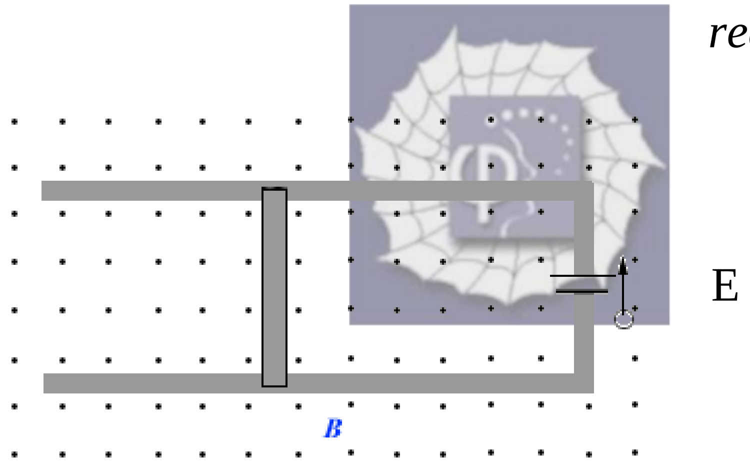
492.

<u>**Problem 36.22 (RHK)**</u>

In the preceding problem, **491**, *the constant-current generator G is replaced by a battery that supplies a constant emf* E. *We have to show* (a) *that the velocity of the rod now approaches a constant value v; and also we have to find its magnitude and direction.* (b) *We have to find the current in the rod when this terminal velocity is reached.*



<u>**Solution:**</u>

We will answer this problem by using arguments based on energy transfers. In this problem the source of energy is the battery of constant emf E. Because of the flow of current in the circuit consisting of rails joined by the sliding conducting rod, the rod will experience a force due to the action of the magnetic field on the current flowing in the conductor. As the rod undergoes acceleration, because of the Faraday's law of induction, an induced emf will arise because of the change in flux enclosed by the sliding loop. The induced emf will result in a flow of current in a direction opposite to the flow of current due to the emf of the battery. As the flow of current in the rails connected by the conducting rod is in the counter-clockwise direction, the induced current will flow in the clockwise direction.

The energy supplied by the battery is used in increasing the kinetic energy of the sliding rod, and as the Joule heat dissipation because of the electrical resistance of the rails etc. An equilibrium condition is reached when the induced emf becomes equal in magnitude to E, the emf of the battery. Then, the conductor will begin to slide across the rails with constant terminal speed *v*, because then the conducting rod will not experience Lorentz force, as the current flow ceases. In this situation there is no dissipation of energy due to Joule heat loss either. This situation arises when the induced emf becomes equal in magnitude to E. As the induced emf is

$$\mathrm{E}_{induced} = BLv..$$

We have

$$BLv = \mathrm{E}$$

or

$$v = \frac{\mathrm{E}}{BL}.$$

And the direction of motion is from right to left.