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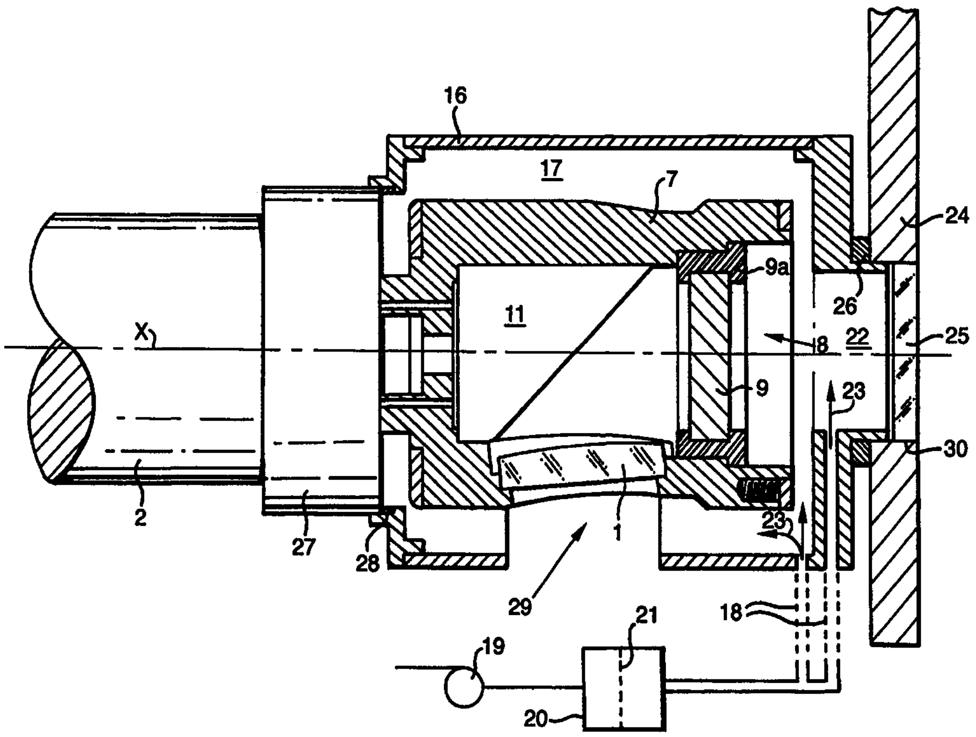

(57) Abstract

A method of reducing the effect of a contaminated environment on a rotating optical element (11) of a scanning assembly. The method comprises supplying substantially uncontaminated gas into a region (17, 22) adjacent to rotating optical element (11) thereby causing any contamination in the region to be displaced away from the rotating optical element.

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A METHOD OF REDUCING THE EFFECT OF A CONTAMINATED ENVIRONMENT

The present invention relates to a method and apparatus for reducing the effect of a contaminated environment on a rotating optical element of a scanning assembly.

In expose scanning, a medium to be scanned is mounted on a scanning drum and exposed to a beam of scanning radiation. In order to generate a good quality image, it is essential that the beam of scanning radiation is incident on the record medium to a high degree of accuracy. This is achieved by directing the radiation beam towards the record medium using a rotating deflector. The rotating deflector is typically a deflector mounted on a spinner which is in turn mounted on an air bearing and coupled to a motor, thereby allowing rotation of the deflector about an axis.

The spinner may optionally be mounted in a dynamic shroud, which rotates with the spinner body to provide additional protection to the rotating deflector. Such shrouds include an input lens positioned in an input aperture and an orbiting lens positioned in an output aperture, through which the beam of scanning radiation must pass.

Operation of such systems in normal atmospheric conditions will lead to contamination of any exposed rotating optical elements by particulate material contained within the ambient air. In the case of an unshrouded spinner, it is the rotating deflector which is exposed, whereas in the case of a shrouded spinner, it is the orbiting lens which is exposed and therefore becomes contaminated.

Studies have shown that such contamination occurs when sub-micron sized particles adhere to the trailing edge of the rotating optical element. Rotation of the rotating optical element tends to cause the movement of air toward the rotating element along the axis of rotation which draws particulate contaminants into the region surrounding the rotating optical element. These particles impinge on the rotating optical element and are deposited to form a layer of contamination which envelopes the rotating optical element from the trailing edge to the leading edge.

Such contamination results in degradation of the scanned image principally by causing intolerable veiling flare. This occurs when unwanted light resulting from scatter and/or unwanted reflections is present in the image plane, or when there is insufficient laser power levels to expose the imaging media at the scanner drum surface.

At present such contamination is generally overcome by regular cleaning of the rotating optical element, which is a time consuming and delicate job. Such cleaning is generally required once every 1-14 days depending on the level of contamination. For example, an environment which contains a 0.5 micron particle count of under 200 per cubic foot results in little or no contamination over a 7 day time period, whereas a count of 18000 per cubic foot results in gross contamination in under 24 hours. However, recent increases in speed from 12,000 rpm to 13,800 rpm have led to an increase in contamination leading to more frequent cleaning and with further speed increases to 18,500 rpm expected a more permanent solution is required.

A solution has been proposed in EP-A-0683415 in which the rotating deflector is contained within a static closed shroud, thus removing the need for an exposed optical element that rotates, therefore reducing the effects of contamination. However, the motor and air bearings that drive the spinner tend to generate a substantial quantity of heat. In the case of a statically shrouded spinner, heat is dissipated by forced convection from the rotating deflector's surface. This causes localised heating of the surrounding sub-layer of air which sheds and forms vortices. This warm air containing the vortices becomes trapped within the static shroud and as a result, the beam of scanning radiation is refracted as it passes through the vortices causing the beam to be displaced relative to its intended position. This leads to further image degradation known as thermal raster. In an assembly in which a static closed shroud is used, the effect of this thermal raster is increased due to the warm air. The effect of thermal raster is increased with the warm air being trapped within the static shroud and it is therefore preferable to avoid the use of a static closed shroud.

There are additional problems in using a static closed shroud. For example, a window would need to be convex and well centred. This is far more expensive than the window for a dynamically closed shroud. Refraction of the beam caused by the curved nature of the lens on a static shroud would also cause phase errors to the imaged dot, reducing image quality.

In accordance with a first aspect of the present invention, we provide a method of reducing the effect of a contaminated environment on a rotating optical element of a scanning assembly, the method comprising supplying substantially uncontaminated gas into a region adjacent the rotating optical element thereby causing any contamination in the region to be displaced away from the rotating optical element.

We have devised a method of reducing the effect of contamination by supplying uncontaminated gas, usually air, into a region surrounding the rotating optical element. This uncontaminated gas displaces contaminated air thereby reducing the levels of contamination in the volume adjacent the rotating optical element. This results in a reduction in the level of contamination of the rotating optical element, thereby reducing the amount of cleaning required.

The substantially uncontaminated gas may be any gas free from sub-micron particles. However, preferably the gas is air that has been passed through a filter to remove the contaminants, as filtering of air is a cheap process that is easily carried out.

In order for the invention to function correctly, the contaminated air adjacent the rotating optical element must be replaced by the substantially uncontaminated gas. This is most easily achieved by ensuring that the rotating optical element is contained within but spaced apart from an open (static) shroud such that the region to which the substantially uncontaminated gas is supplied is defined by the spaced between the rotating optical element and the open shroud. This causes the volume between the open shroud and the rotating optical element to fill with substantially uncontaminated gas ensuring that the rotating optical element is adjacent to substantially uncontaminated gas.

Additionally, it is preferable if substantially uncontaminated gas is supplied to an aperture of the open shroud as this further aids the displacement of contaminated gas from the region adjacent the rotating optical element.

In accordance with a second aspect of the present invention, we provide apparatus for reducing the effect of a contaminated environment on a rotating optical element of a scanning assembly, the apparatus comprising a device for providing a supply of substantially uncontaminated gas, the device being coupled to a delivery system for directing the substantially uncontaminated gas into a region adjacent the rotating optical element.

Typically the device for supplying the uncontaminated gas comprises a pump for generating a supply of compressed air and a filter, wherein the compressed air is passed through the filter to filter out sub-micron particles contained within the air. However, a supply of purified compressed gas would be equally suitable although in general this would be more expensive and therefore less practical.

In order to supply the uncontaminated gas into the region, the delivery system preferably comprises at least one hose positioned so as to direct substantially uncontaminated gas into the region. However any such suitable system would be acceptable.

An example of apparatus according to the present invention will now be described and contrasted with known apparatus with reference to the accompanying drawings, in which:-

Figure 1 is a diagram showing the build up of contamination upon a rotating optical element;

Figure 2 is a side view showing the air currents generated by a spinner mounted with a dynamic shroud;

Figure 3 is a side view of a rotating optical element mounted in an open shroud according to an example of the present invention; and

Figure 4 is a perspective view of the apparatus of Figure 3.

Figure 1 shows in plan view a rotatably mounted spinner 2 upon which is mounted a lens 1 which orbits or rotates with the spinner 2. The spinner 2 is coupled to a motor (not shown) to cause rotation of the orbiting lens 1, about an axis of rotation X, in the direction shown by an arrow 3. As a consequence of this rotation, the orbiting lens 1 has a leading edge 4 which moves into the page in the view shown in Figure 1 and a trailing edge 5 which moves out of the page. Thus the trailing edge 5 impinges on the air surrounding the orbiting lens and as a consequence, contaminants in the atmosphere, which are usually in the form of sub-micron particles, become deposited on the trailing edge 5 of the orbiting lens 1. Continuous deposition of such particles causes a layer of contamination 6 to slowly build up on the lens.

Figure 2 shows a second example of a spinner 2′ which includes a dynamic shroud 7. The dynamic shroud 7 includes an aperture 8 containing a window 9 which is held in place by a window retaining ring 9a. A modulated beam of scanning radiation, passes through the window 9 as shown by an arrow 10. The beam of scanning radiation, typically a laser beam which has been modulated with image data, is deflected by a rotating deflector 11, mounted to and within the shroud 7, and exits the dynamic shroud 7 through an aperture 12, as shown by an arrow 13. This aperture contains a lens 1, similar to that shown in Figure 1.

After exiting the dynamic shroud 7, the scanning radiation will impinge on a record medium mounted on a scanner drum or flat bed 14. By rotating the spinner 2' about the axis of rotation X and also traversing the spinner parallel to the axis of rotation X, the entire record medium may be exposed. Simultaneous modulation of the scanning beam, in accordance with image data, can therefore be used to generate an image on the record medium.

Figure 2 also shows the currents of air generated by rotation of the spinner 2'. The ambient air surrounding the spinner 2' and in particular the dynamic shroud 7 is accelerated by rotation of the spinner 2' about the axis of rotation X causing it to be drawn toward the dynamic shroud 7 in a stream as shown by the arrows 15. It is this stream of air that introduces contaminants into the volume surrounding the orbiting lens 1.

It will be realised by those skilled in the art that scanning may be achieved in a similar manner in the absence of the dynamic shroud 7 and that similar problems will be encountered with ambient air being drawn in by rotation of the spinner 2'. In this instance it will be the rotating deflector 11 that is subject to contamination.

In an example of the invention, the spinner 2' and dynamic shroud 7 of Figure 2 are mounted within an open static shroud 16 which is an enclosing mount made from a robust material, such as high tensile polypropylene, as shown in Figures 3 and 4. The shroud 16 is mounted to a wall 24 to which it is sealed by a seal 26. The shroud 16 is also coupled to a spinner bearing 27 to which it is sealed by a seal 28. The wall 24 includes an aperture 30 into which is mounted a window 25 which allows the beam of scanning radiation to be directed onto the rotating deflector 11. Once deflected the scanning radiation exits the dynamic shroud 7 via the lens 1 and the static shroud 16 through an aperture 29 to impinge on a record medium, not shown.

Uncontaminated air can be delivered to a volume 17 between the dynamic shroud 7 and the open shroud 16, using an air delivery system in the form of hoses 18. The hoses 18 are coupled to a supply of uncontaminated gas which in the current example is in the form of filtered air. The filtered air is obtained from a filter system 20, through which air is pumped using a pump 19. The filter system 20 includes a filter 21 with pores smaller than 0.01 microns in diameter so as to filter out any particulate material greater than 0.01 microns in diameter. It is important to ensure that such a small size filter is used as the majority of the contamination is due to particles of size 0.01 microns and above.

In use, filtered air is delivered through the delivery hoses 18 to a region 22 within the open shroud 16 and to the volume 17 as shown by the arrows 23. The air entering the static open shroud 16 is then accelerated by the rotation of the dynamic shroud 7 causing it to be circulated within the volume 17. The air eventually exits the open shroud 16 through the aperture 29.

The presence of the window 25, mounted in the aperture 30 of the wall 24, prevents the formation of the stream of air designated by the arrows 15 in Figure 2. However, as the rotation of the dynamic shroud 7 still acts to accelerate the ambient air contained within the open shroud 16 causing it to be expelled through the aperture 29, there will be a resulting decrease in pressure within the open shroud 16. This could lead to contaminated air being drawn in through the aperture 29. To prevent this, it is necessary to ensure that the air delivery system delivers a sufficient quantity of air to maintain the pressure within the open shroud 16 above that of the ambient air surrounding the outside of the shroud 16. Experiments have shown that for two 4mm diameter hoses 18, if the dynamic shroud 7 is rotating at a speed of 13,800 rpm, then the supply pressure of filtered air must be 15 psi. If the spinner speed increases, this will require an increase in the supply pressure of filtered air.

Thus, the filtered air supplied to the volume 17 will displace any uncontaminated air thus ensuring that the air adjacent to the rotating deflector 1 is substantially uncontaminated. As a result the levels of contamination of the rotating deflector 1 will be substantially reduced if not eliminated entirely.

It has also been found that the supply of air to the volume 17 and the subsequent acceleration by the dynamic shroud 7 results in the air in volume 17 being continuously mixed around. This causes the air to be homogenized. As described in the introduction, dynamic shrouds tend to radiate heat generated by the motor and the bearings of the spinner 2. This heat is dissipated by force convection from the surface of the dynamic shroud, which can lead to localised heating of the surrounding sub-layer of air which may shed and form vortices. As the beam of radiation passes through the vortices it is refracted causing the beam to be displaced relative to its intended position. This is known as thermal raster. However, in the present invention, the homogenization of the air caused within the volume 17 prevents the formation of vortices thereby reducing the effects thermal raster. (This problem is described also in US-A-4834520).

CLAIMS

1. A method of reducing the effect of a contaminated environment on a rotating optical element of a scanning assembly, the method comprising supplying substantially uncontaminated gas into a region adjacent the rotating optical element thereby causing any contamination in the region to be displaced away from the rotating optical element.

2. A method according to claim 1, wherein the uncontaminated gas is obtained by passing air through a filter to remove contaminants.

3. A method according to any of the preceding claims, wherein the rotating optical element is contained within, but spaced apart from, an open shroud, such that the region into which the substantially uncontaminated gas is supplied is defined by the space between the rotating optical element and the open shroud.

4. A method according to claim 3, wherein the substantially uncontaminated gas is further supplied to an aperture of the shroud.

5. A method according to claim 3 or claim 4, wherein the open shroud is static relative to the rotating optical element.

6. Apparatus for reducing the effect of a contaminated environment on a rotating optical element of a scanning assembly, the apparatus comprising a device for providing a supply of substantially uncontaminated gas, the device being coupled to a delivery system for directing the substantially uncontaminated gas into a region adjacent the rotating optical element.

7. Apparatus according to claim 6, wherein the device for providing a supply of uncontaminated gas comprises a pump for generating compressed air and a filter, wherein the compressed air is passed through the filter to remove the contaminants.

8. Apparatus according to claim 6 or claim 7, wherein the rotating optical element is contained within, but spaced

apart from, an open shroud, such that the region into which the substantially uncontaminated gas is supplied is defined by the space between the rotating optical element and the open shroud.

9. Apparatus according to any of claims 6 to 8, wherein the substantially uncontaminated gas is further supplied to an aperture of the shroud.

10. Apparatus according to any of claims 6 to 9, wherein the delivery system comprises at least one hose positioned so as to direct substantially uncontaminated gas into the region.

11. Image scanning assembly comprising a rotating optical element; apparatus according to any of claims 6 to 10 for reducing the effect of a contaminated environment on the element; a modulated radiation beam source for generating a radiation beam modulated with image information; and a record medium support, the rotating optical element being positioned to receive the modulated radiation beam and scan it across a record medium on the support.

Fig.1.

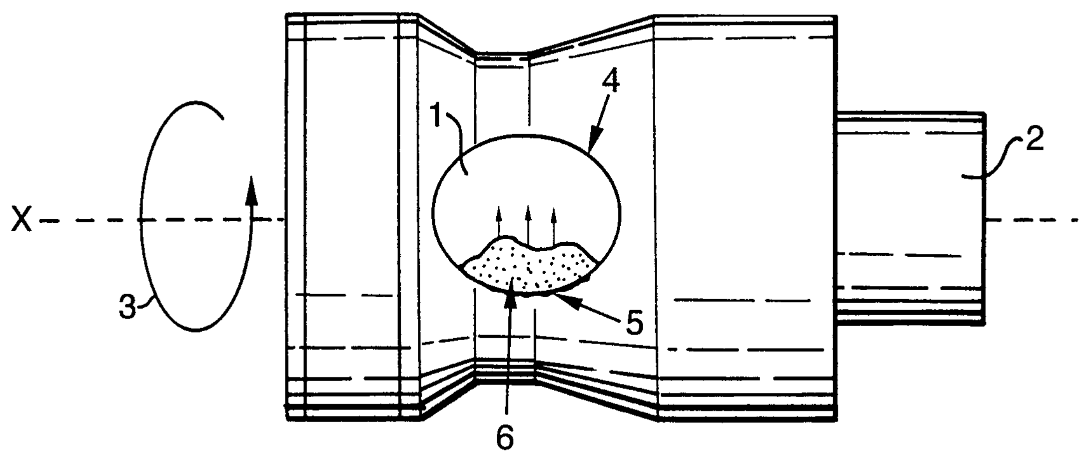
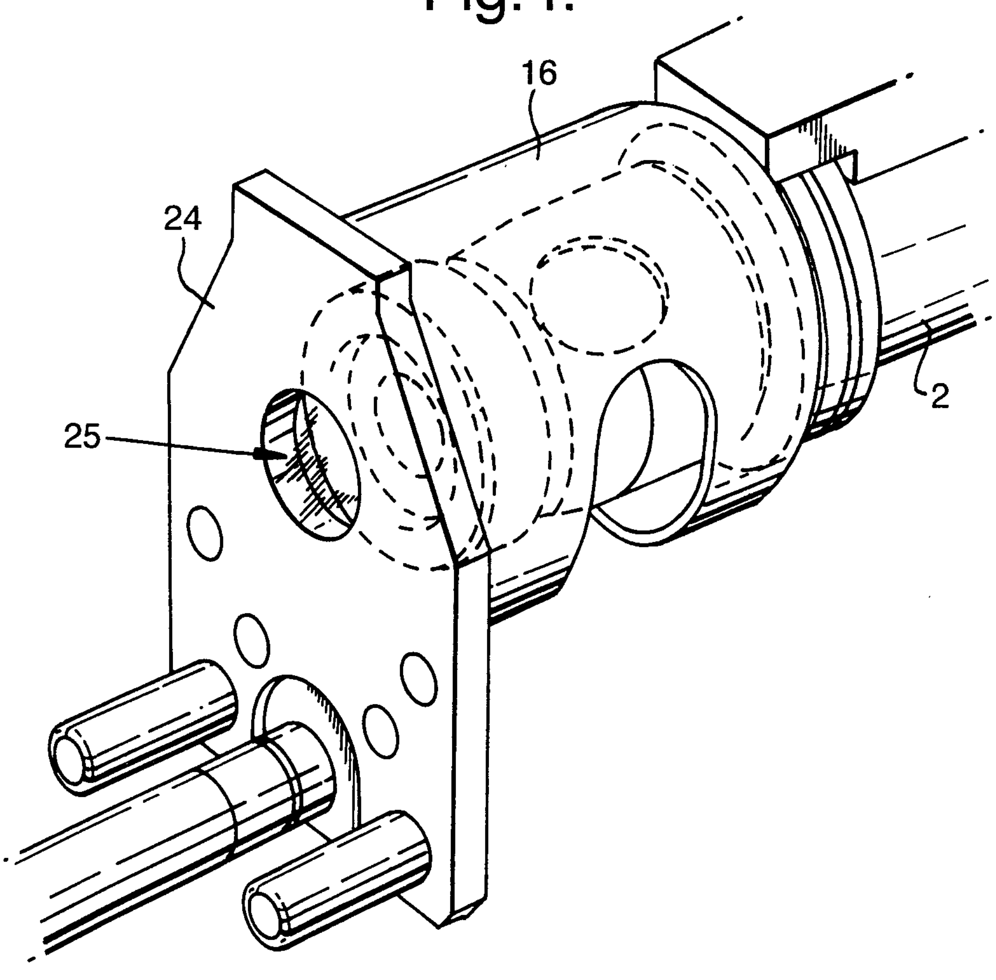


Fig.4.



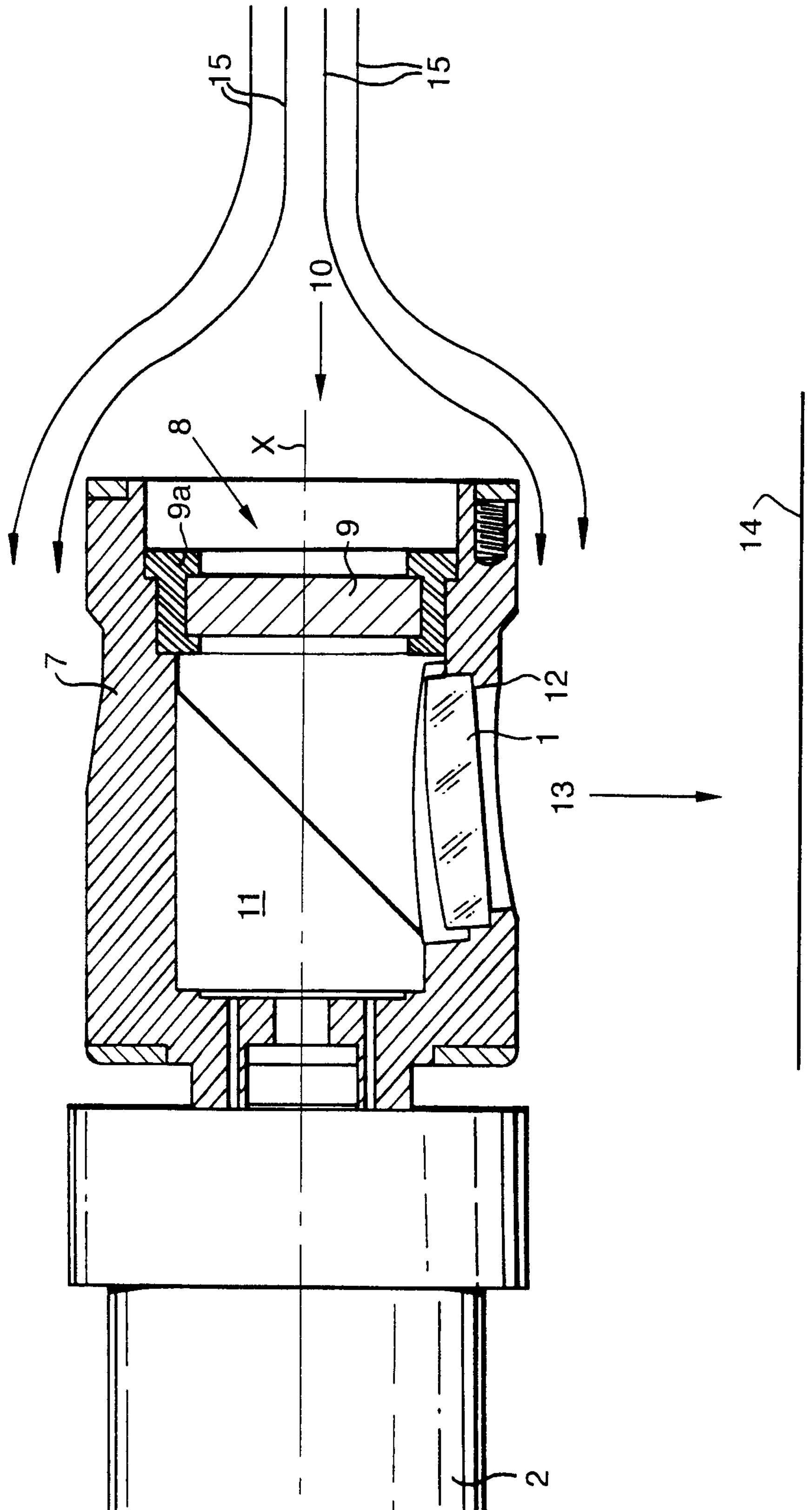
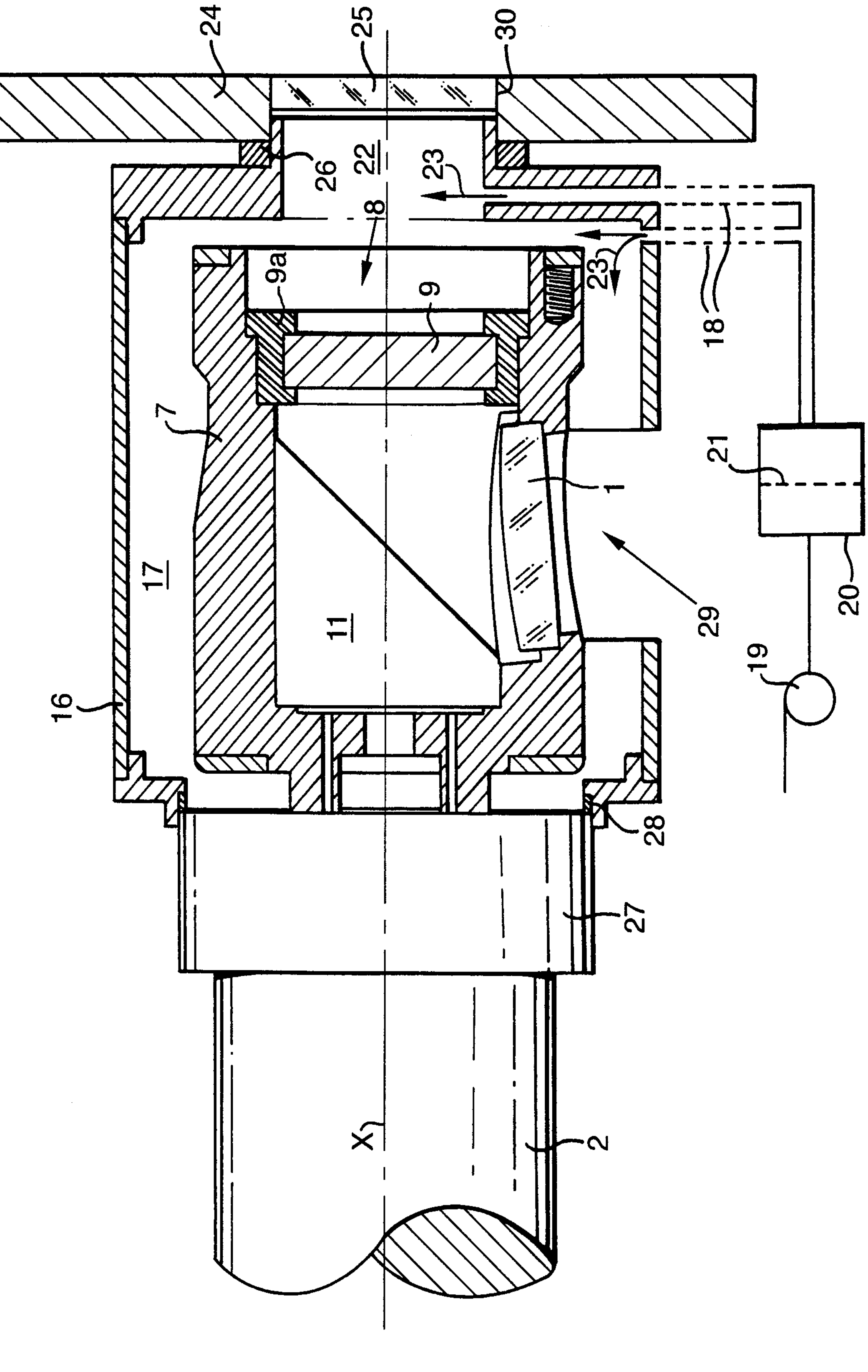


Fig.2.

Fig.3.



INTERNATIONAL SEARCH REPORT

Int. .tional Application No
PCT/GB 98/01366

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 G02B26/10 G02B23/16

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 6 G02B B08B

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)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 5 046 797 A (KURISU AKIRA ET AL) 10 September 1991 see column 3, line 65 - column 6, line 44; figure 2	1,2,6,7, 10,11
X	PATENT ABSTRACTS OF JAPAN vol. 096, no. 007, 31 July 1996 & JP 08 062528 A (CANON INC), 8 March 1996, see abstract	1-6,8,9, 11
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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 836 689 A (O'BRIEN RICHARD J ET AL) 6 June 1989 see column 3, line 54 - column 6, line 45; figures 1-3 ---	1,3-9
A	EP 0 683 415 A (MILES INC) 22 November 1995 cited in the application see column 1, line 34 - line 55 see column 2, line 48 - column 4, line 42; figures 1-5 -----	1,3,5-7, 11

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INTERNATIONAL SEARCH REPORT

Information on patent family members

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