

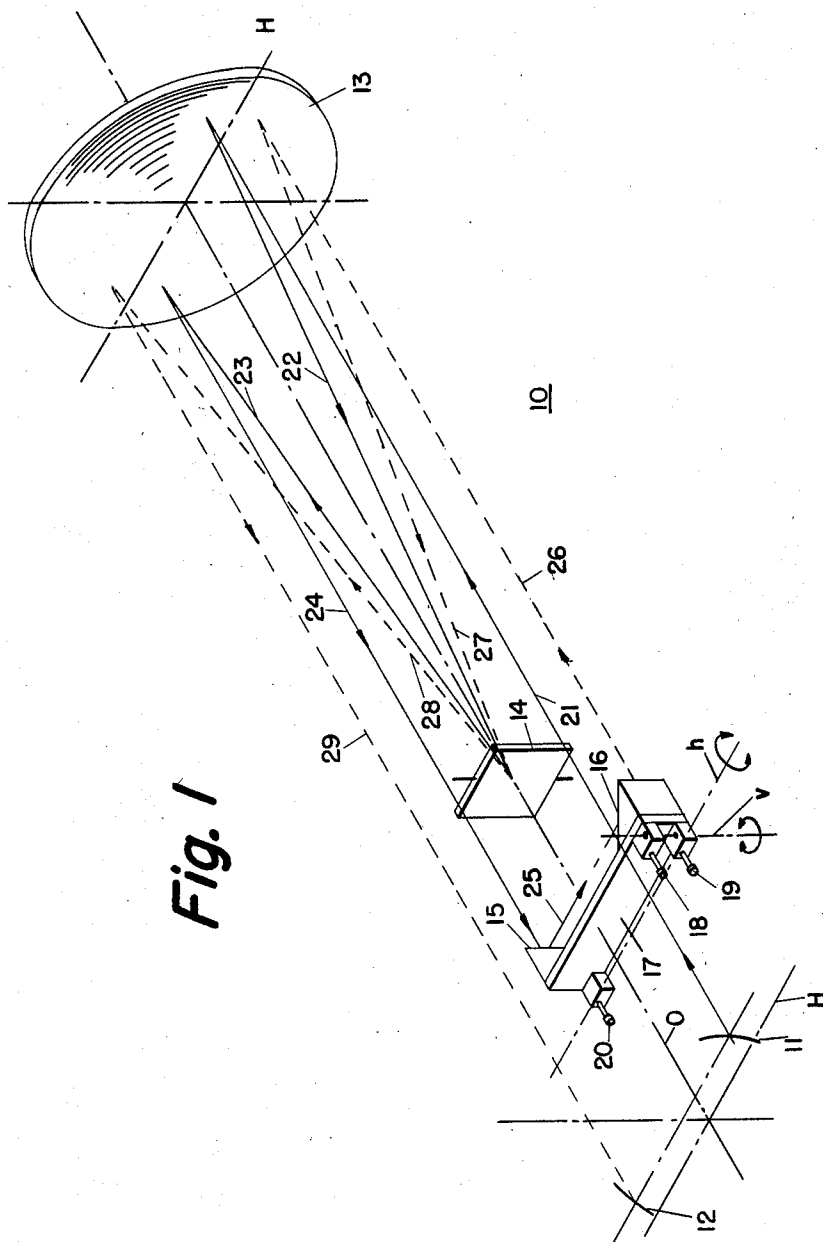
Jan. 13, 1959

E. L. WEISS
ADJUSTABLE MIRROR SUPPORT IN SUCCESSIVE
DISPERSION MONOCHROMATOR

2,868,063

Filed May 16, 1957

7 Sheets-Sheet 1



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7 Sheets-Sheet 2

Fig. 2

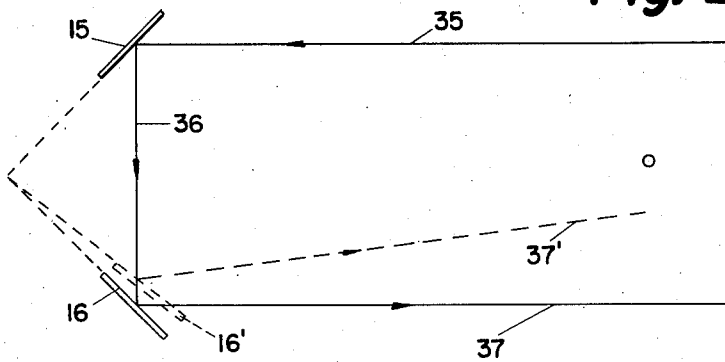


Fig. 3

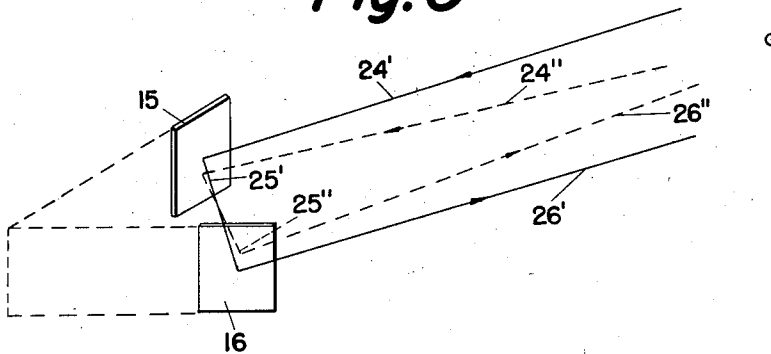
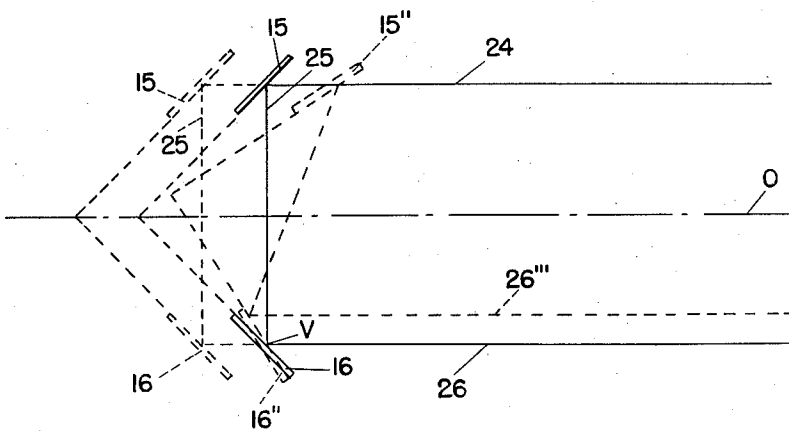


Fig. 4



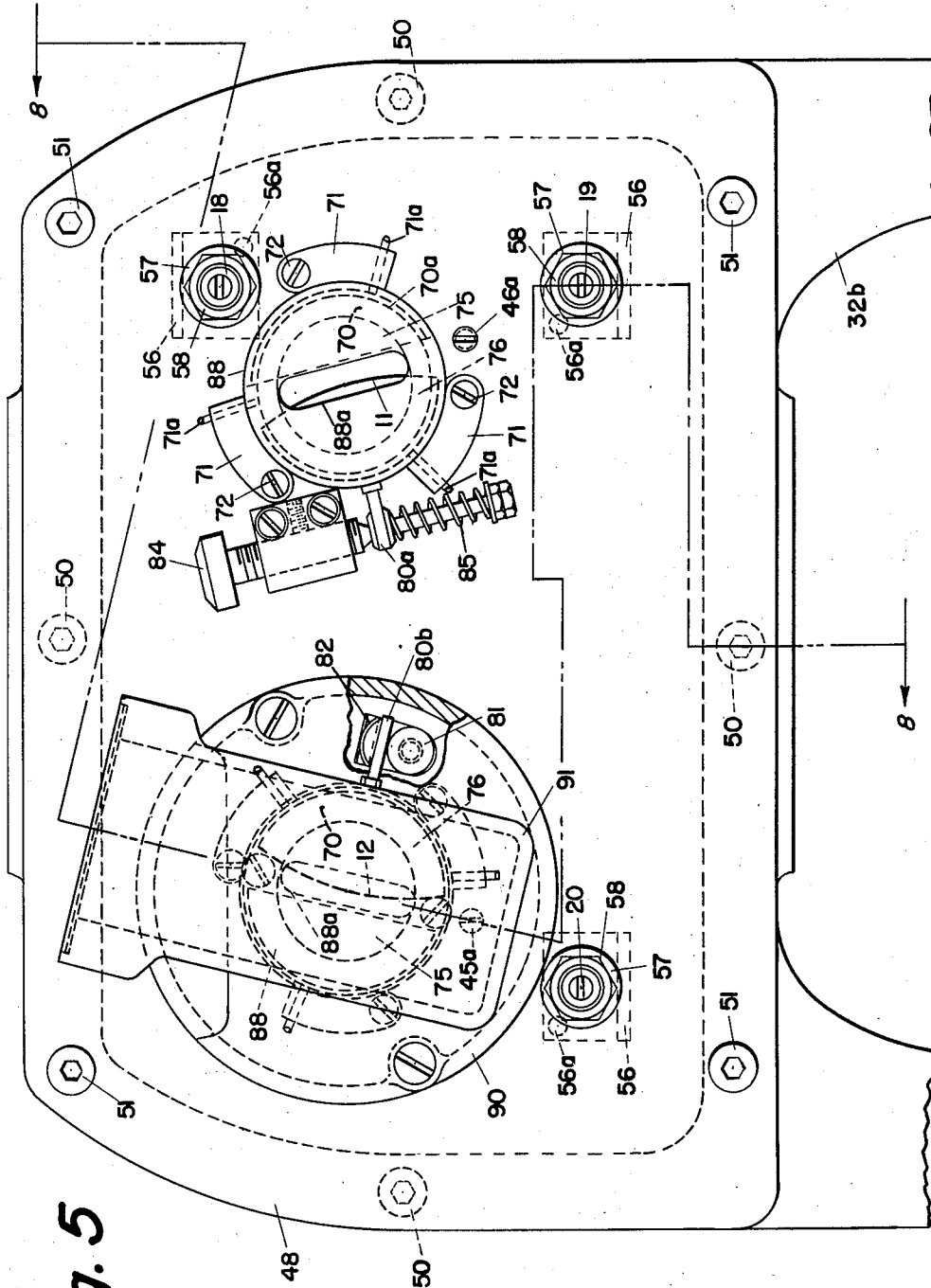
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7 Sheets-Sheet 3



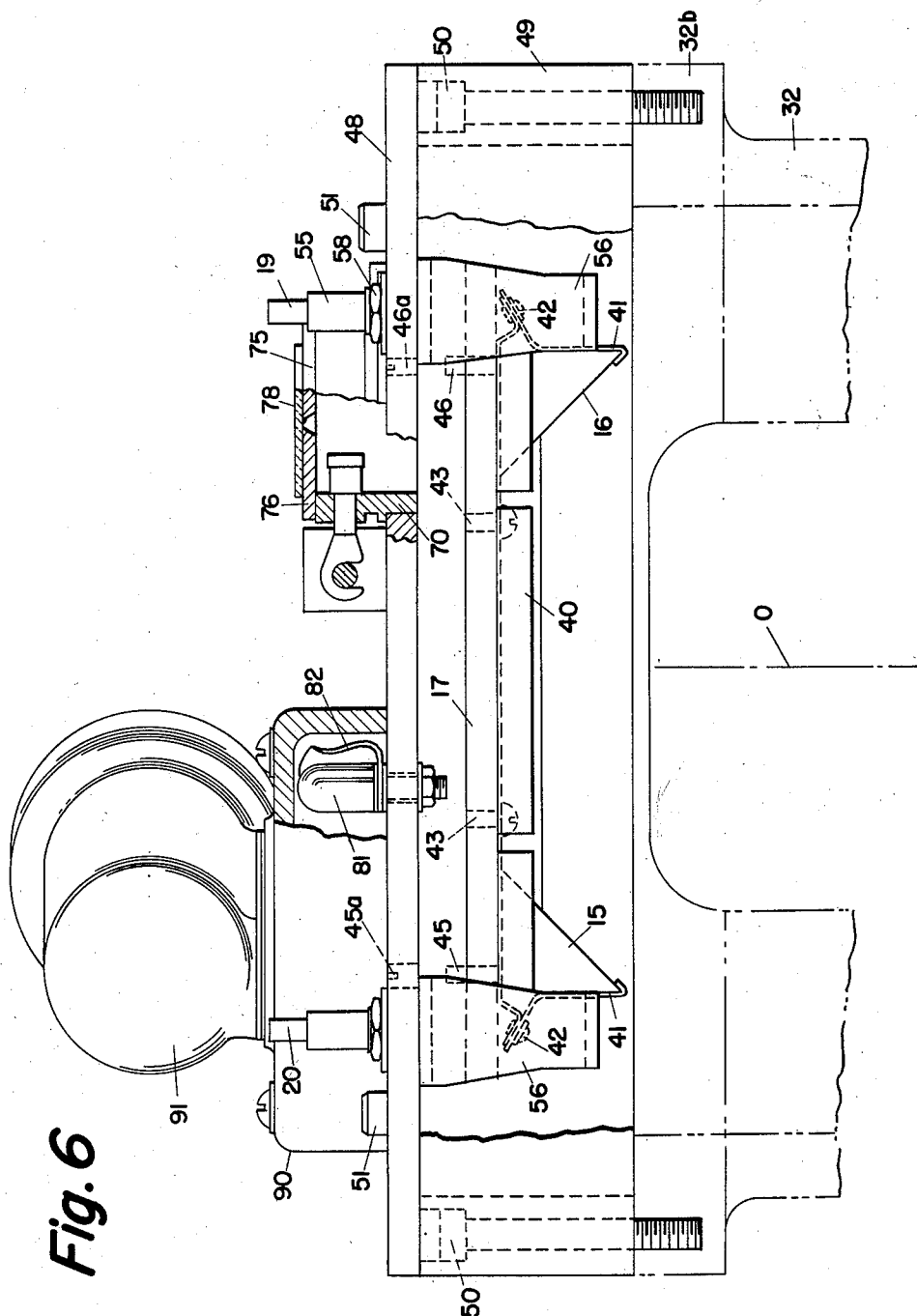
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2,868,063

Filed May 16, 1957

7 Sheets-Sheet 4



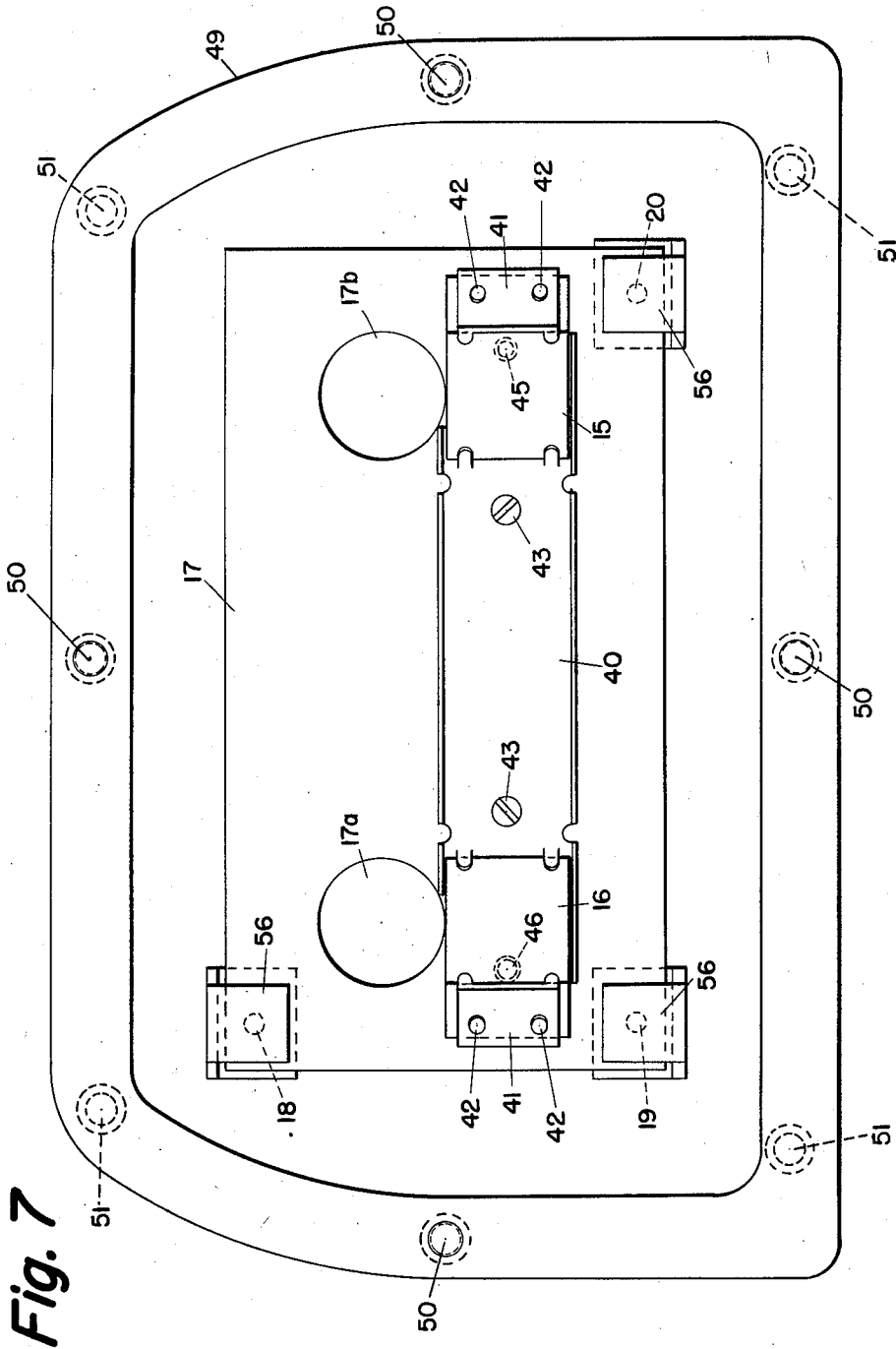
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E. L. WEISS
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2,868,063

Filed May 16, 1957

7 Sheets-Sheet 5



Jan. 13, 1959

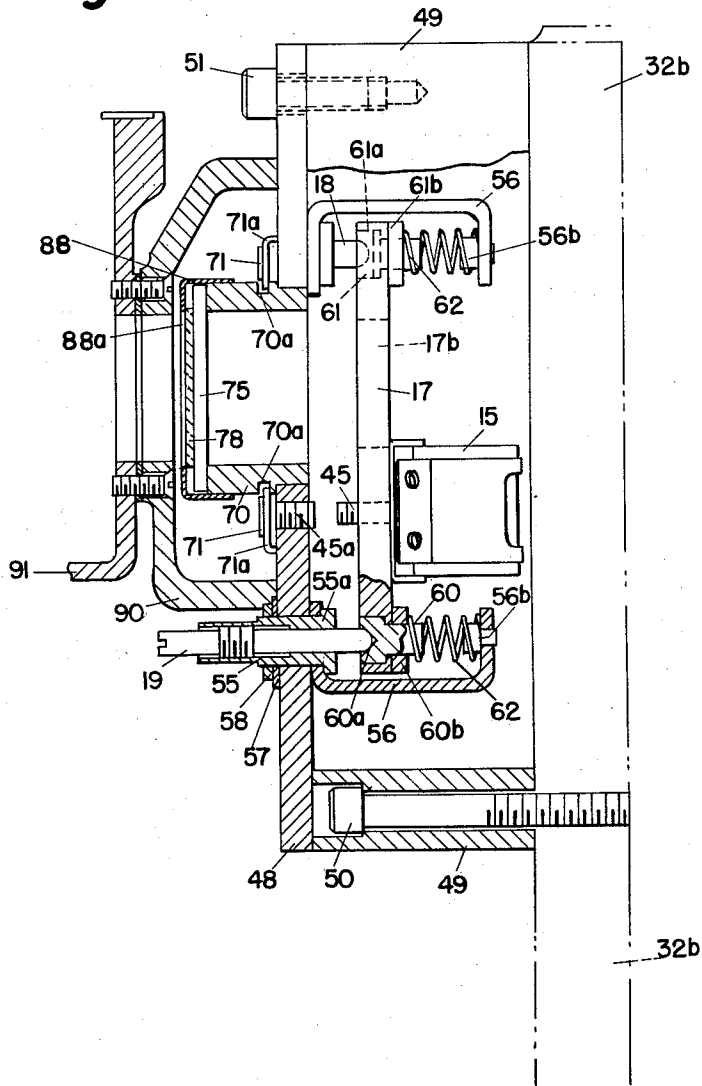
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2,868,063

Filed May 16, 1957

7 Sheets-Sheet 6

Fig. 8



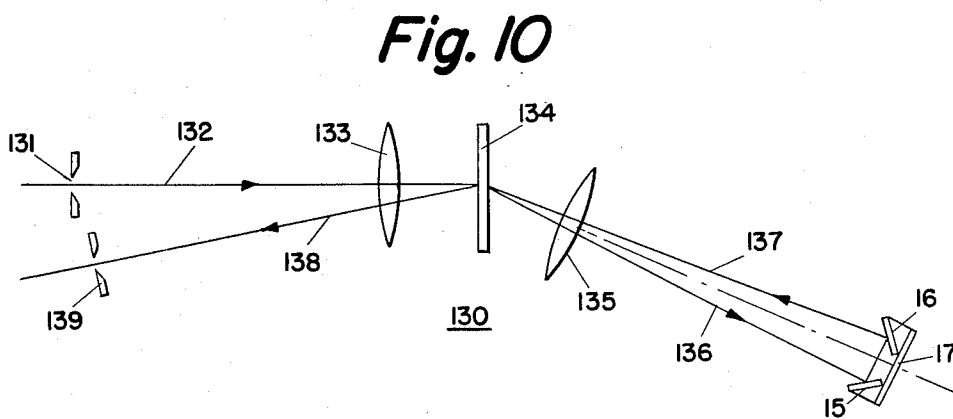
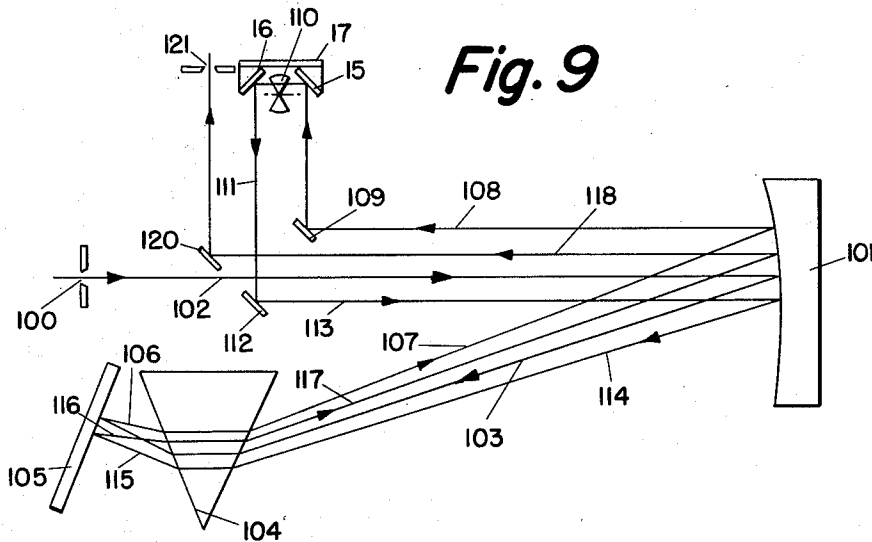
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2,868,063

Filed May 16, 1957

7 Sheets-Sheet 7



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2,868,063

ADJUSTABLE MIRROR SUPPORT IN SUCCESSIVE DISPERSION MONOCHROMATOR

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Application May 16, 1957, Serial No. 659,530

5 Claims. (Cl. 88—14)

This invention relates to a monochromator of the successive dispersion type and has for an object the provision of an improved and simplified focusing arrangement.

The present invention is applicable to the spectral systems of such instruments as the spectroscope, spectrometer, spectrograph, spectrophotometer, and the like, as will be understood after a detailed description of the features as applied to a monochromator. The optical system of a monochromator forms a series of images of its entrance slit in the plane of the exit slit—one for each wavelength. The exit slit is of such size and is so placed that only a small area of this array of images is observed at one time. From this it will be seen that an increase in dispersion of the various images will permit the observation of a narrower wavelength band for a given size of image and of exit slit. The increase in dispersion may be obtained by successive dispersions, i. e., by passing the light or radiant energy a second time through the same dispersing system in the monochromator or by passing the radiant energy through additional dispersing systems. The present invention is applicable to all of the foregoing systems.

In successive dispersion monochromator systems of the foregoing type, there are included radiant energy dispersing means, for example, such as one or more gratings or prisms and a pair of angularly related mirrors for directing the radiant energy through the system to provide successive dispersion. In carrying out the present invention in one form thereof, the mirrors are provided with means for supporting them in a predetermined angular relationship with respect to each other and along the optical path of the system. The support for the mirrors is adjustable forward and backward along the optical path of the system to provide a coarse focus adjustment. The mirror support is also adjustable about an axis parallel to the path of a ray passing between the centers of the angularly related mirrors to provide adjustment of the central ray relative to the center of the dispersing means and the support is further adjustable about an axis parallel to the intersection of the planes of the angularly related mirrors which axis must be located closer to one mirror than to the other to provide a fine focus adjustment.

In a preferred form of the invention the support for the angularly disposed mirrors comprises a plate supported by three adjustment screws disposed with relation to each other so that the two axes joining adjacent pairs of screws form a right angle. With this arrangement the support for the mirrors may be rotated about either axis by adjustment of only one of the screws as later to be described more in detail.

For a more detailed disclosure of the invention and for further objects and advantages thereof, reference is to be had to the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 diagrammatically illustrates in perspective a double-pass monochromator system embodying the present invention;

2

Figs. 2-4 are diagrammatic views useful in explaining the adjustment and focusing features of the present invention;

Fig. 5 is an end elevation of a slit and mirror mounting assembly for a double-pass monochromator of the type illustrated in Fig. 1;

Fig. 6 is a bottom plan view of Fig. 5;

Fig. 7 is a rear view of Fig. 5;

Fig. 8 is a view partially in section taken along the lines 8-8 in Fig. 5 and

Figs. 9 and 10 are other types of optical systems embodying the present invention.

Referring to Fig. 1, there is shown diagrammatically a monochromator system 10 of the type which is disposed symmetrically with respect to a central optical axis O, such as the type disclosed in Fastie Patent 2,757,568. While the entrance and exit slits 11 and 12 respectively made be of any desired shape such, for example, as straight or curved, they preferably are of the curved or arcuate type as described in the aforesaid patent and Patent 2,750,836 which is a continuation-in-part thereof. The specific construction and locations of the curved slits disclosed herein, however, are different from those disclosed in the aforesaid patents. As may be seen in Fig. 1, radiant energy will enter the entrance slit 11 from a source and it will pass to an area of the concave spherical mirror 13 as indicated by line 21. The entrance slit 11 is disposed to one side of axis O of the mirror 13 and is disposed slightly above the horizontal axis H. The radiant energy is redirected from mirror 13 in parallel rays as indicated by line 22 to a dispersing means 14 of any suitable type, a plane reflection grating being illustrated. The grating 14 in face-to-face relationship with the mirror 13, is located along the axis O and has an angular position for directing dispersed radiant energy to a second area of the mirror 13 as indicated by line 23. The mirror 13 redirects the dispersed radiant energy indicated by line 24 to the surface of the angularly disposed mirror 15. The reflecting surface of mirror 15 is disposed to redirect the dispersed radiant energy along a line 25 to a second mirror surface 16. The mirror 16 directs the dispersed radiant energy through the monochromator system for a second time as indicated by broken lines 26, 27, 28 and 29 and thus the radiant energy received at the exit slit 12 has been subjected to successive dispersions.

The optical system of the monochromator illustrated in Fig. 1 in so far as the concave mirror 13 and reflecting grating 14 are concerned has as one of its imaging properties that of symmetry about the optic axis O so that any object in the focal plane will be imaged on the opposite end of the diameter of the circle which has the optic axis for its center and which passes through the object, all being such as is described in the aforesaid patents which disclose single-pass instruments. Use is made of this property in the successive-pass or double-pass instrument shown in Fig. 1. The entrance slit 11 is disposed above the horizontal plane, defined by the horizontal axis H and the optic axis O. This entrance slit would be imaged below that plane at the opposite end of the diameter of a circle as mentioned above were it not for mirror 15. Following, for example, a central ray from the entrance slit it is to be noted that mirror 15 reflects this central ray horizontally to mirror 16 as indicated by line 25. The rays including the central ray form an image of the entrance slit between mirrors 15 and 16 which serves as a virtual object for the second pass through the optical system. This virtual object, which is below the horizontal plane H, is then imaged above the plane at the exit slit 12, thus providing vertical displacement of the second pass of radiant energy from the first pass.

3

The reflecting surfaces of mirrors 15 and 16 preferably are plane and for convenience in construction they have been illustrated in Fig. 1 as comprising right angle prisms having their diagonal face silvered to provide the reflecting surface. The mirrors 15 and 16 are mounted on a holder, as later to be described, which in turn is carried by a supporting plate 17. The plate is provided with adjustable supporting means at three corners thereof as diagrammatically illustrated by adjusting screws 18, 19 and 20.

Referring to Fig. 2, it will be seen that the reflecting surfaces of mirrors 15 and 16 are mounted so that the planes thereof intersect with an angle of approximately 90° therebetween. With the reflecting surfaces positioned at this angle a ray, such as ray 35 which is parallel to the optic axis O, will strike the mirror 15 at an angle of incidence of 45° and will be reflected therefrom at an angle of reflection of 45° as indicated by line 36. The ray indicated by line 36 will strike mirror 16 at an angle of incidence of 45° and be reflected therefrom at a similar angle of 45° thus making the reflected ray 37 parallel to the original ray 35. From the foregoing it will be seen that regardless of what angle the ray 35 strikes the mirror 15, it will be reflected from mirror 16 along a line 37 which is parallel to line 35. As a result of the grating plane being out of the focal plane of the monochromator, the central ray on the grating derived from the bundle of rays from the center of the entrance slit is toed in slightly toward the optic axis O. For this reason the angle between the double-pass mirror surfaces 15 and 16 must be slightly less than 90° if the central ray of the second pass radiation is to fall on the center of the grating as was the case by definition with the first pass radiation. This angle adjustment is illustrated in exaggerated form in Fig. 2 where the reflecting surface of mirror 16 has been moved to the broken line position of 16' thereby directing ray 37 into the path 37'. In actual practice both mirrors are adjusted a small amount by means later to be described.

It is also necessary to adjust the second pass radiation vertically. This is accomplished by adjusting the support for the mirrors 15 and 16, as by screw 18, Fig. 1, about an axis parallel to the path of the ray 25' (Fig. 3) passing between the centers of the angularly related mirrors. This adjusts the central ray 25' relative to the center of the dispersing means 14 as shown by ray 25'' in Fig. 3. While Fig. 3 illustrates the vertical angular motion obtained by rotating the mirrors 15 and 16 together about a horizontal axis which is perpendicular to the optic axis O, for simplicity of illustration the lines 24''—26'' representing the radiant energy rays have been rotated relative to the mirrors instead of the mirrors being rotated relative to the rays, but the effect is unchanged.

The focus adjustment on a monochromator is, in general, an adjustment of the optical path length between the entrance and exit slits. Ordinarily this is accomplished by moving one slit along a line parallel to the optical path. In accordance with the present invention the arrangement of the double-pass mirrors 15 and 16 on a movable plate or support permits a different type of focus adjustment in successive-pass instruments. In Fig. 4 there are illustrated two methods of adjustment of the optical path length. The first, which is used as a coarse focus adjustment, is a pure translation of the mirrors 15 and 16 together along the optic axis O. This is illustrated by the two positions of mirrors 15 and 16 in the full line and broken line positions. The second method, used as a fine focus adjustment, is a rotation of the mirror pair 15—16 about a vertical axis disposed to one side of the optic axis O. This is illustrated by movement of the mirrors 15 and 16 from their full line position to their broken line position, the latter being identified by reference characters 15'' and 16''. With the mirrors in the latter position the optical path length is

4

altered and the return ray 26'' is shifted slightly to one side, but its direction is unchanged. As may be seen in Fig. 1 the plate 17 is supported by the three screws 18, 19 and 20 which are disposed at three corners of a right triangle. Thus the lower left hand screw 20 may be alone to provide the final or fine focusing action after a coarse focusing adjustment has been obtained using all three of the screws 18—20. The recognition of the optimum focusing condition is the same for this type of instrument as for any other, i. e., optimum resolution.

The present invention in its preferred form has been illustrated in Figs. 5—8 as applied to a monochromator of the type disclosed in the aforesaid Fastie patents. The housing for the optical system comprises a tube 32 (Fig. 6) of rugged construction such as a relatively thick walled casting having end flanges of substantial thickness integral therewith. The outer faces of the end flanges are parallel to each other and perpendicular to the central axis O of the tube or housing 32, which axis is to be coincident with the central axis of mirror 13. The mirror 13, Fig. 1, is adapted to be mounted on one of the end flanges of housing 32 and the other or front end flange 32b, Figs. 5, 6 and 8 is adapted to support the double-pass mirror assembly 15—16 and the entrance and exit slit structures 11—12 as hereinafter to be described. The reflection grating 14 is disposed for rotation within the housing 32 intermediate the end flanges and as disclosed in the aforesaid Fastie patents the grating 14 may be provided with mechanism for step by step positioning or with a continuous drive mechanism. It is to be noted that the housing 32 and the front end flange 32b are identified by the same reference characters as in the aforesaid Fastie patents for convenience in explanation.

The mirrors 15 and 16 have been illustrated in Fig. 6 as prisms on which the front or diagonal face has been silvered to provide a substantially flat reflecting surface. The mirrors 15 and 16 are disposed in a channel member 40 and their reflecting surfaces are held at approximately a right angle with respect to each other by the end brackets 41 which in turn are secured to the channel member as by bolts 42, Figs. 6—8. The channel member 40 is secured to the plates 17 by two screws 43, 44 which are disposed in between the mirrors 15 and 16. With this arrangement the central portion of the mounting channel 40 is held tight against the plate 17. However, the ends of the channel 40 are adapted to be moved relative to each other as by the adjustable set screws 45 and 46 which are threaded into the plate 17 and extend therethrough into engagement with the corresponding ends of member 40. By turning the screws 45 and 46 the mirror surfaces on the prisms may be adjusted relative to each other. As mentioned above in connection with the explanatory diagram in Fig. 2, the mirror surfaces 15 and 16 are usually adjusted to an angle slightly less than 90° to be sure that the second pass radiation will fall in the same position on the grating 14 as the first pass radiation. The correct adjustment of the screws 45 and 46 is observed by viewing the grating aperture with the eye placed in the position the exit slit 12 will occupy. The desired condition is reached when the grating 14 is illuminated across its full width by the second pass radiation. Once this adjustment is made on the instrument it will generally not be necessary to change it.

The supporting plate 17 for the mirrors 15 and 16 is in turn supported from a front mounting plate 48 which is disposed at the outer end of a collar or spacer 49, the latter being secured to the flange 32b of housing 32 as by a plurality of cap screws 50. The holes through the collar 49 for receiving the screws 50 are countersunk as shown in Figs. 6 and 8 and thus the front mounting plate 48 is adapted to be held flush against the outer end of collar 49 as by a plurality of screws 51. The set screws 45 and 46 may be reached through the openings in plate 48 which may be covered with removable plug

members 45a and 46a, Figs. 5, 6 and 8. The supporting plate 17 for the mirrors 15 and 16 is mounted on the front mounting plate 48 by three adjustable mechanisms as now to be described. Each of the adjusting mechanisms includes an adjusting screw such as 18-20 and the mechanisms are disposed at three corners of the plate as shown in Figs. 5 and 7. The construction of each of the adjusting mechanisms is substantially identical. However, the adjusting screws of each have been provided with different reference characters (18-20) for clarity in describing the operation. As may be seen in Fig. 8, the adjusting screw 19 is threaded into a bushing 55 which extends through the plate 48 and is adapted to support a C-shaped mounting bracket 56. The bushing 55 is secured to the plate 48 by a lock washer 57 and a lock nut 58 which is threaded on to the exterior surface of the bushing 55. The mounting brackets 56 are held between the plate 48 and a flange 55a on the bushing 55 as may be seen in Fig. 8. To prevent the brackets 56 from rotating about the axis of the bushing 55 the brackets 56 are provided with a locating pin 56a, Fig. 5, which is adapted to be received in a corresponding locating hole in the plate 48. Thus once the lock nuts 58 are tightened the respective brackets 56 will be held in fixed position on the plate 48.

As may be seen in Fig. 8, the outer end of the adjustment screw, such as 19, is provided with a screwdriver slot for adjustment while the inner end is provided with a smooth hemispherical end which is adapted to engage a corner of the supporting plate 17. Each of the three corners of the plate 17 associated with the adjusting screws 18-20 is provided with a recess for receiving the corresponding hemispherical end of the adjusting screws 18-20. In the preferred construction these corners of plate 17 are provided with pressed inserts and as indicated in Fig. 8 the two lower corners of the plate 17 are provided with inserts 60 each having a channel or groove 60a which extends horizontally of the plate respectively cooperating with adjusting screws 19 and 20. The insert 61 adapted to cooperate with the adjusting screw 18 is provided with a groove or channel 61a which extends vertically of the plate 17. The inserts 60 and 61 extend through the plate 17 and are provided with seats 60b and 61b for engaging one end of the compression springs 62. The other end of the compression springs 62 is adapted to fit over the buttons 56b which are carried by the bracket members 56, Fig. 8. With this arrangement the hemispherical ends of the adjusting screws 18-20 are held tightly in the corresponding grooves 60a, 61a, of members 60 and 61 by the corresponding compression springs 62. As the grooves 60a in the lower inserts 60 are disposed horizontally they cooperate with the corresponding adjusting screws 19 and 20 and support the plate 17 for rotation about a fixed horizontal axis passing through these grooves by adjustment of screw 18. The vertical groove in member 61 which cooperates with the hemispherical end of adjusting screw 18 permits the plate 17 to be adjusted about a fixed vertical axis defined by the ends of screws 18 and 19 by adjustment of screw 20.

As earlier described in connection with Figs. 1 and 3, the vertical adjustment of mirrors 15 and 16 is made by screw 18 and thus rotation of the plate 17 about the horizontal axis *h* (Fig. 1) passing through the ends of screws 19 and 20 permits the second pass radiant energy to be adjusted vertically. The proper adjustment is obtained when the full height of the grating is observed to be illuminated. When this condition has been obtained, the coarse focus adjustments are made by moving the supporting plate 17 and the pair of mirrors 15 and 16 in and out along the optical axis *O* without any rotation. This adjustment is accomplished by turning each of the adjusting screws 18-20 an equal number of revolutions or fraction thereof. The effect of such adjustment is illustrated diagrammatically in Fig. 4 when mirrors 15

and 16 were moved from their broken line position to their full line position or vice versa.

To obtain a fine focus adjustment, the adjusting screw 20 alone is turned without affecting the previous adjustments. A very slight translation of the radiant energy relative to the optic axis does occur with the result that the wavelength calibration of the instrument will be shifted slightly. This adjustment is diagrammatically illustrated in Figs. 1 and 4 showing rotation of the supporting plate 17 for mirrors 15 and 16 about the vertical axis *v* (Fig. 1).

While the foregoing focusing arrangement is equally suitable for use in instruments employing either straight or curved entrance and exit slits, it is described and illustrated herein in connection with slits of the curved type. The slit assemblies for the entrance and exit slits 11 and 12 are of similar construction and each comprises a tubular barrel member 70, Figs. 6 and 8, preferably made of brass and adapted to have one end thereof inserted in the spaced entrance and exit openings in the plate 48. These openings are in alignment with the corresponding openings 17a and 17b in plate 17. The barrel members 70 are adapted to be held in place by means of a plurality of spring clip members 71 which have one of their ends secured to the plate 49 as by screws 72 (Fig. 5). The opposite ends of the spring members 71 are provided with pins 71a which are adapted to have one of their ends received in a groove 70a which extends around the outer surface of barrel 70, Figs. 5 and 8. With this construction the barrel 70 may be rotated about the central axis thereof to adjust the tilt of the slits as later to be described. The outer end of the barrel 70 is provided with a straight edge slit blade 75 and a curved edge slit blade 76. Both of these slit blades are adapted to be secured to the member 70. However, the curved edge slit blade 76 may be adjusted transversely of the member 70 to change the slit width as later to be described. In constructing slits for a monochromator the two sides or edges thereof should have mating or matched shapes. In order to achieve this in the present construction the straight edge slit blade 75 has cemented to its outer surface a circular quartz disc 78. The inner surface of the quartz member 78 is coated with an opaque material such as aluminum or silver in the area between the curved edge of blade 76 and the straight edge of blade 75. To provide a curved slit for the passage of radiant energy therefrom the curved slit blade 76 is then moved away from the straight edge slit blade 75 a distance corresponding to the desired slit width. This distance will normally be in the order of five to twenty microns. The entrance slit is indicated by the reference character 11 in Fig. 5 and the exit slit is indicated by the reference character 12. By using the curved slit blade 76 as a mask for the quartz during the opaquing operation and then moving it over and using it as one side of the slit, it is assured that both sides of the slit will have the same curvature or shape.

Each of the slit barrels 70 is provided with an adjusting arm. The adjusting arm for the entrance slit 11 is identified as 80a while the corresponding arm for the exit slit 12 is identified as 80b. As thus far described the slit assemblies for both the exit and entrance slits are the same. As may be seen in Fig. 5 the adjusting arm 80b for the exit slit 12 is secured to the barrel member 70 and extends between a stop stud 81 and a co-operating slit retainer spring 82.

The adjusting arm 80a for the entrance slit 11 is secured at one end to the barrel member 70 and extends outwardly from the barrel between an adjusting screw 84 and a compression spring 85. By turning the adjustment screw 84 the entrance slit 11 may be rotated about the axis of its barrel member 70 and thus there is provided a "tilt" adjustment of the entrance slit so that images of the entrance slit 11 may be aligned with the exit slit 12. This tilt adjustment is a rotation in the

focal plane. The optimum condition to be obtained is one of highest resolution. Although the condition of either focus or tilt may affect the accuracy of adjustment of the other, the two adjustments are substantially independent of each other. Thus once the correct adjustment of either has been obtained, the other may be adjusted without affecting said correct adjustment.

Both the entrance and exit slits are provided with cup-shaped covers 88, Figs 5 and 8, having elongated openings 88a which are adapted to be disposed in alignment with slits 11 and 12 to permit the passage of radiant energy therethrough. The exit slit assembly is additionally provided with a base member 90 which is adapted to support a housing 91 with a photomultiplier tube therein opposite the exit slit 12. The photomultiplier tube, not shown, may be provided with conventional connections to a suitable measuring circuit, for example of the type disclosed in the aforesaid Fastie patents.

The present invention is not limited in its application to so-called symmetrical optical systems such as illustrated in Fig. 1 but is also applicable to other successive pass systems. For example, in Fig. 9 there is illustrated diagrammatically an optical system of the Littrow type which employs the pair of mirrors 15, 16 for passing radiant energy through the system a second time to provide successive dispersions. The radiant energy from a suitable source passes through an entrance slit 100 and strikes the concave mirror 101 as indicated by the central ray line 102. This ray is reflected from mirror 101 along line 103 where it passes through prism 104 causing it to be dispersed before it strikes the Littrow mirror 105. The ray is reflected along the line 106 and again passes through prism 104 and emerges along line 107 to again strike the concave mirror 101. This ray is reflected along line 108 until it strikes a plane mirror 109 from which it is reflected to mirror 15 and thence through a light chopper 110 to the mirror 16. The mirror 16 reflects the ray along line 111 to another plane mirror 112 which directs the ray along line 113 to mirror 101 so that the ray will be passed a second time through the dispersing system. This path of the ray is illustrated by lines 114, 115, 116 and 117. When the ray indicated by line 117 again strikes mirror 101, it is reflected along line 118 until it strikes the plane mirror 120 and forms an image of the entrance slit 100 on the exit slit 121 as was the case in the optical system described in connection with Fig. 1. The light chopper 110 is of conventional type such as a rotating shutter and is employed so that the phototube at the exit slit 121 will respond only to the radiant energy last dispersed. The reason for this is that the radiant energy making up the image at the exit slit 121 in a system of this type will include energy which passed through the system only once and also radiant energy which has passed through the system more than once. By making the photocell responsive only to chopped radiant energy of the last pass, it is assured that it will respond only to the radiant energy which has passed last through the system and thus has been subjected to double or successive dispersions. A suitable light chopper in a similar system is illustrated in Walsh Patent No. 2,652,742.

It is also possible to separate the successive dispersed radiation from the single dispersed radiation by vertical or spacial separation of the two radiant energy passes such as, for example, by the arrangement disclosed in Fig. 1. For the purpose of this invention the manner in which the successive passes of radiation are separated is not critical. The present invention, however, is concerned with the simplified focusing arrangement of double pass or successive pass radiation systems. It will be noted in Fig. 9 that the double pass mirrors 15 and 16 are disposed in the same relationship with respect to each other as in the system described in connection with Fig. 1. The mirrors are adapted to be supported in the

same manner as in the system described in connection with Fig. 1 and they are adapted for the various adjustments described in connection with the explanatory Figures 2-4.

The present invention is also applicable to lens type optical systems, such, for example, as the system 130 illustrated in Fig. 10. In that system there is disclosed a monochromator using transmission optics as distinguished from reflection optics. The radiant energy from the source passes through an entrance slit 131 as indicated by central ray line 132 and passes through a lens 133 before it strikes a transmission grating 134 where it is dispersed. It then passes through a second lens 135 along a line 136 until it strikes the double-pass mirrors 15 and 16. After the ray leaves mirror 16 as indicated by line 137, it again passes through lens 135 and back through the transmission grating 134 for a second dispersion. The twice dispersed radiant energy then passes back through lens 133 as indicated by line 138 and forms an image of the entrance slit on the exit slit 139. It is to be understood that the system in Fig. 10 is intended as an example of a double-pass lens system and that the transmission grating 134 could be replaced by a suitable prism. It will be seen that the double-pass mirrors 15 and 16 again occupy the same relationship with respect to each other in system 130 as they did in the systems previously described in connection with Figs. 1 and 9. The mirrors 15 and 16 in Fig. 10 likewise are adapted to be adjusted in the same manner as illustrated and described in Figs. 2-4.

From the foregoing, it will be seen that the present invention is not limited to optical systems of the symmetrical type but is equally applicable to other types of optical systems in which there is desired the increase in dispersion by the creation of successive dispersions through the employment of a pair of angularly disposed mirrors, such as mirrors 15 and 16. By providing these mirrors with a common support, such as illustrated by plate 17, which in turn is provided with the above described three point adjustable suspension, the support and the mirrors are adjustable forward and backward along the optical path of the system to provide coarse focusing adjustment. By reason of the fact that the mirror support 17 is also adjustable about an axis parallel to the path of a ray passing between the centers of the angularly related mirrors, it is readily possible to provide adjustment of the central ray relative to the center of the dispersing element. An independent fine focusing adjustment is provided by reason of the fact that the support 17 for the mirrors 15 and 16 is also adjustable about an axis parallel to the intersection of the planes of the angularly related mirrors 15 and 16.

It shall be understood the invention is not limited to the particular exemplary embodiments specifically described and illustrated therein and that changes and modifications may be made within the scope of the appended claims.

What is claimed is:

1. In a monochromator system including radiant energy dispersing means and a pair of angularly related plane mirrors for causing radiant energy to make another pass through said dispersing means thereby to obtain greater dispersion of the radiant energy, the improvement of adjustment means for said mirrors comprising a common support for both of said mirrors, means for adjusting said support and said mirrors forward and backward along the optical path of said system to provide a coarse focus adjustment of the dispersed radiant energy, means for adjusting said support about an axis parallel to the path of a ray passing between the centers of said angularly related mirrors to provide adjustment of the rays relative to the center of said dispersing means, and means for adjusting said support for said mirrors about an axis parallel to the intersection of the planes of said mirrors said axis being located closer to one mirror than

to the other to provide a fine focus adjustment of said dispersed radiant energy.

2. In a monochromator system according to claim 1 wherein said means for adjusting said support comprise three screw members located at the three corners of a right triangle with the legs adjacent the right angle providing separate axes of rotation for said support thereby permitting independent rotation of said support about either leg as an axis by adjustment of the screw member opposite said leg.

3. In a monochromator system including radiant energy dispersing means, an attachment for converting the system from a single pass dispersion system to a successive pass dispersion system, said attachment comprising an adjustable support, a pair of plane mirrors carried by said support and disposed with their reflecting faces adapted to reflect radiant energy therebetween, means for adjusting said support and said mirrors forward and backward along the optical path of said system to provide a coarse focus adjustment of the dispersed radiant energy, means for adjusting said support about an axis parallel to the path of a ray reflected from the center of one of said mirrors to the center of the other to provide adjustment of the rays relative to the center of the dispersing means, and means for adjusting said support for said mirrors about an axis parallel to the intersection of the planes of said mirrors and closer to one of said mirrors than to the other to provide a fine focus adjustment of said dispersed radiant energy.

4. For a monochromator system an improved adjustable mirror support comprising a plate, means for supporting a pair of plane mirrors in angular relation with respect to each other, adjustable supporting means disposed respectively at three corners of said plate, said three adjustable supporting means defining the three corners of a right triangle, all of said supporting means being adjustable concurrently to move said plate and said

mirrors forward and backward along the optical axis of said system without changing the angular relationship of the mirrors with respect to the optical axis, and the adjustable supporting means disposed at the acute corners of the right triangle being individually adjustable to produce independently rotation of said plate about the axis formed by the other two of said adjustable supporting means.

5. For a monochromator system an improved adjustable mirror support comprising a plate, means for supporting a pair of plane mirrors in angular relation with respect to each other, means on said plate for adjusting the angular relationship between said mirrors, adjustable supporting means disposed respectively at three corners of said plate, said three adjustable supporting means defining the three corners of a right triangle, all of said supporting means being adjustable concurrently to move said plate and said mirrors forward and backward along the optical axis of said system without changing the angular relationship of the mirrors with respect to the optical axis, and the adjustable supporting means disposed at the acute corners of the right triangle being individually adjustable to produce independently rotation of said plate about the axis formed by the other two of said adjustable supporting means.

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