United States Patent

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[54] **VARIABLE ANGLE INTERNAL REFLECTION ATTACHMENT**
2 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **356/244**
[51] **Int. Cl.** **G01n 21/16;** G01j 3/00
[50] **Field of Search** ..... 356/244, 74; ATR/Digest

[56] **References Cited**

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ABSTRACT: An attachment for reflecting a beam of radiation into and out of a sample mounted in a movable internal reflection means through four reflecting surfaces with the four reflecting surfaces and sample being movable in synchronism so that the beam is held in focus at the entrance of the sample at varying angles of incidence.

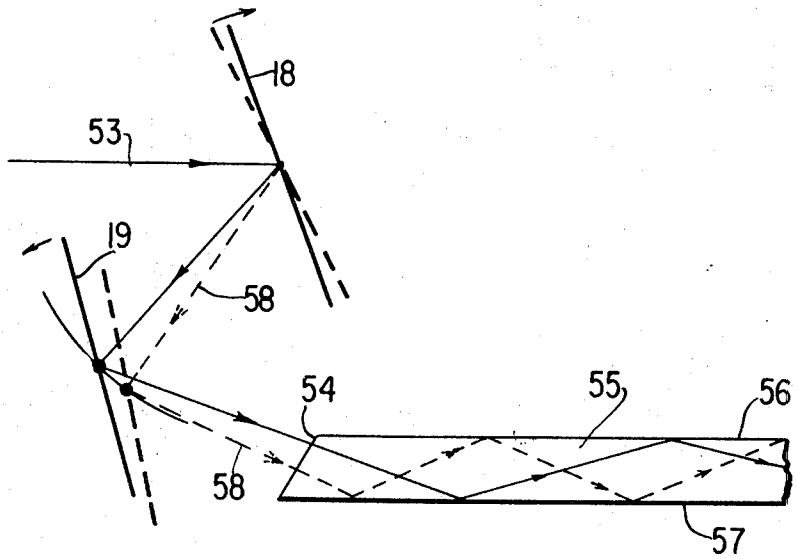
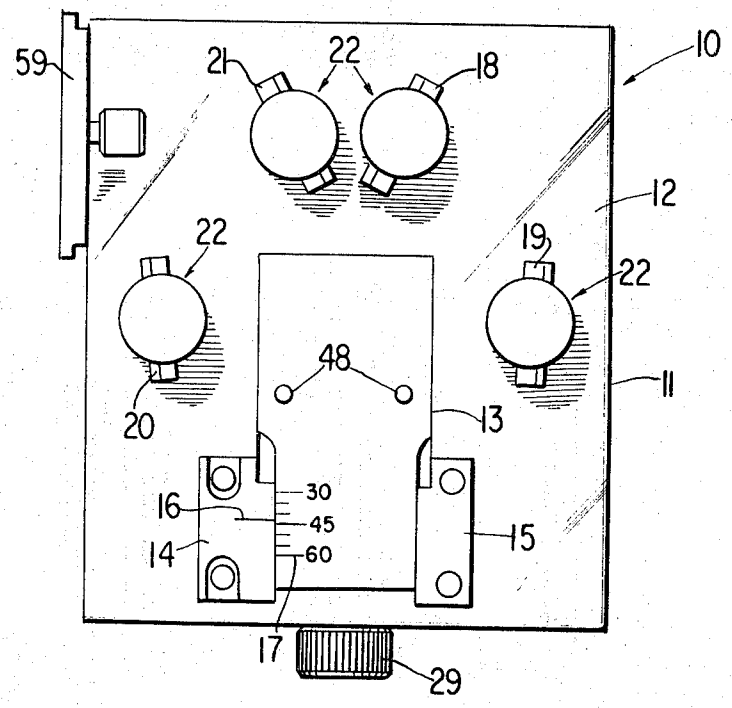


FIG. 1



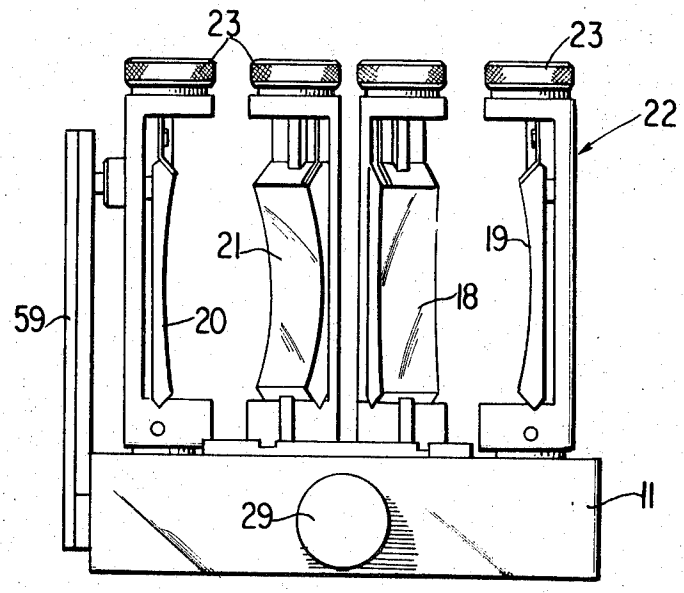


FIG. 2

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FIG. 3

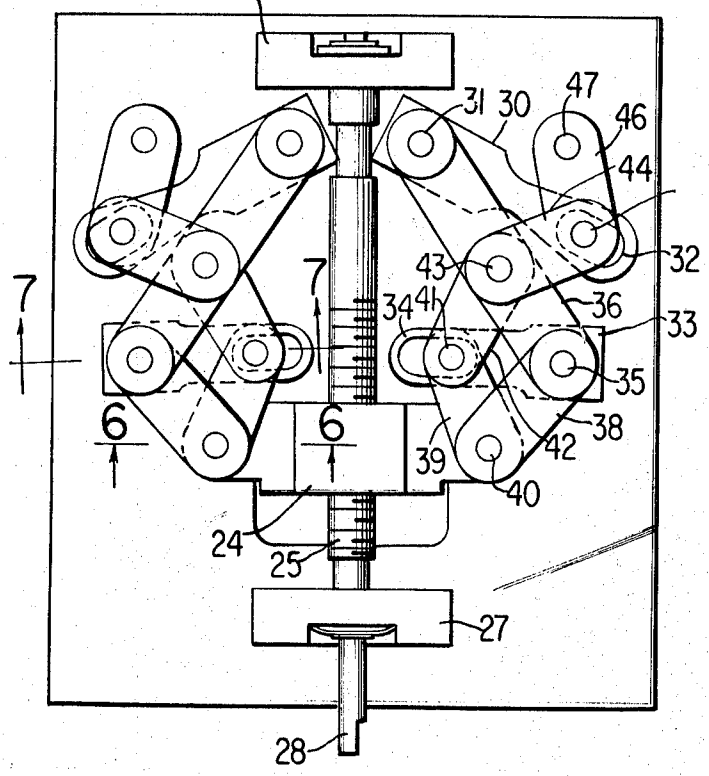
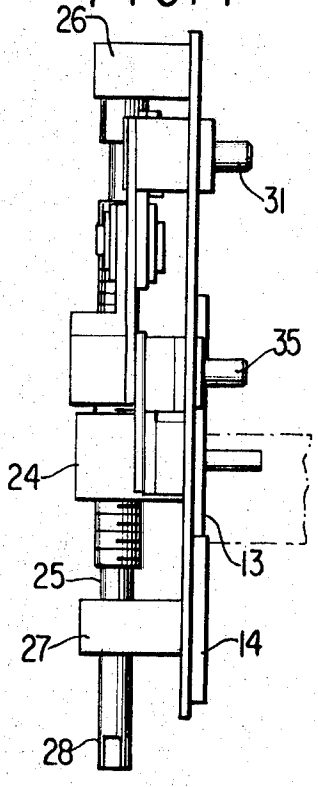


FIG. 4



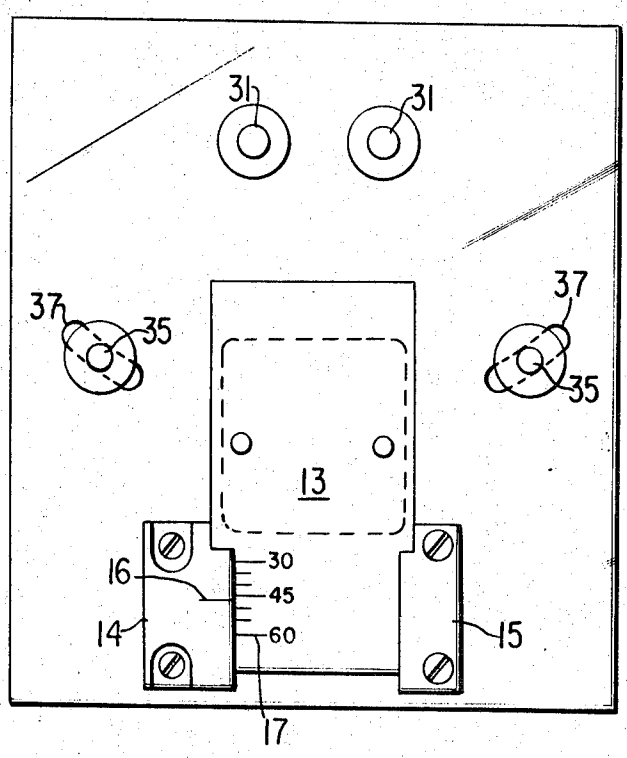


FIG. 5

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FIG. 6

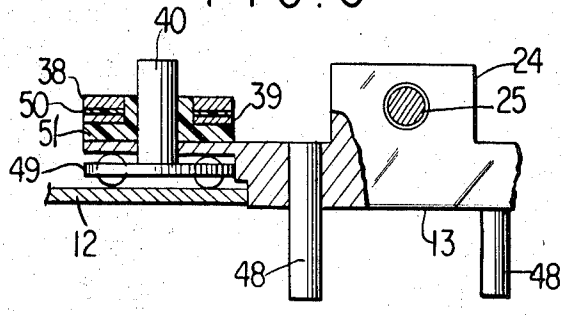
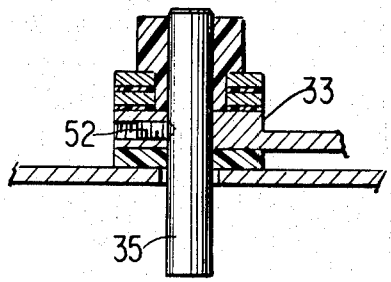


FIG. 7



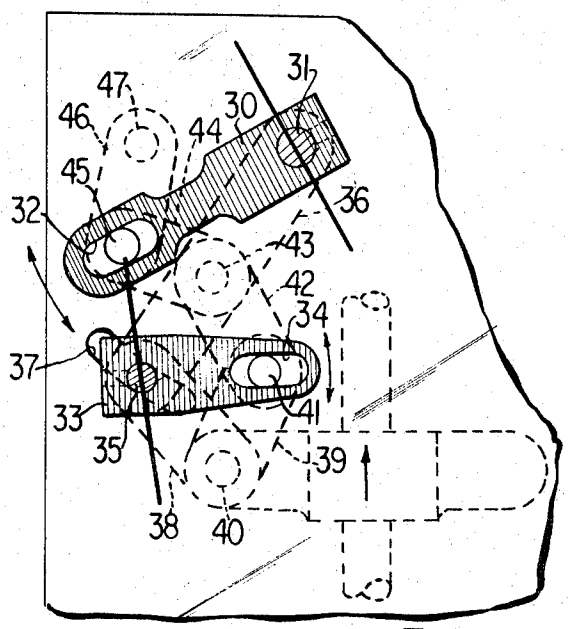


FIG. 8

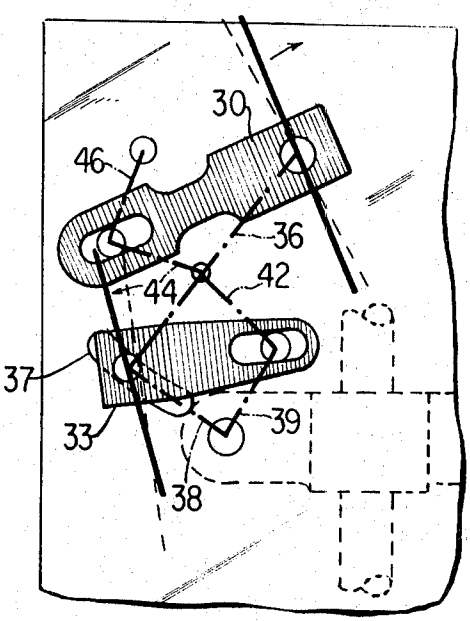


FIG. 9

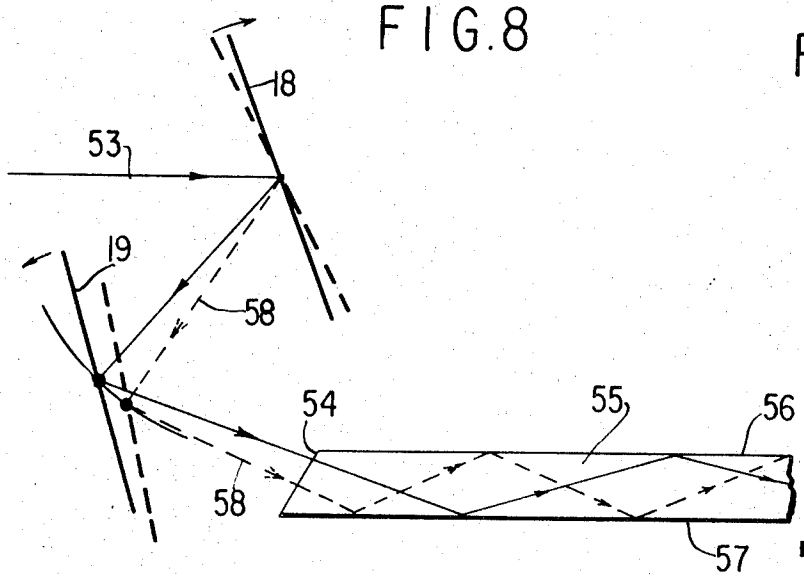


FIG. 10

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VARIABLE ANGLE INTERNAL REFLECTION ATTACHMENT

SPECIFICATION

The present invention relates to internal reflection spectroscopy and more particularly to an attachment for varying the angle of incidence of a beam of radiation entering a sample wherein the beam is reflected within the sample a multiplicity of times.

When a beam of radiation enters a prism it will be reflected internally when the angle of incidence at the interface between sample and prism is greater than the critical angle (a function of refractive index). On internal reflection, all of the energy is reflected. However, the beam appears to penetrate slightly beyond the reflecting surface and then return. When a material which selectively absorbs radiation is placed in contact with the reflecting surface, the beam will lose energy at those wave lengths where the material absorbs energy. This attenuated radiation, when measured and plotted as a function of wave length by a spectrophotometer, will give an absorption spectrum characteristic of the material.

The depth to which the radiation penetrates is a function of: (1) The wave length of light, (2) The refractive index of both the reflector and sample, and (3) The angle of incident radiation. If the depth of penetration versus angle of incidence is plotted in a region where there is maximum absorption by the sample, the penetration will increase most rapidly when the angle of incidence at the interface between the sample and prism is very near the critical angle but it is relatively slight at angles well removed from the critical angle.

Nearly all the energy goes into the sample when the critical angle is exceeded.

A typical plot of the index of refraction of a material versus wave length in the vicinity of an absorption band will show that the index of refraction undergoes radical variation in this region. There will be a point at which the index of the sample is greater than that of the reflector. At this wave length, there is no angle of incidence at which internal reflection can take place and nearly all the energy will pass into the sample. The recorded internal reflection absorption band will, thus, be very strong but broadened toward long wave length and, hence, greatly distorted as compared to that measured by transmission.

It will be apparent that in order to obtain internal reflection spectra that are nearly identical to transmission spectra a relatively high index reflector should be used. Also, an overall angle of incidence should be selected that is far enough from the average critical angle of the sample versus reflector so that the change of the critical angle through the region of changing index has a minimum of effect on the shape of the internal reflection absorption band.

It is possible, however, to multiply the amount of absorption by multiplying the number of reflections. This is analogous to increasing the path length in transmission cells. The multiple reflection approach can thus produce undistorted spectra of any desired intensity provided there are enough reflections.

One of the objects of the present invention is to provide an improved apparatus for varying the angle of incident radiation with a multiple internal reflector plate.

Another of the objects of the present invention is to provide an apparatus for varying the angle of incident radiation onto a multiple internal reflection plate while holding the beam of radiation in focus at the entrance to the plate.

In one aspect of the invention there may be provided a variable angle multiple internal reflection apparatus having a platform upon which there is movably mounted an internal reflection means. A plurality of reflecting surfaces are movably mounted on the platform to reflect a beam of radiation into and out of the internal reflection means. Means operatively connect the internal reflection mean and the plurality of reflecting surfaces for holding a beam of radiation in focus on the entrance of the internal reflection mean at varying angles of incidence. The internal reflection means is mounted on a member which is linearly movable on the platform by rotation of an adjusting knob. The movable member and the reflecting surfaces are linked in pantographlike fashion by a scissors jack assembly. By rotating the single adjusting knob, the reflecting surfaces are moved in synchronism with the internal reflection means mounted on the movable member so that the beam of radiation is held in focus on the entrance face of the plate at each angle of incidence.

Other objects, advantages and features of the present invention will become apparent upon reference to the accompanying description and drawings, which are merely exemplary.

In the drawings:

FIG. 1 is a top plan view of the variable angle internal reflection attachment of the present invention;

FIG. 2 is a front elevational view of the apparatus of FIG. 1;

FIG. 3 is a bottom plan view of the apparatus shown in FIG. 1 with the enclosure removed to illustrate the connecting linkage;

FIG. 4 is an elevational view of the apparatus illustrated in FIG. 3;

FIG. 5 is a top plan view of the apparatus of FIG. 1 but with the reflecting surfaces removed to illustrate the mounting means therefor;

FIG. 6 is a sectional view taken along the line 6–6 of FIG. 3;

FIG. 7 is a sectional view taken along the line 7–7 of FIG. 3;

FIG. 8 is a plan view of a portion of the linkage illustrated in FIG. 3 with the links having the reflecting surfaces mounted thereon being shown in shaded lines and the remaining components of the linkage system shown in dash lines;

FIG. 9 is a view similar to that of FIG. 8 but showing schematically the linkage system and the movement of the reflecting surface; and

FIG. 10 is a schematic view illustrating how movement of the reflecting surfaces varies the angle of incidence of a beam of radiation to the entrance of a sample for multiple internal reflection therein.

Proceeding next to the drawings wherein like reference symbols indicate the same parts throughout the various views a specific embodiment of the present invention will be described in detail.

As may be seen in FIGS. 1 and 2, the attachment according to the present invention is indicated generally at 10 and comprises a base 11 which is in the form of a casing or enclosure with an upper surface or platform 12.

A sample platform 13 is movably mounted between fixed guides 14 and 15 secured to top face 12 with guide 14 having an index 16 thereon which registers with a scale of angles 17 on the sample platform. The angles of the scale 17 represent angles of incidence of a beam of radiation to a sample carried in a fixed plate sample holder (not shown in the drawings) but which is mounted on the movable sample platform 13.

Also mounted on the top face 12 are reflecting surfaces 18, 19, 20 and 21. Each of the reflecting surfaces are secured in their respective mounts 22 each of which is provided with an adjusting knob 23 on the top thereof to adjust by rotation the reflecting surfaces.

Referring next to FIGS. 3 and 4, the adjusting mechanism for moving the reflecting surfaces in conjunction with the sample platform comprises a block 24 mounted on the underside of the sample platform and having a threaded bore therethrough. A threaded shaft 25 is journaled at 26 and 27 within space 11 and is threadedly engaged with the threaded bore of block 24. The outer end of the shaft indicated at 28 may be provided with an adjusting knob 29 illustrated in FIGS. 1 and 2.

The linkage system actually comprises two mirror opposite pantograph linkage arrangements which may be seen in FIG. 3. The linkage comprises a first link 30 which has one end pivotally mounted at 31 and a slot 32 in its other end. Pivot mount 31 is a pin which projects above the top surface 12 and the reflecting surfaces 18 and 21 are mounted thereon.

A second link 33 is provided which has a slot 34 in its inner end and a pivot pin 35 at its other end.

A connecting link **36** is connected between the pivot point **31** and pivot pin **35**.

Pin **35** of second link **33** extends upwardly beyond the top surface through arcuate slot **37** and reflecting surfaces **19** and **20** are attached to these pins.

Links **38** and **39** are pivotally connected at **40** to the movable sample platform and link **38** is pivotally connected to pin **35**. Link **39** is connected to pin **41** which is guided in slot **34** of link **33**. There is a link **42** connected between pin **41** and a pin **43** mounted on connecting links **36**.

A link **44** is pivotally connected between pin **43** and a pin **45** which is guided in slot **32**. There is a remaining link **46** pivotally connected between a fixed pivot pin **47** and the pin **45**.

As can be seen in FIG. **6**, movable sample platform **13** may be provided with vertical pins **48** upon which the sample holder is mounted. The platform is guided on the undersurface of the top surface **12** by antifriction ballbearings **49**. Links **38** and **39** are separated by an antifriction surface **50** which may be of a plastic such as teflon or the like. A further bearing **51** is provided surrounding pin **40** and mounted on the underside of the movable sample platform **13**. A somewhat similar arrangement of antifriction bearings may be used for the remaining pivotal and slot connections of the linkage assembly. Another such pivotal connection may be seen in FIG. **7**. It can be seen that the link **33** is secured to the pin **35** by means of set screw **52**.

The movement of the various links which results in repositioning of the reflecting surfaces may be seen in FIGS. **8** and **9**.

In FIG. **10**, a beam of radiation is indicated at **53** and is reflected from reflecting surface **18** onto reflecting surface **19** and then to entrance face **54** of a sample **55** held between reflecting surfaces **56** and **57**. The beam is multireflected within the sample as indicated schematically.

Movement of the reflecting surfaces **18** and **19** and of the sample platform **13** to vary the angle of incidence will cause the beam of radiation to follow the path of the dash lines indicated at **58**. It will be seen that the angle of incidence of beam **58** with entrance face **54** of the sample will be varied from that of beam **53**.

It will be apparent that during the synchronous movement of the reflecting surfaces and the sample platform, the distances between reflecting surfaces **18** and **19** and **21** and **20** will remain constant. Accordingly, the image of the radiation beam will be constantly focused on the entrance face of the sample. Further requirements of the optical system comprising the reflecting surfaces and the sample are that the perpendicular to reflecting surface **18** must bisect the angle between the incoming beam and the reflecting beam going to reflecting surface **19**. The perpendicular to reflecting surface **20** must bisect the angle from exit face of the sample to reflecting surface **20** and to reflecting surface **21**. The perpendicular to reflecting surface **21** must bisect the angle formed by reflecting surfaces **21**, **20** and the entrance slit of the spectrometer. The spectrometer may be positioned behind a plate **59** mounted on base **11** as shown in FIG. **1**.

Thus it can be seen that the present invention provides an attachment for making multiple internal reflection measurements at a continuously varying angle of incidence. The reflecting surfaces are interconnected by a linkage arrangement which, together with the sample platform, is moved to maintain the proper relationship between the reflecting surfaces and the sample platform.

It is to be understood that various details of construction and arrangement of parts may be made without departing from the spirit of the invention except as defined in the appended claims.

I claim:

1. In a variable angle multiple internal reflection apparatus, the combination including a platform, a movable multiple internal reflection plate holding means, a first reflecting surface means adjustably mounted on said platform for receiving a beam of radiation, a second reflecting surface means adjustably mounted on said platform for receiving the beam reflected from said first reflecting surface and reflecting the beam to the entrance face of a multiple internal reflection plate means on said holding means, a third reflecting surface means adjustably mounted on said platform for receiving said beam from the exit face of said multiple internal reflection plate, a fourth reflecting surface means adjustably mounted on said platform for receiving the beam reflected from said third reflecting surface means and reflecting the beam outwardly of said apparatus, and linkage means connecting said multiple reflection plate holding means and said four reflecting surface means, said linkage means being arranged to hold the distance constant between said first and second reflecting means and the distance constant between said third and fourth reflecting means and to hold said beam in focus relative to the entrance and exit faces of said multiple internal plate means as the angle of incidence is changed by moving said movable internal reflection plate means and the angular relation of said reflecting means to said internal reflection plate means.

2. An apparatus as claimed in claim **1** wherein the second and third reflecting surface means are mounted on pivot means which are also arcuately movable.