flowing through it. The *full-scale current sensitivity*, I_m, of a galvanometer is the current needed to make the needle deflect full scale.

A galvanometer can be used directly to measure small dc currents. For example, a galvanometer whose sensitivity I_m is 50 μA can measure currents from about 1 μA (currents smaller than this would be hard to read on the scale) up to 50 μA. To measure larger currents, a resistor is placed in parallel with the galvanometer. Thus, an ammeter, represented by the symbol –Ⓐ–, consists of a galvanometer (–Ⓖ–) in parallel with a resistor called the **shunt resistor**, as shown in Fig. 19–30. ("Shunt" is a synonym for "in parallel.") The shunt resistance is R_{sh}, and the resistance of the galvanometer coil, through which current passes, is r. The value of R_{sh} is chosen according to the full-scale deflection desired; R_{sh} is normally very small—giving an ammeter a very small net resistance—so most of the current passes through R_{sh} and very little ($\lesssim 50\ \mu$A) passes through the galvanometer to deflect the needle.

Ammeter uses shunt resistor in parallel

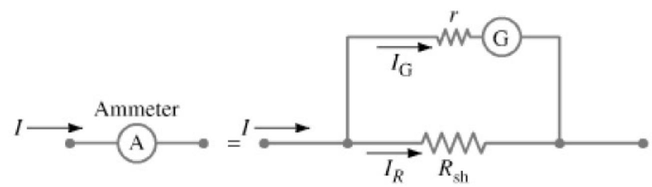

FIGURE 19–30 An ammeter is a galvanometer in parallel with a (shunt) resistor with low resistance, R_{sh}.

EXAMPLE 19–14 **Ammeter design.** Design an ammeter to read 1.0 A at full scale using a galvanometer with a full-scale sensitivity of 50 μA and a resistance $r = 30\ \Omega$. Check if the scale is linear.

APPROACH Only 50 μA $(= I_G = 0.000050\text{ A})$ of the 1.0-A current must pass through the galvanometer to give full-scale deflection. The rest of the current $(I_R = 0.999950\text{ A})$ passes through the small shunt resistor, R_{sh}, Fig. 19–30. The potential difference across the galvanometer equals that across the shunt resistor (they are in parallel). We apply Ohm's law to find R_{sh}.

SOLUTION Because $I = I_G + I_R$, when $I = 1.0$ A flows into the meter, we want I_R through the shunt resistor to be $I_R = 0.999950$ A. The potential difference across the shunt is the same as across the galvanometer, so Ohm's law tells us

$$I_R R_{sh} = I_G r;$$

then

$$R_{sh} = \frac{I_G r}{I_R} = \frac{(5.0 \times 10^{-5}\text{ A})(30\ \Omega)}{(0.999950\text{ A})} = 1.5 \times 10^{-3}\ \Omega,$$

or 0.0015 Ω. The shunt resistor must thus have a very low resistance and most of the current passes through it.

If the current I into the meter is 0.50 A, say, this will produce a current to the galvanometer equal to

$$I_G = \frac{I_R R_{sh}}{r} = \frac{(0.50\text{ A})(1.5 \times 10^{-3}\ \Omega)}{30\ \Omega} = 25\ \mu\text{A},$$

which gives a deflection half of full scale; so the scale is linear.