

SOME
MEDICAL ASPECTS
of the
PRODUCTION OF EXPLOSIVES.

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Toxic Jaundice with Atrophy of Liver followed by
Regeneration and Recovery. Reprinted from the
British Medical Journal, April 20, 1918.

SOME MEDICAL ASPECTS OF THE PRODUCTION OF EXPLOSIVES,

with special reference to the work of the
Medical Department at H.M. Factory, Queen's Ferry, Chester.

In 1915 when the shortage of munitions became acute the Government opened several large new factories for the manufacture of shells and explosives. One of the largest of the latter was H.M. Factory at Queen's Ferry, near Chester, which was rapidly built and adapted to turn out large quantities of High Explosives of various kinds. This factory extended for a mile along the south bank of the river Dee, and during the years when its full output was required it employed between 6,000 and 7,000 workers at the one time, about half of these being women.

The various substances made and handled included nitro-cellulose (Gun Cotton), trinitrotoluene (T.N.T.), dinitrotoluene (D.N.T.), mononitrotoluene (M.N.T.), tetryl, sulphuric and nitric acids. Other forms of work were carried on such as box making; and on the bag-washing plant, recovery of nitrate of soda from the bags in which it arrived at the factory, these then being fit for use again. Labour was employed in the boiler house and power house, and in the plumbing and fitting shops that are required in all large chemical factories. It will thus be seen that the poisonous substances dealt with were many and various - tar derivatives, nitro-bodies, acids, arsenic, lead, and poisonous gases of various kinds.

The necessity for a medical department to guard both the health of the workers and the finances of the factory was soon realised; and from a single Dressing Station in charge of one

nurse it rapidly grew to a staff of 35, including one whole time and two part time medical officers (later two whole time medical officers), a part time dentist, eight fully trained nurses, a dispenser, 14 first-aid assistants, an orderly, and three clerks.

Four Dressing Stations were open night and day during the busiest period, and a small Hospital was built about a mile from the Factory where accidents and illnesses due to the work were treated and where the medical officer resided.

Examination of New Workers.

All new workers were examined before starting work, and as far as possible drafted to work suitable to their physical condition. The supply of male labour was very limited, and medical examination was not so much to exclude the unfit (practically all being more or less unfit), as to have a record of their condition on employment, and to prevent a man being sent to work that would be likely to injure him on account of his previous weakness... for instance a high myope or a one-eyed man would be excluded from the traffic engine drivers section; a bronchitic or asthmatic from the acid plants; a man with eczema from work in chemicals such as T.N.T., Tetryl, etc, which irritate the skin; a hunch-back or a weak and undersized individual from the "heavy gang".

Practically the only classes of men rejected were the insane (of whom several applied), the epileptic, and those in advanced and incurable disease such as tuberculosis in the third stage, or locomotor ataxia, and those suffering from actively infectious disease.

With the women, matters were more satisfactory and the

unfit could be excluded more rigidly and only workers who were considered to be medically suitable were admitted to the process work. Notwithstanding this the standard was far from high; the supply of labour being limited and many of the factory processes light, and such as could easily be carried out even by delicate girls; ^{and} defects such as carious teeth, flat feet, varicose veins (in the older women), verminous heads, etc., being too common to allow of exclusion. Such applicants were given the opportunity of remedying their defects as far as reasonably possible; a nurse gave advice as to the method to be used to cleanse the head; or the worker was offered dental treatment before being employed, as the case might indicate.

It was often found that the history the worker gave of his or her health was quite unreliable, and physical examination was chiefly depended upon. A worker would at the first examination state that his health had always been good and a few days later would return asking for a transfer from the work to which he had been sent on the grounds that he "never had been strong", and that his doctor had "forbidden him to work in damp" or "to lift heavy weights", etc., etc.

Cases of deformity and disease of special interest were met with from time to time at the examination of new workers and in the usual course of the work, such as a case of "lobster claw deformity"¹, and one of congenital absence of many digits of both hands² recorded at the time. Had the press of work allowed many interesting cases would have repaid investigation.

Women's Work.

From the point of view of health the employment of women workers on this factory was an unqualified success. Women were not

asked to perform the heaviest navvying or traffic tasks as very heavy work was found to be unsuitable for the average woman on account of her lack of muscular development, but no difficulties or ill-effects were experienced from moderate labour, and in several departments it was a regular thing for women to have to lift weights of 60-70 lb& many times per hour during the shift. They have carried out every kind of process from stoking and cleaning the boilers to delicate chemical tests requiring observation and accuracy. To enumerate all the kinds of work on which they were employed would be tedious; it is sufficient to mention the more unusual, such as chemical processes (shift work), painting, fire-brigade work, police duties, sanitary work, stoking and cleaning out furnaces, care of machinery, etc.

The women's health was wonderfully good, many not missing a day's work through illness for one, two, or even for three years; though the older women with families did not stand the work so well - chiefly because they had insufficient rest at home through attending to housework and to their children after their work at the factory was finished.

At first when it was proposed to employ women on the various chemical processes of the Acid, T.N.T., M.N.T., D.N.T., and Tetryl Plants, etc, there was much misgiving as to what the results might be on their health, especially with regard to their reproductive physiology. The experience of the past three years has shown however that they are in no way specially susceptible to ill effects from these substances, and in fact they have had a smaller sickness incidence than the men, this being no doubt partly accounted for by the fact that they carry out the various rules and regulations drawn up for their benefit more carefully than do the male workers, and also that the quality of the male labour available was low.

Though women did not prove to be more susceptible to accident and industrial diseases than men they required more personal supervision and advice regarding suitable food and clothing, etc; and where a number of women are employed it is essential to provide accommodation for rest and treatment in charge of a nurse or other suitable woman attendant, where a girl who is indisposed, as at the menstrual period, or, more rarely, a pregnant woman seized with sudden illness, can retire without too much inquiry as to the cause of her absence from work.

Menstrual disorders are not more common than among women of their class who are not industrially employed; the great majority of the women suffered but little discomfort at these periods, but a proportion of about 10%, of otherwise healthy women had some pain and feeling of sickness or headache for the first day of each period. It was found that an hour's rest with some simple comforts such as a hot water bottle and a hot drink enabled many a worker to continue her shift when otherwise a day's work or more would have been lost.

Special sanitary conveniences for the reception of soiled articles were fitted in the women's latrines and were found to be of great use and were much appreciated; some such arrangement should be made in every factory where women are employed.

It was found that a judicious lack of sympathy sometimes greatly benefited the new-comers; while their health was carefully watched they were not encouraged to talk about it, and everything was done both to enable them to be fit for their work and to assure them that they were indeed so. At one time, before the workers had much experience of their own powers, fainting was very common; it being not unusual for four or five girls to be in the

First Aid Station at one time in this condition. Treatment and sympathy only increased the number of cases until a plan was carried out of sending every girl who fainted off work for seven days; the cases at once dropped to less than one per week though at that time about 3,000 women were employed.

It was almost the rule at the re-examinations which take place from time to time to find that the women had gained in weight, were brighter and in better spirits, and felt stronger and in better health since taking up work here. These good results I attribute largely to the eight hours' shift which does not over-tire the workers and ensures that they have sufficient time for rest and recreation before their duties start again the next day; and also to the good conditions as regards canteen and other welfare arrangements; and to the fact that they are all medically examined before commencing employment and are sent to processes suitable to their health and physique; and that those on T.N.T., M.N.T., D.N.T., and other special processes are periodically re-examined and removed from any particular work if it should threaten to affect their health.

Most of the workers preferred shifts to day work, especially the women, who said they could get their shopping done much better that way. An eight hours' shift was found to be easily undertaken and to give sufficient leisure, and not to be too wearisome or exhausting; in fact some of the younger workers wished to do more and had to be prevented from doing two shifts running, or still more frequently what they called a quick change - i.e. an eight hours shift, eight hours off, then another eight hours shift.

The fears entertained by some that morals would be generally relaxed if men and women worked together in a factory were found to have very little foundation in fact; of course in a factory

employing over 6,000 persons of both sexes cases of misbehaviour did occur, but these were quite exceptional and it may be stated as a rule that a girl of good morals at home remains of good morals as a factory worker.

A uniform consisting of tunic, trousers, and a cap to cover the hair, was worn by all the women workers and was an essential provision having regard to the nature of the work; skirts and petticoats would have been highly dangerous as well as unhygienic and would have made women's employment in many of the processes impossible; the furnace workers, the window cleaners, the fire-women, the acid, T.N.T. and other process workers, who were up and down slippery iron ladders, stooping and bending over cauldrons of boiling chemicals or vats of strong acid with no time ~~or~~ spare hands to hold skirts out of the way would have been hampered to the extent of making their work an impossibility by any form of skirt. The cap prevented the hair getting caught in machinery or belting in motion, or accumulating a store of poisonous dust, and was an important safeguard to the workers.

Some such uniform is necessary where women are employed in industries involving the tending of machinery, handling of dangerous materials, or active movements on different levels, and should be insisted on in peace-time occupations as well as in munition factories. Besides lessening the danger of accident such a uniform greatly increases the woman's efficiency, enabling her with unhampered movements to undertake work which would otherwise be unsuitable or impossible, and gives her increased esprit-de-corps and pride in her work.

Employment of pregnant women.

My experience agrees with that of Dr. Rhoda Adamson³ of Leeds who

holds that pregnant women are not injured by selected industrial employment. Such workers however require special provision as regards supervision and rest periods, and the work should be light during the later months and should not be side by side with men; long travelling to and from work is specially undesirable for such workers and night shifts are unsuitable.

Where these measures can be carried out there is no reason against the employment of pregnant women on suitable work until late in the pregnancy. Most mishaps occur early, before the patient's condition is recognised; and as is well known, during pregnancy reasonable exercise is beneficial, and a steady wage with all that this supplies in the way of home comforts and good food and absence of worry is most important. Women who work under good conditions during pregnancy have less trouble, easier parturition and bear healthier children than those who spend the period in idleness and over-carefulness.

In more than one instance, before a definite line of action in these cases was decided upon, pregnancy was concealed in this factory for fear of dismissal; and the mother actually continued working up to the hour of confinement in two cases, and to the day of confinement in others; mother and child being none the worse, but the First Aid staff being perhaps unduly rushed at the event.

The exclusion of married women from industry, as has been advocated by some, would be harsh and unjustifiable and in many cases would act against the object aimed at - namely the welfare of the offspring; it would inevitably lead to concealment of marriage and to irregular unions, for if it were realised that marriage was to be thus penalised and that a woman thereby forfeited her earning power legal marriage would assuredly become impracticable for a certain section of the community. Any State subsidy would

not counteract such as injustice but would only tend to encourage^{9.} the reckless and improvident at the expense of the self-supporting classes.

In a large number of cases that came to my knowledge the mother had to be the wage-earner through hard necessity, in cases of desertion, or where there were ne'er-do-weel husbands, sick and crippled husbands, husbands in prison, or in ~~an~~ asylum or hospital, or unfortunate husbands who had lost their work in one way or another. In these cases the women usually shouldered the double burden of wage-earning and home-keeping with a will, but, if still living with their husbands, dreaded the advent of further pregnancy, as this, besides increasing their burden beyond endurance, would plunge the family in penury. They not seldom took means to avoid it, means sometimes, through ignorance, of a harmful nature. I fully believe that it is not only right and humane but sound economics to instruct all such, and others who may desire the knowledge, in safe and hygienic methods of prevention of conception.

Welfare Work.

The Welfare and Medical Departments were originally united and were under the Medical Officer, but as the work grew they were separated completely, and an independent Chief Supervisor was appointed to look after the welfare of the women workers. This arrangement was found to lead to anomalies of ~~one~~ kind and another and in my opinion it is not a satisfactory one: where there is a medical officer the Welfare department should be subordinate to and should work under his or her authority.

At Queen's Ferry, owing to mutual good will, there were few regrettable incidents; but, even so, workers have been discharged as bad timekeepers when they have been absent through illness, special

visits have been made miles into the country by the medical officer and by the welfare supervisor independently on days following each other to see a sick girl; a welfare supervisor has instructed a worker to claim compensation in cases such as carcinoma and lupus erythematosus, and a case of accident has been hurried home by a welfare supervisor before being seen by the medical officer and has thus become neglected and has been a source of unnecessarily prolonged disablement. Such incidents waste time, energy and public money and could easily be avoided by grouping welfare work and other forms of social enterprise under the medical officer, not necessarily for administrative but for advisory purposes. To demonstrate how undesirable the divorce of these allied services may be it may be mentioned that when notices and instructions regarding precautions to be taken against industrial dermatitis, etc., and the use of safeguards, were posted in the change rooms and mess rooms, in the case of the women workers they had to be sent to the Chief Supervisor to be posted over her signature though they related to hygiene and medical matters only, while they were posted by the medical officer direct in the men's change rooms without this loss of time and of authority.

The Welfare work was undertaken primarily for the sake of the women workers, but also for the men (though not labelled by that name nor undertaken by a special department in their case), and consisted of canteens and change-rooms, bath and other lavatory accommodation, intervals for refreshment, provision of uniform clothing, and general supervision of conduct and of conditions of work. This side of the work has been fully and ably dealt with in the report of the Health of Munition Workers Committee of the Ministry of Munitions⁴, and does not need further reference here except to say that these measures undoubtedly contributed largely

to the efficiency, contentment, and good health of the workers. To one suggestion set forth in the Report alluded to above I must offer strong opposition however: my experience has been very strongly against the recommendation regarding duties of Welfare Supervisors as laid down in Appendix "J" where it is stated that "(1) She should help in the selection of nurses, who should be recognised as belonging to the Welfare Staff. (2) While not interfering with the nurses in the professional discharge of their duties, she should see that their work is carried out promptly and that the workers are not kept waiting long before they receive attention. (3) She should supervise the keeping of all records of accident and illness in the ambulance room. (4) She should keep in touch with all cases of serious accident and illness ... [and] be kept in touch with the Compensation Department...."

Where there is a Medical Officer in charge or a staff of trained nurses these recommendations, if carried out, would only lead to chaos and inefficiency. It is surely obvious that it is inadvisable and unworkable for the untrained and inexperienced to be in charge of the trained and expert, and as the Welfare Departments of most factories have jurisdiction over the women only, while the medical section treats both sexes alike, it is obvious that the first cannot be responsible for the latter. In my experience wherever such officials have interfered or have tried to put in effect the principles quoted above annoyance and obstruction have been the only result.

In many cases Welfare Supervisors have had no previous training at all, and in practically every case have no previous scientific or health training, and often their advice and actions are founded on sentiment and not on accurate knowledge; this has been demonstrated many times here, and where a supervisor has declared

that a certain process was "cruel work for women" not knowing that the substance handled was little more than chalk and could have no deleterious effects on persons of either sex; they have committed other indiscretions due to lack of knowledge and superabundance of feeling and preconceived ideas. These persons should certainly not be in charge of the medical or First Aid arrangements.

Scope of Medical Work.

Many varied opinions are held as to the legitimate scope of the work of a Factory Medical Department, and the majority of writers take the view that treatment should be excluded*. This may hold good for ordinary industrial processes, but certainly does not do so in the case of poisonous and special work. At this factory, treatment for gassing, burns, industrial dermatitis and poisoning by T.N.T. were undertaken from the beginning, and in my opinion was a most essential part of the work.

It is no slight upon the abilities of the general practitioners in the neighbourhood to state that they are not universal specialists and that certain cases are altogether outside the scope of their experience; and that the factory medical officer who knows the worker and the process in which he has been injured, and who has made industrial disease a subject of special study is more fitted to deal with these cases. Moreover a general practitioner has not the necessary staff and appliances at his command, oxygen cylinders and apparatus, nurses to carry out constant treatment and care, large quantities of dressings and special drugs for instant use in cases such as extensive acid burns; and if such patients are sent home it usually means that the doctor (who has perhaps never seen a similar case before) does his

* Among others, see Dr. Janet Campbell's Report in the "Report of the War Cabinet Committee on Women in Industries" She says "An adequate service of factory medical officers is needed, having no duties of treatment".

best but cannot treat the case with experience or certainty, and the patient may suffer from prolonged disability and illness.

It may be urged that such cases should be sent to the nearest general hospital; but besides unduly burdening their accommodation many patients would not consent to go, and where they consent the medical staff would necessarily be unfamiliar with the exact nature of the process in which the patient had sustained injury.

In cases of less severity where the patient is not incapacitated, such as some burns and many minor injuries, work can be continued if treatment is carried out at a Dressing Station in the factory. The time at which treatment is available either at a doctor's surgery or at the out-patient department of a hospital is usually during working hours, and the worker's home is often miles from any such place. If treatment for minor injuries were not provided at the factory it would mean that the worker must either go without it altogether or have to discontinue work.

At Queen's Ferry besides treatment at the Dressing Stations for what may be called walking cases, a cottage hospital containing 12 beds was opened at the end of 1916, and it was found to be of the greatest use, and practically indispensable while the dangerous sections of the factory were working. In it were treated cases of acid burn, eye injuries, and other accidents, industrial dermatitis, T.N.T. absorption, etc. In many cases the workers could not have obtained adequate treatment in their lodgings or at home, and undoubtedly recovery was hastened and the worker was saved from prolonged disability and the Factory from loss of money through needless compensation claims in this way. Over 400 cases were admitted during the two years in which the hospital was open and the average stay of each patient was 10 days.

The medical work undertaken included the examination of all new workers, male and female; periodic re-examination of those engaged in poisonous processes; four first aid stations, open day and night in various parts of the factory for the treatment of all cases of accident or illness occurring in the works; the works hospital for the further treatment of such cases of accident and industrial disease as required it; provision and maintenance of over 40 stretchers and first aid boxes at various points on the plant (these are mentioned again later); oversight of sanitation and of special regulations relating to dangerous trades, - e.g. supervision of lavatory and mess-room accommodation for lead-workers, etc.

A dentist attended at the works one day each week and did much useful work, both extractions and conservative treatment being undertaken.

Owing to the nature of the processes carried on in the factory accidents of a special kind were numerous; during the two years 1917 & 1918 a very large number of such industrial accidents were treated, including

3,813	cases	of	acid	burns
2,128	"	"	eye	injuries
763	"	"	industrial	dermatitis

and in addition over 8,000 women and 4,250 men were examined for employment; and 17,176 re-examinations were made of the workers in poisonous processes. During the two years in question a record was made in our registers of something like 140,935 attendances for treatment on the part of the workers, and it may be said that on an average every worker employed made ten visits for each year of employment to one or other of the First Aid Dressing Stations of the Factory.

The majority of the accidents were not serious, and during

the whole period from the opening of the factory there were only five deaths due to the work, two being due to gassing with nitrous fumes, none of these cases being women. There was no death due to T.N.T., though over 60,000 tons were manufactured and packed by the workers.

Difficulties in connection with the staff of the department were great, the best type of nurse being more or less monopolised by the requirements of the military and the civil hospitals; the nature of the work was not particularly attractive and any experience gained was unlikely to be of use elsewhere. The disadvantages included living out in a neighbourhood where rooms were hard to obtain, the constantly changing shifts, and the work itself resembling an out-patient department more than hospital nursing work; then again the question of assistant nurses was a difficulty, the class from which such vacancies are usually filled being offered much larger pay in the process work of the factory and in other forms of employment.

The living-out system necessitated by the nature of the work was a source of much trouble ... in many cases if a nurse were indisposed or otherwise unable to come on duty she either could not or did not send word in time for arrangements to be made for another to take her place, with the result that her Dressing Station would have been unattended unless hasty and often most difficult rearrangements were made at the last moment when she did not appear; the other members of the staff having to do double duty, or some other equally inconvenient arrangement being made. Judging from our experience here the living-out system would be impracticable for hospitals unless hostels for the staff were maintained nearby or a considerable reserve staff were kept

for such emergencies.

The First Aid arrangements apart from the Dressing Stations consisted (1) of conveniently placed stretchers at frequent intervals in every part of the factory; on the Acid section these were kept in closed wooden boxes made for the purpose with STRETCHER painted on the lid; this was necessary as otherwise the acid in the atmosphere rotted the canvas through in a very short time: (2) of First Aid boxes containing field dressings, tourniquets, soda bicarbonate in solution and powder, and a few other articles for use in an emergency. The habitual use of these was discouraged as it was found to lead to self-treatment by the workers, dressings being unskilfully applied with dirty fingers to save the trouble of going to the dressing station. The contents of the boxes continually disappeared and had to be renewed constantly, though in some cases no accident of any kind had taken place in the part of the factory they supplied since last the boxes were replenished. The prospect of something for nothing seemed to be irresistible even though that something appeared to be useless to the appropriator. In agreement with the late Dr. Mercier's ably expressed theories⁵ one must conclude that, as regards pilfering, the breaking point of many industrial workers is extraordinary low.

Lectures in First Aid were given to the Women Police (the Men Police had this instruction elsewhere as part of their necessary training); and an attempt was made for a time to teach this to selected workers during factory hours and to give them an opportunity of assisting in the First Aid Stations, so that their help would be available in an emergency. This did not meet with success however, as the workers were suspicious of being transferred even temporarily from where they usually worked,

thinking that it was a preliminary to discharge. They were also more highly paid than the junior First-Aid Assistants and the Clerical Staff, and as their remuneration naturally could not be altered for the time it was suggested to train them, this led to obvious injustice and the scheme had to be abandoned. I understand that some such plan was carried out with success elsewhere but how it was done I do not know.

Thus in all accidents help was relied on only from the First Aid Staff and the Police, except as regards stretcher bearers who always volunteered in numbers when required.

Compensation Claims.

Claims for compensation for injury and industrial diseases were numerous, the majority of such claims were genuine and were instantly conceded, but a considerable minority were not of a nature to come within the meaning of the Act. Very few cases of actual wilful malingering occurred but many cases had to be coaxed and persuaded to return to work after the results of a genuine injury had long since passed off; and cases of hysterical and functional contracture of joints and even rarefaction of bone (shewn by X-Ray examination) followed prolonged disuse of a limb after an injury.

In these cases the worker, his friends, and often unfortunately his family doctor combined in the opinion that he was unfit, long after all evidence of injury had disappeared, and they resented advice to attempt work again, seeming to regard such as being an action against the patient instead of in his interest as it truly was.

Cases which would have been back to work in a few days or weeks at most had there been no compensation could hardly be

persuaded to resume light work after many months of idleness.

A case of prepatellar bursitis has remained from work (continuously certified as unfit by her panel doctor) for nine months after the trouble had subsided; one of sprained ankle for fifteen months; one of chipping of the olecranon for seven months; one of bruised muscles of the back for a year and ten months; one of crushed finger of left hand for a year and five months; one of strained muscles of arm for nine months; and others too numerous to mention neglected treatment and thus needlessly prolonged their disability for months and years, if not in order to draw their compensation money, at any rate they have had no love of work and have preferred to remain ill at home with 25/- per week rather than make an effort to an independent working existence.

In genuine cases the 25/- per week was all too little, and in the case of a man with a family very great hardship followed incapacity in several cases: I think that the law needs revision on several points and that the allowance should be better safeguarded in slight cases, that where the allowance is being drawn the patient should be obliged to submit himself to treatment considered suitable to his case, and that in the case of the breadwinner of a family the amount should be larger and should be graduated as were the separation allowances of a soldier's dependents.

Perhaps the most frequent form of attempted fraud was for a worker to claim compensation for health damaged by his work, when in fact it had been impaired before his employment here or had given way from causes quite unconnected with his work; many cases of tuberculosis attempted to place the onus of their disability upon the factory even though in some instances they had been under treatment for the complaint for months or years before coming here; cases of old-standing rheumatism, nephritis, hernia,

and varicose veins all tried to live at the expense of their employer.

In many of these instances the fraud could hardly be described as intentional as recent legislation has helped to plant in the mind of the worker the idea that he has a right to support, life-long if need be, if any ill overtake him while employed, and it is a difficult and thankless task to try to make him understand the difference between illness or injury due to employment and that only occurring while he is employed but not due to the work. Workers have frequently made claims for compensation for accidents sustained while coming to work or on their way home - by a cycle skidding, etc., and have entertained a great sense of grievance when their claim has not been allowed.

Unfortunately this aspect of affairs is likely to become more difficult in future, as a certain large section of the community is being fed with the false sentiment and doctrine that they have large rights with no corresponding duties to the rest of the State.

Eye Injuries.

Eye injuries were numerous and in many cases serious: sparks and fragments of steel in the cornea, and acid and other corrosive burns being of common occurrence. Other accidents such as a blow on the eyeball causing intraocular haemorrhage and separation of the retina, a piece of wire penetrating the eyeball, and cuts from tools or from flying fragments of steel occurred. Out of a total of over 2,000 cases the sight of the eye was completely lost in one instance only, and seriously impaired in one other.

Acid burns of the cornea, so severe as to seem hopeless,

recovered marvellously if treated at once and kept absolutely aseptic. Cases sufficiently severe to leave work were taken into the Works Hospital if willing. With treatment by neutralisation with a saturated solution of sodium bicarbonate in cases of acid burns, and as a routine measure cocaine and castor oil drops for the first dressing, followed by Collosol Argentum drops (Crookes' Laboratory) four-hourly, with careful exclusion of light, these cases gave little anxiety. At the beginning Protargol, Argyrol, Silver Nitrate, and other preparations were used, but the results were more uncertain and the injury was longer in healing; treatment was given two-hourly in some cases, but this was discontinued as it was found to be too frequent, and to retard healing by giving the eye insufficient rest. In one or two cases where the patient would not co-operate and submit to the restrictions as regards exclusion of light, or disturbed the bandages and rubbed the eye, results were disappointing, and nebulae were left after healing.

In dangerous and complicated cases we had the advantage of the advice of the Honorary Staff of the Chester Royal Infirmary.

Chemical Burns.

A burn may be described as being a lesion due to the action of fire or ^{dry} heat, and a scald as one due to the action of a hot liquid or of its vapour. The expression "chemical burns", however, is no misuse of terms; for the lesions caused by various corrosives and escharotics such as strong acids and alkalis are analogous to those caused by fire although there is no real homology and the agents are different. Such injuries certainly are not scalds, the agents not always being liquid and seldom being hot; they are indeed to all intents and purposes true burns.

Over 3,000 cases of acid burns of varying degrees of

severity, from the slightest to some very serious and extensive, were seen. The acids causing these were sulphuric acid, concentrated to 94% in some cases, oleum (a 104% concentration) as it is technically called, nitric acid, and "mixed acid!"

These acids cause very severe burns when concentrated, while nitric acid also causes an intense yellow staining of the skin so that in one or two instances First Aid Attendants have been wrongly accused of painting the burnt part with Iodine. Strong sulphuric acid leaves a dead white or whitish grey stain where the albumin is coagulated in the deeper layers of the skin. These burns closely resemble those caused by fire and steam, and can be classified in the same way — 1st degree reddening, 2nd degree blistering, 3rd degree partial destruction and 4th degree complete destruction of all layers of the skin; 5th degree through skin, subcutaneous tissue and muscle. I have not seen one involving bone.

Acid burns are not infrequently very extensive; vesication and charring of the skin, which sloughs subsequently, is common. Shock is seldom as severe as is met with in fire burns of the same extent.

Invariably the first treatment is neutralisation of the acid with sodium bicarbonate powder or solution. This is followed by a compress of the saturated solution for the first six hours or so; after the first dressing Ambrine with one of the aniline dyes, or Picric Acid $\frac{1}{2}\%$, is used in most cases; or an ointment containing 50% vaseline and 50% Ung. Zinci, B.P., for slight burns.

Picric Acid was most useful and gave excellent results in cases inclined to sepsis, but in the strength usually employed (1%) it was found to be too drying and irritating to the surrounding skin, sometimes causing blistering; it was equally

good and without this disadvantage when used in a $\frac{1}{2}\%$ solution.

"Ambrine" alone was used in a consecutive series of 100 cases and shewed no marked improvement on the other methods; granulations were pale, large and moist, discharge profuse, and healing often slow; when used in conjunction with 1% Scarlet Red solution as advised by Dr. Hull⁶ the results were much better. The open method of treatment described by Dr. Macleod⁷ also gave good results, the part being thickly dusted over with an antiseptic powder* and being protected from dust and flies by a light gauze dressing or screen.

Where a large area of skin is involved, if all the layers are destroyed, skin grafting is required when once the sloughs have separated, and the septic processes are sufficiently under control.

Pain is not a troublesome feature ~~in these~~ in these cases except in burns of the 2nd & 3rd degrees in which the skin is only destroyed through part of its thickness; when severe pain is complained of and is best relieved by frequent wet dressings, e.g. sodium bicarbonate compresses, and a suitable sedative, ~~such as~~ ~~brominia~~. Patients frequently complained of itching as the burns healed. Very often a burn healed fairly rapidly until only a small granulating patch remained one inch or less in diameter, which seemed to resist all efforts at healing; at this stage thick powdering with boric acid and starch equal parts and leaving the

* Zn. Stearate	20
Mag. Carb.	40
Lycopodium	5
Diamatos	25
Paraffin	10
Ol. Citronell	q.s.

part undisturbed for five or six days at a time would sometimes bring about the desired result, or Malachite green 1% ointment, or better still a 10% Allantoin ointment that I had made specially for these cases.

On the hands and forearms contraction and deformity tended to follow these injuries, and burns in these situations needed careful management as to splinting and exercises during the healing.

Keloid is a troublesome and frequent sequel, very disfiguring if on the face and hands, as unfortunately is often the case with these injuries, and in any situation often tender or even painful long after healing has taken place. In one or two instances this keloid formation has continued to spread, tight fibrous bands radiating out into the surrounding healthy skin and causing contraction of the part and alarm to the patient. In one such case this yielded to X-Ray treatment, the scar being healthy and supple after three sittings. In these cases keloid certainly seemed to occur more frequently when healing took place rapidly.

The eyes often escaped damage marvellously, the natural wink reflex protecting them even in cases where the face was badly burned; when the eyes were involved however the danger varied in direct ratio to the extent of surface damaged, a drop of highly concentrated acid doing less damage if neutralised immediately than weak acid over the entire conjunctival sac. Details regarding the treatment of these cases are given above,

Burns caused by caustic alkalis occurred, but were much rarer and less severe; after neutralisation with weak acetic acid (5%) treatment was the same.

As the burns were of all degrees of severity no definite period of disability can be given, some workers not leaving work at all, others in more severe cases being off work for 6-10 months or longer.

Dermatitis.

Besides the forms of skin irritation, which will be described later, caused by T.N.T. and Tetryl, some other forms of industrial dermatitis were seen from time to time. Tar, or its vapour, caused an erythema with itching of the face, neck, hands, and arms of susceptible persons who were engaged in tarring fences or roofs, etc; every case of this particular trouble occurred among the women workers, the men's skins evidently being more resistant to this form of irritation. If neglected the erythema would go through an exudative stage to a troublesome eczema; if seen early it yielded readily to means similar to those used for the other forms of dermatitis described, namely, temporary removal from contact with the irritant (if the attack was at all severe), general measures such as light diet and a laxative mixture, and local application of an alkaline soothing lotion.

The derivatives of T.N.T. and Tetryl, some unnamed and merely classed as nitro-bodies, were very irritating to some skins, and some of the most severe cases of dermatitis met with were due to these, the worker affected having been engaged not on the T.N.T. or Tetryl plants proper but in cleaning out tanks which had contained "spent" acid that had been used in the nitrating processes and deposited a certain amount of altered products on the sides and bottom of the tank.

Gassing.

"Fumes" of many sorts were generated in the different processes, some harmful and some only disagreeable; slight gassing cases were common; more serious cases occurred from time to time including two fatalities, but these were almost always either the result of accident, such as a leak or "blow off", or were due to negligence on the part of the workers. Every reasonable precaution was taken to protect the workers from such fumes as were

evolved in the course of the work; chemists were in charge of all the processes, and air helmets provided for the men whose duties involved cleaning out acid tanks or other forms of work in which they were exposed to dangerous fumes in any quantity.

A careful description of various forms of breathing apparatus and air helmets may be found in Glaister & Logan's text book.⁸

The self-contained "MECO" type with a supply of oxygen, and the Seibe-Gorman helmet supplied with air bellows and armoured tubing were the types used here. These are excellent when properly used and afford good protection, but, except in the case of the firemen who were accustomed to their use, the workers greatly disliked wearing them and would rather take the risk of being gassed than "hamper themselves" with these appliances; they preferred either to use dry gauze respirators (supplied for the dusty processes), which afforded no protection against gasses, or to go without any appliance at all unless constantly supervised.

The fumes included sulphuric acid vapour, sulphur dioxide, nitrous fumes, iodine and chlorine vapours (from impurity in the sodium nitrate used in the manufacture of nitric acid), carbon monoxide and dioxide in the furnace houses and in outbreaks of fire, and other substances such as the fumes from molten T.N.T. which will be mentioned when dealing with their toxic properties. Accounts of the effects on the human system of most of these fumes are given in various well-known works on industrial poisoning.⁹ I shall only mention each gas dealt with at Queen's Ferry very briefly as so much has been written elsewhere.

New workers were always more affected than those who had been employed in the factory for some time, and it was often surprising how a seasoned worker could remain without discomfort or ill-effect in any atmosphere loaded with acid vapour in which I could not stay

more than a few minutes without attacks of coughing and lacrymation, with smarting of the skin of the face and neck.

Sulphuric acid vapour acted as an irritant to the upper respiratory tract. It produced coughing and asthmatic spasm, but these symptoms passed off rapidly when the worker was removed from its vicinity and appeared to leave no after-effects. No doubt death would result were anyone imprisoned in a closed chamber full of this vapour, but when it escapes freely into the open air the danger is almost negligible, the vapour being too pungent and irritating to be fully inhaled so that the worker at once seeks safety in flight and thus experiences transient irritation only. The vapour consisted of a fine spray of actual acid particles and as it is much heavier than air it rapidly falls to the ground level. It destroys all vegetation in the vicinity and any cotton clothing the workers might be wearing; and all on this section were provided with acid-proofed uniform clothing.

Sulphur dioxide, (SO_2) is a more dangerous gas, causing irritation and, if inhaled in large volumes, producing inflammation of the respiratory mucous membrane and lungs; with us it caused very few casualties and no deaths; the plant where it was manufactured being extremely well constructed and allowing practically no escape at any level where it could affect the workers injuriously.

Iodine and chlorine need only be mentioned in passing; they were evolved in very small quantities in the process of drying the nitrate of soda, and they acted chiefly as local irritants to the respiratory mucous membrane if inhaled. No serious cases resulted from this cause but it was credited with causing many symptoms which could hardly be correctly attributed to it. If a man were found asleep at his work the defence might be that "the fumes had overcome him", or if a girl gave way to hysteria "the fumes had

flown to her head".

Carbon monoxide (CO) was only encountered in dangerous quantities when fire broke out, as was the case several times, and the firemen were the chief sufferers. No deaths were caused by this gas but cases of illness lasting for weeks occurred; the men affected sometimes appeared to be drunk, being flushed, incoherent in speech and unsteady on their legs. With rest and oxygen inhalations relief was soon experienced in most cases.

This source of danger, especially in the case of smouldering fires, does not seem to be as generally recognised as it should be; the men taking needless risks and seeming to think that as long as little visible smoke is given off there can be no danger.

For a few weeks sulphur monochloride (S_2Cl_2) was redistilled, but it was not made at Queen's Ferry; no casualties occurred, the work being most carefully carried out and no fume allowed to escape where the workers could be affected.

Carbonyl chloride (Phosgene, $COCl_2$) was also dealt with for a short time an effort being made after the Armistice to recover hydrochloric acid from the gas for commercial use. Several slight cases of gassing occurred but none were serious and there were no fatalities. The symptoms were those of bronchial irritation - pain and tightness of the chest, cough and dyspnoea; all the cases seen yielded to treatment and few required more than a day's absence from work. These were slight cases; for it is well known that phosgene when inhaled in any quantity can cause most serious damage to the bronchial mucous membrane and lungs, and that this may be followed by pulmonary oedema and death. It acts in this way by generating hydrochloric acid within the bronchioles and the pulmonary alveoli themselves in contact with the natural moisture of the parts, and this acid in the nascent state attacks

the living tissues.

Nitrous fumes were certainly the most deadly of any dealt with, and were responsible for two deaths (out of a total of five from all causes) and for many cases of minor illness. They were generated in the manufacture and concentration of nitric acid and in the nitrating processes of the manufacture of guncotton, T.N.T. and tetryl. Nitric and mixed acids should always be dealt with and stored with great caution as "nitrous fumes" are very readily given off on contact with compounds containing oxygen - even water dripping from a leaking tap into a tank of the acid will generate them in poisonous quantity - they are composed of oxides of nitrogen, nitrous and nitric oxides (NO_2 , & N_2O_3). As the latter is brownish or rust red in colour when the fumes are evolved during the day they can usually be seen and avoided but during the night shift this warning is not possible; the smell is pungent and characteristic but unless concentrated is not unpleasant.

These gases are most treacherous and lethal, causing, unless very concentrated, little or no spasm or local irritation at the moment, such as might act as a warning but some time after inhalation causing intense oedema of the lungs which may result in death. The latent period which may occur between the inhalation of the fumes and the onset of symptoms is in itself a source of danger.

A worker may hardly be aware that he has inhaled the poison until he is seized, perhaps in the mess-room, or on his way home later, with dyspnoea so acute that every breath is a struggle, cyanosis may be extreme, delirium occurs, and death may follow rapidly. In less severe cases pneumonia may follow the pulmonary oedema and recovery may take place if the patient survives the first few days. As has been noted by other observers*, muscular exertion always makes

* See Memorandum on Nitrous Fumes issued by the Factory Department of the Home Office. "Persons even apparently slightly affected must not be allowed to walk home until permitted to do so by the doctor".

such cases much worse, and even in slight cases no exertion that can be avoided should be allowed. Inhalation of a few minims of ammonia often helps to give relief, and warmed oxygen should be administered in all cyanosed cases. In slight cases the dyspnoea, cough and weakness, soon pass off with rest in the fresh air.

As long ago as 1873 there was sound knowledge as to the danger from nitrous fumes in the manufacture of explosives, as is shewn by the following extract from the second edition of Taylor's Principles & Practice of Medical Jurisprudence, (vol.1, p.218). "The fumes of nitrous acid vapour, which is generally associated with nitric acid, are of a very deadly kind. In the manufacture of gun-cotton acid vapours are evolved, which, if respired, although they may produce no immediate ill-effects, are liable to cause pneumonia and death. On one occasion, in preparing gun-cotton, I accidentally inhaled the vapour, and suffered from severe constriction of the throat, tightness of the chest, and cough for more than a week".

The following is an account of a fatal case that occurred here in 1918 - a workman, aged 33, was engaged in cleaning out an empty mixed-acid* tank. This was a large cylindrical iron tank 20ft in diameter and 12ft in height entered through a man-hole in the roof; it had a drain in the floor through which the acid, etc., could be emptied, and a compressed-air valve that could be used while cleaning was going on. The cleaning process consists of draining off the acid, then washing ~~in~~ out with water through a hose pipe; a few buckets of lime are then thrown in, and after an interval for any fumes to settle a man goes down to brush and shovel towards the drain outlet the sludge which has collected on the bottom.

The men engaged on this task often preferred to go down without smoke helmets; but these are provided for them and were in use on this occasion.

* Strong nitric acid 79.5% and sulphuric acid 17.8% .

This worker went into the tank about noon along with another man. The other man stated that when they went down there was no fume to speak of, but when they began shovelling the sludge fumes rose and took away his breath, he felt lightheaded and came out of the tank; he found that he could hardly mount the ladder to get out of the tank, but after he had walked about in the fresh air he felt better. He did not enter the tank again.

The victim of the accident wore a respirator of gauze and cotton wool impregnated with "Hypophosphite of Soda & Glycerine" during the first half-hour of his work; he then came up saying he could not breathe in it, and changed this for a "smoke helmet" supplied with air by bellows by a companion in the fresh air above; he remained in the tank for a further quarter of an hour flushing out the sludge with water from a hose-pipe.

On leaving the tank he made no complaint of any sort, and as it was leaving-off time he went to his dinner as usual; later, he worked at cleaning down in another part of the Factory from about two in the afternoon until about 4.30p.m., when he left work for the pay office (being Friday, it was pay day). Several other workers saw and spoke to him about that time and said afterwards that they had noticed nothing unusual about his health or appearance.

At 4.45p.m. he came to the First Aid and told the nurse on duty that "he wanted a dose" as he had had some fumes earlier in the day; he made no definite complaint and wished to hurry off to catch his train, but the nurse noticed that he looked extremely ill and detained him. About 5.15 p.m. I saw him; he was then lying down in a side-ward, the face was of a ghastly grey colour, breathing was difficult and there was a harsh cough with thin frothy blood-stained sputum. Warmed oxygen inhalations were given continuously, but the condition became more and more acute with orthopnoea and violently

laboured breathing, deepening greyish pallor, and much distress; the patient was fully conscious and aware of the seriousness of his condition and spoke of his approaching end; he asked for his sweetheart to be sent for, and this was done. There were occasional intervals of comparative relief when he could speak collectedly and would drowse for a few moments, but these were always followed by renewed distress; the sputum became more abundant, and uncontrollable movements of the bowels took place. During a slight remission he was conveyed to hospital, where in spite of treatment he died at 3.45 the next morning. He was labouring for breath and was fully conscious to the last; the pulse was full, regular, and of good quality almost to the end. For some hours after death much blood-stained froth oozed from the mouth and nostrils. Death was directly due to acute pulmonary oedema following inhalation of nitrous fumes.

A week before the occurrence of this fatal accident, the tank in question had been emptied of its acid and had been well flushed out with water; the chemists and foremen working on that part of the plant were unanimous in declaring that there were no nitrous fumes perceptible to them at any time when the deceased was there, and one or two of the men who had been in the tank for a few minutes at a time without helmet had felt no ill effects. The fact remains, however that this man's fellow workman had felt the fumes affecting him and had slipped out without calling the attention of his companion to the matter.

This case demonstrates the results of inhalation of nitrous fumes even in such small quantities as to be imperceptible to a trained observer: it is an instance of the latent period which in this form of gassing is known to occur.

Acids.

The manufacture and concentration of sulphuric and of nitric acid

was carried out at Queen's Ferry. Two special dangers connected with this work have already been described under the headings of "Chemical Burns" and of "Gassing".

Acid workers were more subject to dyspepsia than those on other sections, and mouth-breathers and those careless of oral cleanliness had the enamel of the front teeth damaged and made irregular by the acid in the atmosphere, the skin of the hands tended to become dry and cracked and the tips of the fingers to be sore and reddened through handling articles contaminated with acid. These conditions could be prevented to a large extent by intelligent workers carrying out simple instructions such as keeping the mouth closed while in the acid rooms and using an alkaline mouth-wash, rubbing a little lanoline into the hands at night, and using rubber gloves for work where these were required.

Workers subject to bronchial catarrh or asthma were unsuitable for these processes as the acid fume aggravated these conditions and it was found that they had to be withdrawn sooner or later.

Lead.

There were very few cases of lead poisoning in this factory and the two or three cases which did occur were of the usual early type; the symptoms met with being colic, constipation, anorexia, asthenia and wasting. No definite case of lead neuritis was seen.

Lead was not worked in or handled to any extent except by the plumbers and painters, and the usual precautions were carried out as regards plentiful washing accommodation and separate messrooms so far as could be done without obstructing output.

T.N.T.

Trinitrotoluene, or T.N.T. as it is popularly called, is manufactured by nitrating toluene, a coal tar product that is also to be met with in certain rock oils. It is commercially in the form of either a powder or flake, as at ordinary temperatures it forms a crystalline mass ranging in colour from pale lemon yellow to deep orange according to the degree of purity and presence or absence of isomers. It melts at about 80°C forming a thick oily yellow liquid with a heavy sickly smell.

So much has been written within the last three years on the subject of the dangers involved in the industrial handling of T.N.T.¹⁰, and more particularly on the subjects of "toxic jaundice" and of the blood condition of the workers,¹² that it is with diffidence that one approaches this already well-worn theme. Dr. B. Moore¹³ and his colleagues, and Dr. W. J. O'Donovan¹⁴, have done much to place this study on a definite basis by experiment and by collecting the observation and experience of a multitude of other workers. The modes of entry of the poison, the pathology, especially the post mortem pathology, the methods of prevention, and of treatment when once symptoms of poisoning have occurred, have all received much attention and able treatment at the hands of these writers and others.

The purely clinical aspect, following the disease from onset to end, and the after-history of such patients is perhaps less well known. I published an account¹⁵ of three such cases, and made reference to a fourth in 1918, and have followed up the histories since, together with that of a fifth milder case which occurred later. All these cases shewed profound symptoms of icterus gravis with destruction of liver substance, though the three cases originally recorded were the most severe; all were instantly withdrawn from contact with T.N.T. on their condition becoming manifest, all were treated on

the lines laid down by Dr. Willcox¹⁶ in the case of a similar industrial poison, with exhibition of alkalis and prolonged treatment in bed, all recovered and have resumed their ordinary work, no disability remaining as the result of their almost fatal experience, and all are alive and well at the present date, one of them having married since his recovery. Perhaps what is most astonishing is that the liver became normal in size and in function (as far as one can judge the function in the light of our present knowledge) after extensive degeneration and shrinkage. That some derangement of renal elimination is a factor in these cases is evident, no T.N.T. (or its decomposition products) could be found in the urine of these patients though it is normally found where a worker is in contact with the substance and for some time after; and the following experiment carried out by me in one case at the suggestion of Dr. O'Donovan, Chief Medical Officer to the Ministry of Munitions, corroborates this view - a small quantity of T.N.T. made up in an ointment was rubbed into the skin of a toxic jaundice patient and an equal quantity into the skin of a healthy adult as control. The urines were tested for the next 48 hours with the result that no T.N.T. could be detected in the patient's urine, while it appeared in that of the control after a few hours.

It is no easy matter to differentiate between an early case of toxic jaundice and one of catarrhal jaundice, influenzal jaundice, etc., occurring in a T.N.T. worker. I noted several cases of the latter¹⁷ during the influenza epidemic of 1918 which might easily have led to confusion. The symptoms are almost identical, and in practice the less serious illness is usually notified and treated as early toxic jaundice; there are points of difference however, which one learns with experience; the stools are darker in toxic jaundice than in the catarrhal form, the patient is often very drowsy, and if one

has the courage to try the experiment mentioned above it might possibly help to differentiate early cases - T.N.T. rubbed into the skin might be found in the urine of a catarrhal case, but not in that of a toxic jaundice patient. When the disease is fully developed it is almost unmistakable, the diminution of liver area, the profound asthenia with stupor or delirium, marking it off from the severest catarrhal case. T.N.T. can be demonstrated in the sweat and in the stools of such patients long after it has disappeared from the urine.

Other forms such as syphilitic jaundice may cause confusion, as of course this may occur in a T.N.T. worker just as in any other person. Here again much care is needed and the history must be gone into very fully; the Wassermann test should be done in any case of doubt.

T.N.T. was credited during the war with the most extraordinary ill-effects, and those who should have known better were not the least noisy in attributing fantastic results to working in this process or even to working on the same factory in different sections altogether. Some of the local doctors were prejudiced to a regrettable extent, allowing themselves to certify such diseases as tuberculous peritonitis, tuberculosis of the lungs (on several occasions), menstrual malaise, abortion, chronic nephritis, acne and impetigo, anterior poliomyelitis, ordinary dyspepsia caused by indiscretions of diet, malaria, and influenza as being T.N.T. poisoning; a case of icterus neonatorum in the child of a male T.N.T. worker was attributed to T.N.T. poisoning by the doctor in attendance. Employes such as messengers, supervisors, and outside labourers engaged in shovelling coal or pyrites who hardly ever entered the T.N.T. Houses and never handled the material were certified to be suffering from it, and, in short,

inaccuracy and prejudice prevailed.

Honest mistakes did occur, but in many of the cases of erroneous certification, as far as could be ascertained, the doctor had not taken the least trouble either to examine the patient or to verify his statements; and culpable carelessness is the least severe term to describe such slackness both of skill and veracity.

The most false and absurd stories circulated in the district, originating in the fears of the workers and their friends and in the love of sensation common to mankind. It was said and believed that there was a burying place in the factory where numbers of the men and women workers were interred after dying of the poison they had handled; the ridged concrete slabs on which cars were washed were pointed out as their gravestones; the box-factory where cases were made in which to pack the T.N.T. for transport was said to be busy manufacturing coffins for the secret burial of the corpses. Tetanus was reputed to be rife, and cases of hysteria (of which not a few occurred at first amongst the girls, due in large part to unwise sympathy) were discussed as convulsions due to tetanus, and later, when this canard was brought down, to T.N.T. poisoning.

T.N.T. is certainly a poisonous and dangerous substance to work in, but given good conditions of work and cleanliness, it appears to be almost harmless to the majority of workers and only to affect certain susceptible individuals as do other substances such as chloroform; some workers are in good health and shew no ill-effects whatever after years of contact and others shew signs of commencing poisoning after a few weeks or days: anything that lowers the health, more particularly if it damages the digestive tract, such as defective teeth, pyorrhoea alveolaris, wrong diet, constipation, or undue fatigue or worry, may cause a worker to become susceptible.

There has been much dispute as to the channel of absorption, one school declaring that the skin is the chief door of entry and another declaring that the respiratory tract is to blame, while still others hold that the digestive tract gives ingress to the poison. My experience and observation for the last two and a half years on a staff of T.N.T. workers numbering on an average about 800 convinces me that all these channels admit the T.N.T., that fumes are the most dangerous, that skin contact is next in importance, and, where the regulations against taking food in the workshops are strictly enforced, that the digestive tract as a mode of entry is almost negligible. It is not peculiar to T.N.T. to have several modes of entry to the human system; it is well known that mercury and mercurial compounds can be either inhaled, ingested, or absorbed by the skin.

All persons working in T.N.T. absorb a certain amount of the substance and this can be demonstrated by examination of the urine (Webster's test^{*}) and the practical problem resolves itself into how a worker can be exposed to as small a contact as possible, how he can be fortified against its deleterious effects, and be speedily withdrawn on shewing signs of poisoning.

The answers to these questions lie in cleanliness of work and of person, with all that these involve in the way of ventilation, fume extraction, minimum of handling, baths for the workers and change of working uniform; a short eight hours' shift, avoidance of undue fatigue and of long hours of travelling to and from work, good canteen arrangements, dental treatment, instruction in personal hygiene (e.g. avoidance of constipation and selection of nourishing and suitable diet); and medical selection and frequent medical

^{*}A small quantity of urine is shaken with ether to remove any T.N.T. of contamination, the ether is separated and removed. Equal volumes of the urine and 20% sulphuric acid solution are then shaken together with a few ccs. of fresh ether. The ether is separated, washed free of acid with water, a small quantity of alkaline alcohol is added and if T.N.T. or its derivatives are present a pink colour is obtained.

inspection of the workers with instant withdrawal of any who shew signs of commencing poisoning - and such susceptible persons should not be allowed to work in T.N.T. again.

Alternation of work was never carried out at Queen's Ferry as was insisted on in the Regulations¹⁶ for filling factories; there ~~the~~ the workers were employed in T.N.T. for two weeks at a time and then had two weeks at some other work in another part of the factory; the manufacturing factories were also exempt from ~~other~~ provisions such as the supply of free milk to the workers - no harm resulted from these omissions. Alternation was quite unnecessary (as was demonstrated here), and besides obstructing output to an extent and exposing a far larger number of persons than was necessary to the risk involved in contact, it gave a false sense of security, for though the workers might be engaged in other work for the two alternate weeks there was no guarantee that they were free from contact during this period; the skin, hair, and underclothing might hold reserves of the poison which would continue to be absorbed. This was recognised in 1918, and where alternation had been enforced it was discontinued.

Apart from toxic jaundice, T.N.T. affected the workers in a variety of ways; those handling or in contact with the substance had their hands dyed a bright orange colour, and sometimes the skin of the forearms, face and neck was slightly tinged also, and the hair in front where it escaped from the cap took on a rich auburn tint. This discolouration was not permanent or very lasting, usually wearing off after two or three weeks away from the work; it was not jaundice but merely a dyeing of the outer layers of the epidermis by the chemical; much of it could be ~~removed~~ removed by rubbing with acetone, which is one of the solvents of T.N.T.

Many workers suffered at first from dyspepsia, from "T.N.T.

cough" and slight pharyngeal irritation when they worked in the houses; these complaints were due chiefly to inhaled T.N.T. dust, some of which was swallowed thus causing the stomach trouble. T.N.T. had a bitter disagreeable taste and this can be felt in the mouth by anyone lingering for a while in the purifying or packing houses. Neither the dyspepsia nor the pharyngitis is serious and they both yield rapidly to treatment such as Mist. Bismuth & Soda, or a gargle of glycerine and potassium chlorate or alum as the case may be, and even without treatment most workers soon become hardened and cease to be troubled in these ways. Very susceptible persons or those out of health however are more seriously affected, and acute gastritis or attacks of asthma and bronchial catarrh may result; such workers should be temporarily withdrawn and, if affected more than once, permanently removed from the process, as they are unlikely to be able to give good service and are a source of weakness, alarm, and discontent to the other workers. It was found that those troubled with recurring gastritis had almost invariably been subject to "bilious attacks" previously, or had neglected and dirty mouths.

Dyspnoeic attacks from inhalation of the fumes were common among the workers, but these were far less serious than the dyspnoea due to nitrous fumes for instance, being more of the nature of an asthmatic seizure which quickly passed off on the inhalation of the vapour of a few minims of ammonia and rest in a well-ventilated room. These attacks were generally believed to be due to the impurities and isomers present rather than to the pure T.N.T. itself.

Dermatitis is another trouble which must be guarded against;

its occurrence is very well known to the workers and the public generally, the rash even being mentioned in general literature such as Rudyard Kipling's Sea Warfare (1917) where he says "If you rake the tri-nitro-toluol by hand out of a German mine you develop eruptions and skin-poisoning".

Any form of skin disease occurring in a T.N.T. worker is usually attributed to T.N.T. by the patient and his friends; impetigo, scabies, pediculosis capitis with eczema, furunculosis, urticaria and even syphilis have all been put down to its account by the workers here, but the rash is easily differentiated, being very typical in distribution and appearance. It attacks a comparatively small proportion of the workers, (about 8%), being a much less formidable business than Tetryl dermatitis. It starts as a papular erythema and goes on to an inflammation of the skin, which becomes intensely itchy, hot, burning, swollen and red, and in some cases exuding serum and later desquamating extensively; sepsis may be superadded and a pustular eczema develop. The exposed parts were chiefly affected, hands, wrists, and forearms, neck, upper part of chest, and face.

Gloves were not found to be of much use as a preventive but strict cleanliness and complete change of contaminated working clothes before leaving work were all that was needed in most cases. Most of the workers are never affected; some are attacked when they first work in T.N.T., and later, after treatment, have no recurrence; a few are affected time and again and should be withdrawn from the work. These latter are usually of the seborrhoeic type whose skins are prone to any irritation.

The treatment found to be effectual in most cases was simply Calamine lotion (with glycerine, not the war-time substitute), and a brisk purge and simple diet for a day or two.

The workers themselves strongly believed that consumption could be brought on or at least greatly accelerated by work in T.N.T., and talked among themselves of instances - many true - of a girl or

boy having been well and strong before starting this work and then being taken ill, wasting away, and dying, and "the sin and the shame of it is the Government would pay his poor mother nothing". I investigated many such stories on behalf of the factory and am fully convinced that these cases were post hoc and not propter hoc; young persons were chiefly employed, early tuberculosis is most difficult to diagnose at a preliminary examination in the absence of any physical signs or of complaint from the entrant, and the numbers affected were less than in an unselected sample of the general population, though many unfit for military service and otherwise below par were employed.

There was an idea current at one time that T.N.T. might produce necrosis of the jaw (as occurs in phosphorus poisoning). No case of this sort has occurred in my experience, and if such can be caused it must be very rare indeed. It was found that workers with carious teeth, dirty and ill-kept mouths, and pyorrhoea alveolaris, stood the work badly and suffered more from T.N.T. minor illnesses than did the rest, and this can be easily explained by the lowered resistance to disease and the decreased vitality of such persons, and the special susceptibility to digestive disturbance due to the chronic gastric catarrh from which they often suffer. As mentioned previously persons suffering from gross oral disease or neglect should not be passed for T.N.T. work. If a few cases of necrosis of the jaw, Ludwig's Angina, or cancrum oris have occurred among the many thousands of persons working in T.N.T., would it not be as well to investigate the state of the mouth as regards septic stumps, carious teeth, alveolar abscesses, etc., before suggesting that T.N.T. is the cause of the trouble? Work in T.N.T. does not confer immunity against these or any other diseases.

Cases of aplastic anaemia have been recorded as occurring at

other factories but fortunately none were encountered here. On several occasions a case was suspected where a worker was pale, tired, and listless, and a blood examination was made, but in each case the blood film showed chlorosis only; these workers were transferred to outside work for a time and later allowed to go back to their own section. Not a few of the workers showed more or less marked cyanosis and these too were temporarily withdrawn from T.N.T. and given work in the open air; the condition in most cases cleared up rapidly and was not the precursor of more serious illness. In three cases only was it considered necessary to withdraw a worker permanently from the process on this account; in these cases there was deep cyanosis which recurred whenever the workers returned to contact with T.N.T., although they made no complaint and were very reluctant to leave the work.

It is a matter of considerable difficulty to differentiate an ordinary "stomach upset" or "bilious attack" from gastritis due to T.N.T. The history must be inquired into - has the worker been eating fish and chips, mushrooms, tinned lobster, etc.? is there constipation? does the complaint yield to a simple aperient? - If not, then one gives the benefit of the doubt, especially if there is epigastric pain and distension with a tendency to drowsiness, and if vomiting occurs more often than once or twice; and in that case the worker is sent off work on "compensation pay" until better.

After I took over this branch of work from the local Certifying Factory Surgeon all T.N.T. workers were personally inspected by me once in three weeks (each time they changed over to work on the morning shift) and any showing signs of being injuriously affected were transferred to other work temporarily, or permanently, as the case required. A trained nurse assisted at the inspections, helped to keep the records, and saw the workers daily while at work on the

T.N.T. section. Workers on certain other sections were medically inspected every week.

Mononitrotoluene (M.N.T.) and dinitrotoluene (D.N.T.) were also made and handled ~~on the same site~~, and the effects on the workers were very similar to those of T.N.T.; with the reservation that M.N.T. was less, and the D.N.T. was more toxic.

To sum up, T.N.T. causes two forms of grave illness - namely toxic jaundice and, much less frequently, aplastic anaemia; and several forms of what may be called minor illness - namely gastritis, pharyngeal catarrh, dyspnoeic attacks, dermatitis, cyanosis with insufficient oxygenation of the blood and accompanying breathlessness and fatigue. Any sign of the first two indicates instant withdrawal from contact with T.N.T. and energetic treatment; the latter though not to be regarded lightly are much less serious and usually yield quickly to treatment, and if the patient is temporarily withdrawn from the work he can resume it with safety later on in most cases.

Tetryl.

Trinitrophenylmethylnitramine, or tetryl (C.E.) as it is called, owing to the former belief that its constitution could be expressed as tetranitromethylaniline, is a fine pale yellow crystalline powder in many respects similar to T.N.T. but it is much more readily detonated and is very much less toxic: in fact as far as I know no death or case of serious illness has been caused by this chemical, and certainly none occurred here.

Quite unreasonably the workers dreaded it far more than they did the truly poisonous T.N.T., and much difficulty was experienced in getting them to work in it at first; this was perhaps due to two causes - the yellow discoloration of the skin which it caused, and the rash, with which most were troubled soon after commencing

work among it.

I have not seen a case of poisoning or of constitutional disturbance caused by this substance and am inclined to believe that its effects are local only, on skin, or on the respiratory, or gastric mucosa as the case may be.

It was reported to have various ill-effects on the system - to cause anaemia and bleeding from mucous surfaces, to cause gastric catarrh, and a condition of toxic weakness of the cardiac muscle known by the chemists and others as "tetryl heart". An account has been published¹⁹ describing alarming symptoms due to this cause such as menorrhagia, blood changes, and all sorts of ills; these in my opinion are not credible, and no doubt the author on further experience will wish to revise what has been written.

At this factory tetryl was the cause of epistaxis in many cases, and was credited with being the cause of many more; the sharp minute crystals when inhaled irritated the mucous membrane of the nasal cavities, in some cases causing sneezing and bleeding, but in most what happened was that the fine tetryl dust on inhalation became partly dissolved in the alkaline nasal secretion changing in this medium from yellow to red in colour when a handkerchief was used it became stained a bright pink, and the worker thought his (or more often her) nose had been bleeding. This is a very different matter from causing such profound blood changes as to give rise to spontaneous haemorrhages from various mucous surfaces of the body.

Though I inquired carefully I could find no evidence whatever that menorrhagia was caused by it; on the contrary many of the younger women told me that since working in the tetryl section their menstrual loss had been less and their periods shorter than before - no doubt due to the active exercise involved in the work.

Gastric catarrh was a common complaint, and was due more to

the acid used in the process of manufacture than to the tetryl itself, though it could no doubt cause gastro-intestinal irritation when swallowed; workers complained of loss of appetite, nausea and heart-burn, and in some cases of diarrhoea, this was never severe and yielded to a simple alkaline mixture and regulation of the bowels and of the diet. When pastry, pickles, fried potatoes, and strong tea were avoided work in tetryl seldom caused dyspepsia.

Here again it was noticed that the older women suffered most, the reason being that many had insufficient rest at home. Those with dirty and diseased mouths or subject to dyspepsia and "bilious attacks" should be excluded from this work.

Pharyngeal irritation with cough was fairly common among new workers but this usually passed off as they became accustomed to the atmosphere of the work-rooms. Some few workers suffered from dyspnoeic or asthmatic attacks due to the inhaled dust or fumes causing bronchial spasm, the attack usually passed off quickly in the fresh air, but a few who were more severely affected or who had repeated attacks were finally sent to other work.

Anaemia was often attributed to tetryl, probably by analogy with that caused by T.N.T.; I never found any proof of this however, and cases on investigation could always be accounted for as chlorosis or secondary anaemia. Most of the workers said their health had improved and that they felt better since commencing work in tetryl.

The cardiac weakness attributed to tetryl was - to use a Scottish legal term - not proven. Contrary to the usual course of things members of the staff complained of this more than did the workers, and in cases investigated by me long hours, sedentary work, unusual responsibility, lack of social amenities, impending medical examination by the military authorities, dyspepsia due to irregular meals, all contributed to make the patient unfit; and when these

causes, or most of them, were removed the palpitation, shortness of breath, sleeplessness, and tired feelings which were the chief complaints cleared up too. In my opinion the so-called "tetryl heart" is in reality a mild form of neurasthenia or nerve exhaustion due to heavy responsibility and long continued dull routine work.

Tetryl rash was the chief trouble, and a very serious one too from the point of view of output, loss of time, and wastage of labour; the incidence among the new workers being over 90%, though a seasoned worker was seldom attacked. Tetryl is certainly a very potent skin irritant, and practically every worker has to undergo a baptism of fire before becoming accustomed to contact; it acts on the skin in two ways (1) as a mechanical irritant, the sharp edges of the minute crystals wounding the epithelium; and (2) as a chemical irritant inducing inflammation.

Tetryl is soluble in the sweat and workers who perspire freely or have a seborrhoeic tendency suffer most from the rash.

Much can be done to prevent it in its severer forms, and where the powder is handled for filling purposes only, and gloves and glass screens can be used, the incidence can be diminished to a small fraction of what was encountered here. The nature of the work made these means out of the question for Queen's Ferry, where the explosive had to be manufactured ab initio, where the powder had to be dug out of vats with scoops by hand, and sifted, corned, and packed in a dry state, and where however good the ventilation might be, the dust filled the atmosphere in almost invisible microscopic particles.

The work done at Queen's Ferry largely kept down the rash incidence elsewhere, for the finished product - minute grains or small round masses of gum arabic and tetryl powder - was easy to handle and gave off comparatively little dust.

The general methods of prevention need not be reiterated here, they are found to be laid down in the report of the Health of Munition Workers Committee and I shall only mention the special precautions found useful here in addition to the baths, change of clothing, etc., provided in all factories where tetryl was handled - any inert substance which would form a thin adherent coating to the skin of the exposed parts was found to be as helpful as a preventive of the rash; several were tried, among others an ointment made of one part of castor oil to two parts of Zinc Ointment (B.P.), a casein varnish, and a dusting powder made of equal parts of starch, calamine and zinc oxide. The latter was preferred after various trials as it was pleasant and easily applied, easily washed off, and non-greasy or sticky. The other methods were quite efficacious if carefully used but were more difficult of application and seldom got a fair trial.

Tetryl dermatitis was much more severe and more frequent in incidence than that caused by T.N.T. A few individuals escaped the rash altogether; the majority soon after commencing work had an attack, which yielded to treatment fairly easily, and in many cases did not return when the worker became more accustomed to the processes and more used to the routine of preventive measures; a few were attacked time and again with increasing severity and had to be withdrawn from that work altogether. These were the seborrhoeic and catarrhal types, and after a time this was recognized and such were not sent to work in Tetryl.

The rash was a typical inflammation of the skin due to irritation, it attacked any exposed part, but the face and neck were particularly susceptible and the eyelids, even in slight cases, were much swollen; there was redness, itching, local heat and swelling,

with serous exudation in severe cases followed by desquamation . Most cases yielded readily to treatment, which consisted of a saline purge, light diet, with local application of a soothing alkaline lotion such as that advised by the Ministry's medical advisers:- Calamine gr 70, Ol. Olivae and Aq. Calcis, aa ʒi. If neglected the inflamed skin becomes septic and impetiginised and much more difficult of treatment.

Conjunctivitis occurred in practically all severe cases of dermatitis of the face. It yielded readily to treatment such as adrenalin (1%), or collosol argentum drops applied to the conjunctival sac, with shading and resting the eyes.

It is important to keep the premises cool in which tetryl is handled as the dermatitis and other troubles are much aggravated by a hot atmosphere; even washing in hot water or sitting too near a fire at home should be avoided, as these can bring on an attack in a susceptible worker who otherwise might have escaped.

The yellow discoloration of the skin already alluded to is a superficial staining only and wears and washes off in a short time when contact with the chemical ceases; many degrees of this staining occur, from the slightest yellow tinge of the hands and face, hardly perceptible in some who carefully use the protections provided, to a bright canary yellow colour of all the exposed parts, and sometimes of the whole body, where the rules regarding bathing are shirked or are half-heartedly carried out.

Conclusion.

In conclusion, the work of a factory medical officer can be both interesting and varied. There is much routine and administrative work in a large factory with an organised medical and First Aid staff that may be dull and unattractive, such as the ordering

and checking of medical stores,engaging and control of staff, inspection of lavatories,latrines,messrooms and workshops; but there is also much that is worth while and that gives opportunities for scientific research or for clinical experience according to the individual temperament. To separate such a service from the clinical aspect and from treatment of cases would be to rob it of much of its interest and of a great part of its value.

A factory medical officer should aim at becoming a specialist in industrial diseases,their prevention and their cure. Such an officer must have large powers and must use them with wisdom; and should not be too recent a graduate. The power and privileges of the position must never be abused to exploit individual fads and fancies regarding social and other reforms. No regulation and no structural alteration should be advised without serious consideration. Output is the purpose for which a factory exists, and if a medical service obstructs this needlessly it is a hindrance and will not be tolerated.

The medical officer should have the power of withdrawing from work instantly any who may be damaged by it,and of selection and rejection of candidates for employment; and also have advisory powers regarding conditions of work and construction of workshops, etc. The welfare work should be carried on under the supervision of the medical officer,who should have a recognised place as a senior member of the staff with direct access to the superintendent.

The factory medical officer should not treat the workers or their families in their homes; for to do so,besides competing unfairly with the local practitioners,robs the position of its independence when cases for compensation come up for consideration. If a dissatisfied worker could remove his name from the factory medical officer's list, could persuade others to do the same and

could take his family with him, this could not but bias the opinion, perhaps subconsciously, of the doctor if a decision had to be made for or against continuation of payment of compensation. This point need not be laboured, but a whole-time salaried medical officer has a great advantage over one whose income depends even in part upon whether he pleases the workers or not. If the work of one factory is not sufficient to keep a doctor fully employed, in my opinion it would be better to group several factories under the care of one medical officer rather than to fill in the time and augment the salary by panel work or general practice in the same neighbourhood, as has been done in certain cases.

There is great scope for further work with regard to industrial diseases and their prevention, and not only so but in connection with the injuries and minor illnesses that are almost inseparable from certain industries. If these questions receive immediate skilled attention in most cases they cause little or no disability or loss of time, but if neglected or if treated by the worker or his fellows may lead to much suffering and disablement.

A factory medical service, efficiently and conscientiously conducted, will repay its cost over and over again; and will result in economy of the workers' time and even on occasion will be found to have to its credit the saving of lives.

As an example of one aspect of the work at H.M. Factory, Queen's Ferry it is worthy of recording that out of a series of over 2,000 cases of eye injury only one eye was lost and one other seriously damaged. Not a single life was lost from T.N.T. poisoning though, as previously mentioned, over 60,000 tons of this body were manufactured, and that often under conditions of great stress. The results were equally encouraging in other instances.

To quote an American writer²⁰ "Industrial medicine is not

only humane but is essential to production. It is beneficial to workers and profitable to employers. It offers splendid advantages to physicians for the development of careers in a field of rapidly growing importance ...". A great and useful future should lie before this branch of medical science.

Sept. 1919.

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