THE LESSENING MENACE OF BENZOL POISONING IN AMERICAN INDUSTRY*

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IN THE issue of *The Journal of the American Medical Association* for March 4, 1922, there appeared an article over my name entitled "The Growing Menace of Benzcnc (Benzol) Poisoning in American Industry." This embodied the results of an inquiry into the industrial use of benzol at the time, made with the assistance of manufacturers and insurance companies. Only six years have elapsed since that date, but so great have been the changes in manufacturing processes during this short period that I am impelled to write a brief report on the now lessening danger from benzol in industry. Were I to wait another year it is probable that the showing would be even more favorable.

The credit for this great and beneficent change should be given primarily to the Chemical and Rubber Sections of the National Safety Council, an association of industrialists and companies writing industrial insurance, which at the annual meeting in Detroit in the fall of 1922 appointed a committee[1] to study and report on the use of benzol in industry and its possible harmful effects. The work of this Committee was prolonged for three years and in May, 1926, a final report was issued (1) (2) in which were described the chief industrial uses of benzol, the methods of use, and the incidence of benzol poisoning among workers as determined by clinical symptoms together with examination of the blood. A quantitative estimation of benzol in the air of factories was made, and by checking up the blood picture of those examined with the air analysis it was possible to determine the lowest concentration of benzol in the air which might bring about a leukopenia. It was found that 32 per cent. of the workers examined had leukopenia, mild or pronounced, and that this occurred in workrooms with good exhaust ventilation and low atmospheric contamination, as low as 100 parts of benzol per million of air. The Committee was thus "forced to conclude that the control of the benzol hazard (except where the substance is used in completely closed systems) is exceedingly difficult; that in practice, systems of exhaust ven-

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[1] The Committee was constituted as follows: C.-E. A. Winslow, Yale, Chairman; Leonard Greenburg, United States Public Health Service, Vice Chairman; W. S. Paine, Aetna Life Insurance Company, Secretary; H. Bradshaw, E. I. du Pont de Nemours & Company; J. W. S. Brady, M.D., Massachusetts General Hospital; A. C. Fieldner, United States Bureau of Mines; C. F. Horan, Hood Rubber Company: L. E. Weber, Consulting Chemist, J. M. Weiss, Manufacturing Chemists' Association.

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tilation capable of keeping the concentration of benzol in the atmosphere below 100 parts per million are extremely rare; and that, even when this is accomplished, there remains a decreased, but substantial, hazard of benzol poisoning." They recommended the substitution of toluol and xylol for benzol, and described experiments carried out at Yale University by J. J. Batchelor (3) which showed that these homologues of benzol are far less toxic than benzol itself, producing only a slight anemia and having no effect on the leukocytes (4).

Even before the publication of the Committee's final report, the changed attitude of industry toward the use of benzol had become evident. A large shoe company which had used benzol in cement wrote me that because of its experience with one girl employee who had excessive and irregular menstruation it had abandoned the use of benzol although the new solvent involved the expenditure of $150 a day more than the old. Machine shops spraying coatings began to use lacquer made with toluol. Many rubber factories returned to the use of petroleum solvents for spread rubber goods and for most of their cements. In dry cleaning, benzol was already disappearing, and the protests of the organized painters against the use of this thinner in quick-drying paints were beginning to have some effect.

It was, however, the introduction of rubber latex (5) as a substitute for rubber dissolved in benzol that made possible the greatest changes in the benzol using industries. Latex is the milky fluid which is drawn off from the rubber tree after slitting the bark. The practice in rubber plantations has always been to coagulate it at once, make it into sheets, and ship it in this form, but by this new method coagulation is prevented by the addition of ammonia, which inhibits the growth of coagulating bacteria, and the latex is shipped to this country practically unchanged. Various substances (secret) are added to it to make it plastic, viscous, waterproof, and rustproof and to color it. This liquid rubber is finding extensive use in industries which formerly required benzol-rubber solutions, or naphtha-rubber, especially for impregnating fabrics, or for cementing, or for producing hermetically sealed containers.

Present Use of Benzol in Industry

The National Safety Council listed as the chief benzol using industries in 1922: *(a)* rubber, especially tire building; *(b)* artificial leather manufacture; *(c)* sanitary can manufacture; (*d*) dry cleaning; (e) paints, varnishes, and stains—their use rather than their production. Let us take these industries in order and see what the situation is at the present day with regard to the use of benzol.

Rubber Industries

Rubber tire building still employs benzol as a solvent for the cement, and large amounts are used. The risk is much greater for the tire builder than for the cement mixer; in fact, when mixing is properly carried on there is no escape of benzol vapor. But in tire building each layer of rubberized cord or cloth is painted over with benzol cement, and the tire is built up of many layers. The nature of the

work does not permit placing exhaust ventilation in such a position as to carry off all the dangerous fumes. It was in tire building that Harrington's (6) five cases of benzol poisoning, with aplastic anemia and hemorrhages, occurred, all in men, all severe, and three fatal. Although benzol has not been displaced in tire building, there are other processes in tire making where latex is being introduced. Thus cord fabric is now made by drawing parallel cords through a bath of latex and drying them carefully in the proper spacing so that a sheet of fabric results in which the cords are held together by a wall of rubber. It is said also that inner tubes can be made from latex.

Benzol is still used in making rubber cement for shoes and for fastening rubber heels on leather shoes, as can be seen from a recent article by Hunter and Hanflig (7) describing six cases of benzol poisoning, three of them in shoe factory workers, and a fourth in a cobbler, all of whom used a cement containing a large proportion of benzol. Two were women, one of whom died; one of the men also died. Many shoe factories, however, have given up benzol cement and are using latex, for leather, for rubber and leather, and for fastening sole welting.

In making spread rubber goods, impregnating fabric by pressing rubber dough into it and driving off the solvent by heat, benzol may be used, although apparently not often as a regular procedure; still it may be used from time to time as the market for the petroleum solvents varies and as benzol is for the time being more available and cheaper than naphtha. Making spread rubber goods is a process which produces almost invariably dangerous quantities of benzol vapor, as the rubber dough is spread by means of a long, fised knife over the fabric which then passes on over steam pipes, to emerge from under a hood or out from a chamber still warm and with some of the benzol still evaporating (8). That the escape of fumes is inevitable is seen from the high fire insurance rates imposed in such a plant. Even when naphtha is used, the work is unhealthful, and it is therefore a great advance in industrial hygiene to be able to substitute latex for rubber solution in making spread rubber, as one of the largest firms in the country is already doing.

Dipped rubber goods, such as surgical gloves, may now be made from latex instead of rubber-benzol, as I have myself seen done, and we are assured that this use of latex will be greatly extended in the future.

Artificial Leather Manufacture

Artificial leather manufacture involves the use of great quantities of coating which, up to the present time, has always contained benzol.[2] In reading the reports of benzol poisoning in the literature it is often difficult to determine whether the victim was occupied in making artificial leather, fabrikoid, by spreading a coating on fabric, or in making patent leather by spreading a coating on skins. Essentially the two processes are the same, for in both the coating contains benzol. These new coatings, which are also used now as lacquers for all sorts of surfaces, consist of nitrocellulose dis-

[2] According to Greenburg of the National Safety Council Committee, there may be as much as 60 per cent. of benzol.

solved in normal butyl acetate or sometimes a mixture of ethyl, amyl, and butyl acetates, together with normal butyl alcohol. Some oil, usually castor oil, is added as a plasticizer, and then benzol or toluol is added as thinner and solvent. Normal butyl acetate would do the work alone, but it is much more expensive than the aromatics and therefore they are used up to the point at which they cease to act as solvents and begin to precipitate the nitro cotton. At present lacquers used for spraying usually contain toluol, but for patent leather and artificial leather the more quickly evaporating benzol is preferred by many manufacturers, although some have given up benzol and are now using toluol because of its greater safety.

The coating may be spread over the fabric in the same way that rubber is spread, or it may be applied by a stiff brush, or pressed into the leather with a broad knife held slantingly. Necessarily, in doing this hand work, the men must bend over the skin or fabric, and it is difficult to see how exhaust ventilation could be so placed as to protect them efficiently, for it is even difficult to provide adequate window ventilation without causing drafts of air which might deposit dust on the coating and spoil it. This is especially true of patent leather where the slightest blemish shows.

Two of Hunter and Hanflig's (7) six cases contracted benzol poisoning in making patent leather, and in a personal communication from New Jersey (1927) I was informed of a fatal case in a man doing the same work.

Sanitary Can Manufacture

Perhaps the most notorious source of benzol poisoning in American industry has been the manufacture of so-called sanitary cans for food products. Selling's (9) famous cases came from a Maryland factory making cans; so did McClure's (10); so did Hogan and Shrader's (11); and two which were reported to me personally in 1925 came, one from Maryland, the other from the Pacific coast. Insurance men have assured me that for every case of benzol poisoning in the can industry. which came to light there were at least ten which remained unpublished. The fact that Maryland factories so often occupied the limelight was due not to worse conditions in these plants but to the brilliant work of Selling of the Johns Hopkins Hospital, which early called the attention of Baltimore to this condition.

These "sanitary cans" began some twenty years ago to take the place of the former lead-soldered cans as hermetically sealed containers for "processed goods," *i.e.*, cooked and sterilized foods. They have several advantages over the old type of can which required skilled solderers, whom it is difficult to find in the remote country districts where most canneries are situated. Moreover, the opening in the old type of can was at the most only 2 inches in diameter, and such vegetables as tomatoes and sweet potatoes had to be crushed to get them in. The new can is made with ends which are the full diameter of the can, so that filling is greatly facilitated. Sealing is effected not by solder but by clamping the end around the body of the can. Something, however,

must be used to make it absolutely air-tight. This can be done by a paper gasket if the contents of the can are somewhat liquid, for then the paper swells and makes the joint tight. I saw paper gaskets in use in the great Dole pineapple cannery at Honolulu. They can also be used in canning tomatoes and corn, but not for drier foods such as spinach, beans, fish, nor for liquids. For these it has been customary to use a thin rubber cement made with benzol, a very fine stream of which is forced into the channel around the edge of the end piece, the benzol being then driven off in a heated chamber and the end piece coming out with a thin band of the rubber in place. Since it is easier for canneries to use one kind of can for all their products, there is not nearly so much demand for paper gaskets as for rubber-sealed cans, and the can making industry was, up to two years ago, one of the largest consumers of benzol in the country. It was among the women and girls who received the can ends from the evaporating oven and inspected and stacked them while still warm that the cases of benzol poisoning developed.[3] As recently as March, 1928, an article appeared in THIS JOURNAL, by Adelaide ROSS Smith (13), describing benzol poisoning in women employed at such work, in three New York can factories. Among twenty-five women exposed to benzol fumes, six showed evidence of chronic benzol poisoning.

During the last eighteen months this industry seems to have undergone a revolutionary change and benzol has been largely eliminated. This was brought about certainly in part by the earnest desire of some manufacturers to put a stop to the continually recurring cases of poisoning among the young women employed as takers-off, cases which appeared even in the best ventilated factories. The new sealing compound is rubber latex, and the rapid development of its use may be seen in the statement of a firm which produces sealing mixtures. Formerly this firm made for the trade about 500,000 gallons of benzol-rubber compound a year; now they make hardly 12,000, all the rest of their production being latex.

Recently it was possible for me to visit five large can factories, belonging to three companies. In all but one of these, latex is used for sealing cans. The largest company in the country has adopted it altogether, the next largest has introduced it only partially, still using in some branches a rubber solution, but not benzol. In visiting these places it was easy to see that contamination of the air with benzol fumes must have been inescapable even in the best factory, while in one where I found fifty-four coating machines closely crowded together in one rather low-ceiled room, the situation must have been fraught with real danger. It is hardly an exaggeration to say that this change in sealing mixture means as great a reform in the large and growing can producing industry as was brought about in the match industry by the substitution of sesquisulphide of phosphorus for yellow phosphorus. The hermetic sealing of bottles, however, is still

[3] The case of fatal benzol poisoning reported by Speidel and Melgard (12) was in a woman who is said to have dipped rubber rings in benzol and then applied them to the ends of the cans.

effected by means of a rubber-benzol mixture.

Dy Cleaning Industry

Dry cleaners do not use benzol any more in New England. As to the rest of the country, I cannot speak with positiveness. I have a personal communication concerning a woman severely poisoned in a dyeing and cleaning establishment in Indiana, in 1927, but that is the only instance which has come to my knowledge in recent years. The fire hazard from benzol is great, leading to high insurance rates, and naphtha is generally used in its place. The naphtha selected has of late years been one of the higher-boiling and less volatile distillates, because the lower-boiling fractions axe needed for motor car fuel. A still less volatile distillate, known as "Stoddard's Solvent" which distils between naphtha and kerosene, is beginning to make its way into dry cleaning establishments, and, since it is classed by the insurance companies after evaporation tests as no greater a risk than kerosene, it is evidently much lees volatile and therefore less toxic than naphtha.

Paint Industries

The fifth important industry in the National Safety Council's list is the painting trade, where benzol is added as a solvent and a thinner to paints, varnishes, and stains, and is an important constituent of paint and varnish removers. Benzol evaporates much more quickly than naphtha or even petroleum ether, and therefore is valued as a thinner for quickdrying paints and for nitrocellulose lacquers. In this field also, recent years have seen a change for the better, for much of the lacquer now used for spray coating is made with toluol, and there is a strongeffort on the part of painters' organizations in such states as New York, Massachusetts, New Jersey, and Wisconsin to prohibit the use of benzol in any coatings which are to be applied by spraying.

Haircloth Manufacture

Another industry which deserves mention although it is not so important as the others is the making of haircloth. Formerly a soiution of rubber in benzol or naphtha was used to bind the material together and prevent the hairs from pulling out; now it is found that latex can be used for this purpose very successfully.

SUMMARY

The use of benzol in American industry has markedly decreased in the past six years and is still decreasing. Credit for this reform is largely due to the Kational Safety Council's investigation and the subsequent campaign of education among its members.

The greatest change is in the making of sanitary cans where benzol-rubber sealing compound is being rapidly replaced by rubber latex. Other occupations in which latex is displacing benzol-rubber are: making cord fabric for tires, cementing shoes, both rubber and leather, making dipped rubber and spread rubber goods.

Toluol is displacing benzol in nit—cellulose coatings and lacquers, while naphtha, or the less volatile petroleum distillate "Stoddard's Solvent," has largely displaced it in *dry* cleaning. Several state organizations of the painters' union have carried on suc-

cessful agitation against the use of benzol in quick-drying paints and other coatings.

Benzol is still generally used for coating patent leather, and sometimes artificial leather; for sealing bottles; for fastening rubber heels on leather soles; for tire building; and as a constituent of paint and varnish removers; but it is believed by insurance men and by many industrialists that in these processes also substitutes for benzol will eventually be found.

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