405.

Problem 33.11 (RHK)

The starting motor of an automobile is turning slowly and the mechanic has to decide whether to replace the motor, the cable, or the battery. The manufacturer's manual says that the 12-V *battery can have no more than* 0.020 Ω *internal resistance, the motor no more than* 0.200 Ω *resistance, and the cable not more than* 0.040 Ω *resistance. The mechanic turns on the motor and measures* 11.4 V *across the battery,* 3.0 V *across the cable, and a current of* 50 A. *We have to identify the defective part.*

Solution:

We will test the performance of each part of the circuit against the manufacture's specifications. Let the internal resistance of the battery be *r*. As the measured voltage across the 12-V battery is 11.4 V when a current of 15.0 A is flowing through the circuit, the resistance *r* will be as given by the equation

$$(12.0 - 50 \times r)V = 11.4 \text{ V},$$

or

$$r = \frac{0.6}{50}\ \Omega = 0.012\ \Omega.$$

The internal resistance of the battery is within the limits specified by the manufacturer. So the battery is good. Resistance of the cable can be estimated from the voltage measured across it, which is 3.0 V. Therefore,

$$r_c = \frac{3.0}{50}\ \Omega = 0.06\ \Omega.$$

It is more than the value specified by the manufacturer, which is 0.040 Ω. Therefore, the cable is defective. Resistance of the motor can be found from the above data. We use the Ohm's law. Total resistance in the circuit is

$$(r_m + 0.012 + 0.06)\ \Omega.$$

Therefore,

$$(r_m + 0.06) \times 50\ (\Omega\ \text{A}) = 11.4 \text{ V},$$

and

$$r_m = \left(\frac{11.4}{50} - 0.06\right)\ \Omega = (0.228 - 0.06)\ \Omega = 0.168\ \Omega,$$

which is less than 0.20 Ω, the tolerance limit specified the manufacturer, and, therefore, the motor is good.