A NOTE ON LIGTENBERG'S

REFLECTIVE MOIRE' METHOD

by

Fu-pen Chiang, Assistant Professor

and

Jack Treiber, Research Student

Department of Mechanics, College of Engineering
State University of New York
Stony Brook, N. Y.

ABSTRACT

A new arrangement of the optical components of the Ligtenberg reflective moire' method is proposed whereby the line density of the reference grating can be varied continuously. As a result the sensitivity of the method can be changed at will to suit the particular problem under study.

INTRODUCTION:

The Ligtenberg reflective moire' method[1]* is certainly one of the best techniques for the study of the bending of plates[2]. By way of analogy it can also be used for the study of two-dimensional stress problems[3]. Directions of principal moments in a flexed plate or principal stresses in a two-dimensional problem can also be obtained from this method with little variation[4].

The optical arrangement of Ligtenberg's method was improved by Reider and Ritter[5] by introducing a partial mirror between the model and the grating. By so doing a plane grating can be used instead of a cylindrical grating as used by Ligtenberg for simplifying the analysis, and it is also easier to use higher density gratings. Advantages of the Rieder and Ritter arrangement are summarized by Theocaris[6]. **The improved version of the method was later** used by Heise[7] for obtaining directly curvature contours of flexed plates. . The present paper offers yet another improvement to the optical arrangement whereby the sensitivity of the method can be changed at will.

THE NEW OPTICAL ARRANGEMENT AND RESULTS:

The new optical arrangement of the system is shown in Fig. 1, where an ordinary slide projector projects the image of a grating onto a large ground glass. **This image is then transmitted via a** 45° **oriented partial mirror to** the model (flexed plate) and reflected back to a recording camera whose optical axis is perpendicular to the original plate plane. **The only difference be-** tween the present arrangement and that of Rieder and Ritter is that instead of

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* Numbers in brackets indicate reference at the end of paper.

a grating of fixed line density placed in front of a diffused light source, a ground glass with projected grating image is used. With this arrangement the line density of the grating (which is directly related to the sensitivity of the method) can be changed continuously and at will without disturbing any other component of the system. The line density of the image grating on the ground glass can be varied by any of the following procedures: (1) if the slide projector has a "zoom" lens, the line density can be changed by simply turning the lens to vary its position; (2) if the slide projector does not have a "zoom" lens, magnification can be easily varied by changing the distance of the projector from the ground glass; (3) there are slide projectors which provide lenses of different focal lengths. Then magnification can be changed by using different projecting lens; and (4) gratings of different line densities can be used in the projector.

As a demonstration of the versatality of the new arrangement a circular plate with fixed boundary under uniformly distributed transverse load was used. Fig. 2 shows the picture of the double-exposured moire' patterns. The loading was the same for all the three cases, only the line-density of the image grating was varied. The variation was achieved by changing the distance between the ground glass and the slide projector. The grating of 100 lpi was printed on a piece of Kodak High Resolution Plate cut to fit the lantern-slide projector used (it is also possible to use a 35mm - slide projector). Note the number of fringes in the field was considerably increased, from four in Fig. 2(a) to ten in Fig. 2(c) . It is possible of course to obtain many more fringes if so desired by increasing even more the line density of the image grating. However, care must be excercised to the following factors: First, the

illumination on the ground glass tends to become nonuniform if the projector
is too close to it. The intensity of the projecting light is higher at the
center as evidenced by the picture in Fig. 2(c). Second, the contrast of the
pattern is usually reduced when the fringe is too dense. (The contrast of
course is also reduced if the illumination is not uniform). A way to improve
poor-contrasted moire' patterns is to eliminate the background light through
optical spatial filtering[8,9]. An example is given in Fig. 3 where the same
picture as in Fig. 2(c) is shown with enhanced contrast.

ADVANTAGES OF THE NEW ARRANGEMENT:

If the line density of the grating is fixed as in the Ligtenberg and
Rieder-Ritter arrangements, one might run into a situation where the response
of a model is too small (for example, the pattern shown in Fig. 2(a)) to
render a meaningful analysis. It may not be easy to increase the sensitivity
of the system. With the present arrangement one can always vary the sensitivity
continuously and almost without effort. Furthermore, in this system one can
place different types of grating into the slide projector so as to suit the
problem at hand best. For example, circular or radial grating may be used for
problems of axial symmetry and cross-grating may be used to obtain two families
of moire' patterns simultaneously. It may also be mentioned that gratings used
in this system are very small (only a few square inches) in comparison with the
large ones usually used in the Ligtenberg or Rieder-Ritter system and can be
easily made from master gratings employed in the "plane" moire' method.

ACKNOWLEDGEMENT:

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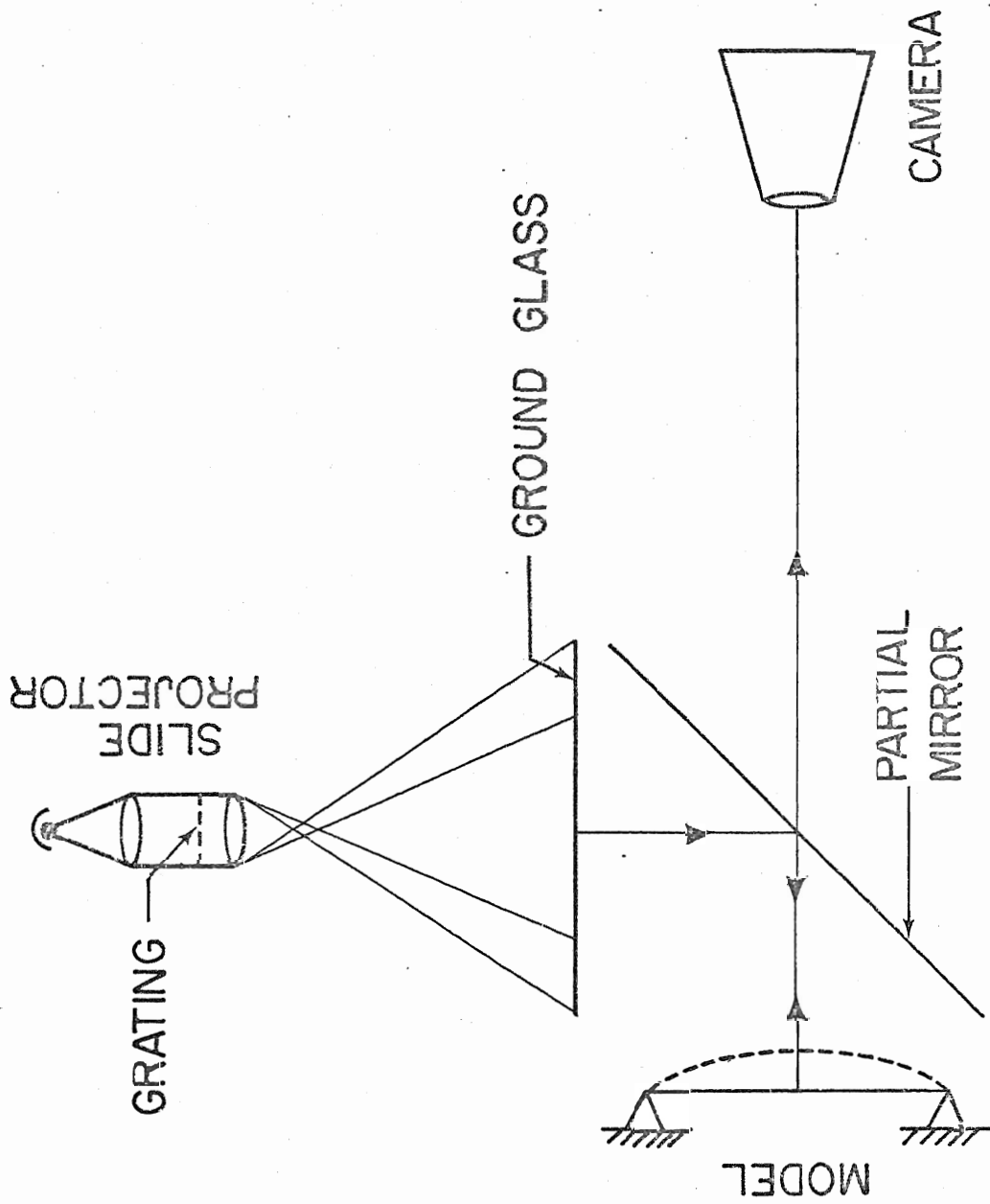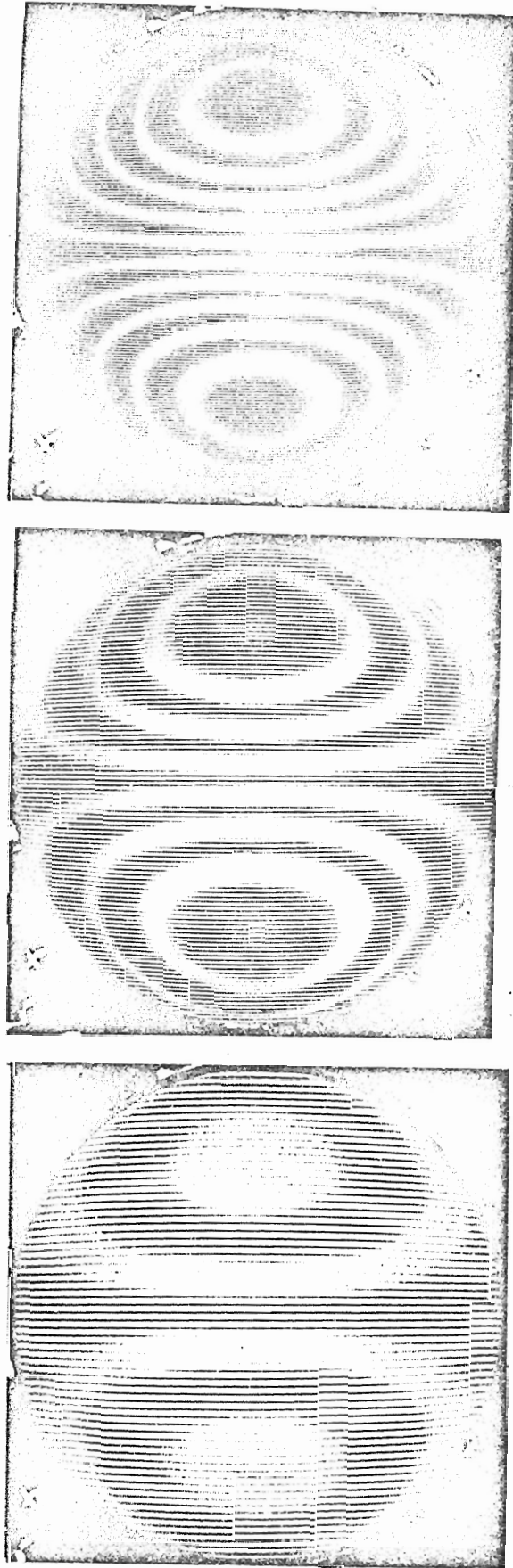
Fig. 1 Sketch of the Optical Arrangement

a)   b)   c)

Fig. 2   Moire' Patterns showing the increase of sensitivity (Model under constant load).
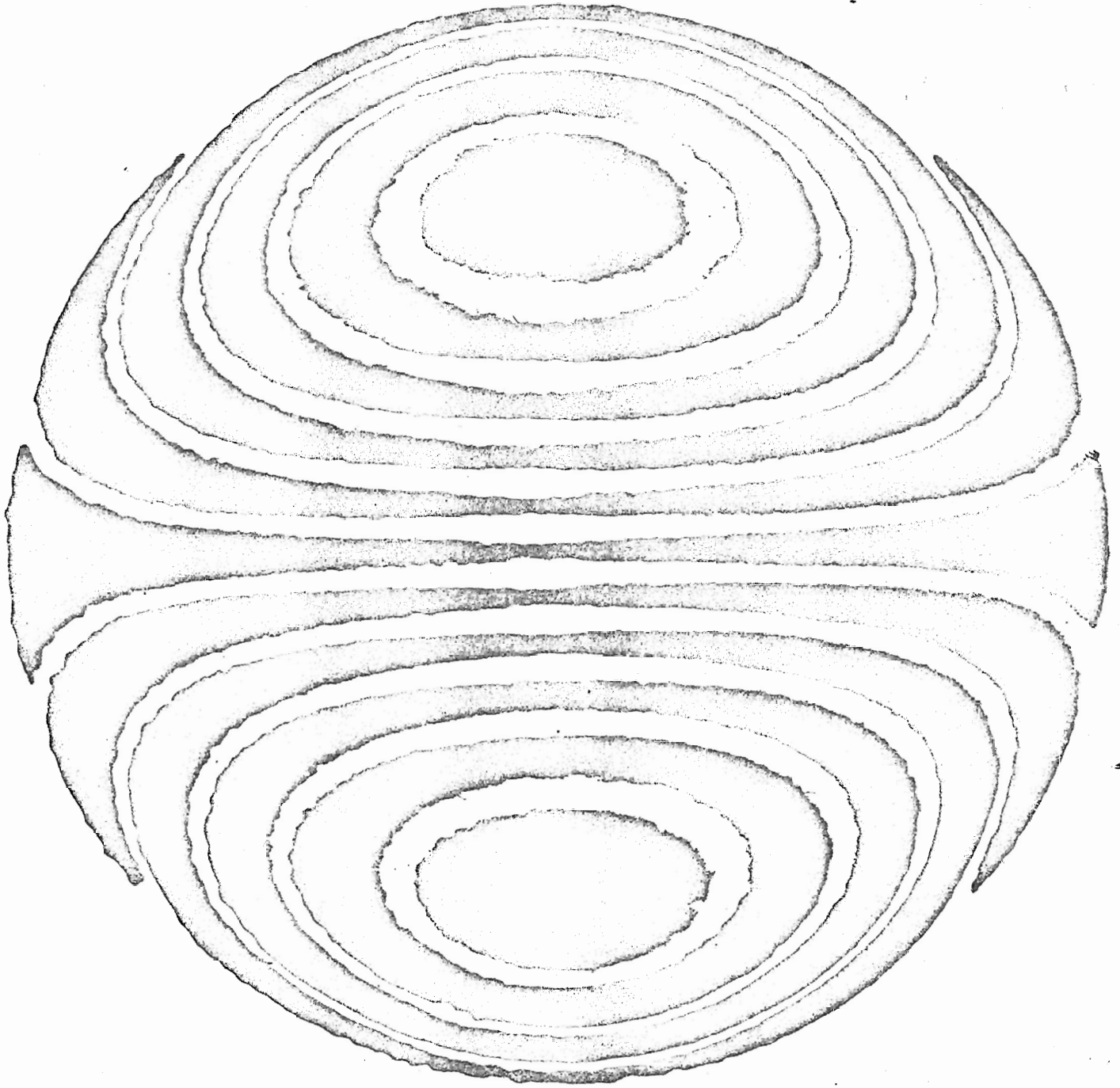
Fig 3   Moire' Pattern identical to Fig. 2 – (c) with enhanced contrast.