(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) **World Intellectual Property Organization**
International Bureau

PCT

(43) **International Publication Date**
12 February 2009 (12.02.2009)

(10) **International Publication Number**
WO 2009/019703 A2

(51) **International Patent Classification:**
A61B 1/04 (2006.01)

(21) **International Application Number:** PCT/IL2008/001093

(22) **International Filing Date:** 7 August 2008 (07.08.2008)

(25) **Filing Language:** English

(26) **Publication Language:** English

(30) **Priority Data:**
185112 7 August 2007 (07.08.2007) IL

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(81) **Designated States** *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BR, BW, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IS, JP, KE, KG, KM, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PG, PH, PL, PT, RO, RS, RU, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) **Designated States** *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LS, MW, MZ, NA, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MT, NL, NO, PL, PT, RO, SE, SI, SK, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *without international search report and to be republished upon receipt of that report*

(54) **Title:** LARYNGOSCOPE APPARATUS WITH ENHANCED VIEWING CAPABILITY

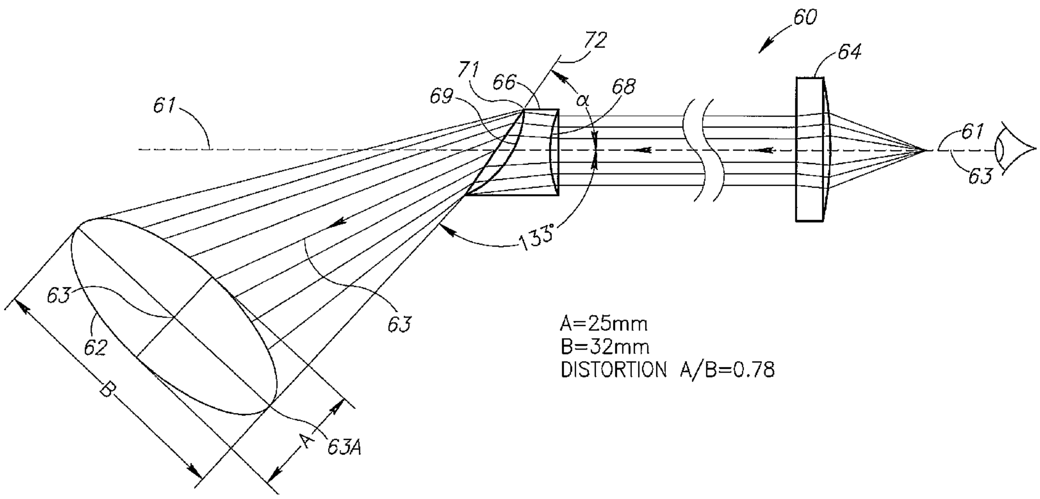


FIG.5

(57) **Abstract:** Laryngoscope apparatus including a curved laryngoscope blade and an optical system for affording a field of view along a deflected line of sight for reducing patient manipulation and/or the degree of force required to achieve a good glottic view.

WO 2009/019703 A2

LARYNGOSCOPE APPARATUS WITH ENHANCED VIEWING CAPABILITY

Field of the Invention

The invention pertains to laryngoscope apparatus with enhanced viewing capability.

Background of the Invention

Physicians performing an intubation procedure with a conventional laryngoscope assume an appropriate position behind a patient's head and manipulate his head to maximize visualization of his laryngeal area for enabling Endotracheal Tube (ETT) placement. In certain instances, a patient's head cannot be moved which can considerably complicate an intubation. Physicians can use a laryngoscope blade to apply force to a patient's internal surfaces to assist visualization of his larynx to enable intubation. Applying a greater force typically improves a physician's visualization of a patient's larynx but traumatizes surrounding tissues. Most patients suffer at least some trauma during conventional intubation procedures.

US Patent No. 5,873,818 to Rothfels, the contents of which are incorporated herein by reference, illustrates and describes an optical system (44) for use with a curved laryngoscope blade (16) with a leading blade tip (46) for optically assisting visualization of a patient's laryngeal region thereby reducing the need for manipulation of a patient's head and/or application of force for sighted intubations. The optical system (44) includes a plano-convex eyepiece lens (48) and a prism lens (50) having a prism optic (54) with a smooth or flat sloping prism surface (not denoted by a reference number) and a further lens (56) with a concave surface (also not denoted by a reference number) facing the eyepiece lens (48). The concave surface of the further lens (56) serves to provide a wide angle view while the companion prism optic (54) directs the view toward the blade tip (46) to better expose the larynx. Also, the further lens (56) "miniaturizes" objects view while the eyepiece lens (48) compensates for the miniaturization as well as for providing focusing (see US '818 Col. 3, lines 21 to 25). The prism optic (54) and the further lens (56) can be assembled together or optionally molded in one piece. Laryngoscope blades can be integrally formed with an optical system or alternatively be configured to removable receive a discrete optical view tube housing an optical system (see US '818 Col. 2, line 67 to Col. 3, line 3).

Summary of the Present Invention

The present invention is for laryngoscope apparatus for optically assisting a good glottic view thereby minimizing the need for manipulation of a patient's head and/or application of force. The present invention is based on the realization that an increased Field Of View (FOV) magnification compared to a FOV magnification achievable in a Rothfels arrangement serves to provide a Line Of Sight (LOS) with a most deflected LOS ray which is more deflected than its counterpart most deflected LOS ray in the Rothfels arrangement. This increased FOV magnification for an identical Rothfels arrangement typically having a rearmost concave surface serving a maximum possible FOV is enabled by replacing Rothfels' forwardmost flat inclined prism surface by a forwardmost concave inclined prism surface.

It should be noted that the inclination of the proposed forwardmost concave inclined prism surface limits its radius of curvature to a far greater radius of curvature compared to the radius of curvature at its opposite rearmost concave surface facing the eyepiece lens and therefore affords a relatively small additional FOV magnification but its contribution to the LOS deflection is surprisingly significant in minimizing the need for manipulation of a patient's head and/or the application of force for a good glottic view. Moreover, the forwardmost concave inclined prism surface introduces additional FOV distortion and also is more difficult to manufacture than the hitherto forwardmost flat inclined prism surface but these disadvantages are more than compensated by the advantageous clinical considerations.

Laryngoscope apparatus in accordance with the present invention can be implemented as a laryngoscope blade with either an integral optical system or intended for use with a discrete optical view tube. Such laryngoscope blades preferably include an illumination arrangement for providing illumination light for assisting intubation and a defogging arrangement for defogging their forwardmost concave inclined prism surface. Such laryngoscope blades are permanently mounted on a laryngoscope handle and pivotal between an inoperative storage position and an operative intubation position in a penknife-like manner or detachably mounted on a laryngoscope handle. Exemplary handheld penknife-like laryngoscopes are illustrated and described in commonly owned PCT International Application No. PCT/IL2005/001232 entitled Handheld Penknife-Like Laryngoscope published under PCT International Publication No. WO 2006/056976 on June 1, 2006, the contents of which are incorporated herein by reference. Detachable laryngoscope blades can be of either the ISO 7376/1 type including a light source for detachable mounting on a laryngoscope handle having a power pack only or the ISO 7376/3 type including a light pipe for detachable mounting on a laryngoscope handle including both a power pack and a light source.

Brief Description of the Drawings

In order to understand the invention and to see how it can be carried out in practice, preferred embodiments will now be described, by way of non-limiting examples only, with reference to the accompanying drawings in which similar parts are likewise numbered, and in which:

Fig. 1A is a pictorial representation showing a laryngoscope including laryngoscope apparatus for affording a magnified Field Of View (FOV) along a deflected line of sight in a median plane through the midline of a human body for assisting an intubation procedure;

Fig. 1B is a pictorial representation of Figure 1A's FOV having a minor axis A and a major axis B in the median plane;

Fig. 1C is a pictorial representation showing the use of Figure 1A's laryngoscope;

Fig. 2 is an exploded view of laryngoscope apparatus with a discrete optical view tube;

Fig. 3 is a side view of laryngoscope apparatus including an integral optical system;

Fig. 4 is a ray diagram of a conventional optical system showing its FOV;

Fig. 5 is a ray diagram of an optical system of the present invention showing its FOV;

Fig. 6 is a pictorial representation of Figure 4's FOV;

Fig. 7 is a pictorial representation of Figure 5's FOV;

Fig. 8 is a side view of an eyepiece lens of Figure 5's optical system; and

Fig. 9 is a side view of an aperture lens of Figure 5's optical system.

Detailed Description of Preferred Embodiments of the Present Invention

Figures 1 to 3 show a laryngoscope 10 including a laryngoscope handle 11 and laryngoscope apparatus 12 including an optical system 13 having a straight optical axis 14 corresponding to a non-deflected Line Of Sight (LOS) and affording a Field Of View (FOV) 16 along a deflected LOS 17 in a median plane through the midline of a human body for assisting an intubation procedure. The FOV 16 has a most deflected LOS ray 17A relative to the optical axis 14 and a minor axis A and a major axis B in the median plane resulting in a distortion value A/B. The laryngoscope apparatus 12 includes a curved laryngoscope blade 18 with a base 19 for double snap fitting onto the laryngoscope handle 11 into an operative intubation position in a conventional manner. The laryngoscope blade

18 has a spatula 21 with a tongue engaging surface 22 and a teeth engaging surface 23. The laryngoscope blade 18 includes a trailing spatula section 24 and a leading spatula section 26 terminating in a leading blade tip 27.

The laryngoscope apparatus 12 includes an optical view tube 28 having an eyepiece 29 and housing the optical system 13. The optical view tube 28 is coextensive with the trailing spatula section 24 and demarcates the leading spatula section 26 extending therebeyond. The laryngoscope apparatus 12 can be a two part system including a discrete optical view tube 31 for use with a laryngoscope blade 18 formed with an elongated holder 32 for sliding receiving the optical view tube 31 (see Figure 2). The holder 32 has a recess 33 for receiving a stopper 34 formed on the optical view tube 31 for aligning the optical view tube 31 relative to the holder 32. The laryngoscope apparatus 12 can include a laryngoscope blade 18 with an integral optical system 13 (see Figure 3).

The laryngoscope apparatus 12 is preferably designed such that FOV's most deflected LOS ray 17A coincides with the leading spatula section 26. This arrangement maximizes visual utilization of the available FOV 16 but prevents occurrence of a blind spot between the FOV 16 and the blade tip 27 which would otherwise exist if the leading spatula section 26 be deflected away from the optical axis 14 to a greater extent than the FOV's most deflected LOS ray 17A. Against this, in the case the FOV's most deflected LOS ray 17A is deflected away from the optical axis 14 more than the leading spatula section 26, the laryngoscope apparatus 12 would not be fully utilizing the available FOV 16.

The laryngoscope 10 preferably includes a conventional illumination arrangement for providing illumination light for assisting intubation and a conventional defogging arrangement for defogging the forwardmost optical surface of its optical system.

Truphatek International Ltd., Netanya, Israel, the owners of the present invention, supply laryngoscope apparatus 12 based on the Rothfels principle under the tradename Truview™ Evo-2. Figure 4 shows a Truview™ Evo-2 optical system 40 having a straight optical axis 41 corresponding to a non-deflected LOS and affording a FOV 42 along a deflected LOS 43. The FOV 42 has a most deflected LOS ray 43A and a minor axis A=23mm and a major axis B=29mm resulting in a distortion value A/B=0.79 (see Figure 6). The optical system 40 includes an eyepiece lens 44 and an aperture lens 46. The eyepiece lens 44 has a plano-convex shape with a rearmost convex surface 47. The aperture lens 46 has a rearmost concave surface 48 facing towards the eyepiece lens 44 and a forwardmost flat inclined prism surface 49 facing away therefrom. The forwardmost flat inclined prism surface 49 defines an imaginary plane 51 subtending an inclined acute prism angle α=55±0.5° with the optical axis 41. The aperture lens 46 has a Clear Aperture Diameter (CAD) of about 8.5mm and effects a total FOV magnification defined by the major axis B/CAD = 29/8.5 ≈ 3.4±0.1. The Truview™ Evo-2 optical system 40 deflects the most deflected LOS ray 43A away from the optical axis 41 by 42° shown as the complementary angle 138°.

Figure 5 shows an optical system 60 similar in construction and operation to the optical system 40. The optical system 60 has a straight optical axis 61 corresponding to a non-deflected LOS and affording a FOV 62 along a deflected LOS 63 and having a most deflected LOS ray 63A. The optical system 60 includes an eyepiece lens 64 and an aperture lens 66 with the same Clear Aperture Diameter (CAD) as the aperture lens 46. The eyepiece lens 64 includes a rearmost convex surface 67 similar to the eyepiece lens 44. The aperture lens 66 includes a rearmost concave surface 68 similar to the rearmost concave surface 48 and a forwardmost concave inclined prism surface 69. The forwardmost concave inclined prism surface 69 has an annular rim 71 which defines an imaginary plane 72 subtending the same inclined acute prism angle α=55±0.5° with the optical axis 61.

The FOV 62 has a minor axis A=25mm and a major axis B=32mm resulting in a distortion value A/B=0.78. The aperture lens 66 effects a total FOV magnification defined by the major axis B/CAD = 32/8.5 ≈ 3.7±0.1 and deflects the most deflected LOS ray 63A away from the optical axis 61 by 47° shown as the complementary angle 133°. The total FOV magnification of about 3.7±0.1 is achieved by a major contribution by the rearmost concave surface 68 serving to provide an initial FOV magnification of about 3.4±0.1 as per the aperture lens 46 whilst the forwardmost concave inclined prism surface 69 provides the remaining additional FOV magnification.

Figure 8 shows the dimensions and other technical details of the eyepiece lens 64 including *inter alia*:

D=15mm; Focal length +150mm

Surface 67: Radius Of Curvature (ROC) 77.52±0.2mm

Figure 9 shows the dimensions and other technical details of the aperture lens 66 including *inter alia*:

D=9mm; Focal length -37.63mm

Surface 68: ROC 22.06±0.1mm

Surface 69: ROC 180.0±3.0mm

<u>Comparison between optical systems 40 and 60</u>

The optical system 60 provides a total FOV magnification B/CAD of about 32/8.5≈3.7±0.1 compared to the optical system 40's total FOV magnification 29/8.5≈3.4±0.1 thereby affording a 47° most deflected LOS ray 63A in comparison to the 42° most deflected LOS ray 43A. This additional LOS deflection enables a more curved laryngoscope blade coinciding with the most deflected LOS ray 63A which enables less patient manipulation and/or application of force to achieve the same visualization. The FOV 62 also has a 25mm minor axis A which is wider than the FOV 42's 23mm minor axis A which further assists in correct ETT placement. The optical system 60 marginally increases the optical system 40's distortion value A/B 0.79 to 0.78.

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications, and other applications of the invention can be made within the scope of the appended claims.

Claims:

1. Laryngoscope apparatus comprising:

(a) a curved laryngoscope blade having a trailing spatula section and a leading spatula section terminating at a leading blade tip; and

(b) an optical system having a line of sight with a field of view and including an eyepiece lens and an aperture lens defining an optical axis,

said aperture lens located along said laryngoscope blade for demarcating said leading spatula section,

said aperture lens having a rearmost concave surface and a forwardmost concave inclined prism surface respectively facing towards and away from said eyepiece lens,

said rearmost concave surface providing an initial magnified field of view along said line of sight,

said forwardmost concave inclined prism surface further magnifying said initial magnified field of view along said line of sight,

said forwardmost concave inclined prism surface defining an imaginary plane subtending an included acute prism angle with said optical axis in a side view of said laryngoscope blade for deflecting said line of sight away from said optical axis beyond said aperture lens towards said blade tip.

2. Apparatus according to claim 1 wherein said rearmost concave surface provides an initial field of view magnification of about 3.4±0.1 of a total field of view magnification of said aperture lens of about 3.7±0.1.

3. Apparatus according to claim 2 wherein said plane subtends an included prism angle $\alpha = 55° \pm 3.0°$ and said forwardmost concave inclined prism surface has an 180±6.0mm radius of curvature.

4. Apparatus according to claim 3 wherein said plane subtends an included prism angle $\alpha = 55° \pm 0.5°$ and said forwardmost concave inclined prism surface has an 180±3.0mm radius of curvature.

5. An optical view tube for use in laryngoscope apparatus according to any one of claims 1 to 4.

6. A laryngoscope blade for use in laryngoscope apparatus according to any one of claims 1 to 4.

7. A laryngoscope including a laryngoscope handle and laryngoscope apparatus according to any one of claims 1 to 4 permanently mounted on the laryngoscope handle and pivotal between an inoperative storage position and an operative intubation position.

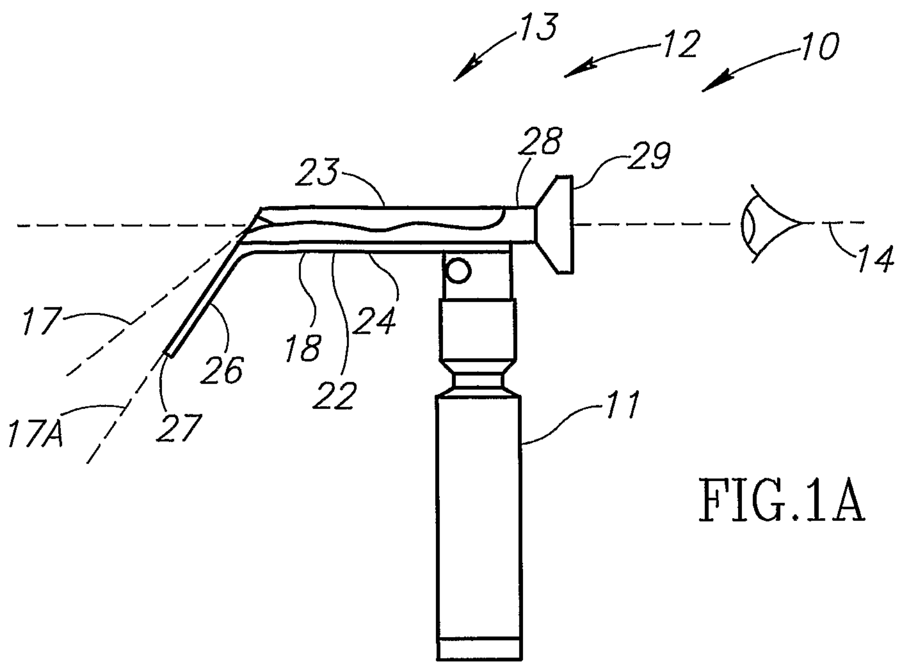


FIG.1A

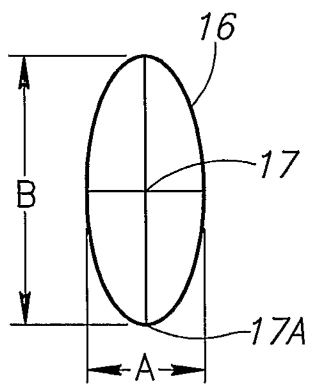


FIG.1B

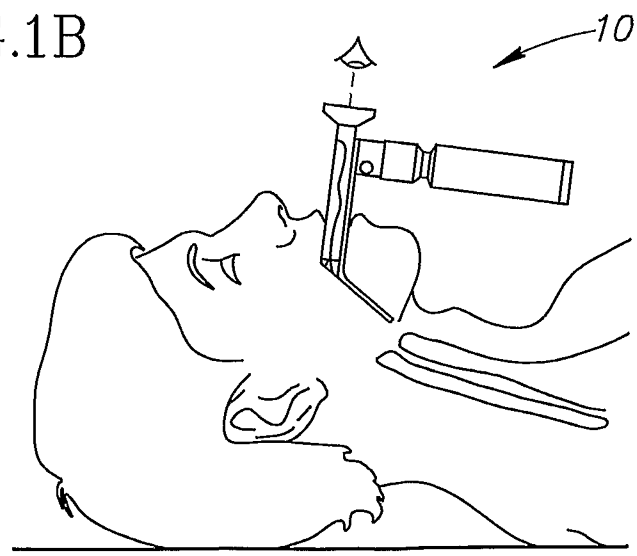


FIG.1C

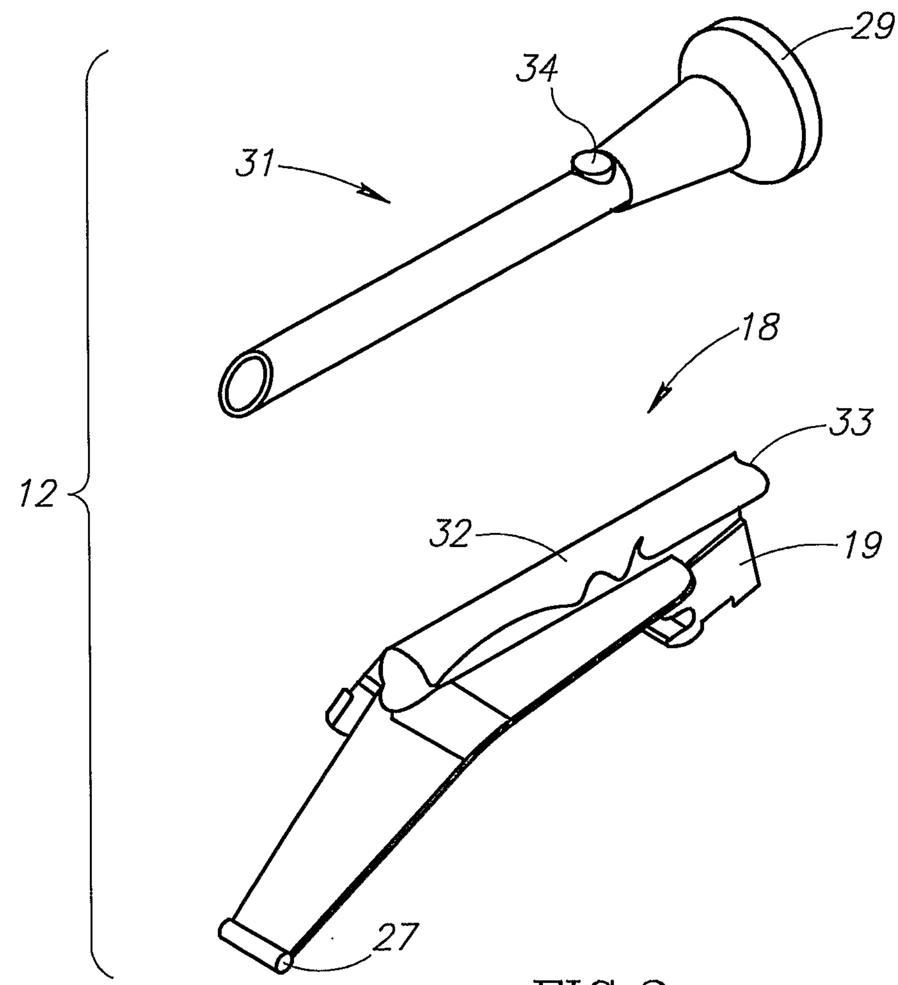


FIG.2

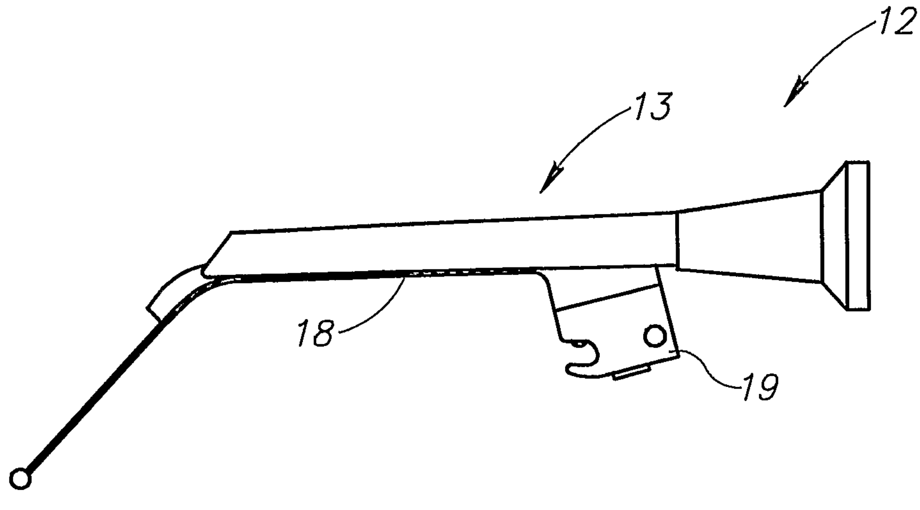


FIG.3

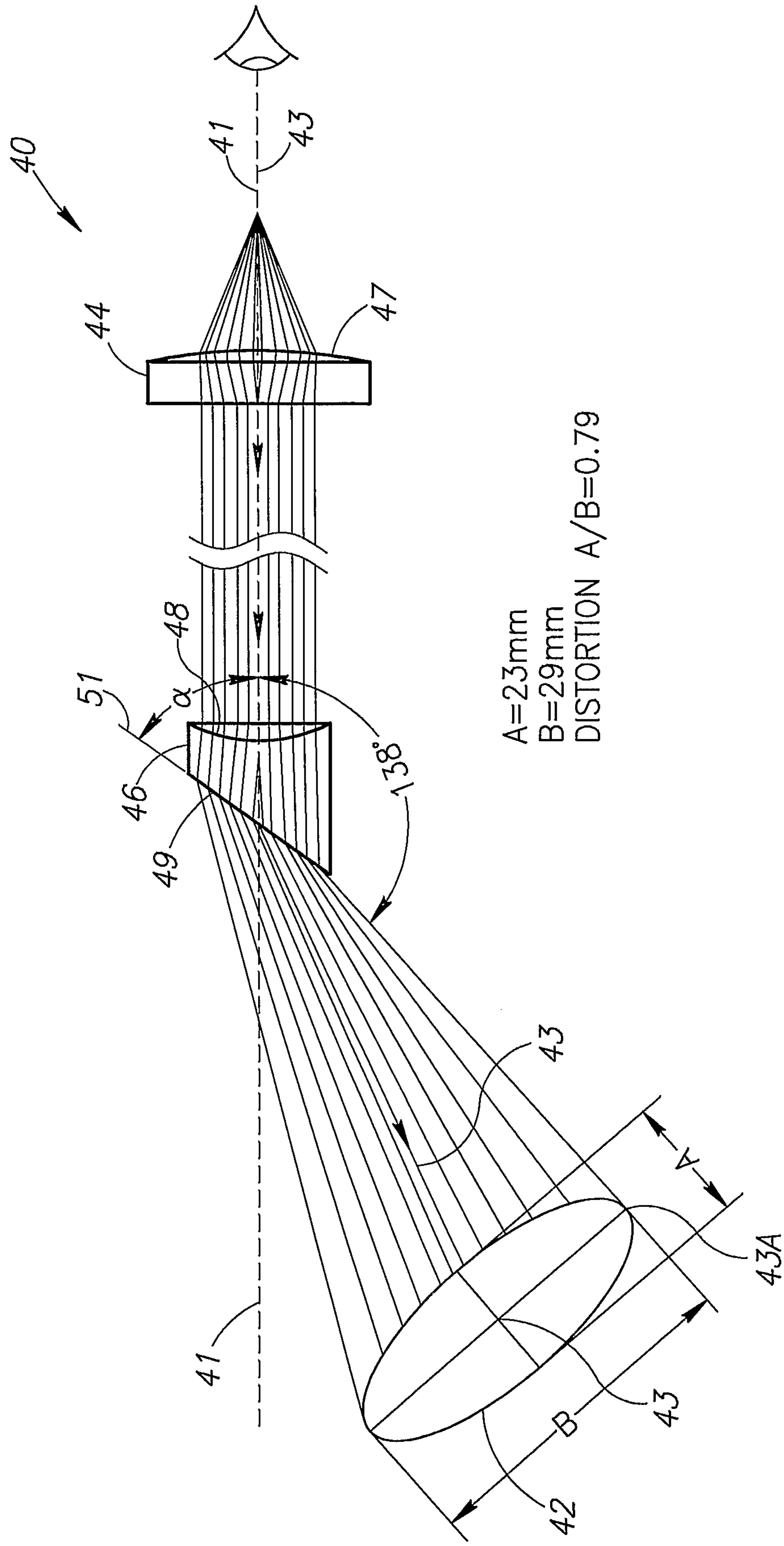


FIG.4
(PRIOR ART)

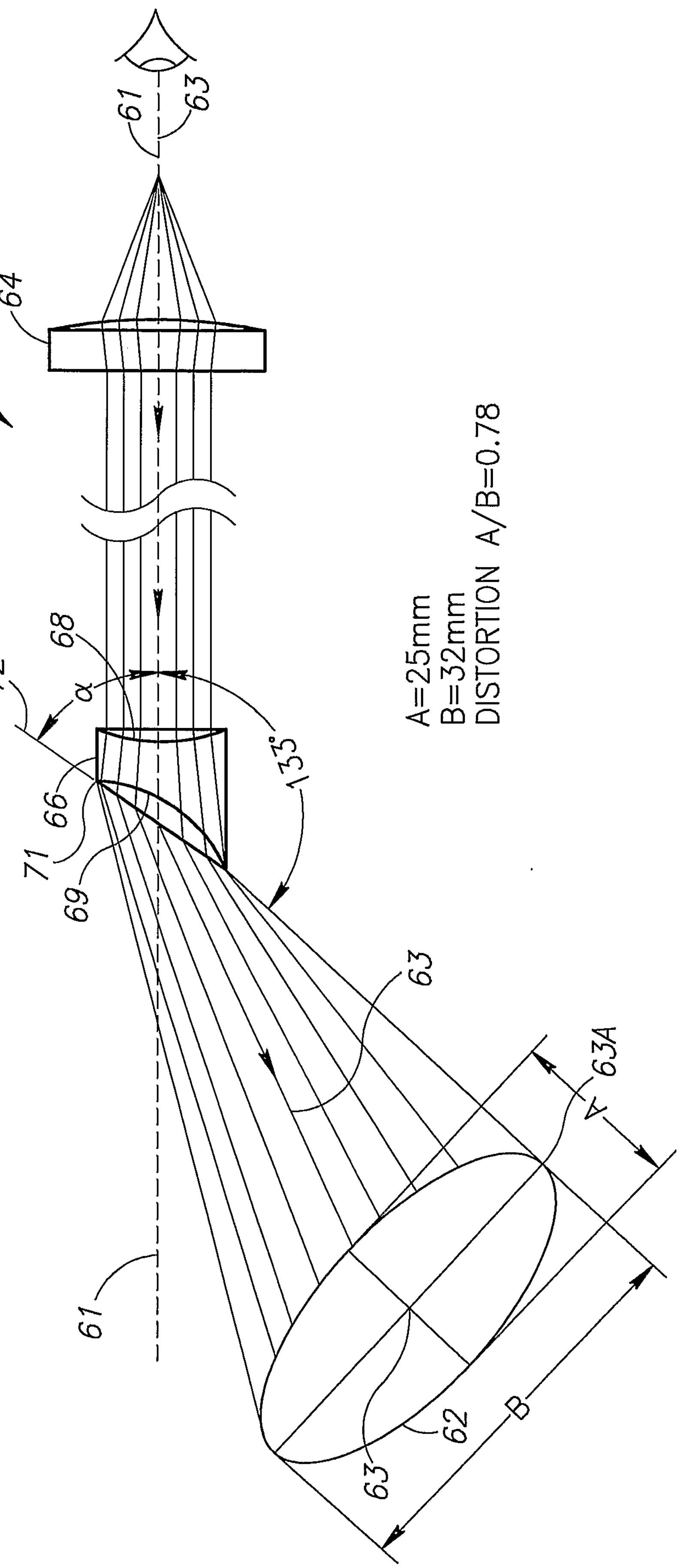

61
63
64
60
68
72
α
133°
66
71
69
63
63A
A
61
62
63
B
A=25mm
B=32mm
DISTORTION A/B=0.78

FIG.5

A=23mm
B=29mm
DISTORTION A/B=0.79

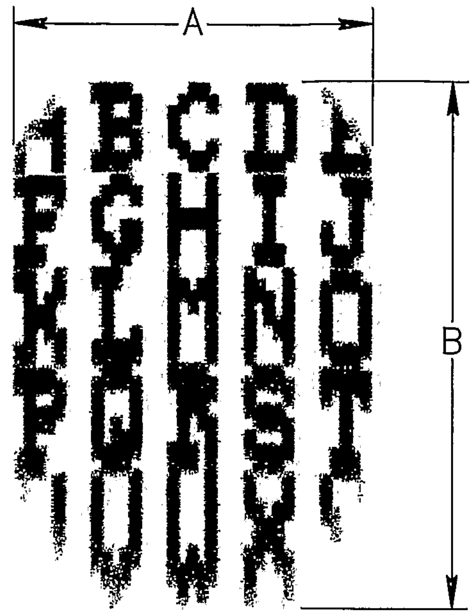


FIG.6
(PRIOR ART)

A=25mm
B=32mm
DISTORTION A/B=0.78

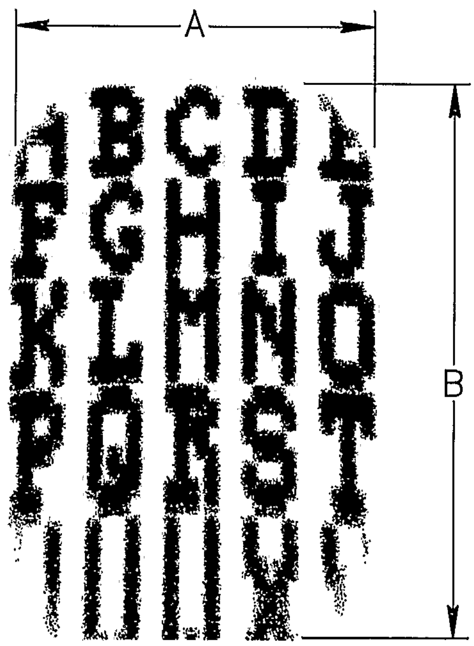
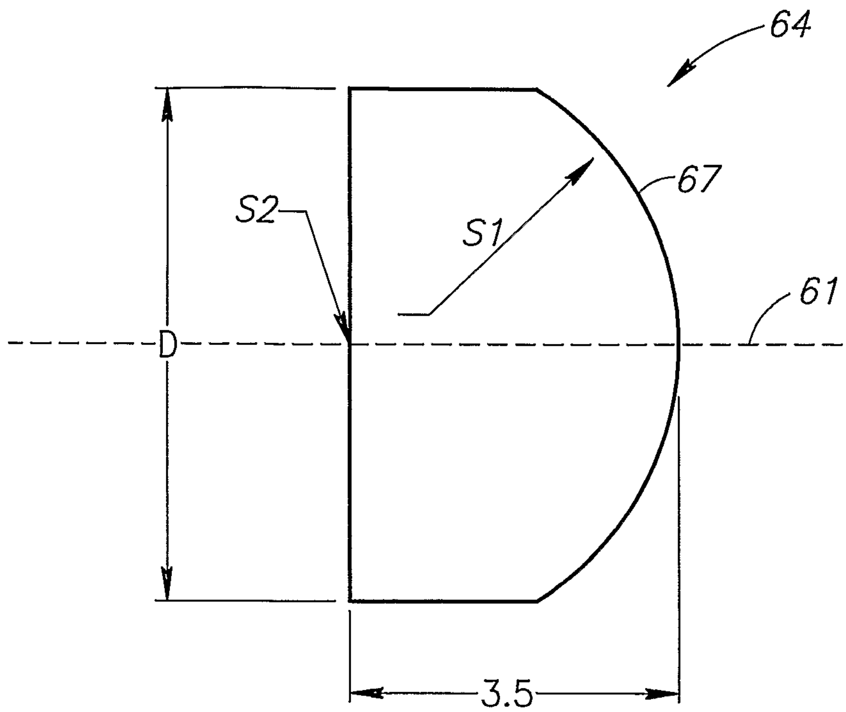


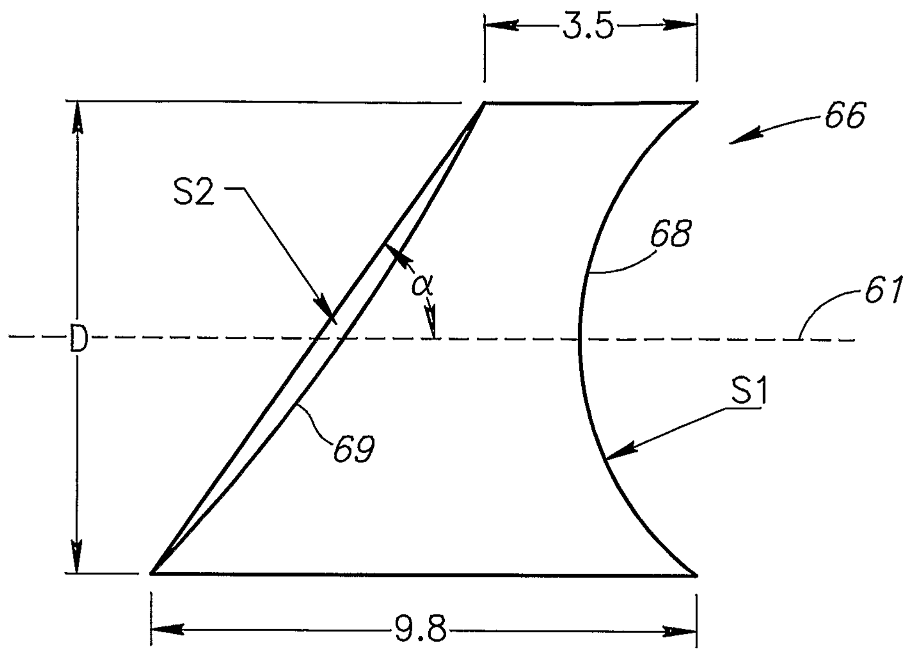
FIG.7



SURFACES	SCHOTT BK7
ROC (mm) S1	77.52 ±0.2
ROC (mm) S2	∞
INDEX OF REFRACTION	1.517 @ 0.588μ

SURFACES	S1	S2
SURFACE SHAPE	CONVEX	PLANO
CLEAR APERTURE	ϕ8.5	ϕ8.5
SURFACE FIGURE (POWER)	2λ @ 0.633μ	2λ @ 0.633μ
SURFACE IRREGULARITIES	λ @ 0.633μ	λ @ 0.633μ
SURFACE QUALITY (MIL 0-13830A)	60/40	60/40
ETV	<15μ	

FIG.8



MATERIAL: SCHOTT 8K7 OR EQUIVALENT	
INDEX OF REFRACTION: 1.517 @ 0.588μ	
DIAMETER: 9.0 −0.05mm	
THICKNESS: SEE DRAWING	

SURFACES	S1	S2
ROC (mm)	22.06 ±0.1	180.0 ±3.0
SURFACE SHAPE	CONCAVE	CONCAVE
CLEAR APERTURE	φ8.5	φ8.5
SURFACE FIGURE (POWER)	2λ @ 0.633μ	2λ @ 0.633μ
SURFACE IRREGULARITIES	λ @ 0.633μ	λ @ 0.633μ
SURFACE QUALITY (MIL 0−13830A)	60/40	60/40
PRISM ANGLE α		55°±0.5°

FIG.9