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AN INDUCTIVE THICKNESS GAUGE

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Summary

An inductive thickness gauge is described for measuring wooden panels in instruments. A prototype has been built and measures over the range 0-10mm to an accuracy of about 0.2mm.

This work has been done in conjunction with a Galpin Society Research Award and may be published in the Journal at some future date.

Description

Measurement of the plate thickness of intact instruments is difficult. Callipers must be specially made for each instrument. If they are thin enough to manipulate through f-holes they will be too flexible for great accuracy. They also risk damaging the f-holes and frighten museum curators. An alternative method is required which does not need a mechanical coupling between the inside and outside measuring probes.

For this gauge the coupling is electromagnetic. The Outer probe is an inductor wound on a Ferrite core. The inner probe is a small piece of soft magnetic material. Wood has practically no effect on a magnetic field and the measurement is the same as if the outer and inner probes were separated by an air gap. The thickness is measured by making the inductor one arm of an a.c. bridge circuit. The bridge is balanced with an infinite gap. As the inner and outer probes are brought closer together the bridge becomes unbalanced and the unbalance voltage gives a meausre of the gap.

With a large gap only a small fraction of the flux goes through the inner probe and so the change in inductance caused by a small change in gap is very small. However the bridge is near its balance point and a very small change of inductance gives a large proportional change in bridge unbalance voltage. When the gap is small most of the flux passes through the inner probe. The inductance increases rapidly as the air gap is decreased giving a similar proportional change of out of balance voltage with a similar change of gap.

On the prototype instrument the gap is almost proportional to minus the logarithm of the out of balance voltage. This is handy because most a.c. millovoltmeters have a logarithmic scale for reading decibells. The reading varies from 0 dB for zero gap to-36 dB at 10mm i.e. 300mV to 4mV. and A typical linear meter must be switched over four sensitivity settings to read this range accurately, but at each sensitivity a 1mm change in gap gives a similar angular movement of the pointer of from 20 to 30 degrees.

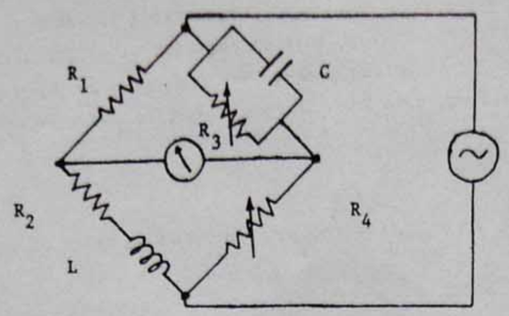
Construction

The outer probe is a coil of about 750 turns of 40 swg enamelled coper wire wound on one half cut from a Mullard DT2284 coil former. This is araldited into a Mullard FX3286 30mm. Ferrite transformer pot core. A 5 thou sheet of polystyrene is araldited over the face of the coil and core since Ferrite is rather hard and scratchy. The inner probe is a convex disc of soft iron cut from a beer bottle top. This is fixed to a length of 16 swg brass by a hinge.

The coil parameters at infinite gap were found to be:-

R_2 = 70 Ohms
L = 45 milli Henrys

Bridge Circuit



For balance $R_1.R_4 = R_2.R_3 = L/C$

Suitable values for the bridge components are:-

R_1 = 200
R_4 = 22.5 K
R_3 = 64.3 K
C = 0.01 μ F

The bridge was built using 10K 22 turn cermet trimmers in series with a fixed resistor for R_3 and R_4. A high stability capacitor is advisable. The bridge supply is about 1 volt 880Hz sinewave. It is important that the bridge supply should be a pure sinewave as the out of balance voltage is frequency dependent. The indicator is an a.c. millivoltmeter with 1 Megohm input impedence.

Operation

The bridge is balanced to give a null reading with the probes far apart. The two probes are then put in contact and moved so that they are aligned one over the other as shown by a maximum out of balance voltage. The oscillator output is adjusted to give 300mV out of balance voltage. The instrument can now be calibrated using small spacers of known thickness. Formica is about 1.6 mm thick.

It is a good idea to recheck the balance, oscillator output and calibration from time to time. Frequency drift in the oscillator causes a change in shape of the calibration curve.

When taking measurements it is easiest to position the inner probe and then move the outer probe to the position which shows minimum thickness (maximum voltage). The gauge will readily detect nails or other iron objects at a distance of 10 cm.

Further Work

Several improvements are being considered. The transformer pot core is rather an inefficient shape for maximum sensitivity. Alternative geometries will allow a smaller inner probe.

The inner probe could be pulled into contact with the outer probe magnetically. This would allow one handed operation. The ultimate would be to measure lute bellies with a free inner probe small enough to pass through the rose.

Range changing on the millivoltmeter is inconvenient. A suitable instrument with a logarithmic scale law, similar to a sound recording peak program meter, could be directly calibrated in millimeters.

Drift in calibration is slight but could be reduced by improved meter and oscillator design.

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