June 8, 1926. 1,588,221

W. BAUERSFELD

METHOD OF MAKING MARK PLATES FOR MICROMETER OCULARS AND MOUNTING OF THE SAME

Filed August 15, 1924 3 Sheets-Sheet 1

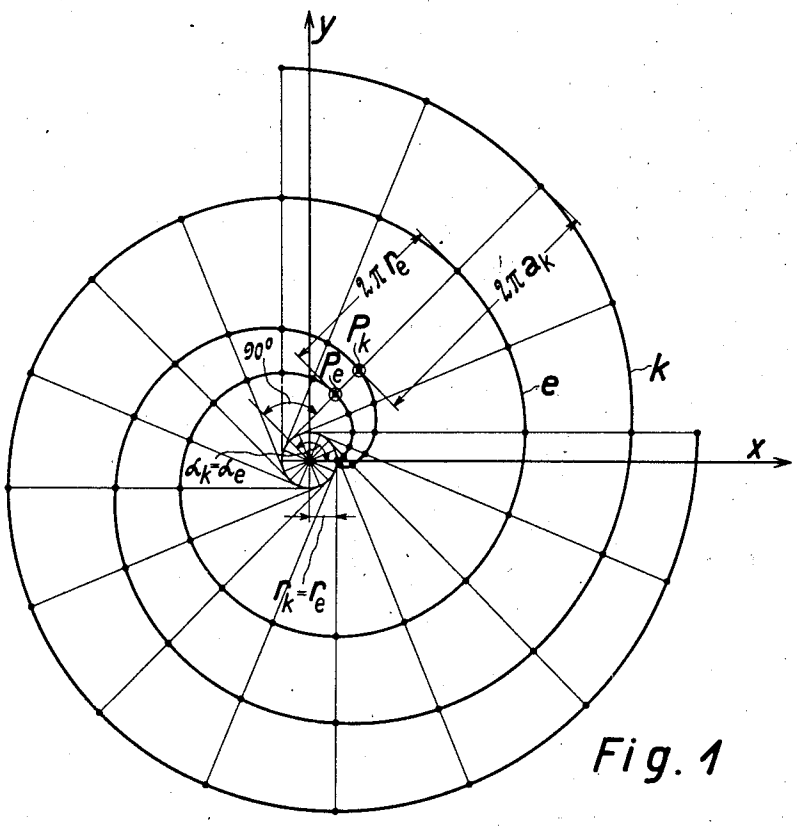


Fig. 1

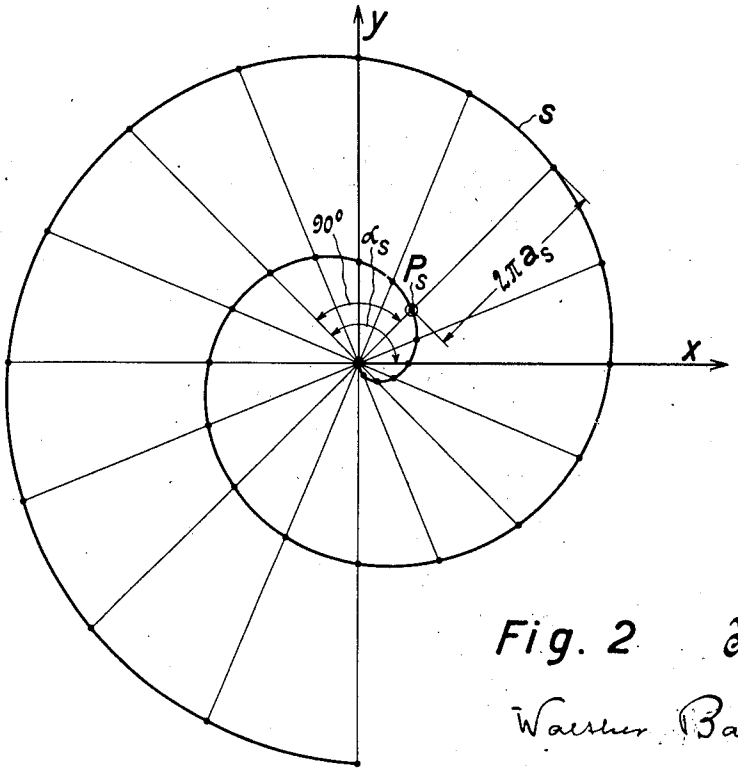


Fig. 2

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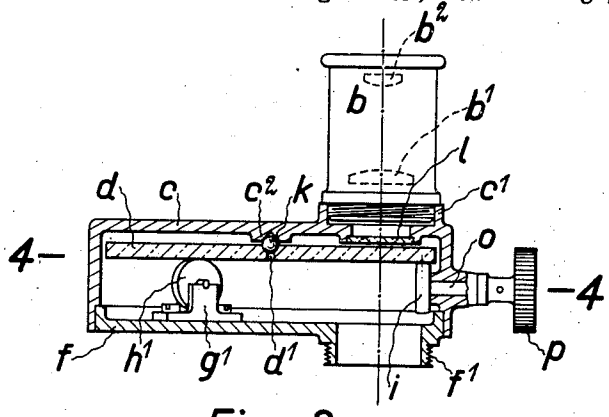


Fig. 3

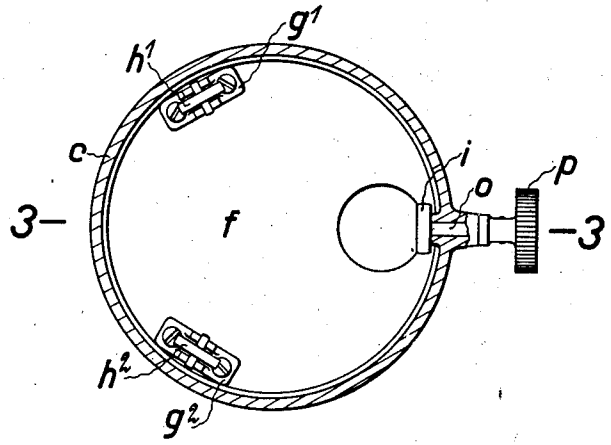


Fig. 4

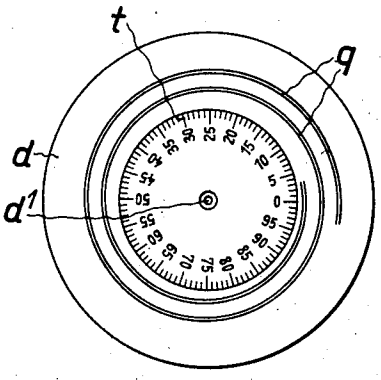


Fig. 5

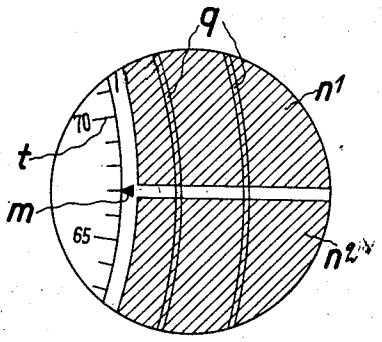


Fig. 6

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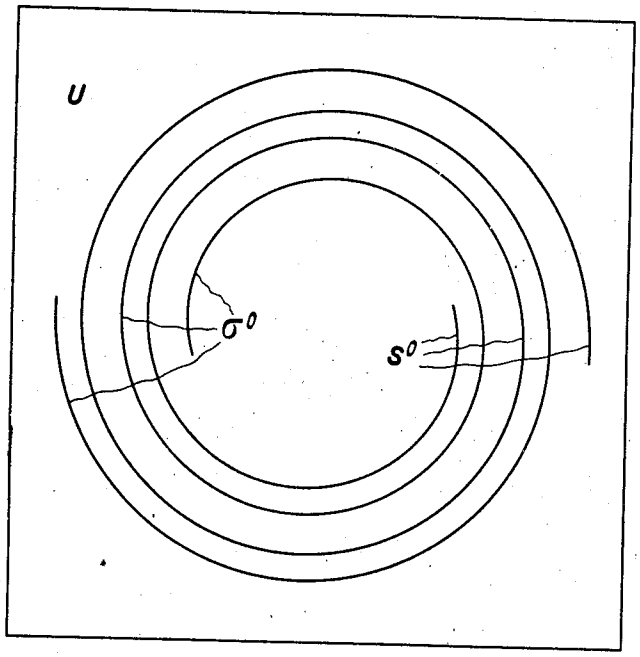


Fig. 7

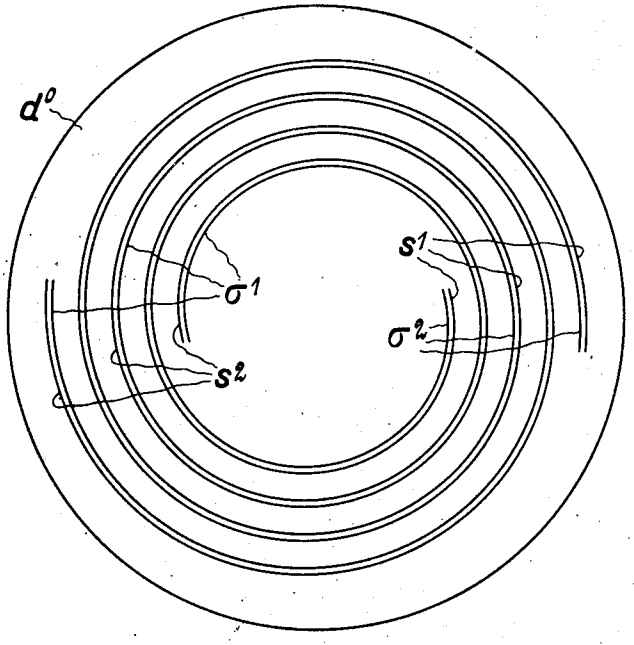


Fig. 8

Inventor:

Walther Bauersfeld

Patented June 8, 1926. 1,588,221

UNITED STATES PATENT OFFICE.

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METHOD OF MAKING MARK PLATES FOR MICROMETER OCULARS AND MOUNTING OF THE SAME.

Application filed August 15, 1924, Serial No. 732,296, and in Germany October 1, 1923.

The examination of short distances (e. g. graduations of rules) is frequently carried out with optical observation instruments which are provided with micrometer oculars. The present invention relates to such micrometer oculars in which a rotatable mark plate is fitted with a spiral, embracing the point of intersection of the axis of rotation with the plane of the mark as a pole, which spiral is successively brought into coincidence with the image, adjusted on a radial ray, of the extreme points of the distance to be meausred, whereby the radial distance of the two spiral points coinciding with the extreme points can be directly read off on a circle-division fixed concentrically with the axis of rotation on the mark plate itself. The present invention affords a method of making the mark plates and prevents the point of rotation of the plane of the mark from deviating from the pole of the spiral, and consequently the curve from having an eccentric error which might impair the result of measurement. The new method provides mark plates in which the mark consists of several spirals embracing the axis of rotation of the mark plate in the point of rotation of the plane of the mark. Thereby the construction of these spirals rests upon a circle (whose radius may in a given case assume the limit zero) described about the point of rotation of the plane of the mark and they fulfil the condition that the distance of two adjoining windings measured on a pencil of tangents of this circle has a constant magnitude. For it is by no means suitable that the mark is formed by a single spiral because, as is well known, it is difficult to attain the exact coincidence of a point (e. g. an extreme point of the distance to be measured), which is as usual denoted by a line perpendicular to the distance to be measured, with a curve likewise represented by a line. If, however, the curve be an imagined line, which bisects the distance between two real curves travelling beside each other at an invariable, comparatively short distance, the adjustment is possible in a much more exact manner. The spirals which obey to the said law may be represented by the following two equations related to a rectangular co-ordinate-system, the origin of which coincides with the point of rotation of the plane of the mark.

$$(1) \quad x = r.\cos\alpha + a.\alpha.\sin\alpha$$

$$(2) \quad y = r.\sin.\alpha - a.\alpha.\cos.\alpha$$

In these equations a denotes an optional distance, r the radius of a circle on which the construction of the curve rests and α the angle which the normals of the tangents of this circle, apertaining to the single curve-points, form with the axis of abscissas. When using the curves characterized by the equations the position of the image of the distance to be measured during the measurement must be so chosen that this image falls upon one of the tangents forming the said pencil of tangents.

According to the invention the mark plate is made by photographically transmitting the mark by means of a double exposure from a pattern to the mark plate, whereby the mark plate is rotated between exposures through 180° about the same axis of rotation about which it is to be subsequently rotated with the rotations taking place for measuring purposes in the micrometer ocular. Thereby the pattern is provided with two spirals, of which the one has originated from the other by means of rotation about the centre of the circle, on which its construction rests, through an angle deviating a little from 180°. Hence, there arise on the mark plate two double spirals which are congruent to each other and each of which bisects the interval between the windings of the other one. As, however, one only requires one double spiral for the measurements, one can suitably cover with the twofold transmission of the pattern to the mark plate in the one position of the latter the one spiral and in the other position the other spiral. In the event of an eccentric error both curves forming the double spiral would be uniformly displaced in opposite direction, viz, by the amount of the eccentricity relatively to their correct position and consequently the width of the interval between the double lines would vary. However, a simple consideration shows that the curve bisecting the interval itself is again a spiral congruent to the two spirals forming the double curve with which the centre of the circle, on which its construction rests, bisects the connecting line of the two centres of the

circle appertaining to the two spirals of the double curve. Thereby it is achieved that with this imagined curve, which is actually used for the measurement, the eccentric error is eliminated.

For the use in micrometer oculars it is suitable to select from the number of the available spirals those, whose construction can be carried out as exactly as possible with the simplest possible means in order that the pattern, serving as a base for making the mark plate, is not afflicted already with objectionable defects. Such curves of simplified construction result if in the equations (1) and (2) the magnitude a assumes the value

$$(3) \quad a=r$$

or the magnitude r the value

$$(4) \quad r=O$$

In the former case the equations of the curve read:

$$(5) \quad x=r\ (\cos\alpha+\alpha.\ \sin\alpha)$$
$$(6) \quad y=r\ (\sin\alpha-\alpha.\ \cos\alpha)$$

and represent an involute of a circle. The second case with the equations

$$(7) \quad x=a.\ \alpha\ \sin\alpha$$
$$(8) \quad y=-a.\ \alpha\ \cos\alpha$$

is realized by an Archimedean spiral.

For the actuation of the mark plate suffice the simplest means since the measurement is not impaired by back lash between the actuating member and the mark plate. Special care must, however, be used for the bearing and guide of the mark plate. The usual construction with a cylindrical guide-pivot, guided in a likewise cylindrical bearing, is not to be recommended owing to the unavoidable defects connected therewith through the play which always exists between the two elements. According to the invention it is possible to provide micrometer oculars with a rotatable mark plate made after the above described method which mark plate is actuated by a friction wheel and guided by a ball held by a bearing fixed on the micrometer ocular and engaging into a recess of the mark plate in such a way that its centre lies in the plane of the mark.

In the annexed drawing Figs. 1 and 2 show examples of the curves corresponding to the equations (1) and (2), (5) and (6) as well as (7) and (8).

Figs. 3 to 8 represent a constructional example of a micrometer ocular provided with a rotatable mark plate according to the invention. Fig. 3 shows partly in a cross section the micrometer ocular in elevation, Fig. 4 shows in a plan elevation a section on the line 4—4 of Fig. 3. Fig. 5 shows a top view of the rotatable mark plate and Fig. 6 represents on an enlarged scale the image perceived by the observer in the ocular with an optional position of the mark plate. Fig. 7 is a greatly enlarged top view of a pattern available for making the rotatable mark plate and Fig. 8 is on the same scale a top view of an unfinished mark plate made with this pattern by photographic process and with which the exposures are assumed to be made without covering a part of the curves of the pattern.

Fig. 1 not only shows the general case according to the equations (1) and (2) with a curve k but also the first special case according to the equations (5) and (6) with an involute e. The parameters r and a have thereby magnitudes r_k and a_k and r_e respectively as shown in the drawing. By α_k and α_e respectively are denoted the angles which the normals of the tangents of a circle appertaining to optional curve-points P_k and P_e respectively form with the axis of abscissas. An Archimedean spiral s (Fig. 2) corresponds as the second special case to the equations (7) and (8) and has a parameter a of a magnitude a_s as shown in the drawing. As hereby $r=O$, the tangents of the circle on which the construction of the curve is based appear as radial rays through the zero point of the co-ordinates, whereby α_s denotes the angle formed by the normal on the radial ray appertaining to an optional curve-point P_s with the axis of abscissas.

In the example illustrated in Figs. 3 to 8 there is screwed by means of a threaded tube c^1 on an ocular tube b (Figs. 3 and 4) fitted with two ocular lenses b^1 and b^2 a casing c for a rotatable, circular mark plate of glass d. The casing c is closed with a lid f which is provided with a threaded tube f^1 in order to be able to fix the micrometer ocular on an optical observation instrument. On the lid f are also provided two bearings g^1 and g^2 in which are supported two rollers h^1 and h^2 which carry conjointly with a driving-pulley i the mark plate d. The latter is pierced at its centre at d^1 and a ball k which is ground at this place in the mark plate d up to the depth of half the diameter of the ball and which, on the other hand, rests in a conical bearing c^2 of the casing c, serves for guiding the mark plate d. The top surface (vide the drawing) of the mark plate d lies in the front focal plane of the ocular and must during the use of the ocular simultaneously lie in the rear focal plane of the imaging system of the optical observation instrument. In the threaded tube c^1 there is disposed a second, fixed mark plate l in such a way that its bottom surface (vide the drawing) lies close to the rotatable mark plate d. This surface carries an index m (Fig. 6) and two semi-transparent diaphragm surfaces n^1 and n^2 which partly cover the field of view. For actuating the driving-pulley i which is fixed on a bolt o serves

a milled head p. The rotatable mark plate d (Fig. 5) carries an Archimedean double spiral q and a circle-division t, whose centre lies with the pole of the spiral q in the axis of the bore d^1 and with which the index m coacts. A pattern plate u (Fig. 7) is provided with two uniform Archimedean spirals s^0 and σ^0 with a joint pole, of which the one almost bisects, but not exactly, the interval of the windings of the other one. A mark plate d with copies s^1, s^2 and σ^1, σ^2 of the two spirals s^0 and σ^0, for the manufacture of which by means of a twofold exposure on the mark plate rotated through 180° the pattern u is suitable, is shown in Fig. 8.

The method of making the mark plate illustrated in constructional example is as follows. On a pattern-plate u one makes at first two uniform Archimedean spirals s^0 and σ^0 by bringing the exactly drawn spiral s^0 into the position σ^0 by means of rotation about its pole through an angle deviating but little from 180°. After the spiral σ^0 has been covered, a photographic exposure of the pattern u is made on a suitable mark plate d. Thereupon the spiral s^0 is covered instead of the spiral σ^0 and a second exposure made on the mark plate d after the same has been rotated through exactly 180°, whereby as a guide during this rotation the ball k was used which was placed into the bore d^1 corresponding to the pole of the spiral-image s^1 first photographed. The mark plate d is therefore provided with the spiral-images s^1 and σ^2 which form the double spiral q. Moreover, the graduation t is traced in an optional way upon the mark plate d. The manufacturer of a mark plate with curves which obey to the equations (1) and (2) or (5) and (6) is the same except that instead of the Archimedean spiral one of the above mentioned curves is first traced upon the pattern-plate u.

The measuring process with the micrometer ocular as illustrated consists in this that both extreme points of the distance to be measured, which is imaged in the plane of the mark by the imaging system of the observation instrument, are successively brought, by rotating the milled head p, into such a position relatively to the double spiral q that they bisect the interval between the two lines. The difference between the values read off on the index m and the graduation t for these two adjustments of the rotatable mark plate d indicates with a corresponding gauging of the graduation t the length sought of the distance to be measured. It is, of course, just as well possible to carry out measurements with a mark plate provided with two double spirals, during the manufacture of which none of the single curves is covered. Such mark plates require, however, a double graduation, each of which extends to half a circumference of the mark plate. When using Archimedean spirals, the two semi-transparent diaphragm surfaces are to be so disposed that the intermediate strip which is not cut off from the light is in radial direction to the point of rotation of the mark plate d. When using the involute or the curve represented by the equations (1) and (2) as a measuring curve, this strip ought to lie on the place of the mark tangentially on the circle upon which the construction of the measuring curve is based. The cutting down of the light has for its object to confine the space of measurement in the ocular without rendering difficult, as it might easily occur with opaque shutters, the detection and adjustment of the image of the distance to be measured in the ocular field.

I claim:

1. Method of making rotatable mark plates destined for micrometer oculars, consisting in tracing two congruent spirals on an auxiliary plate, each of these spirals being related to a circle in such a way that the distance of two adjoining windings of the spiral as measured on a pencil of tangents of the circle, has a constant magnitude, and the two spirals being so traced that the two appertaining circles coincide with each other and the one spiral is rotated relatively to the other through an angle differing but little from 180°, and then in twice photographically transmitting the auxiliary plate to the mark plate, and rotating the mark plate in its plane about its centre through 180° between the two exposures.

2. Method of making rotatable mark plates destined for micrometer oculars, consisting in tracing two congruent spirals on an auxiliary plate, each of these spirals being related to a circle in such a way that the distance of two adjoining windings of the spiral as measured on a pencil of tangents of the circle, has a constant magnitude, and the two spirals being so traced that the two appertaining circles coincide with each other and the one spiral is rotated relatively to the other through an angle differing but little from 180°, then covering one spiral and photographically transmitting the other spiral from the auxiliary plate to the mark plate, then rotating the mark plate in its plane through 180° about its centre, then in uncovering the covered spiral and covering the photographed spiral and then repeating the photographic transmission of the spiral from the auxiliary plate to the mark plate.

3. Method of making rotatable mark plates destined for micrometer oculars, consisting in tracing two congruent spirals on

an auxiliary plate, each of these spirals being related to a circle in such a way that the distance of two adjoining windings of the spiral as measured on a pencil of tangents of the circle, has a constant magnitude, and the two spirals being so traced that the two appertaining circles coincide with each other and the one spiral is rotated relatively to the other through an angle differing but little from 180°, in the fitting on a mark plate a bearing device allowing of rotating the mark plate in its plane, and then in twice photographically transmitting the auxiliary plate to the mark plate in such a way that the common centre of said circles falls into the axis of the bearing device, and rotating the mark plate in its plane about the said bearing device through 180° between the two exposures.

4. Method of making rotatable mark plates destined for micrometer oculars, consisting in tracing two congruent Archimedean spirals on an auxiliary plate, the centres of the two spirals coinciding with each other and the two spirals being displaced relatively to each other through an angle differing but little from 180°, and then in twice photographically transmitting the auxiliary plate to the mark plate, and rotating the mark plate in its plane about the common centre of the two spirals through 180° between the two exposures.

5. The combination of a casing fitted with a fastening device, adapted to fix the casing on an optical observation instrument, a transparent plate provided with measuring marks and disposed within the casing, a ball inserted between the centre of the plate and the casing, a bearing device keeping the plate, the ball and the casing in contact with each other, a friction disc, rotatably supported in the casing and coacting with the plate, an actuating device connected to the friction disc, and an ocular fixed on the casing and allowing of observing the plate.

6. The combination of a casing fitted with a fastening device, adapted to fix the casing on an optical observation instrument, a transparent plate provided with measuring marks and disposed within the casing, a ball inserted between the centre of the plate and the casing, two rollers, rotatably supported in the casing and acting upon the face of the said plate, opposed to the said ball, a friction disc, rotatably supported in the casing and acting on the same face of the plate as the said rollers, the rollers and the friction disc cooperating to keep in contact the plate and the ball, and an ocular fixed on the casing and allowing of observing the plate.

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