LABORATORY AND PLANT

THE MANUFACTURE OF PICRIC ACID FROM THE MEDICAL STANDPOINT

By F. O. West, M.D., Resident Surgeon

New England Manufacturing Company, Woburn, Massachusetts

A study of the medical complaints of workmen engaged in the manufacture of picric acid has furnished much material that is interesting, and some of which, I trust, will be of value to others. Although this investigation has covered the short period of nine months, a report is made at this time because, owing to the excellent system of manufacture recently installed, the number of accidents from this trade will be greatly reduced. A subject as many-sided as this cannot be fully discussed in a short paper: therefore, as the chief danger arises from the fumes of nitric and mixed acids, this particular part will be more fully treated.

The conditions under which our men work, and the vigorous medical supervision, have been important factors in minimizing the accidents of a dangerous trade. The building devoted to making picric acid was erected especially for this purpose and is a modern, substantial structure. The systems of lighting and ventilating are adequate; exits are numerous and of easy access. The new method of manufacture has almost eliminated the escape of fumes in the building, and has markedly reduced the number of acid burns. Our hospital department, described in a recent publication,¹ is thoroughly organized and completely equipped.

The examination of all new men, and the reexamination of the older employees at frequent intervals, have much to do with preventing accidents by weeding out the unfit and discovering intercurrent disease. This work has given much valuable information, and has been the means of rejecting 9 per cent of all men applying for employment. The reasons for rejection include: heart lesions, albumin and casts in the urine, asthma, bronchitis, aortic aneurysm, mediastinal tumor, arteriosclerosis, and alcoholism.

PHYSICAL EXAMINATIONS

Realizing that a permanent and well-trained force of able-bodied men is of great value in preventing accidents and illness, much attention has been given to accomplishing this thing. As a result there have been many changes in the employees of this department; signs of unfitness and inborn carelessness soon show themselves. Our records give the interesting information that we have had the representatives of 18 nationalities and 4 races among the men working with picric acid; moreover, we have recruited from 32 different occupations, varying from laborers to college graduates. None of these men were familiar with this particular trade before coming to this plant. No class or race of men seem to be especially sensitive to the dangers of this trade: a strong, healthy, non-alcoholic man, free from arteriosclerosis, has proved a good risk, even in regard to fume poisoning.

¹ Boston Medical and Surgical Journal, December 21, 1916.

The information concerning fume poisoning has been obtained from 398 cases reported at our hospital, and we make a strenuous effort to have all men so affected come for treatment.

No. of Men.....	50	29	25	13	7	2	4	3	2	2	2	Total Cases
No. of Attacks...	1	2	3	4	5	6	7	8	9	10	13	398

Twenty-nine cases were serious enough to require bed treatment in our hospital ward, for periods varying from 1½ day to 3 days. The absence of any deaths in this series of 398 cases is due, we believe, to the vigorous method of handling such accidents.

DELAYED ACTION OF FUMES

Our experience is in accord with that of other observers in that mild and apparently insignificant attacks may result in serious consequences, which, at the time, could not be foreseen, and also, that fume poisoning may have a delayed action. The following case will illustrate both points. One of the older employees, having become careless and believing himself immune to fumes, neglected to report at the hospital after two very slight attacks. When he left work some time later, there was absolutely nothing to indicate that he was not perfectly well. He ate supper and went to bed in his usual good health. On being called to breakfast, about twelve hours after the last attack, he was found to be semiconscious and breathing with great difficulty. He remained in this condition three days, but finally recovered and soon reported back to work. Since then, about three months, he has worked here but in another department, and as far as we are able to see, has not suffered from his experience.

The symptoms given by our cases do not vary from those already stated by other observers, and will not be taken up in this paper.

AFTER-EFFECTS OF FUME POISONING

As to serious complications and sequelae of fume poisoning, our observations do not include a large enough number of cases or extend over a long enough period to warrant making any positive statements. Our investigation, however, has not disclosed any cases of pneumonia or any predisposition to affections of the respiratory apparatus. Although we have had 398 cases of fumes, there have been only 7 cases of coryza and 7 of bronchitis in this series treated at the hospital, and the men having the greatest number of attacks of fumes were not more susceptible than the others. Neither do repeated examinations of the urine show any evidence of renal irritation. It has been noticed that men working where fumes are present show a tendency to headache, constipation and indigestion. How much of these can with fairness be attributed to fumes is problematic, for these workers have changed more frequently than those in other departments of the plant, and many "sour stomachs" among men who cannot hold a job for any length of

time can easily be blamed on something else besides employment.

METHODS OF TREATING "FUMES"

The method of handling "fumes" is the same in all instances regardless of the mildness of the attack, or whether we believe it due to apprehension or malingering. Foremen are instructed to send to the hospital all men affected, and the hospital department sees to it that such men do not leave the plant till they have again reported. Treatment, whether the man is coughing or complains simply of a slight oppression in the chest, is started with the lungmotor, which we have modified somewhat to suit our needs (see Fig. 1).

FIG. 1—LUNG MOTOR MODIFIED TO TAKE UP AMMONIA FUMES

Instead of using simply air or oxygen, we have so arranged that the air takes up ammonia fumes by being drawn over the surface of aromatic spirits of ammonia. This mixture is so regulated that the ammonia fumes can be forced into the lungs without causing any great inconvenience to the patient, and can be kept up indefinitely. Prolonged treatment, however, has not been necessary, as the relief is almost immediate. If oxygen is used, it is supplied from a small cylinder, and not taken from the generator that accompanies the apparatus. When cough and substernal distress are relieved, the patient is kept under observation for some time before being allowed to return to work, and from time to time inhales ammonia fumes from a small bottle of ammonium carbonate cubes. Internal treatment consists of aromatic spirits of ammonia and a saline laxative. Chloroform has not been used. The men are also instructed to refrain from smoking and the use of alcohol. Bed treatment in our hospital is insisted upon in cases that cause any anxiety, or when the man lives away from this vicinity and under unfavorable home surroundings.

There has been one case of chronic fume poisoning in a man who had frequent slight acute attacks, and was indifferent to the methods used for self-protection. This man showed a slight cough and bluish lips. He did not report till forced to by a severe attack and was thus discovered. These symptoms cleared up when he was put to work outside and he shows no ill effects.

EYE BURNS

There are other ailments worthy of note that affect men in this employment. The next most serious class of injuries that we have to deal with are mixed acid burns of the eyes; and these are difficult to prevent as the men will not use the goggles provided. It is not uncommon, on calling a man to account for not wearing his goggles, to have him state he had them in his pocket. The gambling instinct to "take a chance" is responsible for a large percentage of accidents. Under the old method of manufacture in earthenware pots, these injuries were numerous and sometimes serious. But it is marvelous to see an eye clear up that has been so badly burned that the sclera is edematous and lies in folds that protrude between the lids, and has the appearance of the white of a fried egg, the cornea being at the same time obscured by a brownish opacity. There have been 50 acid burns of the eye, varying in severity. In only one case, as far as we have been able to learn, has there been resulting interference with vision. In our first-aid racks we have a bottle of limewater to be used at the time of accident. At the hospital the eye is irrigated with a quart of limewater to make certain that all the acid is neutralized; this is followed with an irrigation of warm boric acid solution and hot boric compresses applied till the inflammation subsides.

DERMATITIS

Dermatitis of the forearms and parts of the body that come in contact with dirty hands is very resistant to treatment. In the summer, when men perspire freely and do not change their clothing frequently enough, a dermatitis is set up, apparently due to acid irritation; failure to keep the hands clean carries this trouble to other parts of the body. Treatment consists in first cleaning the part thoroughly with soap and water, and then going down the list of the conventional lotions, ointments, and powders till the most beneficial one is discovered.

Indigestion, headache, and constipation have been very frequent causes for complaint. Whether these are due to hasty eating, many times to poor lunches, to alcohol, to improper attention to the bowels, is hard to say, but these certainly have been very important factors. I believe we should be reluctant to attribute these complaints to working conditions, till the other contributing causes are ruled out.

ACTUAL PICRIC ACID POISONING

Finally, there have been very few cases of an interesting condition that we have attributed to picric acid poisoning. These have been men who had been engaged in scraping the brick lining of the diluting tanks. Inhalation of the dust made the men light-headed, dizzy, and caused them to say things which they were conscious were silly and absurd, but which they could not control. At the same time they were unsteady on their feet. There was no cough, substernal oppression, or praecordial distress. Benzol was not in any way concerned. After a short period of rest in the fresh air, these symptoms disappeared.

Repeated physical examinations of the older employees and careful inquiry have failed to discover a symptom-complex that could be attributed to chronic picric poisoning. If the digestive disturbances above mentioned are evidences of such poisoning, then we must admit that such a condition is very easily and rapidly acquired, as many of the men with these complaints reported shortly after being employed. The men working with this substance for the longest time show no predisposition.

This is without question a dangerous trade and many accidents occur as a natural result. Even though a company makes every effort to protect its men, trouble will still follow gross carelessness on the part of employees; and it is entirely proper to attribute a very large percentage of accidents to this cause. Also, because it is a dangerous occupation, and the men are working with something that is more or less a mystery to them, they are prone to find in their work a cause for all their bodily ills, regardless of how absurd may be the relation of cause to effect.

WOBURN, MASSACHUSETTS

A NEW DIRECT READING PRECISION REFRACTOMETER WITH UNIFORMLY DIVIDED SCALE

By G. W. MOFFITT

Received December 18, 1916

I—INTRODUCTION

It has long been known that the value of the index of refraction frequently serves as a valuable criterion of the qualities of a liquid. That the means for testing thus afforded is not in more general use seems to be due to the lack of satisfactory means for easily determining the index of refraction rather than to any inherent weakness in the method itself. If some dependable instrument combining ease of operation with accuracy of results were at hand it is probable that there are many who would avail themselves of its possibilities. While there are several good refractometers which may be obtained, their use involves a great deal of care and skill if results are to be obtained showing the necessary high degree of accuracy. In some of them the operation is long and the result is not available without more or less calculation and reference to tables.

There seems, therefore, to be a real demand in the field of food and industrial chemistry for a simple, accurate refractometer so simple in operation that one without any special knowledge of optics could obtain accurate results easily and with certainty. Such an instrument has been recently designed by the writer¹ and a brief description of the refractometer and a discussion of its theory are here given for the purpose of placing the instrument before those who have need of it in their work. The good points of the instrument will appear in the discussion, and may be briefly summarized as follows:

1—A linear scale calibrated directly in terms of the index of refraction of the liquid under examination.

¹ *Physical Review*, December, 1916.

2—The possibility of so constructing the instrument that white light may be used when it is desired to determine the mean index, the instrument still retaining approximate achromatization in many cases.

3—Simplicity, and ease of manipulation.

4—Few adjustments other than those fixed permanently in the construction of the instrument.

5—Settings obtained by comparing the dimensions of an image with those of an eye-piece scale—an accurate means of determining the proper adjustment.

6—Adequate means for temperature control whenever required.

7—Small amount of the liquid required for a determination, a single small drop being sufficient.

8—Ability to determine the index to one or two points in the third decimal place—a degree of precision equal to, if not better, than that of the total reflection instruments.

The entire operation of determining the index of refraction of a liquid consists in placing a drop of the liquid at the proper place on a convex surface, bringing the nose of the microscope down upon it, and focusing the eye-piece. The value of the index is then read off directly from the uniformly divided scale on the focusing tube of the instrument. In an instrument of convenient size the change in setting for a change of index from 1.000 to 1.500 may be more than 10 cm. With an eye-piece of fairly high power the uncertainty in a setting need not be more than 0.02 cm. In most cases it will be less. The sensitiveness will, therefore, compare favorably with that of the best total reflection instruments.

II—THEORY

CASE 1—Consider the arrangement shown in Fig. I. Let a point source of light be placed at C, distant R below the surface of the liquid. Its image, due to the refraction at the surface of the liquid, will be at S, so that $ST = R/n$, where n is the index of refraction of the liquid. Let S act as a virtual object at distance $k + R/n$ from a converging lens L of focus f , and let the image of S formed by this lens be at I, distant p from the lens. Then

$$\frac{1}{k + R/n} + \frac{1}{p} = \frac{1}{f} \quad (1)$$

Clearing of fractions,

$$npf + knf + Rf = pkn + Rp. \quad (2)$$

This equation becomes linear in n and p when

$$npf = npk, \text{ or when } k = f. \quad (3)$$

Equation 2 then becomes

$$n = \frac{R}{f^2} p - \frac{R}{f}. \quad (4)$$

That is, if Equation 3 is satisfied, the position of the image depends directly on the index of the liquid.

CASE 2—Consider the arrangement shown in Fig. II. Let the point source be placed at C, the center of curvature of a spherical lens having concentric surfaces, and let a drop of the liquid be placed between the lens