AMSLER

Instructions

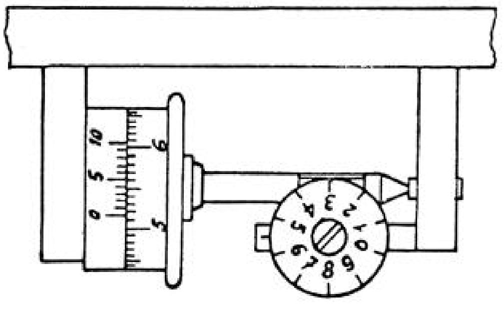
for using Amsler Original Integrators

Placing the Integrator

Place the rail upon the drawing to be measured. Then arrange the Integrator in such a way that the two wheels run in the groove of the rail, and the measuring rollers rest on the paper. Affix the counterweight at the rear of the carriage-frame. The two gauges which are supplied with the instrument are then set in such a way that their edges hold in the groove of the rail and their points rest on the drawing. Now move the rail backwards or forwards until the points of the gauges rest exactly on the axis of moments x-x (i. e., on that line on which are to be based the static moments and the moments of inertia). The rail is then at the proper distance and parallel to the axis of moments. To obtain this position accurately it is advisable to use the magnifying glass that accompanies the instrument.

Readings

The drum of each measuring roller is divided into 100 parts. Tenths of a part are read on the vernier. Complete revolutions of the measuring roller are shown on the counting disc which advances one line at every such turn. The counting disc is arranged for total 10 revolutions of the measuring roller.



Each complete reading is a figure of four digits, the thousands being read on the counting disc, the hundreds and tens on the drum, and the units on the vernier.

The reading of the roller and disc, shown, for example, in the adjoining figure, is 5515. The division of the vernier to be read, i. e., in the present example the seven, is the division which is just opposite, or nearest, to a division of the roller.

Theoretically if the vernier is on the zero of the measuring roller, the index marks should be exactly opposite a division of the counting disc. This may not always exactly be the case, in consequence of the imperfection of the worm wheel gear, and this should be taken into account, in the same way as with a watch, when the minute hand points to 12, whilst the hour hand fails to indicate exactly the hour. When taking the second reading after the first measurement, be careful to ascertain whether the motion of the measuring roller has been forward or backward, and how many times, and in what revolving direction the zero of the counting disc has passed the fixed index mark, no account being taken of the short to and from passages through the index mark. If the total travel of the measuring roller has caused more than one complete turn of the counting disc, the figure 10 000 must be added to the difference of readings, as often as the counting disc has gone round. If the motion of the roller has been backward, a corresponding multiple of 10 000 must be added to the initial reading before taking the difference between the initial and final readings.

The process is as simple as calculating the difference in time by a clock between 10 a. m. and 2 p. m. on the same day, or between 10 a. m. and 7 p. m. of the previous day.

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Circumscribing a figure

Make a mark on the outline of the figure to be measured. Set the No. 1 tracing point on the mark and write down the readings of the graduated measuring rollers. Move the tracing point carefully along the outline of the figure from left to right in the direction of the movement of the hands of a watch till it comes back to the starting position. Read again the measuring rollers and write down the readings under the corresponding first readings. Subtract the first readings from the second and write down the differences to the right of the corresponding readings.

The figures then express the travel of the respective rollers.

In the following formulae the travel of roller A is denoted by a
" " " M " " " m
" " " I " " " i
" " " P " " " p

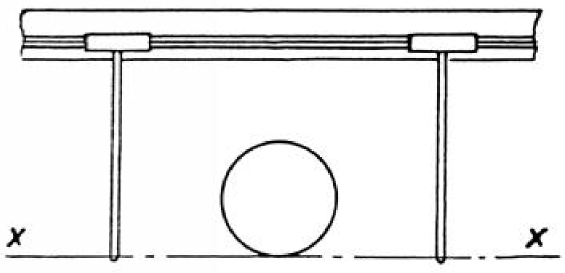
When the fixed No. 1 tracing point has been used, then:

For the English Instrument

Amsler Integrator		No. 1		2		3		4	
Area	A =	0.02 a	$ins.^2$	0.04 a	$ins.^2$	0.02 a	$ins.^2$	0.04 a	$ins.^2$
Moment	M =	0.04 m	$ins.^3$	0.16 m	$ins.^3$	0.04 m	$ins.^3$	0.16 m	$ins.^3$
Moment of inertia	I =	0.32 a — 0.1 i	$ins.^4$	2.56 a — 0.8 i	$ins.^4$	—		2.56 a — 0.8 i	$ins.^4$
Moment of 4^{th} order	P =	—		—		—		5.12 (4 m — p)	$ins.^5$

For the Metric Instrument

Amsler Integrator		No. 1		2		3		4	
Area	A =	0.1 a	cm^2	0.2 a	cm^2	0.1 a	cm^2	0.24 a	cm^2
Moment	M =	0.6 m	cm^3	2.4 m	cm^3	0.6 m	cm^5	2.4 m	cm^3
Moment of inertia	I =	10 a — 4 i	cm^4	8 (10 a — 4 i)	cm^4	—		32 (3 a — i)	cm^4
Moment of 4^{th} order	P =	—		—		—		480 (4 m — p)	cm^5



Example:

Given a circle of respectively 4 ins. and 10 cm in diameter. To measure: The area of the circle, the moment and the moment of inertia in reference to the tangent x — x.

Place the rail as shown in the adjoining figure, the circle being inside i. e., above the axis of moments. Circumscribe the circle in the way explained. Thus, using Amsler Integrator No. 1, for the fixed No. 1 tracing point:

English Instrument

	A roller		M roller		I roller	
Initial reading	1832	628	4495	628	3721	1381
Final reading	2460		5123		5102	
	a = 628		m = 628		i = 1381	

Area $A = 0.02 \times 628 = 12.56$ sq. ins.

Moment $M = 0.04 \times 628 = 25.12$ ins. × sq. ins.

Moment of Inertia $I = 0.32 \times 628 - 0.1 \times 1381 = 62.86$ sq. ins. × sq. ins.

Metric Instrument

	A roller		M roller		I roller	
Initial reading	3271	785	1427	654	8843	1350
Final reading	4056		2081		10193	
	a = 785		m = 654		i = 1350	

Area $A = 0.1 \times 785 = 78.5\ cm^3$

Moment $M = 0.6 \times 654 = 392.4\ cm \times cm^2$

Moment of Inertia $I = 10 \times 785 - 4 \times 1350 = 2450\ cm^2 \times cm^2$

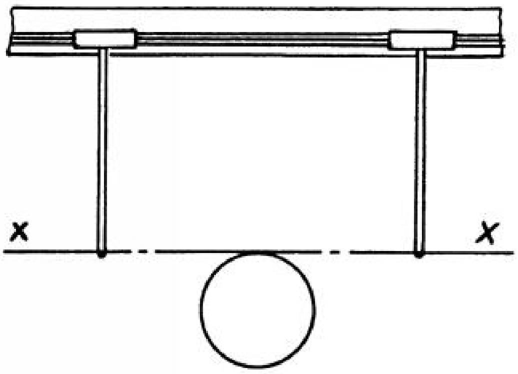
For another example, take as axis of moments the top tangent of the same circle and repeat the measurement starting from the same first readings as before. Then:

English Instrument

A roller		M roller		I roller	
1832	628	4495	— 628	3721	1381
2460		3867		5102	
a = 628		m = — 628		i = 1381	

Metric Instrument

A roller		M roller		I roller	
3271	785	1427	— 654	8843	1350
4056		0773		10193	
a = 785		m = — 654		i = 1350	



This shows that the A and I rollers perform the same travel whether the diagram lies inside or outside the axis, but that the M roller moves in the opposite direction in the latter case. The travel must then be taken into account as a negative quantity.

The travel of the A roller is always a forward one. The travel of the M roller is forward or backward — positive or negative — according as to whether the greater portion of the diagram lies inside or outside the axis of moments. If the travel of the M roller turns out negative, the centre of gravity of the diagram lies outside, i. e. below the the axis of moments.

The travel of the I roller is in most cases a forward one. It is only negative if the whole diagram lies far off the axis of moments. In such cases the I roller may turn backward, then its travel i must be taken as negative and the second member in the formulae for I must accordingly, now be added instead of subtracted.
As is the case with roller M, the travel of roller P and, consequently, the value of the moment of 4th order, may become negative. This will be the case if the major portion of the figure again lies outside the axis of moment. Before or after an exact measurement let the tracing point follow roughly, the outline of the diagram while watching the counting disc of the rollers in order to ascertain the direction and the approximate amount of the travel of each roller.
Each measurement claiming reliability ought to be gone over at least twice.

In addition to the fixed point No. 1, the tracing arm of the Amsler Integrators No. 1 and No. 3 is provided with a moveable (vertically sliding) point No. 2, which is of value for measuring small figures. The tracing arm of the Amsler Integrators No. 2 and No. 4 bears a further moveable point No. 3.
Wherever practicable, trace the diagram of small height with one of the moveable points, in order to obtain a greater travel of the rollers and consequently more accurate results than with the fixed point.
When tracing the diagram by No. 2 or No. 3 point, guide the No. 1 point with the hand, and follow with the eye No. 2 (or No. 3) point running on the outline of the diagram.
When using No. 1 point, take off the sliding points No. 2 and No. 3.
For No. 2 and No. 3 points the following formulae must be used:

No. 2 point

For the English Instrument

Amsler Integrator		No. 1	2	3	4
Area	$A =$	0.01 a ins.²	0.02 a ins.²	0.01 a ins.²	0.02 a ins.²
Moment	$M =$	0.01 m ins.³	0.04 m ins.³	0.01 m ins.³	0.04 m ins.³
Moment of inertia	$I =$	$\frac{0.32\,a - 0.1\,i}{8}$ ins.⁴	0.32 a — 0.1 i ins.⁴	—	0.32 a — 0.1 i ins.⁴
Moment of 4th order	$P =$	—	—	—	0.32 (4 m — p) ins.⁵

For the Metric Instrument

Amsler Integrator		No. 1	2	3	4
Area	$A =$	0.05 a cm²	0.1 a cm²	0.05 a cm²	0.12 a cm²
Moment	$M =$	0.15 m cm³	0.6 m cm³	0.15 m cm³	0.6 m cm³
Moment of inertia	$I =$	$\frac{10\,a - 4\,i}{8}$ cm⁴	10 a — 4 i cm⁴	—	4 (3 a — i) cm⁴
Moment of 4th order	$P =$	—	—	—	30 (4 m — p) cm⁵

No. 3 point

For the English Instrument

Amsler Integrator		No. 2	4
Area	$A =$	0.01 a ins.²	0.01 a ins.²
Moment	$M =$	0.01 m ins.³	0.01 m ins.³
Moment of inertia	$I =$	$\frac{0.32\,a - 0.1\,i}{8}$ ins.⁴	$\frac{0.32\,a - 0.1\,i}{8}$ ins.⁴
Moment of 4th order	$P =$	—	0.02 (4 m — p) ins.⁵

For the Metric Instrument

Amsler Integrator		No. 2	4
Area	$A =$	0.05 a cm²	0.06 a cm²
Moment	$M =$	0.15 m cm³	0.15 m cm³
Moment of inertia	$I =$	$\frac{10\,a - 4\,i}{8}$ cm⁴	0.5 (3 a — i) cm⁴
Moment of 4th order	$P =$	—	$\frac{15}{8}$ (4 m — p) cm⁵

Example: Determine the resistance of a rail under cross-bending stress. (The diagram below is drawn full size, so that the following results can be obtained again almost exactly by measuring directly on the diagram, using Amsler Integrator No. 1.)

Draw the line x—x parallel to the foot line a—b of the rail, so that No. 2 point of the integrator takes in the whole profile, the line x—x being chosen as the axis of moments.

Adjust the rail to the line x—x, as the axis of moments, measure the area and the moment of profile by means of No. 2 tracing point (the moment of inertia is not wanted now). Thus:

English Instrument

A roller		M roller	
9729		1344	
	435		135
(1) 0164		1479	
	436		134
(2) 0600		1613	

Means: a = 435.5 m = 134.5

$A = 0.01 \times 435.5 = 4.355$ sq. ins.

$M = 0.01 \times 134.5 = 1.345$ ins. × sq. ins.

$h = \frac{M}{A} = \frac{1.345}{4.355} = 0.309$ ins.

Metric Instrument

A roller		M roller	
6202		7108	
	564		147
6766		7255	
	562		148
7328		7403	

Means: a = 563 m = 147,5

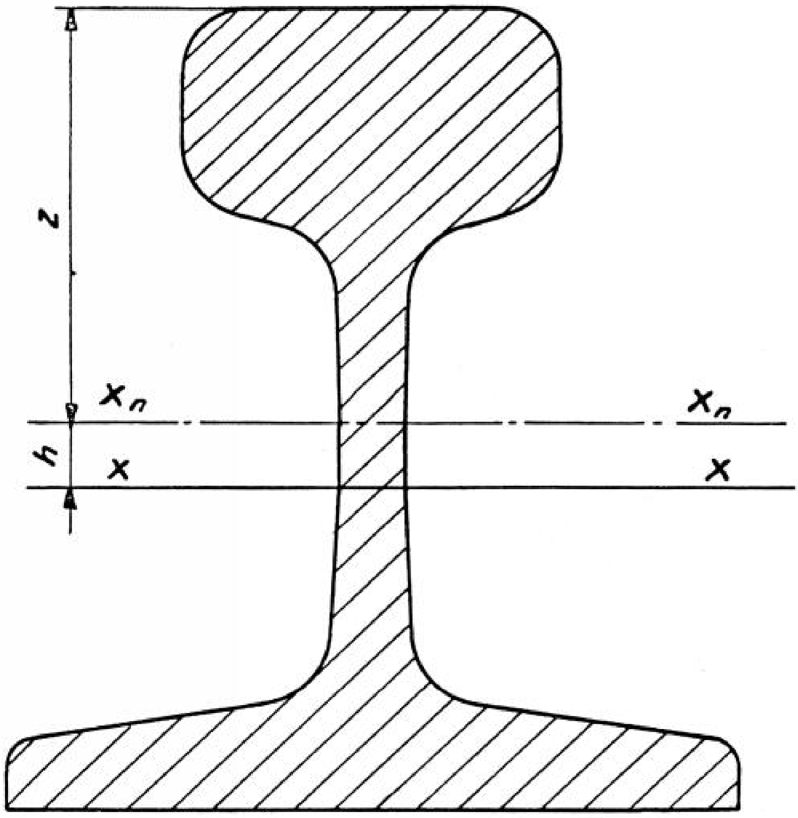
$A = 0.05 \times 563 = 28{,}15$ cm²

$M = 0.15 \times 147.5 = 22{,}12$ cm³

$h = \frac{M}{A} = \frac{22{,}12}{28{,}15} = 0{,}786$ cm

h being the height of centre of gravity of profile above axis x—x.

(If m were negative, then the M and h would be negative too, and x_n — x_n would lie below x—x.)



Set off the neutral axis $x_n - x_n$, adjust the rail to the line $x_n - x_n$ as the new axis of moments, and again circumscribe the profile by means of No. 2 tracing point, taking readings on all the rollers. Thus:

English Instrument

A roller		M roller		I roller	
0800	435	2584	0	1436	652
(1) 1235		2584		2088	
(2) 1671	436	2583	— 1	2740	652

Mean values:

a = 435.5 m = — 0.05 i = 652

Metric Instrument

A roller		M roller		I roller	
7864	564	7730	— 2	6761	631
8428		7728		7392	
8990	562	7728	0	8022	630

Mean values:

a = 563 m = — 1 i = 630.5

(The measurements of a and m are to check the foregoing operations.)

English Instrument

Moment of inertia $I_n = \frac{0.32 \times 435.5 - 0.1 \times 652}{8} = 9.27$ sq. ins. × sq. ins.

Distance of extreme fibre of rail from neutral axis z = 2.06 ins. or 5.25 cm.

Moment of resistance $W = \frac{I_n}{z} = \frac{9.27}{2.06} = 4.50$ ins. × sq. ins.

Metric Instrument

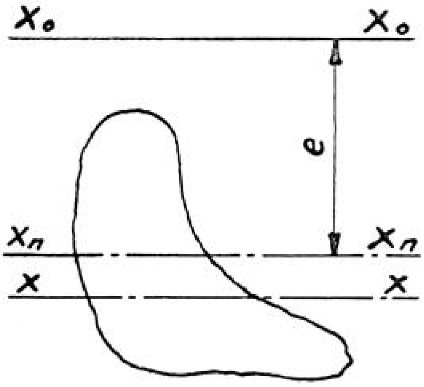
$I_n = \frac{10 \times 563 - 4 \times 630.5}{8} = 388.5 \text{ cm}^4$

$W = \frac{I_n}{z} = \frac{388.5}{5.23} = 74.1 \text{ cm}^3$

Suppose the diagram is so far off the axis of moments $x_0 - x_0$ (shown in the adjoining figure), that the tracing point cannot reach the whole outline when the integrator is adjusted to $x_0 - x_0$.

Then draw another parallel axis $x - x$ across the diagram, so that the whole diagram now falls within the reach of the tracing point when the integrator is set to $x - x$. Adjust the integrator to axis $x - x$ and determine the area and the position of the neutral axis $x_n - x_n$ (line through centre of gravity of area parallel to $x_0 - x_0$).

Adjust now the integrator to axis $x_n - x_n$ and measure the moment of inertia I_n about axis $x_n - x_n$.



If e expresses (in inches) (or cm) the distance between the lines $x_0 - x_0$ and $x_n - x_n$, A the area of the diagram, M_0 the moment and I_0 the moment of inertia about the axis $x_0 - x_0$, then:

$$M_0 = e A \qquad I_0 = I_n + e^2 A$$

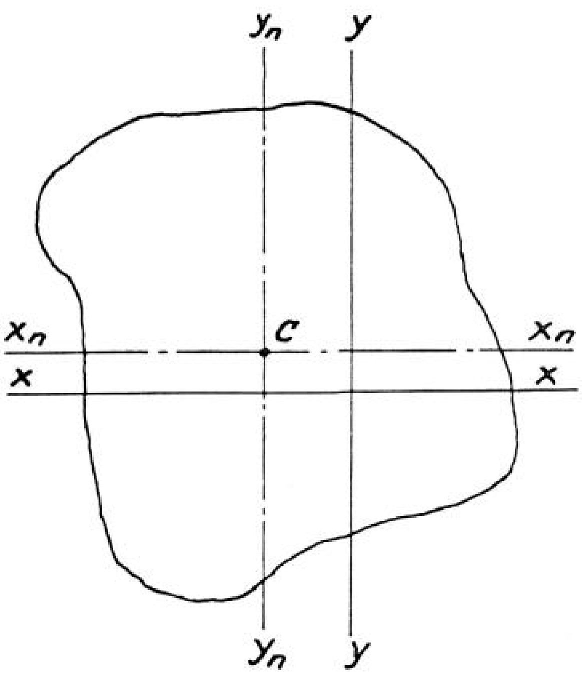
It would be possible, but not advisable, to determine M_0 and I_0 directly from the measurement about axis $x - x$.

Large diagrams exceeding the range of the tracing point must be cut into smaller portions. If it is found impossible to follow the single portions with the tracing point after setting the rail of the Integrator to the axis of moments, an auxiliary axis parallel to the original axis of moments must be drawn for each portion.
Then determine in each portion of the diagram the neutral axis parallel to the original axis, the moment of inertia about the neutral axis and the area, and deduct the moment and the moment of inertia of each portion about the original axis by means of the formulae:

$$M = e\,A \qquad\qquad I = I_n + e^2 A$$

Lastly, sum up the areas A of the single portions, the moments M, and the moments of inertia I.
The above sums will represent the area and the moments of the whole diagram.
Very long but narrow diagrams, as, for example, the plan of the water lines of a ship, cause but little trouble; they may simply be intersected by a set of lines at right angles to the axis of moments. The sum of the moments of the portions will then make up the moment of the whole diagram.

Position of centre of gravity of an area. Draw across the diagram any two lines $x - x$ and $y - y$, approximately at right angles to one another. Measure the area A and the Moment M_x about axis $x - x$, and afterwards the moment M_y about axis $y - y$. $\frac{M_x}{A}$ will then be the distance of the line $x_n - x_n$ from the parallel axis $x - x$ and $\frac{M_y}{A}$ the distance of $y_n - y_n$ from $y - y$. The point C of intersection of $x_n - x_n$ and $y_n - y_n$ will now be the centre of area.



Scales. The foregoing formulae apply to measurements on full-size drawings. If the scale of the drawing be n ins. = 1 ft., respectively 1 cm = n cm, the following formulae are to be used:

For No. 1 tracing point

English Instrument

Amsler Integrator No.	1	2	3	4
Area A =	$0.02\,a \times \frac{1}{n^2}$ sq. ft.	$0.04\,a \times \frac{1}{n^2}$ sq. ft.	$0.02\,a \times \frac{1}{n^2}$ sq. ft.	$0.04\,a \times \frac{1}{n^2}$ sq. ft.
Moment M =	$0.04\,m \times \frac{1}{n^3}$ cb. ft.	$0.16\,m \times \frac{1}{n^3}$ cb. ft.	$0.04\,m \times \frac{1}{n^3}$ cb. ft.	$0.16\,m \times \frac{1}{n^3}$ cb. ft.
Moment of inertia I =	$(0.32\,a - 0.1\,i) \times \frac{1}{n^4}$ sq.×sq. ft.	$(2.56\,a - 0.8\,i) \times \frac{1}{n^4}$ sq.×sq. ft.	—	$(2.56\,a - 0.8\,i) \times \frac{1}{n^4}$ sq.×sq. ft.
Moment of 4th order P =	—	—	—	$5.12\,(4\,m - p) \times \frac{1}{n^5}$ sq.×cb. ft.

Metric Instrument

Amsler Integrator No.	1	2	3	4
Area A =	$0.1\,a \times n^2$ cm²	$0.2\,a \times n^2$ cm²	$0.1\,a \times n^2$ cm²	$0.24\,a \times n^2$ cm²
Moment M =	$0.6\,m \times n^3$ cm³	$2.4\,m \times n^3$ cm³	$0.6\,m \times n^3$ cm³	$2.4\,m \times n^3$ cm³
Moment of inertia I =	$(10\,a - 4\,i) \times n^4$ cm⁴	$8\,(10\,a - 4\,i) \times n^4$ cm⁴	—	$32\,(5\,a - i) \times n^4$ cm⁴
Moment of 4th order P =	—	—	—	$480\,(4\,m - p) \times n^5$ cm⁵

For No. 2 tracing point

English Instrument

Amsler Integrator	No. 1	2	3	4
Area	$A = 0.01\,a \times \frac{1}{n^2}$ sq. ft.	$0.02\,a \times \frac{1}{n^2}$ sq. ft.	$0.01\,a \times \frac{1}{n^2}$ sq. ft.	$0.02\,a \times \frac{1}{n^2}$ sq. ft.
Moment	$M = 0.01\,m \times \frac{1}{n^3}$ cb. ft.	$0.04\,m \times \frac{1}{n^3}$ cb. ft.	$0.01\,m \times \frac{1}{n^3}$ cb. ft.	$0.04\,m \times \frac{1}{n^3}$ cb. ft.
Moment of inertia $I =$	$\frac{0.32\,a - 0.1\,i}{8} \times \frac{1}{n^4}$ sq.×sq. ft.	$(0.32\,a - 0.1\,i) \times \frac{1}{n^4}$ sq.×sq. ft.	—	$(0.32\,a - 0.1\,i) \times \frac{1}{n^4}$ sq.×sq. ft.
Moment of 4th order $P =$	—	—	—	$0.32\,(4\,m - p) \times \frac{1}{n^5}$ sq.×cb. ft.

Metric Instrument

Amsler Integrator	No. 1	2	3	4
Area	$A = 0.05\,a \times n^2$ cm²	$0.1\,a \times n^2$ cm²	$0.05\,a \times n^2$ cm²	$0.12\,a \times n^2$ cm²
Moment	$M = 0.15\,m \times n^3$ cm³	$0.6\,m \times n^3$ cm³	$0.15\,m \times n^3$ cm³	$0.6\,m \times n^3$ cm³
Moment of inertia $I =$	$\frac{10\,a - 4\,i}{8} \times n^4$ cm⁴	$(10\,a - 4\,i) \times n^4$ cm⁴	—	$4\,(3\,a - i) \times n^4$ cm⁴
Moment of 4th order $P =$	—	—	—	$30\,(4\,m - p) \times n^5$ cm⁵

For No. 3 tracing point

English Instrument

Amsler Integrator		No. 2		4
Area $A =$	—	$0.01\,a \times \frac{1}{n^2}$ sq. ft.	—	$0.01\,a \times \frac{1}{n^2}$ sq. ft.
Moment $M =$		$0.01\,m \times \frac{1}{n^3}$ cb. ft.		$0.01\,m \times \frac{1}{n^3}$ cb. ft.
Moment of inertia $I =$		$\frac{(0.32\,a - 0.1\,i)}{8} \times \frac{1}{n^4}$ sq.×sq. ft.		$\frac{(0.32\,a - 0.1\,i)}{8} \times \frac{1}{n^4}$ sq.×sq. ft.
Moment of 4th order $P =$		—		$0.02\,(4\,m - p) \times \frac{1}{n^5}$ sq.×cb. ft.

Metric Instrument

Amsler Integrator		No. 2		4
Area $A =$		$0.05\,a \times n^2$ cm²	—	$0.06\,a \times n^2$ cm²
Moment $M =$		$0.15\,m \times n^3$ cm³		$0.15\,m \times n^3$ cm³
Moment of inertia $I =$		$\frac{10\,a - 4\,i}{8} \times n^4$ cm⁴		$0.5\,(3\,a - i) \times n^4$ cm⁴
Moment of 4th order $P =$		—		$\frac{15}{8}\,(4\,m - p) \times n^5$ cm⁵

If, for example, the scale be $\frac{1}{4}$ in. = 1 ft., then for the *English instrument*

$$n = \frac{1}{4}, \text{ make } \frac{1}{n} = 4, \frac{1}{n^2} = 16, \frac{1}{n^3} = 64, \frac{1}{n^4} = 256.$$

For the metric instrument the unit of measurement for A, M, I, P again is the centimetre. If, for instance, in the earlier example of the rail the scale had been 1 : 2, the proceeding formulae would have been used, and as now 1 : n = 1 : 2, make n = 2. As $n^2 = 4$, $n^3 = 8$, $n^4 = 16$, the formulae are in this particular case as follows:

$$\text{Integrator No. 1:} \quad A = 0.2\ a \qquad M = 1.2\ m \qquad I = 20\ a - 8\ i$$

for the movable tracing point No. 2 used for the measurements.

If it is desired to obtain the results in metres instead of centimetres, as is usual in shipbuilding, make use of the following formulae

For No. 1 tracing point

Amsler Integrator	No. 1	2	3	4
A =	$0.1\ a \left(\frac{n}{100}\right)^2$	$0.2\ a \left(\frac{n}{100}\right)^2$	$0.1\ a \left(\frac{n}{100}\right)^2$	$0.24\ a \left(\frac{n}{100}\right)^2$
M =	$0.6\ m \left(\frac{n}{100}\right)^3$	$2.4\ m \left(\frac{n}{100}\right)^3$	$0.6\ m \left(\frac{n}{100}\right)^3$	$2.4\ m \left(\frac{n}{100}\right)^3$
I =	$10\ a - 4\ i \left(\frac{n}{100}\right)^4$	$8\ (10\ a - 4\ i) \left(\frac{n}{100}\right)^4$	—	$32\ (3\ a - i) \left(\frac{n}{100}\right)^4$
P =	—	—	—	$480\ (4\ m - p) \left(\frac{n}{100}\right)^5$

For No. 2 tracing point

Amsler Integrator	No. 1	2	3	4
A =	$0.05\ a \left(\frac{n}{100}\right)^2$	$0.1\ a \left(\frac{n}{100}\right)^2$	$0.05\ a \left(\frac{n}{100}\right)^2$	$0.12\ a \left(\frac{n}{100}\right)^2$
M =	$0.15\ m \left(\frac{n}{100}\right)^3$	$0.6\ m \left(\frac{n}{100}\right)^3$	$0.15\ m \left(\frac{n}{100}\right)^3$	$0.6\ m \left(\frac{n}{100}\right)^3$
I =	$\frac{10\ a - 4\ i}{8} \left(\frac{n}{100}\right)^4$	$(10\ a - 4\ i) \left(\frac{n}{100}\right)^4$	—	$4\ (3\ a - i) \left(\frac{n}{100}\right)^4$
P =	—	—	—	$30\ (4\ m - p) \left(\frac{n}{100}\right)^5$

For No. 3 tracing point

Amsler Integrator	No. 2	4
A =	$0.05\ a \left(\frac{n}{100}\right)^2$	$0.06\ a \left(\frac{n}{100}\right)^2$
M =	$0.15\ m \left(\frac{n}{100}\right)^3$	$0.15\ m \left(\frac{n}{100}\right)^3$
I =	$\frac{10\ a - 4\ i}{8} \left(\frac{n}{100}\right)^4$	$0.5\ (3\ a - i) \left(\frac{n}{100}\right)^4$
P =	—	$\frac{15}{8}\ (4\ m - p) \left(\frac{n}{100}\right)^5$

If, for instance, the scale of the drawing to be evaluated be 1 : 50, then n = 50, viz.:

$$\frac{n}{100} = \frac{1}{2}; \left(\frac{n}{100}\right)^2 = \frac{1}{4}; \left(\frac{n}{100}\right)^3 = \frac{1}{8}; \left(\frac{n}{100}\right)^4 = \frac{1}{16}$$

and the above formulae are for this particular case as follows:

Amsler Integrator No. 1.

No. 1 tracing point	No. 2 tracing point	No. 3 tracing point
$A = \frac{0.1\ a}{4}$ sq. m	$A = \frac{0.05\ a}{4}$ sq. m	A = —
$M = \frac{0.6\ m}{8}$ cb. m	$M = \frac{0.15\ m}{8}$ cb. m	M = —
$I = \frac{10\,a - 4\,i}{16}$ sq. × sq. m	$I = \frac{10\,a - 4\,i}{128}$ sq. × sq. m	I = —

and so on for integrators No. 2, No. 3 and No. 4.

General remarks on Mechanism

Avoid touching the rims of the measuring rollers. They are liable to be spoiled by rust.

Do not try to set the rollers to zero; this would involve more time and trouble than taking the readings as they stand.

The rollers must rotate very easily and for this reason must have a little play between the pivot centres; the edge of the roller, however, should not touch the vernier. All the other axles should be without back-lash, it being of no importance whether they revolve very easily or not.

The pivot centres should occasionally be lubricated with fine oil.

Any alterations of the tracing arm or axial sliding of the wheels of the carriage disturb the adjustment of the integrator and should therefore be avoided.

On the other hand, the rollers can be slightly displaced in axial direction, without influencing the accuracy of the instrument. The rollers may then be removed for cleaning purposes without danger of disturbance, provided the necessary precaution be taken. It is of the utmost importance that the rims of the rollers remain always unaltered. Do not polish and avoid scratching them. Protect the pivots of the roller axles from becoming damaged, because the use of the Integrator is very dependent on this point.

Should the adjustment of the Integrator be slightly disturbed, it is nevertheless possible to get good results by going over the measurements twice, first in the usual way and the second time by turning the drawing upside down, so that part of the figure which was first situated between the axis of moments and the steel rail the second time lies below the axis of moments. The average of both measurements should then be taken.