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

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
1 February 2001 (01.02.2001)

PCT

(10) International Publication Number
WO 01/06912 A1

(51) International Patent Classification[7]: A61B 1/002, G02B 23/24

(21) International Application Number: PCT/GB00/02883

(22) International Filing Date: 27 July 2000 (27.07.2000)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
9917716.4 28 July 1999 (28.07.1999) GB

(71) Applicant *(for all designated States except US)*: **KEYMED (MEDICAL & INDUSTRIAL EQUIPMENT) LTD.** [GB/GB]; Keymed House, Stock Road, Southend-on-Sea, Essex SS2 5QH (GB).

(72) Inventors; and

(75) Inventors/Applicants *(for US only)*: **RAMSBOTTOM, Andrew, Paul** [GB/GB]; 408A Westborough Road, Westcliff on Sea, Essex SS0 9TH (GB). **COATH, Philip, Michael** [GB/GB]; 6A Hawkwell Chase, Hawkwell, Hockley, Essex SS5 4NH (GB).

(74) Agent: **BOULT WADE TENNANT**; Verulam Gardens, 70 Gray's Inn Road, London WC1X 8BT (GB).

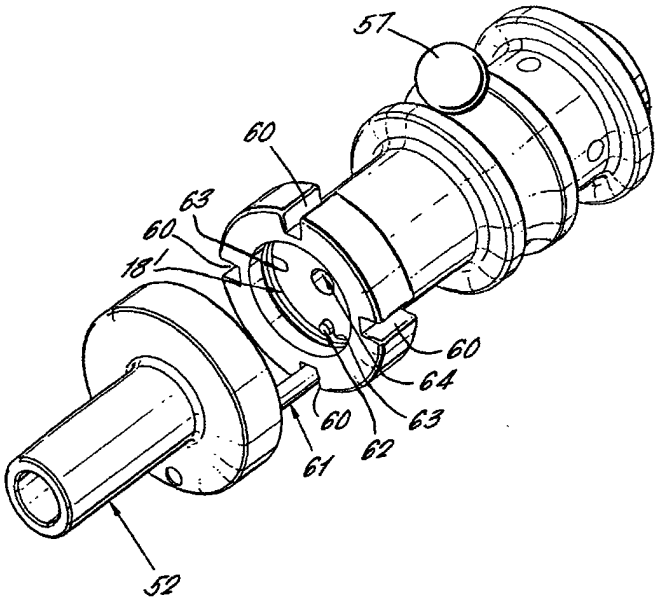
(81) Designated States *(national)*: JP, US.

(84) Designated States *(regional)*: European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE).

Published:
— *With international search report.*

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: MONOCULAR BORESCOPE OR ENDOSCOPE WITH OFFSET MASK



(57) Abstract: A monocular borescope or endoscope is provided with an image relaying means (16) defining a longitudinal axis (L) and with a viewing means comprising an ocular lens (20) and field mask (18) defining a central axis (C) which is parallel to and offset from the longitudinal axis (L). In one embodiment the ocular lens (20) is coincident with the central axis (C) of the mask (18), while in another embodiment the ocular lens (20) is coincident with the longitudinal axis (L). The mask (18) is arranged to be mountable in a number of different rotational orientations each providing a different offset between the longitudinal axis (L) and the central axis (C).

WO 01/06912 A1

MONOCULAR BORESCOPE OR ENDOSCOPE WITH OFFSET MASK

The present invention relates to rigid monocular borescopes and endoscopes which are well known devices for viewing objects at remote or inaccessible locations. The invention in particular relates to means for providing an accurate direction of view in such rigid borescopes and endoscopes.

Although there are many detailed design variations, rigid borescopes and endoscopes generally consist of the basic arrangement shown schematically in Figure 1. When an object O lies within the scope's field of view (f.o.v.), an image I of the object O is formed within the insertion tube 12 of the scope 10 by means of an objective lens assembly 14. This intermediate image I is then transferred or relayed to the proximal end of the scope 10 by a series of relay lenses 16 to form a final intermediate image superimposed on a field mask 18. The purpose of the field mask 18 is to provide a sharp, well-defined edge to the specified field of view. Finally an ocular lens system 20 then projects this final image to form a virtual image some distance away, say about 1m, so as to present a comfortable view to the eye E (a normal, unaided eye can generally focus comfortably on objects from a distance of about 25cm to infinity). Additionally an adaptor lens attachment (not shown) may be fitted to re-focus this image on to a camera or CCD chip to provide an image of appropriate size for the camera.

The distal end of the scope 10 will generally use a prism arrangement 22 to establish the required

direction of view (d.o.v.), unless this is a 0° forward viewer in which case no prism is required. The direction of view is the angle between the longitudinal axis L of the scope 10 and the viewing axis V where the viewing axis is defined as the line bisecting the extreme directions delineating the diametric edges of the visible field of view. The actual direction of view that is achieved in practice may vary from the design specification for a number of reasons:

- the prism 22 may not be set at precisely the correct angle
- the individual lenses 14,16 comprising the objective and relay systems may not be manufactured such that the optical and mechanical centres coincide precisely
- the individual lenses 14,16 comprising the objective and relay systems may not be precisely centred or aligned in the lens tube 12

In a borescope or endoscope there may be large numbers of individual lenses and the build up of very slight centring errors of this type may easily result in a shift in the measured d.o.v. outside acceptable limits. The conventional method of controlling this is to place very tight tolerances on the items listed above in order to ensure the resultant d.o.v. is within the specified limits (typically ± 5°). For scopes where the specified tolerance for d.o.v. is particularly tight (e.g. ≤ 3°) it may not be possible (or would be prohibitively expensive) to control these individual tolerances to the required level of precision. There is therefore a need to achieve a high tolerance d.o.v. without relying on particularly

tight individual centration tolerances.

Accordingly, the present invention provides apparatus for use as a monocular borescope or monocular endoscope, comprising a tube having a distal end and a proximal end connected to a housing, a viewing port adjacent a distal end through which an object may be viewed in use, an image relaying means operable to relay an image of the object to a viewing means provided in the housing, the viewing means including an ocular lens and a mask positioned distally of the ocular lens and having an aperture through which the image is viewed, wherein the image relaying means defines a longitudinal axis and the aperture of the mask defines a central axis and wherein the central axis is parallel to and offset from the longitudinal axis.

In a first embodiment, the ocular lens defines a central axis which is coincident with the longitudinal axis.

In a second embodiment, the ocular lens defines a central axis which is coincident with the central axis of the aperture in the mask.

In order to provide the desired offset, the mask may be mounted so as to be adjustable into the correct position. Alternatively, the mask may be moved and replaced with a second mask having the correct offset. However, the current preference is for the mask to be mountable in different rotational orientations each providing a different offset between the longitudinal axis of the image relaying means and the central axis of the mask. Preferably the ocular lens is adjustable together with the mask. This allows the mask to be provided with different offsets, but does not require

a selection of different masks to achieve this aim.

The present invention also provides a method of providing a desired direction of view in a monocular borescope or monocular endoscope, the borescope or endoscope comprising a tube having a distal end and a proximal end connected to a housing, a viewing port adjacent to the distal end through which an object may be viewed in use, an image relaying means operable to relay an image of the object to a viewing means provided in the housing, and the viewing means comprising an ocular lens; the method comprising the steps of providing a mask distally of the ocular lens, the mask having an aperture through which the image is viewed and the aperture having a central axis; determining the angular difference between the actual direction of view and the desired direction of view; calculating the amount and direction of offset of the central axis of the mask aperture relative to the longitudinal axis required to achieve the desired direction of view and detaching the mask and fitting a mask having an aperture defining a central axis with the required offset.

The steps of detaching and fitting the mask preferably comprise detaching the mask, rotating the mask to a different rotational orientation with the required offset and fitting the mask into position. Preferably, the ocular lens is rotated together with the mask to the required offset.

The method may further comprise step of replacing the ocular lens with a second lens having a central axis coincident with the central axis of the second mask.

In the method, the amount of offset required may

be calculated in accordance with the relationship:

$$\delta = \frac{\alpha.\eta}{\varphi}$$

where δ is the amount of offset required, α is the angular difference between the actual direction of view and the desired direction of view, η is the size of the image at the position of the mask and φ is the field of view of the scope.

The invention will now be described in detail, by way of example only, with reference to the accompanying drawings in which:

FIGURE 1 is a schematic view of a prior art rigid borescope or endoscope;

FIGURE 2 is a schematic diagram illustrating a first embodiment of the present invention;

FIGURE 3 is a schematic view illustrating a second embodiment of the present invention.

FIGURE 4 is a cross section through the proximal end of a borescope with the handle removed for clarity; and

FIGURE 5 is a perspective view of the borescope of FIGURE 4 with the housing removed.

Figure 1 shows in schematic form the configuration of a conventional rigid borescope or endoscope and has been discussed above.

As mentioned above the scope 10 has a longitudinal axis L. The field mask 18 is a plate with a circular aperture, the aperture having a central axis C passing through its centre. In the

prior art, the central axis C is coincident with the longitudinal axis L. An orbital scanning scope will also have a rotational axis R which is usually coincident with the longitudinal axis L.

A first embodiment of the present invention, for incorporation in a scope of the type shown in Figure 1, is illustrated schematically in Figure 2.

In the present invention, the field mask 18' is shifted laterally compared with a conventional field mask 18 (shown for comparison purposes only) so that its central axis C remains parallel to but is no longer coincident with the longitudinal axis L of the scope as a whole. Accordingly, the virtual image 30' of the field mask 18' formed by the ocular lens, and thus the image 30 on the retina of the eye E (or in the camera), are offset laterally from the virtual image 32' of the object and the corresponding image 32 on the retina, respectively. In turn, this shifts the measured direction of view of the scope by a small amount.

In the first embodiment illustrated in Figure 2, the field mask 18' is positioned in a housing (not shown) at the proximal end of the insertion tube (not shown) such that the central axis C of the aperture will be offset from the longitudinal axis L of the scope 10. This embodiment is entirely suitable for correcting the direction of view in scopes in which there is no orbital scan facility, i.e scopes in which the insertion tube is not rotated about its longitudinal axis.

However, this embodiment is not suitable where orbital scan is required or where the scope 10 is rotated relative to the eye or attached camera. This

is because, in offsetting the field mask 18' from the longitudinal axis L of the scope, an offset in the position of the image 30 of the field mask 18' formed on the retina of the eye E (or in the camera etc.) relative to this axis L, and relative to the image 32 of the object on the retina, is also introduced. If the optical system now rotates about its longitudinal axis L the direction of the bundle of rays associated with the centre of the field mask will precess around the longitudinal axis L causing the field mask image position as formed on the retina of the eye or on the CCD chip of a video camera also to move in rotary motion about the longitudinal axis L. This effect will be noticeable when viewing with the naked eye but would be particularly apparent when viewing by means of an attached video camera and could even cause the field mask image to shift off the active area of the CCD chip as the scope rotates.

In order to overcome this problem, a second embodiment of the present invention is provided and is illustrated in Figure 3.

In this second embodiment, both the field mask 18' and ocular lens 20' of the scope 10 are offset from the longitudinal axis L of the scope 10 by the same amount and in the same direction. (A conventional field mask 18 and ocular lens 20 are also shown for comparison purposes only.) This results in a shift in the measured direction of view of the scope 10. However, as the tube 12 is rotated about the longitudinal axis L, although the bundle of light rays associated with the centre of the field mask will shift in position laterally about the longitudinal axis L, their direction does not change and since the ray bundle is substantially parallel, i.e the eye or camera lens is essentially focussed at infinity, this

does not give rise to any shift in the position of the field mask image 30 on the retina of the eye or the CCD camera chip as the scope rotates. Accordingly, this embodiment is suitable for orbital scan scopes without resulting in any field mask image movement.

The present invention can be implemented in various ways which are easy to implement in the final stages of scope assembly.

Typically, the actual direction of view of a scope is measured using a standard field mask and ocular assembly with a central axis C coincident with the longitudinal axis L of the scope so as to determine the amount and direction of field mask shift which will be required to give a desired direction of view.

This desired d.o.v may then be provided by selecting an appropriate ocular assembly from a range of assemblies constructed to provide incrementally differing amounts of offset in the position of the field mask 18' and ocular lens 20'. Alternatively, the ocular assembly for each particular scope may be machined such that the internal bore is offset by precisely the amount calculated to achieve the desired direction of view.

As those skilled in the art will appreciate, there is a limit to the amount of direction of view correction which is achievable by this means. If the shift in the field mask position is too great then the image seen within the field mask will start to be clipped by the physical boundaries of the lens tube, prism, relay or objective lenses and so on. The present invention therefore relaxes the centration tolerances on a borescope assembly to within practical

limits even though it does not remove them entirely.

The level of offset required in order to provide a given shift in d.o.v. will depend on the particular design of the borescope. In general we can state the following relationship between the required d.o.v. shift α, the field of view φ, the intermediate image size (at the field mask position) η and the amount of offset required δ:

$$\delta = \frac{\alpha.\eta}{\varphi}$$

The intermediate image size for a scope is a design parameter selected against a variety of other parameters to achieve particular performance trade-offs. However, it will generally be some fraction ε of the scope diameter D. Hence the above equation becomes:

$$\delta = \frac{\alpha.\varepsilon.D}{\varphi}$$

This equation is only strictly accurate for a system with zero distortion. However, it serves to indicate the general relationships. It will be noted that to achieve a given shift in d.o.v. the ocular offset required increases with the diameter of the scope, and inversely as the field of view. Typically, in order to achieve a 1° shift in d.o.v. a 6 mm diameter scope covering a 60 degree field of view would require an offset of 0.05 mm. A 10 mm diameter scope covering a 35° field of view would require an ocular offset of 0.19 mm.

FIGS 4 and 5 show a borescope in accordance with the second embodiment in which a single mask assembly

can be used to provide a number of different offsets.

Many of the features of the borescope of FIGS 4 and 5 are conventional and are only described briefly below.

The housing 50 is provided at its distal end with an orbital scan control 51 while a lens tube sleeve 52 extends from the housing and supports a lens system 52' extending to the distal end of the borescope. The viewing means comprises a housing eye piece 53 have a window 54 and a conventional focus control 56 which advances a ball 57 in a helical groove 57' to alter the axial position of ocular body assembly 58.

The ocular body assembly 58 comprises the field mask 18' at its distal end which is adjusted to the correct axial position by means of packing/spacer shims, while a dove prism 59 may optionally be provided at its distal end. The ocular body assembly 58 has four axially extending grooves 60 which equally spaced about its circumference. An orbital scan link pin 61 extends from the lens tube sleeve 52 into one of the grooves 60 to ensure that the lens tube 52 rotates together with the ocular body assembly 58.

As best shown in Figure 5, the mask 18' is located within the ocular body assembly by means of an alignment pin 62. The mask is provided with four grooves 63 (only two of which are shown in Figure 5) any one of which can be engaged with the alignment pin 62. A field mask direction of view indicator 64 indicates the orientation of the field mask 18' within the ocular body assembly 58. The field mask 18' is retained in the ocular body assembly 58 by a locking ring (not shown) which engages with the outer peripheral area of the field mask 18'.

When the borescope is being assembled, the degree of offset required of the mask is determined in accordance with the equation given above. The lens tube sleeve 52 is then mounted to the ocular body assembly to give a direction of view in accordance with acceptable limits. Thus, if the offset is determined to be outside of the acceptable limits, the ocular body assembly is rotated to an orientation in which it gives a positive or negative shift in the direction of view. If the offset is within acceptable limits, the ocular body assembly is mounted in a nominal position that just provides a shift in direction of view in a direction normal to the plane containing the longitudinal slope axis and the nominal viewing axis.

Depending upon the relative positions of the lens tube sleeve 52 and ocular body assembly 58, it may also be necessary to change the orientation of the field mask 18' so that the direction of view indicator 63 points in the right direction. It should be noted that as the field mask is mounted so as to be concentric with the ocular lens 20', this rotation of the field mask 18' does not provide any additional offset to the image, but simply changes the position of the direction of view indicator 64.

CLAIMS:

1. Apparatus for use as a monocular borescope or monocular endoscope, comprising a tube having a distal end and a proximal end connected to a housing, a viewing port adjacent a distal end through which an object may be viewed in use, an image relaying means operable to relay an image of the object to a viewing means provided in the housing, the viewing means including an ocular lens and a mask positioned distally of the ocular lens and having an aperture through which the image is viewed, wherein the image relaying means defines a longitudinal axis and the aperture of the mask defines a central axis and wherein the central axis is parallel to and offset from the longitudinal axis.

2. Apparatus as claimed in claim 1, wherein the ocular lens defines a central axis which is coincident with the central axis of the aperture in the mask.

3. Apparatus as claimed in claim 1, wherein the ocular lens defines a central axis which is coincident with the longitudinal axis.

4. Apparatus as claimed in any preceding claim, wherein the mask is mountable in different rotational orientations each providing a different offset between the longitudinal axis of the image relaying means and the central axis of the mask.

5. Apparatus according to claim 4, wherein the ocular lens is rotatable together with the mask between the different rotational orientations.

6. A method of providing a desired direction of view in a monocular borescope or monocular endoscope, the borescope or endoscope comprising a tube having a

distal end and a proximal end connected to a housing, a viewing port adjacent to the distal end through which an object may be viewed in use, an image relaying means operable to relay an image of the object to a viewing means provided in the housing, and the viewing means comprising an ocular lens; the method comprising the steps of providing a mask distally of the ocular lens, the mask having an aperture through which the image is viewed and the aperture having a central axis; determining the angular difference between the actual direction of view and the desired direction of view; calculating the amount and direction of offset of the central axis of the mask aperture relative to the longitudinal axis required to achieve the desired direction of view and detaching the masked and fitting a mask having an aperture defining a central axis with the required offset.

7. A method according to claim 6, wherein the step of detaching and fitting the mask comprises detaching the mask, rotating the mask to a different rotational orientation with the required offset and fitting the mask into position.

8. A method according to claim 7, wherein the ocular lens and mask are coaxial, and the method further comprises rotating the ocular lens to the required offset together with the mask.

9. A method as claimed in any of claims 6 to 8, further comprising the step of replacing the ocular lens with a second lens having a central axis coincident with the central axis of the second mask.

10. A method as claimed in any of claims 6 to 9, wherein the mask has a projection providing a visual

indication of its orientation, and the method further comprises rotating the mask on its own about its axis to change the position of the projection.

11. A method as claimed in any of claims 6 to 10, further comprising calculating the amount of offset required in accordance with the relationship;

$$\delta = \frac{\alpha.\eta}{\varphi}$$

where δ is the amount of offset required, α is the angular difference between the actual direction of view and the desired direction of view, η is the size of the image at the position of the mask and φ is the field of view of the scope; and positioning the mask at the calculated offset.

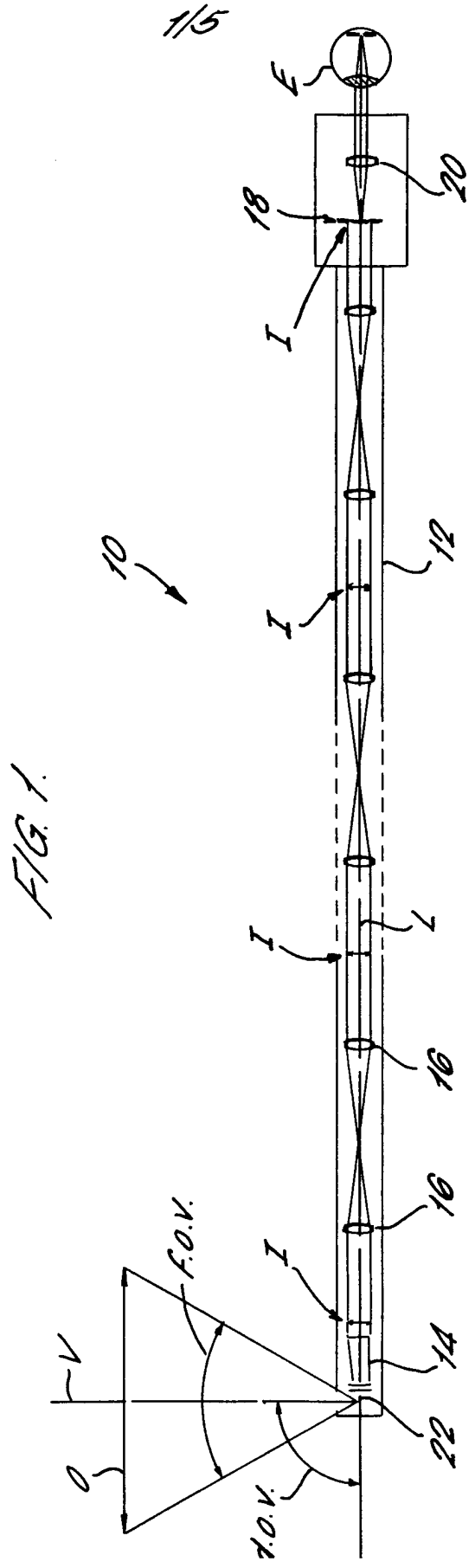


FIG. 1.

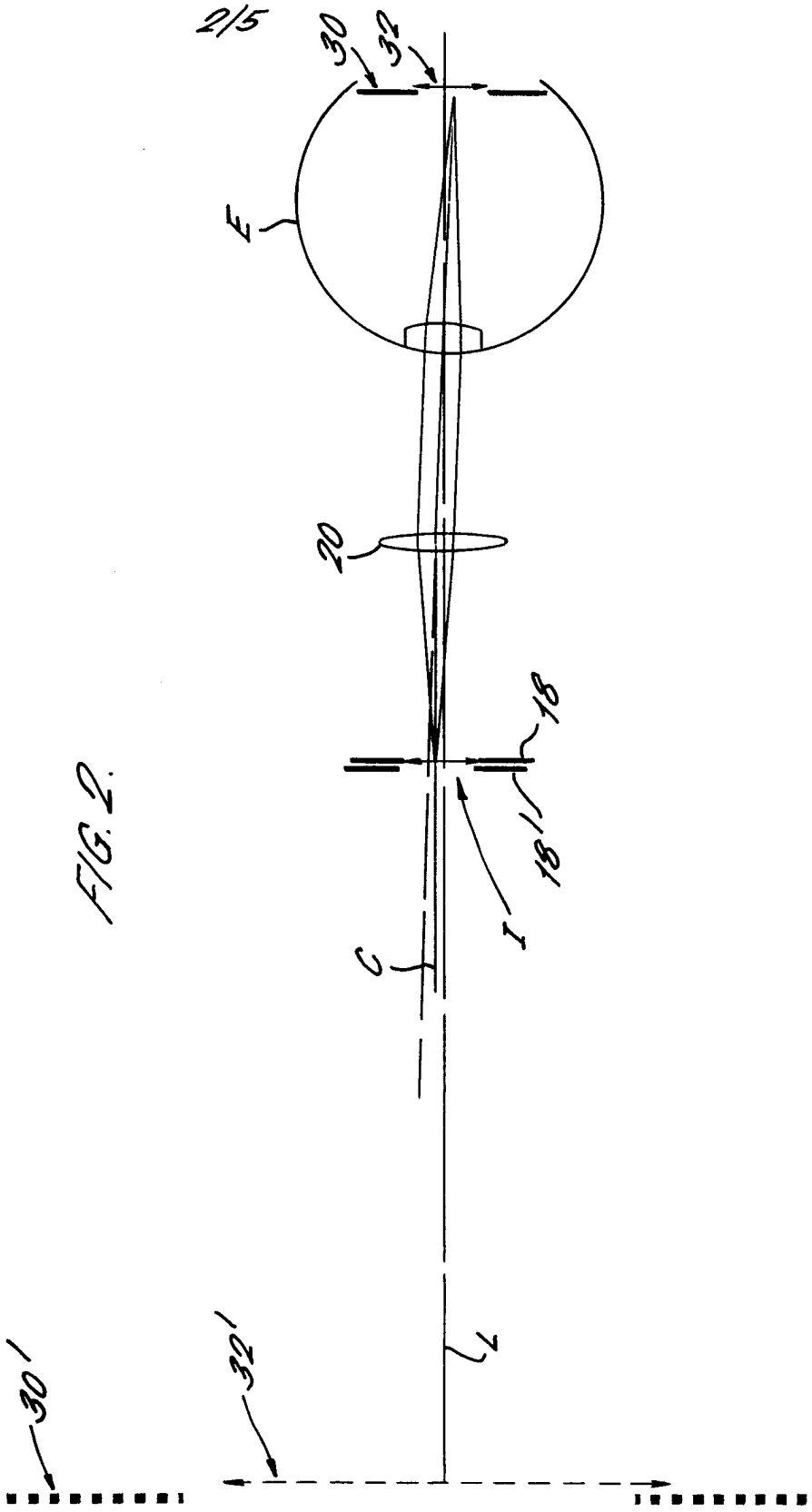


FIG. 2.

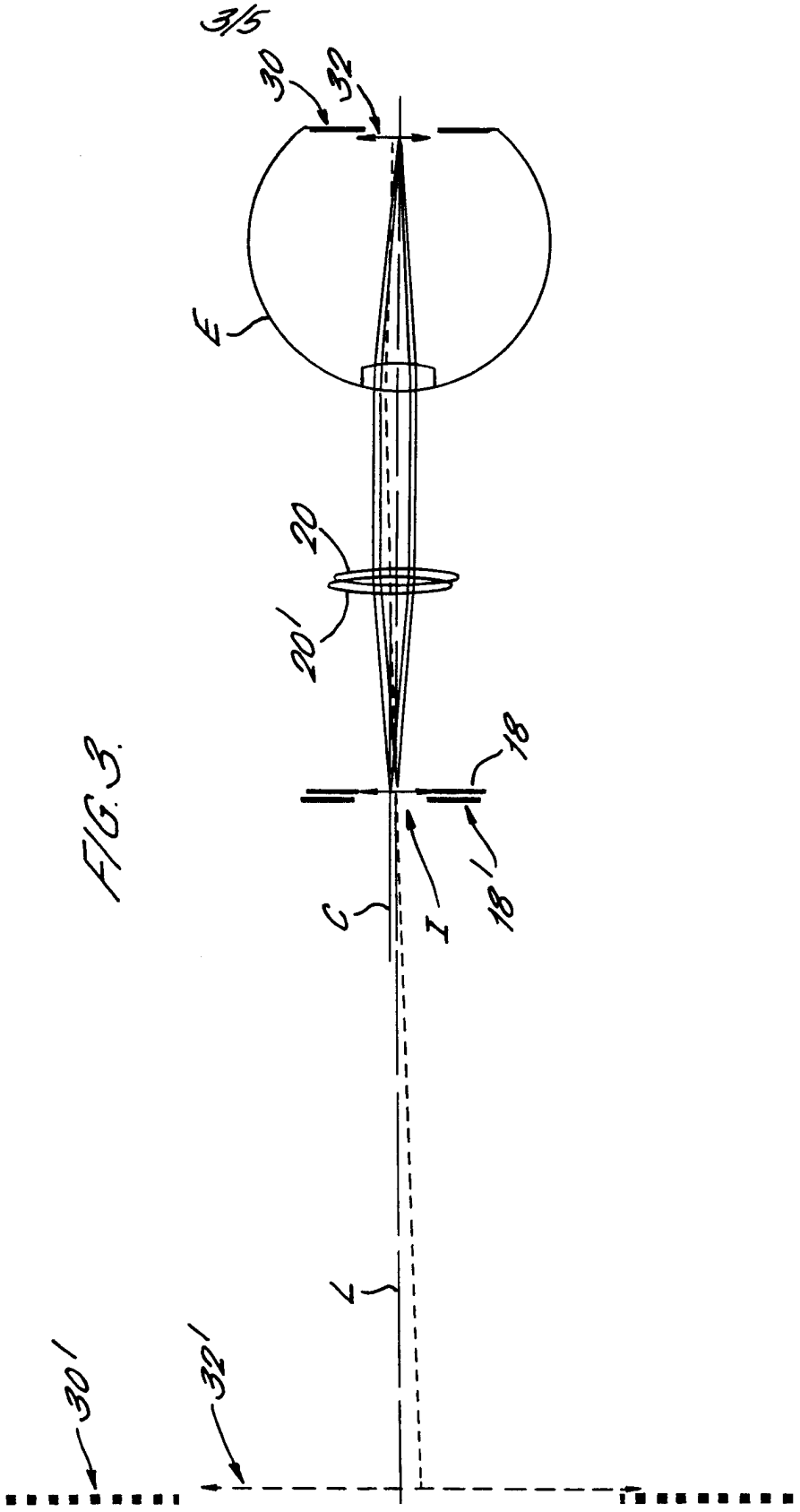


FIG. 3.

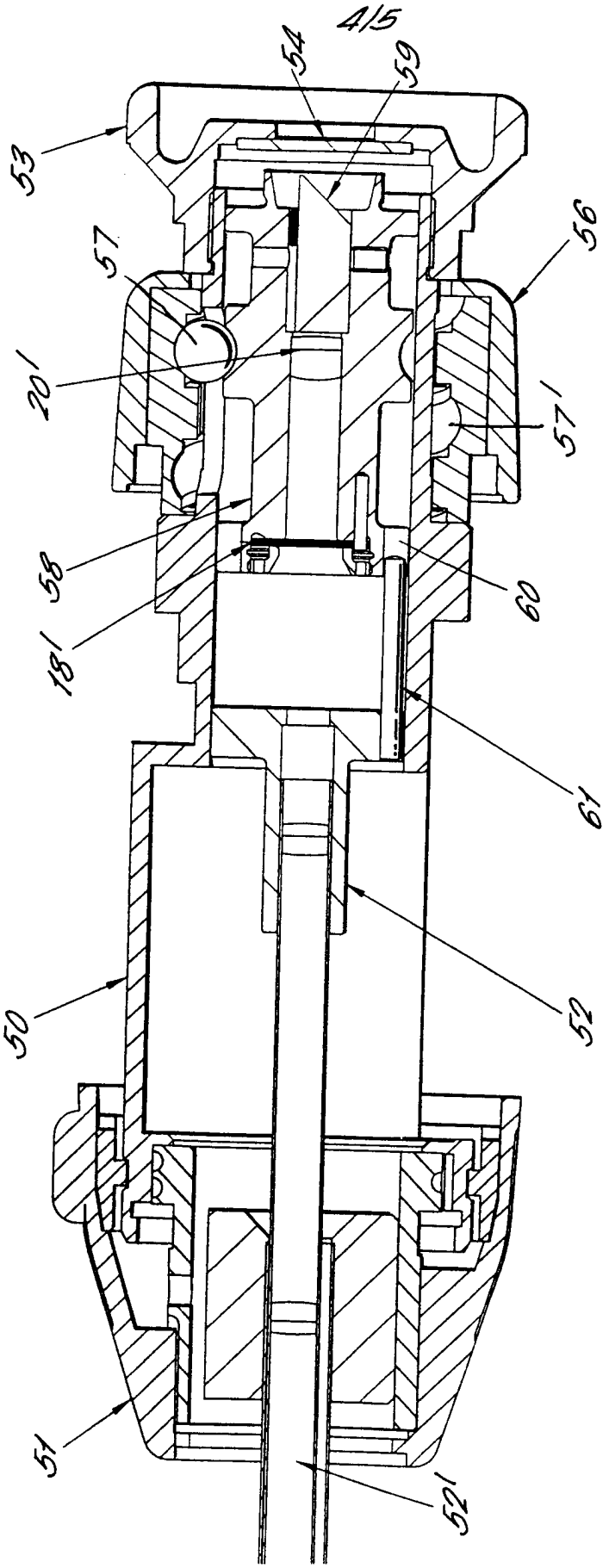
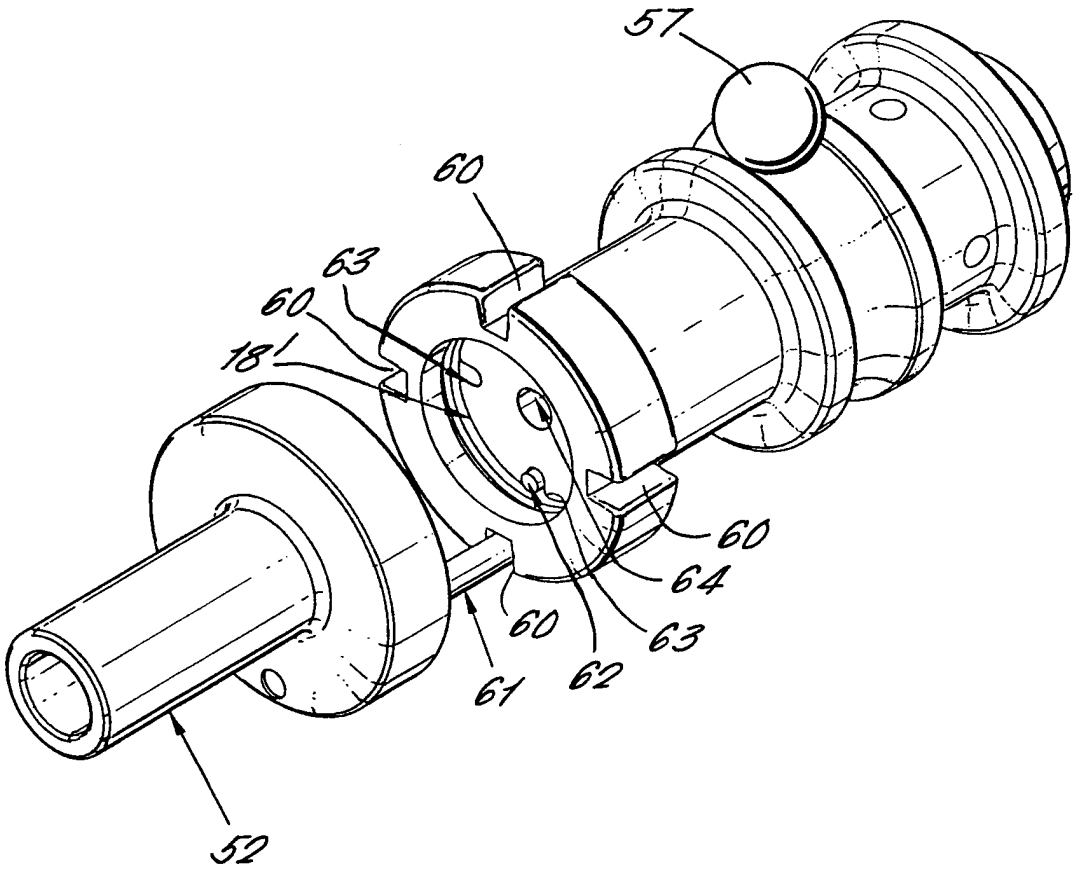


FIG.4.

FIG. 5.



INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 00/02883

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 A61B1/002 G02B23/24

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 A61B G02B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)
EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 94 13189 A (P.S. KEMPF ET AL.) 23 June 1994 (1994-06-23) page 19, line 1 - line 24 page 20, line 19 -page 22, line 17 page 23, line 9 - line 27	1,4,6-8
A	US 4 838 247 A (J.F. FORKNER) 13 June 1989 (1989-06-13) column 2, line 5 - line 31 column 3, line 1 - line 66	1,2,4-6, 8
A	EP 0 636 915 A (KEYMED LTD.) 1 February 1995 (1995-02-01) column 1, line 33 -column 2, line 51	1,3,6

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

° Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 October 2000	11/10/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Rieb, K.D.

1

INTERNATIONAL SEARCH REPORT

Inter nal Application No
PCT/GB 00/02883

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9413189 A	23-06-1994	US 5459605 A	17-10-1995
		AT 193812 T	15-06-2000
		DE 69328875 D	20-07-2000
		EP 0680271 A	08-11-1995
US 4838247 A	13-06-1989	CA 1312511 A	12-01-1993
		DE 68922176 D	18-05-1995
		DE 68922176 T	28-09-1995
		EP 0363118 A	11-04-1990
		JP 2156923 A	15-06-1990
EP 636915 A	01-02-1995	GB 2280514 A	01-02-1995
		DE 69409046 D	23-04-1998
		DE 69409046 T	02-07-1998
		JP 7174983 A	14-07-1995
		US 5540650 A	30-07-1996

专利名称(译)	单眼管镜或带偏移面罩的内窥镜		
公开(公告)号	EP1117322A1	公开(公告)日	2001-07-25
申请号	EP2000948163	申请日	2000-07-27
[标]申请(专利权)人(译)	卡麦德(医疗器械)有限公司		
申请(专利权)人(译)	KEYMED（医疗及工业设备）有限公司		
当前申请(专利权)人(译)	KEYMED（医疗及工业设备）有限公司		
[标]发明人	RAMSBOTTOM ANDREW PAUL COATH PHILIP MICHAEL		
发明人	RAMSBOTTOM, ANDREW PAUL COATH, PHILIP MICHAEL		
IPC分类号	G02B23/26 A61B1/00 G02B7/02 G02B23/24 G02B25/00 A61B1/002		
CPC分类号	G02B23/2446		
优先权	1999017716 1999-07-28 GB		
其他公开文献	EP1117322B1		
外部链接	Espacenet		

摘要(译)

单目管镜或内窥镜设置有限定纵向轴线（L）的图像中继装置（16）以及具有限定中心轴线（C）的视觉透镜（20）和视野掩模（18）的观察装置，所述中心轴线到并且从纵向轴线（L）偏移。在一个实施例中，眼睛透镜（20）与掩模（18）的中心轴线（C）重合，而在另一个实施例中，目镜透镜（20）与纵向轴线（L）重合。掩模（18）布置成可以以多个不同的旋转取向安装，每个旋转取向在纵向轴线（L）和中心轴线（C）之间提供不同的偏移。