Freely suspended

Precision Pantographs

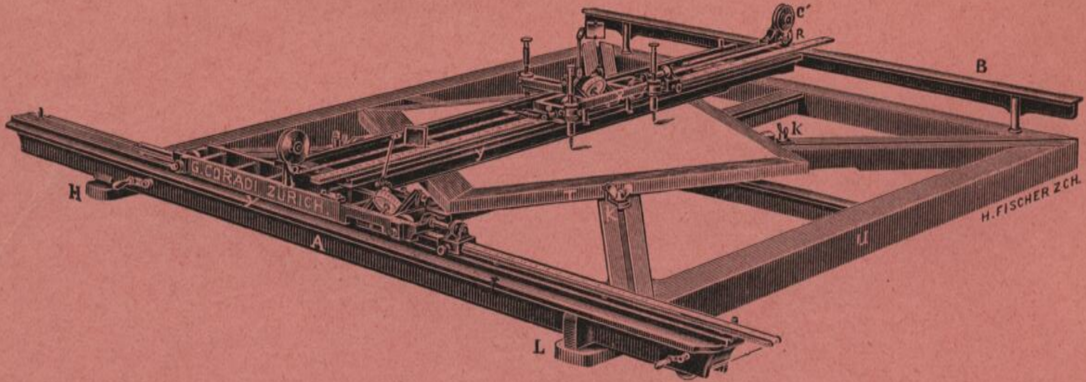
of

G. Coradi, Zurich

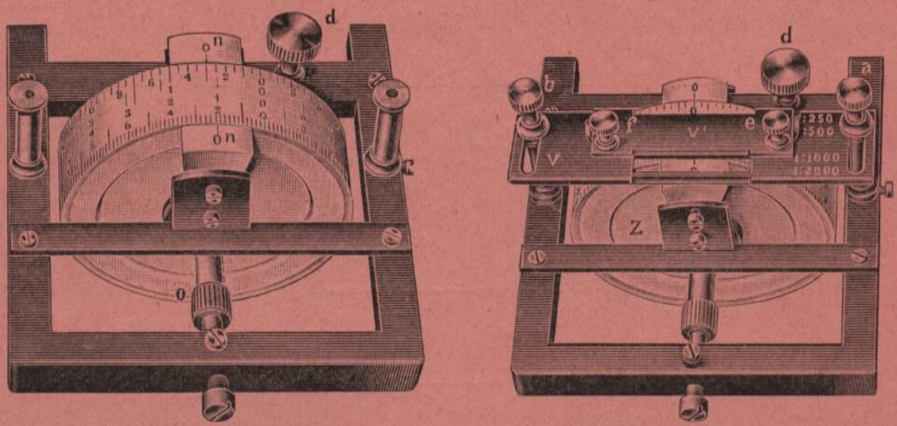
1914

ZURICH
Typography Aschmann & Scheller, Predigerplatz
1914

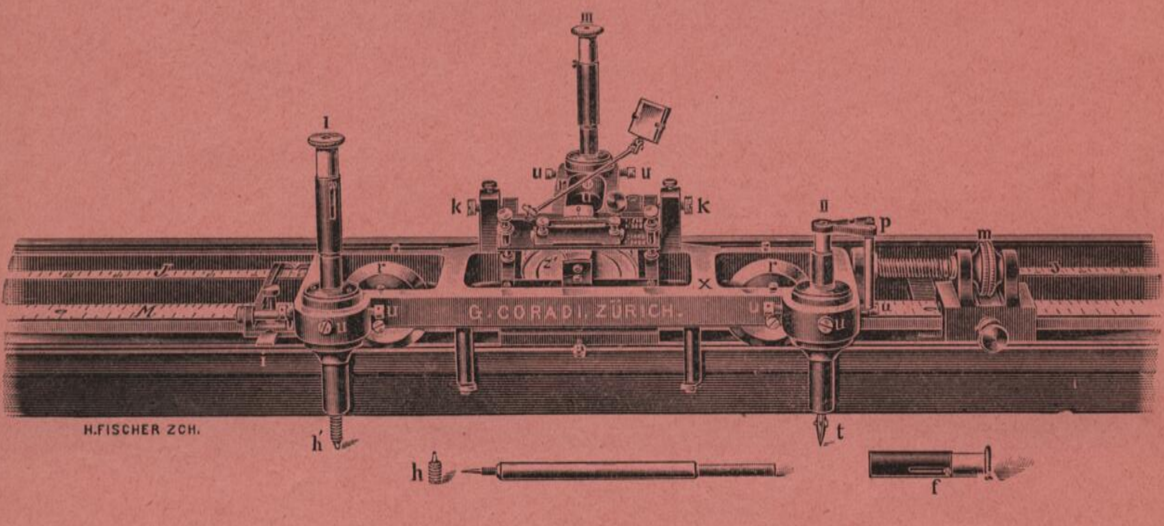
Coordinatograph (with iron table).



Measuring wheels for Coordinatograph.



Ordinate-carriage for Coordinatograph.



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Introduction.

The pantograph is used for copying full size, reducing or enlarging drawings. The original is traced by a point called a tracer and a pencil point draws the copy in the desired scale, according to the setting of the instrument.

The old pantographs rested by means of universal casters on the surface of the table. They were awkward to use, difficult to guide, and their exactitude dependent on the condition of the surface of the table, which had to be disproportionately large. In 1864 J. Goldschmid of Zurich constructed the first freely suspended pantograph, the idea being suggested to him by a lithograph. His instruments, however, met with but little acceptance, the mode of suspension (the Nurmberg shears) being unsuitable, so that these instruments did not furnish the necessary requirement of stabilty and exactitude.

Precision pantographs should furnish a perfect reproduction of the original in the desired proportion and the error should never exceed $^1/_{10}$ mm in any direction, so that the process cannot be carried out as accurately by any other means.

Precision pantographs are principally used for the reproduction in any scale of all kinds of maps and plans, and in spite of all the numerous reproduction processes constantly cropping up these instruments will always find employment where exactitude is the first requirement. The demand for the precision pantographs of G. Coradi of Zurich is steadily increasing.

The firm of G. Coradi of Zurich has, since its establishment in the year 1880, made a speciality of the manufacture of freely suspended precision pantographs. The founder of the firm (G. Coradi) was engaged, as far back as the years 1864—1867, with the inventor of these instruments (J. Goldschmid of Zurich) in the manufacture, adjustement and designing of freely suspended precision pantographs, and in the years 1875 to 1880 as partner of the firm Ott & Coradi, had introduced the manufacture of these instruments to the latter firm. Since the year 1880 the firm of G. Coradi of Zurich has been continually endeavouring to perfect and improve the freely suspended precision pantographs, so that these instruments have now reached a high grade of perfection and are not equalled in precision and facility of use by any other instrument. Up to the present 4000 pantographs have been made and sold, at home and abroad. Public authorities, architects, surveyors and engineers have repeatedly given orders for a large number of pantographs, without requiring any alteration in same, which is the best recomandation of the quality and practical construction of these instruments. We shall be pleased to furnish the addresses of users of these instruments, to those seeking to acquire them and this information can be obtained either from the firm G. Coradi of Zurich or from their representatives abroad, who catalogue the instrument.

The comparison of the illustrations of the instruments from the year 1881 with those in the following description will afford a clear view of the advances made in their construction.

The present members of the firm of G. Coradi of Zurich (G. Coradi, Richard, Oscar and Oswald Coradi) have for years devoted their ceaseless attention to the construction of special tools and apparatus for the uniform and exact production of precision pantographs, so that their exact production is quite independent of manual labour.

Only through the employment of these special machines has the firm been enabled, in spite of the numerous perfections in the construction and the ever increasing cost wages and material to adhere to the old prices and execute the orders with greater despatch. For the fine work the firm has a special staff of trained assistants, many of whom have been with the firm for 10 to 20 years. We will endeavour to maintain and add to the high reputation of our instruments and beg to express our thanks to those who have honored us with their confidence and also to those who have favoured us with suggestions for improvements.

The freely suspended precision pantographs

of G. Coradi, Zurich.

I. General Description of the Pantograph.

a. Pole at the end.

All pantographs of the firm G. Coradi of Zurich are constructed on the same system, as is shewn diagrammatically in Fig. 1.

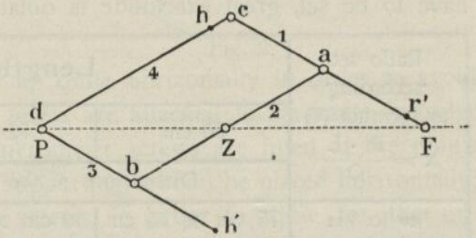


Fig. 1.

Four horizontal bars 1, 2, 3, 4 are connected so as to form by means of the vertical axes a, b, c, d a movable parallelogram. The axis d forms at the same time the pole P, which rests in a frame, and about which the whole instrument turns. Z is the sleeve carrying the pencil point and F the sleeve carrying the tracing point. By means of metallic wires the instrument is suspended at h and h' to a frame. At r' the instrument rests on the table. The distance of the axis a from b and the axis c from d is invariable and exactly equal to the invariable distance of the axis c from the tracer F. a b = c d = c F. The distance c F. determines the size of the pantograph, which is made in 4 different lengths viz: 600 mm, 720 mm, 840 mm and 960 mm, the zero for c F being at c, for a b at b and for d b at d, i. e. at P. The distances a c, d b and b Z can be varied, but a c must always = b d = b Z. In this hypothesis c a : c F as P Z : P F. If O represents the linear magnitudes of the original, R those of the reduction, then R : O = P Z : P F = c a : c F = b Z : b a.

As the length c F is known, it is only necessary, in order to find for a desired ratio $\frac{R}{O}$ the position x of the axes a and b, and of the pencil point Z, to multiply this length L by $\frac{R}{O}$; $x = \frac{R \cdot L}{O}$ (1)

For example if it be required to reduce a drawing so that the reduction is to the original as 2 : 3; $\frac{R}{O} = \frac{2}{3}$ and if the pantograph have a length of 840 mm, then $x = \frac{840 \cdot 2}{3} = 560$ mm, the distance c a = d b = b Z, to which the axes a and b, and the pencil point Z have to be set. If the drawing is to be enlarged, the original and reduction change places, i. e. the drawing to be enlarged is placed under Z and the paper on which the enlargement is to be made under F; the tracer is placed in the sleeve Z and the pencil point in the sleeve F; in the above mentioned equation R in this case represents the original and O the reduction.

Example: If it be required to reduce a map from the scale 1 : 1000 to the scale 1 : 1500, the ratio $\frac{R}{O} = \frac{1000}{1500} = \frac{2}{3}$ i. e x = 560 mm as above; or if it be required to enlarge a map from the scale 1 : 1440 to the scale 1 : 960, the reduction R is then treated as the original and the ratio is therefore $\frac{960}{1440} = \frac{2}{3}$ the setting x again 560 mm and so on. The system shewn in Fig. 1 has proved the best for a steady suspension and adapts itself easily to the unevenness of the surface of the table. Moreover, as the distances a b, c d and c F are invariable and accurately fixed, once for all, at 600, 720, 840 and 960 mm and only three variable distances have to be set, great exactitude is obtained.

Ratio set according to formula (1) $x = \frac{R \cdot L}{O}$	Length (cF) of pantograph			
	60 cm	72 cm	84 cm	96 cm
	Dimensions of the greatest rectangle which can be traced			
$^1/_{20}$ to $^1/_{12}$	75 cm × 75 cm	90 cm × 90 cm	105 cm × 105 cm	120 cm × 120 cm
$^1/_{10}$ to $^1/_8$	70 cm × 70 cm	85 cm × 85 cm	100 cm × 100 cm	115 cm × 115 cm
$^1/_6$ to $^2/_5$	65 cm × 65 cm	80 cm × 80 cm	95 cm × 95 cm	108 cm × 108 cm
$^1/_2$	50 cm × 60 cm	60 cm × 72 cm	70 cm × 85 cm	80 cm × 100 cm
$^3/_5$	40 cm × 60 cm	48 cm × 72 cm	56 cm × 85 cm	66 cm × 100 cm
$^2/_3$	35 cm × 60 cm	42 cm × 72 cm	50 cm × 85 cm	56 cm × 100 cm
$^3/_4$	22 cm × 60 cm	27 cm × 72 cm	30 cm × 85 cm	36 cm × 100 cm
$^4/_5$	18 cm × 60 cm	22 cm × 72 cm	26 cm × 85 cm	30 cm × 100 cm

The above table gives the greatest dimensions of a rectangle which can be traced with the point F of a pantograph, without shifting the pole, for the 4 sizes which are made and for different ratios. The lesser figure gives the dimensions in the direction P F, the greater figure the dimensions in the direction vertical thereto.

b) Pole in the centre.

From the above table, as also from the setting formula $x = \frac{R \cdot L}{O}$ it is seen that the dimension of the greatest rectangle which can be traced diminishes in the direction P F according as the ratio set approaches 1 : 1, and that if the latter ratio is required i. e. a copy of the same size as the original, the pencil point and tracer would fall at the same point F, i. e. the reproduction of a drawing in the same size would be impossible. In order, however, to be able to set the instrument at 1 : 1 and to obtain largest dimensions for the ratios near 1 : 1 for surfaces to be traced in one position of the pole, arrangements have been made in the types I and III d (see page 16) of the pantographs hereinafter described for the pencil point Z and the pole P also to be exchangeable, i. e. to change places, so that the pole, the turning point of the whole instrument at Z, lies between the tracer F and the pencil point Z, see the diagrammatic illustration in Fig. 2 in which the letters and figures have the same signification as in Fig. 1. Most of the wheigt of the pantograph is supported by a diagonal tube, kept horizontal at h' by a metallic wire fixed to the frame vertically over the pole P which rests in the frame; a second wire, the lenght of which can be varied according to the setting chosen, is suspended at h' to the bar 2; at r and r' the instrument rests on the table. Consequently there are two points, besides the pole P, which rests on the table, and as the surface of the latter is rarely sufficiently level and horizontal, the whole instrument must be set up quite horizontally in order to avoid strain. For this purpose screws and box levels are attached to the frame, in order to make the axis P quite vertical, and micrometer screws are fitted at the points of suspension to enable the bars and the supporting tube to be placed horizontally; r and r' are also adjustable in height by screws, in order to allow for the unevenness of the surface of the table. For the purpose of setting to various ratios PZ : PF, the two axes a and b and the pole P are adjusted and a c must always = b d = b P; P Z : P F is then always as a c : a F = b d : a F = P b : P a. As the zero for the division of the bars 1, 2, 3 is at c, d and b respectively, as in Fig. 1, therefore the formula for the setting x of the three variables distances c a, d b and b P is

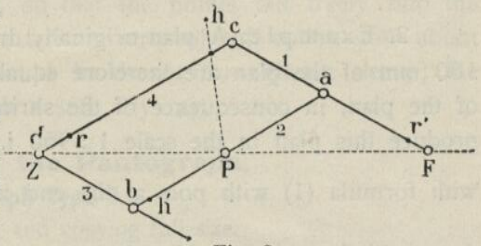


Fig. 2

$$x = \frac{R \cdot L}{(O+R)} \qquad (2)$$

n which $\frac{O}{R}$ represents the linear proportion of the original and reduction.

For example, if it again be required to reduce a map from the scale 1 : 1000 to the scale 1 : 1500, the ratio is $\frac{1000}{1500} = \frac{2}{3}$ and if the pantograph again have a length L 840 mm the setting $x = \frac{840 \cdot 2}{(2+3)} = 336$; or if it be required to enlarge a map from the scale 1 : 1440 to the scale 1 : 960, as the tracer, when enlarging, does not change places with the pencil point the ratio $\frac{1440}{960} = \frac{3}{2}$ is to be taken as the ratio for setting. Therefore $\frac{3 \cdot 840}{(2+3)} = 504$ as the setting for a, b and P.

If the plan which is to be enlarged or reduced is shrunk, so that its indications no longer stand in the original relation to the true values, the pantograph can be set, by a simple calculation, so that the reduction made with same stands in the proper relation to the full values.

1. Example: A plan originally made on the scale 1 : 1000 has shrunk 1 %; 100 mm of the plan are therefore equal to a length of 101 m in the full size; the scale of the plan is therefore no longer 1 : 1000 but 1 : 1010. If it be required to reproduce this plan in the scale 1 : 1500 i. e. to reduce it, the ratio R : O is therefore $\frac{1000}{1500}$; in accordance with formula (1) for the pole at the end (Fi. 1(

the setting x, when L is 840 mm is $x = \frac{840 \cdot 101}{150} = 565{,}6$ mm and in accordance with formula (2) with pole in the centre (Fig. 2) $x = \frac{840 \cdot 101}{(101+150)} = 338{,}0$ mm

2. Example: A plan originally drawn in the scale 1 : 1440 has shrunk 1%; 100 mm of the plan are therefore equal to 145,44 m in the full size. The scale of the plan, in consequence of the shrinkage, is 1 : 1454. If it is required to reproduce this plan in the scale 1 : 960 i. e. enlarge it, the setting x in accordance with formula (1) with pole at the end is: $x = \frac{840 \cdot 960}{1454} = 554{,}6$ and in accordance with formula (2) with pole in the centre (Fig. 2) the setting is $x = \frac{1454 \cdot 840}{(1454+960)} = 505{,}95$ mm.

The following table gives the greatest dimensions of a rectangle which can be traced with the tracer F of a pantograph of 960, 840, 720 or 600 mm lengtht without shifting the pole, when the pole lies between the tracer F and the pencil, point Z.

Ratio set according to the formulas $x = \frac{R\,L}{(R+O)}$	Length (cF) of the pantograph			
	600 mm	720 mm	840 mm	960 mm
1 : 1	35 cm × 55 cm	42 cm × 68 cm	50 cm × 80 cm	60 cm × 90 cm
2 : 3	40 cm × 65 cm	50 cm × 75 cm	60 cm × 90 cm	72 cm × 100 cm
3 : 2	20 cm × 35 cm	25 cm × 45 cm	35 cm × 55 cm	45 cm × 65 cm

II. General rules for using the pantograph.

The table on which the instrument is to be used should be as even as possible, approximately horizontal, and preferably rectangular in shape: the size varies with the size of the pantograph used. The width may be from 0,9 m to 1 m 20. The length should be about twice the length of bar of the pantograph. Slate or marble table tops covered with thick smooth linoleum have been found very suitable.

The pantographs of the types I to III are, when put in their cases, set to the ratio $^1/_2$ (or $^1/_1$) so that they must always be set to the same ratio before being returned to their cases. The sleeves F and Z, as also P are placed in the middle of the case, the joint C to the right. When taking the instrument out of the case and carrying it to and from same, hold it with the right hand near the joint C at the two bars 1 and 4, the left hand being placed against the joint B at the bars 2 and 3, to avoid bending the bars or straining the joints; for the same reason the instrument should be supported by a book or the like at the points of suspension h and h' when laid on the table, before being suspended. The setting of the pantograph to a determined ratio is effected only after it is suspended and adjusted horizontally, as the sleeves of the bars 1 and 3 can only be properly adjusted with the whole instrument in a horizontal position. The bars must be carefully protected from bending and always clean, so that the sleeves can be moved easily on same. The points Z and F and their sleeves must always be kept clean and free from oil or dust, so that the points fall freely into the sleeves. When it is necessary to clean the latter a strip of soft cotton-cloth about 4—5 cm long, twisted at the corner, should be drawn through the sleeve; the points should be rubbed occasionally with a soft, dry rag.

III. Description of the Pantograph.

1. Pantograph type I.

For reducing, enlarging, and copying full size.

a) Setting with pole in the centre (Fig. 2 and 3.)

The bars 1, 2, 3 and 4 are hard-drawn brass tubes of rectangular cross-section. Their joints move between pointed screws, so that very easy working is obtained and any play can be at once removed by their adjustment. On the bars 1 and 3 sleeves are fitted which can be moved easily along their whole length; to these sleeves the pointed screws for the joints A and B are attached: by adjusting these screws the distance CA and PB can be varied. On the bar 2 is a similar sleeve carrying the guide for the pole pin and enabling its distance from the joint B to be varied; a shorter sleeve in each case carries the necessary micrometer screw for the fine adjustment. All the sleeves can be fixed to the bars from underneath by the means of set screws; the screw of the short sleeve is first tightened and, after the instrument is set the screw of the longer sleeve.

The bars 1, 2 and 3 are divided on one side of their upper surface in millimeters, with division on the other side for the most usual ratios. The latter are marked $^1/_{20}$ to $^4/_5$ and $^2/_3$ to $^1/_1$ to $^3/_2$. The figures for the arrangement with pole at the end (Fig. 1) are on the left, those for the arrangement with pole in the centre (Fig. 2) on the right of the respective division. Each

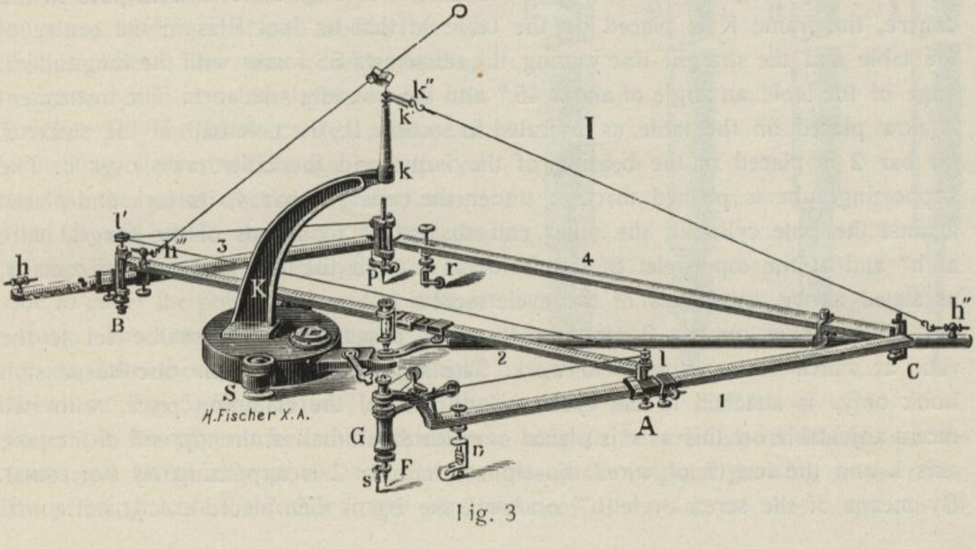


Fig. 3

sleeve carries a vernier for $^1/_{10}$ mm and an index for setting to the ratio division. The zero of the divisions and of the verniers is so arranged that the latter indicate accurately the distances of the adjustable axis A from C, and B from P or the turning point (pole) of the instrument from the joint B; with the verniers the distances calculated by the formulas $x = \frac{R \cdot L}{O}$ and $x = \frac{R \cdot L}{(R + O)}$ can be immediately set.

The instrument is principally supported by the frame K, in the foot of which at P (Fig. 6) the pivot bearing of the instrument, a hollow half sphere recessed in a steel cylinder, is fixed. Vertically over the pivot P is the axis piece k' k'', on a crane-like arm, around which the suspending wires turn. This axis piece is taken out when forwarding the instrument and is provided with a hole, through which an ordinary pin or point is passed for screwing same on firmly. The straight line P k' should be vertical, which is effected by means of the two set screws S S and the box level; whether the latter is correctly placed i. e. whether the axis P k is shewn to be truly vertical by the box level can be easily verified by the supporting tube 1. The fork end of this tube is supported at P, where the ball bearing screws into the steel cylinder, the other end is attached to the suspending bolt at h'' by means of the longest wire and at k'' to the frame, so that the supporting tube can be turned in a horizontal plane almost 360°. The small level accompanying the instrument is now placed in the 2 positions parallel to the straight line joining the set screws S S and rectangular thereto on the supporting tube, as near as possible the frame, on the same side of the tube. By means of these set screws S S an the eyelet screw h'' the level can be brought into all three positions for determining if the axis of rotation P k is quite vertical; the box level should now indicate this; if not, it must be adjusted without shifting the frame, by means of the correcting screws (2 draw-screws and 2 pressure-screws).

If the pantograph is to be used as shewn in Fig. 2, i. e. **with pole in the centre,** the frame K is placed on the table so that its foot P is in the centre of the table and the straight line joining the set screws SS forms with the longitudinal edge of the table an angle of about 45° and the box levels balance. The instrument is now placed on the table, as indicated in section II, the pole-ball in the sleeve Z on bar 2 is placed in the bearing of the frame and the bolt drawn over it. The supporting tube is pushed through under the caster of bar 4, its fork end placed against the pole cylinder, the other end suspended by means of the longest wire at h'' and at the top eyelet of the frame at k'' and the tube adjusted horizontally, as stated above, by means of the eyelet screw h''.

The sleeve on bar 2 carrying the pole pin must now first be set to the ratio at which it is required to work. The wire provided with one suspension hook only, is attached to the eyelet h''' on bar 2, the clamping piece, with ball recess adjustable on this wire is placed over the small ball at the top end of the pole axis k and the length of wire adjusted so that bar 2 is approximately horizontal. By means of the screw eyelet h''' on bar 2 the bar is then placed exactly horizontal then by means of the screw on the caster r bar 4 is placed horizontal, and likewise bar 1 by means of the screw on the caster r'. By reason of the unavoidable deflection of the bars it is advisable always to place the level in the middle of same. It will then be seen if the axis Pk of the frame is vertical. If the pantograph is correctly suspended and horizontal it will, when guided by the handle G, move easily in all directions.

According to the ratio set, a smaller or greater part of the weight of the instrument rests on the caster r' of bar 1. So as to obtain for all settings a uniformly easy motion for the exact guiding of the tracer, a regulating device is attached to the caster. A part of the weight rests on the support p **(Fig. 5)** the other part on the caster r'. If the caster r' alone carries the weight, the motion of the instrument would be too light; if the weight rested on p alone the motion would be too heavy. If the spiral spring is strengthened by screwing up the nut m, the caster r' supports a greather weight and the motion is easier; if the nut m is unscrewed the spiral spring is slackened and the motion becomes heavier, as p then carries a greater load; in this way the desired heavier or lighter motion can be easily obtained.

In the following figure the necessary points for the pantograph are illustrated; viz: tracer point F, pencil point B, pricking point P and the ink point R. (The latter is only supplied to order.) All the shafts of the points are exactly cylindrical, of uniform diameter and fit properly in the three sleeves F, Z and P. Faber leads of 1,9 mm diameter fit the **pencil holders.** The point of the lead should be as central as possible, so that, if the pencil resting on the paper is turned in its sleeve Z, a dot only is made on the paper and not a circle. The pin t can be put in at the top with one or more loading discs, to obtain finer or thicker lines. The pin t, with loading weights, can also be placed on the **pricker** P. The latter carries a screwed protecting sleeve, which can be adjusted so that the point does not project more than it will enter the paper; when the pricker is not in use this sleeve is screwed out to cover the point, and protect it from injury. The **tracer** F is screwed at the top to take the nut with spring sleeve shewn in Fig. 5. This serves to keep the tracer off the paper when the reduction is only to be pricked, in which case the tracer can be quickly moved from one angle of the original drawing to the other. By pressing with the index finger on the tracer the point of the latter can be

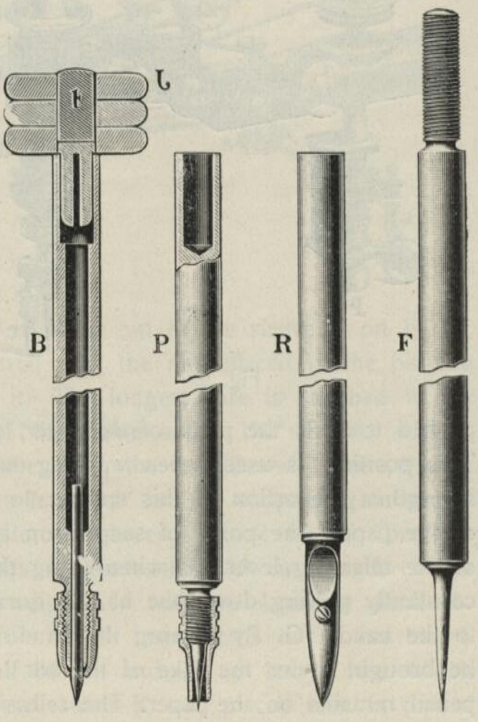


Fig. 4.

pressed down at the precise place to obtain a very accurate setting. When tracing the lines of the original, if the drawing is to be reproduced in pencil or ink, it is however better to screw up the spring sleeve so that the tracer rests on the prop c, placed so that the tracer point travels just clear of the paper, without tangent it.

The clamping arm S fixed to the releasing cord (see illustrations of pantographs IIIa, III and IV) is fastened to the bottom of the cylindrical shaft of the pencil, pricker or pen points which are first placed in their guide sleeves, under which the clamping arm is put on and fixed by its screw.

When using the ink point, the lines can be made in ink at once: the pen is so ground that it enables uniform fine lines to be made in all directions (also transversely to the split opening of the pen): the indian ink must, however, be very thin and the stem of the pen kept very clean, so that it falls freely in the sleeve without requiring to be loaded.

The handle G (see Fig. 5) embracing the tracer sleeve, serves both for guiding the instrument and raising and lowering the pencil (pricker or pen). It can be moved vertically if the handle is drawn down the pencil also sinks on the paper; when using the pricker the handle is pulled down quickly which imparts a free falling movement to the pricker. A spiral spring keeps the handle raised, so that, when at rest, the pencil is also raised. The arrangement and action of the releasing cord is to be seen from Fig. 5; the releasing lever turning around a horizontal axis engages its front horizontal arm in the groove of the handle G, the back arm is drawn down by a spiral spring, which on the one side is attached to the tracer bar and on the other side to a part adjustable on the arm. If the latter is pushed towards the pivot of the lever, the action of the spring becomes weaker. This position is used when working with the pencil or ink point. In order to strengthen the action of this spring, to enable it to draw the pricking point out of the paper, the point of suspension is removed from the turning axis (pivot) of the releasing lever. As when using the pencil the hand gets overtired, through constantly pulling down the handle during the tracing, the vertical pin t is fitted to the handle G. By turning the handle, when in its lowest position, this pin can be brought under the yoke of the bar 1, so that the handle remains down i. e. the pencil remains on the paper. The releasing cord is carried from the reel 1 round the fixing screw at the back arm of the releasing lever between the two discs at the clamping screw 2, round the nut 3, over the pulleys 4 and 5, in the direction of the arrow. Thence it is carried over the pulley 1 (Fig. 3) at hinge A, then over the pulley 1' at hinge B. Care is to be taken that the cord is carried over these

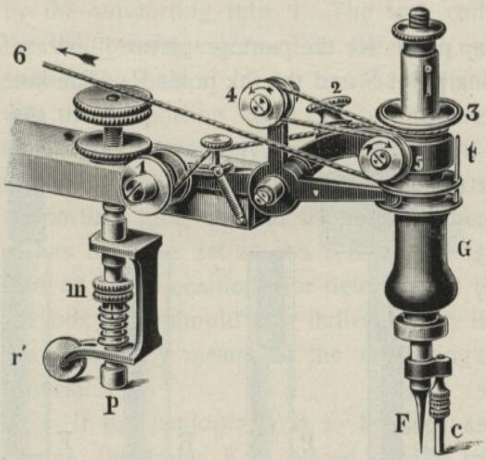


Fig. 5.

two pulleys in the same direction ⌒, otherwise the cord will become lengthened or shortened by the movement of the instrument during work. From the hinge B the cord is carried to the pulley on the pencil sleeve (P Fig. 3) and gastened to the clamping arm under the sleeve of the pencil point. By winding or unwinding the reel 1 the cord is given such a length that, when the handle G is raised, the pencil point is also raised as much as possible, and, when handle the G is lowered, the pencil point rests on the paper and the cord is slack. This length of cord is maintained by tightening the clamping screw 2 on the tracer bar yoke. The instrument is now ready for use.

b) Setting with pole at the end (Fig. 1 and 6).

If the pantograph is to be used for ratios under $^2/_3$, it is advisable to set it up with the pole at the end, see Fig. 1. For this purpose the frame is placed at the end of the table and the axis P k' is made vertical by means of the screws

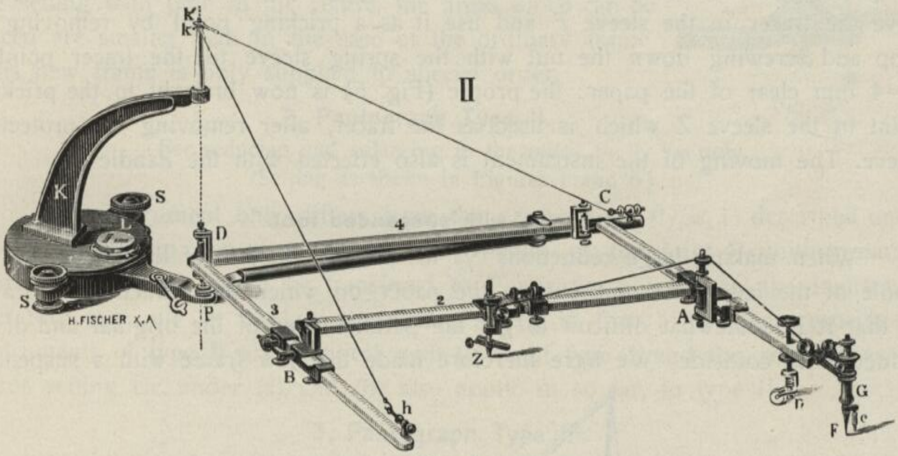


Fig. 6

S S and the box level. The pole-ball pin is taken out of the sleeve Z on bar 2, placed in the sleeve at the hinge P, secured with the nut, placed in the bearing at the foot P and the bold drawn over it. The longest wire is attached to the supporting tube and to the top eyelet of the frame at k': the shortest wire is attached at h to the bar 3 and to the frame at k', the bars 3 and 4 are adjusted horizontally by means of the eyelet screws h and h' on the supporting tube and bar 1 by means of the screw on the caster r' whereby bar 2 is also brought into a horizontal position. For pantographs of more than 60 cm length of bar the frame must be loaded with additional weights, in order to obtain an absolutely steady position of the axis P k on the table. With instruments of 72 cm length one such weight is supplied, with those of 84 cm and 96 cm length two, which are pushed from the back over the curved stand K and placed one on top of the other. After these weights are applied, the vertical position of P k, and the horizontal position of the bars 3 and 4 must again be examined and, if necessary, adjusted. The pencil point is now placed in the sleeve Z on bar 2 and connected with the releasing mechanism by fastening the clamping lever of the releasing cord to the bottom of the pencil holder and leading the cord over the pulley on the pencil point sleeve, over the pulley 1 at hinge A, and thence to the releasing lever in the same way as described under a).

For enlarging with this setting of the instrument (Fig. 1) the tracer is placed in the sleeve Z on bar 2 and the original drawing also placed there. The pencil point is placed in the sleeve F on bar 1, underneath which the clamping arm of the releasing cord is fastened to the pencil point. From here the cord is now led over the pulley 5 on the tracer bar (Fig. 5) over the pulley at hinge A and thence, as when reducing, back again over the pulley 5 to the releasing lever. In the case of big enlargements it is advisable only to set the angles of the rectilinear figures as exactly as possible, to reproduce them on the enlargement and then join them up with lines. In the case of curved figures, points are also marked at suitable distances and joined up by free hand on the enlargement. When using the pantograph for this purpose, i. e. for enlarging by pricking, it is advisable to leave the tracer in the sleeve F and use it as a pricking point by removing its prop and screwing down the nut with the spring sleeve till the tracer point is 3—4 mm clear of the paper: the prop c (Fig. 5) is now brought to the pricking point in the sleeve Z which is used as the tracer, after removing the protecting sleeve. The moving of the instrument is also effected with the handle G.

c) Frame with suspended foot.

When making large reductions $^1/_5$ to $^1/_{20}$, the foot P of the frame, or the whole of the latter rests entirely on the paper on which the reduction is drawn, so that it is somewhat difficult to get the parallel sides of the original and of the reduction to coincide. We have therefore made the new frame with a suspended

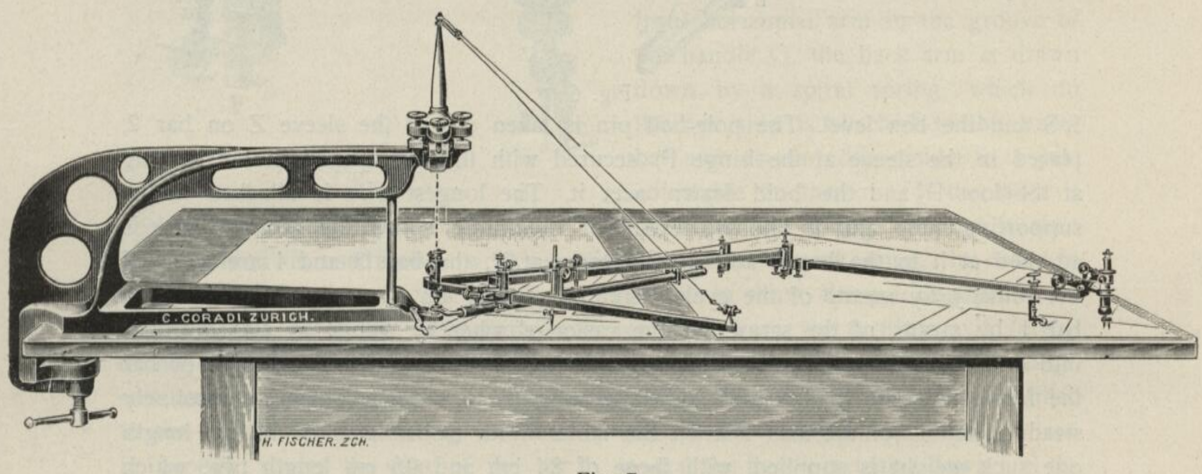


Fig. 7

foot. This foot stands about 5 mm above the surface of the table and reaches 40 cm over the table, from the edge, so that the drawing paper can be easily pushed under the foot, until the pencil point stands at the same angles of the reduction to which the tracer is set on the original.

The above illustration Fig. 7 shews the application of this new frame and its connection to the pantograph, which is effected in the same manner as described under a) and b). The head, with the four set screws S (Fig. 8), is put in the case separately. For connecting same with the frame the ends of the four screws are placed in the grooves in the top of the frame, the connecting pin, fixed thereto by a cord is pushed through, and the screws S slightly tightened. In order to make the axis o o (corresponding to P k in Fig. 6) vertical, a box level with connecting rod accompanies the instrument, the application of which can be seen distinctly from Fig. 8; the box level is set by means of the 4 screws S and the correct position of the same is examined and corrected in the same way as indicated under a) for the axis P k. When using this new frame for the setting with pole in the centre, the areas which can be traced are smaller than in the case of the ordinary frame. This new frame is only supplied to special order.

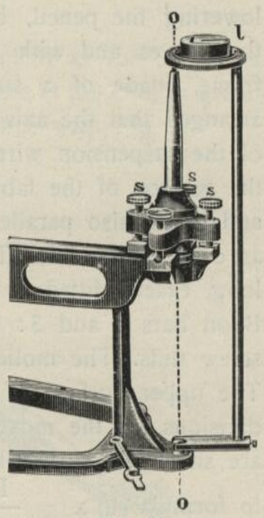


Fig. 8

2. Pantograph Type II.

For reducing and enlarging in the ratios 4/5 to 1/20 only,
(Setting as shewn in Figures 1 and 6.)

This instrument only differs from the pantographs (type 1) described under III (a) and (b) in the more simple construction of the joint P uniting bars 3 and 4. The pencil cannot be transfered to P nor the pole to Z; the instrument therefore can only be used in the setting shewn in Fig. 1. In other respects the instruments of type II are identical with those of type 1 and the remarks as regards setting etc. under (a) and (b) also apply, in so far, to type II.

3. Pantograph Type III.

For reducing and enlarging in the ratios 4/5 to 1/20.
(Setting as per Figure).

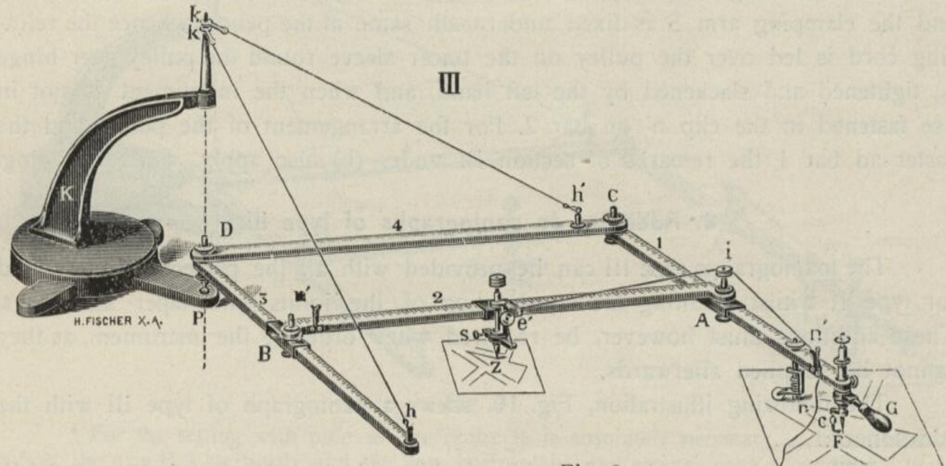


Fig. 9

The pantograph illustrated in Fig. 9 differs from type II, described under 6, in the more simple construction of the joints and of the device for raising and lowering the pencil, by dispensing with verniers and micrometer adjustment at the sleeves and with the horizontal adjustment of the frame and the bars. The frame, made of a solid iron casting with screwed on steel pivots kk', is so arranged that the axis P k is at right angles to the surface of the table, the length of the suspension wires is so proportioned that the bars 3 and 4 are parallel to the surface of the table and the caster r' is so fixed to bar 1, that the bars 1 and 2 are also parallel to the surface of the table; the latter should therefore be as even as possible. The joints A B C D consist of taper steel axes, about 3 cm long, exactly fitted in bronze sleeves and secured to the adjustable sleeves A and B on bars 1 and 3: the bronze sleeves are fastened to the bars 2 and 4 by screw nuts. The motion of the instrument is very light and thoroughly reliable. The upper surface of the bars 1, 2 and 3 is divided in millimeters, with ratio divisions for the most usual proportions. On the sleeves, adjustable on these bars are silver plated bevelled edges, by means of which the adjustment x according to formula (1) $x = \frac{R\,L}{O}$ i. e. the distances C A, P B and B Z is effected on the division. On the bevelled edges a space is left, so that the bevelled edge only covers half the length of the millimeter line: by this it is possible with a little practice to set exactly to 0,1 mm. The instrument is guided by the handle G, which can turn around the tracer sleeve. The cord for raising and lowering the pencil is, as shewn in the drawing, carried from the clamping arm S over the pulley e', round the pulley at hinge A and either wound round the index finger of the guiding hand or held in the left hand, to effect through tightening or slackening, the raising and lowering of the pencil, or through rapid slackening, the dropp:ng of the pricking point. When the instrument is not working, the cord is fixed to the clip n on the bar 1.

When enlarging, the tracer, as with type 2, is placed in the sleeve Z on bar 2 and the original placed there. The pencil is put in the sleeve F on bar 1 and the clamping arm S is fixed underneath same at the pencil, whence the releasing cord is led over the pulley on the tracer sleeve round the pulley over hinge A, tightened and slackened by the left hand, and when the instrument is not in use fastened in the clip n' on bar 2. For the arrangement of the points and the caster ad bar 1 the remarks of section III under (b) also apply, when enlarging.

4. Additions to pantographs of type III.

The pantograhps type III can be provided with all the perfections described for type 1, whilst retaining the construction of the joints with taper steel axes. These additions must however, be required when ordering the instrument, as they cannot be supplied afterwards.

The following illustration, Fig. 10, shews a pantograph of type III with the addition of.

a) The mechanical release for raising and lowering the points as in types I and II.

Further additions are:

b) The device for the vertical adjustement of the axis P k and the horizontal adjustment of the bars.

c) The fitting of the verniers and micrometer adjustment at the 3 sleeves.

***d)** Arrangement of the instrument for setting with pole at the end, in accordance with Fig. 1, and with pole in the centre, in accordance with Fig. 2.

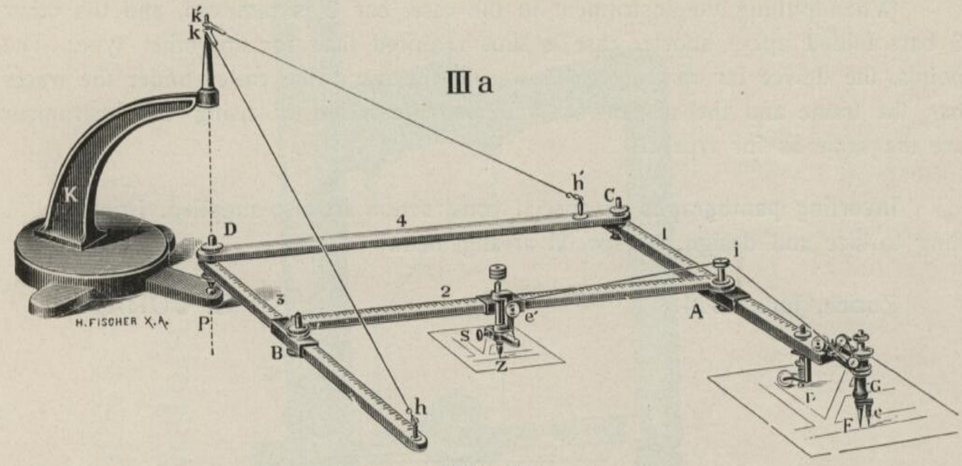


Fig. 10

All these devices are the same as for type 1 and the observation in section III under (a) and (b) also apply to the respective additions for type III.

5. Pantograph type IV.

(Without division on the bars).

The following illustration shews a simple pantograph without division on the bars, and designed for determined ratios only. The axes of the joints are con-

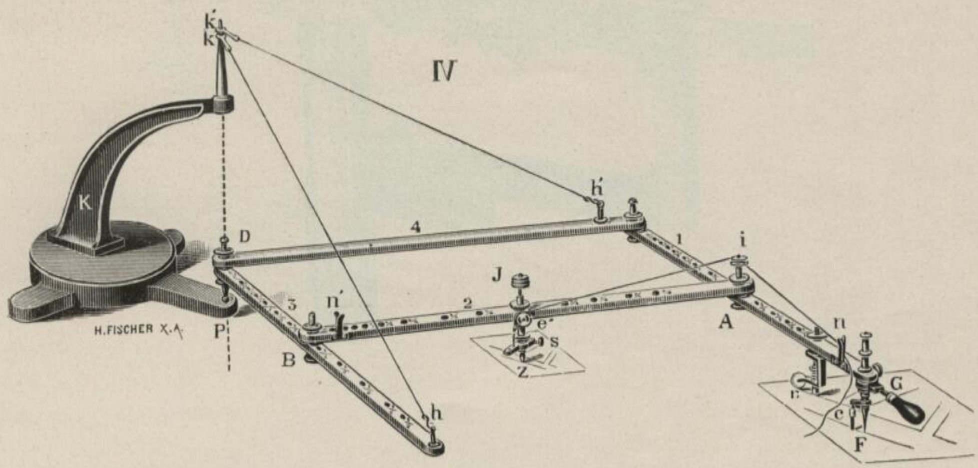


Fig. 11

* For the setting with pole in the centre it is absolutely necessary to be enabled to adjust the axis P. k. vertically and the bars horizontaly; the arrangement d conditions therefore the device b.

structed identically to type III, but the two steel axes for the joints A and B are placed directly in holes of the bars 1 and 3 and secured unterneath by nuts. The pencil sleeve is placed in holes of the bar 2 from underneath and secured by nuts at the top. The holes in the bars 1, 2 and 3 are accurately bored, by special devices, for the following ratios; 1/20, 1/12, 1/10, 1/8, 1/6, 1/5, 1/4, 1/3, 2/5, 1/2, 3/5, 2/3, 3/4, 4/5.

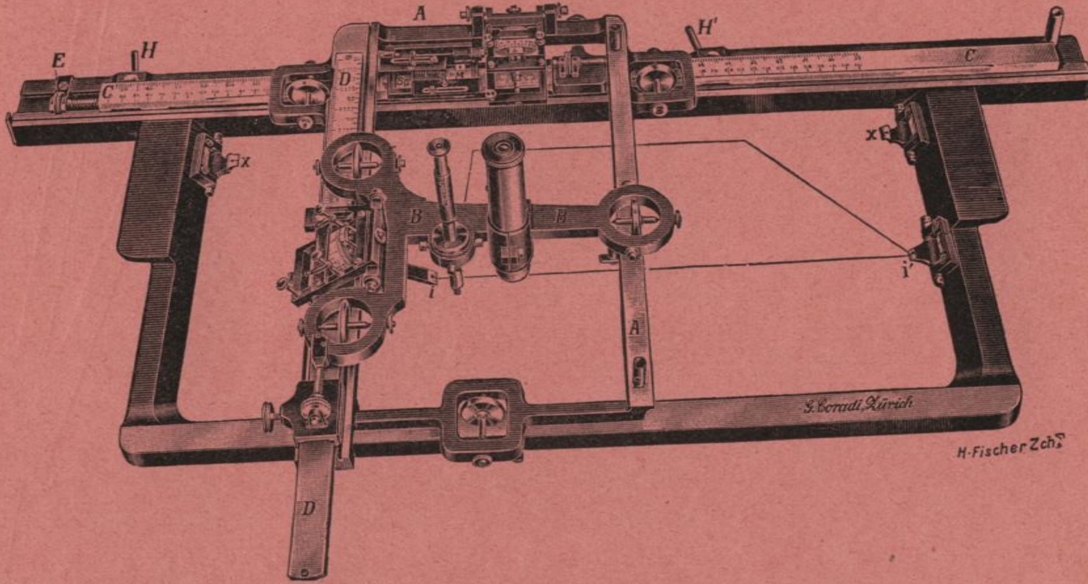
When putting the instrument in the case, bar 2 is removed, and the other 3 bars folded up. A shorter case is thus required than for the other types. The points, the device for raising und lowering the same, the caster under the tracer bar, the frame and the suspension, and also the mode of using the instrument are the same as for type III.

Inverting pantographs of special construction are also supplied. Prices according to size and design, by special arrangement.

Zurich, June 1914. **G. CORADI.**

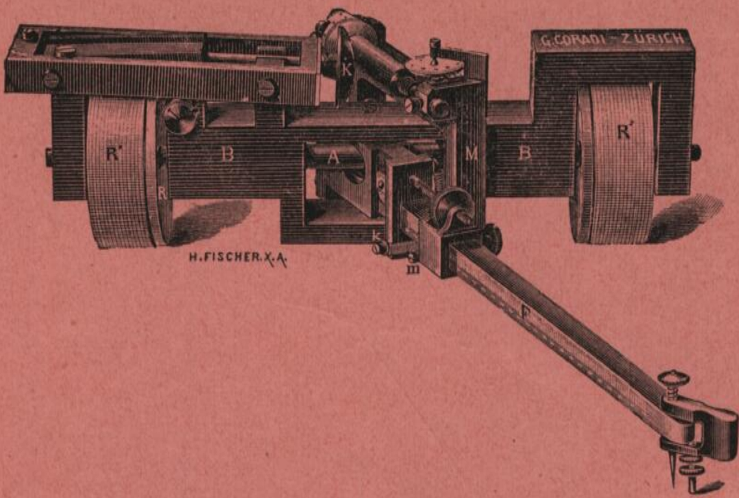
CORADI'S

Detail-Coordinatograph

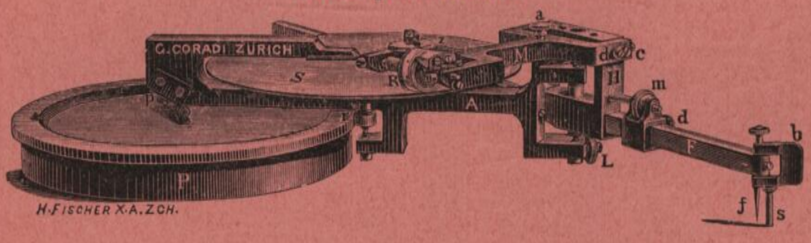


Price:

Rolling sphere planimeter



Disc planimeter



Compensation planimeter