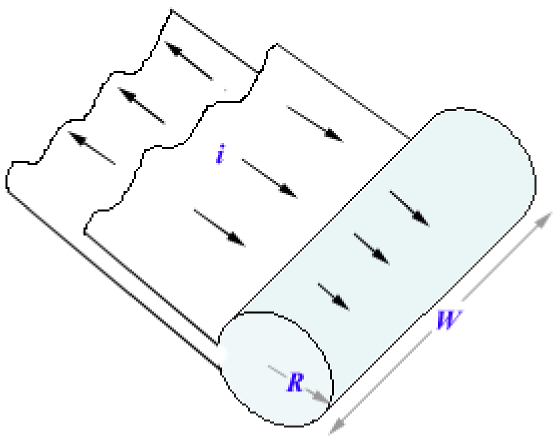
519.

<u>Problem 38.12 (RHK)</u>

A wide copper strip of width W is bent into a piece of slender tubing of radius R with two plane extensions, as shown in the figure. A current i flows through the strip, distributed uniformly over its width. In this way a "one-turn-solenoid" has been formed. (a) *We have to derive an expression for the magnitude of the magnetic field* $\vec{B}$ *in the tubular part (far away from the edges).* (b) *We have to find the inductance of this one-turn-solenoid, neglecting the two plane extensions.*



<u>Solution:</u>

From the cylindrical symmetry, we expect that the magnetic field inside the *"one-turn-solenoid"* will be uniform and axial, and the magnetic field outside can be assumed to be zero (negligible). We consider an Amperian surface one edge of which is parallel to the axis of the cylindrical portion and lies within it and the other is outside it.

By applying Ampere’s law,

$$\oint \vec{B}.d\vec{s} = \mu_0 i,$$

we get

$$BW = \mu_0 i,$$

or

$$B = \frac{\mu_0 i}{W},$$

as the total current that cuts through the Amperian surface is i.

The magnetic flux enclosed by the one-turn-solenoid, neglecting the two plane extensions, is

$$\Phi = \pi R^2 B = \frac{\pi R^2 \mu_0 i}{W}.$$

As the inductance is defined to be the flux per unit current, the inductance of the *“one-turn-solenoid”* will be

$$L = \frac{\Phi}{i} = \frac{\pi R^2 \mu_0}{W}.$$