DEFECT IMAGES BY PLANAR ECT PROBE OF MEANDER-MESH COILS

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Abstract **- This paper presents results pertaining to image data obtained from a planar meander-mesh coupled coil type ECT probe. The image data makes it possible to detect not only the existence of a defect but also to extract detailed information regarding the nature of the defect, such as its position, shape, length, and direction. In order to recognize a defect distinctly, we have fabricated the high sensitive planar coil which can be used to image a 2-D representation of the ECT signal. The relationships between the image pattern and defect shape are discussed.**

I. INTRODUCTION

Advanced planar type ECT (eddy-current testing) probe have been proposed for detecting crack in metallic objects[1]. The ECT technique is simple to implement and can be used to provides the high-speed inspection of metallic surfaces at a testing site. But recently the ECT technique is requested to detect not only the existence of a defect but also to obtain the detailed information including its position, shape, length, direction, and material parameters.

Imaging technology can further expand the use of ECTs by enhancing the resolution and sensitivity of the visual record. Unfortunately ECT data acquisition for 2-D image takes too long. In this paper we apply the graphical technique without compute processing to interpret the acquired ECT data. Also the relationships between the imaging pattern and the nature of the defect are discussed.

II. PLANAR ECT PROBE AND MEASUREMENT

The ECT probe consists of a pair of planar coils, a meander type exciting coil and a mesh type detecting coil as shown in Fig.1. The magnetic fields are generated by a meander coil and have a striped pattern of alternating positive and negative vertical components. The key point for this probe is that eddy currents induced on a conductive plate have the same pattern as the meander pattern except at the coil's periphery. The mesh coil is a 2-D distributed pick-up coil which senses a localized magnetic fields. Fig.2 shows the cross-section of the used ECT probe which was used. The NiZn magnetic plate enhances the strength of the magnetic field and also shields pick-up coils from external noise. The patterns of the planar coils are shown in Fig.3. These coils are fabricated using an etching technique. The mesh coil which senses the magnetic distribution has a three turn winding structure so as to enhance output voltage. The width of the mesh coil is the same as the meander coil. Both coils have the same pitch and are lined up with each other exactly. With no defects the magnetic fields become regular and thus eddy currents have the direction at each pitch as shown in Fig.4(a). On the other hand, Fig.4(b) shows that the distribution of eddy currents has a localized pattern if a defect exists. The eddy-current distribution for defected plate has the variance as shown in Fig.5. The area where uniform positive and negative flux distributions exists do not

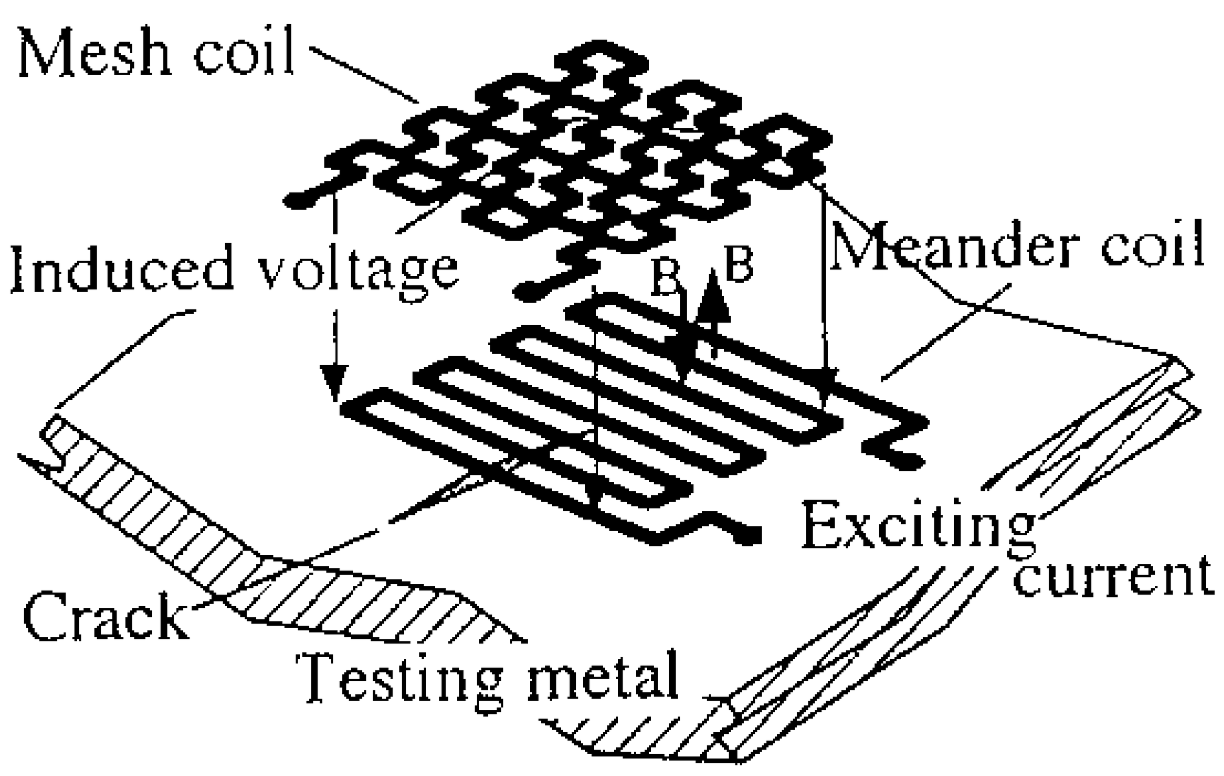

Fig.1 Configuration of meander/mesh coupled ECT probe.

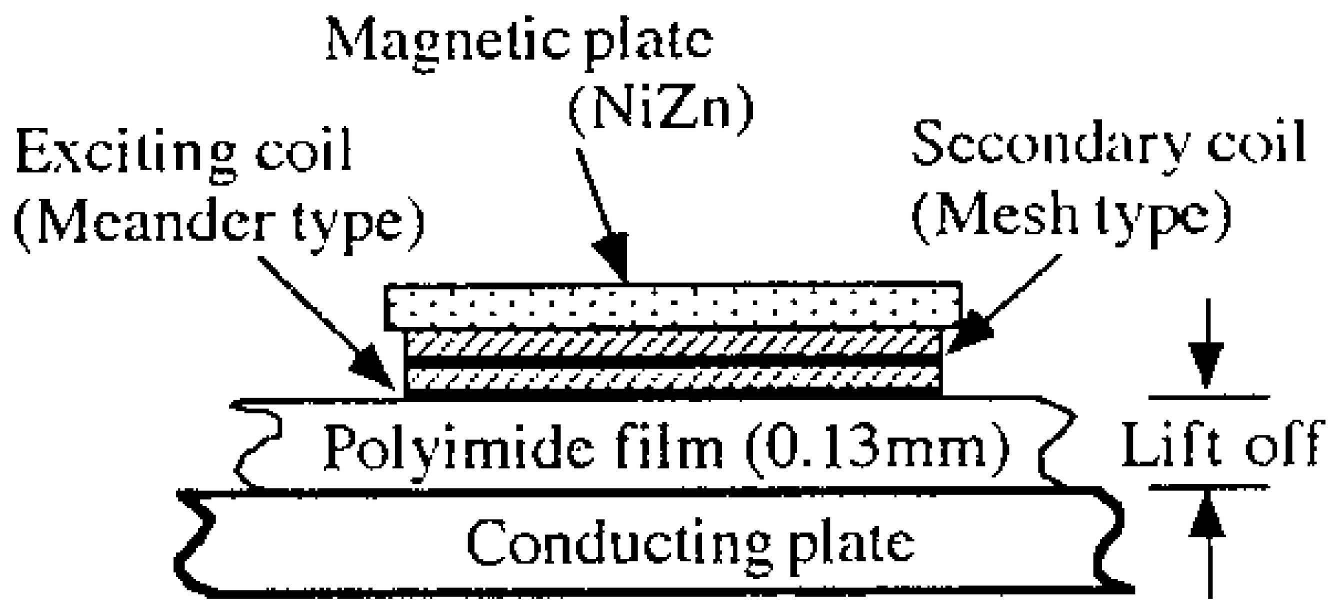

Fig.2 Cross section of planar ECT probe.

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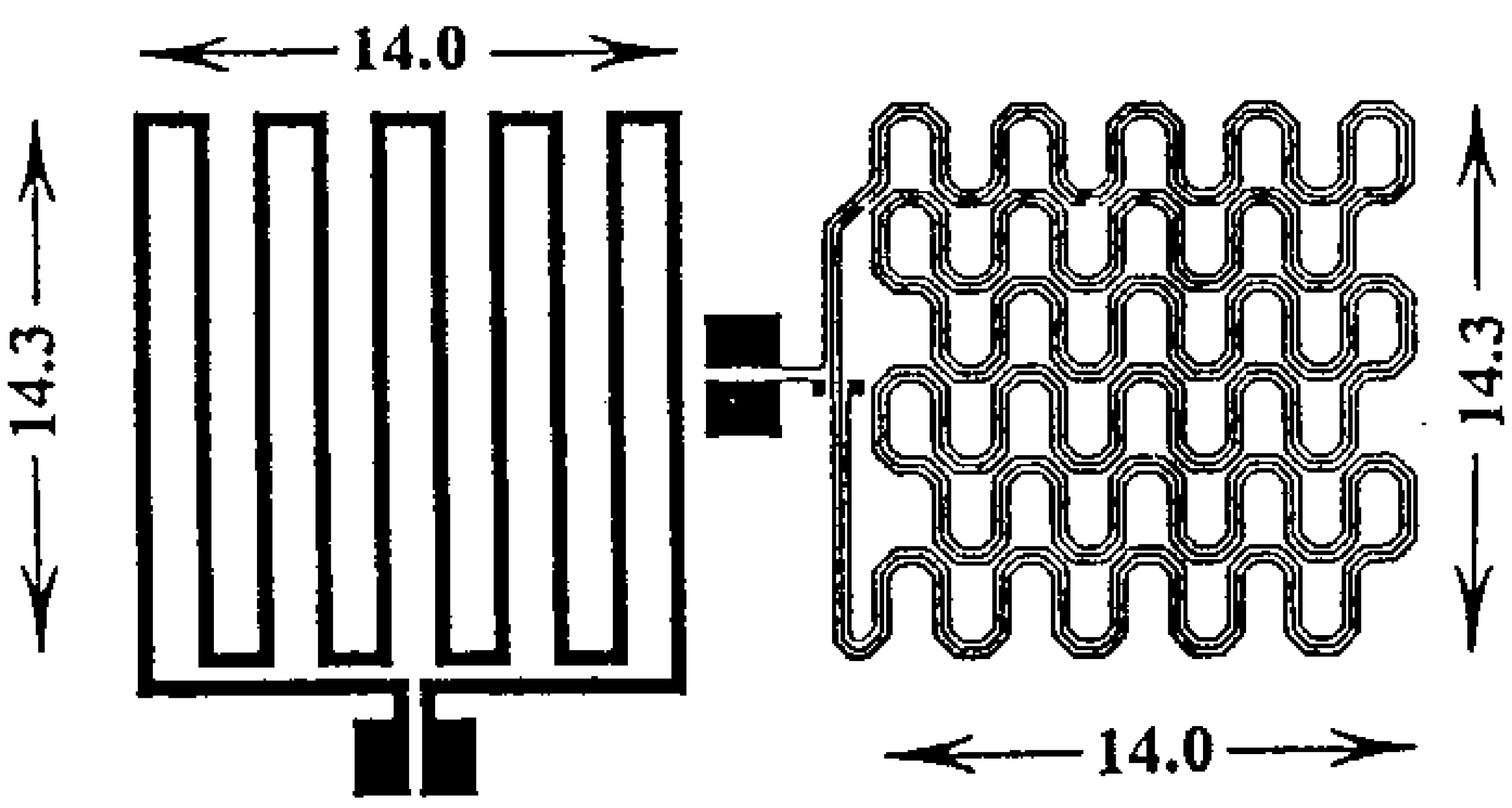
contribute an induced voltage at the output terminal of the mesh coil. In contrast the variance in the flux linking the gray area of the mesh coil induces a voltage thus indicating the presence of a defect.

III. 2-DIMENSIONAL SCANNING AND IMAGE

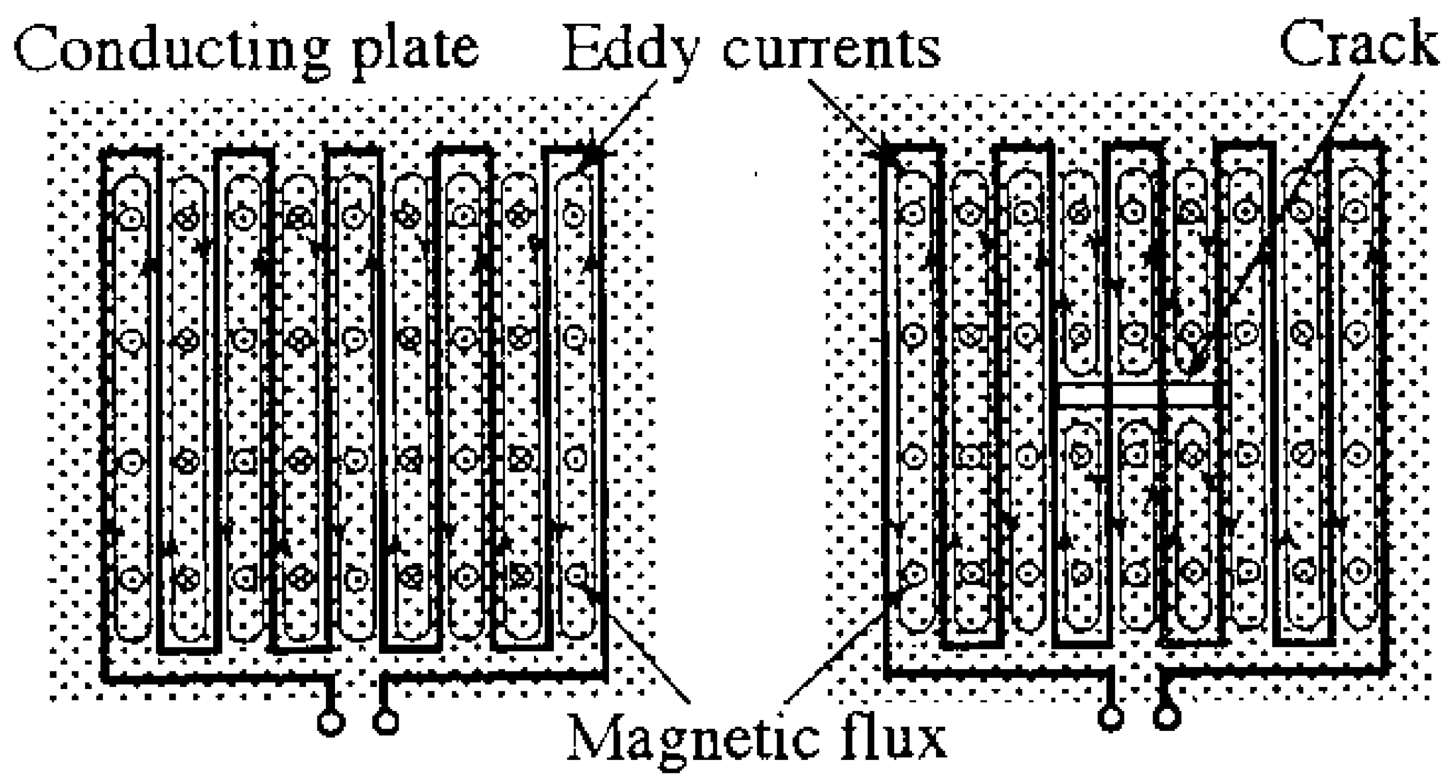
Two types of defects as shown in Fig.6 have been considered in order to examine the images obtained from an advanced ECT probe. One of the defects is a crack with a scratch which penetrates half way into the copper plate. The other type of defect is a 2.5mm diameter hole which extends through metallic object. The probe was scanned around the defect as shown in Fig.6. For crack shape defect, the angle θ for scanning probe is defined as shown in Fig.6(a). The output voltage appearing across the mesh coil is measured by lock-in amplifier. The 2-D data of position and sensing voltage are stored on a point-by-point basis.

Fig.7 shows the wire-frame diagram of the ECT signals obtained for the crack model. We can observe three stripes of maxima and minima where the number of stripes depend on the winding number of the mesh. In the case as shown in Fig.4, the positive voltage is induced across the mesh coil. When the crack is located above the next pitch of the mesh coil, the negative output voltage appears. Then three strip peaks are observed on the ECT image. However the striped figure are not related to the pattern of an defect. There is a noticeable offset voltage in the those regions which are away from the defect. This is mainly attributed to the difference between the segments of the mesh coil which have positive



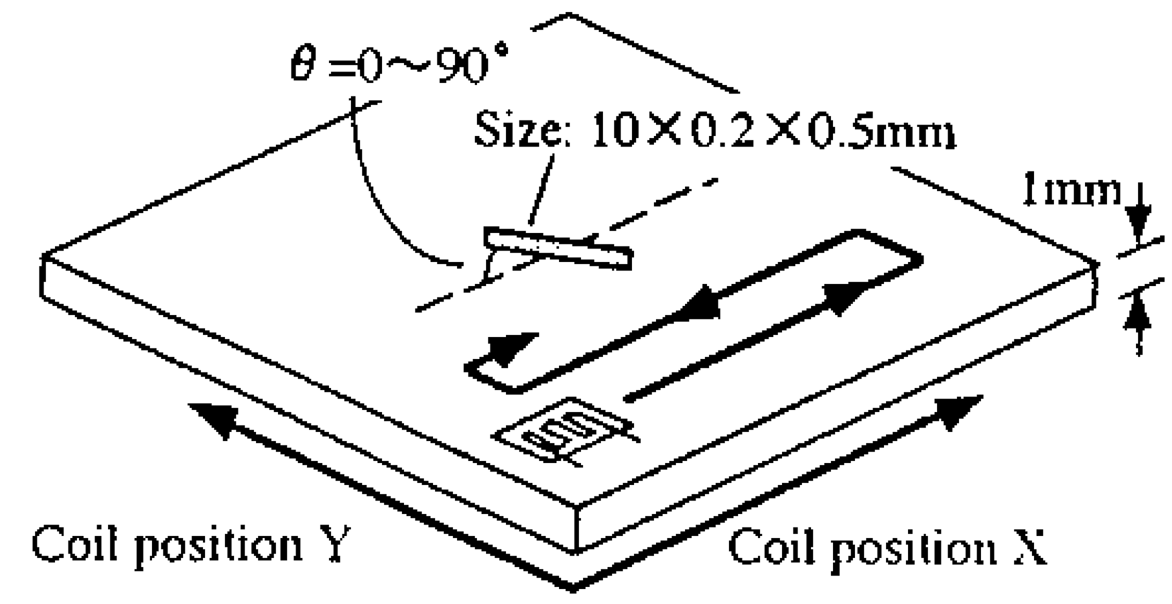
Width:0.5, Coil pitch:1.0 Width: 0.1, Coil pitch:0.1
Thickness:0.012mm Thickness:0.012mm, N=3turns
(a) Meander coil (b) Mesh coil

Fig.3 Patterns of meander and mesh coils.

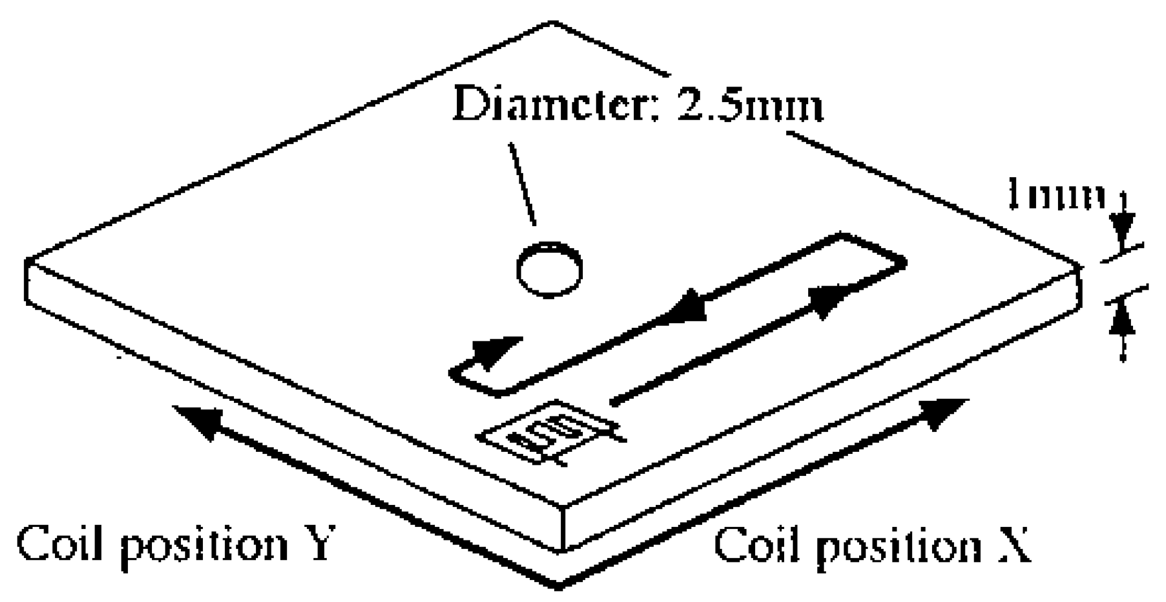


(a) Without defect (b) With crack

Fig.4 Distributions of induced magnetic flux and eddy currents.



(a) Crack model



(b) Through-hole model

Fig.6 Defect models.

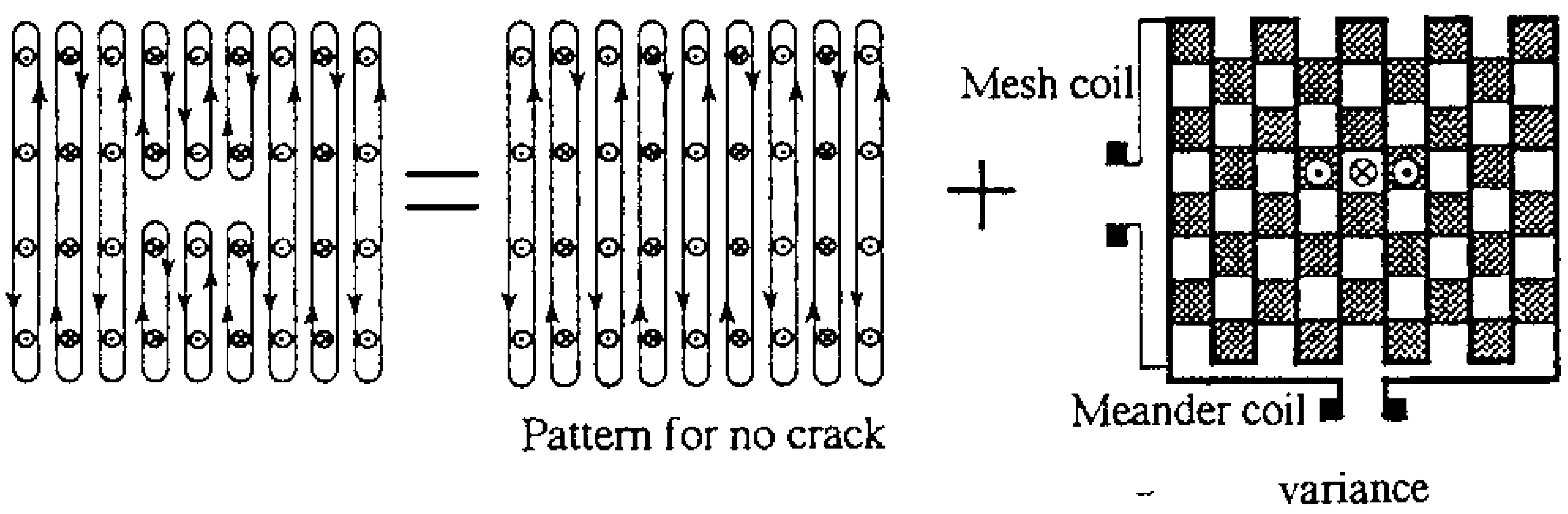


Fig.5 Principle of induced voltage of mesh coil.

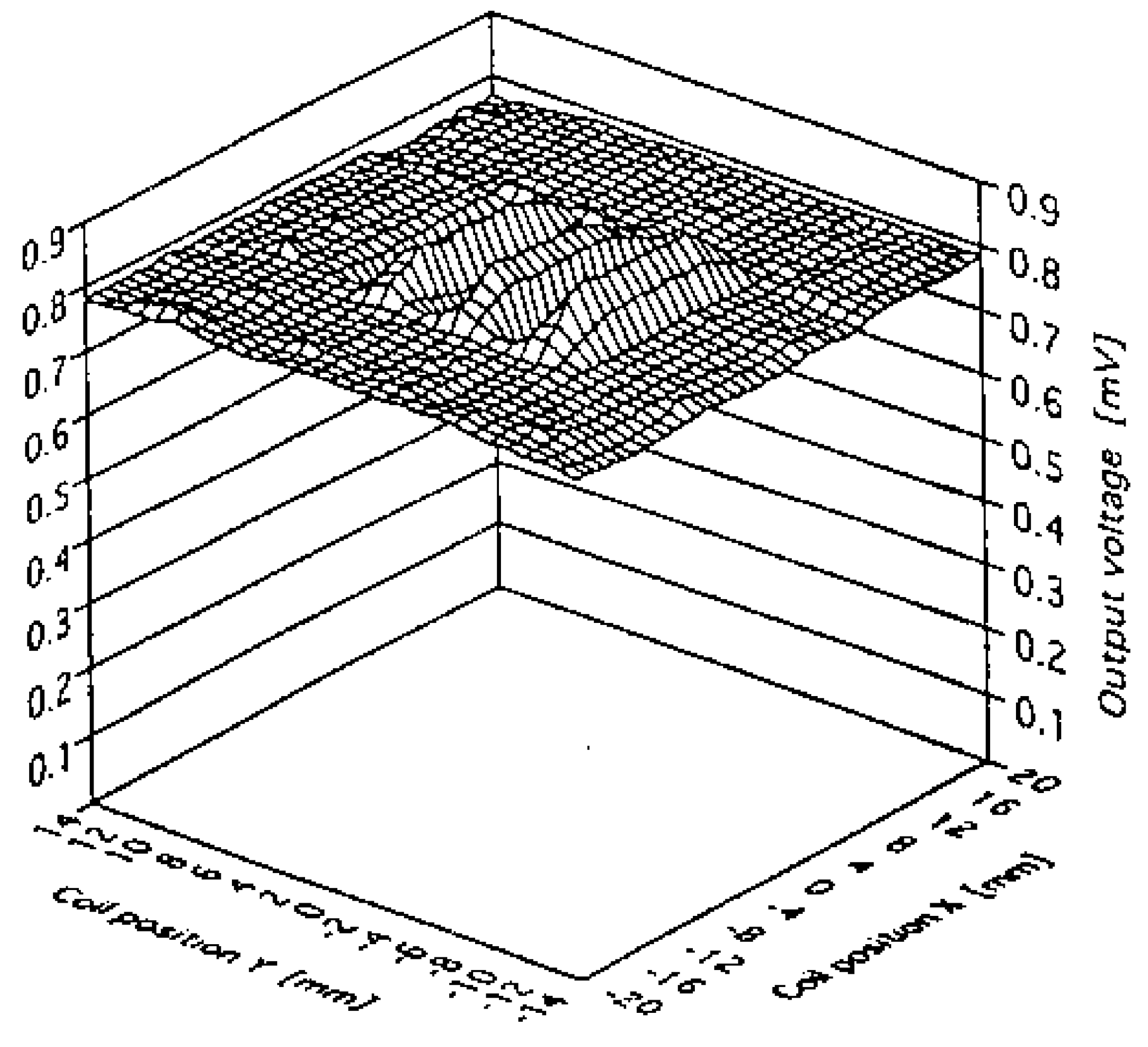


Fig.7 Wire frame diagram for crack model ($\theta = 0$).

and negative rotation. The use of a differential type configuration of two mesh coils would lead to a reduction in the amount of offset voltage[1].

Fig.8 shows the gray-scale diagrams for the crack-type defect. This image reveals clearly the nature of the crack compared to the pattern in Fig.7. The uniform gray level outside of the crack area represents the noise level in the absence of the offset voltage. The length of the strip pattern denotes the size of the crack. The size of the pattern, 24mm, indicates the sum of the planar coil(14mm) and crack (10mm) dimensions. Figs.8(b) and (c) show the effect of the scanning direction on the shape of the pattern. The sensed voltage is observed to decrease in smaller steps as the orientation angle θ increased. The image has the striped pattern with a skew determined by the orientation angle θ. These results show the possibility of being able to infer the crack's direction.

Fig.9 shows the results for the hole defect. The sensed image shows the broad pattern of the planar sensor's shape. The pattern for a hole-like defect is distinctly different from that of a crack-like defect.

IV. Conclusion

This paper has discussed the 2-D image of the pick-up signal obtained by the meander/mesh coupled coil probe. The image data give added information about defect details. Positioning the probes at different orientation angle and lateral distances allows us to extract information about the defect geometry.

Reference

[1] S.Yamada, M.Katou, M.Iwahara, and F.Dawson, "Eddy-current testing probe composed of planar coils", *IEEE Transaction on Magnetics*, vol.31, no.6,1995, pp.3185-3187.

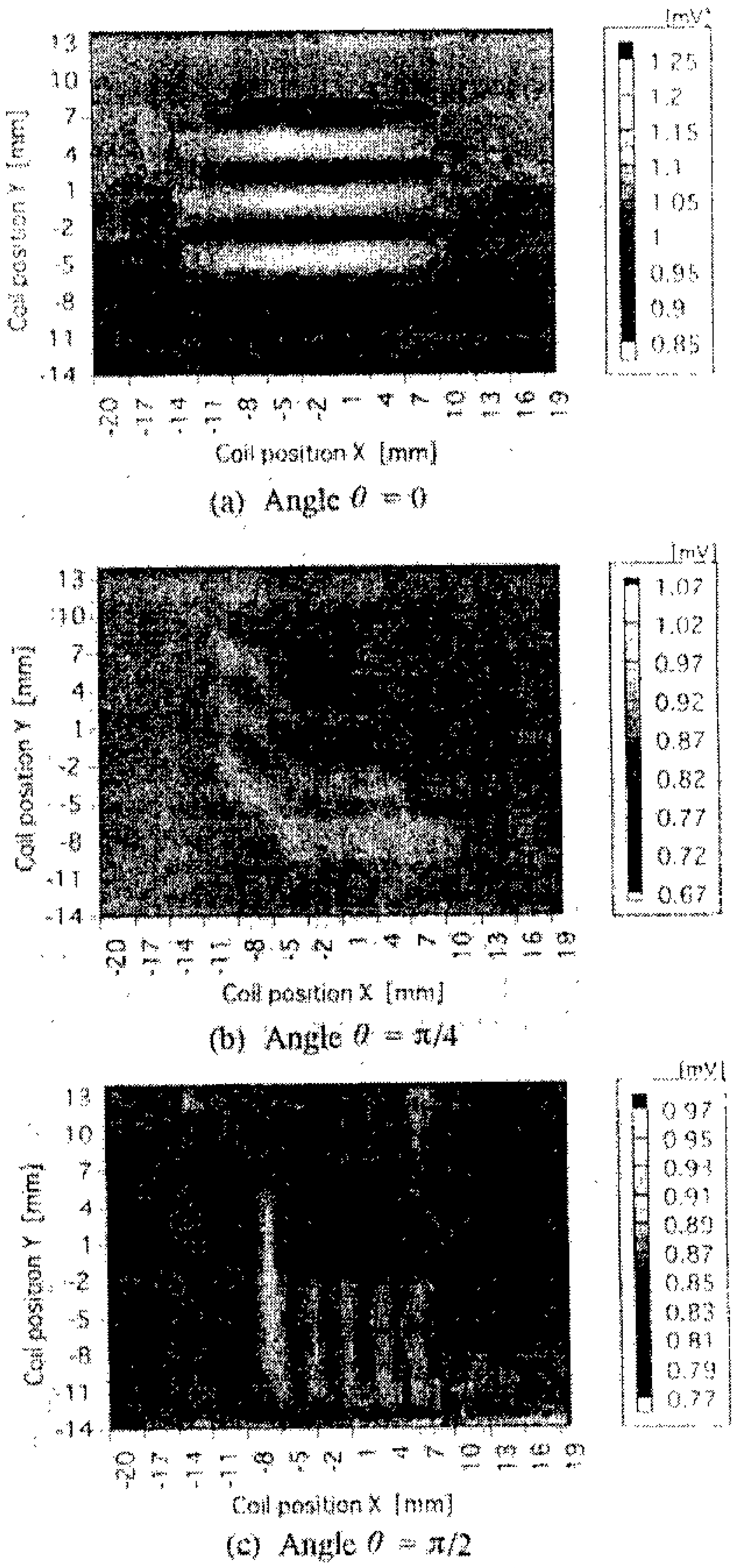


Fig.8 Gray-scale diagram for crack model

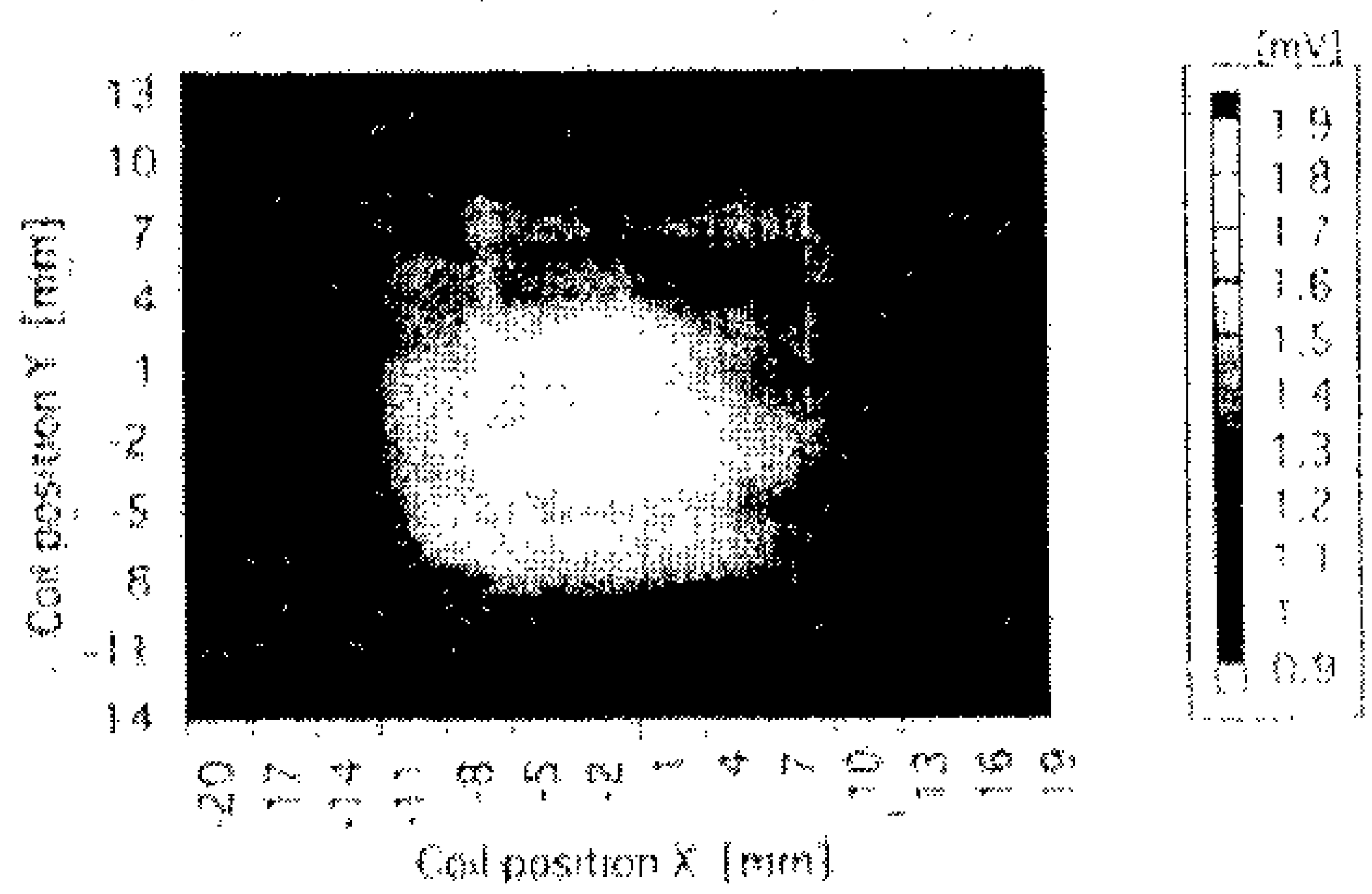


Fig.9 Gray-scale diagram for through hole model.