TABLE III.—RELATION OF AIR POLLUTION TO NUMBER OF PASSENGERS.

No. of Pass.	Carb. diox.; parts per 10,000 Cars with nat. vent.	Cars with exhaust vent.
Under 10	5.91	5.58
10 to 15	6.62	5.95
15 to 20	7.38	6.46
Over 20	8.85	7.24
Average	6.88	6.11

When taking samples of air from the berths it was the rule to take, as near simultaneously as possible, an average sample from the aisle for comparison. Samples from each place were generally repeated at 15-min. intervals, until 20 or more had been collected in the car. Two lower berths on each side of the car were generally selected, and one or two uppers when possible.

In order to gain some information concerning the conditions that would obtain if the closed berth had to lose its carbon dioxid by diffusion through the curtain, a series of experiments was conducted with the purpose of determining the rate of diffusion under similar conditions. The results show that the berth does not act as a closed compartment, but is essentially a part of the general space of the car body, and is subject to the effects of air-currents through and around the curtain very much as it would be were the curtain entirely absent.

Observations were made in crowded smoking-rooms of cars without ventilators. The occupants were from 4 to 7; the carbon dioxid from 10.5 to 20.5 per 10,000. The average carbon dioxid (14.88) with the average occupants (5.85) would be maintained by an air supply of 3,225 cu. ft. per hour for the room. Similar observations in smoking-rooms equipped with exhaust ventilators showed carbon dioxid from 7 to 16.5 per 10,000, with 4 to 8 occupants. The averages were 6.1 occupants and 11.41 carbon dioxid; the equivalent air-supply would be 4,940 cu. ft. No account is taken of the carbon dioxid produced by the burning of tobacco and matches.

About 200 samples of air from still cars have been analyzed. It is usual to find that the carbon dioxid rapidly increases when a train stops running. This increase reaches its maximum only after a considerable time, and the final height is variable, depending largely on the force of the outside wind. A strong wind will drive much air into the car, a light one proportionately less. Among these 200 observations the carbon dioxid passed 20 per 10,000 but twice (20.5 and 21.5), both in lower berths. It is usual to find the maximum around 15 in cars that are occupied at stations awaiting very late departures.

Sleeping-cars are snugly built; the crevices are small, but no crevice is too small to admit air, provided a little pressure is behind it. A row of windows covers each side of the car, another row of small ones extends along each side at the deck level, and each end has a door. There is a sum total of approximately 500 lin. ft. of crevices at their edges. If they average 1-50-in. in width and admit air at the rate of the train speed, the 40,000 cu. ft. would be more than accounted for. Some of these crevices are much larger than assumed, some are probably smaller. It is not unusual to find air entering certain areas of open windows at a rate equal to half the train speed, or even more. The crevices may act in the same way; the passage of air through such invisible openings is a much more important means of ventilation than might be thought. Pettenkofer showed that when all visible chinks were closed in a room the rate of ventilation was decreased only 28 per cent. as compared with the rate when the doors were closed in the ordinary way.

Samples of air were taken simultaneously from various locations in sleeping-cars with exhaust ventilators and the carbon dioxid determined, in an attempt to find where the contamination is greatest. So long as the samples are taken well within the body of the car they show nearly uniform results for different levels and different locations; hence the general mixing of the air must be good. The carbon dioxid, on the average, is a little less close to the floor than higher up. This is consistent with the upward trend of the flow to the ventilator exits. There is essentially no difference between the breathing zone and the bell-cord level. There is a slight difference between samples taken at the breathing level and near the ventilator exits, the latter being lower; but the difference is not so great as would be indicated by the difference in the dilution of the lower air and the amount leaving the car through these exits.

It has been attempted to determine the ventilation of sleeping-cars in terms of air-supply, using carbon dioxid as the only available basis of computation. In order to pass judgment on the findings recorded, it is necessary to know the hygienic significance of respiratory contamination of the atmosphere, and, if possible, to establish the cause of discomfort which may arise, supposedly as the result of an insufficient air-supply.

It has happened that a few of the cars considered in this work have been uncomfortable, have been called "close" or "stuffy." The temperature of these cars has invariably been high. There has sometimes been an unpleasant odor. This cannot be ventilated away so long as its source remains. A high temperature renders such odors more noticeable. The most marked offensiveness I have ever noticed was in a day coach where the air was of such a degree of chemical purity as to indicate ideal ventilation by any standard that has ever been proposed. The car was hot and had many filthy people in it. On the other hand, with perfect comfort has been sometimes associated the highest chemical impurity.

Even under the older applied principles of ventilation, the air-supply of sleeping-cars, as determined in this study, is ample under nearly all conditions. The average carbon dioxid in the air of running cars falls well within the limits of contamination, permitted by the earlier investigators, and it is relatively rare that the individual observations show more than 10 parts in 10,000. In the light of the newer conceptions, which have as yet been applied in practice only to a very limited extent, this air-supply is ample under all conditions observed. No danger to health is to be apprehended under the conditions ordinarily obtaining even in still cars. They are occupied only for short periods as a rule and are not uncomfortable if kept cool.

It would seem that the results obtained by the type of exhaust ventilator investigated in this study, which is now a part of the standard equipment of Pullman cars, are entirely adequate to meet the demands of hygiene, and that those difficulties and discomforts which do sometimes arise are due to other causes than lack of a sufficient amount of fresh air or to excessive vitiation. It is extremely unlikely that increasing the air-supply, which now amounts to from six to ten or more times the cubic content of the car each hour, and must maintain considerable motion of the atmosphere, would aid in any other way than by making overheating more difficult to bring about.