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Optical System Design for Optimum Working Distance Fitting Medical Telescope

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Surgeons and dentists need an optical assistant apparatus when performing clinical operation. The maximum resolving ability of usual human eyes is one minute of arc, so medical doctor can not see big blood vessel(30~40μm) and big nerve inside the teeth(2.8μm) at 40cm distance. One of the optical aid-apparatus is an operating microscope. It has big magnification and clear images. However this operating microscope is not only large and heavy to use but also can cause fatigue to the eyes when being used for a long time. Moreover, it is difficult to illuminate the object through the small opening while using that microscope. So doctors want to wear medical telescope(MT) which is more realistic and convenient for using it.

General Telescopes have two types, Galilean and Keplerian. Galilean telescope of two types has small field of view but merits of light weight and small size. It is suitable for medical telescope with middle and low magnification(×1~×3).

MT must have little inconvenience to wear for a long period and move freely, like general spectacles. And the ergonomic aspect that considers individual characteristics of inter-pupillary distance(IPD), working distance(WD), declination angle(DA) and convergence angle(CA) is emphasized. Of course, it must be corrected users' myopia, hypermetropia, and astigmatism.

Medical telescopes with 2.2 and 1.75 times magnification which developed before were designed to have good quality at only one working distance, 400mm. At this distance, the performance of these MTs is very good.

When the previous MT is used at other working distance, not 400mm, its optical performance falls down remarkably and then can not be used as MT. Fig. 1 is MTF curves according to working distance of MT with 1.75 times magnification. It represents the performance is not good at 300, 500 mm. In other words, user has to work at only 400mm. It causes inconvenient posture while operating for a long time and then let user experience chronic pain of neck and shoulder. Medical telescope applied Zoom system as answer to compliment this was designed and manufactured . It has good performance at several distances and is high as 2.8 times magnification. Actually doctors want high power. Generally working distance of MT's user is between 300mm and 500mm. This range is too broad and then good performance can not be obtained at several distances as one module. So dividing range as three modules was considered. Each module is composed eye, field, and object lens as shown Fig.2. There are many WDs that are different from only interval between field lens and object lens. User can choose WD one want. Fig. 3 represents layout about all lens system

including object and image and Table 1. shows the magnification according to WD, the length of system(OAL), distortion which is more important than other aberrations. All distortions were under 1%. To manufacture MT, it was also performed to study equipment of assembly and measurement – focus controller to agree focal length of telescope and WD controlling a part of object lens, a drill to pierce a hole to accord with diameter of MT in spectacles' lens, Control of CA to coincide with images formed by left and right telescope, ray axis controller, and test machine for magnification and resolution etc..
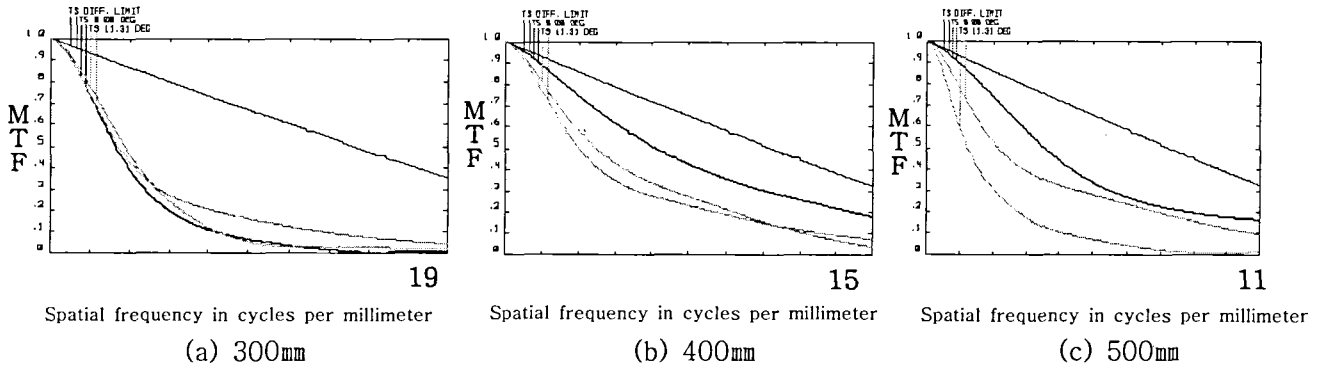
Spatial frequency in cycles per millimeter   Spatial frequency in cycles per millimeter   Spatial frequency in cycles per millimeter

(a) 300㎜   (b) 400㎜   (c) 500㎜

Fig. 1 MTF Curves according to Working Distance of ×1.75 MT
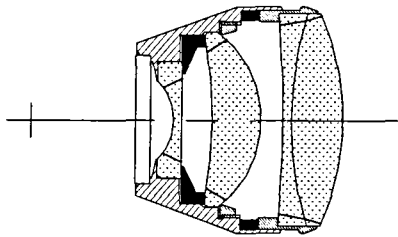
Fig. 2 Lens Composition (Module 1)
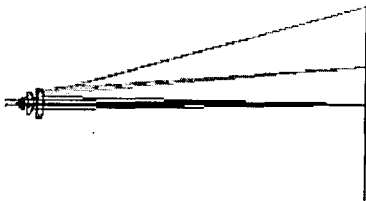
Fig. 3 Overall layout

Module	WD(㎜)	Magnification	OAL(㎜)	Distortion(%)
1	300	2.70	31.00	<1.00
	320	2.67	30.20	<0.92
	340	2.65	29.57	<0.85
	350	2.64	29.31	<0.81
2	360	2.70	31.00	<1.12
	380	2.67	30.41	<1.05
	400	2.65	29.96	<0.98
	420	2.65	29.57	<0.92
3	430	2.70	31.00	<1.08
	450	2.64	30.46	<1.00
	470	2.64	30.11	<0.96
	500	2.62	29.66	<0.90

Table 1. ×3 MT applied for Zoom method

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