4/62

Wayne Kerr Universal Bridge

for highly accurate measurements on components, circuits and materials

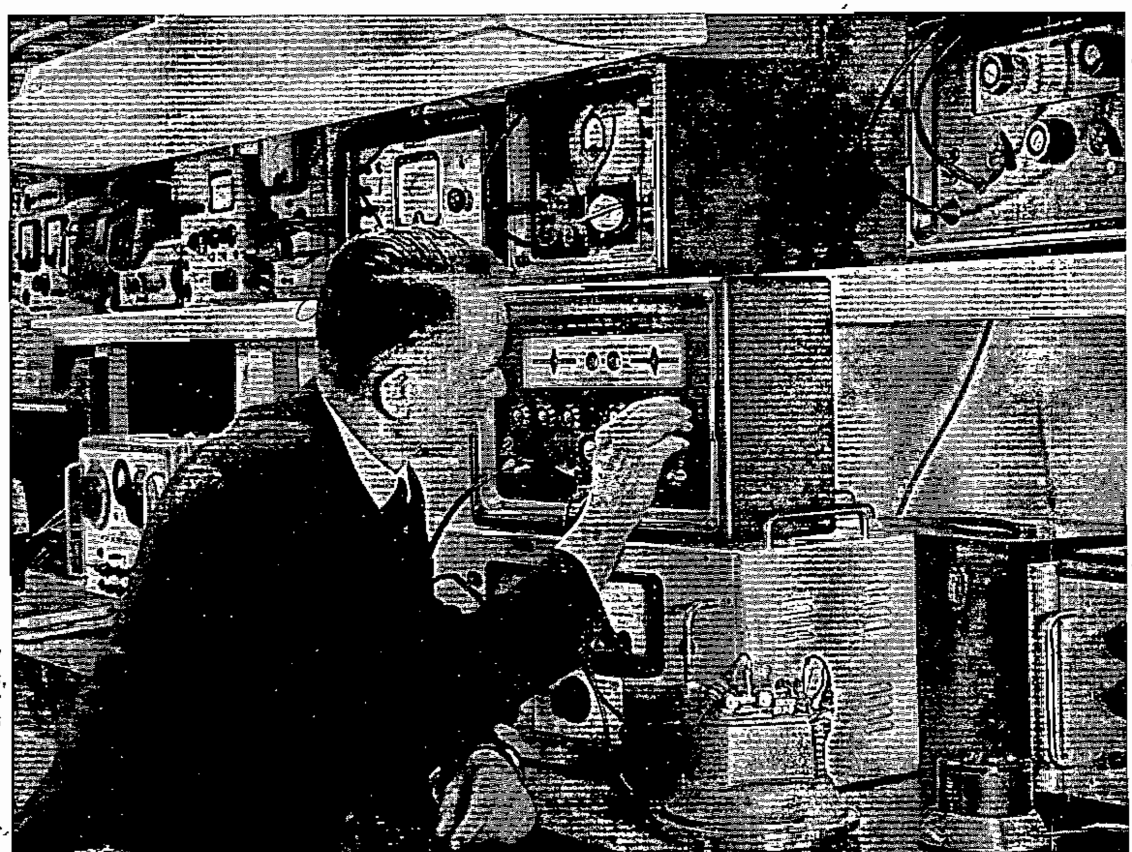
Bridge £225
Adaptor £25

B221

The Wayne Kerr Universal Bridge B221, a versatile and accurate instrument of advanced design, offers facilities for two, three and four terminal measurements. Based on the transformer ratio-arm technique, it overcomes the necessity for removing components from circuit, or samples from industrial processes, when tests are to be made. The instrument is therefore particularly suitable for remote measurements involving components, circuits or materials. The B221 has an in-built source (1,592 c/s) and detector but, with an external source and detector, can be operated at any frequency between 50 c/s and 20 kc/s.

A special design feature is the layout of the controls and displays. A novel mechanism provides direct readings of cyphers, decimals and units of measurement, thus tests can be made quickly and accurately even by unskilled personnel.

...rsal ...use at the ...tation and ...boratories, ...imited, for ... process ...uipment.



Features which make the Bridge of particular interest to Chemists involved in permittivity or conductivity measurements include the following:

1 *Comparative* measurements can be made to an accuracy of 0·02 per cent. This is an inherent advantage associated with transformer ratio-arm bridges.
2 Long measurement leads can be used without impairing the accuracy since the cable capacitance does not form a part of the measurement circuit.
3 The instrument can (to order) be supplied with its source and detector set to operate at 5 kc/s, where the effects of boundary layer impedance are at a minimum.
4 The bridge reads directly in terms of conductance.

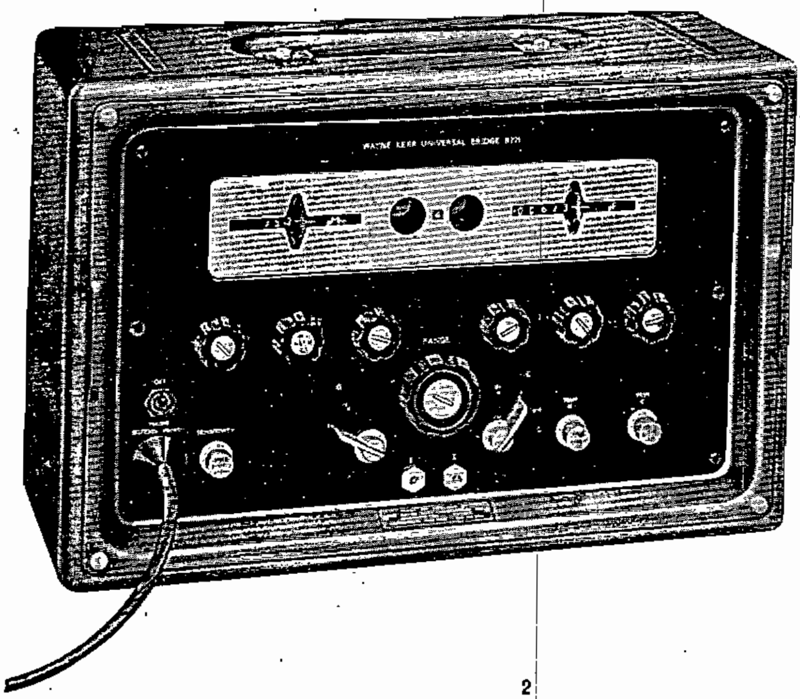
Operation can be obtained at any frequency between 50 c/s and 20 kc/s and the Bridge is supplied with the necessary connectors for an external source and detector. An ideal source (covering 10 c/s to 120 kc/s) is the Wayne Kerr Audio Signal Generator S121 and (above 100 c/s) Waveform Analyser A321 is a suitable tuned detector. These two instruments are described fully in separate publications, available on request.

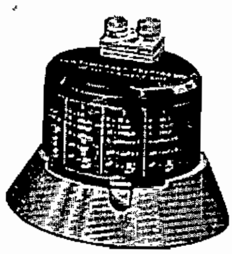
Principle of Operation

In the Universal Bridge B221, as in the rest of the range of Wayne Kerr Bridges, the transformer ratio-arm technique enables many of the most complicated measurements to be readily and quickly undertaken. A full description of this technique is given in Wayne Kerr Monograph No. 1, "The Transformer Ratio-Arm Bridge," available on request.

A simplified diagram of the circuit arrangement is shown in Fig. 1 (page 3). The source is connected to the primary of the voltage transformer Tl, and the secondary winding is tapped to form one of the ratio arms of the bridge. The second ratio arm is provided by tapping the primary winding of the current transformer T2. The neutral or third terminal of the bridge is connected between the two transformers.

The same voltage from the secondary of Tl is applied to both the standard impedance Z_s and the unknown impedance Z_u. If $Z_u = Z_s$, then the ampere turns produced in the two primary windings of T2 are equal in magnitude but opposite in phase, and the resultant core flux is zero. No voltage will therefore be developed across the windings, and the detector will indicate balance.





SPECIFICATION

Overall coverage (Bridge with Adaptor)	
Resistance/Conductance	50μΩ to 50,000MΩ (20,000Mho to 0·00002 μMho)
Capacitance	0·0002μμF to 5 farads
Inductance	0·005μH to 1,000 henrys
Universal Bridge B221	
Source Frequency	1,592 c/s ± 1 per cent ($\omega=10^4$) (other frequencies to special order)
Conductance	0·01μMho—111mMho (9Ω—100MΩ) to an accuracy of ± 0·1 per cent To 0·00002μMho (50,000MΩ) with reducing accuracy
Capacitance	0·1μμF—11·1μF to an accuracy of ± 0·1 per cent To 0·0002μμF with reducing accuracy
Inductance	0·9mH—10,000H to an accuracy of ±0·1 per cent when source frequency is measured: otherwise to ±2 per cent. Higher values of inductance with reducing accuracy
Power Supply	100-125 and 200-250 V, 40-60 c/s Power consumption approximately 25 W
Dimensions	17 in wide (43 cm) 11½ in high (29 cm) 7½ in deep (19 cm)
Weight	Approximately 25 lb (11 kg)
Low Impedance Adaptor Q221	
Resistance Ranges	50μΩ to 10Ω in four ranges Accuracy: ± 1 per cent ± 25 μΩ
Impedance Ranges	As above
Inductance Ranges	0·005μH to 1 mH in four ranges Accuracy: ± 1 per cent ± 0·005μH
Discrimination	0·2 per cent of maximum in both above ranges
Capacitance Ranges	10μF to 5 farads in four ranges Accuracy depends on precise knowledge of bridge frequency
Dimensions	Base diameter 5 in (12·9 cm) Height 3¼ in (8·5 cm)
Weight	Approximately 5½ lb (2·5 kg)

WAYNE KERR

THE WAYNE KERR LABORATORIES LIMITED
Sales and Service, 44 Coombe Road,
New Malden, Surrey.
Telephone: MALden 2202.
Telegraph: Waynkerr, New Malden.

WAYNE KERR CORPORATION
1633 Race Street, Philadelphia 3, Pennsylvania, U.S.A.
Telephone: LOcust 8–6820.
Telegraph: Waynkerr, Philadelphia.

Printed in England

ZB3191/10M/7.61

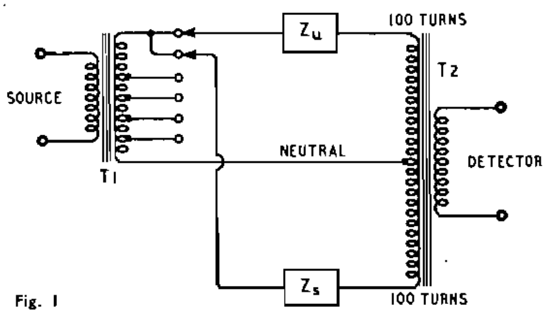


Fig. 1

When the impedances Z_u and Z_s are unequal, balance can be restored by adjusting the value of Z_s and by connecting Z_s to a different tapping on the voltage transformer.

The range of measurement can be extended by connecting the unknown impedance Z_u to varying taps on T1 and T2; by a suitable combination of tappings on both transformers a very wide range of impedances can be measured with a minimum number of standards.

Since at balance no voltage is developed across the windings of T2, it is possible to connect an impedance between Z_u and neutral on the current transformer side without affecting the measurement accuracy. The only effect will be to reduce the sensitivity of the detector, and this can be compensated by increasing the gain. It is also possible to connect an impedance between Z_u and neutral on the voltage transformer side. Although this shunt impedance loads T1 and reduces the voltage applied to Z_u, the voltage applied to Z_s is also reduced in proportion to the turns ratio. Accuracy is therefore unaffected and any loss in sensitivity can again be compensated by increasing the detector gain. The transformers are so designed that very heavy shunting is possible without affecting the accuracy of measurement.

The standards employed are capacitive and resistive and by reversing the sense of their connection to the current transformer, inductance and negative resistance can be measured. In fact the bridge will make measurements in any quadrant of the complex plane.

Applications

Extremely valuable in the electronics industry, the B221 caters for a very wide range of three- and four-terminal measurements as well as the normal two-terminal measurements of conductance, resistance, capacitance, inductance and complex impedance.

A range of special cells and adaptors enables a wide variety of chemical measurements, readily applied to process and quality control, to be undertaken. An important feature is the provision of non-contacting electrodes: the adaptors can be used at a considerable distance from the bridge, and the examination of flowing liquids—important in the chemical and food manufacturing industries—is simply achieved.

Design Features

A special mechanism automatically inserts the cyphers, decimals and units of measurement in the dial windows for each setting of the centrally placed range switch. Thus any errors caused by the use of incorrect multiplying factors are obviated. Three decades, two switched and one continuously variable, are provided for both resistive and reactive measurements; when these controls are operated the values are automatically displayed in the appropriate dial window.

The in-built source consists of a stable LC oscillator and buffer amplifier tuned to 1,592 c/s (10,000 rad./sec.). This frequency is chosen to simplify any calculations involving the factor $2\pi f$. A small trimmer provides the frequency adjustment, which is set to an accuracy of 0·25 per cent.

The detector circuit consists of a two-stage tuned anode amplifier using ferrite pot cores and silvered mica capacitors. Null indication is given by two magic eye indicators placed at points of different gain in the amplifier. Each magic eye has two sections, one having three times the sensitivity of the other; there are thus four stages of sensitivity. A gain control is also incorporated.

The capacitances of the coaxial measurement leads are arranged to shunt the two transformers and not the measured impedance. The cables can therefore be of any length without affecting accuracy. Separate neutral leads cater for three- or four-terminal measurements.

Test Jigs

Conductance and stray capacitance of test jigs etc. can be balanced out within the limits of the trimming controls, and an accurate absolute measurement of the component under test can therefore be made. With the test jig alone connected to the measurement leads, the trim controls are adjusted to give an initial zero balance (this will be correct only for the range on which adjustment is made). Then if the component is connected to the jig its correct value is measured.

Bridge Neutrals

A detailed arrangement of the bridge neutrals is shown in Fig. 2. The primary of T2 is split into two halves, one fed from the unknown impedance, the other from the standards. Each neutral is connected to one of the measurement cable screens; these can be linked together for three-terminal tests or left open when the neutral return is to be used for four-terminal measurements. As already indicated it is possible to connect shunt impedances between the impedance measured and the neutrals without affecting accuracy.

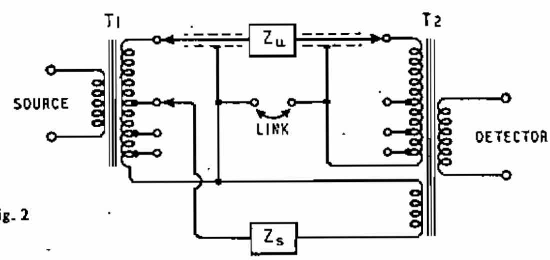


Fig. 2

Three-Terminal Measurements

The ability to measure an impedance *in situ* is often of very great value, whether a remote measurement or a straightforward test of a component wired in a chassis is to be undertaken. In other words, it may be convenient to measure an impedance between any two terminals regardless of the presence of other impedances which may be connected between either or both terminals and a third point.

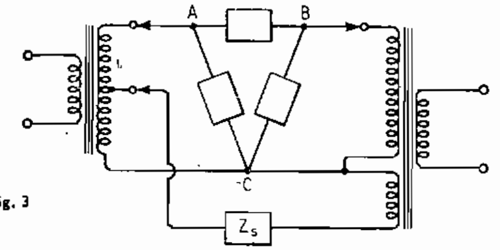


Fig. 3

Generally any circuit can be resolved into a three-terminal network and the arrangement connected to the bridge is shown in Fig. 3. Since the impedances Z_{AC} Z_{BC} shunt the transformer windings only, the impedance Z_{AB} is measured without loss of accuracy.

Network Characteristics

Transfer admittance of networks can be measured by the arrangement shown in Fig. 4. Since at balance the low potential end of R_T is at neutral potential, the network is correctly terminated.

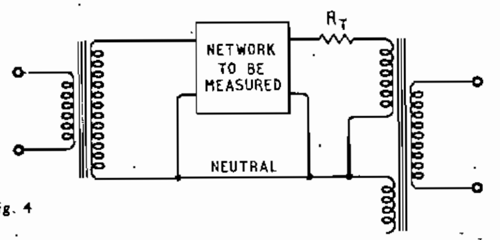


Fig. 4

A similar arrangement is used if the attenuation of attenuators is to be calculated. If the bridge is balanced with the attenuator set to zero a value equal to the matching impedance R_T will be measured. Then if the attenuator steps are switched in, the voltage attenuation can be calculated accurately from the ratio of the apparent change in value of R_T.

Capacitance Measurements

With certain capacitors the value changes with the value of d.c. polarizing voltage. In such instances a polarizing potential can be applied as shown in Fig. 5. The blocking capacitor should have a value at least 100 times that of the unknown.

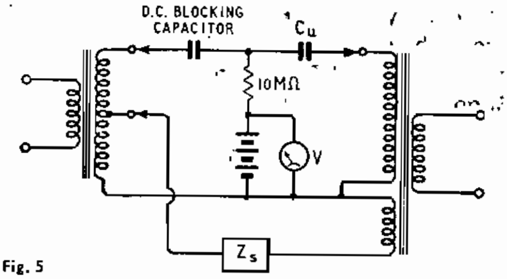


Fig. 5

If it is necessary to measure electrolytic capacitors with a d.c. potential applied the arrangement shown in Fig. 6 can be used. The two capacitors C should be reasonably well matched and of known value, very much smaller than C_u. The unknown is given by $C_u = C^2/C_m$, where C_m is the value measured on the bridge.

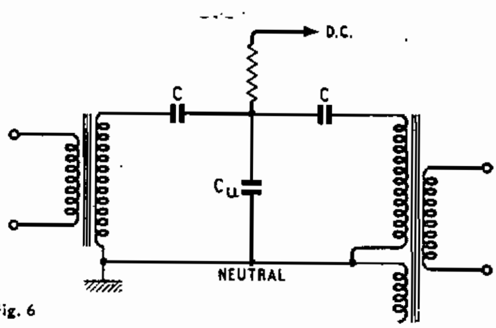


Fig. 6

Inductors Carrying D.C.

To measure inductors carrying d.c. the external d.c. supply, which must be shunted by a large by-pass capacitor, may be connected in series with the inductor provided that the current does not exceed the value specified in the handbook for each range of the bridge. The arrangement shown in Fig. 7 may be used when the d.c. current is heavy. Values of resistance and inductance are given by $R_u = R^2/R_m$ and $L_u = R^2/L_m$, where R_m/L_m are the values measured on the bridge.

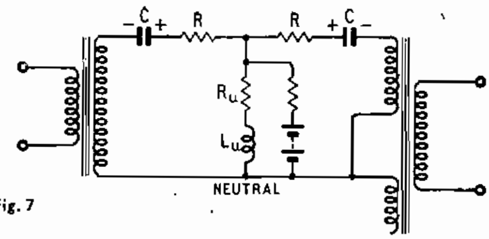


Fig. 7

Low Impedance Adaptor Q221

The lead resistance and the winding resistance of the bridge transformers determine the lower limit of impedance measurement that can be made accurately with the B221. The Low Impedance Adaptor Q221 extends the range to include larger values of capacitance and very small values of resistance and inductance.

The Q221 serves as an impedance inverter between the bridge and the unknown, measurement being made on the bridge itself. This has a high discrimination which, extended to the adaptor ranges, can be most useful for comparison of component values or the detection of small changes such as those encountered in temperature coefficient measurements. With the Q221 the bridge will measure, *in situ* if required, dry joints, switch contact resistance, high capacitance electrolytics, earth bonding efficiency, etc.

Chemical Measurements

An ever-widening field of use in the chemical and food manufacturing industries is described in a separate leaflet, available on request. Special cells and adaptors have been designed to facilitate such measurements as the conductivity of liquids both with and without the use of electrodes, and the dielectric properties of liquids in test tubes. The boundary layer impedance of liquids, as well as the loss factor and permittivity of solids and liquids, are among the other possible measurements. The provision of non-contacting electrodes means that the adaptors can be used at a considerable distance from the bridge.

The Wayne Kerr Applications Group is always glad to advise prospective users on any aspect of the bridge technique of measurement and to explain how it can be applied to particular problems.