CHAPTER IV

TRAVELING MICROSCOPE CONSTRUCTION AND TEST

4.1 The Traveling Microscope Construction

The traveling microscope was designed for use in both vertical and horizontal positions. It can be carried easily and used in many ways. The parts of the traveling microscope are made of various kinds of material, i.e. brass, plastic, iron, and stainless steel.

A lathe, drill, saw cut, end mill, file, tap and screw driver were used to construct the various parts of the traveling microscope, the designs of which are shown in Appendix 2.

4.2 Vernier Scale Design[20]

Vernier scale was designed to be accurate to 0.01 cm. The main scale has 0.5 mm divisions. The design of the vernier scale is determined in following manner.

Desiring that least count = $(S - V) = \frac{1}{n} \times S = 0.1$ mm.

we set $S = 5.0$ mm.

This required that $n = 50$

The quantity $V = 5.0 - 0.1 = 4.9$ mm.

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[20] W.A.Schneider, and L.B. Ham, Experimental Physics for Colleges (New York: The Macmillan Company, 1958), pp. 24-30.

Therefore one division on the vernier scale must be 4.9 mm. Five divisions were made on the vernier scale used in our traveling microscope.

4.3 Lens Test

After finishing with the lens making, 4 single lenses were obtained. According to the method described in section 2.14, the radius of curvature of each lens surface was measured, where D is the diameter of dark rings, p is the number of rings, and λ is the wavelength of the sodium light (5893×10^{-7} mm). The data of p, D and D^2 are whown in Table 4-1. The sphericity of lens surface could be proven by measuring the values of D in many direction for a dark ring, the values of D are equal if the lens surface is spherical. We observed that the lens surfaces are spherical. The values of D^2 against p of each surface were plotted as shown in Fig. 4-1, 4-2, 4-3 and 4-4. The apparatus for observation of Newton's rings is shown in Fig. 4-5. The radii of curvature are obtained from graphs by applying (2.69), we have

$$r = \frac{\Delta D^2}{4\lambda\Delta p}$$

Then we get

For the objective
- r_1 = 77 mm, from Fig. 4-1.
- r_2 was not measured because its surface was cemented.
- r_3 = 46 mm, from Fig. 4-2.

For the eyepiece
- r_1 is nearly flat.
- r_2 = 16 mm, from Fig. 4-3.
- r_3 = 17 mm, from Fig. 4-4.
- r_4 is nearly flat.

Surface		p	D (mm.)	D^2 ($\times 10^{-2} mm^2$.)
For the objective	r_1	1	0.430	18.5
		2	0.607	36.8
		3	0.742	55.1
		4	0.857	73.4
		5	0.958	91.8
	r_2	-	cemented	-
	r_3	1	0.332	11.0
		2	0.467	21.8
		3	0.572	32.7
		4	0.660	43.6
		5	0.736	54.2
For the eyepiece	r_1	-	no ring	-
	r_2	1	0.192	3.7
		2	0.270	7.3
		3	0.337	11.4
		4	0.390	15.2
		5	0.440	19.4
	r_3	1	0.210	4.4
		2	0.282	8.0
		3	0.344	11.8
		4	0.393	15.4
		5	0.444	19.7
	r_4	-	no ring	-

Table 4-1. The values of p, D and D^2 of the objective and the eyepiece.

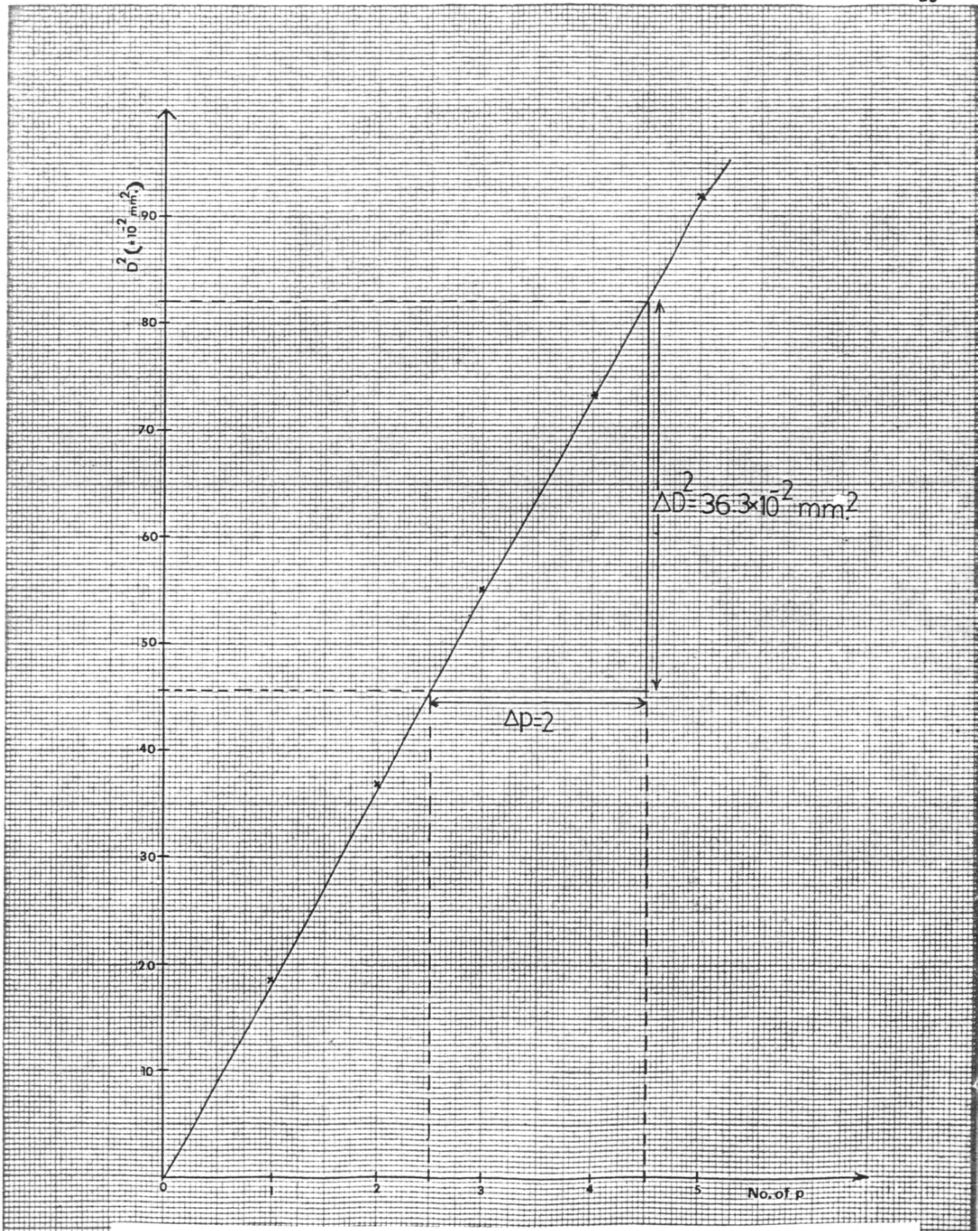

Fig.4-1. The curve showing the sphericity of the objective surface r_1.

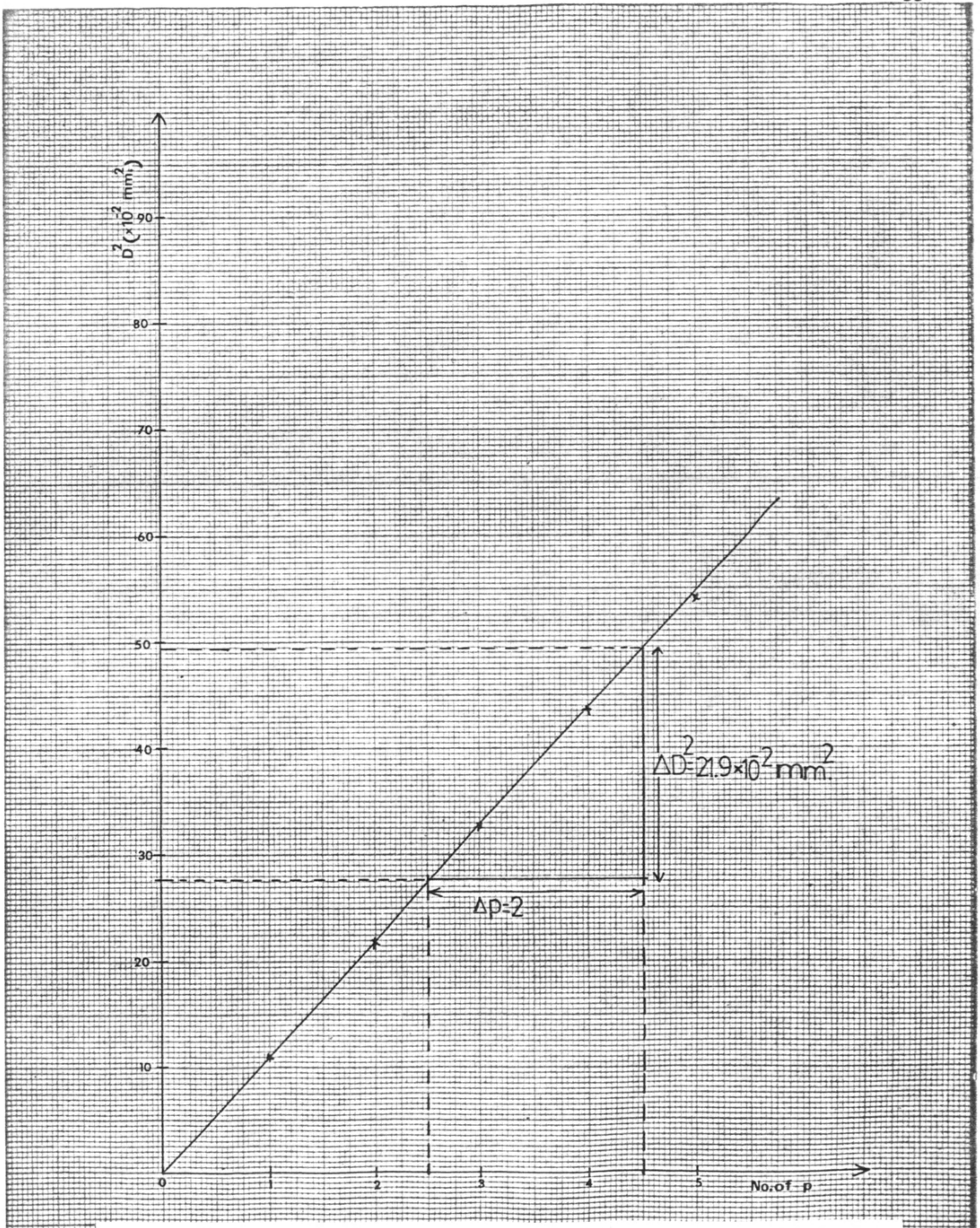

Fig.4-2. The curve showing the sphericity of the objective surface r_3.

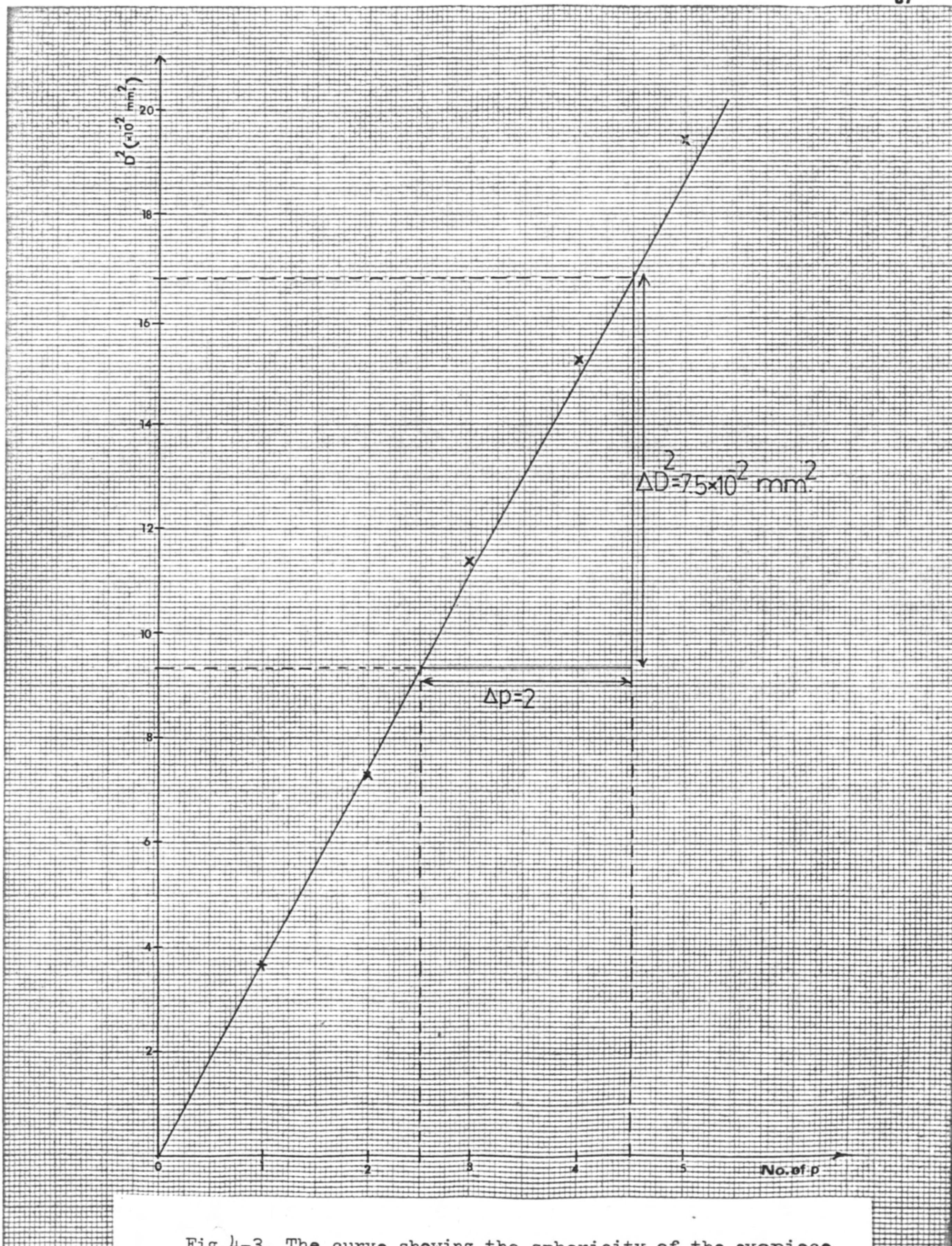

Fig.4-3. The curve showing the sphericity of the eyepiece surface r_2.

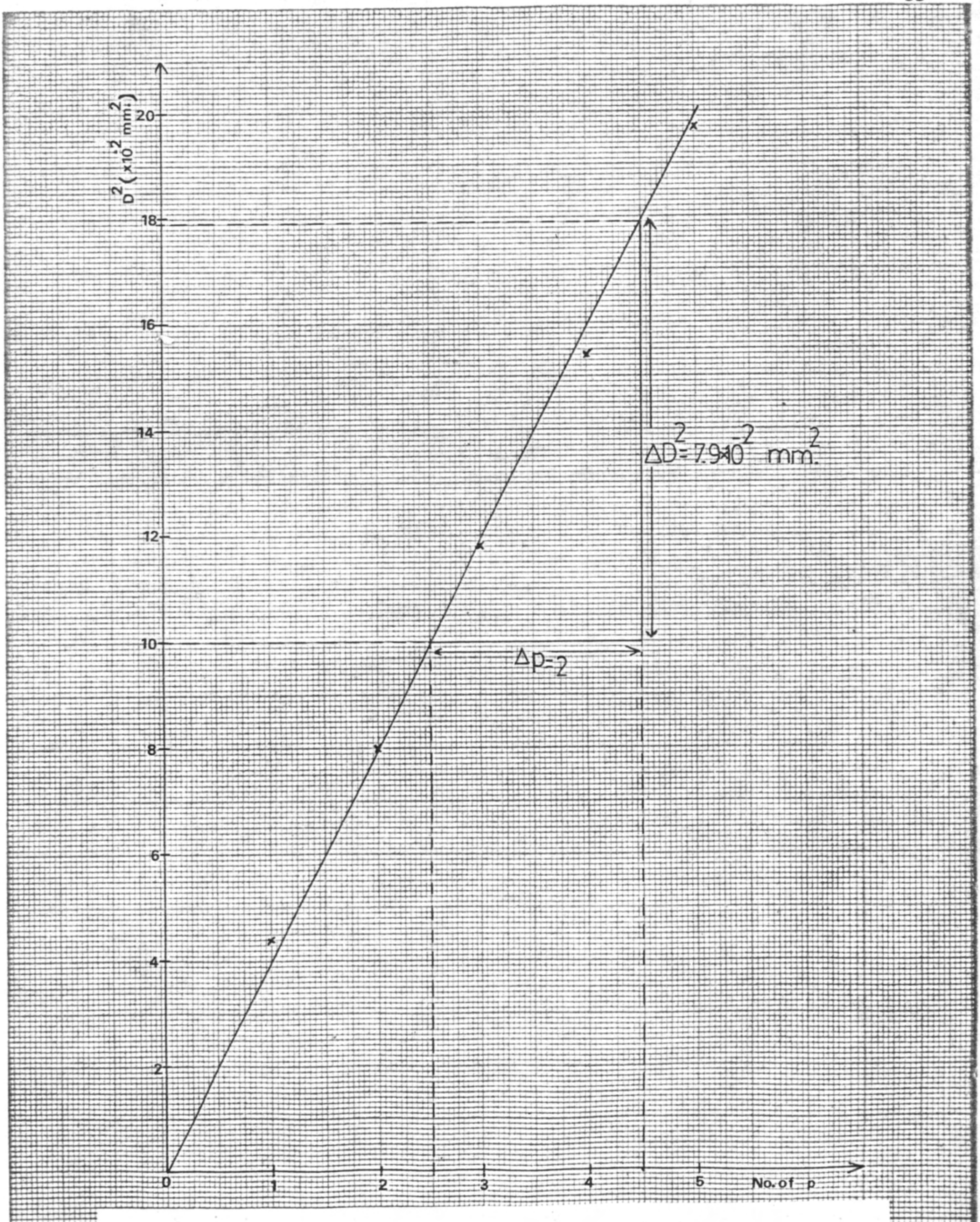

Fig. 4-4. The curve showing the sphericity of the eyepiece surface r_3.

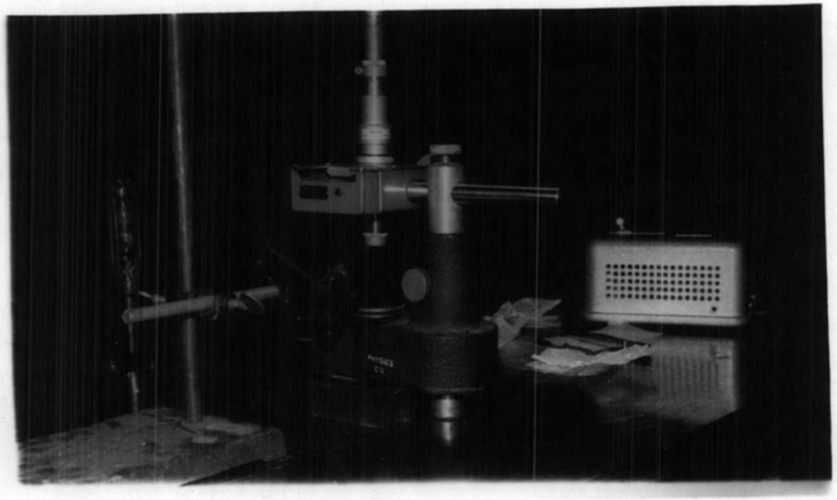

Fig.4-5. Apparatus for observation of Newton's rings.

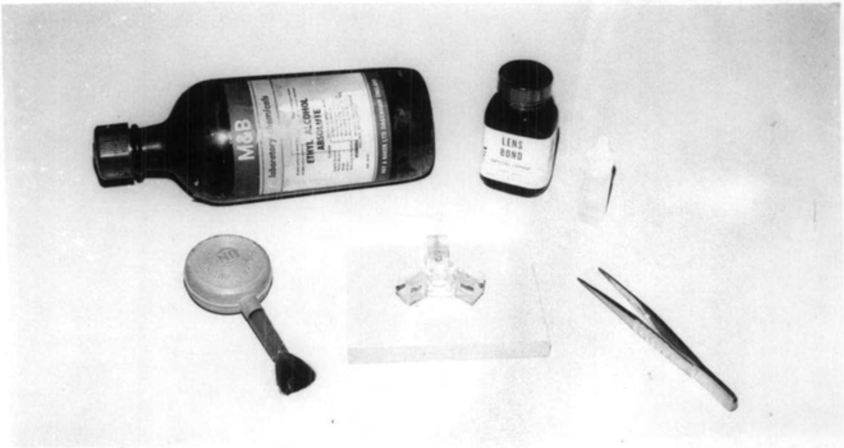

Fig. 4-6. Cementing lenses.

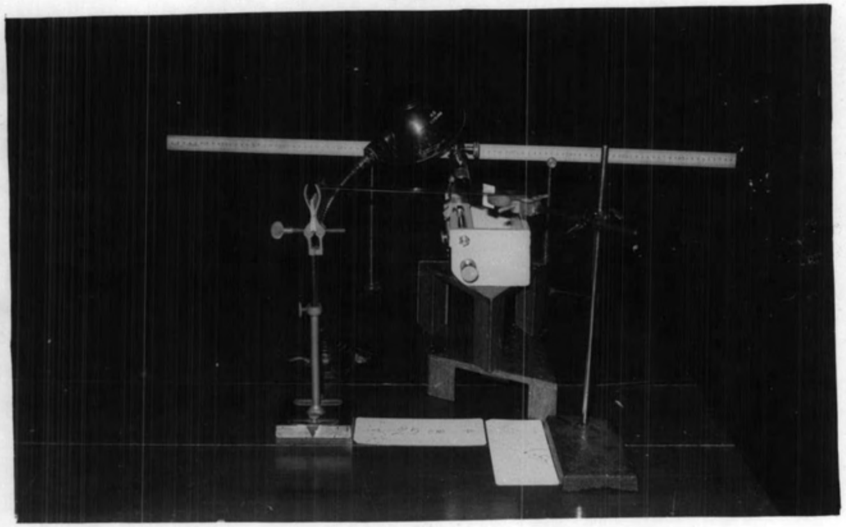

Fig.4-7. Apparatus for measurement of the total magnification .

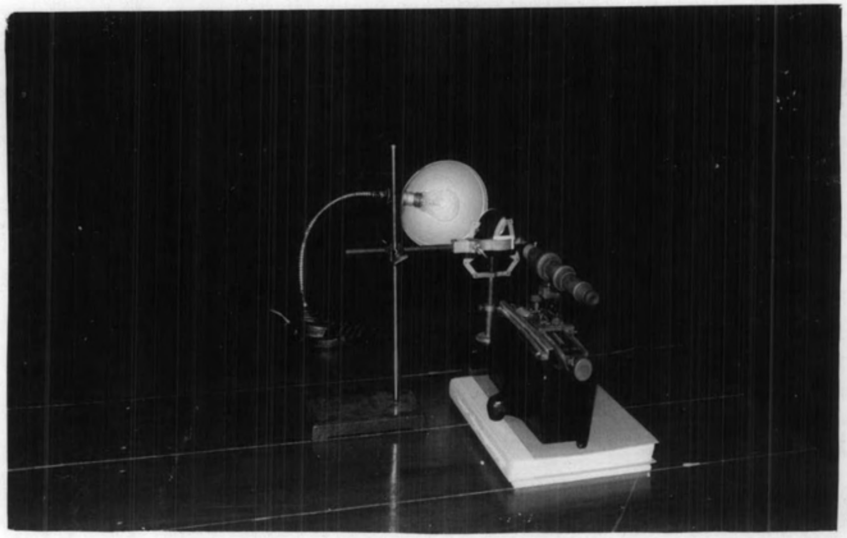

Fig. 4-8. Apparatus for test of objective with "Star" test method.

The resolving power of our microscope objective was obtained by using the method described in section 2.17. It was a trouble to see the object scale in white light, so that the sodium light was used as the source. The resolving power of our microscope objective is found to be 7.5 μm in monochromatic light.

For achromatic objective, two lenses are cemented together with "Lens Bond" shown in Fig. 4-6. The total magnification of the traveling microscope was found by applying the method described in section 2.16; which gives the average value of 49 times. The apparatus is shown in Fig. 4-7.

According to the method described in the section 2.15, we obtain the focal length of the objective of about 4.2 cm and the focal length of the eyepiece of about 2.1 cm.

Finally, the "Star" test which described in section 2.18 was used to test the performances of the objective and eyepiece. The results are as follows:

For the test of the objective lens, white light was used as shown in Fig. 4-8. A colourless light was observed at the focal point. Inside the focus, yellowish disc with greenish at the center, fringed with an orange-red border was seen. Outside the focus there appeared an outer fringe of apple-green surrounding a yellowish disc with a faint reddish-violet center. From the above results it was concluded that the objective lens had only a little chromatic aberration. Spherical aberration and coma weretested by the similar method with monochromatic light used instead. A small amount of spherical aberration and a small amount of coma were observed.

For the eyepiece, small amounts of spherical aberration and coma were also present (see Fig. 4-9).

4.4 Traveling Microscope Test

All objects were on the optical axis of the system during operation. It was found that no error resulted from using the constructed traveling microscope in comparison with commercial traveling microscopes to measure a division of the standard vernier scale in horizontal position, but a small error in measuring of the apparent depth of an object under a plain glass slide in vertical position was found.

The data of testing the constructed traveling microscope in comparison with commercial traveling microscopes are shown in the following table :

The measurement of	Horizontal position (cm.)				Vertical position (cm.)			
Constructed traveling microscope	0.05	0.06	0.19	0.20	0.11	0.12	0.39	0.64
Commercial traveling microscopes	0.05	0.06	0.19	0.20	0.10	0.11	0.38	0.63

Table 4-2. Comparison of the measurements made with the constructed traveling microscope and commercial traveling microscopes.

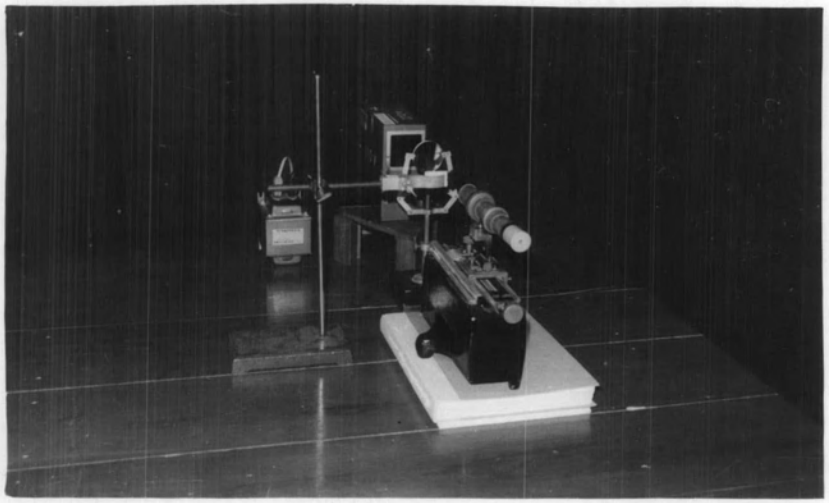

Fig.4-9. Apparatus for test of eyepiece with "Star" test method.

Fig.4-10. The use of the constructed traveling microscope in vertical position.

Fig.4-11. The use of the constructed traveling microscope in horizontal position.

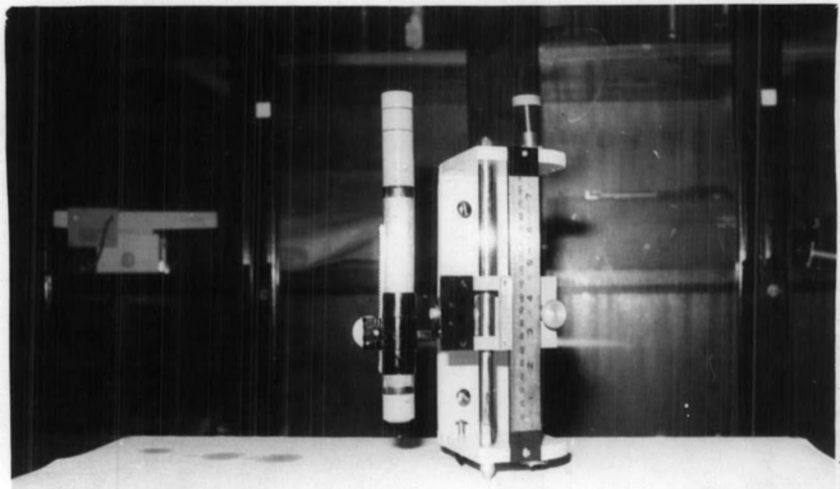

Fig.4-12. The constructed traveling microscope.

The use of our traveling microscope in the vertical and horizontal positionsare shown in Fig. 4-10 and 4-11. The traveling microscope which we made is shown in Fig. 4-12.