Before proceeding to an analysis of the finding it is necessary to know the amount of carbon dioxid in the air surrounding trains in order to have some basis for computing air-supplies to cars. The locomotive emits an enormous volume of this gas, which, it is easily conceived, might play a considerable part in the amount of carbon dioxid found in the air of the cars. According to Leissner the air surrounding trains contains from 18 to 22.8 parts carbon dioxid per 10,000. My results are at variance with this; 46 determinations averaged 4.04; the highest was 10, the lowest 3.

It is a matter of ready observation that any lateral wind carries all the smoke from a locomotive stack well out of the path of the following train. Presumably this is true of the invisible gases as well as the visible carbon. When the wind is straight ahead or directly with the train, the smoke and steam are, as a rule, carried high enough by their propulsion from the stack and their heated condition to allow the train to pass under with a clear interval, the heavier particles only, such as the small cinders, falling in its path.

Of course, the smoke and condensed steam do not diffuse as do the invisible gases; but with these is mixed a quantity of sulphur dioxid, for which the sense of smell is very delicate. My observation has been, in the examination of tunnel air, that where flue gases have contaminated the air with 15 to 20 parts of carbon dioxid in 10,000, sulphur dioxid is readily detected. It occasionally happens that sufficient gas is carried into a train running in the open to render sulphur dioxid noticeable. It seems that my determinations of carbon dioxid in the air surrounding trains have not dealt with the conditions that could bring this about. Consequently I conclude that this is a relative rarity, and that 4 in 10,000 is a proper average to deal with in considering the air outside of moving trains.

It was soon observed that a few open windows in a moving train admit such a volume of the surrounding air as to render the respiratory contamination almost undetectable. Ventilation as a problem in furnishing an adequate amount of fresh air then disappears. This is a fact which may be verified easily by directly measuring the rate of flow of air through an open window. I have measured up to 50,000 cubic feet per hour entering through a single side window raised only 6 inches. So we may dismiss the car with open windows from further consideration. And with it the whole subject of summer ventilation, so far as the term "ventilation" refers to supplying air and not to keeping the car closed and turn to the car running in cold weather with windows closed.

Adding to the open deck windows by opening one or both end doors to the vestibule (the outside vestibule doors remaining closed) would be expected to cause a greater air-supply. Such is the case, as shown by the records. [Table I.] Observations were made also where both doors and all the deck sash were closed. Whatever amount of the outside enters the car under these conditions must find it way in through natural crevices and is driven in and out by the pressure of the wind and the suction effects produced by the motion of the train. As wuold be expected under these conditions, the average carbon dioxid is greater than in either of the preceding groups and the computed air-supply is smaller.

The air-supply to sleeping-cars, as computed from 555 carbon dioxid determinations, is (for all but that of the completely closed car depending upon natural ventilation) a large one relative to the number of passengers, and would not allow the average carbon dioxid to go above 10 in any but this one condition unless the cars were crowded beyond their natural capacity. Such overcrowding in sleeping-cars is prevented by the assignment of space and refusing further applicants when this is all taken. It very rarely happens that sleeping-cars carry more than 25 passengers.

It should be understood that all of the above observations apply to the main compartment of the standard sleeping-car in motion; and in setting down the number of passengers only those persons were counted who were actually in this compartment, and who had been there for a

* "The Passenger Car Ventilation System of the Pensylvania R. R.," C. B. Dudley.
† "The Air and and Ventilation of Subways," Soper, 1908."
‡ The Garland Ventilator; Eng. News, December 23rd, 1909.
[Table I. gives a summary of the authors tables of records of observations in sleeping cars; Table II. shows the comparison of observations made in various place, and includes the figures of the Master Car Builders' Association mentioned above—Ed.]