AIR POLLUTION IN DIESEL BUS GARAGES

BY

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Motor vehicles emit exhaust products which are potentially noxious to a degree which depends on their ultimate concentration in the ambient air. Fitton (1957) has discussed some aspects of air pollution by road transport and has compared the emission of pollutants from petrol and diesel engines; well maintained and properly operated diesel engines emit much less carbon monoxide and unburnt fuel than petrol engines. Diesel engines are, however, liable to emit black smoke; in well maintained vehicles this may be limited to a small puff on acceleration, but in others dense black clouds may be emitted, particularly at full load. Kotin, Falk, and Thomas (1955) have reported the presence of carcinogenic hydrocarbons in smoke from an inefficiently operating diesel engine. Other potentially harmful exhaust products include oxides of nitrogen and aldehydes; these are emitted in similar concentrations by both petrol and diesel engines.

Though much analytical work on the composition of motor exhausts has been published, relatively little is known about the concentrations of pollutants (other than carbon monoxide) which traffic may produce in the air men breathe; without this information it is difficult to make any reasonable assessment of possible hazards to health. The work reported in this paper is the first part of a larger attempt to fill this deficiency in our knowledge of air pollution. We have studied air pollution in diesel bus garages where there are clearly defined groups of men who are regularly exposed to relatively high concentrations of exhaust products. In some cases the same men have been employed on similar work over long periods and sickness records are available. Raffle (1957) has studied the deaths, retirements due to ill health, and transfers to alternative work due to lung cancer amongst various groups of London Transport employees. Results of pollution measurements in any garage are only applicable to the particular types of vehicle involved and to the running conditions obtaining within it, but they are of direct relevance to the health of the men employed there.

The measurements reported here were made in two London Transport garages, and form part of a larger programme of work in which individual buses are also being tested under various running conditions. An interim report on smoke in one of the garages has already been published (Commings, Waller, and Lawther, 1956). Pollution in London streets is also being measured and further work is planned to study pollution in tunnels and in garages housing petrol-engined vehicles.

London Transport's central fleet is made up of two main types of diesel bus, designated RT and RTL; for reasons of engineering maintenance they are segregated in different garages. Both have 6-cylinder engines of 9.6 litres capacity. There are also many variations in the sizes and plans of garages. In consultation with London Transport two garages with relatively poor ventilation were selected for study. The first was Merton (Fig. 1) which houses nearly 200 buses the majority of which are RTs. It is situated in a residential and manufacturing area about seven miles to the south of Charing Cross. The second was Dalston (Fig. 2) where about 120 buses, mainly RTLs, are housed. This is in a densely populated area in north-east London. Merton garage was constructed in 1913 and Dalston in 1907. Both garages are ventilated only by natural draught.

Most of the buses leave the garages in the early morning and some return for periods during the day. All finally return during the evening, when each bus is washed and re-fuelled before being parked. There are three sets of conditions which cause pollution. First, when the buses are started up from cold in the morning a lachrymatory mist is produced for short periods; the intensity and duration of this mist varies with the temperature of the engine and of the ambient air. Secondly, a few buses remain in the pits for repairs during the day and smoke is sometimes emitted when the engines are tested, but pipes are provided to carry this away. Thirdly, high pollution is produced during the run-in in the evening; drivers leave their buses with the engine

FIG. 1.—Plan of Merton garage, showing sampling sites.
 A Fuelling and washing points. C Outside sampling site (roof).
 B Annexe. D Office.
 E Dock.

stopped at the mouth of the garage, and the engines are later re-started by garage staff who drive the buses up to be re-fuelled and washed. In most cases the engines are left running during these operations. The movements involve several short bursts of acceleration and a visible smoke haze is produced. Pollution is highest during this period.

Procedure

A preliminary inspection of each garage indicated that the highest pollution occurred near the fuelling and washing points. The main sampling sites were therefore established at *A* (Fig. 1) and *P* (Fig. 2). In addition to the pollution produced by the buses themselves, the air of each garage is polluted from

domestic and industrial sources in the vicinity. To enable the essential comparison to be made between the air inside and outside samples were taken on the roof of each garage at sites *C* (Fig. 1) and *R* (Fig. 2). Additional samples were taken at sites *B*, *D*, and *E* (Fig. 1) and *Q*, *S*, and *T* (Fig. 2) in order to check the distribution of smoke within the garage. The staff at Merton reported that when the buses start up in the early morning the pollution is much worse in the annexe than in the rest of the garage, and for this reason the main samples at that time were taken at site *B* instead of *A* (Fig. 1). At Dalston it was less obvious which part of the garage would be the most polluted in the early morning, and in one experiment the main samples were taken at site *Q* instead of at *P* (Fig. 2).

FIG. 2.—Plan of Dalston garage, showing sampling sites.
 P Entrance. R Outside sampling site (roof).
 Q End of garage. S Office.
 T Dock.

Each experiment was carried out throughout one night which was divided into four periods:—

Period 1	6 p.m. to 11 p.m.	Buses re-fuelled and washed at intervals
Period 2	11 p.m. to 1 a.m.	Including main run-in; fuelling and washing in progress most of the time
Period 3	1 a.m. to 5 a.m.	Practically no vehicular activity
Period 4	5 a.m. to 7 a.m.	Including main run-out when buses leave garage at intervals

During the night of April 18/19, 1956, measurements were made at Merton garage. As the weather on this occasion was cold and misty, with high levels of pollution from local sources, the experiment was repeated on June 21/22, 1956, when pollution was lower. Two similar experiments were carried out at Dalston garage, on October 24/25, 1956, and June 19/20, 1957.

At each of the main sites samples of smoke were collected for the determination of polycyclic hydrocarbons. Measurements were made of the concentrations of nitrogen dioxide, aldehydes, carbon monoxide, and sulphur dioxide.

Methods

Samples of smoke for hydrocarbon analyses were collected on weighed glass fibre filter sheets measuring 8 in. by 10 in. overall. These were supported on a wire mesh framework and air was drawn through with a vacuum cleaner motor. The air flow through the filter was measured with a miniature float-type meter mounted in the outlet. The flow, which gradually fell as the filter became laden with smoke, was about 1 cubic metre per minute. In addition small filters were used to determine the concentration of smoke (and, at Dalston, sulphur dioxide) at five points around the garage. These were of the type specified by the Department of Scientific and Industrial Research for atmospheric pollution measurements (Parker and Richards, 1952). A continuous strip recorder (King, 1955) was used to obtain a semi-quantitative record of smoke concentration over long periods; it was started at the beginning of each experiment and was left running for one week (Dalston) and two weeks (Merton) to check day-to-day variations.

Each glass fibre filter was weighed and extracted with cyclohexane in a Soxhlet apparatus for three hours, and the yellow solution so obtained was reduced to small volume and transferred to a column of alumina. The hydrocarbons were separated by elution with cyclohexane and were determined spectrophotometrically (Commins, to be published).

The two main samplers which were used to collect smoke for hydrocarbon analyses were run side by side on a separate occasion and the concentration determined from each to ensure that they were giving comparable results. These samples were combined and used to provide material for repeated determinations of 3 : 4-benzpyrene and some other hydrocarbons. The cyclohexane extract was divided into four parts and the results

of repeated analyses are given in Table 1. This experiment gave only a rough estimate of the standard deviation, but it enables some assessment to be made of the significance of differences in the main experiment. The coefficients of variation are of the same order as those found in repeated determinations on general atmospheric smoke (Commins, to be published).

TABLE 1
REPEATED DETERMINATIONS OF POLYCYCLIC
HYDROCARBONS IN A SAMPLE OF SMOKE FROM
MERTON GARAGE

Hydrocarbon	Hydrocarbons ($\mu\text{g./g. smoke}$)				Coefficient of Variation (%)
	69.8	60.2	66.9	69.5	
Pyrene	36.4	33.6	31.9	31.4	7
1 : 2-benzpyrene	28.3	31.4	27.6	32.4	8
1 : 12-benzperylene	22.8	23.0	29.5	22.8	14

Nitrogen dioxide was determined colorimetrically by the method described by Saltzman (1954). Aldehydes were absorbed in sodium bisulphite solution and determined by the method of Goldman and Yagoda (1943). At Merton garage two samples of air were collected in evacuated bottles and the concentration of carbon monoxide was determined with an infra-red analyser. In addition, blood samples were taken from two subjects before and after exposure to pollution within the garage. The carbon monoxide in these samples was determined by the method of Lawther and Apthorp (1955).

Results

Smoke and Hydrocarbons.—The amounts of smoke and hydrocarbons per 100 cubic metres of air sampled inside and outside each garage are shown in Tables 2 to 5.

Except where otherwise stated the figures represent single estimations. Anthracene and 1 : 2-benzanthracene were detected but, as their determination was interfered with by some other compounds, results are not quoted. Phenanthrene, chrysene, coronene, and anthanthrene were also found in some samples. During periods 1, 2, and 4 on each occasion buses were moving in the garage, and the concentration of smoke was much higher inside than out. In general the differences in the concentrations of hydrocarbons inside and outside each garage were less marked.

Table 2 gives the results of the first experiment at Merton and shows that the concentrations of 1 : 2-benzpyrene, 3 : 4-benzpyrene, and 1 : 12-benzperylene were virtually the same inside and outside the garage during each of the four periods. Pyrene and fluoranthene concentrations were at times somewhat higher in the garage than outside. Since the concentration of smoke was higher inside the garage than outside, it is clear that the smoke produced by the buses contains a lower proportion of hydrocarbons than that outside.

TABLE 2
CONCENTRATIONS OF SMOKE AND HYDROCARBONS AT MERTON GARAGE ON APRIL 18-19, 1956

Period	Site	Smoke (mg./100 m. ³)	Hydrocarbons (μg./100 m. ³)				
			Pyrene	Fluoranthene	1:2-Benzpyrene	3:4-Benzpyrene*	1:12-Benzperylene
1	Garage	181	50	38	15	28	9
		92	51	18	14	34	14
2	Garage	304	95	62	35	46	29
		146	73	60	36	47	28
3	Garage	77	30	24	18	21	13
		66	28	27	15	24	11
4	Annexe	172	48	35	18	27	12
		55	17	14	20	20	10

* Mean of two estimations.

TABLE 3
CONCENTRATIONS OF SMOKE AND HYDROCARBONS AT MERTON GARAGE ON JUNE 21-22, 1956

Period	Site	Smoke (mg./100 m. ³)	Hydrocarbons (μg./100 m. ³)				
			Pyrene	Fluoranthene	1:2-Benzpyrene	3:4-Benzpyrene	1:12-Benzperylene
1	Garage	81	4.6	3.5	1.7	2.7	1.7
		24	1.3	1.1	1.1	1.5	1.1
2	Garage	144	17	10	2.5	2.6	1.8
		23	2.5	1.5	0.9	1.4	0.9
3	Garage	21	1.1	0.8	1.0	1.1	0.5
		18	1.3	1.8	1.9	1.8	0.5
4	Annexe	48	1.3	1.4	0.6	0.5	0.5
		14	1.1	1.4	0.5	0.6	0.3

TABLE 4
CONCENTRATIONS OF SMOKE AND HYDROCARBONS AT DALSTON GARAGE ON OCTOBER 24-25, 1956

Period	Site	Smoke (mg./100 m. ³)	Hydrocarbons (μg./100 m. ³)				
			Pyrene	Fluoranthene	1:2-Benzpyrene	3:4-Benzpyrene	1:12-Benzperylene
1	Garage	90	6.0	6.0	3.7	9.9	6.6
		64	4.6	4.3	3.4	11	5.6
2	Garage	26	1.4	1.4	1.1	2.4	1.4
		14	1.3	1.4	0.8	2.3	1.0
3	Garage	8	0.7	0.7	0.5	1.1	0.8
		7	0.4	†	0.4	0.9	0.5
4	Garage*	54	2.2	2.0	1.4	2.9	1.5
		16	0.9	1.1	1.2	2.2	1.9

* End of garage (Q, Fig. 2).

† Not determined.

TABLE 5
CONCENTRATIONS OF SMOKE AND HYDROCARBONS AT DALSTON GARAGE ON JUNE 19-20, 1957

Period	Site	Smoke (mg./100 m. ³)	Hydrocarbons (μg./100 m. ³)				
			Pyrene	Fluoranthene	1:2-Benzpyrene	3:4-Benzpyrene	1:12-Benzperylene
1	Garage	55	2.3	2.8	1.7	2.9	1.6
		26	1.0	0.8	1.2	2.7	0.7
2	Garage	27	0.4	0.7	0.3	0.9	0.3
		12	0.2	0.3	0.2	0.5	0.1
3	Garage	14	0.2	0.2	0.2	0.3	0.2
		6	0.05	0.1	0.1	0.3	0.1
4	Garage	36	0.6	1.1	0.8	2.3	1.1
		7	0.07	0.1	0.2	0.6	0.2

This first Merton experiment was carried out on a cold, still night and the concentration of smoke outside the garage was exceptionally high for the time of year. To assess more closely the effect of the buses the experiment was repeated in June when the general level of smoke was much lower. The concentrations of all hydrocarbons (Table 3) were very much lower than on the previous occasion, and were higher inside the garage than out during periods 1 and 2, indicating that the buses produced small amounts of hydrocarbons.

The experiments at Dalston garage were carried out in exactly the same way as those at Merton. Results from the first experiment on October 24/25 are shown in Table 4. The concentration of smoke was higher at the main sampling point inside the garage than outside at all times when buses were moving. As in the first Merton experiment the concentrations of 1 : 2-benzpyrene, 3 : 4-benzpyrene, and 1 : 12-benzperylene were virtually the same inside and outside the garage, and again the concentrations of pyrene and fluoranthene were higher inside. Although a reasonably clear day had been chosen for this experiment, the concentrations of smoke and hydrocarbons outside during the first period were rather high, due to the emission of smoke from a number of nearby domestic chimneys. Hence, as at Merton, it was necessary to repeat the experiment when the emission from chimneys was expected to be at a minimum. The results of this experiment (June, 1957) are shown in Table 5; in general the concentrations of hydrocarbons were higher inside the garage than outside, indicating again the emission of small amounts by the buses.

The results obtained with the small smoke filters at various points in and around Merton garage are given in Table 6.

TABLE 6
CONCENTRATION OF SMOKE (mg./100 m.³) AT MERTON GARAGE ON MAY 17, 1956

Site	Period	
	1	2
A, fuelling	195	210
B, annexe	24	14
C, outside	5	2
D, office	38	74
E, dock	16	4

These measurements, which were made on a separate occasion, covered the first two periods only. They indicate the relative concentrations of smoke in and around the garage, but the absolute values are only approximate. The site (A) chosen for the main samples within the garage did in fact show the highest concentration of smoke. Next in order of magnitude came the office site (D) past which most

buses run; the office door was on the same side as the exhaust pipes. At Dalston garage small filters were run concurrently with the main samplers covering each of the four periods; they also were left for a fifth period (7 a.m. to 5 p.m.). Results from the first visit are shown in Table 7. Again the site (P) chosen for the main samples during the first three periods showed the highest smoke concentration.

TABLE 7
CONCENTRATION OF SMOKE (mg./100 m.³) AT DALSTON GARAGE ON OCTOBER 24-25, 1956

Site	Period				
	1	2	3	4	5
P, entrance	70	12	*	67	85
Q, end of garage	22	*	*	*	17
R, outside	52	*	*	*	43
S, office	12	*	*	*	23
T, dock	42	*	*	27	37

* Sample too small for assessment.

During the fourth period the main samples were collected at Q. It can also be seen from Table 7 that three of the garage sites showed lower concentrations of smoke than the outside sampling point (R). This suggested that an excessive amount of local pollution was being collected at the outside site. It came from nearby domestic chimneys, and this made it necessary to repeat the experiment during the summer when the amount of smoke from this source would be less. Results from the small filters on this second visit are shown in Table 8.

TABLE 8
CONCENTRATION OF SMOKE (mg./100 m.³) AT DALSTON GARAGE ON JUNE 19-20, 1957

Site	Period				
	1	2	3	4	5
P, entrance	63	46	11	61	20
Q, end of garage	24	8	3	21	19
R, outside	13	6	3	6	3
S, office	11	4	3	17	10
T, dock	29	20	4	34	20

The garage entrance (P) again showed the highest concentration of smoke in each period. On this occasion at none of the garage sites was there substantially less smoke than outside. During the day (period 5) the concentration in the dock was as high as that at the garage entrance. Sulphur dioxide concentrations were measured at each of the sites in the Dalston garage on the second visit and were well within the levels normally found in urban areas; there was no marked excess of sulphur dioxide within the garage, the highest concentration being 0.04 parts per million.

The continuous smoke sampler referred to earlier

was installed at Merton (site *A*, Fig. 1) at the beginning of each visit, and was left running for a period of two weeks. It was also installed at Dalston (site *P*, Fig. 2) at the beginning of the first visit there and was left running for one week. A smoke trace of greatly varying density was obtained with distinct "bursts" where buses had passed near during the run-in. The pattern of these "bursts" was similar on each week day with some variations at weekends. The "background" pollution was generally highest in the evening. The record showed that the level of smoke was much higher during the experiment at Merton on April 18/19 than on any of the succeeding 13 days, but that the general pattern was similar each day. There was little difference between successive days in June and the day chosen for the second experiment at Merton could be regarded as typical for the time of year. The record from Dalston showed that there was rather less pollution on the day of the first experiment there than on some of the subsequent days.

On the second visit to Dalston the continuous smoke filter was fitted with paper impregnated with thymol blue and was run through periods 1 to 4 only. A similar smoke trace was obtained, and the most intense "bursts" during the run-in in the evening showed a pink coloration around the smoke. This indicated the presence of small quantities of acid, probably sulphuric acid. The effect was no greater than that observed at times in ordinary urban air.

The concentrations of nitrogen dioxide found in Merton and Dalston garages are shown in Table 9. Some samples were taken continuously throughout

TABLE 9
CONCENTRATION OF NITROGEN DIOXIDE IN MERTON AND DALSTON GARAGES

Period	Nitrogen Dioxide (p.p.m.)			
	Merton		Dalston	
	April 18-19, 1956	June 21-22, 1956	October 24-25, 1956	June 19-20, 1957
1	1.2	0.13*	0.13	0.38
2	1.7 2.9*	2.7*	0.11 0.70*	0.16
3	0.04	†	0.01	0.06
4	0.30	1.3*	0.05	0.15

* Samples taken instantaneously.

† Samples not determined.

each period and others were collected instantaneously in evacuated litre bottles. Analyses from the first Merton experiment show that the nitrogen dioxide appears to follow the concentration of smoke. The results quoted from the second visit to Merton are not necessarily representative of the average concentrations during each period, since they are based on instantaneous samples only. Continuous samples

were taken during each of the two visits to Dalston and these followed the concentration of smoke in a similar manner. The maximum concentration of nitrogen dioxide found outside Dalston garage was 0.02 p.p.m. Samples taken in evacuated bottles a few feet from the end of the exhaust pipes of several buses at each garage contained up to 15 p.p.m. nitrogen dioxide.

Table 10 shows the concentrations of aldehydes found in Merton and Dalston garages; any ketones

TABLE 10
CONCENTRATION OF TOTAL ALDEHYDES IN MERTON AND DALSTON GARAGES

Period	Aldehydes (p.p.m.)		
	Merton		Dalston
	April 18-19, 1956	June 21-22, 1956	June 19-20, 1957
1	†	0.2	0.1
2	0.4	0.2	0.03
3	0.02	0.05	*
4	0.2	0.3	0.2

* Sample too small for assessment.

† Sample not determined.

Dalston October 24/25 results omitted because of doubts as to their validity.

present would be included in these figures. Results obtained during the three periods when buses were moving in the garage were considerably higher than those obtained during period 3. Two samples taken in evacuated bottles directly from the exhausts of buses at Merton garage were found to contain 20 and 50 p.p.m. of carbon monoxide. The amount of carbon monoxide in the blood of one subject (BTC) rose from 0.038 to 0.075 volumes % between 5.30 p.m. and 12.30 a.m., whilst that in the blood of another subject (REW) fell from 0.350 to 0.075 volumes % during the same period. Neither subject was a smoker.

Discussion

The results enable a comparison to be made of the pollution of the air inside and outside two garages. The differences in smoke concentration were greater at Merton, where there are more buses, than at Dalston. However, despite large differences in the total amount of smoke, the differences in 3 : 4-benzpyrene concentration were small. Tables 2 and 4 show that when there was moderate pollution outside there was virtually no difference between the benzpyrene concentrations inside and outside each garage. In Tables 3 and 5 it can be seen that the concentrations of 3 : 4-benzpyrene in the garages were at times a little higher than those outside. The concentrations of pyrene were, with two minor exceptions, consistently higher inside the garages. The results do not suggest that there is any difference in the emissions from RT and RTL buses.

There are two possible methods by which effects of the buses may be estimated: subtraction of the concentrations of pollutants in the outside air from those found in the garages will give valid answers only if certain assumptions are made regarding the mixing and diffusion of the two atmospheres under widely varying meteorological conditions; alternatively the outside pollution may be ignored on the occasions when it was low, and the whole of the pollution inside the garages attributed to the buses. The latter method, which will over-estimate the contribution of the buses, is to be preferred. It leads us to conclude that the buses might have been producing a concentration of 3 : 4-benzpyrene of up to $2.7 \mu\text{g./100 m}^3$ at Merton garage on June 21/22, 1956, and up to $2.9 \mu\text{g./100 m}^3$ at Dalston on June 19/20, 1957. These concentrations are barely one-tenth of those found in the outside air at Merton on April 18/19, 1956. The variations in the benzpyrene content of town air have been reported by one of us (Waller, 1952).

The form in which our results are presented in this paper tends to obscure the manner in which the investigation evolved; its history underlines its main conclusions. We went to Merton with no knowledge of the order of magnitude of the garage variables and we found that any contributions made by the buses to the hydrocarbon content of the air were so small as to be unrecognizable amid the high urban pollution. The experiment was repeated when the town pollution was low and a small effect of the buses was then revealed. We went to Dalston because it houses buses with a different type of engine, and, in view of our experience at Merton, we chose a day when outside pollution was expected to be low. In general pollution was low, but the smoke from a few nearby cottage chimneys made it again impossible to give a valid estimate of the rôle of the buses. We had to repeat the experiment when coal consumption in London was probably minimal. The difficulty experienced in finding conditions which permitted an assessment to be made of the hydrocarbon production of the buses in the garage illustrates the order of magnitude of their effect as compared with other urban sources of air pollution.

The special attention paid in this work to polycyclic hydrocarbons is due to their possible rôle in the aetiology of lung cancer. It is pertinent to quote at this point one of the conclusions from the paper by Raffle (1957) to which we have already referred:

" . . . all that can be said, on the basis of the small figures so far available, is that there is no excess of lung cancer among any group of London Transport staff such as would have been expected if diesel exhaust fumes were a serious contributory factor in producing an excess of lung cancer in urban dwellers."

The highest concentration of nitrogen dioxide found was 2.9 p.p.m. during the run-in at Merton on April 18/19, 1956, and this is below the threshold limit value of 5 p.p.m. for an eight-hour shift exposure adopted by the American Conference of Governmental Industrial Hygienists (1956).

Aldehydes merit special comment. Considerable eye irritation was experienced at Merton and Dalston particularly when buses were started from cold. Aldehydes were known to be present in exhaust fumes and, as acrolein is notorious for its lachrymatory properties even in extremely low concentration, it was thought that the eye irritation might have been caused by this substance. Acrolein could not be detected, however, by separating on paper sheets the 2 : 4-dinitrophenyl hydrazine derivatives of aldehydes (Buyske, Owen, Wilder, and Hobbs, 1956) which were collected from bus exhausts on another occasion, although other aldehydes and ketones could be identified readily. The quantities of aldehydes collected in the main experiments were insufficient for such detailed analysis but this work is continuing. The concentrations of aldehydes found did not approach the threshold limit value for formaldehyde (10 p.p.m.).

The low concentration of carbon monoxide in the garages deserves to be carefully noted.

We must emphasize again that the work reported here is of strictly limited application to the problem of pollution of the common air. It deals with air pollution in the confined spaces of garages where many buses operate under special conditions and where many men work. The results are not to be applied without qualification to air pollution under the different conditions obtaining in streets in the open air. It must be noted that London Transport derate 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 the engines are kept in excellent mechanical order. Work on wider aspects of the problem of air pollution by motor vehicles is continuing.

Summary

Air pollution in two London Transport diesel bus garages has been studied. Results of determinations of smoke, polycyclic hydrocarbons, nitrogen dioxide, aldehydes, carbon monoxide, and sulphur dioxide are given. These results are compared with analyses of the outside air.

Despite large differences in the concentrations of smoke inside and outside each garage only small differences in the amounts of 3 : 4-benzpyrene were noted.

Concentrations of nitrogen dioxide and alde-

hydrides did not approach the threshold limit values for eight-hour shift exposures adopted by the American Conference of Governmental Industrial Hygienists in 1956. The carbon monoxide concentrations were negligible; there was no evidence of abnormal concentrations of sulphur dioxide.

The significance of these findings is discussed. Work on the problem of air pollution by motor vehicles is continuing.

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