Development of a Fault Point Locator for the Freight Train Command Line

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Freight trains are equipped with an automatic air brake system. Under this system, however, the longer the train set (also known as a consist) is, the more time is required until the required brake force is established throughout the train set (consist). This makes it difficult to run trains at high speeds. To solve this problem for high-speed freight trains in Japan, an electromagnetic automatic air brake system is used. This is similar to the electronically controlled pneumatic (ECP) brake systems used in other countries. The system uses a command line running throughout a train set and electromagnetic valves installed on the brake pipe to send brake commands to each car to apply the brakes evenly on all cars in the train set. The continuity of the command line is checked in the inspection after a train set has been marshalled. However, when a break in the command line is detected, it can take several hours to locate the fault point thus resulting in potential delay or cancellation of train operation. Each freight car has several cables connected to jumper connector receptacles and thus the cables are laid along the whole length of the train. Locomotives have brake notches called “release,” “service brake” and “emergency brake.” According to the selected notch position, the corresponding electromagnetic valve is activated. The train command line is used as a power source to activate the electromagnetic valves. Figure 1 shows the composition of the command line circuit viewed from the end of a freight train set. An example of a break point is marked “X” on the command line. Figure 2 shows a diagram of the electric circuit network to calculate the combined resistance of the command line based on Fig. 1. Figure 2 shows just two cars although there are a maximum of 26 cars in a train set. The elements of the command line of each car are the resistance r of the command line for a one-car length and the resistance R of the coils of electromagnetic valves. The voltage E for resistance measurement and the current I (A) are shown at the end of the freight car (the left side in Fig. 2). Calculations of (1) the current I through the analysis of the circuit network and (2) its ratio to the applied voltage E give the theoretical combined resistance between the command line and the ground conductor.

Figure 3 shows the results of a static test to simulate a break of the command line. As shown, the combined resistance is smaller for longer train sets. Figure 3 demonstrates that the values of the resistance measured and calculated based on a model of the circuit network are approximately in agreement. Based on this finding, we developed an algorithm to locate the fault point on the command line from the end of a freight train set by concentrating on the combined resistance of the command line, as shown in Fig. 4. We also developed fault point locators, a portable and car-borne type (Fig. 5), used to determine whether and where a command line break exists. We developed a car-borne type fault point locator assuming the installation on locomotives in revenue service operation and a portable one to be applicable to the present inspection service.

A command line break simulation test proved that it is possible to accurately locate the fault point within 30 seconds up to approximately 20 cars from the end of a train set. For the 21^{st} car and beyond, however, an error of one car or so occurred. This is because the difference of the combined resistance between the fault-suffering car and adjacent ones is 5% or less, due to the effect of the accuracy of the current sensor and/or the coil resistances. Regarding the car-borne type on the other hand, we performed a command line break simulation test on a freight train set running for test purposes to confirm that it is possible to locate a break on the command line from the locomotive without being affected by the activation of electromagnetic valves. The results of this study indicate that the application of this locator improves the reliability of the electromagnetic automatic air brake system and supports positive operation of high-speed freight trains to ensure stabilized freight transport.

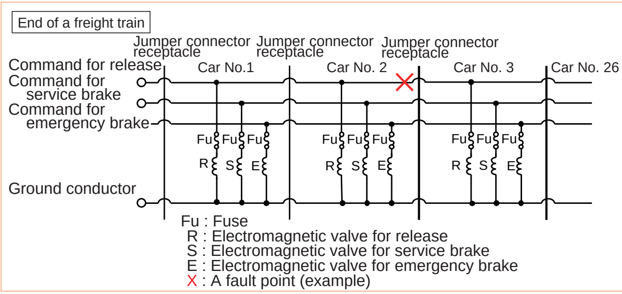

Fig. 1 Composition of the circuit of the train command line for freight train sets

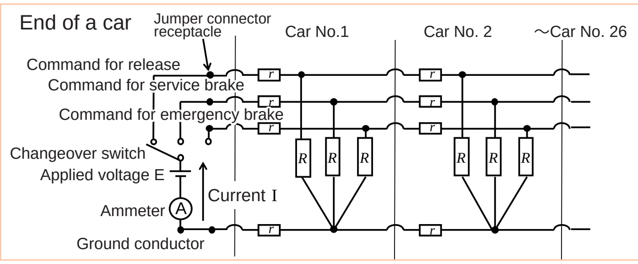

Fig. 2 Model of the electric circuit network for the command line

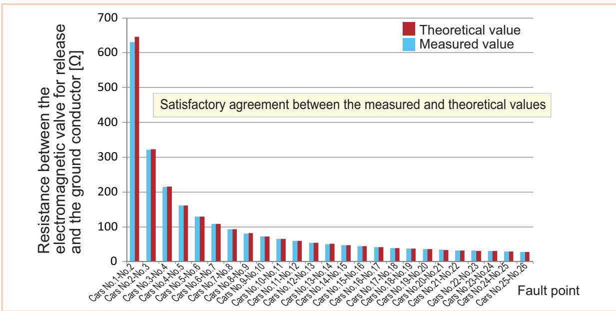

Fig. 3 Results of a test to simulate a command line break

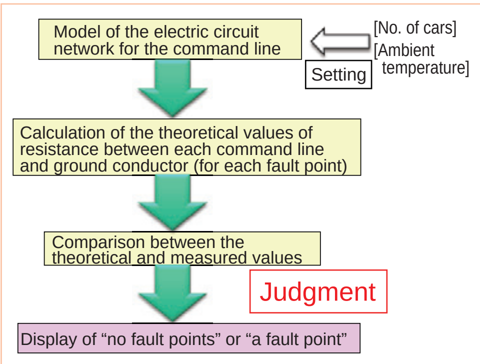

Fig. 4 Flow chart to locate the fault point

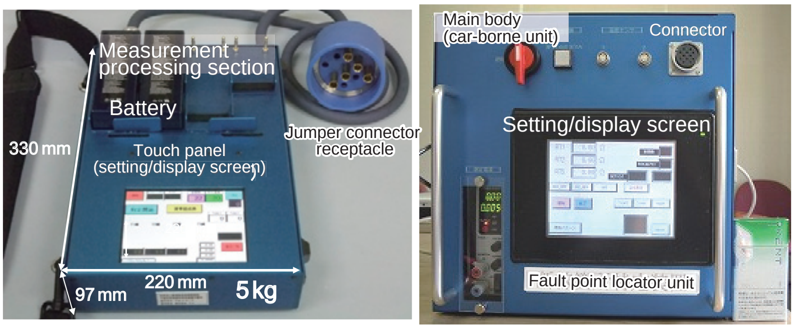

Fig. 5 Fault point locator unit (left: portable unit, right: car-borne unit)