APPARATUS FOR TESTING DEFLECTION DUE TO THIN PRISMS

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ABSTRACT

An instrument for testing deflection due to thin prisms, which has been designed and fabricated at IRDE, Dehradun is described in this paper.

Introduction

Thin prisms or wedge prisms as they are generally called are optical glass plates of circular or rectangular or of any other suitable geometrical shape, with two optically polished surfaces inclined to one another at an angle of the order of fraction of a degree (say 10 to 20 minutes of an arc). These are generally included in optical systems of such instruments as levels, theodolites, range finders, test instruments and so on, to function as optical verniers or to deflect the optical path. The deflection so produced is calibrated and is used for measurement of certain parameters, such as small angles, ranges etc. The angle of a thin prism or the deflection due to a thin prism, introduced in an optical instrument, contributes to the accuracy and the least count of the instrument and is, therefore, required to be known to a very high accuracy. These angles can be measured accurately on a Goniometer which however requires rigid mounting, accurate and time consuming alignment and careful handling; but in regular production, the optical worker and the inspector require a rugged but accurate instrument which can be used for rapid measurement and check in the shop. An instrument to meet the above requirements has been designed, produced and put into regular use at the Instruments Research and Development Establishment, Dehra Dun.

Description of the Apparatus

The instrument consists of (Plate I) a collimator, a telescope and a test prism mount, a deflection mirror, all mounted on a rigid base and a wooden table. The collimator is fitted with a lamp (house) to illuminate the graticule, a diffuser and a green filter to provide diffused monochromatic illumination, a graticule and a well corrected object glass (collimating lens). The graticule is a plane parallel glass plate with a cross and series of vertical lines on either side of the central line marked at intervals of one minute (see fig. 2, plate I). The object glass is of about 29 "focal length and nearly 2" aperture. Such large dimensions are chosen for sufficient magnification and resolution to enable accurate setting of the collimator graticule against the telescope graticule. As an alternative to the lamp for illuminating the graticule of the collimator, the instrument is also fitted with an adjustable mirror which can reflect light on to the graticule either from a pendant lamp or diffused sun light. A low wattage lamp with a well ventilated lamp house is designed lest the dissipated heat might cause distortion in the instrument. The collimator is assembled vertical on a rigid hollow pillar.

Inside the collimator *i.e.*, in between the graticule and the collimating lens is mounted a thin prism called the vernier prism which can be moved along the column *i.e.*, along the optic axis of the collimator over a graduated scale. The movement of this prism causes a shift of the image of the collimator graticule in the plane of the telescope graticule.

The test prism mount (see plate I) carries a rotatable cell for alignment of the test prism axis with respect to the collimator graticule. The test prism is kept

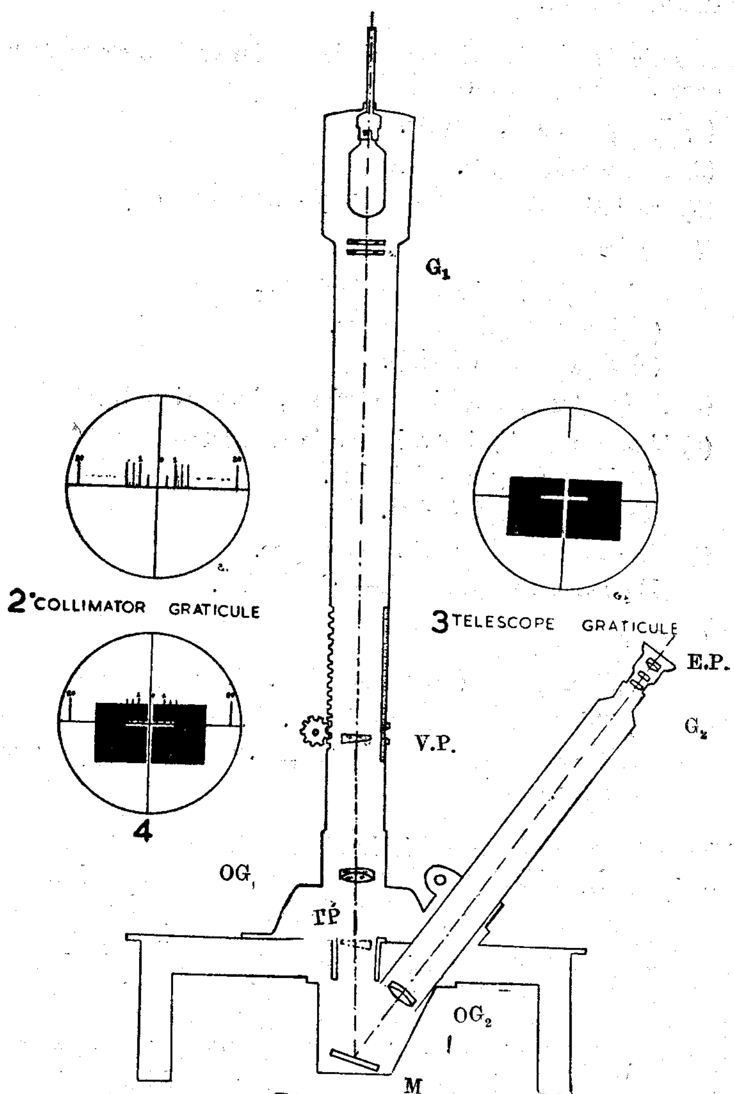

PLATE .

in the cell and is rotated until the horizontal line of the image of collimator graticule is super-imposed on the horizontal line of the telescope graticule.

For the sake of convenience of working, the collimator and the telescope are mounted inclined and the optical path is deviated by a reflecting front silvered mirror mounted on a rigid but adjustable mount.

The telescope is of the conventional type with an eye-piece (adjustable focus type) an objective and a graticule. The objective is of long focal length and the eye-piece of a high magnification. This is done for ease of alignment of the graticule position.

The optical and other characteristics of the various elements used in the system are as given below:—

(1) Lamp—220 V, 5 watt.

(2) Filter—Hg Green.

(3) Deviation due to Vernier Prism—41 minutes.

(4) Collimator

Object glass, achromatic doublet—
(*a*) Focal length—29 inches.
(*b*) Diameter—2 inches.

(5) Reflecting mirror—Plane mirror, front silvered.

(6) Telescope objective achromatic doublet—
(*a*) Focal length—29 inches.
(*b*) Diameter—2 inches.

(7) Telescope eye piece Ramsden type.
Equivalent focal length—0·75 inches.

(8) Graticules—

(*a*) Collimator—(see plate I Fig. 2).

(*b*) Telescope—(see plate I Fig. 3).

(9) Movement of the vernier prism—1·7 cm (approx.), divided into 17 divisions.

The collimator is aligned with the aid of a Gauss eye-piece employing auto-collimation method. The deflecting mirror is adjusted in such a way that the image of the collimator graticule is seen in the centre of the telescope graticule. The telescope is adjusted for infinity with the aid of the above collimator. The telescope graticule is fitted with antagonistic screws such that exact super imposition of the image of the collimator graticule over the telescope graticule is obtained. The eye-piece of the telescope is adjustable for ease of focussing on the graticule. The vernier prism is provided with adjustment for rotation about the optic axis of the collimator in order to facilitate alignment of the prism base with the collimator graticule. Initially the vernier prism is kept at zero marking on the graduated scale.

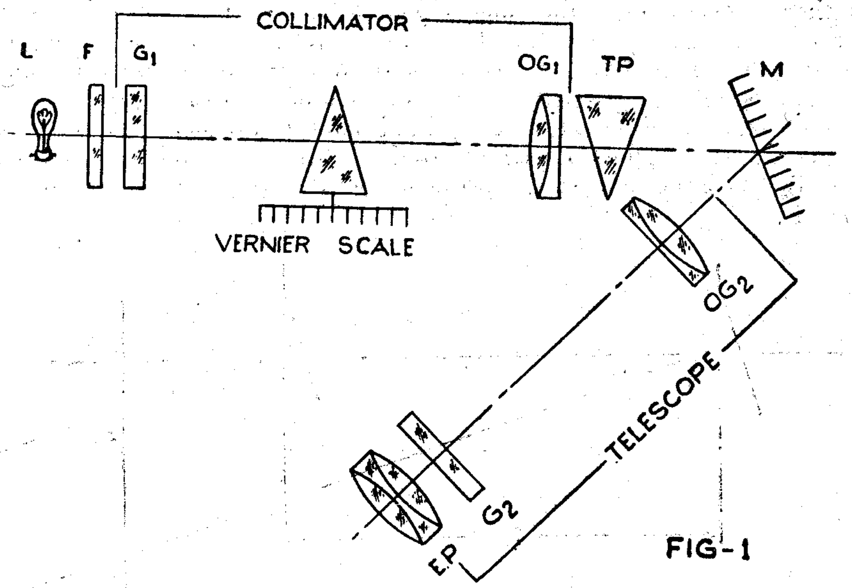

FIG-1

Theoretical considerations

G1 is an accurately calibrated graticule, each division representing one minute. This is placed exactly at the focal plane of the object glass (O.G.1). The instrument is initially aligned such that the centre of the image of the collimator graticule (G 1) coincides with the centre of the telescope graticule (G 2). The movement of the vernier prism (V. P.) along the optic axis of the collimator causes a shift of the image of the collimator graticule over the telescope graticule (G 2). The movement of the vernier prism which causes a shift of one division of the collimator graticule over the telescope graticule corresponds to one minute, as the distance between two adjacent lines on the collimator graticule represent one minute. The collimator graticule is initially designed to suit the focal length of the collimator object glass. The movement of the vernier prism may be sub-divided into 60 equal parts, each sub-division to represent one second. If the deflection due to the vernier prism is θ and the prism is moved through a distance L, inside the collimator, the deflection caused in the optical path S_1 S_2 due to this movement (L) is (see Fig. 2)

$$S_1 \; S_2 = L \; \tan \; \theta$$

If S_1 S_2 correspond to 1 minute of arc, L can be divided into 60 equal parts each division to represent 1 second.

From the above it may be seen that the accuracy of the instrument can be increased by reducing the angle of the prism. The accuracy is, however, limited by the magnification and definition of the system and the resolving power of the human eye. In actual working when the test prism (T. P.) is introduced in the system and the shift produced in the collimator graticular image over the telescope graticule does not coincide with any one integral division, the integral division of the collimator graticule on either side of the central vertical line (gap) of the telescope graticule may be noted as n or n+1. The vernier prism is then moved until the line either n or n+1 is brought to the centre of the telescope graticule. If the vernier prism is moved by x divisions to bring the nth line to coincidence, then the deviation due to the prism under test is n minutes $+x$ seconds, as each division of the vernier prism scale represents one second. If the vernier prism is moved through x' divisions on the vernier scale to bring the n+1th line to the centre of the telescope graticule then the deviation due to the prism under test=(n+1) minutes minus x' seconds.

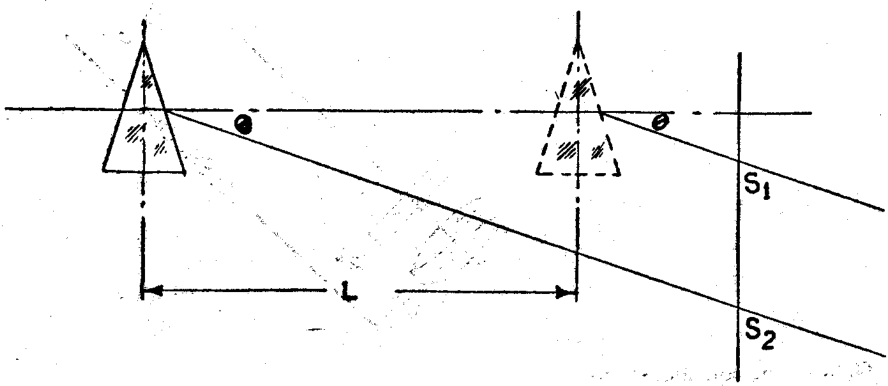

FIG-2

Experimental procedure

The prism under test is placed in its mount and is rotated until the horizontal line of the collimator graticule image coincides with the horizontal line (gap) of the telescope graticule. The vernier prism is then moved over the graduated scale until one of the vertical lines of the collimator graticule coincides with the vertical line (gap) of the telescope graticule. (For ease of setting, the telescope graticule is made of dark patches with central horizontal and vertical gaps into which the collimator graticule lines are brought). Each vertical line of the collimator graticule represents one minute. The number of lines by which the central vertical line of the collimator graticule is off from the telescope vertical line $\pm$ the deviation caused due to the movement of the vernier prism to obtain exact coincidence as read on the graduated scale will give exactly the deviation due to the prism under test.

The instrument is designed to test thin prisms of the order of 10 minutes to 40 minutes to an accuracy of ± 4 seconds. To obtain the accuracy it is necessary that the instrument is very rigid and does not wobble during operation. The collimator graticule lines have to be drawn very fine, on an accurate dividing machine as the ultimate value and accuracy of the measurement depend upon the accuracy of this graticule. The movement of the vernier prism should be smooth and uniform (without jerks) and should be exactly along (parallel to) the optic axis of the collimator. In order that the deviation produced in the system due to movement of the vernier prism by one division of the graduated scale is a discreet number and not an odd value, it is necessary that the angle of the vernier prism should also be specific. For this purpose, it is necessary that two prisms of approximately the order required may be taken and mounted in such a way that the combination gives the desired value as otherwise it is difficult to produce a thin prism to the desired accuracy *i.e.*, ± 4 seconds. This angle may be measured on an accurate Goniometer to one second accuracy. The introduction of two prisms (the vernier prism and the test prism) in the optical system gives rise to chromatic aberration and astigmatism. A green filter has been used in the system to obviate the chromatic aberration. As a further precaution to reduce both the above mentioned errors, the two prisms *i.e.*, the vernier prism and the prism under test are mounted opposite to one another such that the combination more or less acts as a slab and not as a prism. For the sake of convenience of working and to make the instrument more useful to the worker in the shop, the collimator graticule is marked with a few vertical lines only, drawn at a distance from the central vertical line, nearly equal to the angle of the prism under manufacture or test. The vernier prism used also has an angle nearly equal to the prism under manufacture. Thus the instrument is made single purpose. If it is to be made more versatile, a series of vertical lines on either side of the central vertical line of the collimator graticule have to be drawn to a very high degree of accuracy. This instrument has been designed to test specifically thin prism used in range finders whose angle of deflection is of the order of 19-20 minutes. For testing prisms of other angles, it may be necessary to replace the collimator graticule and the vernier prism to suit the particular prism under manufacture or test.

A few prisms of known angles of deflection (measured with a precision Goniometer) were tested on this instrument and the results obtained are very satisfactory and are within the required accuracy.

Angle of deflection as measured earlier and marked on the prism	Angle of deflection as measured over this instrument	
19′ 50″	19′ 50″	
	19′ 53·3″	Average 19′ 51·2″
	19′ 50·2″	
19′ 45″	19′ 45·4″	
	19′ 43·3″	Average 19′ 44·8″
	19′ 45″	

Acknowledgements

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