for every 100 workers. In other words, though dental cases are a little more than twice as numerous, the cost in sick pay is more than seven times as great. This seems to point to the fact that extraction is the dearest form of dentistry, from the conditions under which it is enforced, as, where the treatment is by filling, there is not the necessity of secluding the patient from the works either before or after treatment.

The highest sick pay allowance at Aix was 66·33 francs, 33 days off; the next, 32·34 francs, 16½ days off; and the lowest, 4·26 francs, 2 days off. The highest sick pay allowance at Marseilles was 1,115·84 francs, 319 days off; the next, 885·21 francs, 367 days off; another, 849·08 francs, 271 days off; another, 760·22 francs, 271 days off; and the lowest, 2·32 francs, 1 day off.

From an analysis of the numbers of days the workers were off duty it appears that only three were more than 10 days off at the Aix factory Therefore the Pantin rule of two months' seclusion before extraction cannot be in application here. It was unable to learn the rule in application at Marseilles, but from an analysis of the "days off," it cannot well be the Pantin one (which we can take to be equal to 50 working days plus 15 to 21 days for prompt healing, say, 70 days), because one-third of the cases were under 30 days and one half under 70 days.

With regard to the surgical cases, it is evident that the incidence is about equal, the per-centage at Aix being only 3 per cent. more than at Marseilles. The amount of sick pay at Marseilles, however, is more than two and a half times that at Aix. In both factories the accidents are slight. Such cases as a splinter of wood from a match leading to a superficial abscess of the finger or palm of the hand seemed the most frequent. One severe case would lead to the total amount of sick pay being greatly increased.

I saw no returns of medical ailments as apart from surgical cases, except one in connexion with Aix, where (*see* Appendix VIII., Table D., p. 233) two medical cases are noted with 34·82 francs as the total sick pay. The monthly returns varied somewhat from time to time, and there may have been others; but it is fair to conclude that, apart from accidents and dental ailments, the health in both factories is good.

Occasionally one found the usual allowance of 20 francs had been made for childbirth, but no return was made as to the number of days the mother was off duty.

VII.—RECOMMENDATIONS.

To sum up briefly the conclusions arrived at—

(1.) There is no evidence whatever to show that red phosphorus *per se* is injurious to the workpeople.

(2.) There is no evidence to show that yellow phosphorus produces decay in teeth that are sound, or which have been properly stopped.

(3.) There is no case known in which a person has contracted phosphorus necrosis of the jaw unless either his teeth were decayed and not properly stopped, or the bone was exposed by recent tooth extraction or other injury, or the formation of tartar round the necks or the roots of the teeth had driven the gums away, and led to pus formation and absorption of the thin bone forming the tooth socket.

(4.) It is practically certain that anyone who works while exposed to yellow phosphorus fumes, even slight in amount, with teeth decayed and unstopped, or with the gums diseased, or with the bone of the jaw exposed from recent tooth extraction, is in grave danger of contracting necrosis of the jaw.

(5.) On the Continent the view prevails that continued exposure to phosphorus fumes produces a state known as "phosphorism." But I concur with Bristowe in thinking that there is no evidence of this.

I now have to consider the precautions which it may be advisable to take against the danger of necrosis.

(1.) Disuse of Yellow Phosphorus.

Inasmuch as it seems to be universally conceded that only yellow phosphorus gives off the fumes which are dangerous, and that red phosphorus is innocuous, the most obvious remedy, if it were possible, would be to prohibit the use of yellow phosphorus.

There is no doubt that consumers prefer strike-anywhere matches, but there is no reason to think that the compulsory use of safety matches would inflict any very great hardship upon them, and, on the other hand, the risk of fire might be greatly decreased by the universal use of safety matches.

Bristowe's fear that the difference in price alone would enable the older match to hold its own against any form its younger rival might assume, has been more than justified, and, as he said, unless the matches made with amorphos phosphorus are helped by legal enactment no appreciable difference will be found to operate upon the general adoption of safety matches.

Since 1862, the consumption of safety matches has enormously increased, partly from a decrease in price, and greatly from the lesser risk of accidents by fire; but it is still very far from equalling that of the "strike anywhere" match. There cannot be the slightest doubt that the prohibition of the use of common phosphorus would create an enormous disturbance of the trade, the saddest feature of which would be the loss of occupation to large numbers of an industrial and deserving class who have acquired great skill in their work by many years of service. The annihilation of an important and lucrative industry should not lightly be undertaken; and certainly not until every available precaution for the safety of the workers has been taken.

There is, however, another aspect of the question, viz., the export trade. This trade deals very largely in strike-anywhere matches, and hence the sudden prohibition of the use of yellow phosphorus would no doubt throw a considerable number of persons out of employment.

A number of schemes have been advertised for making strike-anywhere matches without yellow phosphorus. I have had a number of specimens of such matches in my possession, but I am not able to say that their use in commerce is as yet practicable. Accidents of some severity have already occurred to those engaged in handling them, even in small quantities.

M. M. J. Herotte, Chief Inspector of the Belgian Ministry of Industry and Labour, in discussing the renewed proposal for the radical suppression of yellow phosphorus, says, after a special inquiry to that end, that it could not be entertained, as to the manufacture of what are termed "allumettes anglaises" (paraffin matches) and "allumettes bougies" (wax vestas), because that suppression would have deprived over 1,000 workpeople of all ages and both sexes of their livelihood.

On page 195, I have given a description of the unsuccessful efforts of the French State factory to produce a practical match without phosphorus.

I do not propose to deal further with this suggestion because it seems rather foreign to the main scope of my portion of the inquiry, and therefore in what follows I will assume that yellow phosphorus is to continue to be used, and discuss the best precautions to be observed respecting it.

(2.) Juvenile] and Female Labour.

The first suggestion that deserves consideration is the question whether the labour of children and young persons in yellow phosphorus works should be prohibited or restricted.

This has been loudly demanded by many persons. At first sight it appears a reasonable precaution. Of late years factory legislation, and the rules made by the Secretary of State in dangerous trades, have taken the direction of restricting juvenile labour.

For it is considered, and rightly, that exposure to risk of poison of any sort should be restricted so far as possible to adults, who by their constitution are better adapted to resist it, and who are presumed to have better judgment, and therefore to be more likely to take proper care. And, further, it has always been considered a less interference with liberty to restrict a young person than to endeavour to limit the action of an adult.

But in the case of phosphorus the application of these principles presents peculiar difficulty. For, as I have shown, it is impossible that necrosis should occur except by reason of decayed teeth, or an unhealthly mouth. And, again, it has been demonstrated that among persons of the match-working class the proportion of decayed teeth increases at an alarming rate as they get older. Whence the curious fact results that on the average children are less likely to be affected with necrosis than young persons, and young persons are less likely to be affected than those of more mature years. Fortunately the number of cases of necrosis in England of late years has not been large enough to enable averages to be taken, but so far as they go no "young persons" have been attacked. Again, in Switzerland it is reported that less necrosis is found among children than among grown persons. I do not think that if the teeth are equally bad, it can at all be shown that children are less iikely to take necrosis. But having regard to the average conditions of children's teeth as compared with that of persons over 20 years of age, it seems to me by no means surprising to find that older people are more subject to disease.

Indeed, I will go so far as to say that if rigorous precautions were taken in phosphorus factories to keep the teeth in good order, a worker who had been in the factory from an early age would be more likely to have his teeth in a sound condition, and hence actually less likely to be attacked by the disease, than a new comer taken at random from outside.

From this it follows that while I am by no means averse to seeing the labour of children and young persons in factories restricted, yet I do not think that restriction in this direction could be counted upon as very efficient in dealing with the peculiar evil which is under discussion.

On hygienic grounds alone, it is obviously a disadvantage that a child of 13 years should, on account of his better education, be allowed to count for match factory purposes not as a "child" but as a "young person," and therefore capable of being fully employed. Moreover, from a dental point of view, a child at that age is more likely to be suffering from decayed and suppurating temporary teeth than a year or so later.

No statistics exist which would enable us to determine with certainty the relative susceptibility of men and of women to phosphorus necrosis. On the whole, my conviction is that the teeth of the women are in a worse

condition than those of men of a corresponding age employed in match factories. And this view is strongly supported by such limited statistics as I have been able to obtain.

On this account it would, therefore, appear that women are more liable to the disease than men. But I am unable to say that the distinction is very marked. It is certainly not so marked as the difference which exists in the case of lead poisoning. The difference, such as it is, results, I think, entirely from the fact that the diet of men is more nutritious than that of women, and with an improved diet for the latter would probably disappear. I can only, therefore, say with certainty that mere restriction of the labour of women, though it might do something, would not, in my opinion, go very far towards the extirpation of the disease.

(3.) Ventilation.

The next precaution which may be mentioned is ventilation.

It seems indubitable that, though yellow phosphorus may to a certain extent be introduced into the system in a solid condition through the mouth, the larger portion is received in the shape of vapour. Therefore ventilation is all-important.

I have called attention on page 138 to an improved method of ventilating dippers' tables which is well worthy of consideration.

I do not see why any workman should go into a drying room. In Belgium and in France warm tunnels are used, which I have described on p. 198, and the matches are placed on trolleys which are driven into the tunnels, and removed when dry. I think this system should be adopted wherever possible, for, as I shall presently show, any worker in phosphorus who carries on his work with his teeth in an imperfect condition undoubtedly runs considerable risk.

(4.) Overalls.

I consider overalls a useful precaution. Clothes worn week after week must undoubtedly become impregnated with phosphorus, and this, where so volatile a substance is concerned, becomes a source of danger. Nor can I insist too strongly on the women and girls being equally protected in this respect with the men and boys.

(5.) Food.

It is impossible to insist too strongly upon the absolute necessity that no food should be eaten or brought into any place where yellow phosphorus is being used.

I have reason to know that thoughtless young persons bring to their work cakes or apples and eat them when at their machines. This practice is most dangerous, for it is very probable that portions of the phosphorus become mixed with the food, and being masticated find their way into the system.

It is, therefore, desirable that a separate eating place should be provided. I will go further than this, and say that those employed should have reasonable proportion of nourishing food. To persons exposed to the danger of necrosis, and in whom, therefore, the system is struggling against, perhaps, incipient forms of the disease, it is essential that that system should be properly nourished, so that there may be a sufficiency of healthy blood.

Hence, therefore, a well-nourished person is in a far better position to resist the disease than one who has had improper or innutritious food.

In this respect the Diamond Match Factory has set a good example by taking care that the workers at their factory have some soup, and ascertaining by constant inspection that the soup is really good. Variety is secured by giving the workpeople other substitutes.

(6.) Washing.

A further precaution of capital importance is that the hands should be thoroughly washed, after each cessation of work, with plenty of soap and water. It is desirable that the water should be warmed, so that the hands may not be chapped in cold weather: hot water, too, is a far better agent than cold for the removal of phosphorus.

It is important to provide proper washing accommodation, and plenty of warm water and soap, and to make such arrangements that the workers have proper time to wash without crowding or scrambling, or having to wait unreasonably long, and thus either lose their work hours or else have their meal time unduly abridged.

I think, too, that it is of importance that juveniles should be inspected so as to see that they really do wash their hands, and scrub them thoroughly. I feel bound to say that at present it appears to me considerable pains are taken to secure this result.

In the course of the present inquiry I have examined hundreds of workpeople in different factories, at the mid-day and also at the evening exits, without discovering a single case of neglect to wash the hands.

I should desire not only that the hands should be washed, but also that the teeth should be cleansed, but I will deal with that subject later, when I come specifically to describe the precautions that should be taken with regard to the teeth.

I should, with many manufacturers, like to see bathing made obligatory on every operative undertaking dangerous work.

(7.) Hygienic Instruction of the Workpeople.

The rules for the provision of washing conveniences, overalls, places for meals, &c. must be supplemented by rules for the employed.

I have shown how thoroughly many of these are carried out, notably as regards washing the hands, and feeding outside the factory, but I am thoroughly convinced that something should be done to educate the workers by some sympathetic adviser (who is in no way identified with the employer's interests) as to the purposes of the rules made solely in their interests, for otherwise it is unfair to expect adoption, still less appreciation, of hygienic provisions by them, and even supposing a penalty is attached to infringement it is not likely to be enforced.

The experiment has been tried with the happiest results by the Directors of the Diamond Match Company. They allowed me to give their employees a popular lecture, illustrated by lantern projections, on how to preserve their teeth, and furnished them and their friends with a printed summary of instructions and advice. The result has been an increased cleanliness of the teeth; the work of the dental department has been greatly facilitated; and it is proposed to extend this scheme of health lectures to other subjects besides the mouth and the teeth.

Foreign writers have insisted on the fact that it is easy to make hygienic rules for workpeople, but extremely difficult to get them applied.

(8.) Preliminary Medical and Dental Examination of the Workpeople.

The above regulations as to ventilation, overalls, food, and washing will I think in the future, as they have done in the past, do much, and if I have said very little upon them it is because I desire to deal principally with the dental aspect of the question, not because I underrate their importance. There are, however, certain other precautions which I would suggest. If I treat them at greater length, and in greater detail, it is not because I would rely on them exclusively; but because they specially belong to that branch of the inquiry upon which I am most qualified to express an opinion.

I have shown, I think successfully, that, so far as medical and dental knowledge goes, even in a factory quite full of phosphorus fumes, necrosis would be impossible in the case of a person with teeth in perfect order, or with no teeth at all.

Therefore, whatever other precautions we may take, it is important that the condition of the workpeople should be such as to render disease unlikely.

I have shown how deplorable is the condition of the teeth of persons employed in match factories. To my mind, the only matter for wonder is not that they suffer from necrosis, but that so many of them escape. I can only attribute the rareness of the disease to the other precautions that are observed.

In the first place, I do not think a worker, of whatever age, ought to be allowed to go to work in a yellow phosphorus match factory unless, not only his physical condition is fit for it, but his teeth have been put into proper order.

The preliminary examination should therefore be both medical and dental.

Some forms of disease, for instance, syphilis, appear specially likely to lead to necrosis. Alcoholic tendencies are also very prejudicial. A weak anæmic condition of body might also be a danger. On the other hand, tuberculosis would probably not be a source of risk, if, as I believe, reliance can be placed on Dr. Malin's investigation.

The general duty of inspecting young persons has hitherto been done by the certifying surgeon.

By the kindness of Mr. Bartholomew I was enabled to examine the registers as kept by Dr. Bate at the Fairfield Works. Between November 1896 and September 1898, 1,700 young persons were examined, of whom 50 were rejected, for the following causes.

Carious teeth, 39.
Biting nails, 3.
Wound on arm, 1.
Fracture of radius, 1.
Tonsilitis, 2.
Eczema, 2.
Struma, 1.
Conjunctivitis, 1.

It is to be observed that Dr. Bate rejected many of these on account of teeth; but that the proportion so rejected was extremely small, only 39 out of 1,700.

It may, however, be said that as a general rule certifying surgeons do not pay any heed to the conditions of the teeth in giving their certificates.

This arises, partly from the fact that it has not been usual to do so, partly from the fact that if they did the numbers rejected would be very large, but mostly that the condition of the teeth can only be satisfactorily determined by a regular detailed examination by a dentist.

In support of my opinion I deem it important to quote that of Dr. Wayland Ancrum, F.R.C.S., surgeon to the Gloucester Infirmary, who has had considerable experience of phosphorus necrosis in that district.

"I believe whenever an individual, male or female, wishes to enter a match factory, he or she should be obliged before they are engaged to bring a certificate *from a dentist* that their teeth are in good order. Also whenever anything wrong is discovered with their teeth or jaws after they have been at work, and they are stopped work for that cause, before they are allowed to resume their work again they should bring a certificate *from a dentist*. At present all certificates are given by medical men. The ordinary medical man neither knows nor pretends to know about teeth, so that his certificates are often worthless. I believe that a dentist should be appointed to all match works, who not only should examine all who enter for the first time on the work, but should also make periodical examinations of those when requiring who are at work there.

"If these appointments were made, from the experience I have gained from having seen many cases whilst house surgeon at the infirmary here, I am sure that the large number of cases of phosphorus poisoning which occur at present would in a very short time be considerably diminished. In this town there is no dentist on the staff of the infirmary, so that many of the cases which present themselves there in an early stage are not properly treated or recognised; consequently they only come under the surgeon's hands when requiring operation for advanced necrosis."

(9.) Periodical Dental Inspection and Care of the Teeth.

Assuming that the preliminary examination has been properly conducted, and followed by such dental operations as are necessary, the question now arises how this condition is to be maintained.

At present the Special Rules provide that persons who complain of toothache shall be examined by a medical man at the employer's expense; that

no person who has suffered from necrosis, or had a tooth extracted, shall return to work without a certificate from a qualified medical practitioner that the jaw has healed.

But it is impossible for any one in authority to tell whether or not this rule is obeyed.

It is notorious that workpeople make a habit of omitting to report the fact that they have had teeth extracted, and that they return to work next day as if nothing had happened, and even if necrosis commences, its first symptoms are only those of an ordinary toothache.

Having regard, therefore, to the difficulty of diagnosing the disease, and the inducement there is for the workpeople to conceal it, the only effective way of guarding against danger will be by a periodical examination of the teeth, followed by such dental operations as are necessary to keep them in good condition.

The difficulty of enforcing this seems to rest upon two grounds. First, objections on the part of the workpeople; and secondly, objections on the score of expense.

That there will be some objection on the part of the workpeople seems very probable. This is due to the natural fear that the dentist will order the extraction of a number of teeth, and that this may be followed by 10 days or a fortnight, or perhaps even three weeks, loss of wages. This loss may be a most serious matter to a widow with a child, or some helpless dependant upon her earnings, and places her in the alternative of suffering starvation or else of being exposed to the risk of necrosis at the factory.

To meet this difficulty some means must be taken to show the workpeople that inspection will not be followed by a wholesale reckless extraction of their teeth, and the dentist must be a person in whom they have confidence.

With regard to expense, it will not be so great as to present any insuperable difficulty. The rule I propose is already in force in French and American factories which I have described.

To give some idea of what would be required, I may state that in a factory in which there were 600 persons engaged in work upon yellow phosphorus, and whose mouths had once been got into order, one man could keep them so. I do not suggest that he should be a dentist of the highest celebrity. I only desire that he should be a reasonably good workman, properly qualified. He might also have the duty of acting as certifying dentist. But he should be subject to supervision by an inspector qualified to judge of his work.

Such a man might, I think, be obtained at a salary not so great as unduly to press upon the trade. The nature of his duties and his qualifications should be similar to those required by the Local Government Board in the appointment of dental officers to schools, and as set forth in Appendix XII., p. 236.

This regular supervision would also have other incidental advantages. Each workman would have a chart of his mouth entered in a book, marked so as to show the condition of every tooth in his head. If he had one extracted without reporting the fact it would be observed at the next examination.

I admit that this certainly seems to be treating adults as children. But what other alternative can be presented?

Is it not notorious that unless some regular system is devised the workpeople will go on in their present condition, taking their chance.

Such preliminary and periodic examination takes place in the army and navy, the police, and other bodies of men in which physical condition is essential to working with safety, and if it be not resorted to I know of no means save the total disuse of yellow phosphorus which can secure immunity.

I am inclined to believe that the money spent in paying a dentist will be less than that now spent upon sick pay and doctor's attendance upon persons suffering from necrosis. It is no part of my province to suggest whether he should be paid wholly or in part by the employees. In America the dentist or dentists are so paid. In France the Government provides free dentistry for those employed in the Government works.

But even if the workers paid their share in the cost of this work they would, in my opinion, richly benefit by it. The amount of bad digestion

that is caused by defective teeth among the poor is so great that, in physical health alone, not to speak of the removal of the danger of necrosis, this dental attention would far more than repay its cost. In America, where opinion on these points is more advanced than in England, workmen even have gold stoppings. But the use of gold is not indispensable. Perfectly efficient stoppings can be found of an inexpensive character, which, if occasionally inspected and renewed, will be amply sufficient. Amalgams stoppings if equal care is taken in shaping the cavity and inserting the filling, are quite as efficient as gold, which latter is principally employed on account of its appearance.

Whether the workers can afford to pay, or partly pay, for the care of their teeth is a question partly depending on the amount of their earnings, partly on whether a well arranged scheme is invented to assist them.

Match-making is a poorly paid trade at present, involving but little skill. The following table from Charles Booth's work on the "London Poor" shows the average wages received by women :—

"PER-CENTAGE of WOMEN and GIRLS' EARNINGS.

WEEK ENDING	4s. to 6s.	6s. to 8s.	8s. to 16s.	10s. to 12s.	12s. to 15s.	Over 15s.	Comparative No. of Workers.
February 8th, 1889 - - -	14·06	19·92	28·60	25·18	11·62	0·62	100
September 14th, 1888 - - -	11·48	17·97	27·16	30·00	12·03	1·36	90
September 16th, 1887 - - -	17·02	20·44	29·03	23·87	8·32	1·32	91·2
May 11th, 1888 - - -	21·59	29·73	29·63	14·86	3·96	0·23	102

"These wages do not represent the wages that can be earned, but the wages that are earned. Even in February several girls were absent at least one day in the week, Monday being the favourite day for the holiday. Delays may also be caused owing to the state of the atmosphere, which may prevent the matches from drying so quickly as usual."

Boys earn from 6s. to 16s. a week. Both girls and boys are somewhat difficult to manage, and resent interference.

Hence, then, so long as the match trade continues to be carried on by low-paid hand labour, I do not see how it is possible for the workpeople to pay for the care of their teeth, as is done by the workpeople in America.

This leads to the inquiry whether our hospitals can supply the deficiency.

Upon this point I cannot do better than to reprint here a portion of a Preface by Sir John Tomes, F.R.S., to a small work published by me in 1887 upon the question :—

"In medicine and surgery provision has been made for the poor to share with the rich all the advantages arising from the increase of professional knowledge by means of our numerous medical institutions. Persons whose earnings will not allow them to pay the fees of our great surgeons, can in serious cases, with but little trouble, place themselves under their gratuitous care. There is, throughout the length and breadth of the country, a vast amount of gratuitous attendance given by highly competent and distinguished practitioners to the poor, both in medical and surgical cases. The like should be said in respect of dental cases, but for the present it cannot, save to a very limited, though increasing extent. That the dentists have not been unmindful of the great dental needs of the poor, the following valuable papers and others that have preceded them, bear ample testimony.

"The problem as to how adequate medical and dental attendance can be rendered to the poor cannot be solved wholly on the same lines; for where one person requires medical, ten will require dental, assistance—where ten minutes may be sufficient for determining medical treatment, several hours must be spent in effecting dental treatment. Take for instance the case of a school of a hundred young people, ranging from the ages of 10 to 18 years, whose teeth have been neglected for several years, and it will be found that eight out of ten will require dental treatment, and that taking one with another not less than an average of two hours per patient must be given to restore the teeth to a healthy state. Now 200 hours is a larger amount of time than a professional man, who has his living to get, can afford to give. Even this amount will not carry us further than the first year, and it is probable that a similar expenditure of time will be

required in each successive year up to the patients reaching 12 years of age, that is if the full advantages of conservative treatment are to be secured.

"Take again the position of affairs at a general hospital. A dental surgeon is appointed who has yet to make his way in practice. He having ample leisure, devotes himself to the treatment of cases as they present themselves by removing very bad teeth (an easy and short matter) and proceeds to treat by filling teeth savable by treatment (a difficult and lengthy matter). It becomes known that he is saving faulty teeth, and patients come in ever increasing numbers, and the practitioner finds that the whole of his time would not suffice to meet the demands upon his skill. He cannot live by gratuitous practice and so is constrained to fall back upon the old way of limiting his assistance of the poor to the removal of painful teeth. And it cannot be otherwise. If anyone will go carefully into the question he will soon see that the relief from extensive dental trouble, involving as it does so large an expenditure of time, cannot as a whole be gratuitously given by the dentists. Till lately there were not a sufficient number of capable dentists to render any general plan of relief practicable. Under the provisions of the Dentists Act the ranks are being, and have been, year by year, strengthened by the addition of highly competent practitioners. The services of these are at the disposal of the public for the treatment of the poor gratuitously to the extent that medical men give gratuitous service, mostly a service of advice, and of short operations. Beyond this, remuneration to some extent must be provided by those whose duty it is to provide for the necessities of the needy; for certainly, dental surgery would not be worth following as a profession if limited to gratuitous practice.

"The subject of the supply of artificial for the replacement of lost teeth has not been touched upon, yet in many cases of indisposition, the first and most effective prescription of the physician is that lost teeth shall be replaced for securing proper mastication. In cases of rupture, institutions exist for the gratuitous or partly gratuitous supply of trusses. Why should there not be like institutions for the supply of sorely needed artificial teeth? But this question though close upon us, may not be ripe for discussion. It will perhaps await the further development of the scheme for the saving of the natural teeth of the unmonied workers. A worthy purpose, but one that cannot be fulfilled by the dentists alone. It can be rendered effectual only by the joint action of the public and the dental profession.

"It cannot be doubted that mastication is necessary to health, and that sound teeth natural or artificial will alone effect proper mastication. The upper classes act upon this knowledge, and it may be reasonably hoped that ere long, the advantages of dental treatment which they secure to themselves, they will assist in securing to those who cannot otherwise obtain it. To this end the thoughtful perusal of the following papers is asked, as an instalment in the discussion of a large and pressing subject, for the full investigation of which other papers embracing different points of view are needed, and will no doubt appear both from the professional and public supporters of this beneficial movement. For dental troubles of a nature which can be relieved are not limited to sailors, soldiers, and school children."—*Dentistry and its Relation to the State, by George Cunningham, B.A., with a Preface by Sir John Tomes, F.R.S., London,* 1887.

All this tends to show that the hospitals which deal efficiently with disease among the poor cannot be relied on to keep the teeth of the match-workers in order.

I am therefore compelled to come to the conclusion that some means —whether by making dental supervision part of the remuneration of their labour, or else by philanthropic societies—must be adopted to enable them to obtain regular dental care; should any employer be so unwise as not to follow the example of the Diamond Match Company and Messrs. Bryant and May, Limited, in immediately providing gratuitous and efficient dental service.

The temporary disablement from work which follows tooth extraction only relates to employment in a part of the works which is exposed to the phosphorus fumes. Still I do not think it safe to let people come near those fumes whose teeth have been recently extracted. Therefore it may be necessary, in addition to arranging for their employment in some place where no fumes exist, to provide some form of society for providing them with wages till they are well again. Unless this is done they will always try to conceal the first approaches of disease.

Independently, however, of regular supervision of the teeth by a dentist, is the need for daily care of the teeth by the workpeople themselves. The tartar that forms on the teeth is at first soft, but when left to accumulate it gradually indurnates, forming yellow crusts round the roots of the teeth which gradually force their way downwards until they leave the bone of the jaw exposed, and the subject liable to necrosis.

Both to remove the tartar, and also to cleanse the teeth of any phosphorus, I think the daily use of a tooth brush after work indispensable, or at least a necessity of the peculiar work in which the people under consideration are employed.

In America, promotion in a factory is denied to a girl who habitually keeps her mouth in a foul condition. This rule has, it is said, had much effect in promoting a desire for cleanliness.

Indeed, if prejudice could be overcome, and the system be got into working order, I have little doubt that considerations of personal appearance would weigh so powerfully with the girls as to make them actively support it. As the matter stands, in another part of my report I have indicated the curious fact that the men at present seem to use their tooth brushes more than the women.

Such ignorance prevails on the part of the public on the subject of the care of the teeth, that I would advise that in each factory a notice should be posted showing what should be done, and how to clean the teeth. At the request of Messrs. Bryant and May, and of the Diamond Match Factory, I prepared a notice of this kind, several of which are now hanging up in their factories, and have been distributed to the workpeople, and which I print in an Appendix. (*See* Appendix IX., and a similar set of rules for children, Appendix X.)

I have also turned my attention to the preparation of a tooth wash. This, I think, should be provided by the employers, and every encouragement given to the use of it.

I cannot too strongly urge the necessity of attention to detail. On two occasions the excellent permanganate wash provided by the employers was found to be unfit to use, simply because it had been made too strong. On other occasions I found that the water for the hands was scalding.

The employers had, in fact, been too liberal, but the efficiency of the preventive means had been negatived by want of attention to detail.

I think it should, if possible, be the duty of the person who periodically inspects the workpeople's mouths, or their health, to look also to the way in which the conveniences for cleanliness are carried out, and to the use the workpeople make of them.

It may be that the carrying out of these provisions would increase the price of matches, for the profits on the industry, except in a few cases, are small, and the wages low.

I do not, however, know that this would necessarily bear hardly on the consumer. I am informed that in 1866 wax vesta matches used to cost 6*s*. 6*d*. or 7*s*. a gross. Now a better match of the same sort is sold for 1*s*. 10*d*. a gross.

Without pledging myself to these figures I may say that it is certain that matches are now so cheap that they are recklessly wasted. There are therefore grounds for thinking that a dearer match would mean greater safety to property owing to less danger from fire. So that it by no means follows that the expenditure incurred in taking dental precautions, even if it increased the price of matches at all, which I greatly doubt, would be attended with very serious consequences.

(10.) Notification of Necrosis Cases.

I lastly have to deal with the provisions for the notification of cases of necrosis.

This is most important, because if one can be sure that all cases of necrosis are reported, the difficulty of dealing with the matter is much diminished. And recent events have shown that the provisions for reporting have been evaded.

The difficulty in the case is that, in its incipient stage, necrosis is very difficult to recognise. I think that all suspicious cases should be reported, whether the reporting surgeon considers them to be necrosis or not.

At present section 29 of the 1895 Act requires that any case of phosphorus poisoning contracted in a factory or workshop shall be reported—

To the Chief Inspector, by the practitioner attending the patient;
To the District Inspector, by the occupier;
To the Certifying Surgeon, by the occupier.

The notification of phosphorus cases has been incomplete, notwithstanding the multiple provisions of Acts and rules, but too much blame must not be attached to these persons on this account.

Occupiers can hardly notify either necrosis or phosphorus poisoning until informed of the diagnosis upon medical authority. In illustration of the readiness and the thoroughness with which many of the manufacturers carry out these provisions for the health of their workpeople, I quote the following experience. I found that a number of workpeople had had their teeth extracted on a Saturday, and were allowed to return to the works on the following Monday. On inquiry some seven weeks after this incident whether that practice was still continued, the following reply was received:—

"We do not allow any one to start work after being operated upon until the medical man certifies that the man is fit to return to work. We have had but few extractions since your visit, and all have been so dealt with. On your making the suggestion, I at once saw the force of it, and have had it carried out, relying entirely on the medical opinion as to whether a man was or was not fit to return to work. Regarding the extractions where the men were allowed to resume work afterwards, it was all done with the best intentions, and not without taking what one is bound to consider the only available opinion on the subject."

Private medical practitioners, including hospital surgeons, have been, in many instances, unaware of the duty which the Factory Act of 1895 placed upon them. Inspectors visiting the factories would not, even if they had medical knowledge, find there the necrosis cases, the disease being severe enough to incapacitate them from work. Workpeople have not been careful to report dental troubles to the employer, as contemplated by the rules, even when they realised the danger involved by continuance of work. On the contrary, many instances have occurred in which the workman has returned at once to work after the extraction of a tooth, giving no intimation to his employer. Something too, is attributable to the lax use of medical terms in the Acts and rules. Necrosis following exposure to phosphorus is not an immediate result. There are intermediate stages of inflammation of the bone and of its covering membrane, attended with suppuration, and the actual necrosis or death of the bone comes later. The necrosis may be extensive or limited, but in either case its dependence upon phosphorus is to be ascertained by consideration of the patient's exposure to the poison, and not by any physical examination of the part of the surgeon. This greatly increases the difficulty of notification.

Obligatory medical inspection has hitherto been limited to the following points:—

(1) The ordinary examination by the certifying surgeon of children and young persons under 16 before commencing employment in the factory.

(2) Examination by a surgeon, at the expense of the occupier, where a person employed complains of toothache or swelling of the jaw. In some works a surgeon is appointed for the purpose, but in others the arrangements are of a more casual kind, the patient being often sent as an out-patient to a hospital or dispensary.

(3) Enquiry by the certifying surgeon where a case has been reported under section 29.

Some employers have voluntarily gone further than this. At Bryant and May's, for example, medical attendance is provided at the expense of the firm during illness arising from phosphorus, and, in the case of dippers, a certificate is required before commencing work. At the Diamond Match Factory, in Liverpool, there is periodical medical and dental examination.

(11.) Summary of Recommendations.

The observations I have to offer may thus be summed up :—

(1.) I do not consider the yellow phosphorus match trade as presenting any exceptional dangers to the workpeople which cannot be met by proper precautions, nor do I think that any case has been made out for the prohibition of the use of yellow phosphorus.

(2.) I see no necessity for any further restrictions upon the labour of women or young persons.

(3.) I think that the special rules affecting the trades should be strengthened so as to require:

(*a*) A better and more thorough preliminary examination, both medical and dental of all persons engaged in the industry, and the keeping of a register containing the results of the examination.

(*b*) The systematic periodical examination, both medical and dental, of all persons engaged in the industry, of whatever age or sex, and the recording of the results in a register.

(*c*) Proper provision for preventing persons from working whose teeth are in a bad condition, and, as ancillary to this, arrangements should be made for securing the services of a dentist for the workpeople, and for sick pay allowance for them while temporarily incapacitated from work.

(*d*) A supply of mouth-wash for the workpeople should be provided.

4. I am decidedly opposed to the wholesale extraction of carious teeth. I am aware that by many medical practitioners in France it is considered safer to extract than to preserve them, but I do not share that opinion. Wholesale extraction is certainly not the more economical treatment, because it is cheaper *for the match worker* to have a tooth filled than to have it extracted and lose wages until the gum is healed (*see* page 204, par. 3). Besides this, the mastication of the food is more effectual, and a better condition of general health is the result of preserving such teeth as admit of being saved. Moreover, a system of sick pay has induced some persons to prefer extraction and refuse to have the teeth filled.

APPENDICES.

In the Appendices I have put together some matter that may be useful, especially as the works quoted are difficult to procure, and are mostly in foreign languages. I have, so far as I could, confined these extracts to the dental aspect of the matter. I have visited two factories in France and examined the teeth of the workpeople, and I have received full information as to what is being done in America. Beyond this, however, I have not gone, and the adequate treatment of the condition of the industry on the Continent can only be looked for in the reports which are being made to the Secretary of State by experts specially employed for that purpose.

I think, however, that a perusal of the extracts I here give will support the view I have taken of the necessity of considering the dental aspect of the question.

APPENDIX I. (*see* pages 189 and 194).

SUMMARY OF A REPORT ON THE DENTAL SERVICE AT PANTIN AND AUBERVILLIERS (1892-1894), by Dr. MOIRAUD (Chirurgien Dentiste des Hôpitaux).

The dental service is on the following lines :—

(1.) Examination of the teeth of all new hands.
(2.) Examination of all the hands about four times yearly.
(3.) Consultations every week alternately at Pantin and Aubervilliers.

He points out that extreme attention to the teeth is as necessary as good ventilation of the workrooms. For if the teeth are in perfect condition, the phosphorus fumes will not be able to reach the maxillary bones. Phosphorus necrosis, he believes, does not differ in character from the necrosis following on certain infective diseases. Its extension is due to pathogenic micro-organisms from the mouth. This explains the relapses which sometimes occur when all the diseased bone has not been removed, leaving behind some of the septic bacteria. But the micro-organisms alone do not supply a complete explanation ; it is necessary for them not only to have an entrance made for them, but also for the phosphorus fumes to effect some modification of the tissues so that they become a suitable soil for the development of the bacteria.

The regulations enforced for the protection of the workers is based on this theory :—

(1.) To prevent phosphorus intoxication by efficient ventilation.
(2.) To suppress all causes of infection from the mouth. To attain this end, the teeth and gums must be in a healthy state. All remains of carious teeth must be removed, and all teeth, the pulp cavity of which is exposed, should be extracted, or at any rate watched so that on the slighest symptoms of periostitis intervention may take place. Tartar should be carefully removed and appropriate treatment applied to the affected gums. The workpeople should be further strongly recommended to wash out the mouth with an antiseptic solution several times a day and to brush the teeth night and morning with some dentrifrice.
(3.) The existing rules to clean their hands and clothing should be rigorously enforced.

He thinks there should be some department in which no yellow phosphorus is used, set aside for those workpeople who are undergoing treatment.

In the cases under his care after extraction of teeth cicatrication has been complete in 15 to 25 days.

There had been six cases of necrosis during 1892 and 1893, three in each year. The cases were at once surgically treated in hospital.

APPENDIX II. (*see* pages 144 and 189).

SUMMARY OF THE REPORT OF A COMMISSION ON MAKING THE MANUFACTURE OF MATCHES HEALTHY ; by MM. THÉOPHILE ROUSSEL, MAGITOT, CH. MONOD, HANRIOT, and VALLIN (Reporter), 1897)—(Bulletin de l'Académie de Médecine, Paris.)

The Committee was appointed by the Academy of Medicine, at the instigation of the Minister of Finance.

The factories visited were those of Pantin, Aubervilliers, Aix, Marseilles, and Grammont, and Ghent, in Belgium. The Committee was of opinion, after visiting them, that although in some of them much progress had been made, the industry in France was almost as unhealthy as it was 30 years ago, and that radical reforms were necessary both as regards hygiene and the processes of manufacture.

Since 1889 the State has had a monopoly in the manufacture of matches, and, recognising the grave defects in the existing processes of Pantin and Aubervilliers, was anxious to know what hygienic principles should be required in any new factories that might be built.

In 1896 MM. Vallin, Magitot, and Ch. Monod examined 225 workpeople notified as ill out of 620 employed. Of these 189 were found in good health, general and local, and capable of resuming work at once; 124 out of the 189 had one or many carious teeth, and, as this is the condition predisposing to necrosis, they were advised to secure other employment. Twenty were found to have suffered from phosphorus necrosis, of recent date, or going back to a time before 1890.

The source of the disease has been traced by M. Magitot to the entrance of the poison by way of a carious tooth, in which the pulp cavity has been exposed, leading to periostitis and the laying bare of the alveolar border; local septic infection then causes extensive separation of the periosteum from the bone, and subsequent necrosis of the bone. Antiseptic treatment, commenced early and carried out thoroughly, has notably limited the ravages of the necrotic process, which usually is arrested and becomes healed after the removal of portions of dead bone.

Between 1888 and 1896, among the 620 workpeople annually employed, there have been 47 cases at Pantin and Aubervilliers:—

Necrosis with disfigurement	8
Necrosis cured or in process of being cured without operation	12
Commencing probable necrosis	21
Doubtful cases of phosphorism	18
Total	47

Since 1892 there have been only four deaths in the two factories, of which two only were ascribed to phosphorus.

At Grammont, in Belgium, from 1860–95, with an annual population of 1,100 workmen in the six factories, there have been 34 cases, with 14 deaths, most of which occurred before 1890, at which date ventilation and hygienic precautions were made obligatory.

The workers at the match factory, and even the medical attendants, have a tendency to ascribe every illness to the effects of phosphorus—as, for instance, ulceration of the mouth, cardiac diseases, albuminuria, cirrhosis, paralysis, even phthisis and insanity.

Every death of a match worker from one of these last diseases is attributed, even by the medical practitioner, to the effects of phosphorus.

The sanitary condition of a factory can be judged of much better by the presence or absence of fumes and the smell of phosphorus than by mortality statistics. And in all the factories of France the odours of phosphorus is perceptible to a marked extent.

Another cause which might be detrimental to health is the employment of lead oxide in the manufacture of matches. Some French pastes contain as much as 55 or 64 per cent. of oxide of minium, *i.e.*, a mixture of yellow oxide of lead and nitrate of lead. (?) The high temperature disengaged in striking matches made with this paste volatilises the lead which may be inhaled and leads to chronic plumbism. In France, however, the manufacture of matches with lead is not done on a large scale.

In attempts that have been made for some time past to manufacture strike-anywhere matches of red phosphorus, metallic oxides have been used to moderate the reaction between the chlorate and the phosphorus. Thus oxides of manganese, of iron, of zinc, or of insoluble chromates can replace the lead.

The Government can adopt one of the following radical measures for improving the condition of things:—

(1.) Suppression of the use of yellow phosphorus and the use of red phosphorus or other substances.

(2.) The use of automatic machines entirely shut in.

(3.) In the meantime, improvement may be made in the existing factories.

I. In 1856 the Comité consultatif de France approved of the entire prohibition of white phosphorus in the manufacture of matches and the substitution of red in its place. In 1860 the same measure was again unanimously approved by the Comité consultatif, in 1860 by the Academy of Medicine, in 1888 by the Conseil d'hygiène de la Seine, and again by the Academy of Medicine, and in 1889 by the Société de médicine publique et d'hygiène professionnelle.

For 40 years, therefore, the medical profession has been unanimous in calling for the suppression of yellow phosphorus. The sole arguments in favour of its retention come from the trade and the public.

A more important objection is to be found in the demand the public makes for matches that will strike on any surface, even on cloth. The resistance of the consumer cannot be denied, since of the 28 millions of matches made in France yearly only 8 millions are safety matches.

In 1895 the Minister of Finance appointed an expert Commission to consider on the practicability of abolishing paste made with yellow phosphorus in favour of one made with red.

The Commission induced the State to undertake the sale for some weeks of a match made without phosphorus (50 millions) and if the experiment was not entirely successful it shows that success is not far distant.

II. *The use of automatic machines entirely shut in.*—For some years such machines have been used in America.* They are extremely ingenious, and abolish largely the dangers in the manufacture. Six workpeople suffice for managing each machine, which is 12 metres in length. They produce excellent matches, and the Commission heartily recommends their introduction.

The unhealthiness of the occupation is considerably reduced by the diminution in the number of workers and by the possibility of carrying on the processes under glass. The expense of these machines has forced the Government in France to consider whether similar machines could not be constructed by their own engineers.

III. *Improvements in the existing factories.*—Ventilation is nowhere efficiently carried out, although in some of the foreign factories, as at Ghent and Grammont the ventilation is efficient. At the latter place, for instance, an engine of 30 horse-power drives nine fans, each of a diameter of one meter or more. Even in winter the workpeople stand the removal of air at the rate of 1 metre a second without being chilled. At the dipping table the air is removed at the rate of 1·40 metres per second.

M. Vallin refers to other defective arrangements in the factory, such as the picking out of the matches from the frames which have not taken up sufficient of the paste. They sometimes amount to 25 per cent. Again, the accommodation in the drying rooms is inadequate, so that the passages are blocked with hundreds of thousands of freshly dipped matches. The process of dipping is complicated, and does not allow the fumes to be carried away completely.

The proportion of yellow phosphorus varies from 6·5 to 10 per cent. A paste used cold gives off far less fumes than if warmed, and consequently in badly ventilated buildings the former paste might alone be allowed.

The occupation of dipping is the one fraught with most danger. It is amongst those who have been dippers for many years that the worst cases of necrosis are seen. It is accepted as a principle (often, however, not observed) that this employment should always be temporary and of short duration. In all dangerous processes, indeed, and not only in dipping, there should be an alternation of work. But such an alternation of work presupposes complete isolation of the rooms in which phosphorus fumes are given off from the others, and this, unfortunately, does not exist in some of the French factories.

A careful selection of the workers is of extreme importance. A medical examination, therefore, of each worker before employment is absolutely necessary, and the presence of a single case of caries where the pulp cavity is exposed ought to be sufficient cause for rejection. Every three months, or more once, at least every six months, a medical examination is necessary to see to the general health and the condition of the teeth. Exclusion from employment should be compulsory on all with teeth in a very bad condition, or with an exposed pulp cavity or with an abscess. Every person with necrosis should have a pension, and ought never to be allowed to resume work in a match factory.

In the match factories, therefore, contrary to the usual practice in other industries, it is not advisable to keep the same hands for a number of years. Employment should only be guaranteed for a few years.

Although the importance of this selection of the workers is great, it is impossible not to see that it is associated with administrative and financial difficulties.

The final conclusions of the report are:—

(1.) There is urgent need to put a stop to the insanitary condition which is found in several of the match factories in France.

(2.) The abolition of the use of yellow phosphorus is the sole means of definitely securing this result.

(3.) The use of automatic machines is of very great value provided the ingenious processes are carried on under glass, where no workpeople can be employed.

(4.) Until the above measures can be effected ventilation must be improved, the employment in the dangerous processes should be of short duration, and alternated with other work, the workpeople should be carefully selected, there should be periodical medical examination with temporary or permanent exclusion of workpeople with teeth in a bad state, and the provision of suitable dining rooms, cloak rooms, and lavatories, &c.

M. Magitot alone dissented from the report, believing that, with careful selection of the workpeople in the first instance and thorough ventilation, the condition of the factories could very soon be made, for all practical purposes, perfect.

---

* This is an error on the part of the reporter, as the machines are not enclosed (see page 144, par. 10).

APPENDIX III. (*see* page 195).

CRITICAL AND EXPERIMENTAL RESEARCH ON A FORM OF INFECTIVE OSTEITIS CALLED "PHOSPHORUS NECROSIS:" by Dr. V. Galippe, Dentiste des Hôpitaux, Chef de Laboratoire à la Faculté de Medecine. 1897. (Abstract.)

Phosphorus necrosis, so called, does not exist—what goes by this name is only an infective osteitis not differing in character from other forms of osteitis of microbial origin; the soil on which it developes alone is different.

According to the author's view, phosphorus necrosis is due to the same influences as necrosis due to syphilis, tuberculosis, &c., inasmuch as a soil is prepared suitable for the development of infective and pyogenic bacilli. It may arise not only from a carious tooth, but also through the gums when these are the seat of inflammation, either acute or chronic.

Those who hold the view that necrosis is due to the local action of phosphorus fumes have adopted theories, sometimes of a puerile nature, to support their contention. Thus it has been attributed to the irritating chemical action of phosphorus fumes upon the tissues, to the extreme acidity of the saliva, to the acid dissolved in the saliva traversing the mucous membrane, and accumulating underneath the periosteum, where it has been supposed to form a super-phosphate or hypophosphate incompatible with the life of the bone. The view which has found most favour is that of a carious tooth, in which the pulp cavity has been exposed, opening a channel to the special action of the phosphorus fumes. It is difficult to conceive of the phosphorus fumes threading their way through a channel so narrow as is the dental canal so as to act on the maxilla, while leaving unaffected the tooth itself, which is in other cases more susceptible to the action of acids than the bone. The supporters of this view have overlooked the fact that if anything passed through the canal it would be infective matter rather than the acid products of phosphorus.

Many authors have taken the view that general impregnation of the system with phosphorus takes place.

The author's view is that impregnation with phosphorus does not modify the minute structure of bone, but that the chemical nature and nutrition of the tissues become affected.

In the examination of sequestra and teeth removed from persons who had suffered from phosphorus necrosis, there was evidence of the absorption of osseous tissue, as seen by the numerous cavities in the bone, and this process is due to the action of bacteria. This, then, is a proof of the existence of lesions of an infective character, not differing in any essential feature from other infective inflammations of bone.

The author calls attention to an osteitis of the lower jaw, which he believes to be of the same nature as phosphorus necrosis, not unfrequently occurring in badly nourished children. The lower jaw becomes swollen, sinuses discharge into the mouth, and ulceration of the gums, &c. take place.

These children left to themselves rapidly succumb, but if the sequestrum is removed and the fungoid growths scraped, the condition rapidly improves, leaving, however, some deformity.

Once a person is recognised as affected with necrosis, surgical interference should be called in, and the infected part removed. Only in this way can the lamentable consequences of the infection be avoided. Operation is useless when the sufferers are profoundly affected or have become cachetic.

He believes that this form of osteitis may be avoided by careful attention to the teeth and gums, as it is through them that the disease commences. Hygienic measures, including antisepsis, can neutralise completely the inconveniences of phosphorism.

If necrosis has actually supervened, then it should be a principle to interfere surgically at as early a date as possible, and by resection of the bone beyond the necrosed portions to remove the diseased portions.

APPENDIX IV.

MATCHES AND PHOSPHORUS NECROSIS. A. Riche, Journal de la Pharmacie et la Chimie, 1897.*

Safety Swedish matches have not proved very popular, for of a total of 28,000 million matches manufactured in France, only 8,000 million consist of safety matches,

* pp. 6, 244–51, 289–96, 341–50.

and there has been an increase of phosphorus necrosis of the jaw. Of the many attempts to prepare matches without the use of phosphorus none has proved successful. Not only are such matches apt to inflame with explosion, to emit sparks and to cause ignition of the whole box, but their manufacture is complicated and very uncertain. Moreover they usually contain poisonous lead—thio-sulphate (this Journal, 1896, p. 133). Schwarzenbach, of Berne, proposes to substitute copper for lead, but the preparation of the former compound, by pouring a solution of sodium hypo-sulphite into a solution of copper sulphate, is attended by a violent evolution of gas, requires great care, and does not give reliable results. Latterly, Hardmeyer, of Zurich, and Holbecke, of Belgium, have invented matches which have engaged the attention of the French Commission. The former, according to M. Rossel, gives satisfactory results, and negotiations with the Government are pending; but the latter, which contains lead thio-sulphate, after a fortnight's public trial, were found to be unsatisfactory. Matches containing calcium plumbate or potassium permanganate have also been suggested. (*See* Journal for 1896, p. 228.)

The Academy of Medicine, on March 2nd, 1897, reiterated their opinion that the suppression of white phosphorus is the only means of ensuring healthier conditions in this industry. The author maintains, however, that with suitable dental precautions and improved sanitary conditions, especially as regards ventilation, the manufacture may be rendered practically harmless. According to Vallin's report, the State factories of Aubervilliers and Pantin are in a very insanitary condition. The former is situated in a populous neighbourhood, which is itself a contravention of the law in regard to trades dangerous on account of explosion of fire. But even here, from 1888 to 1897, only eight cases of necrosis requiring operation, 18 requiring no operation, 21 probably due to phosphorus, and 18 doubtful cases, were relieved, and between 1892 and 1897 there were only four deaths which could possibly be attributed to phosphorus. According to Magitot, in the factory of the Société Causeemille, at Algiers, which turns out 18,000,000 of matches in a year, and finds employment for 400 workpeople, of whom 160 are children, only one case of necrosis had occurred up to 1895. This immunity is attributed to Dr. Fleury, professor of medicine, to ventilation, change of work, and compulsory cleanliness. In Belgium, since the decree of 1890, which enforced ventilation and reduced the proportion of phosphorus in the paste to 10 per cent., cases of necrosis have become much rarer, and there was not a single case in 1895.

Magitot regards necrosis as only an accidental symptom, due to decayed teeth, of a sort of chronic phosphorus poisoning, which he names phosphorism. The former may be prevented by careful selection of the workmen by medical examination, and the latter by ventilation. Dr. Moiroud (J. des Connaissances Medicales, 3 Juin 1897), in the light of Gallippe's proof of the septic nature of certain stomatitis, such as that due to mercury, is of opinion that phosphorus necrosis is only a result of infection communicated by means of decayed teeth, or by the diseased alveo-dental ligament. According to Gallippe (J. des Connaissances Medicales, 29 Avril 1897) phosphorus is in itself incapable of producing necrosis, but when absorbed into the system, renders it favourable for the growth of certain microbes which usually obtain entry through decayed teeth or diseased gums and produce an infectious osteitis. In this case the prophylactic treatment, which consists of the exclusive use of milk and of oxidising substances, such as oxygen, ozonised air, preparations of terebenthine, &c. should be modified, and an antiseptic treatment substituted. Gargling, probably best with a faintly alkaline solution, to neutralise the acid secretions, should be enforced in every factory. The author insists on the necessity of efficient ventilation for each operation in the manufacture of matches. Vallin states that there are two French factories where no ventilation is employed, even in the room where the paste is mixed. In the better equipped works the materials are prepared on a table, close to the ventilation fan, and the mixing is effected in a closed box communicating with the draught. Moreover, this room should be built apart from the others, and especially from the dipping room. The proportion of phosphorus in the paste should be reduced to a minimum. The excellent wax matches made in Belgium, and exported to England, only contain 3 to 4 per cent. of phosphorus, whereas in France the paste contain at least 6 per cent., besides nitrate and peroxide of lead. These latter should also be used as sparingly as possible for Schlœsing (*see* Journal for 1896, p. 133) has shown that they give rise to fumes containing lead. The employment of a cold paste, as in the case of wax matches, would be a great boon, and experiments on dipping wooden matches in such a paste yielded excellent results. The dipping rooms are throughout defectively ventilated. In the sorting room, where the imperfect matches are removed, the nose and mouth of the operators are within 30 to 35 centimetres of the press, which, in the older factories, contains 5,000 matches, yet here the draught is usually only that obtained from a perforated iron plate, placed below the table, and often choked with dirt. At the Aix factory, the number of matches in each press is reduced to 1,800, and during sorting and stripping, the press is kept in an almost closed box. In the better French factories about 25 per cent. of the dipped matches are rejected, in others about 7 per cent., whilst abroad the quantity is reduced to 2 per cent. These matches lie in heaps at the feet of the workpeople and constitute a serious danger. The sorting room should be a separate

room and not used also, as is often the case, for filling the boxes. The drying chambers ought to be large enough to accommodate all the sorted frames, and arranged so as to extend to the stripping tables.

At Gramont, where 15 to 20 million matches a day are made, a 30 horse-power engine is employed in driving nine ventilators ranging from a metre. On the boxing benches the velocity of the draught is 0·3 to 0·5 metres, and on the dipping stones 1·4 metres per second. The latter is not at all excessive, for Marey has shown that a speed of 1·5 metres per second, which is equivalent to the draught felt by a man walking in a calm atmosphere, is not dangerous. In one of the best French factories, producing 15 million matches daily, the draught in the room for sorting, boxing, &c. only effects a complete change of air in 45 minutes. In America, automatic machines which turn out four million matches a day practically abolish all danger. But, besides ventilation, alternation of work and cleanliness are important factors. Dipping, which is the most injurious operation, should only be worked at intermittently. The dippers in the Algerian Factory only work every third week, being employed in the packing sheds, &c., during the remaining time. A premium, it is suggested, might also be advantageously offered to the dipper whose matches contained the fewest imperfect ones.

The dining rooms, cloak rooms, and lavatories are for the most part in a deplorable state, and often abut on passages where waggons convey matches in process of manufacture. It is true that in one new factory these arrangements are irreproachable, and each workman is provided morning and evening with a solution of boric acid or potassium chlorate, which is said already to have rendered dental caries less common, and in another there are tepid and douche baths, but such precautions should be the rule and not the exception.

Medical examination with a view to rejection of workmen with carious teeth is scarcely practicable, for such teeth are not always easy to detect. This constant inspection, it may be added, led to a strike in 1894.

The following data from phosphorus works lay additional stress on the necessity of ventilation. In Coignet's Factory, at Lyons, which produces 150,000 to 200,000 kilos of phosphorus yearly, and which from 1866 to 1872 also manufactured matches, only six cases of necrosis were registered from 1838 to 1897. None of those occurred in the furnace rooms, where the fumes of phosphoric acid are abundant, though the ventilation good, but all in the moulding room. Up to 1860 the sticks were made by suction from the mouth, since then, however, they have been cast under water, and there has been only one case of necrosis. A similar method is used in the factory of Jacquand et Cie, at Givors, established in 1882, where 75,000 to 100,000 kilos of phosphorus are made yearly, and here there has been no case of necrosis, nor even illness, attributable to the poisonous action of phosphorus.

APPENDIX V. (*see* page 193).

GENERAL DIRECTION OF STATE MANUFACTURES AT THE MATCH MANUFACTURE OF PANTIN-AUBERVILLIERS.

Hygienic Regulations.

It is forbidden to bring food or drink into the workshops. These articles of consumption must be left in the refectory.

Workpeople who desire to make a light repast during the day or to take their meal in the establishment during cessation of work must attend at the refectory at the hours fixed for that purpose, and having previously comformed to the following regulations:—

1. To leave in the cloakroom their working costumes.
2. To wash their hands with soft soap.
3. To rinse the mouth with the mouth-wash placed at their disposal by the Administration.

Similar precautions must be taken at the time of leaving off work, as is recommended by articles 30 and 31 of the regulations as to order and internal discipline.

The heads of departments and the foreman and forewoman will see that all those under their charge have rigorously observed these regulations; they will take care that the vessels which contain the mouth-wash as well as those containing the essence of turpentine are kept clean and filled each day; they will take care that the mouth-wash is always in perfect condition.

Finally, they will make the necessary arrangements for the workpeople being examined regularly by the dentist on the days appointed.

These rules will be posted in all the workshops and will be read aloud on the first Saturday of each month; the foreman of each workshop will inscribe in his memorandum book the date on which the monthly reading of the rules has been made.

The Director, BRANDEIS.

DIRECTION GÉNERALE DES MANUFACTURES DE L'ÉTAT.

MANUFACTURE D'ALLUMETTES DE PANTIN-AUBERVILLIERS.

Rappel des Prescriptions D'Hygiéne.

Il est interdit d'apporter des aliments ou des boissons dans les ateliers. Ces objets de consommation doivent être déposés au réfectoire.

Les ouvriers, qui désirent faire une légère collation dans la journée ou prendre leur repas l'Etablissement pendant l'interruption du travail, doivent se rendre au réfectoire aux heures fixées à cet effet et accomplir au préalable les formalités ci-après :

1° Déposer dans les vestiaires leurs vêtements de travail.
2° Se laver les mains au savon noir.
3° Se gargariser la bouche avec les gargarismes mis à leur disposition par l'Administration.

Les mêmes précautions seront prises au moment de quitter le travail pour la sortie des ateliers, ainsi qu'il est recommandé par les articles 30 et 31 du règlement d'ordre et de discipline intérieure.

Les chefs de section et les préposés des ateliers veilleront, sous leur responsabilité, à ce que ces prescriptions soient rigoureusement observées ; ils auront soin de faire mettoyer et remplir chaque jour les récipients qui doivent contenir les gargarismes, ainsi que ceux qui renferment l'essence de térébenthine ; ils veilleront à ce que les gargarismes soient toujours en parfait état.

Enfin ils prendront les dispositions nécessaires pour que les ouvriers passent régulièrement à la visite dentaira aux jours prescrits.

Cet ordre de service sera affiché dans les atelier et sera lu, à haute voix, le premier samedi de chaque mois ; les préposés inscriront sur leur carnet la date à laquelle cette lecture mensuelle aura été faite.

Le Directeur, BRANDEIS.

DIRECTION GÉNÉRALE DES MANUFACTURES DE L'ÉTAT.

RÈGLEMENT concernant la PARTICIPATION des OUVRIERS de l'Administration des MANUFACTURES de L'ÉTAT a l'Institution de la CAISSE NATIONALE des RETRAITES pour la VIEILLESSE.

Art. 1.—Les salaires des ouvriers inscrits sur les registres matricules des Etablissements de l'Administration des Manufactures de l'État seront majorés à raison de 4 p. 0/0 du montant desdits salaires, et le produit de ces majorations, calculé à la fin du premier et du second semestre de chaque année, sera versé dans le cours du trimestre suivant à la Caisse nationale des retraites pour la vieillesse.

Toutefois seront déposées provisoirement à la Caisse des dépôts et consignations les majorations effectuées sur les salaires des ouvriers ne comptant pas encore une année de services effectifs. Lorsque cette condition sera remplie, les majorations ainsi mises en réserve seront versées au profit des ayants droit à la Caisse nationale des retraites pour la vieillesse. Quant aux majorations afférentes aux salaires des ouvriers sortis avant l'expiration de la période d'attente indiquée ci-dessus, elles feront retour au Trésor.

Feront également retour au Trésor, lorsqu'elles n'auront pas encore été versées à la Caisse des retraites, les majorations afférentes aux salaiaes des ouvriers sortis, à quelque catégorie qu'appartiennent ces ouvriers.

Art. 2—Les versements seront constatés sur des livrets individuels dont les contrôleurs des établissements, chargés des fonctions d'intermédiaires, resteront détenteurs tant que les titulaires de ces livrets seront en activité de service ; ces versements s'effectueront dans les conditions suivantes :—

1° L'ouvrier sera laissé libre d'opter entre l'aliénation et la réserve du capital. Toutefois, pour être admis à réserver le capital constitué par les majorations, l'intéressé devra, au préalable, avoir opéré de ses deniers personnels, sur un second livret qui restera en sa possession, un versement supplémentaire représentant au moins 25 p. 0/0, desdites majorations, s'il est âgé de moins de 25 ans, 50 p. 0/0, s'il a de 25 à 45 ans, et 100 p. 0/0, s'il a plus de 45 ans ;
2° L'entrée en jouissance de la pension viagére sera fixée uniformément â l'âge de 55 ans pour les nommes et â l'âge de 50 ans pour les femmes. Elle sera reculée d'année en année tant que l'ouvrier restera au service de l'Administration ;
3° Les majorations seront versées au profit exclusif des ayants droit.

Art. 3.—Lorsqu'un ouvrier comptant au moins 30 ans de services à l'État sera, quel que soit son âge, reconnu incapable de continuer son travail, la pension viagère provenant de ses versements à la Caisse des retraites sera complétée, s'il y a lieu, jusqu'à concurrence de 600 francs pour les hommes et de 400 francs pour les femmes.

Si l'ouvrier reconnu hors d'état de continuer son travail compte plus de 25 ans de services et moins de 30, les chiffres qui précèdent seront réduits de 1/30e par année de service au-dessous de 30.

Art. 4.—Les pensions minima de 600 francs pour les hommes et de 400 francs pour les femmes seront assurées, à leur sortie des établissements de l'Administration, aux ouvriers âgés d'au moins 60 ans, quel que soit à ce moment leur état de validité, mais à la condition qu'ils comptent au moins 30 années de services.

Si l'ouvrier remplissant la double condition d'âge et durée de service ainsi fixée continue son travail, sa pension minima s'augmentera, pour chaque année de service en sus, de 1/30e des chiffres qui précèdent.

Art. 5.—Lorsqu'il y aura lieu d'appliquer les dispositions des articles 3 et 4 à un ouvrier dont tout ou partie des versements auront été effectués sous la clause de la reserve du capital, on calculera la pension que cet ouvrier aurait obtenue, s'il avait été constamment soumis au régime du capital aliéné, et, si le résultat de ce calcul donne un chiffre inférieur à 400 ou à 600 francs ou à la quotité définie par le deuxième paragraphe de l'article 4, la différence constituera le complément annuel à lui allouer.

Dans le calcul de la pension complémentaire, il sera tenu compte également, le cas échéant, du supplément de rente viagère que serait susceptible de donner l'aliénation immédiate, à la Caisse nationale des retraites pour la vieillesse, des sommes que l'intéressé aurait en dépôt à la Caisse d'épargne, en vertu de règlements antérieurs.

Enfin, dans le décompte des compléments à servir à un ouvrier marié, on ne fera pas intervenir la pension viagère dont son conjoint pourrait être titulaire par suite de versements effectués antérieurement à l'application du présent règlement.

Art. 6.—La veuve d'un ouvrier décédé en activité de service après vingt-cinq ans de présence dans les établissements de la Régie aura droit à une pension totale représentant au moins le tiers de celle que son mari aurait pu obtenir.

La veuve d'un ouvrier retraité après trente ans de services, ou après vingt-cinq ans pour cause d'infirmités, aura droit à une pension totale représentant au moins le tiers de celle dont jouissait son mari.

La pension ainsi définie sera indépendante de celle que la veuve aura pu se constituer en qualité d'agent de l'Administration.

Les dispositions qui précèdent ne concernent pas les veuves dont le mariage a été contracté moins de six ans avant la cessation des fonctions du mari, non plus que les femmes divorcées ou contre lesquelles la séparation de corps a été prononcée.

Art. 7.—Les orphelins de père et de mère âgés de moins de 18 ans auront droit à un secours annuel dont la quotité sera égale à la pension que la mère avait obtenue ou aurait pu obtenir en qualité de veuve, conformément à l'article 6 du présent règlement. Si la mère a été au service d'l'Administration, ce secours sera majoré d'une somme égale au tiers de la pension d'ouvrière à laquelle elle avait droit au moment de son décès.

L'allocation temporaire ainsi calculée sera payée jusqu'à ce que le plus jeune des enfants ait atteint l'âge de 18 ans.

S'il existe une veuve et un ou plusieurs orphelins provenant d'un mariage antérieur de l'ouvrier, il sera prélevé, sur la pension de la veuve et sauf réversibilité en sa faveur, un quart au profit de l'orphelin du premier lit, s'il n'en existe qu'un âgé de moins de 18 ans, et la moitié, s'il en existe plusieurs.

Art. 8.—Les dispositions des articles 3, 4, 6 et 7 ne seront pas applicables aux ouvriers de nationalité étrangère ni à leurs veuves ni à leurs enfants. Elles ne seront pas non plus applicables aux ouvriers et aux veuves et orphelins d'ouvriers renoyés par mesure disciplinaire.

Art. 9.—Les contrôleurs se conformeront de tous points, pour les diverses opérations qu'en leur qualité d'agents intermédiaires ils auront à effectuer auprès de la Caisse nationale des retraites pour la vieillese, aux instructions publiées à leur usage par la Caisse des dépôts et consignations.

Art. 10.—Lorsque la rent viagère inscrite sur le livret d'un ouvrier aura atteint le maximum fixé par la loi, les majorations afférentes aux salaires ultérieurs de cet ouvrier seront déposées en son nom à la Caisse d'épargne, et livret correspondant lui sera remis au moment où il quittera le service.

Art. 11.—Le présent règlement abroge tous les règlements antérieurs sur la matière.

Arrêté en Conseil d'Administration le 23 mars 1895.

Les Administrateurs,

BARDOT, BRUNET.

Paris, le 20 juin 1895.

Approuvé :
Le Président du Conseil, Ministre des finances,
RIBOT.

Vu et approuvé :
Le Directeur général,
FAVALLELLI.

Direction Générale des Manufactures de l'État.

Reglement concernant L'assistance des Ouvriers en Cas de Maladie.

Art. 1er.—L'Administration des Manufactures de l'État assure à tous ses ouvriers inscrits à titre définitif sur ses registres matricules des secours en cas de chômage pour cause de maladie.

Ces secours sonte distribués soit directement, par les soins du service, soit par l'intermédiaire des sociétés de secours mutuels.

Art. 2.—L'ouvrier n'appartenant à aucune société de secours mutuels recevra, en cas de maladie, une indemnité journalière en argent dont la quotité est la suivante :—

Ouvriers des établissements de la Seine -	Hommes.	1f 60.
	Femmes.	1f 10.
Ouvriers des établissements de province -	Hommes.	1f 35.
	Femmes.	0f.85.

Cette allocation. dont le payement sera effectué chaque dizaine, comme les salaires, sera soumise aux règles ci-après :—

1° L'indemnité journalière ne sera pas payée les jours où les ateliers seront fermés ;

2° Elle ne sera pas attribuée pour les indispositions qui ne dépasseront pas trois jours, et elle ne sera due qu'à partir du quatrième jour de maladie ;

3° Il ne sera alloué que trois mois d'indemnités entières et trois mois de demi-indemnités dans une période de douze mois ;

4° Il ne sera pas accordé de secours journalier pour les maladies ou iddispositions qui accompagneraient l'accouchement ou qui surviendraient dans les trois mois avant ou les vingt jours après la délivrance, à moins que le médecin ne certifie que la maladie a été étrangère à l'état de grossesse ;

5° Aucun secours ne rera concéde pour les maladies causées par la débauche et l'intempérance, ni pour les blessures reçues dans une rixe, une émeute ou une rébellion ;

6° L'ouvrier en interruption de service pour cause de maladie qui ne se trouvera pas à son domicile lorsque le médecin de la Manufacture ou un agent délégué par la Directeur s'y présentera, ou qui sera rencontré dehors sans une autorisation écrite du médecin traitant, sera considéré comme guéri, et perdra, en outre, tout droit aux indemnités afférentes à la dizaine en cours.

Art. 3.—L'ouvrier appartement, comme membre participant, à une société de secours mutuels approuvée par l'autorité préfectorale ou autorisée dans les conditions prévues par les articles 291 et 292 du Code pénal recevra une Indemnité annuelle dont le taux est fixé comme suit :—

Sociétaire participant âgé de moins de 30 ans. - - - -	8 francs.
Sociétaire participant âgé de 30 ans au moins et de 39 ans au plus.	9 —
Sociétaire participant âgé de 40 ans au moins et de 44 ans au plus.	11 —
Sociétaire participant âgé de 45 ans an moins et de 49 ans au plus.	12 —
Sociétaire participant âgé de 50 ans au moins et de 54 ans au plus.	14 —
Sociétaire participant âgé de 55 ans et au-dessus - - -	16 —

Ces chiffres seront augmentés de 3 francs pour les membres des sociétés du département de la Seine.

L'âge du sociétaire au 1er janvier de chaqur année fivera la base de l'allocation administrative pendant l'année entière. Cette allocation sera payée à la fin de chaque trimestre sur la présentation du livret l'intéressé attestant que sa qualité membre participant ne lui a pas été retirée.

Art. 4.—Les sociétés de secours mutuels pourront, si elles en font la demande, à la suite d'un vote formel de l'assemblée générale, encaisser trimestriellement les sommes résultant de l'application du tarif ci-dessus à chacun des membres participants. Le versement sera effectué sur la présentation d'une liste nominative des sociétaires dont l'exactitude sera certifiée par les membres du bureau.

La participation d'un même ouvrier à plusieurs sociétés de secours mutuels ne donnera droit qu'à une indemnité unique.

Art. 5.—En aucun cas, les indemnités prévues à l'article 2 ne pourront se cumuler avec celles qui sont déjà concédées, dans les conditions rappelées ci-dessous, aux ouvriers blessés en cours de travail et aux femmes accouchées, à savoir :

1° Tout ouvrier blessé en cours de travail, quand il n'y a pas eu imprudence de sa part, reçoit, pendant la durée de sa maladie, une indemnité journalière égale à la moitié de son salaire ;

Si la blessure est grave ou si l'accident est fortuit et étranger au travail dont l'ouvrier est chargé, ou encore s'il est survenu en cours d'essais de machines nouvelles, l'indemnité peut être majorée et portée jusqu'au salaire entier ;

2° Toute ouvrière accouchée reçoit, après accouchement, une indemnité de 30 francs.

Art. 6.—En dehors des allocations prévues à l'article 3, il pourra être accordé, aux sociétés de secours mutuels, une allocation supplémentaire. dans les limites des crédits disponibles sur l'ensemble du chapitre des Institutions d'assistance.

Ces allocations feront chaque année l'objet de propositions qui seront soumises à l'approbation du Ministre.

Art. 7.—Le règlement ministériel du 6 juillet 1895 est abrogé en ce qu'il a de contraire aux présentes dispositions.

Arrêté en Conseil d'administration, le 23 novembre 1897.

Les Administrateurs,
BARDOT, BRUNET.

VU ET APPROUVÉ :
Le Directeur général,
JOBERT.

APPROUVÉ :
Paris, le 22 avril 1898.
Le Ministre des Finances,
GEORGES COCHERY.

APPENDIX VI. (*see* pages 158 and 162).

ABSTRACT OF A REPORT TO THE DEPARTMENT OF INDUSTRY AND AGRICULTURE ON 55 CASES OF PHOSPHORUS NECROSIS IN SWITZERLAND; by Dr. KOCHER, Professor of Surgery, Bern. 1893.

The observations relate almost entirely to cases of phosphorus necrosis occurring in the Frutig Valley of the Canton of Bern. Factories for the manufacture of matches with yellow phosphorus have been in existence there since 1840, except for a short interval from January 1st, 1881, to the end of 1882, when the manufacture was prohibited. It was, however, during those two years that the cases of necrosis were most numerous, owing to the manufacture of matches with yellow phosphorus being carried on clandestinely.

It would not appear that phosphorus poisoning in Switzerland has ever reached the dimensions it has in some other countries. Dr. Schären, who has practised in the district for many years, considers that the number of cases has been usually from 5–10 yearly, and has not, in the worst years, exceeded 10. This, on an average population of phosphorus workers of 300, comes out at 2–3 per cent. annually.

Dr. Kocher's observations were made on 55 cases of necrosis, all of which came within his own knowledge. They extend over a period of 25 years, and include not only officially notified cases but also returns from hospitals and medical men, and information from patients themselves. No other form of illness beyond necrosis of the jaw bones could he attribute to phosphorus poisoning.

Disease of the bones apart from the jaw bones is curiously not found. As bearing on this, however, he relates the case of a dipper who had worked in a factory for 37 years with teeth and maxillary bones perfectly sound, but who had broken the upper part of a femur no less than five times; the cause of fracture generally having been a trivial one. Boney union had always taken place, but the position was not good, and there was a considerable amount of thickening.

In cases of severe phosphorus necrosis, with complete neglect of the maiady in the early stages, the inflammation and formation of pus may extend to the other bones of the face and skull and cause inflammation of the membranes of the brain. Further, in such neglected cases, interference with digestion and diseases of the lungs may be induced through swallowing or inhaling the pus.

Of the nine fatal cases directly due to necrosis of the jaw, in all, without exception, the necrosis affected the superior maxillary bone, accompanied in two cases by necrosis of the inferior. Danger to life, therefore, is much greater in the case of affection of the upper jaw than in that of the lower. The reason for this is not far to seek. In surgical practice generally disease of the upper jaw leads far more frequently to complications and disease of other organs than disease of the lower jaw. Abscesses in connexion with the lower jaw usually open in such a way that the pus can flow outwards by fistulous tracts discharging under the chin and along the lower border of the inferior maxilla. In the upper jaw, although not unfrequently the abscesses open through the external skin, it is more usual for the pus to be directed towards the mouth and nose, and there can be a large collection of pus in the cavities of the bone, which is impossible in the case of the lower jaw. After operations the cavities of the upper jaw are often found filled with very fœtid pus. This retention of pus and its subsequent discharge into the mouth and nose, leads to an admixture of the pus with the sputum, which may set up ultimately digestive disturbances. An even greater danger is that the pus may flow down and be drawn into the lungs, chiefly at night-time, and so give rise to catarrh and inflammatory disease of the lungs, with fatal result.

A second difference between disease of the upper and lower jaws, which accounts for the different course of the symptoms, is the different connexion of these two bones with the other bones of the face and skull. The inferior maxilla is only connected by soft tissues, such as ligaments and muscles. The superior maxilla, on the other hand, is directly connected with the other bones of the face and skull, and the periosteum and soft parts pass over from the one to the other without interruption. If, then, there is inflammation and formation of pus on the upper surface, they can extend directly on to the other bones and towards the base of the brain. This explains the common experience that sufferers from phosphorus necrosis finally succumb to some brain disease. Three out of the nine fatal cases were due in this way to the extension of the purulent inflammation from the superior maxilla to the membranes of the brain with abscess formation in the substance of the brain itself. Surgically it is much more difficult to diagnose the presence of pus in the upper jaw than in the lower. The bone is a much more irregular one, and, a great part of it lying in the cavities of the mouth and nose, the pus, when detected, is less easily reached.

A fatal result is fortunately comparatively rare, and is chiefly influenced by the seat and extent of the disease, combined with neglect to adopt treatment and a weak constitution. The majority of cases of phosphorus poisoning are mild, involving disease of the jaw in immediate connexion with the teeth, the presence of which is shown by a loosening of, and falling out of, the teeth, with separation of small portions of the maxillary bones immediately connected with the tooth cavities. Dr. Schären, of Frutigen, has noted these slight cases as the rule, and, as the result of many years of experience asserts that, after removal of the teeth or the necrosed pieces of bone, they become permanently cured on cessation from work. Occasionally when the work has been given up, even through the case to begin with is slight, there may be a relapse and further extension of the necrotic process.

The number of the slight cases it is difficult to estimate. They do not come permanently under medical treatment, but it is unlikely thot they can be very numerous, because the number which undergoes spontaneous cure is few. Cure follows after the loss of particular teeth, and resulting slight defects and thickening of the jaw bones which do not occasion any noticeable disfigurement. Some cases in which it is possible to replace lost teeth by means of an artificial plate might be regarded as mild, even when the patient has lost a number of teeth, together with the portion of the jaw connected with them. So long as the necrosis only involves the tooth process of the jaw the pain is not much worse than in ordinary toothache, and the removal of the bone is as easy as the removal of the loose teeth. But the fact must not be lost sight of that there is in these cases considerable disfigurement, and considerable interference with the action of the jaw bone, which can only be overcome by the use of a suitable plate.

Of the 13 mild cases the histories of which were carefully inquired into, the superior maxillary bone was affected in 11 and the inferior in only two This is due to (1) the changes in the upper jaw remaining much more frequeutly limited in extent than in the lower, and (2) to the fact that a smaller or larger portion of the alveolar edge may necrose without involving to any extent the remaining portion of the bone. This difference in behaviour is accounted for by the following reason:—

The superior maxillary bone has a quite different structure from the inferior; it consists mainly of flat, thin, more or less cancellous bone, while the inferior consists of compact bone. The compact nature of the inferior maxilla explains why, when pus is formed, the circulatory disturbance is greater and the periosteum is separated more extensively, just as is the case in the large bones of the extremities where necrosis of large portions of bone is common. In inflammation of bone from other causes (as in acute periostitis of the bones of the upper and lower extremities so frequently observed in children), necrosis of large portions of bone results when the inflammation attacks the shaft, while in inflammation of the epiphysis only occasionally is there much destruction of bone.

The position of the bones is also of moment in explaining the extent of the disease. So long as there is no discharge through the skin the pus flows down into the mouth from the upper jaw, while in the case of the lower jaw the pus remains in contact with the bone.

A further reason why so many cases of necrosis of the superior maxillary bone are included among the mild class is that a piece of it, when lost, does not cause such disfigurement. The neighbouring bones of the face serve as supports for the soft parts, and the processes of repair remedy the defect. In the lower jaw, on the other hand, there are no bones to support the soft parts about the chin, and much greater deformity results.

In a third class of cases, numbering 29, a cure was only effected after severe operation, and in them, notwithstanding the success of the operation, considerable deformity permanently remained. They refer entirely to hospital cases.

Of these 29 cases eight involved partial removal of the lower jaw. The deformity which resulted was not very marked, consisting chiefly in a falling backwards of the

chin and the adduction of this towards the operated side. The patients can use the jaw bones fairly well when the new bone is formed. Serious trouble is only encountered when the ascending ramus of the jaw and the joint are involved.

In 11 cases total removal of the whole of the inferior maxillary bone was necessary.

It is impossible, in discussing the cases of total extirpation of the inferior maxilla, not to regard this as the worst form of phosphorus necrosis, so far as local injury is concerned. It has already been pointed out, that so far as danger to life is concerned, it is not so serious, even when completely neglected, as necrosis of the superior maxilla.

In all cases the disease begins by a loosening of the teeth, so that they either fall out or, as is often the case, if they remain for some time in the mouth, they must be removed with the dead bone at the time of operation. It is impossible after that, without an artificial plate, to masticate solid food. An attempt is sometimes made to leave the teeth adhering to the gums, but without success. A regeneration of the dental process of the maxillary bone never takes place. On the other hand, without exception, a complete new growth of the lower jaw takes place. No matter how the dead bone be removed, whether by natural process or by operation, the periosteum which is left behind is endowed with quite special energy in replacing the bone in its entire extent. Not only is the lower jaw replaced, but between this and the skull a new movable joint is formed resembling closely the old one. The principal muscular process of the bone, the coronoid process, to which the powerful temporal muscle is attached, is formed afresh as a rule, and serves admirably as a point from which the bone can be moved. The masseter and internal pterygoid muscles, in comparison with their previous important functions, do little work, as they are much shortened and the ascending ramus of the bone is only partially completed, the angle of the jaw not being replaced. The external pterygoid, the function of which is to draw the lower jaw forwards, also resumes its former action.

In cases of complete loss of the lower jaw, it is the rule for the new bone to be so movable that the patients can eat without difficulty with the aid of an artificial plate, and without one they can at least take soft articles of food. Only in a few cases is the speech indistinct.

Although it is undeniable that all patients who wear a plate suffer less deformity and enjoy a greater usefulness of the new bone, insomuch so that the majority can eat the same food healthy persons can, it is not found that the shape of the new bone is in any way improved by the wearing of the plate. The improvement is due to the exercise the plate allows to the muscles. Such deformity as remains is due to the new jawbone lying in one plane instead of its consisting, as in the normal condition, of a horizontal part with two ascending rami, and to the masseter, internal pterygoid, and temporal muscles tending to draw the bone backwards and upwards. The new bone is usually about half the depth of the original one, which is accounted for by the fact that the tooth processes are never repaired. Sometimes the new bone is thicker than the normal one, especially in its middle portion. The new bone on the whole resembles more the jawbone of the child than the atrophic toothless jaw of old age.

The new bone in the mouth is always covered with smooth mucous membrane like the gums.

Dr. Kocher asks the question—Does phosphorus, in the form of fumes as used in match factories, bring about a general disease which finds its expression in a local malady, or does it act directly upon the maxillary bones?

*Wegner placed rabbits for a period extending over months in an atmosphere contaminated with phosphorus fumes, and found that it did not affect their maxillary bones, or at the most only a slight thickening of the bones, especially of the nose, resulted. He found also that injuries to the jaw bones of animals taking small doses of phosphorus with their food healed up as quickly and as well as they would have done in perfectly healthy animals. But the animals breathing an atmosphere charged with phosphorus fumes at once developed necrosis if pieces of the mucous membrane were removed, thereby exposing the maxillary bones.

All the cases observed by Dr. Kocher in the human subject are in agreement with the experiments of Wegner, namely, that the injurious effect of phosphorus fumes is local in its effect on bone. He does not believe that a workman with a perfect set of teeth, and gums intact, can suffer from necrosis. But those cases of necrosis which develop months, it may be, after the time the workman has entirely given up employment in a match factory, and, again, those where the necrosis appears only after many years' work in the most dangerous branches of the industry, serve to explain the influence exerted on the one hand by the phosphorus and on the other by the harmful constituents of the sputum in inducing necrosis. Just as surely as it can be maintained that phosphorus by itself without carious teeth cannot produce necrosis, so surely can it be maintained that phosphorus does exercise an influence on the bones of the jaw even though direct contact with the poison is excluded. It brings about, not structural

* Virchow's Archiv, 1870, Vol. 55.

changes, but a disturbance in the nutrition of the part which gives it the disposition to necrose on the appearance of a purulent inflammation. The proposition may therefore be stated thus: Phosphorus fumes only then lead to necrosis when accompanied by the influence of decomposing sputum containing virulent micro-organisms. Without a septic process there can be no necrosis.

The pathological changes in the necrosed bones due to phosphorus are not peculiar. They are the same as are the changes brought about by the combination of a very extensive necrosis, as in certain acute infective diseases, and a chronic, slowly developing new growth of bone.

As pointing to a disposition to necrosis on the part of match workers, is the fact, noted in the histories of the cases, that it makes hardly any difference whether an operation is done early or late in the course of the malady. When once the septic inflammation has started it is almost certain that it will spread so far as the nutrition and circulation has been affected by the phosphorus.

Although this is the case, early operation is recommended, because if it be not done the patient is exposed to the danger of prolonged discharge of pus. Dr. Kocher's final conclusions are:—

1. Since only yellow phosphorus acts poisonously, red or amorphous phosphorus being harmless, efforts should be made to replace the former by the latter in the manufacture of matches.
2. The danger in the employment of yellow phosphorus can be and ought to be reduced to a minimum.
3. The liability of the employer to the employed ought to extend to at least two years after the latter has left the factory.
4. All employés should be informed when taking up the work of the dangers associated with it. The possibility of avoiding them should be fully explained to the workers. They should be required, under penalty, to notify to the visiting surgeon within eight days any disease either of the jaw or teeth.

APPENDIX VII. (*see* page 162).

ABSTRACT OF A PAPER ON PHOSPHORUS NECROSIS: An analysis of 18 cases treated at the Jena Hospital between 1890 and 1895; by Dr. J. KUIPERS.

Phosphorus necrosis, despite the regulations of 13th May 1884, still plays an important rôle among the diseases of occupations in the Thuringian district. Since the regulations, indeed, the number of cases has increased. Thus in the 33 years from 1857 to 1890 the number of cases was 56, or 1·7 per cent. annually, whereas in the 5 years, 1890 to 1895, there were 18 cases, or 3·6 per cent. annually.

The earliest views held as to the manner in which the poisoning was brought about were that the necrosis was a local indication of a general chronic infection of the system by phosphorus, and in this way the symptoms of cachexia, bronchitis, and gastritis, so frequently accompanying it, were explained. But these symptoms are best regarded as the result of a general weakening of the system induced by the local affection.

It is clear now that phosphorus necrosis is a primary disease local in nature. It can only arise either through defective teeth or through an inflammation of the gums at the neck of the tooth by which the periosteum is exposed. Cases where necrosis has arisen in persons with perfect teeth have been due to the tartar deposit causing slight inflammation and depression of the gum at the neck of the teeth, and thus exposing the periosteum. No special sex predisposition was shown at the Jena clinic.

As regards the frequency of attack in the case of the upper and lower jaw bones, the lower is the more frequently affected. Thus of 23 cases treated by Billroth, 7, or 30·5 per cent., related to the upper jaw, and 16, or 69·5 per cent. to the lower. In 56 cases treated by Haeckel 33, or 58·9 per cent., were lower jaw, and 20, or 25·7 per cent., upper and 3, or 5·7 per cent., both upper and lower. Of the 18 cases in question, 10 (59 per cent.) were upper jaw, and 8 (41 per cent.) lower.

The first symptoms are toothache, loosening and falling out of the teeth, and lastly swelling of the region over the maxillary bone. The pain increases to such an extent that the patients can find no remission by day or by night. Finally the abcesses open at various points and discharge fœtid pus. The necrosed bone soon becomes exposed, and the old bone is pressed up to such an extent as to narrow the mouth opening considerably and to interfere greatly with mastication. Inability to take solid food and the swallowing of pus together with prolonged sleeplessness, quickly reduce the patient's strength.

Three methods have been adopted in surgical practice for dealing with the necrosed bone.

(1) *The old expectant method.* In this the necrosed bone was not removed until it was quite loose. Its only recommendation was that the new bone formed subsequently was more perfect than that which could be obtained by any other process, and the resulting disfigurement was slight. The mortality, however, was very high, the patient succumbing to exhaustion or other disease before the sequestrum had separated and been removed.

(2) *Early sub-periosteal resection.* This method is the opposite of that above described. The newly-formed jaw bone is not quite so perfect as that obtained by the first method, but in actual usefulness falls very little short of it. Its success at first was not great owing to the operators trying to save too much of the bone; by doing so there was a great danger of incomplete removal of the diseased bone. Relapses in consequence frequently occurred. Since, however, Reid and Reidel have adopted the method of carrying the resection well beyond the diseased area so as to ensure the total removal of all dead and diseased bone relapses have been very rare. The advantages of their improved method are:—

(*a*) The mortality is lowest;
(*b*) The duration of the illness is shortest;
(*c*) There is no fear of a relapse.

(3) *The subosteophytic method.* In this an attempt was made to combine the merits of the two preceding methods by waiting until a line of demarcation had formed but in some cases no line of demarcation is formed, and in others only after a long time. It is, therefore, of little value.

Of the 18 cases none were fatal. 15 (89 per cent.) completely recovered, 2 (11 per cent.) had relapses.

As a rule the operative treatment adopted was very radical.

In necrosis of the lower jaw affecting the incisors and canines generally the entire bone was removed; affecting the molars, only the corresponding half of the jaw was removed. The periosteum was most carefully preserved under all circumstances. The following table shows the extent of the operative treatment:—

1.	Total	removal	of	both	superior	maxillæ.
2.	„	„	„	„	„	„
3.	„	„	„	right	„	maxilla.
4	„	„	„	„	„	„
5.	„	„	„	„	„	„
6.	Partial	„	„	left	„	„
7.	„	„	„	„	„	„
8.	„	„	„	right	„	„
9.	„	„	„	„	„	„
10.	„	„	„	„	„	„
11.	„	„	„	„	„	„
12.	Total	„	„	both	inferior	maxillæ.
13.	„	„	„	„	„	„
14.	„	„	„	„	„	„
15.	„	„	„	„	„	„
16.	„	„	„	right	„	„
17.	„	„	„	„	„	„
18.	„	„	„	left	„	„

APPENDIX VIII. (*see* pages 202 & 203).

TABLES SHOWING THE MEDICAL AND DENTAL CONDITION OF THE WORKPEOPLE AT AIX-EN-PROVENCE AND MARSEILLES COMPILED FROM DOCUMENTS IN THE STATE DEPARTMENTS AT PARIS.

TABLE A.—SHOWING THE RESULTS OF PERIODICAL MEDICAL AND DENTAL MONTHLY VOLUNTARY AND QUARTERLY COMPULSORY INSPECTIONS OF PHOSPHORUS WORKERS IN THE AIX MATCH FACTORY FOR THE YEAR ENDING JUNE 1898.

M.	F.	Total.	Condition.	M.	F.	Total.	Condition.	M.	F.	Total.	Condition.	M.	F.	Total.	Condition.	Total for Year.			
																M.	F.	For Treatment.	
74	166	240	Good.	72	170	242	Good.	74	179	253	Good.	69	170	239	Good.	—	—	—	—
—	28	28	Requiring fillings.	3	33	36	Requiring fillings.	2	18	20	Requiring fillings.	1	19	20	Requiring fillings.	6	98	104	Requiring filling.
—	1	1	Requiring extraction.	—	—	—	—	—	—	—	—	—	—	—	—	—	1	1	Requiring extraction.
1	1	2	Medical cases.	—	4	4	Medical.	—	2	2	Medical.	2	2	4	Medical.	3	9	12	Medical.
75	196	271		75	207	282		76	199	275		72	191	263		9	108	117	
7	—	+7	Men not fit to work P.					4	—	+4	Men not fit to work P.	6	—	+6	Men not fit to work P.				
		278								279				269					

NOTE.—This table has been prepared from the 12 separate monthly returns, four of which have been marked specially as "trimestrialle," or quarterly. The average number of employees for the year is 156. The apparent discrepancy in the total number of persons examined is, no doubt, due to partial duplication of persons, probably from voluntary inspections or cases under treatment, or both. At each quarterly marked inspection the number of "Good" was always more than 30 per cent. greater than at the inter-quarterly inspections.

APPENDIX VIII.—(*continued*).

TABLE B.—SHOWING THE RELATIVE NUMBER OF WORKPEOPLE SUSPENDED FROM DUTY IN CONSEQUENCE OF (A.) DENTAL DISEASE AND (B.) INJURIES IN THE STATE MATCH FACTORIES OF AIX-EN-PROVENCE AND MARSEILLES, FOR THE YEAR ENDING 25TH JUNE 1898.

Monthly Return.	Aix-en-Provence.			Marseilles.		
	Number in Factory.	Number Suspended for		Number in Factory.	Number Suspended for	
		Dental Disease.	Injuries.		Dental Disease.	Injuries.
1897 July	155	2	1	524	17	15
,, August	157	0	0	520	23	11
,, September	157	1	0	519	17	8
,, October	154	0	2	519	22	8
,, November	153	0	2	519	17	7
,, December	156	0	0	518	28	8
1898 January	157	0	1	517	26	10
,, February	156	2	0	515	22	7
,, March	156	0	3	514	20	7
,, April	156	0	0	514	25	6
,, May	158	1	1	512	23	10
,, June	158	0	1	509	23	6
	156	6	11	517	263	101
	Average.	Total Dental.	Total Injured.	Average.	Total Dental.	Total Injured.
Per-centage	100	3·8	7	100	50·9	19·5

MARSEILLES STATE MATCH FACTORY.

TABLE C.—*List of Workpeople suspended from Duty in consequence of* (a) *Dental Disease and* (b) *Injuries, who have resumed Duty before the following Dates:—*

Date.	Name.	Department.	—	Dental.		Injured.	
				Number of Days suspended.	Amount of Sick Pay allowed.	No.	Total Amount of Sick Pay allowed.
					Frs. Cts.		Frs. Cts.
25.11.97	S. F.	Frame releasing	—	271	760 22		
	H. A.	,, ,,	—	107	305 90		
	C. A.	Stamping	—	15	22 50	8	279 06
25.7.97	C. J.	Frame releasing	—	319	1,115 84		
	A. E.	,, ,,	—	18	43 56		
	B. C.	,, ,,	—	27	60 00		
	G. M.	,, ,,	—	31	72 00		
	M. R.	,, ,,	—	8	16 80		
	C. R.	Day labourer	—	6	15 00	19	430 60
25.8.97	P. J.	Frame releasing	—	20	36 40		
	R. P.	,, ,,	—	13	26 00		
	M. R.	,, ,,	—	9	18 90		
	C. L.	,, ,,	—	7	19 45	17	547 62
25.9.97	B. M.	Frame filling	Wax	21	31 50		
	T. V.	,, ,,	Wood	24	60 18		
	B. M.	,, ,,	,,	49	134 82		
	M. M.	Stamping	—	49	155 00		
	B. J.	Frame releasing	,,	63	172 62		
	M. M.	,, ,,	,,	57	137 53		
	L. M.	,, ,,	,,	57	143 36		
	B. M.	Packing	—	43	107 00		
	V. A.	Frame releasing	,,	51	121 50		
	S. M.	,, ,,	,,	31	65 80	16	384 21

APPENDIX VIII.—(*continued*).

Date.	Name.	Department.	——	Dental.		Injured.	
				Number of Days suspended.	Amount of Sick Pay allowed.	No.	Total Amount of Sick Pay allowed.
					Frs. Cts.		Frs. Cts.
25.9.97.	A. M.	Stamping - -	—	271	849 08		
	T. A.	Frame releasing -	Wood	76	304 88		
	T. T.	Packing - -	—	31	81 25		
	L. R.	Frame releasing -	Wood	1	2 32	9	166 45
25.11.97	M. M.	,, ,, -	Wax	112	306 67		
	M. M.	Stamping - -	—	98	257 04		
	F. L.	,, - -	—	100	322 50		
	S. M.	Frame releasing -	Wood	86	205 32		
	C. V.	,, ,, -	,,	65·5	105 65		
	P. F.	Frame filling - -	—	55	137 83		
	G. J.	,, releasing -	Wood	18	35 10		
	S. M.	,, ,, -	,,	25	42 89		
	C. M.	,, ,, -	,,	34	81 40	12	624 36
1.12.97	L. C.	Day labourer -	—	2	2 80	11	428 40
5.1.98	R. R.	Stamping - -	—	200	620 46		
	F. A.	Frame releasing -	Wood	63·5	160 55		
	B. H.	,, ,, -	,,	40	86 64		
	C. P.	Stamping - -	—	21	58 80		
	A. D.	Frame releasing -	Wood	73·5	195 11		
	B. L.	,, ,, -	,,	37	67 64		
	C. A.	,, ,, -	Wax	17	25 50		
	L. C.	Day labourer -	—	2	2 80	8	281 45
25.2.98	S. M.	Frame releasing -	Wood	168	380 78		
	A. R.	Stamping - -	,,	148	385 50		
	S. A.	Frame releasing -	,,	132	245 00		
	B. T.	,, ,, -	,,	58	152 00		
	A. C.	,, ,, -	,,	93·9	211 96		
	G. M.	,, ,, -	,,	57	143 04		
	S. M.	,, ,, -	Wax	9	15 75		
	L. P.	Stamping - -	—	5	11 85	12	338 58
25.3.98	G. P.	Frame releasing -	Wood	81	140 70		
	T. A.	,, ,, -	,,	78	216 46		
	K. M.	,, ,, -	,,	40	82 00		
	B. J.	Day labourer -	—	32	75 80		
	D. E.	Frame releasing -	Wood	5	11 25		
	B. P.	,, ,, -	,,	121·5	384 16		
	P. C.	,, ,, -	,,	133	340 20	17	463 16
25.4.98	V. A.	,, ,, -	,,	249	713 06		
	S. A.	,, ,, -	,,	54	84 00	12	257 59
25.5.98	S. J.	,, ,, -	,,	207	587 02		
	V. M.	,, ,, -	,,	88	193 60		
	F. J.	,, ,, -	,,	41·5	122 57		
	A. D.	,, ,, -	Wax	18·5	31 63		
	L. F.	,, ,, -	Wood	23·5	42 85	8	325 41
25.6.98	O. V.	Stamping - -	,,	367	885 21*		
	R. C.	Frame releasing -	,,	123	355 17		
	A. E.	Boxing - -	—	72	155 50		
	C. L.	Frame filling -	Wood	82	132 02		
	P. A.	,, releasing -	,,	26	48 45		
	L. R.	,, ,, -	,,	68·5	75 35		
	T. A.	,, ,, -	,,	30·7	72 11		
	T. V.	,, ,, -	,,	10	23 00	11	253 22
		Total - - -		5346·6	14,002 10	160	4,780 11
No. of dental cases.	75						
		Average - -		71·3	186 70	1	29 87

APPENDIX VIII.—(*continued*).

AIX-EN-PROVENCE STATE MATCH FACTORY.

TABLE D.—*List of Workpeople Suspended from Duty in consequence* (a) *Dental Disease or* (b) *Wounded, who have resumed Duty before the following Dates*:—

Date.	Name.	Department.	Dental.		Injured.	
			No. of Days Off.	Amount of Sick Pay Allowed.	No.	Total Amount of Sick Pay Allowed.
1897.			Days. Hrs.	Frs. Cts.		Frs. Cts.
July 25	- - -	- - -	—	—	4	38 80
August 25	C. F.	Picking out	33 0	66 33		
	L. M.	" "	12 0	24 00	3	94 39
September 25	- - -	- - -	—	—	3	21 16
October 25	M. C.	Picking out	16 5	32 34		
	S. M.	Stamping	2 4	4 29	3	23 98
November 25	C. T.	Boxing	3 1	5 36	6	52 62
December 3	G. M.	Picking out	2 1	4 26	6	63 13
1898						
January 2	- - -	- - -	—	—	2	9 06
February 25	- - -	- - -	—	—	7	36 62
March 25	J. J.	Boxing	6 0	12 90		
	A. B.	Picking out	14 0	29 54	3	16 71
April 25	R. E.	Boxing	10 4	23 08	10	89 74
May 25	- - -	- - -	—	—	3	25 95
June 25	C. T.	Boxing	10 5	18 99	3	57 46
Total for year	10	Dental cases	110 0	221 09	53	529 62
Average	1	—	11	22 10	1	10 00
		In addition, 2 Medical Cases			2	34 82 francs.

APPENDIX IX.

THE PRESERVATION OF THE TEETH.

Without good teeth there cannot be thorough mastication.

Without thorough mastication there cannot be perfect digestion, and without perfect digestion one cannot have good health.

Hence the paramount importance of sound health.

CLEAN TEETH DO NOT DECAY.

Food left on the teeth ferments, and the acid formed produces decay.

Decay leads to pain and the total destruction of the tooth.

When decay occurs it should be attended to, whether giving pain or not.

The immediate stopping of a small cavity is of the greatest service in preventing the necessity for extraction.

The following rules should therefore be closely observed:—

1. The teeth should be cleansed at least once *daily*, with tooth-brush and powder.
2. The best time to clean the teeth is *after* the last meal.
3. A small tooth-brush with stiff bristles should be used, brushing up and down, and across; inside and outside, and in between the teeth.
4. A simple tooth-powder, or a little soap and some precipitated chalk, taken up on the brush should be used. If the teeth are dirty or stained, a little fine pumice powder may be used; but very occasionally.
5. It is a good practice to rinse the mouth out after every meal.
6. All rough usage of the teeth, such as cracking nuts, biting thread, &c., should be avoided; but the proper use of the teeth in chewing is good for them.
7. **All persons engaged in these works should rinse their mouths thoroughly before meals and before leaving the works.**

APPENDIX X. (*see* page 213).

RULES RECOMMENDED BY THE SCHOOL CHILDREN'S COMMITTEE OF THE BRITISH DENTAL ASSOCIATION, AND CIRCULATED FOR THE INFORMATION OF MANAGERS AND TEACHERS OF NATIONAL SCHOOLS IN IRELAND.

To Managers and Teachers of National Schools.

The Preservation of the Teeth of School Children.

Without good teeth there cannot be good mastication.

Without thorough mastication there cannot be perfect digestion, and poor health results.

Hence the paramount importance of sound teeth.

Clean teeth do not decay.

The importance of a sound first set of teeth is as great to the child as a sound second set is to the adult.

Children should be taught to use the tooth brush early.

Food left on the teeth ferments, and the acid formed produces decay.

Decay leads in time to pain and the total destruction of the tooth.

The substance of the following rules should therefore be impressed constantly upon all children :—

(1.) The teeth should be cleansed at least once *daily*.

(2.) The best time to clean the teeth is *after* the last meal.

(3.) A small toothbrush with stiff bristles should be used, brushing up, and down and across; and inside, and outside, and in between the teeth.

(4.) A simple tooth-powder, or a little soap and some precipitated chalk taken upon the brush may be used if the teeth are dirty or stained.

(5.) It is a good practice to rinse the mouth out after every meal.

(6.) All rough usage of the teeth, such as cracking nuts, biting thread, &c., should be avoided, but the proper use of the teeth in chewing is good for them.

When decay occurs it should be attended to long before any pain results.

It is the stopping of a small cavity that is of the greatest service.

In 10,000 children's mouths examined, 86 in every 100 required skilled operative treatment.

APPENDIX XI. (*see* page 148).

Circular of the Diamond Match Company, U.S.A.

Since the organisation of the Diamond Match Company the management have been keenly alive to the horrible distress and misery caused by phosphorus necrosis, a disease incident to the manufacture of matches by old methods. It has spent many thousands of dollars in remedial methods to prevent the disease. The management are now quite confident that they have now so perfected the system of manufacture of matches and ventilation of factories that no fear need exist of the disease if the operatives will take ordinary care of themselves.

Dr. S. D. Stewart, who has made a study of the disease and its treatment for many years, has prepared the following paper on the preventive measures which should be taken by the operatives in match factories. The respective managers of the factories of the Diamond Match Company are directed to see that each employee of the Diamond Match Company under their charge be furnished with a copy of the same.

O. C. Barber, President.

First.—Environment.—General Hygienic Condition of Factory.—Work Rooms, Lunch Rooms, Lavatories, Closets, &c.

Second.—Personal Hygienic Condition, Clothing and Body.

Third.—Special Hygienic Conditions of Mouth and Teeth.

To secure immunity from necrotic conditions to employees of factories proper environment is absolutely necessary and certain rules of action indispensable.

Environment, which pertains almost wholly to internal arrangements of factories, is one of the most important elements in securing the greatly desired freedom from necrotic troubles.

In this an abundant supply of fresh air is perhaps the greatest factor, for in securing this important element you are at the same time being freed of phospho-sulphurous fumes and increasing the quantity of oxygen in rooms as well. While this is a very important point in factory environment, it is only a part of the preventive system, which system must include, among other things, well-arranged and properly located lunch-rooms, a sufficient number of and conveniently-located lavatories and running closets, all of which must be kept in a thorough hygienic condition.

A. Operatives in Factories: Rules of Action.

While operating the operatives should avoid the putting of their hands up to their mouths for the purpose of picking at teeth or gums, as the fingers are not only covered with sand or glass from boxes, which by lodging in the mouth is very liable to irritate gum margins, but they are also constantly in contact with the phosphoric compound of the heads of matches, particles of which are forced under finger nails. At the same time, the hands and finger surfaces retain certain quantities of this compound, which in picking at teeth or gums there is a liability of particles being left in contact with same. The necessity of refraining from this thoughtless and uncleanly habit is perfectly plain to all thoughtful operatives.

B. Lavatory and Lunch Room.

Before luncheon, the lavatory should always be resorted to, using utmost care in efforts to free the hands and finger nails of all foreign matter. This need not necessarily require so much time as it requires thoughtfulness as to intent or purpose of the act.

The lunches of operatives should never be deposited in rooms or adjacent to rooms where the fumes of the phospho-sulphurous compound has access, for both meats and butter will readily take up or absorb the same, thereby not only rendering the foods less nutritious, but adding largely to risk of future troubles.

Second.—Personal and Home Hygiene.

The operatives should upon returning to their homes immediately change their outer clothing at least, after which comes a thorough washing of hands, arms, face and neck, and at least once a week in winter, and twice a week or more in summer, take a full bath, not forgetting at the same time to wash the hair and scalp thoroughly. This is a most important and valuable precautionary measure, as unctuous surfaces of scalp and hair retain the phosphoric odour longer than the body, and possibly hold it in greater quantity than any other surface of the body.

Third.—Mouth and Teeth.

The thorough cleansing of the mouth and teeth and gums is an absolute necessity, not only to health of same, but to securing immunity from the ravages of necrotic conditions. They must be thoroughly cleansed by use of tooth brush, with castile soap (it being both efficacious and cheap) every morning immediately after breakfast, then again after supper in the evening, preferably before retiring, using a sufficient quantity of the soap to make "suds," and while the "suds" made from the friction of the brush and soap is in the mouth, make a sort of "bellows" out of the cheeks and force the same between and around the teeth, and into every part of the mouth, thereby securing thorough and complete hygienic condition of mouth, gums, and teeth.

The teeth must necessarily be kept in comparatively good repair and absolutely free from all deposits. At first symptoms of decay a thorough and competent dentist should be consulted at once.

Resumé.

All persons with scrofulous habits or taint should avoid working in match factories, as they, perhaps more than any other class of people, from the abnormal condition of the blood, are liable to have serious trouble from the phospho-sulphurous fumes. This should be seriously considered by all who propose to enter the employ of match manufacturing companies.

A strict compliance with the above rules of action for employees is absolutely necessary to obtain the results desired. It is also true that any deviation from the same will add to the risk of employees in almost exact ratio to the deviation.

APPENDIX XII (*see* page 210).

STATEMENT OF CONDITIONS RECOMMENDED FOR ADOPTION BY BOARDS OF GUARDIANS, OR OF MANAGEMENT, IN REGARD TO THE APPOINTMENT OF DENTAL OFFICERS.

(1.) The officer appointed should be required—To attend at the school or other appointed place according to his agreement with the guardians or managers. To inspect the teeth of all children admitted since his last visit. From time to time, according to his agreement, to inspect the teeth of all the children in the school or workhouse as the case may be. To attend duly and punctually at each visit upon each child requiring dental treatment, and upon any child who may be brought to him for treatment in the intervals of such visits. To keep a record of his work, and to report the same to the guardians or managers, in a book to be provided by them for the purpose, under the following heads:—

Date.
Number of children inspected.
" temporary teeth extracted.
" permanent " "
" teeth filled.
" scalings.
" other operations performed.

Any matters which the dental officer may deem necessary or desirable to bring to the notice of the guardians.

This book should ordinarily be kept at the school or workhouse, and should be laid before the guardians or managers by the clerk at each meeting, and should be produced to the inspectors of the Local Government Board when required.

(2.) The dental officer must be duly registered in accordance with the statutes in that behalf (41 & 42 Vict. c. 33., 1878, and 49 & 50 Vict. c. 48., 1886), or if not so registered, by reason of any medical or surgical qualification exempting him from the obligation of registration as a dentist, the officer appointed shall produce satisfactory evidence that he holds a license in dental surgery from either of the following:—

The Royal College of Surgeons of England.
" " " Edinburgh.
" " " Ireland.
The Faculty of Physicians and Surgeons of Glasgow, or other approved authority.

(3.) The guardians or managers may pay a dental office either by—(*a*) an inclusive salary, or (*b*) partly by salary and partly by fees on a fixed scale for specified operations, provided that all payments for extractions shall be included in the salary assigned to the officer and shall not be made by fee.

(4.) If the dental officer attends at the school or workhouse, it would be necessary that the guardians or managers should provide for his use a suitable equipped surgery, including a dental chair and a dental engine, and such other apparatus as may be necessary. It is desirable that they should also provide the requisite materials for fillings, and such special appliances as may be needed for mechanical treatment.

Local Government Board,
July 1897.

APPENDIX XIII.

This appendix consisted of the rules and regulations in force in foreign countries which have been embodied in Dr. Thorpe's Report, pp. 23–4, 37–9, 63–75. In regard to these Dr. Cunningham writes:—

> They are important as showing the recognition of the dental aspect of the question by making provision for the hygienic care of the teeth, though I fear they may never have been thoroughly applied.