SMOKE IN A LONDON DIESEL BUS GARAGE

AN INTERIM REPORT

BY

B. T. COMMINS, M.Sc., A.R.I.C.

R. E. WALLER, B.Sc.

AND

P. J. LAWTHORP, M.B., M.R.C.P.

Medical Research Council, Group for Research on Atmospheric Pollution, St. Bartholomew's Hospital, London

Exhaust products from motor vehicles are known to be potentially harmful to man in that they contain substances which, if inhaled in sufficiently high concentrations, are noxious. Much is known of the composition of vehicle exhausts, but such analytical data, though essential, are of limited toxicological value unless the degree of dilution in the ambient air is known. No practical assessment of the potential danger is possible without knowing what man is likely to breathe. The highest concentrations of exhaust products to which men are regularly exposed probably occur in garages, and we are at present studying air pollution in one of London Transport Executive's garages for diesel buses. This study is being supplemented by extensive analyses of exhaust products of various diesel vehicles under different running conditions on the L.T.E. test track at Chiswick. Our work is being done in the closest co-operation with London Transport Executive, which has offered us every facility for the investigations.

Our efforts have been directed initially to the study of diesel exhausts as a matter of urgency in view of recent suggestions that, because 3:4-benzpyrene has been found in soot from diesel engines, they might be at least partly responsible for the rise in the incidence of lung cancer. It is with this urgency in mind that we have prepared an interim report of our findings with respect to smoke and benzpyrene; a detailed account of our findings with respect to all suspect pollutants will be published later.

Site of the Investigation

In consultation with the London Transport Executive, the garage at Merton, S.W.19, was selected for a pilot study. It is one of the executive's older garages, situated about seven miles S.S.W. of Charing Cross in a fairly densely populated area with some factories near by. Nearly 200 buses are parked there every night, and most of them have the same type of 6-cylinder 9.6-litre diesel engine. Ventilation of the garage is by natural draught (through the length of the garage) and at present no extractor fan is in use. Most buses leave the garage in the early morning, and at this time a lacrimatory mist is produced for short periods as groups of buses are started up. The effect is most marked on cold mornings and is worst in the "annex," a poorly ventilated section adjoining the main garage. Some buses return for periods during the day, and all finally come back during the evening. At this time buses are left by their drivers in the mouth of the garage and are moved on, generally within a few minutes, for re-fuelling, washing, and parking. These manoeuvres involve several short bursts of acceleration with periods of idling in between, and, when a number of buses are running at once, smoke haze is visible.

Methods

The main object of this pilot survey was to determine the concentration and composition of smoke inside the garage. It was desirable to sample the air at sites where pollution was highest, and it was essential to take simultaneous samples of the air outside the garage, as there was likely

to be an appreciable amount of smoke from general urban sources. That the sampling sites we selected were indeed those with the highest concentration of smoke was later confirmed by direct experiment. The first survey was made on the night of April 18/19. It was cold and misty, and there was much town smoke in the air. It was later felt that the high levels of ordinary urban pollution on this occasion might have obscured any contribution made by the buses to the benzpyrene content of the garage air, and a second survey was therefore made on the night of June 21/22, when there was very little town smoke. This night was mild and there was some light rain. Exactly the same procedure was followed each time.

The nights were divided into four periods, during which the air inside and outside the garage was sampled continuously. The first two simultaneous samples were taken between 6 p.m. and 11 p.m., during which period buses were coming in a few at a time to be re-fuelled and washed at intervals. The second period was from 11 p.m. to 1 a.m., when there was maximum activity and greater pollution; buses were coming in almost continuously, and fuelling and washing were in progress most of the time. During the third period, from 1 a.m. to 5 a.m., there was no vehicular activity. In the fourth period, from 5 a.m. to 7 a.m., buses were being started up, and on the first occasion some were run for a few minutes before leaving the garage. The first three indoor samples were taken at one of the fuelling points, and the fourth in the annex. All four outdoor samples were taken on a flat roof adjacent to the garage.

Samples were obtained by drawing air at a rate of about 40 cu. ft. (1.13 cu.m.)/min. through weighed sheets of glass-fibre filter-paper. Between 20 and 430 mg. of smoke was collected on each filter, and in Table I these amounts are expressed as milligrams per cubic metre of air sampled. Each filter was extracted for several hours with cyclohexane, and the yellowish solution obtained analysed for polycyclic hydrocarbons by a modification of the method described by Cooper (1954).

Results

Determinations were made of the amounts of anthracene, pyrene, fluoranthene, 1:2-benzanthracene, 1:2-benzpyrene, 3:4-benzpyrene, and 1:12-benzperylene in each extract, and in some cases there was enough material to allow two determinations to be made on aliquot parts. In Table I, the amounts of 3:4-benzpyrene are expressed as micrograms per cubic metre of air sampled. Results are arranged in pairs, so that comparison can be made between the concentrations inside and outside the garage at any given time.

Concentration of Smoke and 3:4-Benzpyrene at Merton Garage

Period	Site	April 18-19		June 21-22	
		Smoke mg./m. ³	3:4-benz- pyrene* µg./m. ³	Smoke mg./m. ³	3:4-benz- pyrene µg./m. ³
(1) 6-11 p.m.	Garage	1.81	0.28	0.81	0.027
	Outside	0.92	0.34	0.24	0.015
(2) 11 p.m.-1 a.m.	Garage	3.04	0.46	1.44	0.026
	Outside	1.46	0.47	0.23	0.014
(3) 1-5 a.m.	Garage	0.77	0.21	0.21	0.011
	Outside	0.66	0.24	0.18	0.018
(4) 5-7 "	Annex	1.72	0.27	0.48	0.005
	Outside	0.55	0.20	0.14	0.006

* Mean of two estimations.

Discussion

To interpret the results it is necessary to assume that in the absence of pollution by buses the concentration of smoke inside the garage would be the same as that outside, and that it would contain similar amounts of 3:4-benzpyrene. That this is approximately so is borne out by the similar smoke concentrations found between 1 and 5 a.m., when all buses were parked. The slight differences in the concentration of 3:4-benzpyrene at that time could be due to chance. At all other times the concentration of smoke was much higher in the garage than outside, and it seems

reasonable to attribute the excess to exhaust smoke. The greatest difference noted between the concentrations of smoke inside and outside was about 1.6 mg./cubic metre, and this represents a 100% increase over the outside level. However, despite these considerable differences in the total amount of smoke, the amount of 3:4-benzpyrene in the garage remained virtually the same as outside. The estimations are not accurate enough for the detection of small differences in benzpyrene content, and the results from the first night are consistent with a hypothesis of no difference between the benzpyrene concentration of the air inside and outside the garage at any time. The results from the second night, when there was very much less smoke outside the garage, suggest that the buses might have added a small amount of benzpyrene to the garage air, an amount of perhaps the same order as that existing outside. As each figure is based on a single estimation only, these small differences cannot be established with any degree of certainty, but it is certain that the concentration of 3:4-benzpyrene does not rise in proportion with the concentration of smoke. It is also clear, by comparing results on the two nights, that any contribution of 3:4-benzpyrene by the buses is negligible in comparison with the fluctuations which may arise from the varying levels of smoke outside. The smoke from the buses must then contain little, if any, 3:4-benzpyrene, and certainly less than coal smoke.

These findings have been supported by the results of experiments carried out on individual buses running round a test track at London Transport's Chiswick works. No 3:4-benzpyrene has been detected in the exhaust smoke from several buses in average condition, but in samples from others small amounts have been found. In all cases the proportion of 3:4-benzpyrene in the smoke has been smaller than that found in coal smoke, and experiments are continuing in order to determine the conditions under which it is emitted. Kotin, Falk, and Thomas (1955) found no 3:4-benzpyrene in the exhaust smoke from a diesel engine operating efficiently, but they found considerable quantities under conditions of inefficient operation. It is important to note that London Transport derate all their engines by 10% in order to reduce the possibility of heavy smoke emission, and they also ensure, by a carefully arranged maintenance routine, that they are kept in excellent mechanical order.

Summary

Measurements have been made of the concentration of smoke and its associated 3:4-benzpyrene in the air inside and outside a London bus garage. Whilst the concentration of smoke is greatly increased when the buses are running in the garage, there is little difference in the concentration of 3:4-benzpyrene. It is concluded that the exhaust smoke from these buses contains little, if any, 3:4-benzpyrene, and this conclusion is supported by the results of experiments carried out on individual buses. Small quantities of 3:4-benzpyrene have been found in the exhaust smoke from certain buses, and experiments are continuing in order to determine the conditions under which it is emitted.

ADDENDUM.—Since this report was written, analyses of further samples of smoke, including quadruplicate determinations of 3:4-benzpyrene, have been completed. These results, together with the determinations of other polycyclic hydrocarbons, confirm the conclusions reached in this interim report and will be published later in full. The experiments reported here are to be repeated in the near future at another garage housing buses powered by engines of a different make.

Miss P. M. Harrison, B.Sc., of this group, carried out most of the analyses reported here. We are indebted to the London Transport Executive for providing facilities for this investigation.

REFERENCES

- Cooper, R. L. (1954). *Analyst*, 79, 573.
Kotin, P., Falk, H. L., and Thomas, M. (1955). *A.M.A. Arch. industr. Hyg.*, 11, 113.

Medical Memoranda

Intra-arterial Thiopentone Injection in a Patient with Anomalous Forearm Vessels

The dangers of intra-arterial injection of thiopentone have been amply recorded in medical journals and textbooks of anaesthesia, yet cases still occur in which the drug is given into an artery, not because of ignorance on the part of the operator but often because what is believed to be a vein happens, in fact, to be an anomalous artery. The following case illustrates this point.

CASE HISTORY

A fit young man aged 24 was admitted to hospital for removal of a ganglion on his left wrist. To induce anaesthesia, a light rubber tourniquet was placed around the right arm proximal to the cubital fossa and a prominent subcutaneous vessel in the fossa was entered with the needle. Blood spurted into the syringe, the tourniquet was released, and a test injection of 2 ml. of 5% solution of thiopentone was made. Immediately the patient complained of pain at the injection site and tried to withdraw his arm, and the distal half of his forearm and hand noticeably blanched. The radial pulse disappeared. The needle was withdrawn, and during the next two to three minutes the colour of the skin and the radial pulse returned to normal.

Similar procedures were carried out on a vessel on the radial side of the cubital fossa and then on one on the ulnar side. at the junction of upper and middle thirds of the forearm. In these, only 0.5 ml. of solution was injected, and the reaction, although similar to the first, was less severe.

The patient was anaesthetized with ethyl chloride and ether, and suffered no ill effects from his experience.

At first it was thought that he was in some way abnormally sensitive to the drug, but careful examination of his right arm showed that the distal 3 in. (7.5 cm.) of the brachial artery, the proximal 3 in. (7.5 cm.) of the radial, and the proximal two-thirds of the ulnar artery were all superficial, as shown in the diagram. The numbers indicate the three injection sites.

COMMENT

There is little doubt that superficial arteries in the upper limb are relatively common. Cohen (1948) emphasizes their frequency and the dangers inherent in their non-recognition. Dubreuil-Chambardel (1926) found 90 in 500 subjects, about 50% bilateral; and he cites Testut, who found an incidence of 12.5%, and Ancel, who had an incidence of 15.9%.

Out of 481 limbs, Quain (1894) found 64 high divisions of the brachial artery at various levels upwards to the lower border of the axilla; the radial artery was the branch prematurely separated in 75%, but sometimes the ulnar artery, and more rarely a vas aberrans which joins one of the forearm arteries.

McCormack, Cauldwell, and Anson (1953) found 18.5% of 750 limbs with major variations in brachial or ante-brachial patterns, the commonest (15.45%) being a high origin of the radial artery. A high radial origin associated with an unusual course of the ulnar artery occurred in 1.9%, and a superficial brachial artery forming a common trunk for radial and ulnar arteries in 1.27%.

This patient had the common radio-ulnar trunk. Characteristically there is a high or low origin of a common trunk