March 11, 1924. 1,486,203

H. THUN

APPARATUS FOR THE MEASUREMENT OF PLANE SURFACES

Filed Dec. 7, 1920

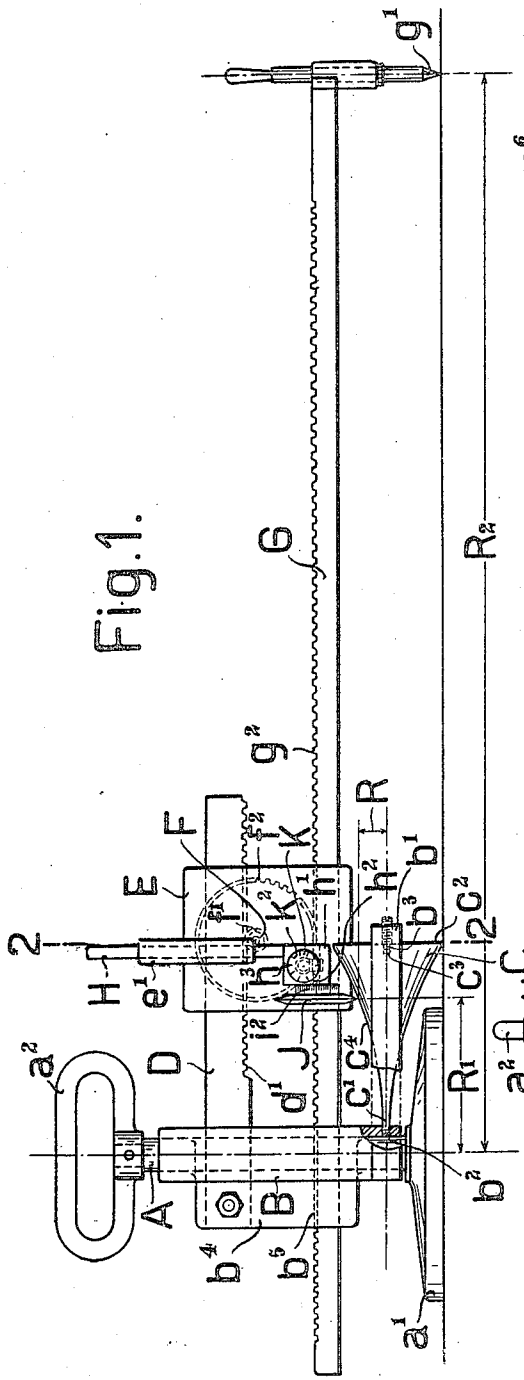


Fig. 1.

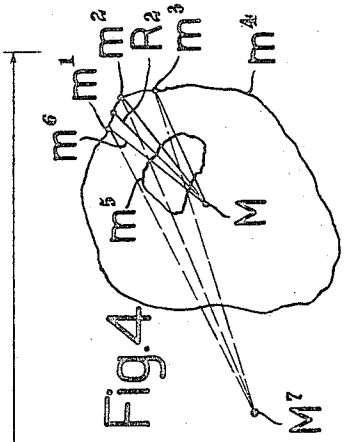


Fig. 4.

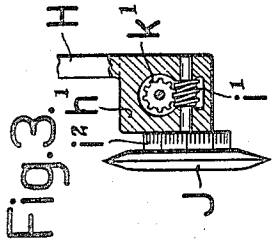


Fig. 3.

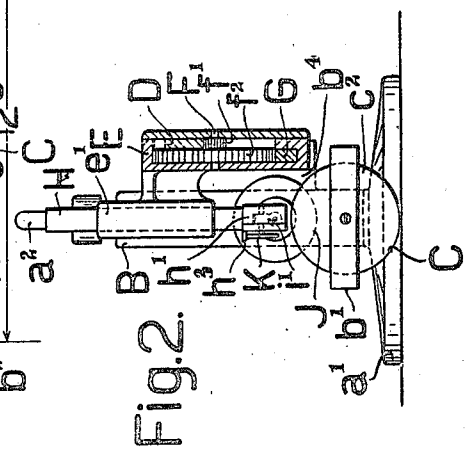


Fig. 2.

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UNITED STATES PATENT OFFICE.

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APPARATUS FOR THE MEASUREMENT OF PLANE SURFACES.

Application filed December 7, 1920. Serial No. 429,027.

To all whom it may concern:

Be it known that I, HERMANN THUN, residing at Essen, Germany, a citizen of the German Republic, have invented a certain new and useful Improvement in Apparatus for the Measurement of Plane Surfaces, of which the following is a specification.

The present invention relates to an apparatus for measuring plane surfaces, which is distinguished by a particularly advantageous construction and method of working.

A constructional example of the subject matter of the invention will be described with reference to the accompanying drawings in which,

Figure 1 is a longitudinal elevation, partially in section of a construction according to this invention,

Figure 2 is a section on the line 2—2 of Fig. 1 looking from the right, and on a larger scale.

Figure 3 is a detail of Figure 1 partially in section and

Figure 4 is a diagram which serves to explain the manner in which the apparatus works.

On a cylindrical column A (see Figure 1) which is provided at the bottom with a foot plate a^1 and at the top with a handle a^2, is mounted a rotating sleeve B. The lower end of this sleeve B is fitted with a laterally projecting frame b^1 and into an aperture b^2 located in the lower end of the said sleeve B projects the point c^1 (constructed in the form of a pivot pin) of a revolution paraboloid C, which has in its circular base c^2 an axial aperture c^3 into which projects a pivot pin b^3 carried by the frame b^1 (see Figure 1). The longitudinal axis of the revolution paraboloid C determined by the axes of the pivot pin c^1 and the aperture c^3 cuts the axis of rotation of the sleeve B at right angles. The axis of symmetry of the generative parabola c^4 of the revolution paraboloid C coincides with the axis of rotation of the column A. The apparatus is so constructed that when the column A is placed with its foot plate a^1 on a foundation or support, the paraboloid C just touches this foundation or support with the peripheral edge of its base in the manner shown in Figures 1 and 2, so that when the sleeve B is rotated about the column A the paraboloid C rotates on the foundation or support.

The sleeve B has a projection b^4 (see Figures 1 and 2) to which is attached a rack D provided with teeth d^1 on its underside. Fitted to the rack D is a longitudinally movable slide E, in which are mounted two rigidly united gear wheels f^1 and f^2 which are both carried and rotate on the same shaft F. The gear wheels f^1 gears into the teeth d^1 of the rack D and the gear wheel f^2 into the teeth g^2 of a rack G which is movable longitudinally in the slide E. The rack G is parallel with the rack D and carries on one end a downwardly extending pin g^1, which is intended to travel round the portion of surfaces to be measured. A rectangular recess b^5 (see Figure 1) is provided in the projection b^4 for the other end of the longitudinally movable rack G and acts as a guide therefor.

The slide E has a projection e^1, in a vertical opening of which a rectangular bar H is slidably guided, and on the lower end of the bar H is mounted a hollow block h^1, in which is mounted and rotates a worm i^1 (see Figures 2 and 3). The worm shaft has one end projecting from the block h^1, and a friction wheel J is mounted thereon on which is inscribed a scale i^2. The worm i^1 gears into a worm wheel k^1 also mounted in the block h^1 and having on the end of its shaft which projects from the block h^1 a wheel K, on which is inscribed a scale k^2. Each of the scales i^2 and k^2 is provided with a reading off mark h^2 and h^3 respectively, inscribed on the block h^1. The divisions of the scales i^2 and k^2 have numbers (not shown) allotted to them which denote units of surface area. The friction wheel J, hereinafter termed the measuring wheel, bears upon the outer surface of the paraboloid C and the arrangement of the several parts is such that the axis of rotation of the measuring wheel J lies in the plane including the axis of rotation of the sleeve B and parallel to the axis of the paraboloid C. The mechanism actuated by the wheel J and carried by the block h is termed the registering mechanism and this mechanism and the wheel together constitute the measuring mechanism.

For the purpose of illustrating the manner in which this apparatus for the measure-

ment of plane surfaces works, let it be assumed that the reading off marks h^2 and h^3 are opposite the zero divisions of the corresponding scales i^2 and k^2. Supposing that a plane surface bounded by a series of curved lines m^4 is to be measured, the column A is placed with its foot plate a^1 on a point of the surface to be measured which lies within it for example as denoted in Figure 4 by M and is held rigidly in this position during the measuring operation. The pin g^1 is next guided by pushing along the rack G to any desired point m^1 on the boundary line m^4 of the surface to be measured. During this longitudinal movement of the rack G the slide E is moved longitudinally by means of the toothed wheel gearing g^2, f^2, f^1, d^1 on the rack D mounted on the sleeve B, and the ratio of transmission of this toothed wheel gearing is such that the ratio of the distances (denoted in Figure 1, by R_1 and R_2) of the measuring wheel J and the pin g^1 from the axis of rotation of the sleeve B remains constant.

The measuring operation is now carried out by guiding the pin g^1 (starting from the point m^1) in one and the same direction round the boundary line m^4 of the surface to be measured. During this guiding of the pin g^1 both a longitudinal and a rotary movement of the rack G are produced.

For the purposes of further comprehension of the working of this apparatus let it be supposed that the surface to be measured is divided up into an infinite number of elementary triangles with equal angles at the center, all of which proceed from the point M and of which two are shown on an enlarged scale in the drawing. The area of each of these elementary triangles is proportional to the square of the radius R_2 (see Figure 4) corresponding to this triangle proceeding from the point M and bisecting the angle at the center.

The operations which take place while the pin g^1 is guided from the point m^1 to the point m^2 of the boundary line m^4 will first be described. In consequence of the longitudinal movement of the rack D which takes place during this guiding of the pin g^1 the slide E moves along the rack D and consequently the measuring wheel J is moved on the outer surface of the paraboloid C in an axial direction. The radius R (see Figure 1) of its point of contact with the outer surface of the paraboloid C is at the same time, as the relationship $R_1 : R_2 =$ a constant already mentioned still exists, proportional to the square of R_2 (see Figures 1 and 4) according to the equation which applies for the generatrix of the paraboloid C.

In consequence of the rotary movement of the rack G, which takes place when the pin g^1 is guided in the manner above described, the sleeve with all the parts mounted upon it is rotated round the axis of the column A and at the same time the paraboloid C, rotating about the axis determined by the pin c^1 and the aperture c^3, rolls over the foundation or support. This rolling of the paraboloid C causes the measuring wheel J to turn also and the amount of turning of the measuring wheel J is a linear function of the radius R and consequently a quadratic function of the distance of the pin g^1 from the axis of rotation of the sleeve B, which is denoted by R_2. Since, as has already been stated, the area of the elementary triangle determined by the points M, m^1 and m^2 is proportional to the square of the distance R_2 and consequently is also a quadratic function of the distance R_2, the angular path traversed by the measuring wheel J forms directly a measure of the elementary triangle which is determined by the points M, m^1, m^2.

The scales i^2 and k^2 which take part in the rotary movement of the measuring wheel J are so numbered that the area of this elementary triangle can be read off by means of the fixed reading off marks h^2 and h^3. As the pin g^1 is moved on during the further progress of the measuring operation from the point m^2 to the point m^3 of the series of lines, the above described operations are repeated in accordance with the facts and there is added to the angular path already traversed by the measuring wheel J an angular path which is a measure of the elementary triangle determined by the points M, m^2, m^3. The area of the two elementary triangles M, m^1, m^2 and M, m^2, m^3, can therefore now be read off on the reading off device formed by the scales i^2 and k^2 and the marks h^2 and h^3. On guiding the pin g^1 still further along the series of lines m^4 the areas of the elementary triangles passed through will be added in a similar manner to the result which can be read off on the reading off device i^2, h^2, k^2, h^3 and it is therefore clear that the moment the pin g^1 again reaches the point m^1, the reading off device i^2, h^2, k^2, h^3 indicates the sum of the areas of all the elementary triangles in the surface included in or bounded by the series of lines m^4 or in other words indicates the area of this surface.

It can be proved that the area of the surface bounded by the series of lines m^4 can be determined by passing round it once, if the column A be placed on a point M^7 (see Figure 4) outside the surface to be measured.

Furthermore it is possible to deduct from the total result a smaller surface lying within the surface bounded by the series of lines m^4 in the following manner. After passing round the series of lines m^4 in the direction of rotation above given, the pin g^1 is guided on the line m^6 to the series of lines

m^5 and after having been passed round the series of lines m^5 in the reverse direction, is again returned on the line m^6 to the point m^1.

An important advantage of the apparatus forming the subject of the present invention results from the fact that the member (i. e. the paraboloid C) which drives the reading of apparatus travels over an arc of a circle, the centre point of which does not change during the measuring operation, whereby it is possible to see at once whether the point selected for the position of the apparatus will enable the measuring operation to be carried out or not. Also another and very important advantage is that in comparison with known surface measuring appliances there are no positions for the column A of the machine which are capable of causing an error in the result of the measurement. For this reason therefore no special attention need be paid to the selection of the point on which the apparatus is set up.

Claims:

1. An apparatus for the measurement of plane surfaces comprising a tracer pin adapted to be moved around the surface to be measured, a column, means connecting said tracer pin to said column whereby said tracer pin may be moved radially to and circumferentially about said column, a registering device, a measuring wheel operatively connected thereto, a paraboloid, means whereby said paraboloid is revolubly supported to roll in contact with said measuring wheel and with a fixed surface about an axis which is radial to said column and is constrained to move thereabout in accordance with the circumferential movements of said tracer pin, means connecting said first named connecting means to said measuring wheel so that when the tracer pin is moved around the surface to be measured the wheel will be so positioned radially that the rotation imparted thereto by said paraboloid is a quadratic function of the distance of said tracer pin from said column.

2. An apparatus for the measurement of plane surfaces comprising a column, a carrier rotatably mounted on said column, a slide supported by said carrier to move at right angles to the axis of the column, a tracer pin supported by said slide, a measuring wheel mounted to move with said slide, a revolving paraboloid mounted on said carrier with its axis at right angles to that of said column, said paraboloid being adapted to roll upon a fixed surface when said carrier is rotated and said measuring wheel being adapted for rolling on the outer surface of said paraboloid.

3. An apparatus adapted for measuring plane surfaces comprising a rotatably mounted carrier, a slide supported thereby to move at right angles to the axis of rotation of the carrier, a tracer pin, means for supporting said tracer pin from said carrier whereby the pin will be moved circumferentially with the carrier but may be moved radially with reference thereto, a measuring wheel and registering mechanism mounted to move with the slide, the wheel being adapted to actuate said mechanism, a revolving paraboloid supported by said carrier and adapted to revolve by contact with a fixed surface when said carrier is rotated, said measuring wheel contacting with said paraboloid to cause said registering mechanism to function, for the purpose of indicating the area of the measured surface.

4. An apparatus of the class described adapted for measuring plane surfaces comprising a rotatably mounted carrier, a rack radially projecting therefrom, a slide supported on the rack and movable therealong, a radially movable rack supported by said carrier, a tracer pin carried by the end of said last named rack, a measuring means including a measuring wheel supported by said slide, a connection between said first mentioned rack, said slide and said longitudinally movable rack whereby the ratio of the distances of the measuring wheel and of the tracer pin from the axis of rotation of the carrier is maintained constant.

5. An apparatus for the measurement of plane surfaces comprising a tracer pin, means forming a pole or pivot, means connecting said tracer pin to said pivot whereby said pin is adapted for movement radially to said pivot and circumferentially about it, a registering device, a measuring wheel operatively connected to said device, an axially-elongated rolling body, circular in cross section and comprising a paraboloid, means supporting said body whereby its axis is maintained radial to said pivot and is controlled to swing about it in accordance with the circumferential movements of the tracer pin, the body being thus adapted for rolling upon a fixed surface and about the pivot, and means for so connecting said measuring wheel to a part of said pin-and-pivot-connecting means that the wheel will be maintained in rolling contact with the paraboloid and will be so bodily moved axially therealong, by the radial movements of the pin, as it is caused to trace the outlines of the area being measured, that the revolutions imparted to the wheel by the resulting rolling of the elongated body will be a quadratic function of the distance of said pin from the axis of the pivot.

6. A polar planimeter comprising a frame adapted to turn about a pole perpendicular to the surface to be measured, an outline-tracing pointer, means whereby said pointer is guided by the frame for movement relative thereto in a straight path directed sub-

stantially towards the pole, and area-registering means adapted for actuation upon pivotal movement of the frame over a stationary surface by rolling contact of one of the elements of the means with said surface, said means including an axially elongated pivoted member mounted in the frame with its axis radial to the pole and substantially parallel to the path of movement of the pointer, said member being so actuated as to rotate in harmony with any circumferential movement of the pointer about the pole, said area-registering means also including a friction wheel mounted for rolling contact with said member and for bodily movement lengthwise thereof and means whereby said bodily movement is controlled by the pointer to be in harmony with the movement of the latter radial to the pole, said axially elongated member being circular in cross-section and so varying in size along its axis that for any plane of contact with the wheel its diameter will bear a fixed ratio to the square of the corresponding distance of the pointer from the pole.

The foregoing specification signed at Essen, Germany, this 17th day of August, 1920.

HERMANN THUN.

In presence of—
HANS GOTTSMANN,
CARL MÜLLER,