THE OWEN BRIDGE FOR INDUCTANCE MEASUREMENT

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Many types of bridge circuits have been proposed for the measurement of inductance. The circuits may use direct or alternating current or both. Over a period of a few years the author has tried many of the well known bridge circuits such as those of Anderson, Maxwell, Rosa and Grover, Rimington, Carey and Foster, and others. These circuits

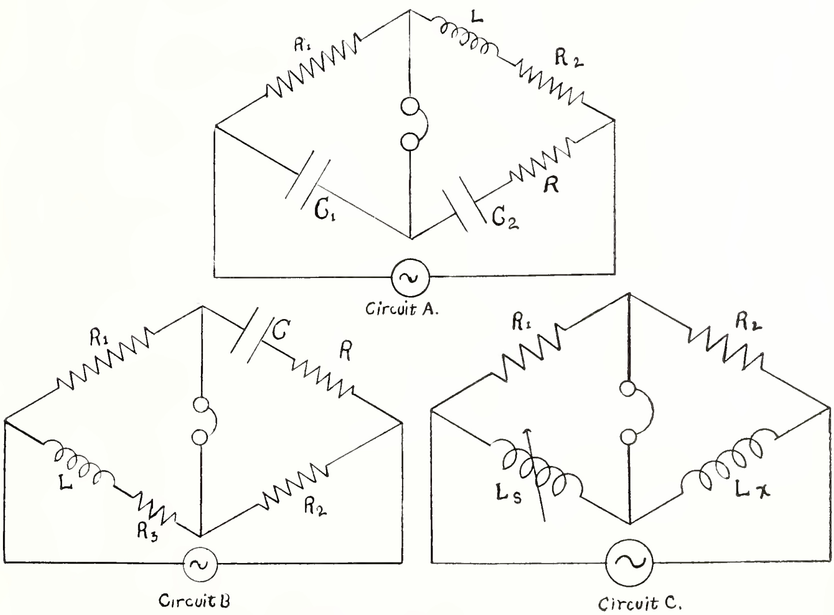

Figure 1. Bridge Circuits.

will all give good results under certain conditions which are not always obtainable with the equipment at hand.

An alternating current bridge suited to ordinary laboratory apparatus should be independent of wave form, should give accurate results, and should cover a range from one microhenry to thirty henries. It would be desirable to eliminate a direct current balance necessitating galvanometer balancing. The source of current should be inexpensive and the detector of balance a pair of head phones. The standards should be those available in most college measurements laboratories.

Such a bridge was first described by David Owen in the "Proceedings of the Royal Society of London", volume 27, page 39. There seems to be no reference in American texts on electrical measurements to this

"Proc. Ind. Acad. Sci., vol. 41, 1931 (1932)."

circuit, although Starling,[1] Moullin[2] and Stanley[3] of England refer to its application.

In figure 1 is represented three alternating current bridges for purposes of comparison. Circuit A is the Owen circuit, circuit B is a modified Owen circuit for measuring coils in which the resistance is small in comparison to the reactance, circuit C is the typical inductance bridge for comparing the unkown inductance to a standard inductometer.

In circuit A, figure 1, L is the inductance to be measured, R_1 may be a known fixed or variable resistor from 1 to 1000 ohms, depending upon the range desired in measurements (small values of L require small values of R). R_2 is a variable resistance (0-2000 ohms) the value of which need not be known. C is a fixed or variable standard condenser. (For small values of L a variable air standard can be used). C_2 is a fixed condenser preferably mica insulated .1 - .5 mfd. capacity—value need not be known.

The source may be any type of audio oscillator[4] or high frequency buzzer with a telephone transformer to couple the buzzer circuit to the bridge. The detector may be a 2000 ohm headphone.

The equations of such a bridge can be derived as follows:

Referring to figure 1, circuit A

$$R_1I_1 = \frac{-jI_2}{\omega C_1} \tag{1}$$

$$(R_2 + j\omega L)I_1 = (R - \frac{j}{\omega C_2})I_2 \tag{2}$$

Dividing (1) by (2)

$$\frac{R_1}{R_2 + j\omega L} = \frac{-j/\omega C_1}{R - j/\omega C_2} \tag{3}$$

Expanding

$$R_1R - \frac{R_1j}{\omega C_2} = \frac{-R_2j}{\omega C_1} + \frac{\omega L}{\omega C_1} \tag{4}$$

Equating reals and imaginaries

$$R_1R = \frac{L}{C_1} \text{ or } L = R_1RC_1 \tag{5}$$

$$\frac{-R_1j}{\omega C_2} = \frac{-R_2j}{\omega C_1} \text{ or } R_1C_1 = R_2C_2 \tag{6}$$

By alternate adjustment of R and R_2 equations (5) and (6) may be satisfied and the bridge balanced.

The accuracy of balance and consequently the accuracy of the measurement depends upon obtaining complete silence in the telephones. Hearing, being a logarithmic function as to judgment of intensity, only by reducing "background" noise can small changes in balance be obtained. A one ohm change in R can easily be detected.

[1] Starling, S. G., Electricity and Magnetism, 5th Ed. p. 376.

[2] Moullin, E. B., Radio Frequency Measurements.

[3] Stanley, R., Wireless Telegraphy, Vol. I, p. 420.

[4] An Audio Frequency Laboratory Oscillator. Proc. Ind. Acad. Sci. **40**:267-269.

In the tables are some examples of measurements made with this bridge. Table I represents measurements made upon a 1500 turn honeycomb coil and upon a standard inductance of .030 and .040 henries.

TABLE I. INDUCTANCE VALUES FOR VARIOUS COILS

C_1	C_2	R	R_1	L	R_2
			L = .030		
.5	.02	1490	1000	.0298	26
.5	.05	6000	1000	.0300	90
.5	.08	370	1000	.0296	150
.2	.08	370	1000	.0296	390
.2	.08	3700	100	.02960	24
.2	.06	493	1000	.02958	287
.2	.07	423	1000	.02961	337
			L = .040		
.2	.08	500	1000	.0400	383
.2	.05	800	1000	.0400	232
.2	.20	202	1000	.0402	
.2	.4	100	1000	.0400	1986
.2	.4	300	333	.03996	
		1500 Turn H. C. Coil			
.2	.236	670	1000	.15812	
.2	.240	658	1000	.15782	
.2	.250	631	1000	.15775	
.2	.560	282	1000	.15790	
.2	.560	941	300	.15808	
.2	.500	1056	300	.15840	

Table II shows the range of inductance values that may be easily covered.

TABLE II. EXAMPLES OF OWEN BRIDGE FLEXIBILITY.

Magnavox output transformer	Henrys
Primary	4.88
Secondary	.009588
60 Turn Solenoid (4″ diameter)	Microhenries
Bridge (average)	465
Calculated	465
Wavemeter 1000 K.C.	474
10 Turn Solenoid (4″ diameter)	Microhenries
Bridge (average)	21.1
Calculated	21.3
Wavemeter (average)	21.7

If desirable a 1000 cycle audio frequency oscillator may be amplified by a two stage vacuum tube amplifyer and the output used as a source for the bridge. If a vacuum tube voltmeter or rectifying tube is used as a detector, by the deflection of the galvanometer in the plate circuit of such a tube the balanced condition of the bridge may be made. This arrangement gives a visual balance and can be used in noisy rooms with quite a degree of accuracy.

By using a known value for L, C_1 can be found from the formula $C_1 = L/RR_1$.