Team Problem 8

Coil Above a Crack:
A Problem in Non-Destructive Testing

1. General Description of the Problem

A block of austenitic stainless steel contains a rectangular slot, representing a flaw (see Fig. 1). A differential probe moves across the surface of the block. The probe (Fig. 2) is a cylinder with an inducing solenoid 4~ mm in diameter and two smaller receptive solenoids 10 mm in diameter. Each of these two solenoids is in a branch of a Wheatstone's bridge (Fig. 3). The voltage or current at point C is proportional to the difference of magnetic flux in the two receivers. An amplifier and a dephasor generate signals and send these to the two pairs of plates in the oscilloscope, representing the real and the imaginary parts of the differential impedance between the metallic block and the receivers. Variation of these output signals is then obtained by moving the probe above the face containing the flaw.

2. Input Parameters

2a. The block is a rectangular block 330×285×30 mm with a 40×10×0.5 mm flaw inn the center of one of the large faces. It is made of austenitic steel type 18-10MO with less than 2% of ferrite. Assume a relative permeability μ_r=1, and a conductivity a 0.14×10^7 S/m

2b. The probe consists of one inducing solenoid B and two induced solenoids B1 and B2; there is no magnetic material. There is a distance of 5 mm from the bottom of the coils to the bottom of the probe. From an electromagnetic point of view only the three coils need to be taken into account (Fig. 2). The frequency is 500 Hz. B1 and B2 are in two branches of a Wheatstone's bridge so that the output display on a cathodic screen is the image in the complex plane of the difference of magnetic fluxes through B1 and B2 (Fig. 3).

2c. Coil Motion. A dielectric plate 3 mm thick is put between the block and the probe so that there is a gap of 5+3=8 mm between the coils and the block. Two different movements of the probe are to be modeled (see Fig. 4).

If x is the distance between the axis of the probe and the center of the flaw the result must be displayed for a movement of the probe from x=80 mm (where the influence of the edge of the block is important) to x=−80 mm (or x=0, the signal being symmetric).

3. Presentation of Results

The output signal is completely defined except for a rotation and a scaling factor. In order to compare results, we will assume that the impedance at x=80 mm is (0, 1) in the complex plane of impedances.

On the impedance plane (scale: 50 mm=1 in real or imaginary direction) plot the signal from x=80 mm to x=0. Label the points corresponding to x=80, 70, 60, . . . , 0 mm.

4. Reference

Experimental results, and some early computed results, can be found in:

J.C. Verite, "Application of a 3-D Eddy Current Code (TRIFOU) to NonDestructive Testing," COMPEL, Vol. 3 (1984) pp. 167-178.

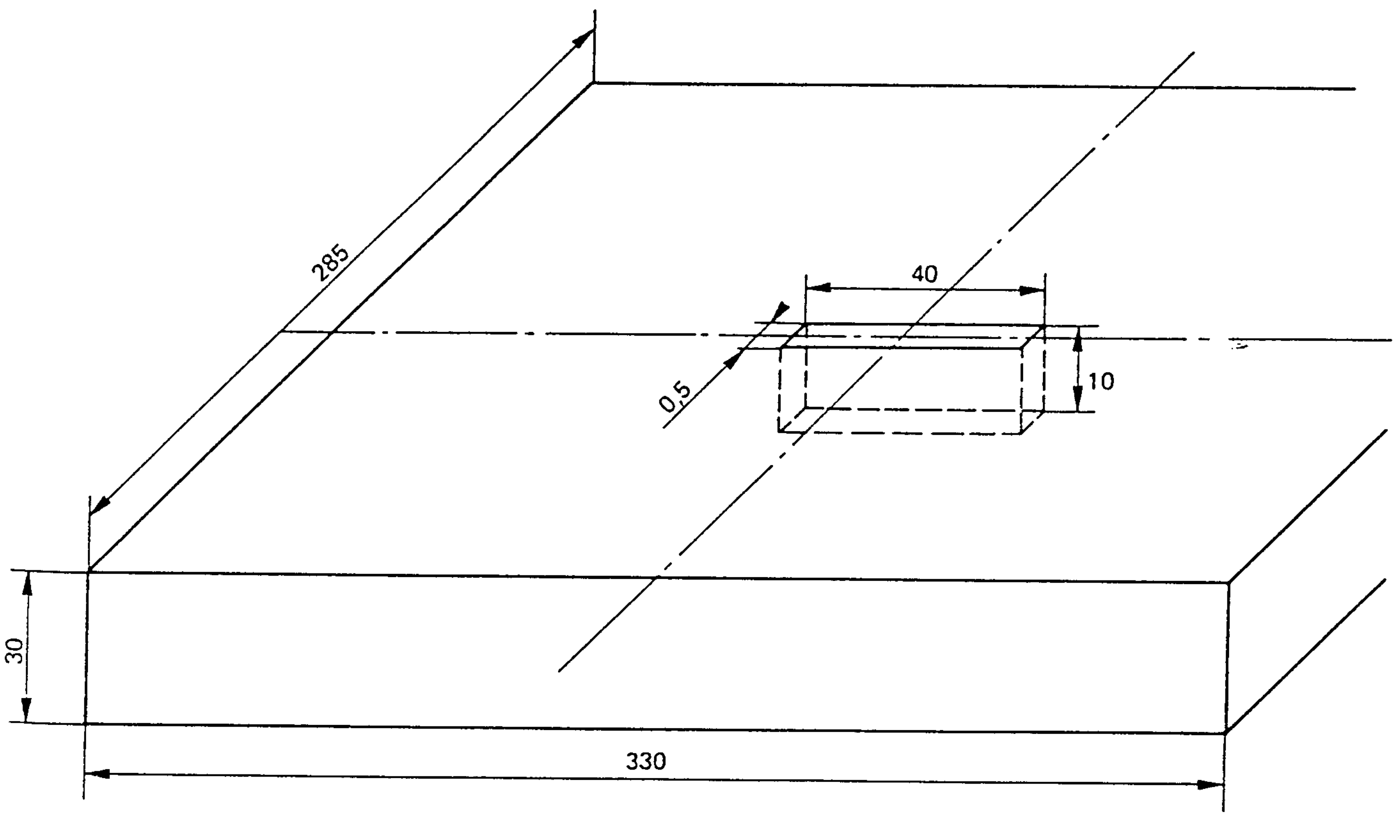

Fig. 1 The Block

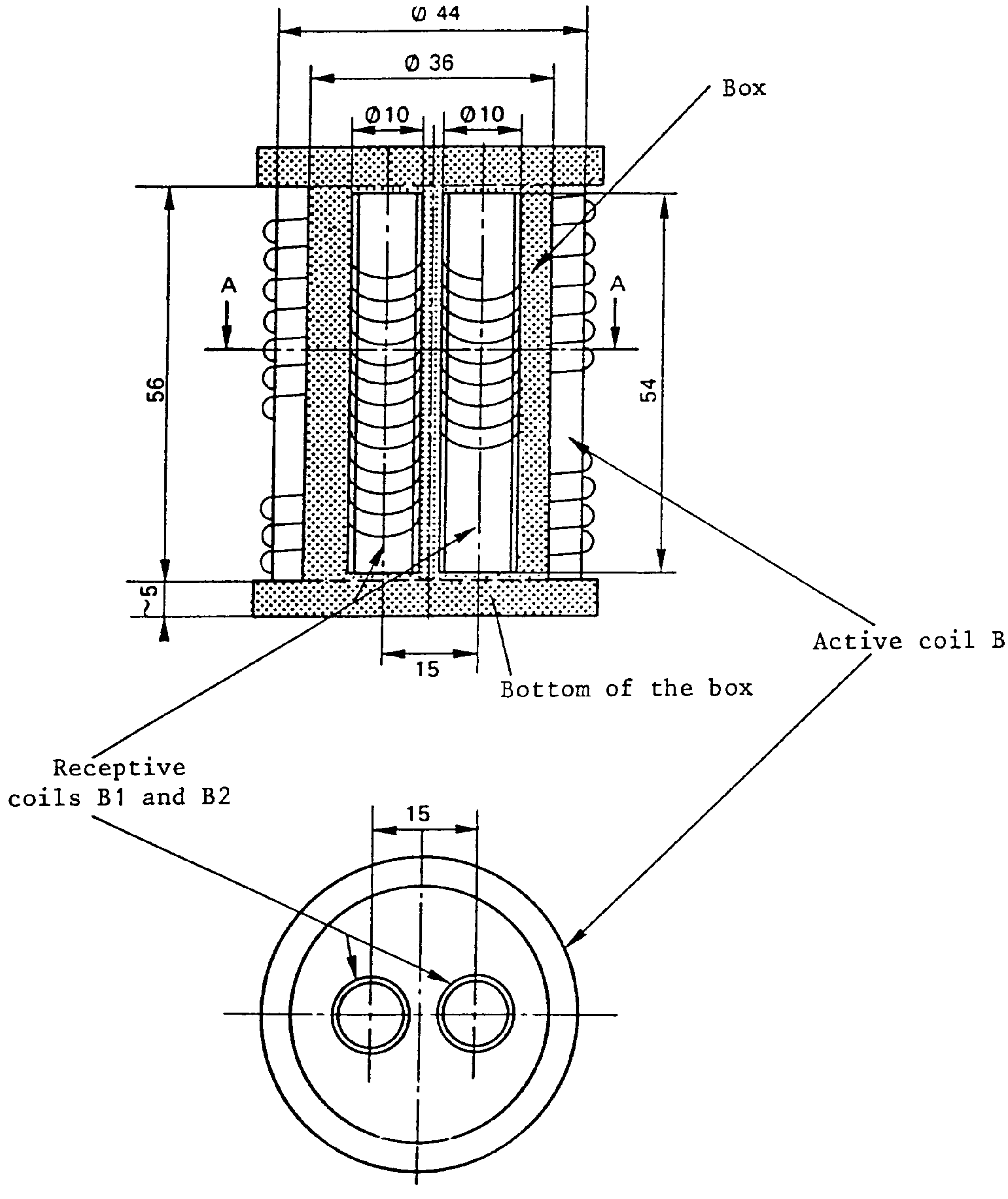

Fig. 2. The Probe

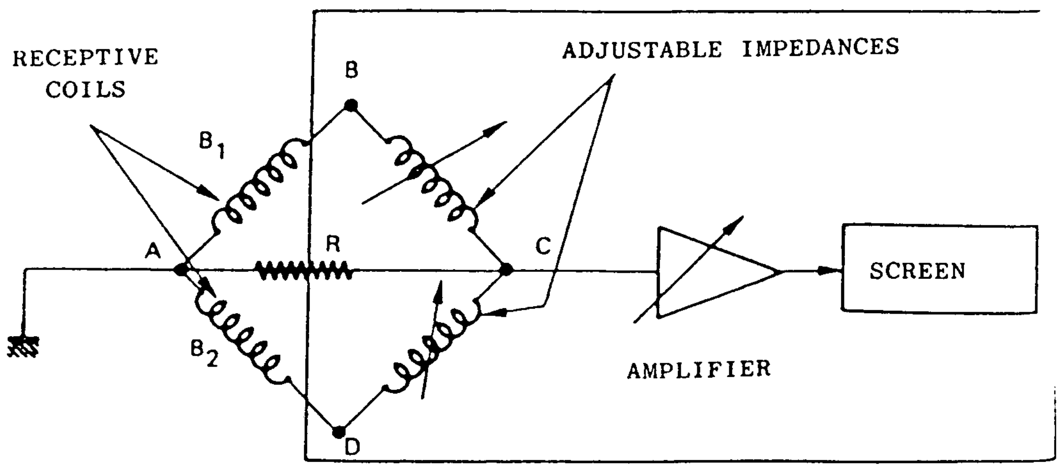

Fig. 3. The Measurement Apparatus

a. Motion perpendicular to the flaw

b. Motion parallel to the flaw

Fig. 4 Coil Motions to be Modeled