From Grover's table, the value of P corresponding to these ratios is 6·92. Hence

$$L = \frac{500^2 \times 5 \times 6{\cdot}92}{2 \times 10^9}$$

$$= \frac{4325}{10^6} \text{ henries, or 4,325 microhenries, as before.}$$

Correction for Thickness of Insulation. As mentioned above, the formulae given take no account of the insulation between turns on the coil. For accurate calculations a correction for this insulation must be applied, although it is usually quite small.

This correction is made by subtracting the quantity $\frac{6{\cdot}283}{10^9} dN(A+B)$ henries (Ref. (5)) from the calculated inductance, where d and N are as above, and A and B are constants depending upon the relative thickness of insulation and number of turns on the coil respectively. Values of these constants are given by Nottage (*loc. cit.*).

(7) **Self-inductance of Flat Coils.** By "flat" coils are meant those whose axial length is small compared with their mean diameter and depth of winding.

Spielrein gave the formula for such flat or "disc" coils of circular form as

$$L = \frac{N^2 dQ}{2 \times 10^9} \text{ henries} \quad . \quad . \quad . \quad . \quad . \quad (132)$$

where N = No. of turns on the coil

d = mean diameter of the coil

and Q is a factor which can be calculated from the expression

$$Q = \frac{\left(1 + \frac{b}{d}\right)^3}{4\left(\frac{b}{d}\right)^2} \left[6{\cdot}96957 - \beta^3\ 30{\cdot}3008 \log_{10} \frac{1}{\beta} + 9{\cdot}08008 \right.$$

$$\left. + 1{\cdot}48044\beta^5 + 0{\cdot}33045\beta^7 + 0{\cdot}12494\beta^9 + \ldots \right]$$

where b = depth of winding

β = the ratio $\frac{\text{inner radius of coil}}{\text{outer radius of coil}}$

A table of values of the factor Q are given by Grover (Ref. (9)) for different values of $\frac{b}{d}$. If the axial length of the coil is appreciable Equation (131) (previous paragraph) applies.

To Correct for Insulation Thickness. In the case of a flat spiral wound with metal strip or ribbon of rectangular cross-section, the quantity

$$\frac{12{\cdot}57}{10^9} Nr(A_1 + B_1) \text{ henries (Ref. Grover, } \textit{loc. cit.}\text{)}$$

is added to the calculated inductance.

N = No. of turns on coil

r = mean radius of coil in centimetres

$$A_1 = \log_e \frac{\nu + 1}{\nu + \tau}$$

$$B_1 = -2\left[\frac{N-1}{N}\delta_{12} + \frac{N-2}{N}\delta_{13} + \frac{N-3}{N}\delta_{14} + \cdots \frac{1}{N}\delta_{1n}\right]$$

$\nu = \frac{w}{D}$ where w = axial length of strip

D = distance between adjacent turns

$\tau = \frac{t}{D}$ where t = thickness of strip

The factors δ_{12}, δ_{13}, etc., are given in tabular form by Grover for different values of τ and ν.

(8) Self-inductance in Other Cases. (*a*) *Coils Wound on Polygonal Formers.* Grover (Ref. (10)), in a Bureau of Standards paper on this subject, gives a method of calculating the inductance of coils of this general form by obtaining, in each case, the "equivalent radius" of the coil, and then treating it as a circular coil having this radius. The formulae for calculation of the equivalent radii are somewhat complex, and reference should be made to the original paper for information on the subject.

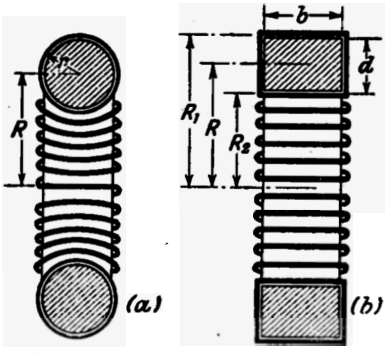

FIG. 100. SELF-INDUCTANCE OF TOROIDAL COILS

(*b*) *Toroidal Coils.* These are coils whose axis and cross-section are either both circular or the former circular and the latter rectangular.

(i) Axis circular, cross-section circular (torus) (Fig. 100 (*a*)).

Russell (*Alternating Currents*, Vol. I, p. 50) shows that the flux inside such a coil, of N turns, when a current of I amp. flows in it, is

$$\phi = \frac{4\pi}{10} NI(R - \sqrt{R^2 - r^2})$$

where R = mean radius of axis of coil in centimetres

r = radius of the cross-section of the coil in centimetres.

Thus, since $L = \frac{\phi N}{10^8 I}$ henries

the inductance is given by

$$L = \frac{4\pi}{10^9} N^2(R - \sqrt{R^2 - r^2}) \text{ henries} \quad . \quad . \quad (133)$$

(ii) Axis circular, cross-section rectangular (Fig. 100 (*b*)).