Feb. 29, 1944. S. J. JACOBSOHN 2,342,737

SPECTROSCOPIC APPARATUS

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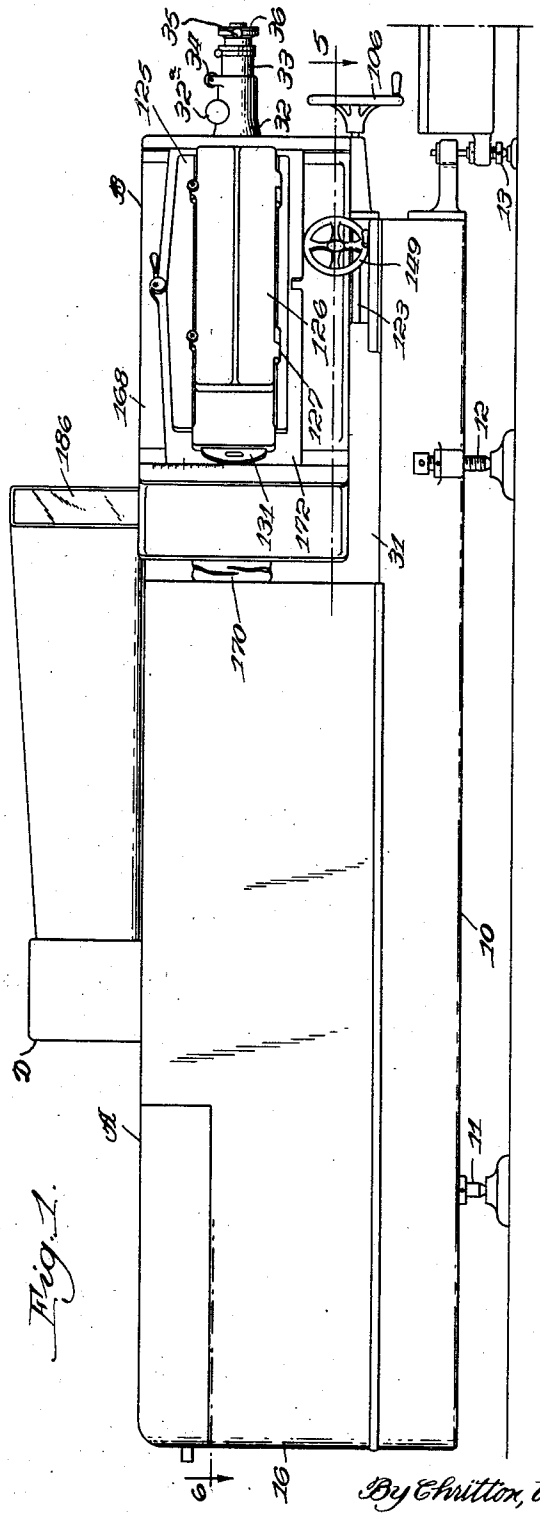


Fig. 1.

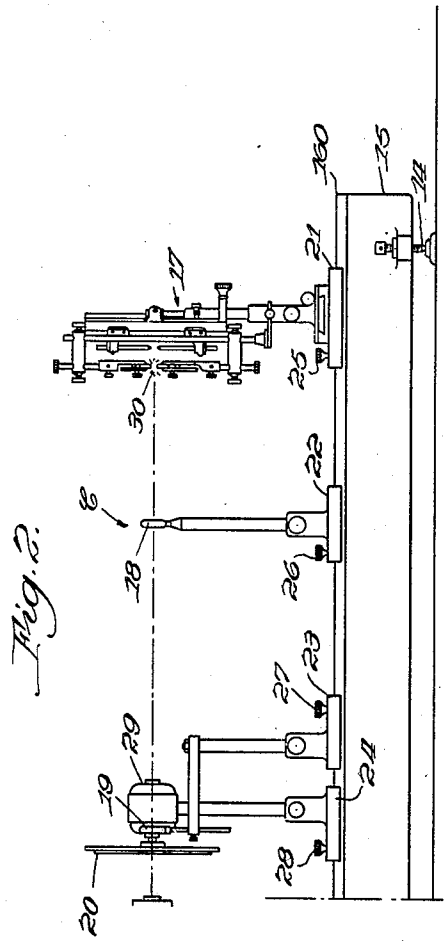


Fig. 2.

Inventor:
Samuel J. Jacobsohn.
By Chrittor, Wiles, Davies and Hirschl. Attys.

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SPECTROSCOPIC APPARATUS

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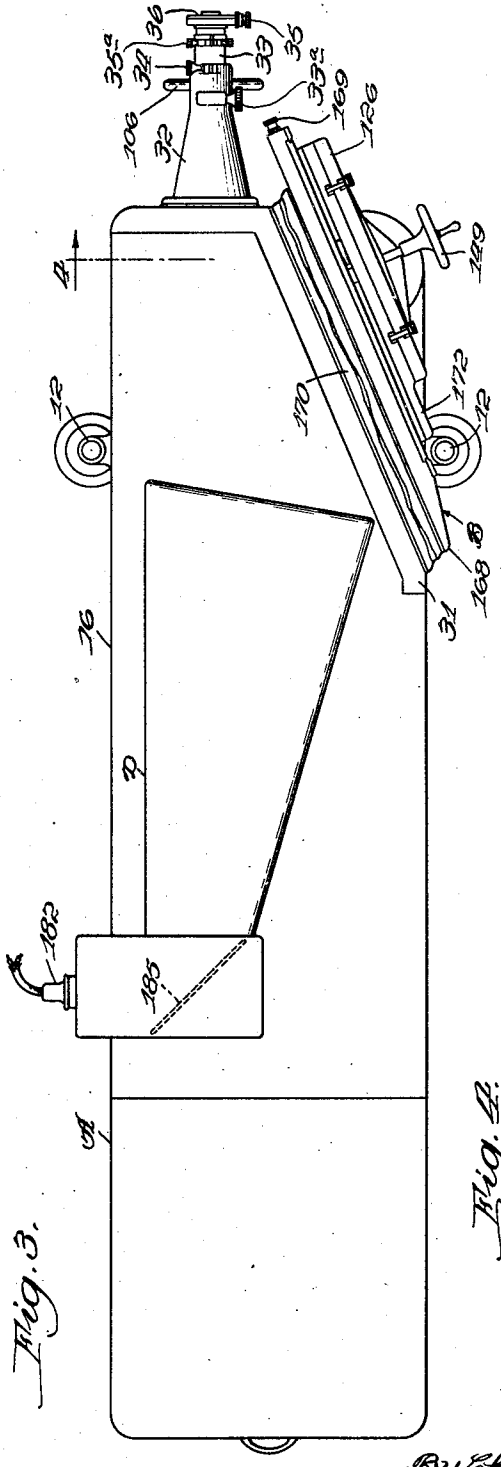


Fig. 3.

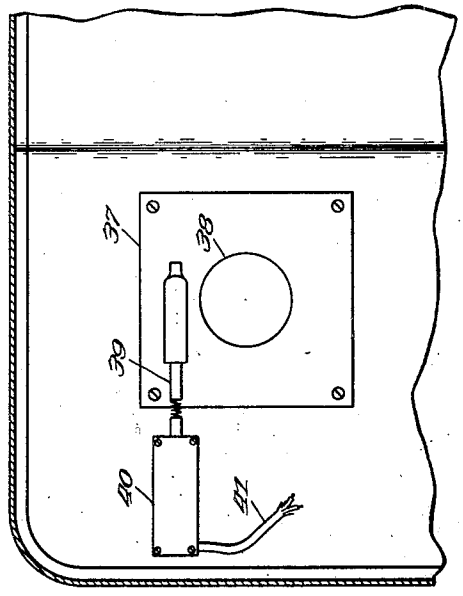


Fig. 4.

Inventor:
Samuel J. Jacobsohn.
By Chritton, Wills, Davis and Hirschl.
Attys.

Feb. 29, 1944. S. J. JACOBSOHN 2,342,737

SPECTROSCOPIC APPARATUS

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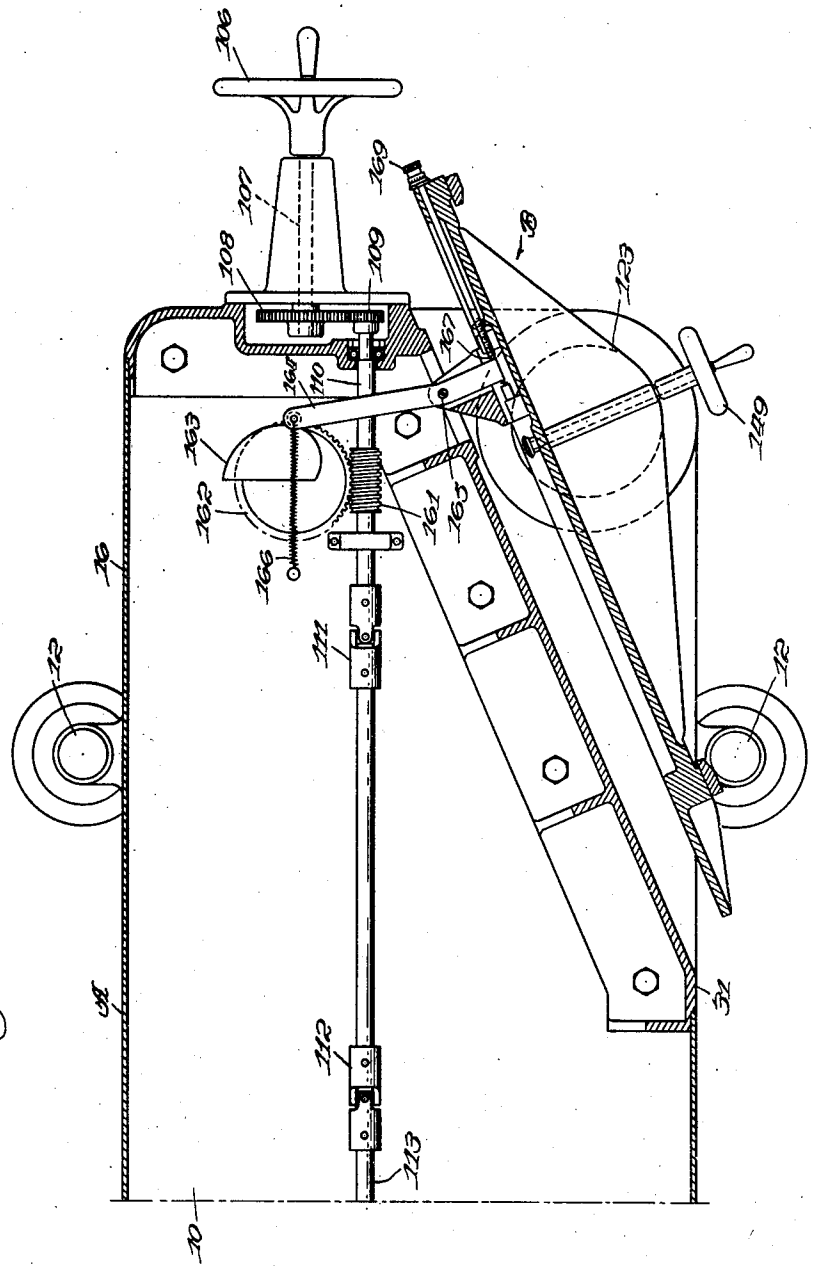


Fig. 5.

Inventor:
Samuel J. Jacobsohn.
By Chritton, Wiles, Davis and Hirschl.
Atty's.

Feb. 29, 1944. S. J. JACOBSOHN 2,342,737

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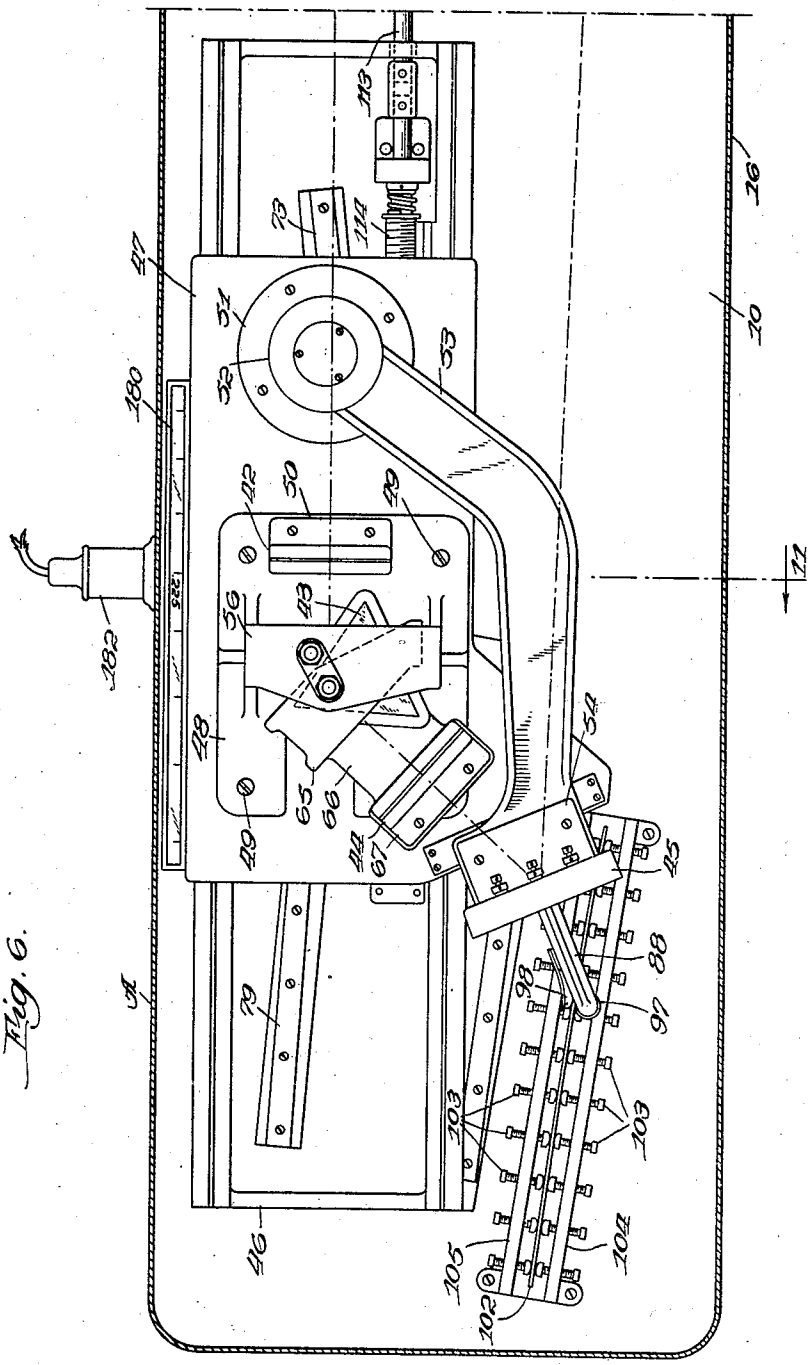


Fig. 6.

Inventor:
Samuel J. Jacobsohn
By Chritton, Wiles, Davies and Hirschl.
Attys.

Feb. 29, 1944. S. J. JACOBSOHN 2,342,737

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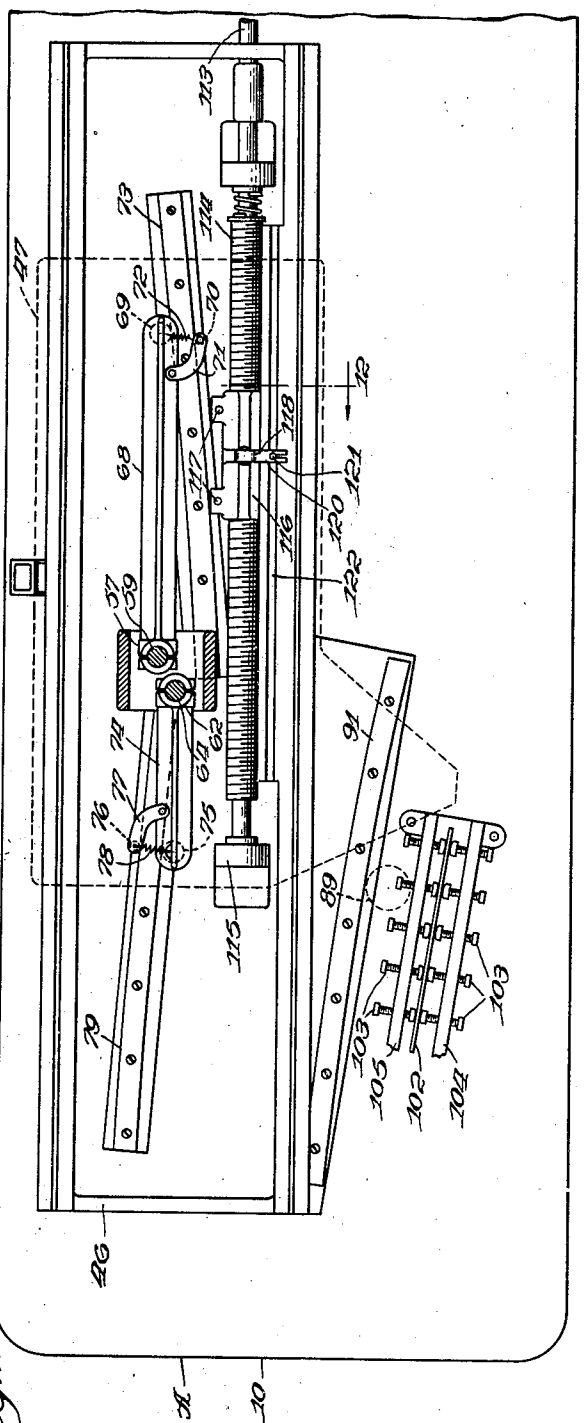


Fig. 7.

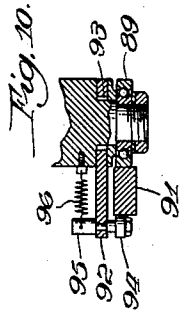


Fig. 10.

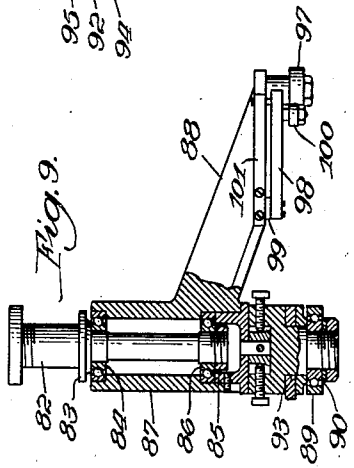


Fig. 9.

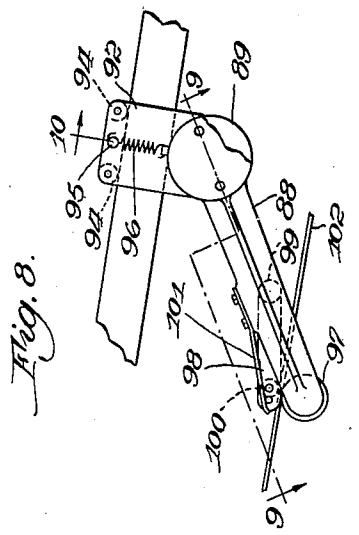


Fig. 8.

Inventor:
Samuel J. Jacobsohn
By Christy, Wiles, Davis and Hirschl.
Attys.

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Fig. 11.

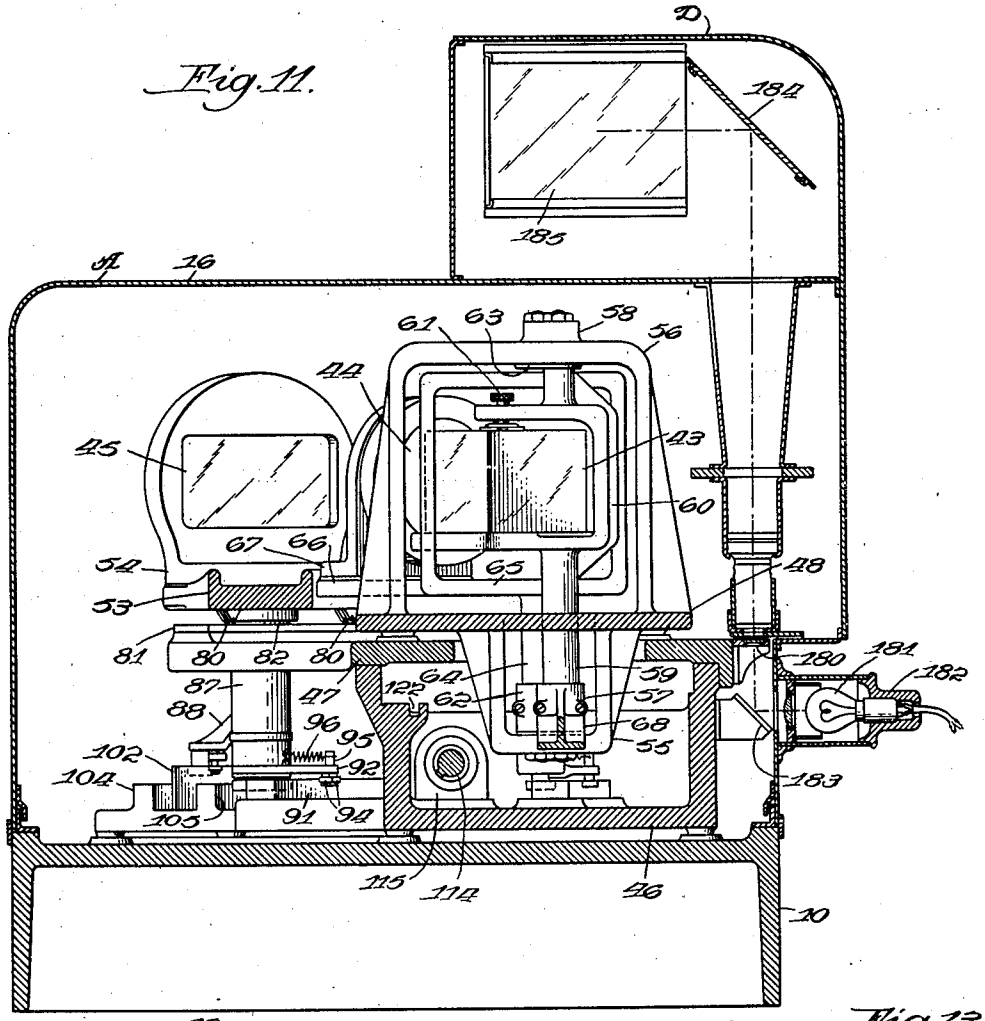


Fig. 12.

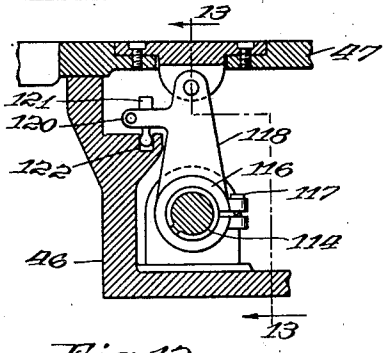
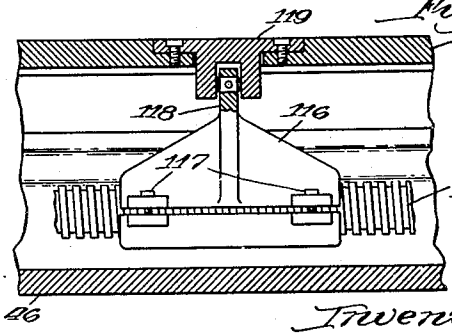


Fig. 13.



Inventor:
Samuel J. Jacobsohn.
By Christton, Wiles, Davis and Hirschl.
Attys.

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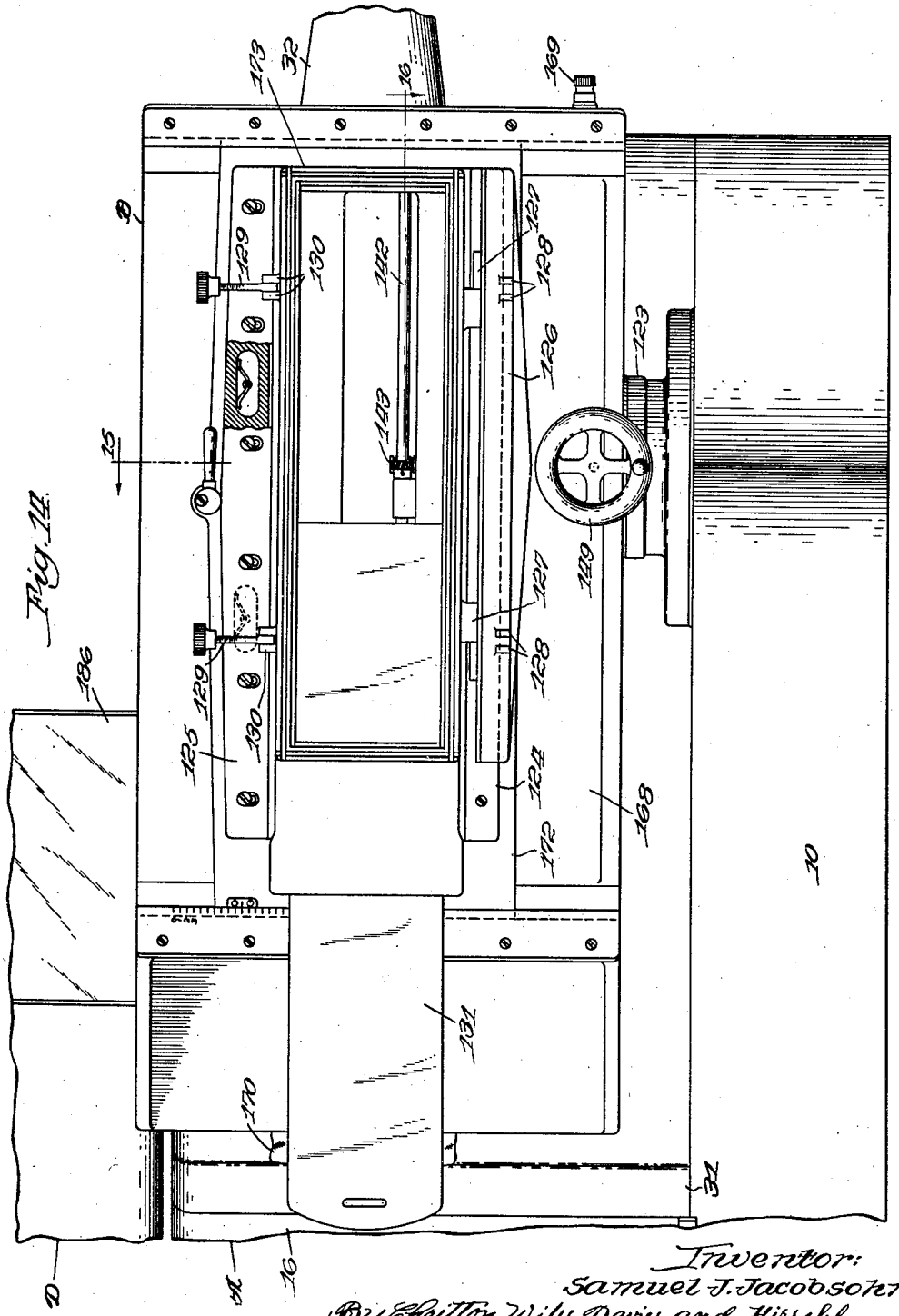


Fig. 11.

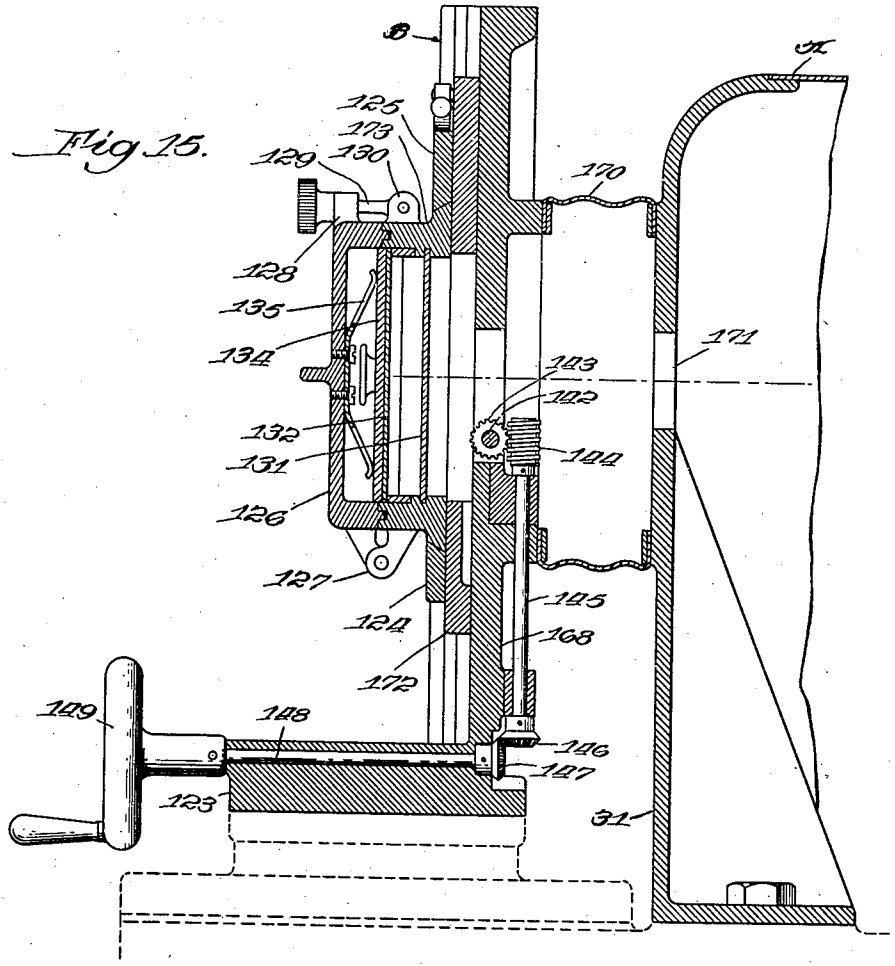
Inventor:
Samuel J. Jacobsohn.
By Chritton, Wills, Davies and Hirschl.
Attys.

Feb. 29, 1944. S. J. JACOBSOHN 2,342,737

SPECTROSCOPIC APPARATUS

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Fig. 15.



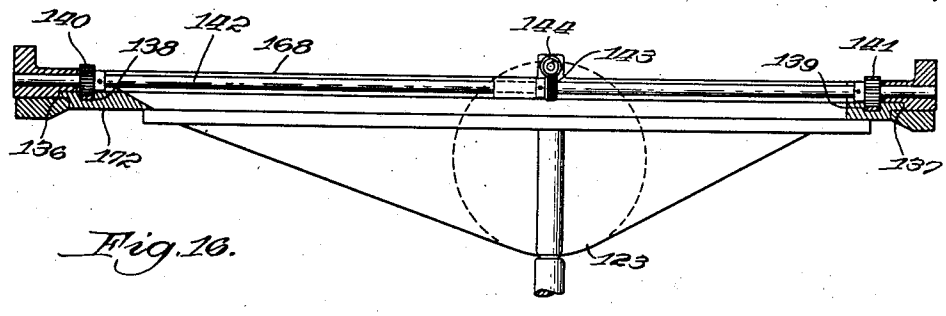


Fig. 16.

Inventor:
Samuel J. Jacobsohn.
By Chritton, Wills, Davis and Hirschl.
Attys.

Feb. 29, 1944. S. J. JACOBSOHN 2,342,737

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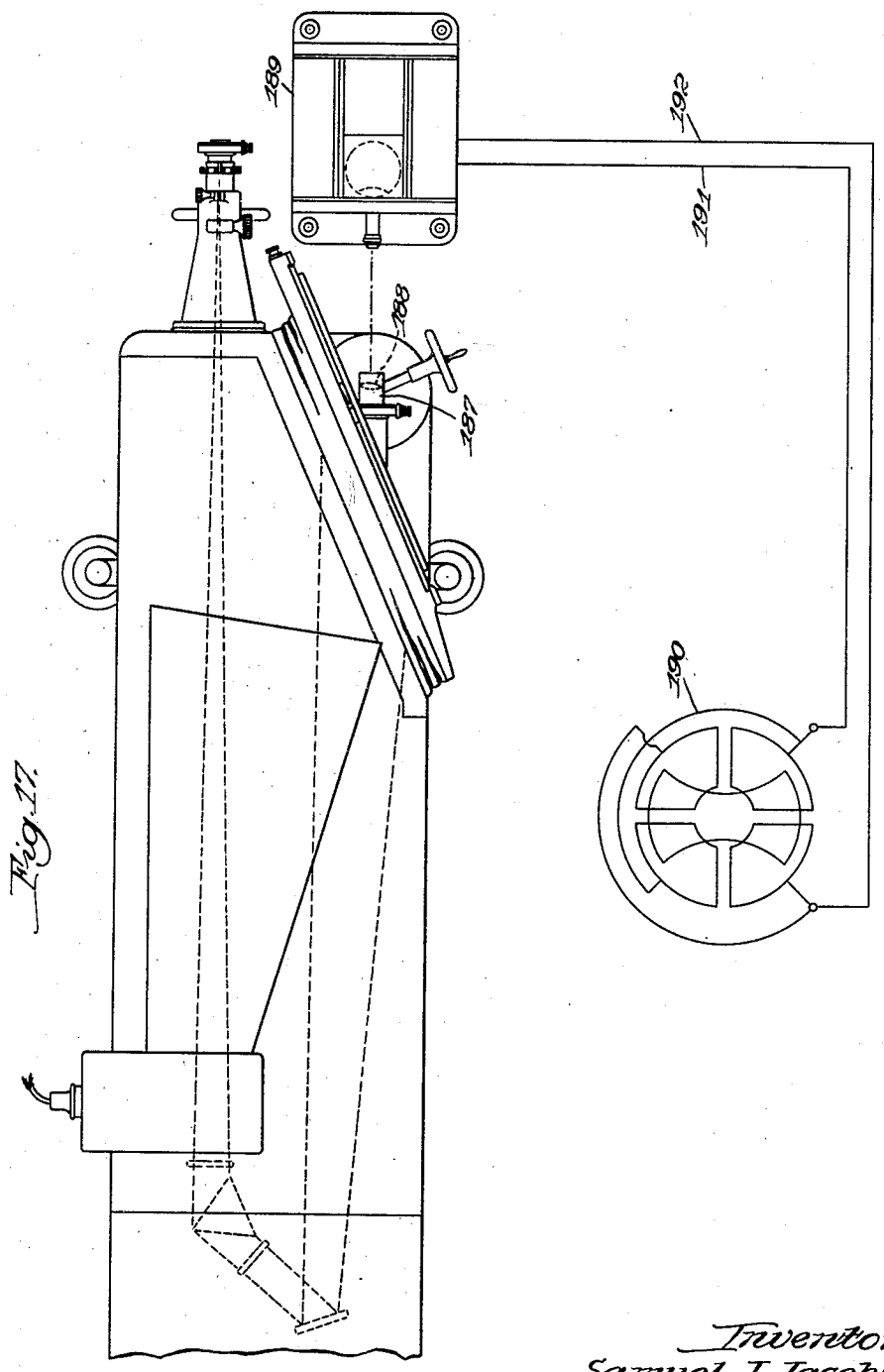


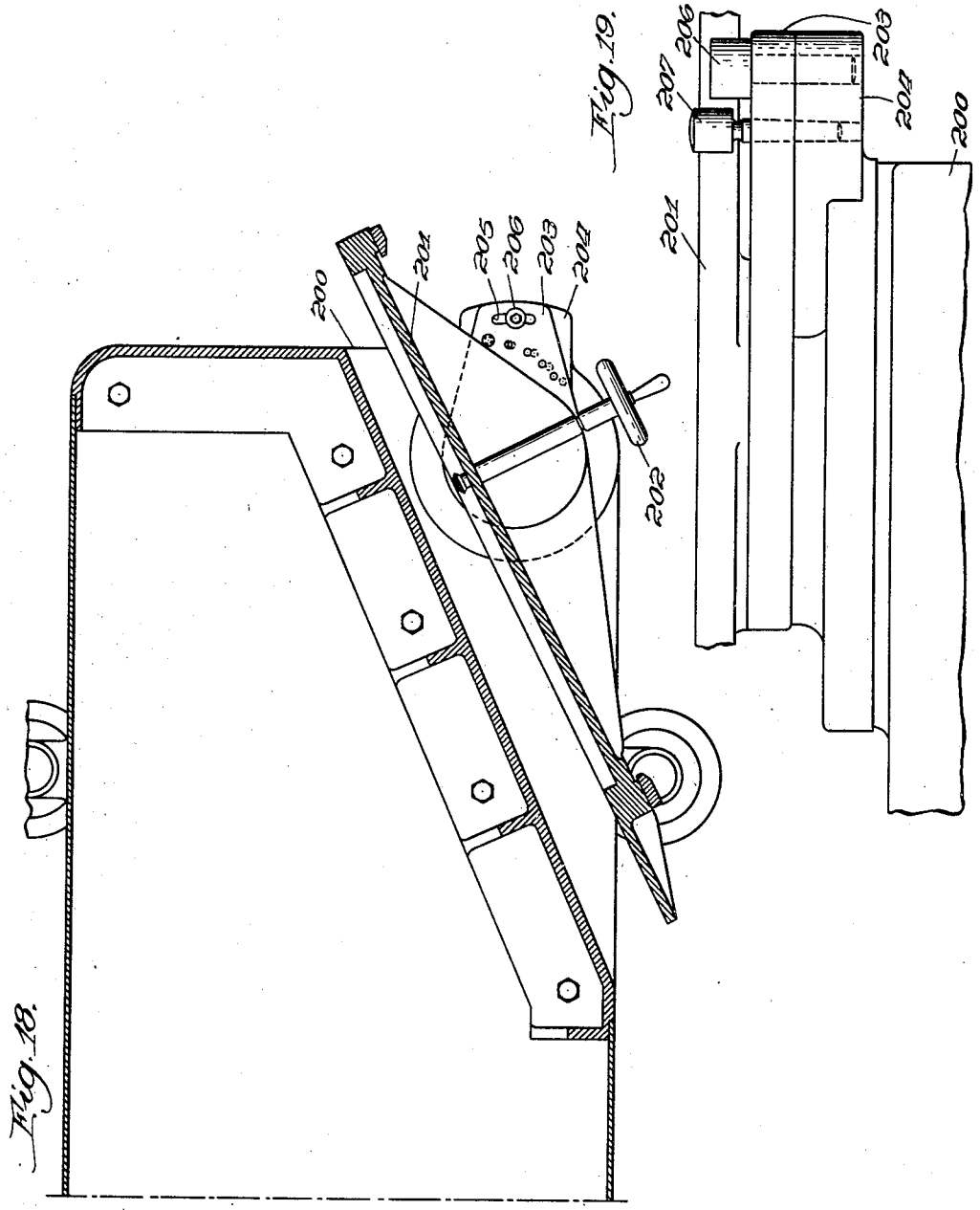
Fig. 17.

Inventor:
Samuel J. Jacobsohn.
By Chritton, Wills, Davis and Hirschl.
Att'ys.

Feb. 29, 1944. S. J. JACOBSOHN 2,342,737

SPECTROSCOPIC APPARATUS

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Inventor:
Samuel J. Jacobsohn.
By Christon, Wills, Davies & Hirschl.
Atty's.

Feb. 29, 1944. S. J. JACOBSOHN 2,342,737

SPECTROSCOPIC APPARATUS

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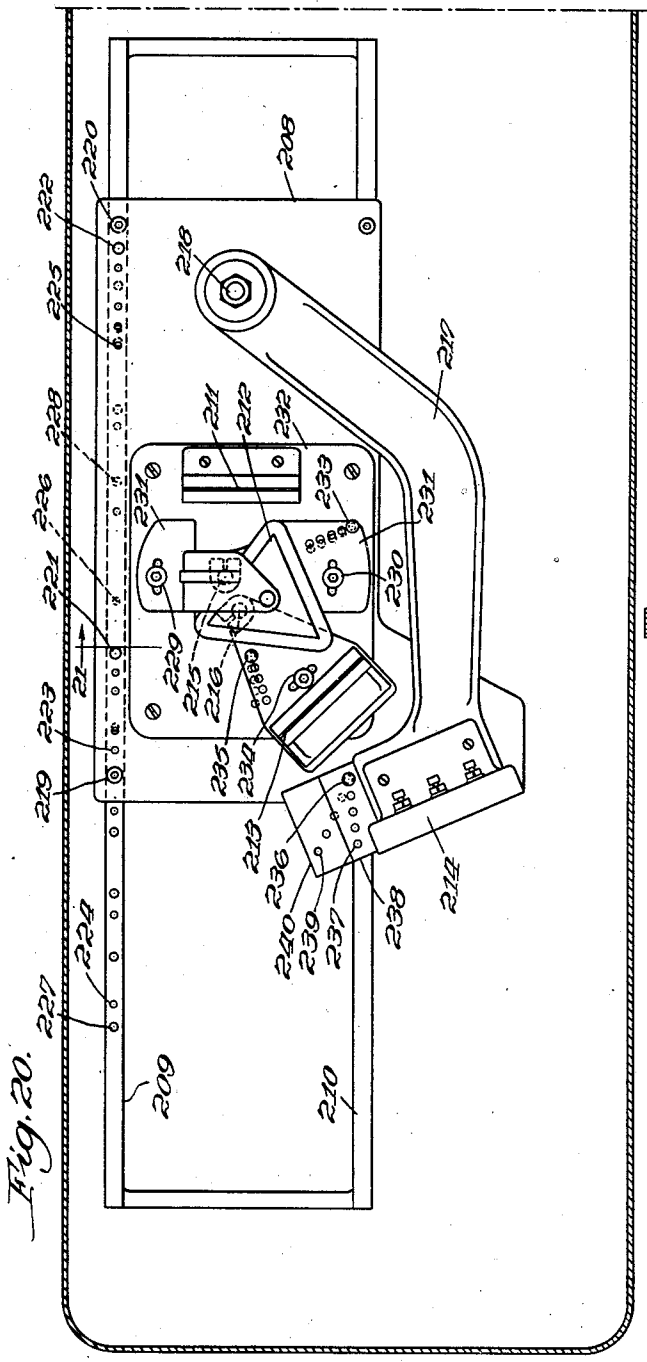


Fig. 20.

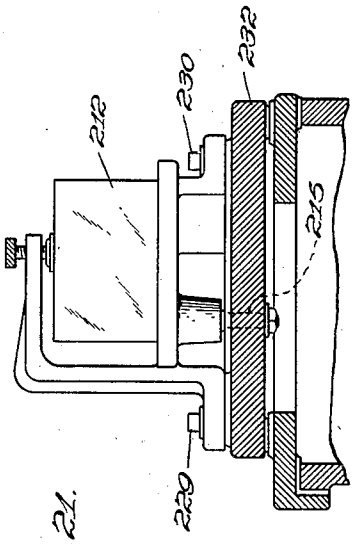


Fig. 21.

Inventor:
Samuel J. Jacobsohn.
By Christton, Wills, Davies and Hirschl.
Atty's.

Patented Feb. 29, 1944

2,342,737

UNITED STATES PATENT OFFICE

2,342,737

SPECTROSCOPIC APPARATUS

Samuel J. Jacobsohn, Chicago, Ill., assignor to The Gaertner Scientific Corporation, a corporation of Illinois

Application March 14, 1941, Serial No. 383,405

6 Claims. (Cl. 88—14)

This invention relates to spectroscopic apparatus, and more particularly to a spectrograph and a monochromator. That is, this invention relates to light dispersing apparatus adapted to be used in combination with photographic means for recording the lines and bands of the spectrum, or in conjunction with means for selecting and isolating a particular line or band of the spectrum, sometimes used with further means for measuring the intensity of the line or band.

One feature of this invention is to provide a spectroscope of such accuracy that it is possible to perform accurate quantitative analysis therewith. Another feature is to provide a highly accurate spectroscope of relatively small dimensions. Still another feature is to provide a spectrograph which may be handled by a single operator, wherein the dispersed light is received on a photographic plate positioned adjacent to the light source. Yet another feature is the provision of a mirror in the optical train of a spectroscope. A further feature is the adjustment of a spectroscope to expose a predetermined light path to various parts of the spectrum while at the same time maintaining the accuracy of the focus thereof. Another feature is to provide compensation for the variations of the focus of rays of different wave lengths by the quartz optical parts used in the spectroscope. Still a further feature is the development of independent means for guiding the movement of each of the adjustable optical parts of the spectroscope. Yet another feature is the provision of adjustable means for providing minute variations in the movement of a part. A further feature is the modification of a highly accurate spectroscope for use as a monochromator. The word spectroscope is used throughout this specification and the appended claims in a generic sense including spectrographs and monochromators.

Other features and advantages will appear from the following specification and drawings, in which:

Figure 1 is a side elevational view of the spectrograph; Figure 2 is a similar view of the work holder and light source for the spectrograph, this figure being a continuation of Figure 1; Figure 3 is a plan view of the spectrograph; Figure 4 is a vertical sectional view, taken along the line 4 of Figure 3; Figure 5 is a sectional view, taken along the line 5 of Figure 1; Figure 6 is a sectional view of the portion of the apparatus not shown in Figure 5, the view being taken along the line 6 of Figure 1; Figure 7 is a plan view, partly broken away, of the apparatus with the upper portion thereof removed; Figure 8 is a fragmentary detail plan view of the guiding means for the mirror arm; Figure 9 is a view taken along the line 9—9 of Figure 8; Figure 10 is a fragmentary sectional view, taken along the line 10 of Figure 8; Figure 11 is a vertical sectional view, taken along the line 11 of Figure 6; Figure 12 is a fragmentary detail sectional view, taken along the line 12 of Figure 7; Figure 13 is a vertical sectional view, partly broken away, taken along the line 13—13 of Figure 12; Figure 14 is a side elevational view of the plate holder mechanism; Figure 15 is a vertical sectional view, taken along the line 15 of Figure 14; Figure 16 is a transverse sectional view, taken along the line 16 of Figure 14; Figure 17 is a schematic illustration of a modification of the apparatus; Figure 18 is a fragmentary vertical view of the plate holder end of another modification of my spectroscope; Figure 19 is a side elevational view particularly showing the adjusting and locking means for the plate holder; Figure 20 is a fragmentary horizontal plan view of the principal working parts of the modified form of my spectroscope, the casing being in section; and Figure 21 is a sectional view along the line 21 of Figure 20, with the lens mounting omitted.

The apparatus may be used with conventional equipment for providing light to be analyzed, as by activating a material to cause the emission of light therefrom, or passing light through translucent material to be modified thereby. The light is received within the apparatus, analyzed or dispersed, and may be delivered to a photographic plate. If the exposure of the plate is made for a predetermined time, the density of the lines on the photographic plate may be used to measure quantitatively the proportion of the various lines of the spectrum present in the emitted light. From this measurement it is possible to determine quantitatively the amount of a particular element present in the original material.

Where quantitative analysis may be accomplished by consideration of individual lines, the apparatus may be adjusted so that the particular line or band of the spectrum characteristic of that element will be cast on an aperture or slit which is substituted for the photographic plate. The intensity of the light passing through the aperture may then be measured by means of a photoelectric cell and an electrometer. From this measurement the quantity of the element or compound in question may be determined.

The apparatus, of course, may be used for the usual purposes of a spectroscope, spectrograph,

or monochromator, in addition to its use for quantitative analysis.

In the specific embodiment of the invention illustrated in Figures 1 to 16 a light-analyzing assembly A is associated with a plate holder assembly B, equipment C for holding the work and providing a light source being positioned adjacent such assemblies. An indicator screen mechanism D shows the portion of the spectrum which is being received on a photographic plate, or the line passing through the exit slit, where the device is being used as a monochromator.

The apparatus is carried on a frame 10 which is equipped with a support 11 and with adjustable supports 12. Similar adjustable supports 13 and 14 are mounted on the frame 15 of the mechanism C. A casing 16, supported on the frame 10, is sealed to prevent light from entering it and provides a support for the indicator mechanism D.

Referring particularly to Figure 2, the mechanism C includes a work holder 17 of conventional construction containing a carbon arc or other suitable means for heating or electrically exciting the material to be analyzed. The work holder is, of course, adjustable as to position; and conventional current controlling means may be used for providing a desired intensity of light, and for keeping the intensity standardized. From the work holder 17 the light emitted from the material passes through a pair of lenses 18 and 19 and an apertured rotatable disk 20.

The frame 15 of the mechanism C is equipped with a way or rail 160 which slidably receives the bases 21, 22, 23 an 24 of the work holder, lenses, and disk support respectively. Locking thumb screws 25, 26, 27 and 28 serve to secure the bases in position on the rail 160. The base 24 supports a motor 29 which drives the apertured disk 20. The lenses 18 and 19, as is usual in such constructions, are adjustable as to position with respect to the work holder 17.

The light emitted from the heated material passes through the lenses 18 and 19 and the apertured disk 20 to the analyzing assembly A. As seen particularly in Figure 3, the casing 16 joins a casting 31 which supports a housing 32. Within the housing 32 a tube 33 is mounted for longitudinal sliding motion adapted to be effected by rack and pinion means operated by the pinion head 33a, and to be clamped in any desired position by rotation of the stud 34. Any suitable or conventional means may be used in conjunction with the tube 33 to provide an aperture or slit adjustable in size both as to width and length. If desired, a pair of spaced jaws may be used for this purpose, the space between the jaws being regulated by the micrometer adjustment 35, and the angular location of the slot by adjusting means 35a. The end of the tube 33, over the jaws, is preferably equipped with a quartz dust cover 36.

The casting 31 supports a plate 37 having therein an opening 38, now referring to Figure 4. A shutter (not shown) of conventional construction in photographic equipment may be placed between the plate 37 and the casting 31. The shutter is controlled by a plunger 39 in an electromagnet 40 which is operated by any suitable current supply entering the electromagnet through the wire 41. Conventional remote control means (not shown) may be provided for the electromagnet. As seen from the dotted line in Figure 6, the light beam passing through the aperture in the tube 33 traverses a path through a collimator lens 42, a prism 43, a camera lens 44 and upon a mirror 45, being reflected by the mirror backwardly along a path nearly parallel to the path through which the beam enters the apparatus.

A base 46 is mounted on the frame 10 and in turn serves as a mounting for a carriage 47 which slidably engages the base. A plate 48 is secured to the carriage 47 by bolts 49. On the plate 48 is mounted a support member 50 for the collimator lens 42, the support 50 being of the usual construction for such purposes. At one end the carriage 47 serves as a mounting for a plate 51 which provides a bearing 52 for the pivotal mounting of the arm 53. The other end of the arm 53 is equipped with a support 54 for the mirror 45.

Referring now to Figure 11, the plate 48 is equipped in the central portion thereof with a stirrup 55 and an upward extension 56. The stirrup and extension serve as mountings for the bearings 57 and 58 in which the shaft 59 is carried. The shaft 59 in turn supports a member 60 which carries the prism 43, the prism being held in place in the member by thumb screw 61. The stirrup 55 and extension 56 also support the bearings 62 and 63 for the shaft 64 which carries a mounting 65. A lateral extension 66 of this mounting carries a support 67 for the camera lens 44, the whole assembly being adapted for pivotal movement about the axis of the shaft 64.

As seen particularly in Figure 7, the shaft 59 and the bearing 57 are attached to an arm 68 which extends laterally therefrom. At the other end of the arm 68 is provided a depending roller 69 and a smaller roller 70 secured to the arm 68 by the pivoted link 71. The two rollers may be disposed on opposite sides of a cam 73 on the base 46, the rollers being urged into yielding engagement with the cam by the spring 72.

Similarly the shaft 64 and the bearing 62 are attached to an arm 74 which carries at its end a depending roller 75. A smaller roller 76 is secured to the arm 74 by the pivoted link 77, the rollers being held in engagement with a cam 79 on the base 46 by the spring 78. Referring again to Figure 11, the mirror supporting arm 53 is equipped with rollers 80 which ride on the plate 81 on the carriage 47 (Figure 6). A depending shaft 82 is attached to the arm 53, and, as seen in Figure 9, is equipped with an annular flange 83 and mounted in a bearing 84. The lower end of the shaft 82 is threadedly engaged by a collar 85 cooperating with the bearing 86 to hold the shaft in place.

A sleeve 87 extends around the bearings 84 and 86 and is equipped with a laterally extending arm 88. To the lower portion of the shaft 82 is attached, by any suitable means, the roller 89 on the ring bearing 90, the roller 89 being eccentrically disposed with respect to the axis of the shaft 82. This roller 89 is adapted to engage the cam 91 and thus guide the movement of the mirror supporting arm. A plate 92 extends across the cam 91 and is provided with a pair of rollers 94 at one end and an opening 93 at the other end. The opening 93 is larger than the lower extension of the shaft 82 which it surrounds (Figure 16), and thus may be moved horizontally away from the shaft 82. A spring 96 attached to the pin 95, operating against the base provided by the rollers 94, continuously urges the roller 89 into engagement with the cam 91, the opening 93 providing sufficient play of the associated part of the shaft 82.

As may be best seen in Figure 8, the laterally extending arm 88 is provided with a roller 97 and with a lever 98 pivotally mounted on the arm at the point 99. The lever 98 in turn carries a roller 100 which is urged into engagement with the flexible strip 102 by the spring clip 101.

The flexible strip 102 (Figure 6) is supported between the bolts 103 in the bars 104 and 105 so that any portion of it may be adjusted as to lateral position by movement of these bolts. Because of the eccentric mounting of the roller 89, movement of the strip 102 causes the position of the arm 53, and thus of the mirror, to be changed. Moreover, the arm 88 provides motion reduction so that a given adjustment of the cam surface shape provided by the flexible strip results in a reduced change in the mirror position. This provision of an adjustable cam is particularly important in that it enables adjustment at any time to compensate for variations in the apparatus.

One of the critical adjustments of the spectroscope is the position of the mirror which must be so related to the other optical elements as to reflect a definite wavelength to a definite position on the photographic plate. The required position is affected by variations in the manufacture of the optical parts. The position of the mirror as actually attained in the instrument is, however, dependent on the length of the arm, the location of the cam surface, of the pivotings, etc., which likewise are subject to variations in manufacture.

It is to enable adjustable compensation for these factors that the flexible cam or strip 102 is provided. In setting up the machine this flexible strip would first be made straight, the theoretically ideal shape, and the machine run through its various positions. Any discrepancies in the position of the mirror at various points throughout its range of movement are then compensated for by movement of the bolts to change the shape of the flexible strip or supplemental cam. This supplemental cam is effective through the motion reduction means and eccentric to cause minute variations in the relation between the mirror and its operative cam, so that relatively coarse, easily made adjustments of the position of the strip 102 will result in very fine and accurate compensation for any minute variations from the proper position of the mirror.

Referring to Figure 5, the movement of the carriage 47 is controlled by the turning of the wheel 106. Motion of the wheel 106 is imparted to the shaft 107 and in turn to the gears 108 and 109 and the shaft 110. The rotation of the shaft 110 is carried through a pair of universal joints 111 and 112 to the shaft 113 (Figure 7). A threaded shaft 114 is attached to the shaft 113, the end of the shaft 114 being supported in a bearing 115. A threaded sleeve 116 engages the shaft 114, and, as seen also in Figures 12 and 13, imparts motion to the carriage 47.

The sleeve 116 is open on one side and is drawn into engagement with the shaft 114 by the bolts 117. An upward extension 118 of the sleeve 116 engages the bifurcated member 119 in the carriage 47. A lateral projection 120 on the extension 118 carries a pin 121 which is guided by the channel 122.

As may be best seen in Figure 5, the plate member assembly B is also moved by the operation of the wheel 106. The worm 161 on the shaft 110 drives a gear 162 which carries a cam 163. A lever 164 pivotally mounted at 165 on the casting 31 engages at one end the cam 163. The engagement is maintained by a spring 166. The other end of the lever 164 is received within the frame 168 of the plate holder mechanism and engages the end 167 of a thumb screw adjuster 169. The plate holder frame is mounted on a bearing 123 which is adapted to rotate about a vertical axis through the center of this bearing. Thus when the wheel 106 is turned, the plate holder assembly B is rotated.

As seen particularly in Figure 15, the frame 168 of the plate holder assembly B is joined to the casting 31 by flexible bellows 170. The casting is provided with an aperture 171 through which the light passes to the photographic plate. On the frame 168 of the plate holder assembly B is mounted a casting 172 which in turn supports the plate holder 173, the plate holder being held in position by the bars 124 and 125. The plate holder 173 is equipped with a cover 126 attached at one end to hinges 127. The other end of the cover 126 is provided with lugs 128 which receive the locking levers 129, the levers being pivotally mounted on the bosses 130 of the plate holder 173.

Within the plate holder is a retractable slide 131 of the type conventionally used in photographic apparatus. Behind the slide 131 is the photographic plate 132 and a support 134 therefor. A spring clip 135 holds the support 134 in position.

Referring now to Figure 16, the casting 172 is received within ways 136 and 137 and is equipped on the surface thereof with a pair of racks 138 and 139 which are engaged by the gears 140 and 141. The gears 140 and 141 are mounted on a shaft 142 driven by a gear 143 which is in turn engaged by the worm 144. A vertical shaft 145 carrying the worm 144 is driven by the bevel gears 146 and 147, the gear 147 being mounted on the shaft 148. A wheel 149 is used to rotate the shaft 158, thus imparting vertical motion to the casting 172.

The screen indicating mechanism D is shown particularly in Figures 1, 3 and 11. The mechanism includes a scale 180 on the carriage 47, the scale being opaque except for the markings thereon. A lamp 181 in the housing 182 casts a beam of light on the mirror 183, the beam being reflected upwardly through the scale 180 to the mirror 184. From the mirror 184 a beam is reflected to the mirror 185 and from there reflected to a translucent ground glass screen 186 upon which the scale is registered. Movement of the carriage 47 and the scale 180 attached thereto causes the scale, as shown on the screen 186, to move horizontally.

In the modification of the invention shown in Figure 17, a tube 187 is attached to or replaces the plate holder. The tube is equipped with a slit or aperture 188 through which a beam of light may pass. The beam of light passing through the aperture 188 is received in a photoelectric cell assembly 189 and converted into electrical energy. The current generated by the photoelectric cell may be measured by an electrometer 190 of the usual construction, the electrometer being connected to the cell assembly by wires 191 and 192. It is thus apparent that a direct reading may be made of the intensity of any given line or band in the spectrum; and where the intensity of the light emitted from the source is standardized, this provides information as to the material being activated by the arc.

To describe the operation of the apparatus, a material 30 to be analyzed is heated or electrically excited in the usual manner in the work holder 17. The light emitted from the material passes through the lenses 18 and 19 and then through the apertures in the rotating disk to the slit or aperture in the tube 33 and thus into the casing 16. The path which the light travels in the casing 16 includes the opening 38 in the plate 37, the collimator lens 42, the prism 43, and the camera lens 44. From the lens 44 the light passes to the mirror 45, from whence it is reflected to the photographic plate 132. In order that different wave lengths of light may be simultaneously focused on the photographic plate, the plate is set at an angle with respect to the path of the light. To obtain proper focusing of the light, the camera lens 44, the mirror 45 and the photographic plate 132 are so spaced from each other that the distance between the camera lens and the plate along the path which the light traverses to the center of the plate is equal to the distance from the slit or aperture in the tube 33 to the collimator lens 42.

The slide 131 and the diaphragm in the plate 37 are operated in the usual and conventional manner for photographic apparatus.

The scale 180, as reflected on the ground glass screen 186, indicates the portion of the spectrum which is being received on the photographic plate 132, and also the wave length falling on the center of the plate. The scale may be empirically calibrated in terms of angstroms in order that a direct reading of the light wave lengths may be made.

The photographic plate 132 may be exposed to different portions of the spectrum by rotating the prism 43. This is accomplished by turning the hand wheel 106 which, through the movement of the gears 108 and 109, causes rotation of the shafts 110, 113 and 114. The rotation of the shaft 114 in turn causes longitudinal movement of the sleeve 116 which engages the carriage 47. As the carriage 47 moves longitudinally along the frame, the roller 69 moves along the cam 73 in engagement therewith causing rotation of the prism 43.

Movement of the carriage 47 also causes the roller 75 to move along the cam 79, rotating the camera lens support 67 about the axis of the member 65, and at the same time the roller 89 engages and moves along the cam 91, moving the arm 53 which carries the mirror 45. The mirror 45 is preferably a plane aluminized mirror, although other types of mirrors may be used, if desired.

Simultaneously, with the movement of the prism 43, lens 44, and mirror 45, the photographic plate 132 is rotated about the axis of the bearing 123. This rotation results from the rotation of the worm 161 and gear 162 when the wheel 106 is turned. The lever 164 is moved by the cam 163 on the gear 162, thus rotating the frame 168 in which the photographic plate 132 is carried. The photographic plate 132 is not displaced, but is merely rotated about the vertical axis of the bearing 123. Because of this automatic compensating rotation of the plate 132, it is possible to obtain a camera focus of the different wave lengths of light to which the plate is exposed.

The prism 43, the camera lens 44, the mirror 45, the photographic plate 132 and the various supporting arms and cams therefor are so arranged and constructed that the distance between the camera lens 44 and the photographic plate 132 along the path of light to the center of the plate remains substantially equal to the distance between the aperture in the tube 33 and the collimator lens regardless of the movement of the various members.

The mirror supporting arm 53 may be adjusted as to position by moving the flexible strip 102. This is accomplished by adjusting the bolts 103 in the bars 104 and 105. The movement of the rollers 97 and 100 engaging the strip 102 causes the eccentric roller 89 to be turned and the shaft 82 and arm 53 to be displaced. This adjustment is, of course, a very fine adjustment and need ordinarily only be used at the time the apparatus is first set in operation.

Micrometer adjustment of the inclination of the photographic plate 132 may also be accomplished by turning the thumb screw 169 in the frame 168.

With this instrument a quantitative analysis may be made by merely exposing the photographic plate to the spectrum for a predetermined length of time. By using the instrument with materials of known composition, an empirical calibration for the various light intensities may readily be made. When the plate is then exposed to the spectrum from a material of unknown composition, the analysis of the material may readily be calculated from the intensity of the spectrum bands on the photographic plate.

The photographic plate 132 is preferably of such a size that two or more exposures may be made thereon by merely shifting the position of the plate. The vertical position of the plate may be shifted by turning the hand wheel 149 which causes rotation of the gears 147 and 146 and the worm 144. As a result, the gears 140 and 141 are rotated and the casting 172 is raised or lowered in the ways 136 and 137.

The operation of the modification of the instrument shown in Figure 17 is substantially the same as that of the preferred embodiment except that an aperture 188 is substituted for the photographic plate 132. The instrument is then adjusted by means of the hand wheel 106 so that a predetermined band of the spectrum is cast on the aperture 188. The intensity of this band is then determined by exposing a photoelectric cell to it for a predetermined length of time, the current generated by the photoelectric cell being measured by means of an electrometer or other suitable means.

Turning now to the modification or form of my invention shown in Figures 18 to 21, this is a simplified form of spectroscope having practically all of the desirable features of my preferred spectroscope heretofore described. The principal difference between this and the earlier described form of spectroscope is that in the modification now to be described only a given predetermined number of positions of the parts are provided. That is, instead of apparatus for maintaining coordinated positions of the various movable parts through any range of positions, the arrangement is such as to provide a given number (here shown as five) positions of the parts, all of the parts being properly coordinated in any one of the given positions.

Referring first to Figures 18 and 19, the means for adjusting the plate holder will be described as illustrative of the means for properly locating and locking all of the movable elements of the spectroscope. As in the other modification of my invention, the base 200 has a plate holder 201 pivotally mounted thereon, apparatus including

the manually rotatable wheel 202 also being provided to enable two or more exposures to be made on one plate. The plate holder is carried on what may be termed a mounting plate 203, this mounting plate being rotatably slideable over a base plate 204 mounted on the frame 200.

As may be best seen in Figure 18, the mounting plate 203 has a slot 205 therethrough cooperating with the thumb screw or locking means 206, this part being threaded into the plate 204. The plate 203 is also provided with a plurality of holes adapted to register with holes in the plate 204 in various positions of the mounting plate 203. These holes are here shown as five in number, since it has been found that the entire visible spectrum and the useful portion of the ultraviolet can be properly covered by five different positions of the spectroscope elements. The use of a plurality of different cooperating holes, of course, is to enable the use of larger holes than would be possible in view of the limited movement of the plate 203.

The parts are shown as properly located and locked in what is here arbitrarily termed the number five position. This is effected by manually pushing a dowel pin 207 through a hole in the plate 203 and into a cooperating hole in the plate 204 when these holes register, as indicated in Figure 19. Forcing the slightly tapered dowel pin down insures proper registry of these number five openings; and then the plates can be locked in this position by tightening of the thumb screw 206. This results in very convenient and accurate location and locking of the movable plate holder in one of the five predetermined positions; and movement to and locking in one of the other positions would be effected by loosening the thumb screw, bringing the other openings into registry with the dowel pin therein, and then again tightening the thumb screw.

Turning now to Figures 20 and 21, it will be seen that all of the other movable elements of the spectroscope are adjustable to and lockable in corresponding positions. As in the first described modification of my invention, a carriage 208 is slideable along a base provided by rails 209 and 210, this enabling movement of the collimator lens 211 toward and away from a light source, not shown in this view. Light passing through the collimator lens strikes the prism 212, as before, and is dispersed into a spectrum, at least part of the spectrum then passing through the camera lens 213 and striking the mirror 214 to be reflected back to a photographic plate in the holder 201 adjacent the light source, or to a selector slit and electric measuring means where the device is used as a monochromator. The carriage, as mentioned above, is slideable toward and away from the light source; the prism 212 is pivotal about the axis 215; the camera lens 213 is mounted for pivotal movement about the axis 216; and the mirror 214 is supported on an arm 217 pivotal about the axis 218. As before, these movable parts, and the rotatable plate holder, form five movable elements of the spectroscope system, and their respective positions must in all cases be coordinated. Instead of being synchronously movable by a single manual means, the various elements in this last modification are all independently movable. However, means for indicating when the elements are in a predetermined position, and locking them in that position, are provided so that if each of the elements is in what may be termed number five position, as illustrated in these drawings, they are all properly coordinated and the desired portion of the spectrum is thrown on the plate with optimum optical results.

In order to locate and lock the carriage in place on the rails, two thumb screws 219 and 220 are adapted to cooperate with two dowel pins 221 and 222. In order to insure against any side play or movement of the carriage on its ways, two locking thumb screws and dowel pins are used, so that the associated holes are duplicated at each end of the carriage and on the associated rail 209. As stated before, the carriage is shown in number five position. If it is to be moved to number one position the thumb screws 219 and 220 are screwed out of their associated threaded holes in the rail 209, and the dowel pins 221 and 222 pulled out. The carriage is then manually slid to the left until the opening 223 in the carriage (the number one opening) is in registry with the opening 224 in the rail, and the dowel pin 221 is then slipped into place. Any slight movements necessary to register opening 225 at the other end of the carriage with opening 226 in the rail is then made, and the dowel pin 222 slipped into these openings. The carriage is then locked in place by threading the thumb screws 219 and 220 into the openings 227 and 228 and tightening them down. Intermediate positions of the carriage, arbitrarily identified as positions two, three and four, can be similarly accurately located and the carriage locked therein.

While the other movable elements are also here shown in number five position, they could be similarly coordinated with the carriage in number one position. With respect to the prism 212, this would be effected by loosening the thumb screws 229 and 230 to rotate the plate 231 carrying the stirrup in which the prism 212 is mounted. The plate 231 is provided with five openings adapted to register with five cooperating openings in the base plate 232; and to effect proper location of the prism in number one position the dowel pin 233 would be withdrawn from the position shown and moved into the holes at the other end of the line, it being assumed that the plate has been manually moved to such a position as to bring these holes into registry. Similarly, movement of the camera lens 213 would be effected by loosening the thumb screw 234, withdrawing the dowel pin 235 from the hole in which it is shown, manually moving the camera lens until the holes at the other end of the cooperating lines of holes are in registry, inserting the dowel pin, and tightening the thumb screw 234. Movement of the mirror would be effected by withdrawing dowel pin 236 from the hole in which it is shown, moving the arm 217 until the opening 237 in the plate 238 is in registry with the opening 239 in the plate 240 on the carriage, and again inserting the dowel pin.

It will be apparent that accurate settings in intermediate positions (speaking of the positions arbitrarily identified as 2, 3 and 4) could be similarly effected, so that there would be five sets of coordinated positions for the five movable elements, giving five positions or segments of the spectrum. While this latter form of the apparatus does not have the advantage of enabling an operator to remain seated at one end of the instrument and effect all movements of the elements by a single manual operation, it does give a very simple and easily operable method of securing coordinated positions of the elements,

while at the same time insuring great precision of their positioning.

While I have described and shown certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims.

I claim:

1. Spectroscopic apparatus of the character described, including: an entrance slit; a non-achromatic quartz collimator lens mounted in the path of light from said slit; a light-dispersing quartz prism for receiving light from said lens; a non-achromatic quartz camera lens adjacent said prism to receive dispersed light therefrom, a mirror mounted adjacent said camera lens and adapted to reflect the light back to a terminal point adjacent the slit, whereby the dimensions of the apparatus are reduced for a given focal length, there being only a single such optical system and the light passing through each optical element thereof only once in its path from the slit to the terminal point; a single carriage movable toward and away from the slit and terminal point to enable adjustment of the distance of the carriage therefrom in accordance with the different focal lengths of a non-achromatic lens for light rays from different portions of the spectrum, and carrying the collimator lens, prism, camera lens, and mirror, the prism, camera lens and mirror being rotationally mounted on the carriage; and a separate cam and cam follower associated with each of the three last mentioned movable elements for effecting simultaneous rotational movement thereof in coordinated relation upon movement of said carriage, the various movements being so coordinated that the distance from the slit to the collimator lens is always equal to the distance traversed by light, of a median wave length of the portion of the spectrum being examined, between the camera lens and the terminal point.

2. Spectroscopic apparatus of the character described, including: an entrance slit; a non-achromatic quartz collimator lens mounted in the path of light from said slit; a light dispersing quartz prism for receiving light therefrom; a non-achromatic quartz camera lens; a mirror adapted to reflect light back to a terminal point adjacent the slit, whereby the dimensions of the apparatus are reduced for a given focal length, the lens and mirror being optically aligned in the path of light from the prism, the camera lens being adjacent the prism, there being only a single such optical system and the light passing through each optical element thereof only once in its path from the slit to the terminal point; translationally movable mounting means carrying the collimator lens, prism, camera lens and mirror, for simultaneous and similar movement toward and away from the slit and terminal point, the prism, camera lens and mirror being rotationally mounted on said mounting means; and means effecting simultaneous rotational movement of the three last mentioned movable elements in coordinated relation upon translational movement thereof in accordance with variations in the focal length of the optical system for a median wave length of the portion of the spectrum being examined, the various movements being so coordinated that the distance from the slit to the collimator lens is always equal to the distance traversed by light of such median wave length between the camera lens and the terminal point.

3. Spectroscopic apparatus of the character described, including: an entrance slit; a non-achromatic collimator lens mounted in the path of light from said slit; a light-dispersing prism for receiving light from said lens; a non-achromatic camera lens adjacent said prism to receive dispersed light therefrom; a mirror mounted adjacent said camera lens and adapted to reflect the light back to a terminal point adjacent the slit, whereby the dimensions of the apparatus are reduced for a given focal length, there being only a single such optical system and the light passing through each optical element thereof only once in its path from the slit to the terminal point; a single carriage movable toward and away from the slit and terminal point to enable adjustment of the distance of the carriage therefrom in accordance with the different focal lengths of a simple lens for light rays from different portions of the spectrum, and carrying the collimator lens, prism, camera lens, and mirror, the prism, camera lens and mirror being rotationally mounted on the carriage; and means associated with each of the three last mentioned movable elements for effecting simultaneous rotational movement thereof in coordinated relation upon movement of said carriage, the various movements being so coordinated that the distance from the slit to the collimator lens is always equal to the distance traversed by light, of a median wave length of the portion of the spectrum being examined, between the camera lens and the terminal point.

4. Spectroscopic apparatus of the character described, including: an entrance slit; a non-achromatic collimator lens mounted in the path of light from said slit; a light-dispersing element; a non-achromatic camera lens; a mirror adapted to reflect the light back to a terminal point adjacent the slit, whereby the dimensions of the apparatus are reduced for a given focal length, the lens and mirror being optically aligned in the path of light from the light-dispersing element, there being only a single such optical system and the light passing through each optical element thereof only once in its path from the slit to the terminal point; mounting means translationally movable toward and away from the slit and terminal point to enable adjustment of the distance of the mounting means therefrom in accordance with the different focal lengths of a non-achromatic lens for light rays from different portions of the spectrum, the mounting means carrying the collimator lens, light-dispersing element, camera lens and mirror, at least the light dispersing element and mirror being rotationally mounted; and means associated with each of the rotationally movable elements for mechanically ensuring angular positioning thereof in coordinated relation upon movement of said mounting means, the various movements being so coordinated that the distance from the slit to the collimator lens is always equal to the distance traversed by light, of a median wave length of the portion of the spectrum being examined, between the camera lens and the terminal point.

5. Apparatus of the character claimed in claim 4, including a second means also operative to vary the angular position of the mirror, this second means being adjustable, adapted to effect only minute variations in such position, and auto-

matically operable upon operation of the first mentioned positioning means.

6. Spectroscopic apparatus of the character described, including: an entrance slit; an element for dispersing the light into a spectrum, said element being movable; a second element adapted to optically affect at least part of the dispersed light, said second element being rotationally movable, the position of one of said elements being dependent upon the position of the other; means for effecting coordinated movement of both elements by a single operating means, including a cam and a cam follower effecting rotational movement of said second element, the contour of the cam being so designed that said cam would effect the required rotational movement of said second element if each of the above-mentioned elements were optically perfect; and a second cam and a second cam follower, the second cam being adjustable to vary the relation between said second element and the first cam follower in response to movement of the first follower, adjustment of said second cam providing compensation for deviations of the optical system from optical perfection.

SAMUEL J. JACOBSOHN.