*(Paper No. 2299.)***“On the Heating of Carriages by Exhaust Steam on the Caledonian Railway.”**

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THE steam used for heating the carriages is taken exclusively from the Westinghouse brake-engine exhaust, which is found to be sufficient. When this source is not available, the engine exhaust is used. In both cases an auxiliary supply-pipe from the boiler is connected to the heating main, and is used as supplementary, if necessary, to the Westinghouse exhaust; and entirely with the engine exhaust for heating trains at terminal stations before starting, or when running without steam on falling gradients.

The steam is conducted from the engine through a wrought-iron pipe of 1-inch internal diameter, fixed to the under-frame of each vehicle. The continuity between the vehicles is effected by flexible india-rubber piping with gun-metal couplings, similar in design to those of the Westinghouse pressure-brake, but with metallic faces. Westinghouse coupling-pipes disused for brake purposes are also employed. As the couplings occupy the lowest points in the main pipe, a hole $\frac{1}{16}$ inch in diameter is provided to keep the depression free from water by condensation. The main steam-pipe under the carriages is covered with felt, with an outside covering of canvas to hold it together.

Each carriage compartment has a thin cast-iron cylindrical reservoir, with an external surface of 8.25 square feet, placed transversely, and under one of the seats. The reservoirs are arranged in pairs, so that one branch from the main pipe supplies steam to two compartments.

The reservoirs have a fall of $\frac{1}{2}$ inch in their length, and a hole $\frac{1}{16}$ inch in diameter at the lower end, passing through a branch carried under the floor, and always open to the atmosphere to allow the air and the water by condensation to escape. The proportion of heating-surface to the cubic capacity of a compartment is 1 square foot of the former to 43 cubic feet of the latter. Each compartment has 20 square feet of glass surface.

With the above proportions a maximum temperature of 62° Fahrenheit can be maintained during the most severe weather experienced in the North on the Caledonian Railway system.

The net cost of fitting an engine and tender and carriages is £4 9s. for the former, and £1 16s. per compartment for the latter.

Twelve trains, heated on this system, have been running for three winters, and have given so much satisfaction that the Directors have ordered all trains to be similarly fitted. It had been first arranged to open and close the passage of the exhaust steam into each compartment of the train, so as to maintain a uniform temperature of 60° Fahrenheit; but the Author came to the conclusion that such a contrivance would be difficult to keep in order; for, since the pressure of steam in the boiler is almost constant, the exhaust from the cylinder varies in pressure from the front to the rear of the train. It only remained to provide heating surface sufficient to keep the compartments up to the temperature required during winter weather, and so do away with any self-regulating contrivance, which, in railway working, is only a source of trouble. The proportion of heating-surface to cubic capacity of space has given entire satisfaction, and the passengers, without receiving any instructions as to the working of this arrangement, have, of their own accord, regulated the temperature of the compartment by means of the ventilator over the door.

The following results were obtained from a train of five carriages fitted with the apparatus described above. The train, with the exception of the brake third-class at the front and rear, consisted of renewed stock. The experiments were conducted with the train at rest, and the temperatures ascertained simultaneously at intervals of five minutes by an observer in the centre compartment of each carriage. Thermometers were placed in the transverse centre of the carriages, with the bulb resting on the seat and the tube supported by the back-cushion, so that the convection currents from the heat-reservoir under the seat were diffused before affecting them. All the windows and ventilators throughout the train were kept closed. The steam-pressure in the boiler was maintained at 150 lbs. per square inch.

In the first experiment, heating was effected with steam from the boiler through an auxiliary pipe $\frac{1}{4}$ inch in internal diameter, connected to the main pipe under the foot-plate. As mentioned above, this method is never employed exclusively; in this case it was tried so that a comparison might be instituted with the Westinghouse-brake engine-exhaust. The results obtained are given in Fig. 1, Diagram No. 1. It should be mentioned that none of the compartments were precisely alike in respect to the ingress and egress of cold and hot air.

Fig. 1.

Fig. 2.

In the second experiment, the heating was accomplished with steam from the Westinghouse-brake engine-exhaust. The pump was working at the rate of 50 double strokes a minute, against an air-pressure of 75 lbs. per square inch. The results are shown by Fig. 1, Diagram No. 2. The relatively low temperature, of the centre compartment of the third carriage, was due to one of the windows having been $\frac{1}{16}$ inch open at the bottom; it was not observed till near the end of the experiment, and was allowed to remain open. This shows that the temperature may be efficiently controlled by means of the ventilators. The highest temperature recorded, but not necessarily the highest attainable under the atmospheric conditions existing, is shown in dotted lines. It was taken one minute after the door had been open for ten seconds.

Fig. 2, Diagram No. 3, shows the velocity of the steam along the train. The points observed were the couplings between the vehicles, which have the hole $\frac{1}{16}$ inch in diameter to allow water by condensation to escape. The time noted was the first appearance of vapour at the hole above-mentioned.

Fig. 2, Diagram No. 4, gives the steam-pressure along the train. The points observed were the same as the preceding, namely, the couplings between the vehicles. A Bourdon gauge was used to ascertain the pressure, and was checked by simultaneous observations of the temperature of the steam at the same point.

The Paper is accompanied by a sheet of illustrations, from which the Figs. in the text have been prepared.