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6 Sheets-Sheet 1



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May 19, 1953

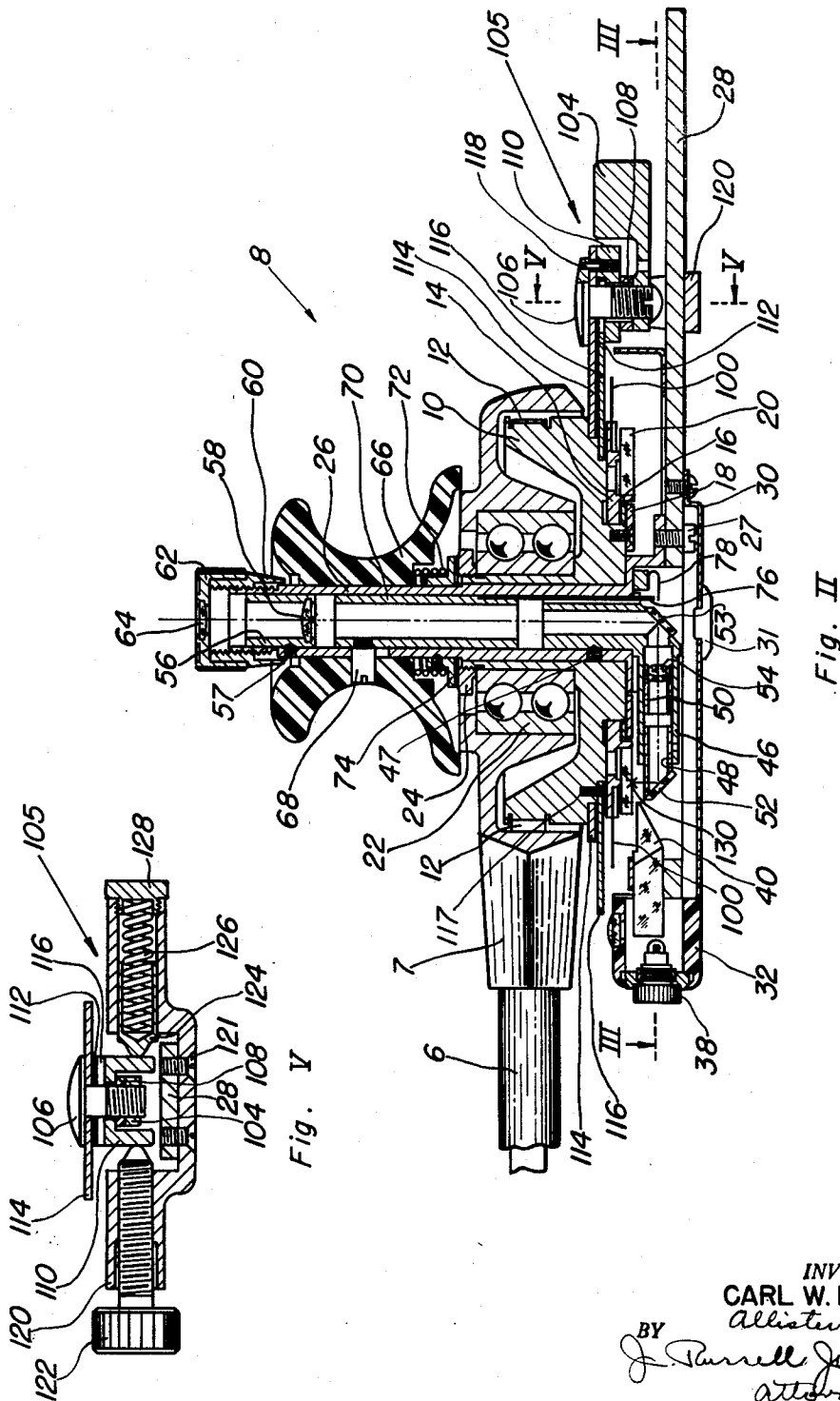
C. W. KEUFFEL ET AL

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DRAFTING MACHINE

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6 Sheets-Sheet 2



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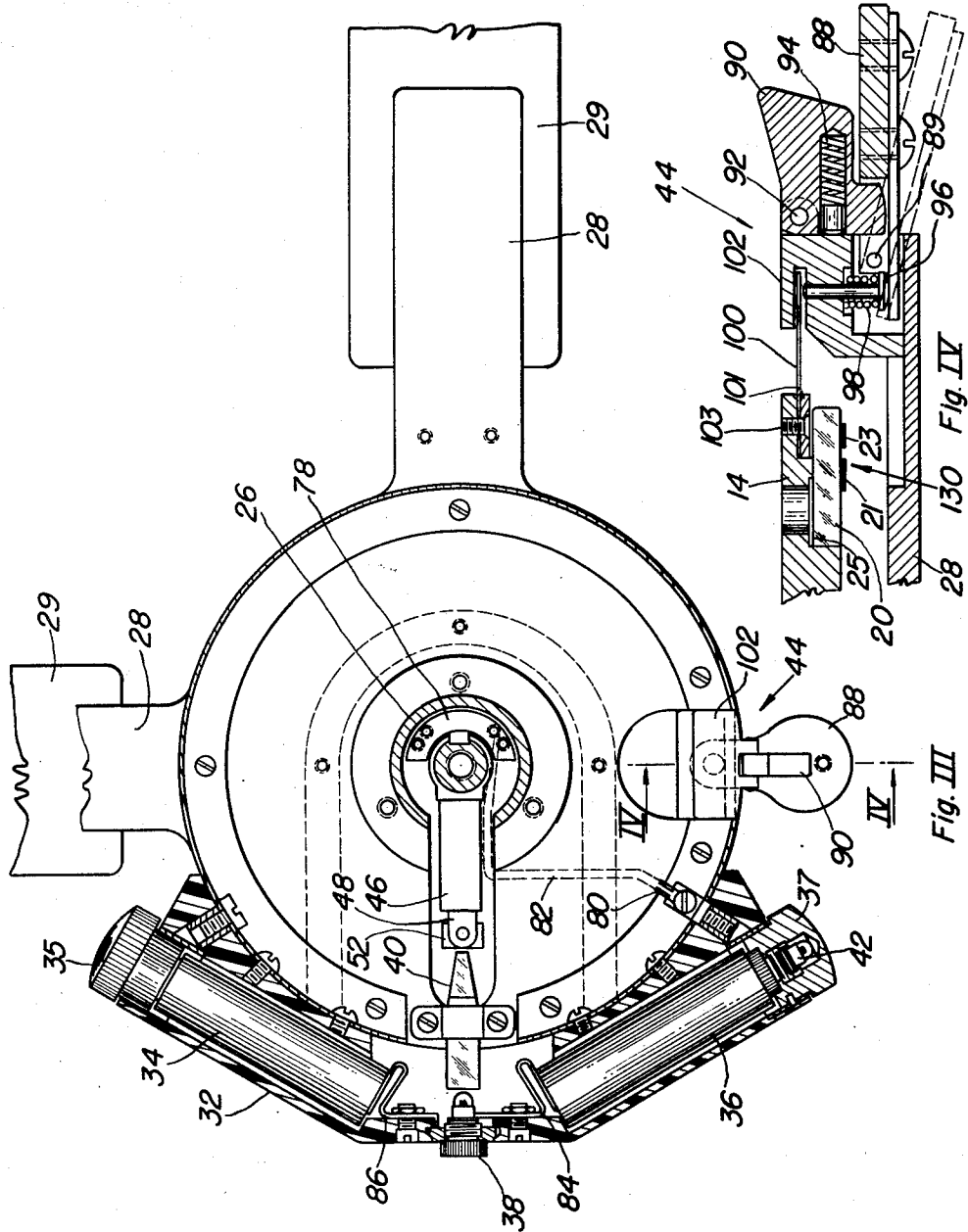
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DRAFTING MACHINE

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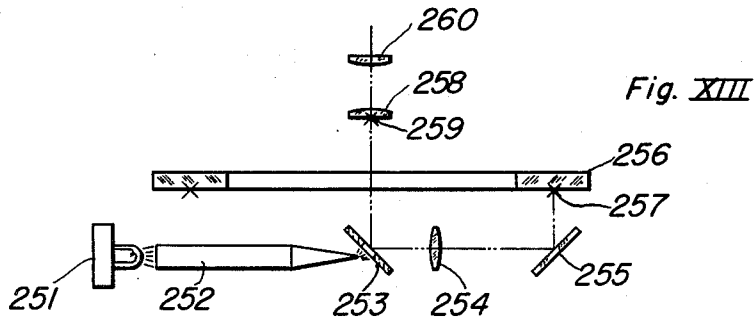
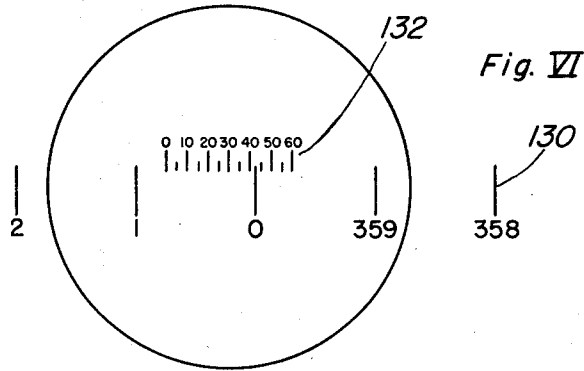
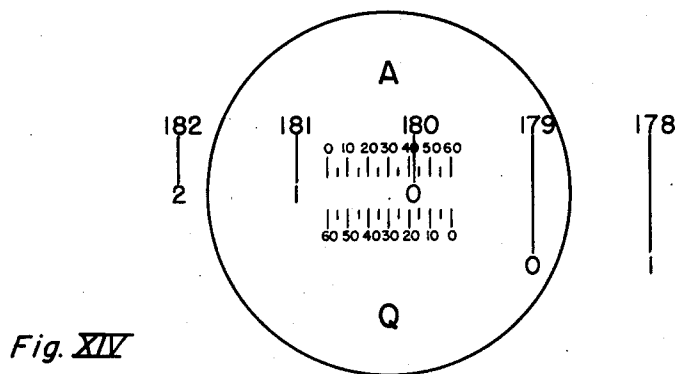
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6 Sheets-Sheet 4



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6 Sheets-Sheet 5

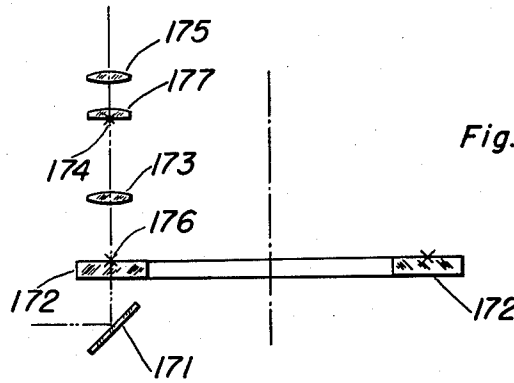


Fig. VII

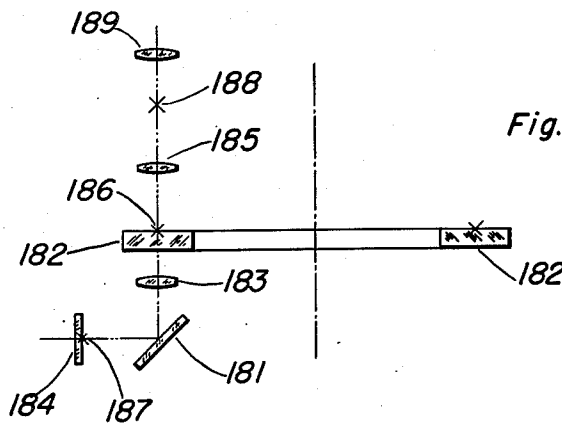


Fig. VIII

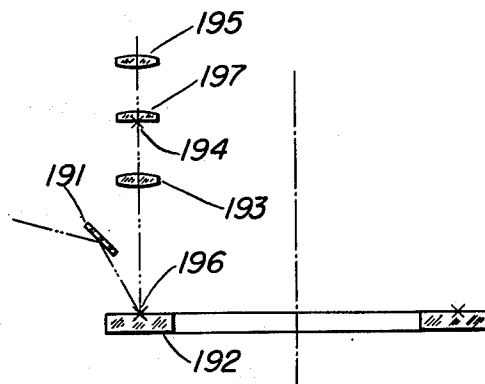


Fig. IX

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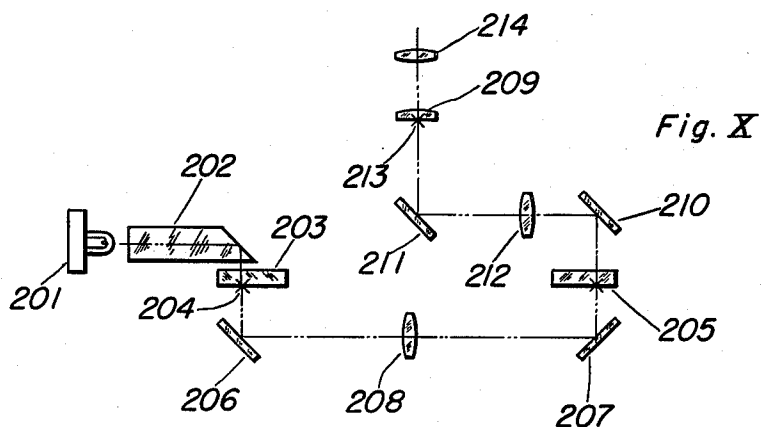
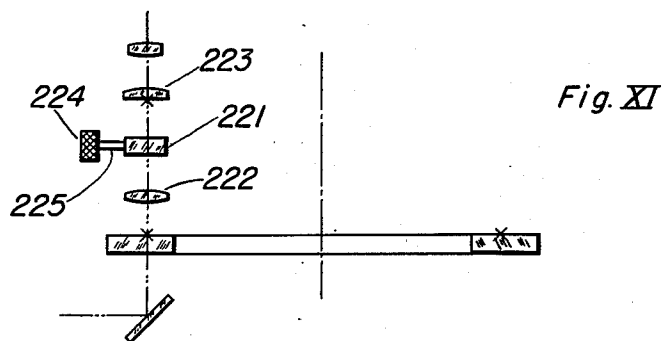
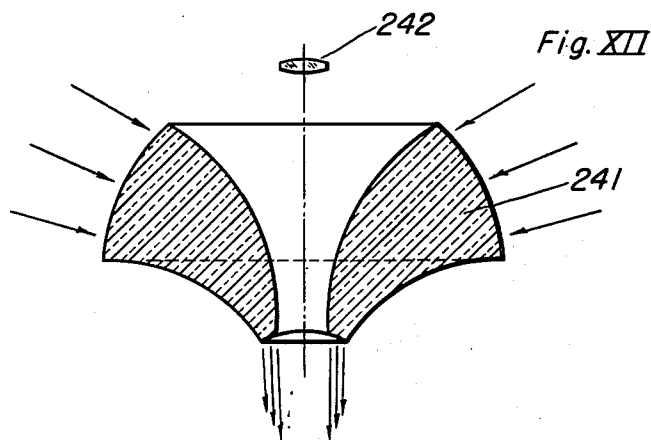
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2,638,675

DRAFTING MACHINE

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Application March 25, 1947, Serial No. 737,050

9 Claims. (Cl. 33—79)

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This invention relates to drafting machines, various forms of which are well known in the art. The usual type comprises a fixed member clamped to a drawing board, a first movable arm pivoted at one end to the fixed member, a second movable arm pivoted at one end to the moving end of the first arm, and a drafting head carried at the free end of the second movable arm and movable over the drawing board. The drafting head includes a protractor and a protractor arm, with means for holding one or more scales, rulers or straight edges, which can be rotated about the protractor. As the drafting head is moved over the drawing board, orientation of the protractor is held constant either by some combination of pulleys and bands or by some combination of parallel arms. The present invention relates only to the drafting head and it should be understood that the form of the other parts of the machine in no way affects the invention.

Specifically, the invention relates to an improved type of drafting head which may be combined in any suitable manner, known in the art, with other parts necessary to make a drafting machine.

In using a drafting machine, it is sometimes necessary to turn the protractor arm which holds the straight edges to some desired angle indicated by the protractor, to set the arm accurately at said desired angle and to hold it at said desired angle as long as desired. The present invention provides optical means to aid in reading the protractor so that the setting of the protractor arm is facilitated. Thus one object of the invention is to provide an optical system to facilitate the setting of the protractor arm.

By means of the optical system used, it is possible to magnify the protractor scale so that its setting relative to an index may be made to greater accuracy. Hence, another object of the invention is to provide a drafting head in which the protractor arm can be set with greater accuracy.

Another object of the invention is to provide an enclosed protractor, thus protecting this accurately graduated member making it possible to use a glass protractor if desired and thereby allowing the manufacturer to take advantage of known methods for producing sharp accurate graduations on glass in making protractors.

These and other objects of the invention and the means for their attainment will be more apparent from the following detailed description taken in connection with the accompanying drawings illustrating several embodiments by

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which the invention may be realized, and in which:

Figure I is a view in plan of a drafting machine provided with the new drafting head.

Figure II is a vertical section taken along the lines II—II of Fig. I and looking in the direction of the arrows.

Figure III is a view in horizontal section taken along the line III—III of Fig. II and looking in the direction of the arrows.

Figure IV is a view in enlarged vertical section taken along the line IV—IV of Fig. III and looking in the direction of the arrows, showing the pin clamp.

Figure V is a view in enlarged vertical section taken along the line V—V of Fig. II and looking in the direction of the arrows, showing the clamp and tangent screw assembly.

Figure VI is a view showing the superimposed protractor and micrometer scales, the portion within the circle being that seen through the eyepiece when used with an optical system such as shown in Fig. II.

Figure VII is a diagrammatic view in vertical section showing an alternative optical system which could be used to read a transparent protractor.

Figure VIII is a diagrammatic view of another optical system for reading a transparent protractor.

Figure IX is a diagrammatic view of an optical system similar to that of Fig. VII but showing an opaque protractor.

Figure X is a diagrammatic view of an optical system for reading a transparent protractor in an averaging manner.

Figure XI is a diagrammatic view of an optical system for reading the protractor including a modified micrometer arrangement.

Figure XII is a diagrammatic view in vertical section of an element of transparent material for transmitting concentrated light into the instrument.

Figure XIII is a diagrammatic view showing an alternative arrangement for illuminating the protractor.

Figure XIV is a view similar to Fig. VI showing a special protractor scale superimposed on two micrometer scales, the portion within the circle being that seen through the eyepiece when used with an optical system such as shown in Figs. II and VII.

In Figure I, the fixed member or anchor 2 is shown with means for clamping it to the draw-

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ing board. The first movable arm 4 is pivoted to this member on its one end and to the second movable arm 6 on its other end. The drafting head 3 is at the free end of the second movable arm 6.

In Figures II and III, the band 12 passes around the drafting head pulley 10 to maintain it in orientation on the drafting board in known manner. Fitted closely over the bottom of this pulley is the protractor holding plate 14. This plate is carried by the drafting head pulley and held in position thereon by the spring washer 16 and the retaining plate 18, which plate 18 is screwed onto the drafting head pulley. The protractor 20, which in this embodiment is of a transparent material such as glass is cemented to the protractor holding plate 14. A ball bearing 22 is between the head bracket 7 of the second movable arm 6 and the drafting head pulley 10 or member maintained in orientation so that the arm may rotate with respect to the pulley which is held in orientation by the band 12. The nut 24 holds this ball bearing onto the drafting head pulley.

The center tube 26 is free to turn inside the drafting head pulley 10. On its lower end it is fastened to the protractor arm 28, as by means of screws 27. The protractor arm 28 as shown in Fig. III may be provided with chucks or other means to receive one or more rulers, scales or straight-edges 29. In some cases provision may be made for only a single straightedge. The bottom cover plate 30, the housing 32 carrying the batteries 34 and 36 and the light bulb 38, as well as the illuminating rod 40 and the pin clamp 44 are all attached to the protractor arm and rotate with it.

The battery caps 35 and 37 hold the batteries 34 and 36 in proper position in the housing 32 so that the necessary electrical contacts are made. The battery caps 35 and 37 are attached so that they may be easily removed to permit changing of the batteries when necessary. The battery cap 37 contains an extra light bulb 42 which can be used to replace the light bulb 38 when necessary.

The bottom button 31 is screwed into the bottom cover plate 30 and is centered at the bottom of the drafting head. The entire head rests by means of this button against the drafting board. In moving the drafting head over the drafting board the head slides on the bottom button 31.

The objective bracket 46 is a right angle part which is tubular on both ends. Its vertical tubular portion fits inside the center tube 26 and is fastened as by a screw 47 to it. The horizontal tubular portion of objective bracket 46 carries the reflector cell 48, to which is fastened the protractor reflector 52, and the objective cell 50 in which is mounted the objective 54. The center reflector 53 is fastened at the corner of the objective bracket 46. Since the objective bracket 46 is fastened to the center tube 26 it rotates with it and therefore it also rotates with the protractor arm.

The reticle cell 56 bears the reticle 58 and is fastened as by screw 57 inside the upper end of the center tube 26. The extreme upper end of the center tube 26 is threaded on the outside and the eyepiece focusing tube 60 is screwed over it. The eyepiece mount 62 bearing the eyepiece 64 is fitted over the eyepiece focusing tube 60. Thus the light bulb 38, the illuminating rod 40, the reflector 52, the objective 54, the reflector 53, the reticle 58 as well as the eyepiece 64 all rotate with

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the center tube 26 and the protractor arm 28 and maintain their relative positions in so doing.

The knob 66 fits over the outside of the center tube 26. The knob screw 68 joins it to the switch sleeve 70 through a vertical slot in the center tube 26. The compression spring 72 acts between the knob 66 and the spring thrust ring 74. Since the spring thrust ring is fastened over the outside of the center tube and cannot move vertically, the compression spring 72 holds the knob 66 up so that the knob screw 68 touches the upper end of the slot in the center tube 26.

If a downward pressure is applied to the knob 66 by the hand, the compression spring 72 is further compressed until the knob screw 68 touches the lower end of the slot in the center tube. The switch sleeve 70 is also moved downwardly with the knob causing the contact strip 76, which it carries and which passes through a slot in the upper sleeve of the objective bracket 46, to make contact with the switch contact 78.

When such contact is made one pole of the battery 36 is grounded to the head, through the clip 80, the wire 82, the switch contact 78 and the contact strip 76. The other pole of the battery 36 is connected to one side of the light bulb 38 by the wire 84. The pole of opposite polarity of the battery 34 is connected to the other side of the light bulb 38 by the wire 86. The other pole of the battery 34 is grounded to the head, to complete a series electrical circuit having the light bulb connected between the two batteries.

The pin clamp 44 for rotating the protractor with respect to the pulley and thereby to establish a new base line, is shown in detail in Fig. IV. In order to clamp the protractor to the protractor arm the trigger 90 is pressed down turning it about the pivot pin 92 and allowing the locking piece 90 to be turned upward around its pivot pin 92 by the action of the compression spring 94. The locking piece 90 holds the trigger 90 in the position shown by dotted lines. In this position, the trigger pushes the clamp pin 96 up against the action of the compression spring 98 causing it to clamp the circle holding plate 100 against the pin clamp body 102.

The circle holding plate 100 may be released by pushing down on the locking piece 90 compressing the compression spring 94 and allowing the trigger 90 to come up under the action of the compression spring 98, which also lowers the clamp pin 96 freeing the circle holding plate 100.

The circle holding plate 100 is fastened to the protractor holding plate 14 by a ring 101 and screws 103 so that when the pin clamp is closed to grip the circle holding plate 100, it, the protractor holding plate 14, and the protractor 20 cemented thereto, will all turn with the protractor arm and the protractor holding plate 14 will slide under the spring washer 16.

The clamp and tangent screw arrangement 105 shown toward the right of Fig. II and in greater detail in Fig. V, can be described as follows:

The locking lever 104, seen best in Fig. II, is provided with a female thread which engages with the clamp screw 106, so that when the locking lever is pushed back it rises upwardly on the clamp screw pushing the clamp washer 108 up against the clamp plate 110 which in turn pushes up the tangent clamp plate 112 squeezing the friction washer 112 between the tangent clamp plate 112 and the tangent arm 114 which is held down by the head of the clamp screw 106. The clamp screw 106, the tangent arm 114 and the clamp plate 110 are pinned together by the set screw

118, in order to prevent the clamp screw 106 and the clamp plate 110 from turning by friction when the locking lever 104 is actuated. The head of the clamp screw 106 is provided with several holes spaced equally in a circle. The set screw 118 will fit each of these holes so that in the event that the clamping action becomes loose it may be tightened by turning the clamp screw 106 to tighten it and using the set screw 118 in another hole.

Through the above means the tangent clamp plate 116 is clamped to the tangent arm 114 when the locking lever is pushed back but the tangent clamp plate 116 is fastened as by screws 117 to the drafting head pulley 10 so that the net result is to clamp the tangent clamp plate 116 as well as the clamp plate 110 to the drafting head pulley 10. When not clamped to the tangent clamp plate 116 the tangent arm 114 is free to turn by sliding over it while carrying the clamp screw 106, the clamp plate 110, the friction washer 112 and the locking lever 104 with it.

The tangent screw bracket 120 is fastened by screws 121 to the protractor arm 28. On the left side of the tangent screw bracket, as shown in Fig. V, a threaded section is provided in which the tangent screw 122 turns. The tangent screw acts against the clamp plate 110. On the right side of the tangent screw bracket, as shown in Fig. V, a hole is provided in which the spring plunger 124 slides under the action of the compression spring 126 which is constrained on its other end by the spring cap 128. The spring plunger 124 acts on the opposite side of the clamp plate 110 from the tangent screw 122 but in line with it.

The tangent screw 122 and the spring cap 128 hold the clamp plate 110 between them. When the protractor arm 28 is rotated about the center tube 26, it carries the clamp plate 119, etc. along with it. The tangent arm 114 being joined to the clamp plate 110 also rotates with it. When the tangent clamp plate is clamped by means of the locking lever 104, the protractor arm is in effect clamped to the drafting head pulley 10. Then the tangent screw arrangement 105 provides a fine adjustment for rotating the protractor arm by turning the tangent screw 122.

The protractor 20 shown in enlarged form in Fig. IV and which in this embodiment is made of glass is provided with graduations 21 and numbers 23 on its lower surface, which together will be called the protractor scale 130. The upper surface 25 of the protractor 20 is provided with a diffuse surface as would result by grinding or etching the glass and is coated with a reflecting material such as aluminum or silver to form an internal diffuse reflecting surface.

When the knob 66 is pushed down, the light bulb 38 is lighted and the illuminating rod 40 directs this light onto the glass protractor 20 to illuminate the protractor scale by internal reflection from the upper surface 25 of protractor 20.

The objective 54 and the reflectors 52 and 53 then image a portion of the illuminated protractor scale 130 onto the lower surface of the reticle 58. This surface is provided with a micrometer scale on which the image of the protractor scale is superimposed. The superimposed scales are viewed through the eyepiece 64.

The appearance of the superimposed scales to the eye is shown in Fig. VI. The protractor scale 130 has one degree divisions and is numbered from 0 to 359 degrees. The micrometer scale 132, the zero line of which may be considered an index mark, is divided into 5 minute divisions and is numbered every 10 minutes. The degree read-

ing is read from the number of the protractor scale division which intersects the micrometer scale. The minute reading is then read from the place at which this protractor scale division intersects the micrometer scale. This reading can readily be made to one minute by estimation.

The arrangement and number of graduations making up the protractor scale as well as the arrangement and number of graduations making up the micrometer scale may be varied as desired and need not necessarily be as shown in Fig. VI. In fact, if the accuracy required is not great, the protractor scale may be divided finely enough so that a micrometer scale would be unnecessary, and only an index mark would be necessary. The index mark could take the form of a line, a pair of parallel lines, an X or a centered dot in which case the protractor scale would be read by estimating the place at which the index mark lies on the superimposed protractor scale. Also the protractor scale may be divided in quadrants instead of in a complete circle depending on the use to which the instrument is to be put.

Having described the interrelation of the various parts of the invention in detail, some of the ways in which the new drafting head may be used will now be described.

A line may be drawn to any angle with respect to the base line to which the protractor has been set as follows. Both clamps 44 and 105 being open, the protractor arm 28 is turned to find the desired angle while the operator looks through the eyepiece 64 and holds the knob 66 down. Then, in order to set accurately to this angle, the locking lever 104 is pushed back to clamp the clamp plate 110 to the drafting head pulley 10 and the protractor arm is adjusted by means of the tangent screw 122 accurately to the desired angle as seen through the eyepiece. Having thus set the protractor arm to the desired angle, the drafting head 8 may be moved over the drafting board. The combination of bands and pulleys maintain the orientation. When the straight edge attached to the protractor arm passes through a desired point, the line is then drawn at the selected angle through this and any other points. Lines may be so drawn through any desired points at any desired angle to the same base line by resetting the protractor arm in the manner described.

If it is desired to change to another base or reference line and make the zero setting of the protractor correspond to this line on the drafting board, this may be accomplished as follows. With both clamps 44 and 105 open, the protractor arm is rotated while the operator looks through the eyepiece and holds the knob 66 down until the protractor reading is close to zero. Then the locking lever 104 is pushed back to clamp the clamp plate 110 to the drafting head pulley and the protractor arm is adjusted by means of the tangent screw 122 until the protractor reading is exactly zero as seen through the eyepiece.

The pin clamp 44 is then closed by pushing down on the trigger 88. This fixes the protractor 20 to the protractor arm 28. The other clamp 105 is opened by means of the locking lever 104. The protractor arm carrying the protractor with it against the action of the spring washer 16 and maintaining the zero reading, can now be rotated until the straight edge 29 is parallel to the desired reference line. If the locking lever 104 is again turned to operate the tangent clamp 105 the clamp plate 110 is clamped to the pulley 10 and the protractor arm 28 still carrying the pro-

tractor 20 can be given a fine adjustment by means of the tangent screw 122, to set the straight edge exactly on or parallel to the desired reference line. The pin clamp is then released by pushing down the locking piece 90. This releases the protractor 20 from the protractor arm 28 and therefore it is maintained in orientation by the pulley 10 with which it is in frictional engagement. The tangent clamp 105 is released from pulley 10 by releasing locking lever 164 and the machine is ready for laying off angles from the new reference line.

Both the pin clamp and tangent clamp described with reference to Figs. II, III, IV and V provide novel means for clamping together the fundamental members of a drafting head without danger of turning the members by friction when actuating the clamps. Clamps of this type could also be used in drafting machines not provided with an optical system for reading the protractor but in machines having optical means for reading the protractor, they are more desirable because of the high accuracy which is made possible.

The use of the tangent screw arrangement as described above and as shown in the drawing, provides a novel method for fine setting of the protractor arm in a drafting machine. It should be understood that the tangent screw can be used between other members of a drafting head for purposes of fine adjustment within the scope of the invention. For example the tangent screw could be made to operate between the protractor arm and the protractor instead of between the protractor arm and the drafting head pulley as shown in Fig. II. The use of tangent screw or other fine adjustment need not necessarily be used in a drafting head having optical means for reading the protractor as shown in Fig. II but the high precision of such an instrument makes this feature desirable. In some cases it may be desirable to use two tangent screws between different pairs of members in the drafting head or it may be desirable to use a tangent screw in combination with a different type of clamp from that shown in Fig. II. All such modifications are within the scope of the invention.

The optical system shown in Fig. II represents only one form which this invention may take. Many variations in the optical system are possible depending on the use to which the drafting machine is to be put, the accuracy desired and other factors. For example, the system shown schematically in Fig. VII may be used. In this system the reflector 171 reflects light from a lamp if one is provided or from some external source through the glass protractor 172, illuminating the protractor scale 176 thereon. The objective 173 images part of this scale (in magnified form if desired) to a focal plane which coincides with the surface of the reticle 177 on which a micrometer scale 174 is provided. The superimposed scales are viewed through the eyepiece 175. In this embodiment of the invention the parts 171, 173, 177 and 175 must be fixed to the protractor arm and rotate with it.

In a drafting head made according to Fig. VII, when the protractor arm is rotated about the head center, it will pass through some positions in which the eyepiece 175 will be situated under some portion of the second movable arm of the drafting machine (part 6 in Fig. I) or the rotation of the protractor arm will be limited by interference between the mechanical part holding the eyepiece and some portion of the second mov-

able arm of the drafting machine. Thus, this type of drafting head should be used for instruments where only limited angular measurements are encountered. Where the protractor must be read through a full 360° the construction shown in Figs. II and III should be used, wherein the eyepiece is situated at a point over the center of the protractor.

It is possible, within the scope of the invention to modify considerably the details of the straight line optical system of Fig. VII. For example, it would be possible in a drafting head provided with an enclosed protractor to provide means for illuminating the protractor and a micrometer or vernier scale held above, below or to the side of it and to provide an ocular or microscope for reading the protractor.

Another modification is illustrated in Fig. VIII in which: Light is directed to pass through a reticle 184 illuminating a micrometer scale 187 provided on one of its surfaces. The micrometer scale is imaged by the reflector 181 and the lens 183 onto the surface of the protractor 182, carrying the protractor scale 186. The superimposed scales are then both imaged by the objective 185 to the focal plane 188, from which they are viewed through the eyepiece 189.

The objective 185 and the focal plane 188 could be omitted and the superimposed scales viewed directly at 186 through an eyepiece.

It would be possible also to utilize a scheme similar to that shown in Fig. VIII in which a micrometer scale is imaged on the protractor scale in a drafting head, and the superimposed scales by suitable optical means are brought along an optical path, following the axis passing through the center of the protractor. An eyepiece may be provided above the center of the protractor, thus making it possible to turn the protractor arm through a full 360° and still read the protractor.

Another possibility based on the embodiment shown in Fig. VIII would be to eliminate the objective 185, the focal plane 188 and the eyepiece 189 and reverse the direction of light by illuminating the protractor 182 from above, imaging a portion of the protractor scale 186 onto the reticle 184 by means of lens 183 and reflector 181 to superimpose it on the micrometer scale 187. An eyepiece could then be provided for viewing the superimposed scales from the side and if desired another reflector or prism could be provided to make the direction of viewing more convenient. Such a reflector or prism could be adjustable for changing the direction of viewing at will.

Instead of imaging one set of graduations on the other they may be combined for the first time at a focal plane separate from either set of graduations.

In Fig. IX an optical system for reading an opaque protractor is illustrated. The reflector 191 directs light onto the opaque protractor 192 illuminating the protractor scale 196 thereon. The objective 193 images a portion of the protractor scale onto the reticle 197 superimposing it on the micrometer scale 194. The superimposed scales are viewed through the eyepiece 195.

This system for reading an opaque protractor may also be modified in many ways. For example, means could be provided to bring the eyepiece over the center of the protractor for reasons already explained or modifications similar to those discussed in connection with Fig. VIII could be used with an opaque protractor.

The opaque protractor could be either enclosed or open as could also the transparent protractors illustrated in Figs. VII and VIII. The illumination of the protractor might be somewhat simplified if it is open.

However, there is also a great advantage in enclosing the protractor in order to protect this precision element and the accurately divided graduations with which it is provided. If the protractor is made of glass its enclosure is even more important in order to prevent breakage.

Fig. X shows an embodiment of the invention, in diagrammatic form, in which an averaging system is used for reading the protractor, thereby eliminating any errors which might be introduced due to eccentric mounting of the circle, and thus providing a modification which is useful where extreme accuracy is desired.

Referring to Fig. X, light from the light bulb 201 or other source is carried by the illuminating rod 202 to the non-graduated side of the transparent glass protractor 203 passing through it to illuminate the first portion of the protractor scale 204. The first portion of the protractor scale 204 is imaged onto the second portion of the protractor scale 205, which is 180° distant by means of the 1st and 2nd reflectors 206 and 207 and the lens 208. The superimposed portions of the protractor scale are then imaged on the reticle 209 by means of the 3rd and 4th reflectors 210 and 211 and the objective 212. A micrometer scale 213 is provided on the reticle 209 upon which the combined images of the two portions of the protractor scale are superimposed. The images are all viewed together through the eyepiece 214. In reading the protractor by means of the micrometer scale on the reticle, a line from each portion of the protractor scale is used. If these lines are imaged parallel, the space between them may be used for reading, or if the lines of the protractor scale are non-radial and are imaged as an X, the point at which they cross may be used for reading. In any event two lines 180° apart are involved in the reading in an averaging manner thereby eliminating errors due to eccentric mounting of the scale.

It is apparent that an averaging scheme may be used for reading the protractor whether the eyepiece is placed above the center of the protractor as shown in Fig. X or placed in a direct path above the second portion of the protractor scale similar to the arrangement shown in Fig. VII. It is also possible to image the micrometer scale onto the first portion of the protractor scale in a manner similar to that shown in Fig. VIII, then image the superimposed scales onto the second portion of the protractor scale 180° distant, viewing all three superimposed scales through an eyepiece or microscope which may or may not be arranged to bring the eyepiece above the center of the protractor. It is also possible to image the two portions of the protractor scale 180° apart and the micrometer scale to a common focal plane without imaging any of the scales directly on each other, or the two portions of the protractor scale 180° apart, may be imaged to a common focal plane without being imaged on each other, said focal plane coinciding with a surface of a reticle on which is provided a micrometer scale. It is even possible to use an averaging scheme with an opaque protractor if the protractor is provided with a specular reflecting surface, and many other variations and modifications are possible within the scope of the invention.

It is also possible to use some form of movable micrometer scale. An example of a system using a movable micrometer scale is illustrated in Fig. XI, in which: A glass plano-parallel plate 221 is rotatable by means of the knob 224 around an axis 225 perpendicular to the optical axis and parallel to the protractor divisions. This rotation of the plano parallel plate 221 moves the image of the protractor scale on the reticle 223 in a direction perpendicular to the protractor scale division.

In this manner the image of the nearest division of the protractor scale can be set on an index line (or between two index lines, or some other scheme) provided on the reticle, by turning the knob 224. A calibrated micrometer scale, not shown, is also turned with the knob 224, the readings of which indicate the subdivisions of the protractor scale. If desired, the micrometer scale may also be imaged on the reticle 223 and viewed through the eyepiece.

It should be realized that other means of moving the image of the protractor scale are possible, for example the objective or one of its elements may be moved perpendicular to optical path. It is also possible to move the reticle. All such schemes when combined with a calibrated micrometer afford accurate methods of reading the protractor scale within the scope of the invention.

Obviously, any of the reading schemes utilizing a movable micrometer scale can be combined with any of the basic optical schemes already described and illustrated in Figs. II, VII, VIII, IX and X, to form an accurate method of reading the protractor.

It is also possible to use an averaging system in which two portions of the protractor scale 180° apart are imaged independently to a common focal plane, each optical system containing a planoparallel glass plate which can be caused to rotate in opposite directions. The two portions of the protractor scale will then appear to move in opposite directions when the planoparallel glass plates are rotated, so that two divisions of the protractor scale exactly 180° apart can be made to coincide or brought into line. The micrometer scale is moved by the same means as the planoparallel plates and is calibrated to read subdivisions of the protractor scale. This scheme could be modified to one having a movable element in only one of the imaging systems which could be used to bring opposite divisions into coincidence.

The protractor instead of being planar could be cylindrical. In such case the inside of the cylinder might carry the graduations and numbers while the outside might be frosted and open to external sources of light to illuminate the graduations and numbers.

The illumination of the protractor when enclosed may be accomplished in many ways, one of which uses an electric light bulb and is illustrated by the drafting head shown in Figs. II and III. If an electric light bulb is used it need not necessarily be used exactly in the manner shown in Figs. II and III. For example, a reflector or prism could be used in place of the illuminating rod or the protractor could be illuminated directly from the light bulb. Also the light could be directed through the protractor from the side opposite the objective and reflectors which image the protractor scale onto the reticle in the case of a transparent protractor. If desired a lens or lenses could be added or diffusing means could

be added between the light bulb and the protractor.

It is also possible to illuminate the protractor from sources external to the instrument or by means of the ordinary lighting present in the drafting room. For example, this may be accomplished by using a reflector or combination of reflectors or prisms for directing the light onto the protractor. The light may or may not pass through a window in the drafting head but preferably it should be passed through a diffusing surface or reflected from a diffusing surface in order to minimize the effects due to the direction of light or any parallax which may be present at the focal plane of the reticle. If desired one of the reflectors could be movable, in order to adjust to the best lighting conditions for a given drafting room or for a given setting of the protractor arm. If desired a lens or combination of lenses could be included in the illuminating systems in order to concentrate the light.

Instead of using reflectors or prisms an illuminating rod or rods could be used for directing light into the drafting head and onto the protractor scale or any combination of reflectors, prisms, illuminating rods and lenses, not necessarily including all types could be used in the illumination system. It would also be possible to include an illuminating rod expanded into a fan shape or the like at its receiving end in order to pick up light from a wider angle in the drafting room.

However, all the schemes mentioned so far will only take in light from a limited angle around the drafting room and if no good source of light happens to be within the angle, illumination will probably be quite poor. Furthermore, the illumination will change as the protractor arm is rotated changing the angle from which light enters the instrument. This may necessitate a readjustment of the illuminating system every time the position of the protractor arm is changed.

A device for receiving light from all angles around the room and directing it on the protractor scale is shown in Fig. XII. Light enters the symmetrical illuminator 241 from all directions as shown by the arrows. The illuminator collects and concentrates this light and sends it forth in a more or less conical form. Then by suitable reflectors or other means, it is ultimately directed to illuminate the protractor scale within the drafting head. The rays of light ultimately return through the center of the symmetrical illuminator 241 for viewing through an eyepiece such as 242.

A method of illumination is illustrated diagrammatically in Fig. XIII which has some advantages over the method of illumination shown in Fig. II. Light from the light bulb 251 is directed by the illuminating rod 252 to the back side of the reflector 253. The reflector 253 is provided with a small central hole or at least a clear spot is provided in the reflecting coating thereon. The light passes through this clear spot or hole and is concentrated by a lens 254 and reflected by the reflector 255 against the protractor 256 to illuminate the protractor scale 257. The lens 254 and the reflectors 255 and 253 image a portion of the protractor scale 257 onto the reticle 258 so as to superimpose it on a micrometer scale or index mark 259. The superimposed scales are viewed through the eyepiece 260. The protractor 256 may or may not be provided with a diffuse reflecting surface.

One of the principal advantages of this method of illumination is that the light is directed against the protractor in a perpendicular direction so that a high percentage of it is reflected back through the optical system to the eye. Another advantage is that the light directed against the protractor is concentrated by the lens 254.

A special arrangement of the protractor scale division used in conjunction with two micrometer scales is shown in Fig. XIV, which makes it possible to read in quadrants as well as in a complete circle. Referring to Fig. XIV, the numbering from 0° to 359° around the complete protractor scale is shown at the top of the field, the numbering of the protractor scale in quadrants is shown at the bottom of the field, i. e. from 0° to 90° to 0° in either direction. Alternate quadrants of the circle are divided with long and short lines. The reticle is provided with two micrometer scales numbered in opposite directions as shown. The upper micrometer scale intersects all the protractor scale divisions. The lower micrometer scale intersects only the long protractor scale divisions.

The upper micrometer scale is always used when reading angles of the complete circle. It is also used when reading angles by quadrants on the short lines. The lower micrometer is used when reading angles by quadrants on the long lines. The numbering by quadrants is displaced by one degree in changing from the long to the short lines in order to compensate for the fact that the two micrometer scales run in opposite directions.

The invention has been described as applied to the art of drafting machines. This art, as is understood, includes not only engineering or architectural drawing and the like but also mapping or surveying. In the latter fields a drafting machine or angle plotting machine of high accuracy and ease of operation such as described herein is of special value.

Various modifications will occur to those skilled in the art in the composition, configuration and disposition of the component elements going to make up the invention as a whole, as well as in the selection and combination of component elements to accomplish the results herein taught.

What is claimed is:

1. In a drafting machine, a drafting head comprising a protractor enclosed within said drafting head, an element of transparent material symmetrical about an axis passing through the center of the protractor and perpendicular to it, said element having an annular light transmitting surface of relatively large surface area exposed to light from outside said drafting head and an annular light transmitting surface of relatively small surface area to transmit concentrated light into said drafting head, and means for directing this light onto said protractor in order to illuminate it.

2. In an instrument for measuring and laying out angles, a protractor provided with a protractor scale, said protractor scale having long and short lines in adjacent quadrants but with one end of all lines being at the same distance from the center of the protractor, these ends of the lines being numbered consecutively from 0 to 359 degrees and the other ends of the lines being numbered in quadrants and having the numbering by quadrants displaced by one degree in changing from the long to the short lines, a reticle, said reticle being provided with two micrometer scales running in opposite directions, and

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said reticle being positioned with respect to the protractor so that one of said micrometer scales appears to intersect all the protractor scale divisions and the other appears to intersect only the long protractor scale divisions and optical means for imaging a portion of said protractor scale onto said reticle.

3. In a drafting machine for use on a drafting board, a parallel motion device, a drafting head comprising a member maintained in orientation by said parallel motion device, a protractor scale rotatable with respect to said member maintained in orientation, a protractor arm for carrying at least one straightedge rotatable with respect to said protractor scale, a reticle provided with an index mark carried by said protractor arm, optical means including a lens carried by said protractor arm imaging a portion of said protractor scale in magnified form onto said reticle and an eyepiece lens for viewing said protractor scale superimposed on said index mark to determine the position of said protractor arm with respect to said protractor scale.

4. In a drafting machine for use on a drafting board, a drafting head comprising a member maintained in orientation, a protractor scale rotatable with respect to said member maintained in orientation, a protractor arm for carrying at least one straightedge rotatable with respect to said protractor scale, a reticle provided with an index mark mounted on a vertical axis passing through the center of said protractor scale, a reflector carried by said protractor arm directing light from a portion of said protractor scale toward the vertical axis, a second reflector directing light from said first reflector upward along the vertical axis and through said reticle, at least one lens along the optical path determined by said first and second reflectors for imaging a portion of said protractor scale in magnified form onto said reticle and an eyepiece above said reticle for viewing said protractor scale superimposed on said index mark to determine the position of said protractor arm with respect to said protractor.

5. In a drafting machine for use on a drafting board, a drafting head comprising a member maintained in orientation, a protractor scale carried by said member maintained in orientation, a center tube free to turn within said member maintained in orientation, a protractor arm for carrying at least one straightedge secured to said center tube for rotation with respect to said member maintained in orientation and said protractor scale, a reticle provided with an index mark mounted in said center tube, a tubular bracket secured to said center tube and extending radially therefrom, a reflector at the free end of said tubular bracket directing light from a portion of said protractor scale toward said central tube, a second reflector at the bottom of said center tube directing light from said first reflector upward through said center tube and through said reticle, at least one lens within said tubular members for imaging a portion of said protractor scale onto said reticle and an eyepiece above said reticle for viewing said protractor scale superimposed on said index mark to determine the position of said protractor arm with respect to said protractor.

6. In a drafting machine for use on a drafting board, a drafting head comprising a member maintained in orientation, a member carrying a protractor scale having a surface in frictional contact with a surface of said member main-

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tained in orientation, resilient means holding said surfaces in frictional contact so that said protractor scale is carried by said member maintained in orientation, a center tube free to turn within said member maintained in orientation, a protractor arm for carrying at least one straightedge secured to said center tube for rotation with respect to said member maintained in orientation and said protractor scale, clamp means for clamping said protractor arm to said member carrying said protractor scale to turn said protractor scale with said protractor arm against friction, a reticle provided with an index mark mounted in said center tube, a tubular bracket secured to said center tube and extending radially therefrom, a reflector at the free end of said tubular bracket directing light from a portion of said protractor scale toward said central tube, a second reflector at the bottom of said center tube directing light from said first reflector upward through said center tube and through said reticle, at least one lens within said tubular members for imaging a portion of said protractor scale onto said reticle and an eyepiece above said reticle for viewing said protractor scale superimposed on said index mark to determine the position of said protractor arm with respect to said protractor.

7. In a drafting machine for use on a drafting board, a drafting head comprising a member maintained in orientation, a glass protractor scale rotatable with respect to said member maintained in orientation, said glass protractor member being enclosed within the drafting head, a protractor arm for carrying at least one straightedge rotatable with respect to said protractor scale, a reticle provided with an index mark mounted on a vertical axis passing through the center of said protractor scale, a reflector carried by said protractor arm directing light from a portion of said protractor scale toward the vertical axis, a second reflector directing light from said first reflector upward along the vertical axis and through said reticle, at least one lens along the optical path determined by said first and second reflectors for imaging a portion of said protractor scale in magnified form onto said reticle and an eyepiece above said reticle for viewing said protractor scale superimposed on said index mark to determine the position of said protractor arm with respect to said protractor.

8. In a drafting machine for use on a drafting board comprising a member maintained in orientation, a protractor scale rotatable with respect to said member maintained in orientation, a protractor arm for carrying at least one straightedge rotatable with respect to said protractor scale, a reticle provided with an index mark mounted on a vertical axis passing through the center of said protractor scale, a reflector carried by said protractor arm directing light from a portion of said protractor scale toward the vertical axis, a second reflector directing light from said first reflector upward along the vertical axis and through said reticle, said second reflector having a central light transmitting opening, means for directing light through said light transmitting opening toward said first reflector to illuminate a portion of said protractor scale, at least one lens along the optical path determined by said first and second reflectors for imaging the illuminated portion of said protractor scale in magnified form onto said reticle and an eyepiece above said reticle for viewing said protractor scale superimposed on said index mark to determine the po-

sition of said protractor arm with respect to said protractor.

9. In a drafting machine for use on a drafting board, a drafting head comprising a member maintained in orientation, a member carrying a protractor scale having a surface in frictional contact with a surface of said member maintained in orientation, resilient means holding said surfaces in frictional contact so that said protractor scale is carried by said member maintained in orientation, a center tube free to turn within said member maintained in orientation, a protractor arm for carrying at least one straightedge secured to said center tube for rotation with respect to said member maintained in orientation and said protractor scale, clamp means for clamping said protractor arm to said member carrying said protractor scale to turn said protractor scale with said protractor arm against friction, a second clamp provided with fine adjustment means for clamping said protractor arm to said member maintained in orientation and for adjusting said protractor arm with respect thereto, a reticle provided with an index mark mounted in said center tube, a tubular bracket secured to said center tube and extending radially therefrom, a reflector at the free end of said tubular bracket directing light from a portion of said protractor scale toward said central tube, a second reflector at the bottom of said center tube directing light from said first reflector upward through said center tube and through said reticle, at least one lens within said tubular members for imaging a portion of said protractor scale onto said reticle and an eyepiece above said reticle for viewing said protractor scale superimposed on said index mark to determine the position of said protractor arm with respect to said protractor.

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References Cited in the file of this patent

UNITED STATES PATENTS

Number	Name	Date
5 669,705	Reeh -----	Mar. 12, 1901
1,360,496	Butterfield -----	Nov. 30, 1920
1,502,223	Abraham -----	July 22, 1924
1,542,397	Konig -----	June 16, 1925
1,550,755	Steinle -----	Aug. 25, 1925
10 1,665,867	Wachtel -----	Apr. 10, 1928
1,763,482	Scheppmann -----	June 10, 1930
1,804,105	Martins -----	May 5, 1931
1,877,340	Kuhlmann -----	Sept. 13, 1932
15 2,130,494	Heine -----	Sept. 20, 1938
2,173,316	Sproule -----	Sept. 19, 1939
2,181,926	Tiger -----	Dec. 5, 1939
2,196,936	Nash -----	Apr. 9, 1940
2,221,317	Wild -----	Nov. 12, 1940
20 2,241,690	Williams -----	May 13, 1941
2,256,445	Weidemann -----	Sept. 16, 1941
2,286,430	Minton -----	June 16, 1942
2,307,951	Plant -----	Jan. 12, 1943
2,413,848	Simpson -----	Jan. 7, 1947
25 2,465,497	Turretini -----	Mar. 29, 1949
2,480,237	Godfrey -----	Aug. 30, 1949

FOREIGN PATENTS

Number	Country	Date
30 619,090	Germany -----	Sept. 21, 1935
617,883	Great Britain -----	Aug. 4, 1939
870,687	France -----	May 7, 1941
869,786	France -----	Nov. 17, 1941
884,265	France -----	Apr. 19, 1943
35 889,251	France -----	Sept. 27, 1943