0.1° Position Calibration Targets

Metric Measure, for A (letter) size paper

31 December 2008

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File Naming

File names are generated as follows:

- The first letter indicates the measurment system: **E** = English measure, **M** = Metric measure.
- The second, third letter(s) indicates the paper size: **A** = letter size ($8\frac{1}{2} \times 11$ inches. **A4** = A4 size (mm).
- The next letter indicates the precision of the targets being generated: **P**.
- The next few letters indicate if a decimal point is to be inserted: **DOT** = yes, nothing = no.
- The last digit(s) indicate the precision of the target: **1** = .1°.

[1] `$Header: d:/Binder2/Targets/RCS/EaPdot1.tex,v 1.3 2008-12-24 09:16:58-08 Hamilton Exp Hamilton $`

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1 Calibration Grid

To aid in determining the pointing accuracy of a Pan/Tilt/Dome a set of targets with calibrated 0.1° and 0.01° marks in pan and tilt have been developed for use at different distances from the unit being tested.

The method of calculating the angular distance required for 0.1° movement at various distances away from the camera is:

$$\pi = 3.1415926$$

English Measure

$$c_{ft} = 2 \times \pi \times r_{ft}$$
$$a_{in} = (c_{ft} \times 12)/(360 \times 10)$$

Metric Measure

$$c_m = 2 \times \pi \times r_m$$
$$a_m = c_m/(360 \times 10)$$

Where:

- 10 = Conversion factor from whole degrees to tenths of a degree.
- 2 = Factor between diameter and radius of a circle.
- 360 = Degrees in a circle.
- English measure
  - a_{in} = Arc of 0.1° width in inches.
  - c_{ft} = Circumference of a circle in feet.
  - r_{ft} = Radius of a circle in feet.
  - 12 = Conversion factor from feet to inches.
- Metric measure
  - a_m = Arc of 0.1° width in meters.
  - c_m = Circumference of a circle in meters.
  - r_m = Radius of a circle in meters.

[2] `$Header: d:/Binder2/Targets/RCS/CalGrid.inc,v 1.3 2008-12-31 07:53:29-08 Hamilton Exp Hamilton $`

For example at 48 feet from the camera, 0.1° of angular distance is 1.01 inch long. (Or 1.005300032 inch if more accuracy is needed.)

For Example at 3.5 meters from the camera, 0.1° of angular distance is .0061 meters (or .61 cm) long. (Or 0.610866 cm, if more accuracy is needed.)

1.1 How to use the targets

The included targets in this series of notes are designed for use with English Measurements at ranges of 2 → 11 feet in full foot increments and from 12 → 56 feet in even foot increments, between the camera and the target[4]. For metric units the range is 1 → 9.5 in $\frac{1}{2}$ meter units and from 10 → 20 in full meter increments.

Each of the larger grids consists of a "large" and a "small" set of dots[5]. The large dots are either 0.1°, 0.25°, or 0.5° apart and the small dots are 0.01° apart. Each target has a central dot with the distance that the target is anticipated to be used at underneath. They also have four large sub-dots which are numbered from 1 to 4 for additional testing.

1. More than one of these may be used at any one time. I.e. there may be two places/directions that it is reasonable to point a camera. These places/directions may be on different walls, or other convenient surface, which may be at different, or the same, distances. Thus two targets would be used for the same series of tests.

2. When selecting a target to use it should be remembered that the distance to be used is the estimated distance from the camera's physical "pivot point". This may or may not be the front of the lens of the camera nor may it be the "optical center" of the camera.

3. When using English Measurement units, for a reasonably accurate indication of distance, it should be remembered that ceiling tiles are two feet on a side (some are two by four with a line down the middle). Over any reasonable distance any errors average out and the result is quite accurate. (Usually better than ±1inch.) It is unknown what the common sizes of ceiling tiles are in other locations/countries.

4. To easily calculate distance, count full tiles and double, or quadruple, their number. (Ceiling tiles being either 2 feet by 4 feet, or 2 feet by 2 feet in size.) The result is the distance between the camera and the target in feet.

5. When using these targets, their accuracy improves somewhat when longer distances are used. The recommended distances to use with these targets are in the 40's of feet (40, 42, 44, 46 and 48). Or use distances greater than 10 meters. The reasons for this are that small errors in determining the exact pivot point of a PTZ become insignificant if there is an error of $\frac{1}{4}$

[3] `$Header: d:/Binder2/Targets/RCS/UseTgt.inc,v 1.1 2008-10-28 08:51:39-08 Hamilton Exp Hamilton $`

[4] Targets may be generated for other distances if needed.

[5] The smaller grids do not have the 0.01° grids because the dots are too close together and tend to make a black box with no obvious dots in it.

inch (6 mm) when the radius is over 35 feet (10 meters), but it is significant when the radius is 3 feet (1 meter).

6. If distances other than those provided in this set of foot or metric distances are needed please let me know and I'll generate some more targets. I am only setup to generate targets on 8 $\frac{1}{2}$ by 11 inch paper (but not A4 size paper, all A4 targets are untested) in portrait format and in whole foot distances. I.e. no landscape formats and no "bigger" paper. (If it is important the distances for which the targets are generated at may be changed on request.)

7. When closer distances are needed than are provided by this set of targets, use the small grids on the larger targets and move the entire target 10× closer. I.e. use the 40 foot target at 4 feet. When this is done the small target is correct for the closer distance.

8. Always remember that custom targets are made on request. So a target may be made for almost any reasonable distance. The only limitations are the size of the paper and the resolution of the printer[6].

9. An accuracy of ±.1° is interpreted to mean: "The unit will point to within .1° from where it is supposed to point. The pointing is to be within a square box that has equal length sides of .2° and the aiming point is to be in the center of the box. This is different than using a circle with a radius of .1°."

A note on the accuracy of the targets

1. Accuracy in the generation of the grid is controlled by the quality of the printer used to print it on and the number of times that the individual target has been reproduced.

   The generated PDF file is correct, however the actual printing process sometimes introduces sizeing errors. When paper is wrapped around a drum, as it is with most laser printers, one surface is longer (one side is on the outside of the circle so its radius is slightly longer than the other side's is).

   While the paper direction that is transverse to the cylinder is almost always "correct". This results in dimensions in one direction being somewhat better than those in the longitudinal direction.

   To get an estimate of the amount of "printing error" that has been introduced to any given target, a rule has been provided on each edge of the target grid. If this rule is checked with an accurate machinist's ruler and indication of the dimensional errors that have been introduced to the copy at hand may be estimated. For almost all uses the introduced error may be ignored. On metric grids there is a metric distance rule on the grids.

[6] And the attitude of the author!

[7] `$Header: d:/Binder2/Targets/RCS/TgtAcc.inc,v 1.3 2008-10-28 08:51:21-08 Hamilton Exp Hamilton $`

2. The target should be tangential to the axis of motion of the PTZ unit. As distances from the center of the target increase, errors in the exact angular distances increase. For the absolute "best" results, the target should have a spherical shape and have all points on it the same distance from the PTZ's pivot point[8]. It is unlikely that this will ever happen, however the errors introduced by having a flat target *vs.* a spherical target are reduced to insignificantce by using larger distances from the PTZ's pivot point to the target.
3. On some PTZ units, pan and tilt have different pivot points. This should be considered when making accurate close measurements.

1.2 Summary of metric distance targets generated

Target #	Accuracy °	Marker	Distance Meters	Step Size mm	Step Size mm	Page
12-31-2008 07:54:41						
1	0.10	10	2.00	3.49066	3.5	Figure 1, page 10
2	0.10	10	2.10	3.66520	3.7	Figure 2, page 11
3	0.10	10	2.20	3.83973	3.8	Figure 3, page 12
4	0.10	10	2.30	4.01426	4.0	Figure 4, page 13
5	0.10	10	2.40	4.18879	4.2	Figure 5, page 14
6	0.10	10	2.50	4.36333	4.4	Figure 6, page 15
7	0.10	10	2.60	4.53786	4.5	Figure 7, page 16
8	0.10	10	2.70	4.71239	4.7	Figure 8, page 17
9	0.10	10	2.80	4.88693	4.9	Figure 9, page 18
10	0.10	10	2.90	5.06146	5.1	Figure 10, page 19
11	0.10	10	3.00	5.23599	5.2	Figure 11, page 20
12	0.10	10	3.10	5.41053	5.4	Figure 12, page 21
13	0.10	10	3.20	5.58506	5.6	Figure 13, page 22
14	0.10	10	3.30	5.75959	5.8	Figure 14, page 23
15	0.10	10	3.40	5.93412	5.9	Figure 15, page 24
16	0.10	5	3.50	6.10866	6.1	Figure 16, page 25
17	0.10	5	3.60	6.28319	6.3	Figure 17, page 26
18	0.10	5	3.70	6.45772	6.5	Figure 18, page 27
19	0.10	5	3.80	6.63226	6.6	Figure 19, page 28
20	0.10	5	3.90	6.80679	6.8	Figure 20, page 29
21	0.10	5	4.00	6.98132	7.0	Figure 21, page 30
22	0.10	5	4.10	7.15586	7.2	Figure 22, page 31
23	0.10	5	4.20	7.33039	7.3	Figure 23, page 32
Continued on the next page.						

[8]I.e. the target should have a spherical shape with the radius of the sphere being equal to the distance from the pivot point of the camera.

Continued from the previous page.

Target #	Accuracy °	Marker	Distance Meters	Step Size mm	Step Size mm	Page
12-31-2008 07:54:41						
24	0.10	5	4.30	7.50492	7.5	Figure 24, page 33
25	0.10	5	4.40	7.67945	7.7	Figure 25, page 34
26	0.10	5	4.50	7.85399	7.9	Figure 26, page 35
27	0.10	5	4.60	8.02852	8.0	Figure 27, page 36
28	0.10	5	4.70	8.20305	8.2	Figure 28, page 37
29	0.10	5	4.80	8.37759	8.4	Figure 29, page 38
30	0.10	5	4.90	8.55212	8.6	Figure 30, page 39
31	0.10	5	5.00	8.72665	8.7	Figure 31, page 40
32	0.10	5	5.50	9.59932	9.6	Figure 32, page 41
33	0.10	5	6.00	10.47199	10.5	Figure 33, page 42
34	0.10	5	6.50	11.34465	11.3	Figure 34, page 43
35	0.10	5	7.00	12.21732	12.2	Figure 35, page 44
36	0.10	2	7.50	13.08999	13.1	Figure 36, page 45
37	0.10	2	8.00	13.96265	14.0	Figure 37, page 46
38	0.10	2	8.50	14.83532	14.8	Figure 38, page 47
39	0.10	2	9.00	15.70798	15.7	Figure 39, page 48
40	0.10	2	9.50	16.58065	16.6	Figure 40, page 49
41	0.10	2	10.00	17.45331	17.5	Figure 41, page 50
42	0.10	2	11.00	19.19865	19.2	Figure 42, page 51
43	0.10	2	12.00	20.94398	20.9	Figure 43, page 52
44	0.10	2	13.00	22.68931	22.7	Figure 44, page 53
45	0.10	2	14.00	24.43464	24.4	Figure 45, page 54
46	0.10	2	15.00	26.17997	26.2	Figure 46, page 55
47	0.10	2	16.00	27.92530	27.9	Figure 47, page 56
48	0.10	2	17.00	29.67063	29.7	Figure 48, page 57
49	0.10	2	18.00	31.41596	31.4	Figure 49, page 58
50	0.10	2	19.00	33.16129	33.2	Figure 50, page 59
51	0.10	2	20.00	34.90663	34.9	Figure 51, page 60

1.3 Targets for metric distances

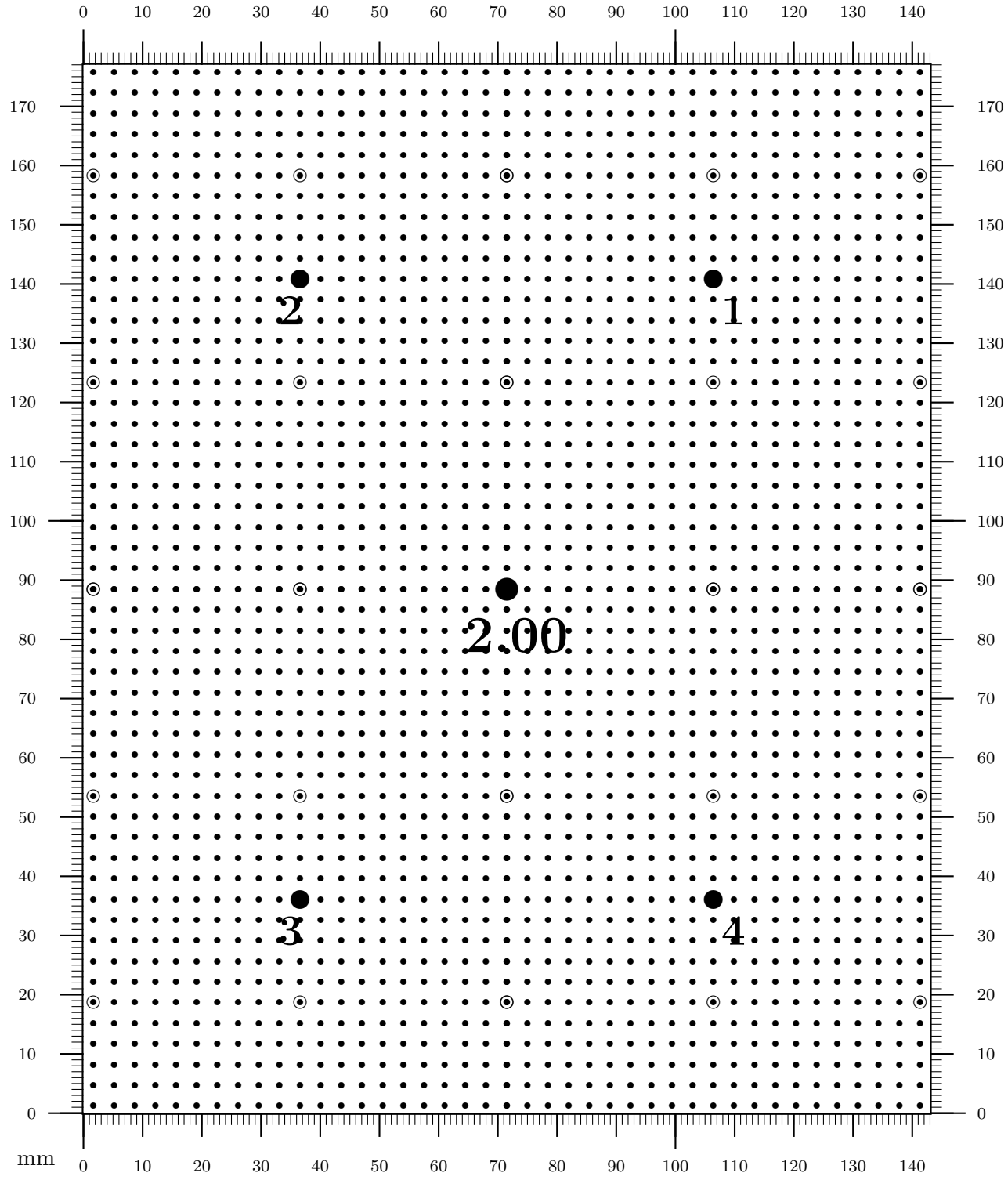

Figure 1: **0.1° at 2.00 meters is 3.490663 mm.**

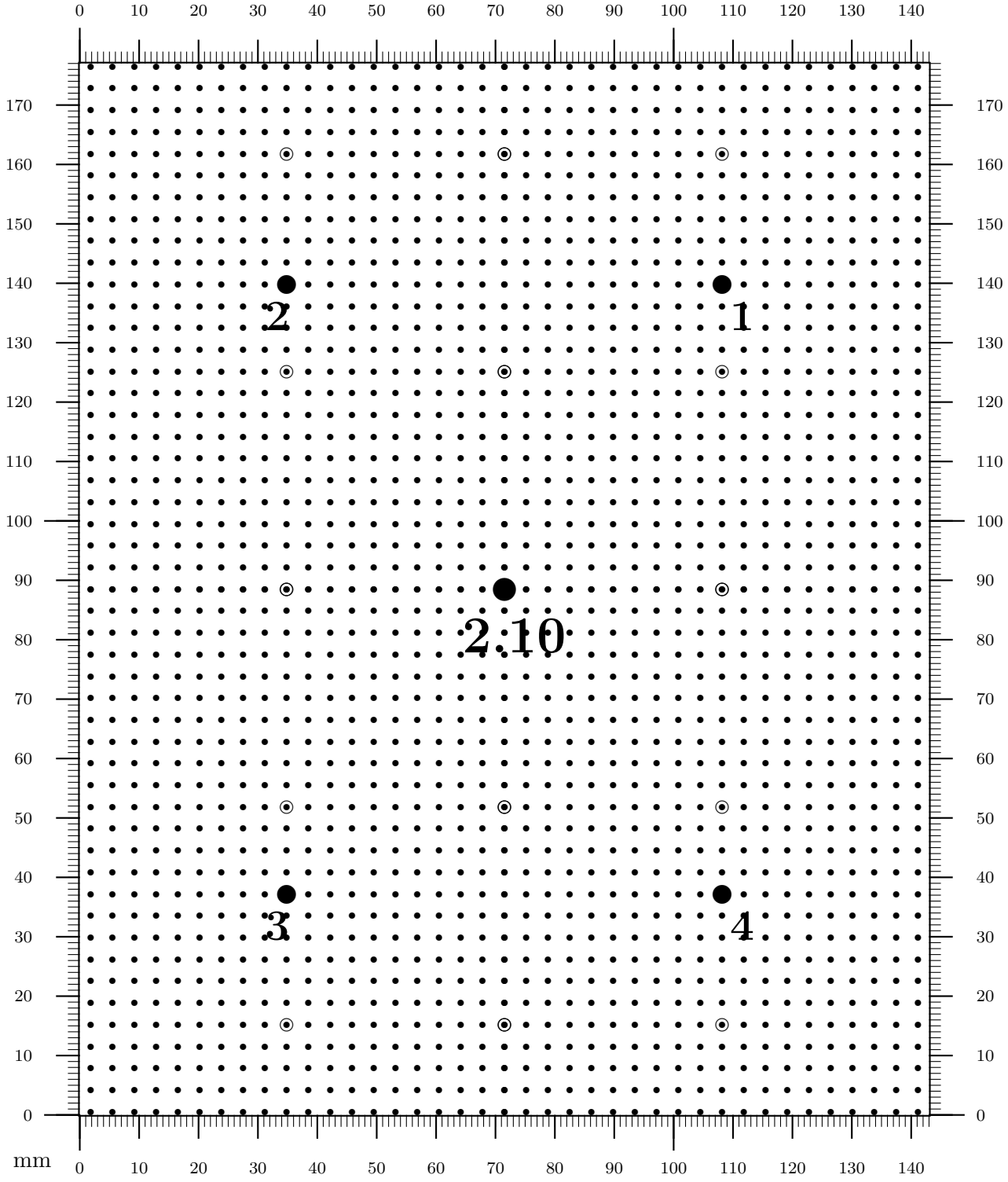

Figure 2: **0.1° at 2.10 meters is 3.665196 mm.**

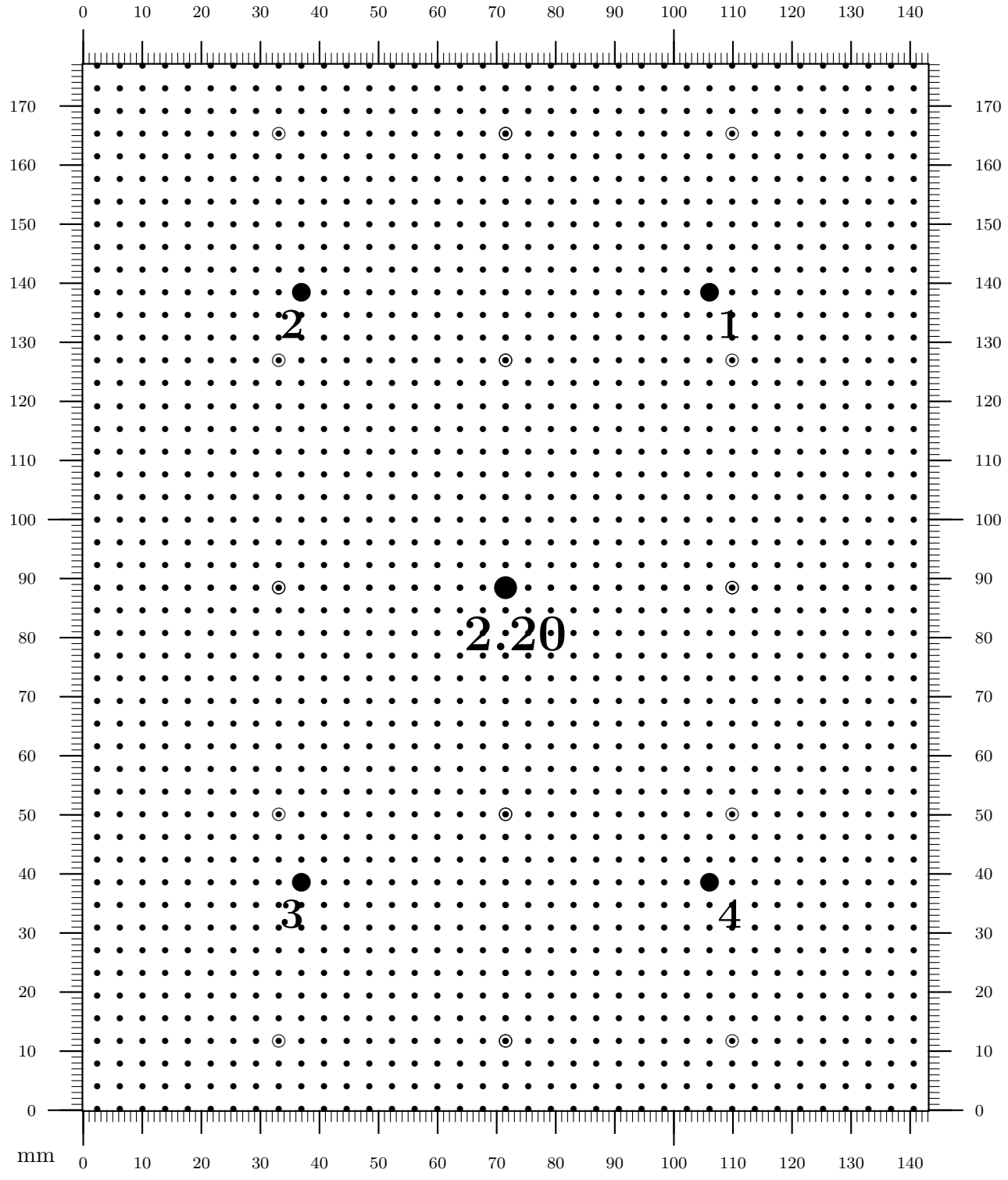

Figure 3: **0.1° at 2.20 meters is 3.839729 mm.**

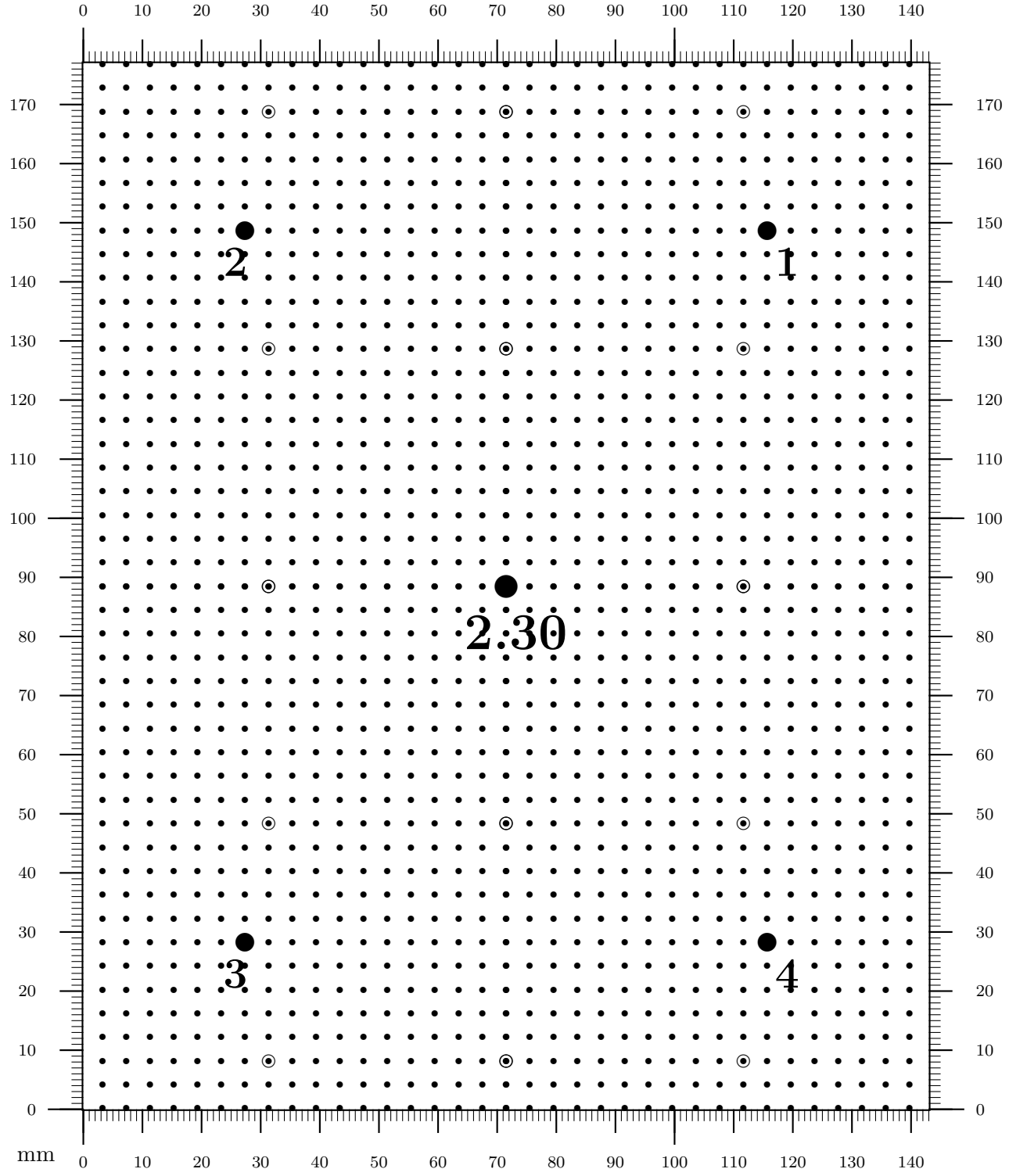

Figure 4: **0.1° at 2.30 meters is 4.014261 mm.**

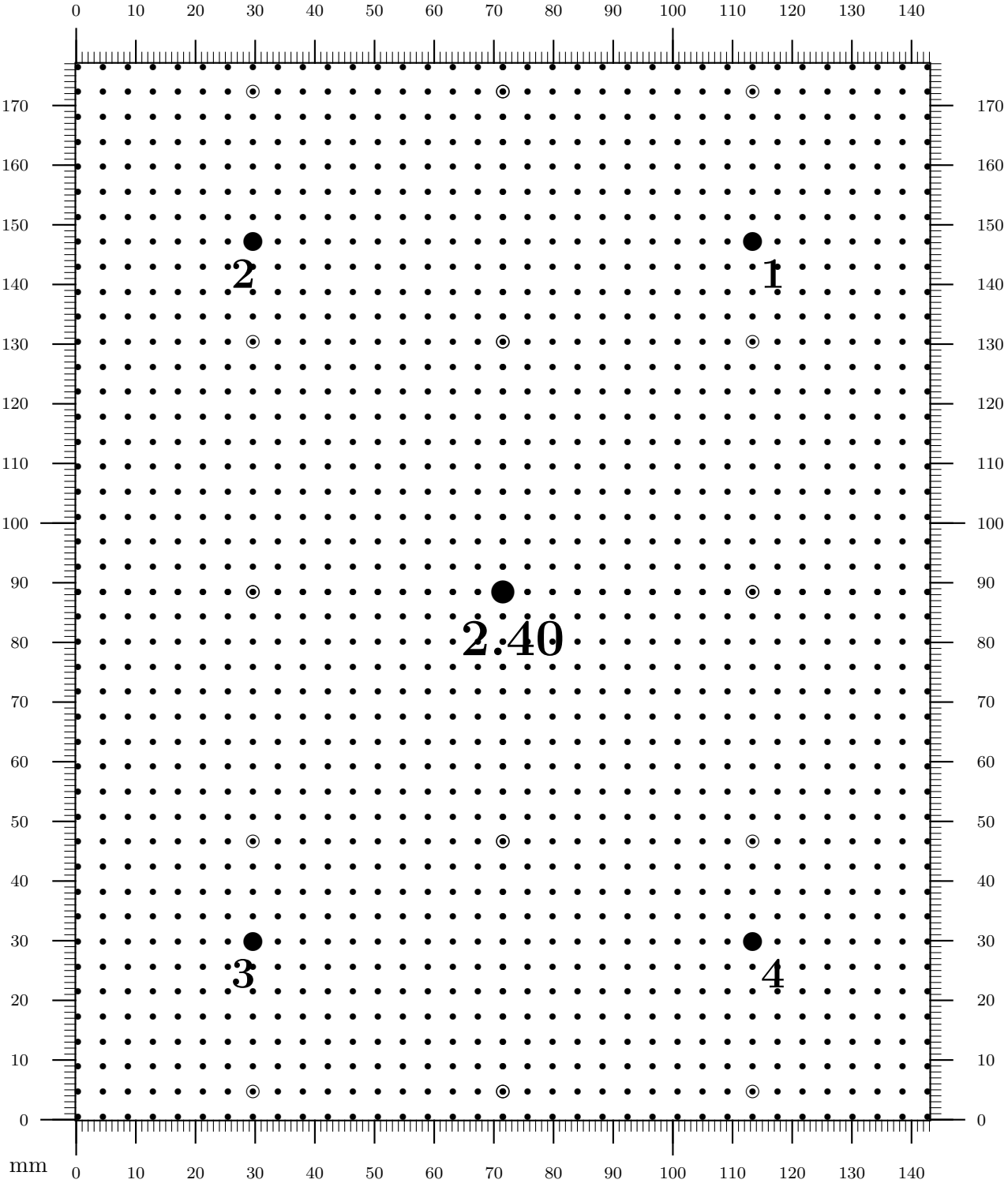

Figure 5: **0.1° at 2.40 meters is 4.188794 mm.**

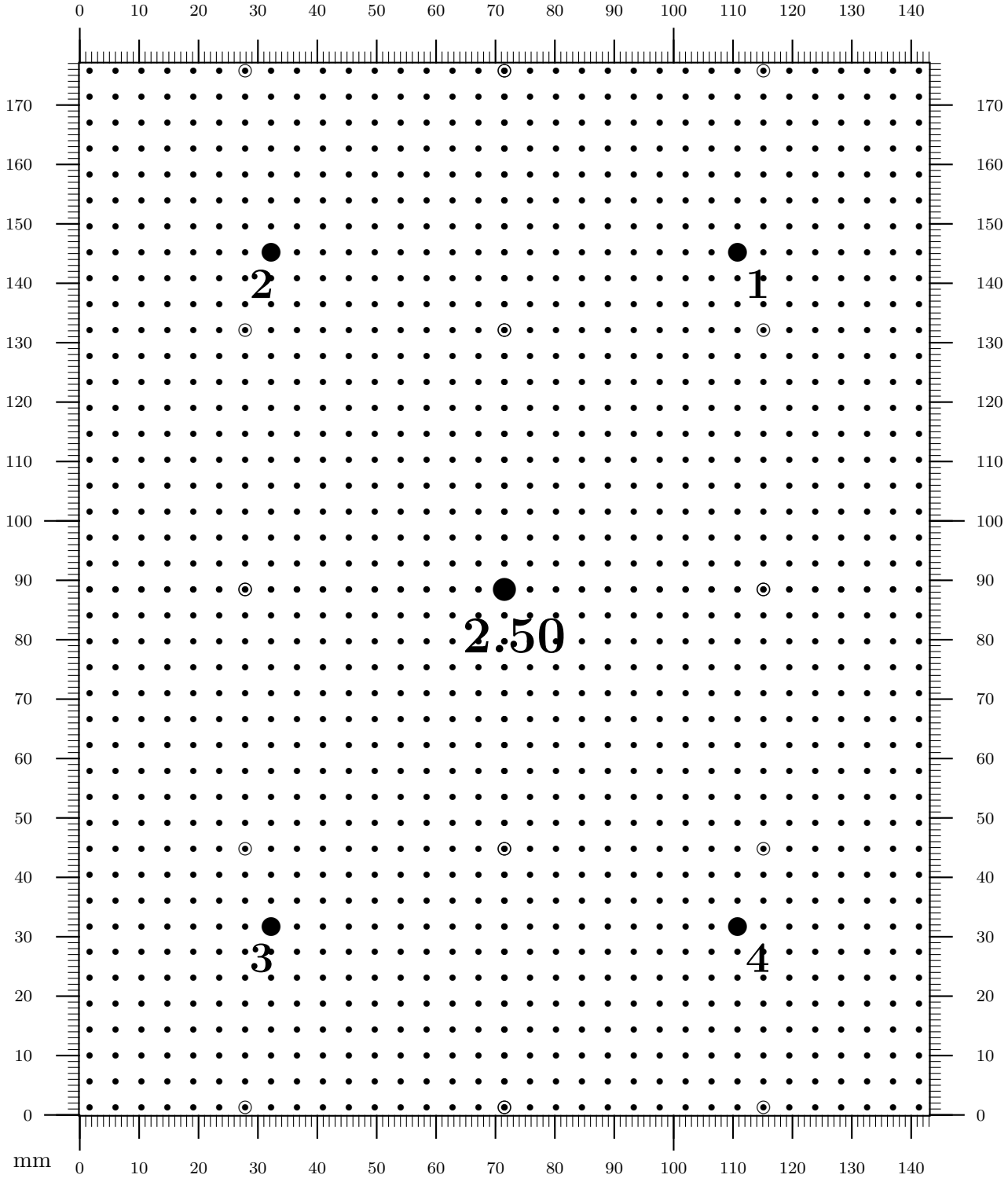

Figure 6: **0.1° at 2.50 meters is 4.363328 mm.**

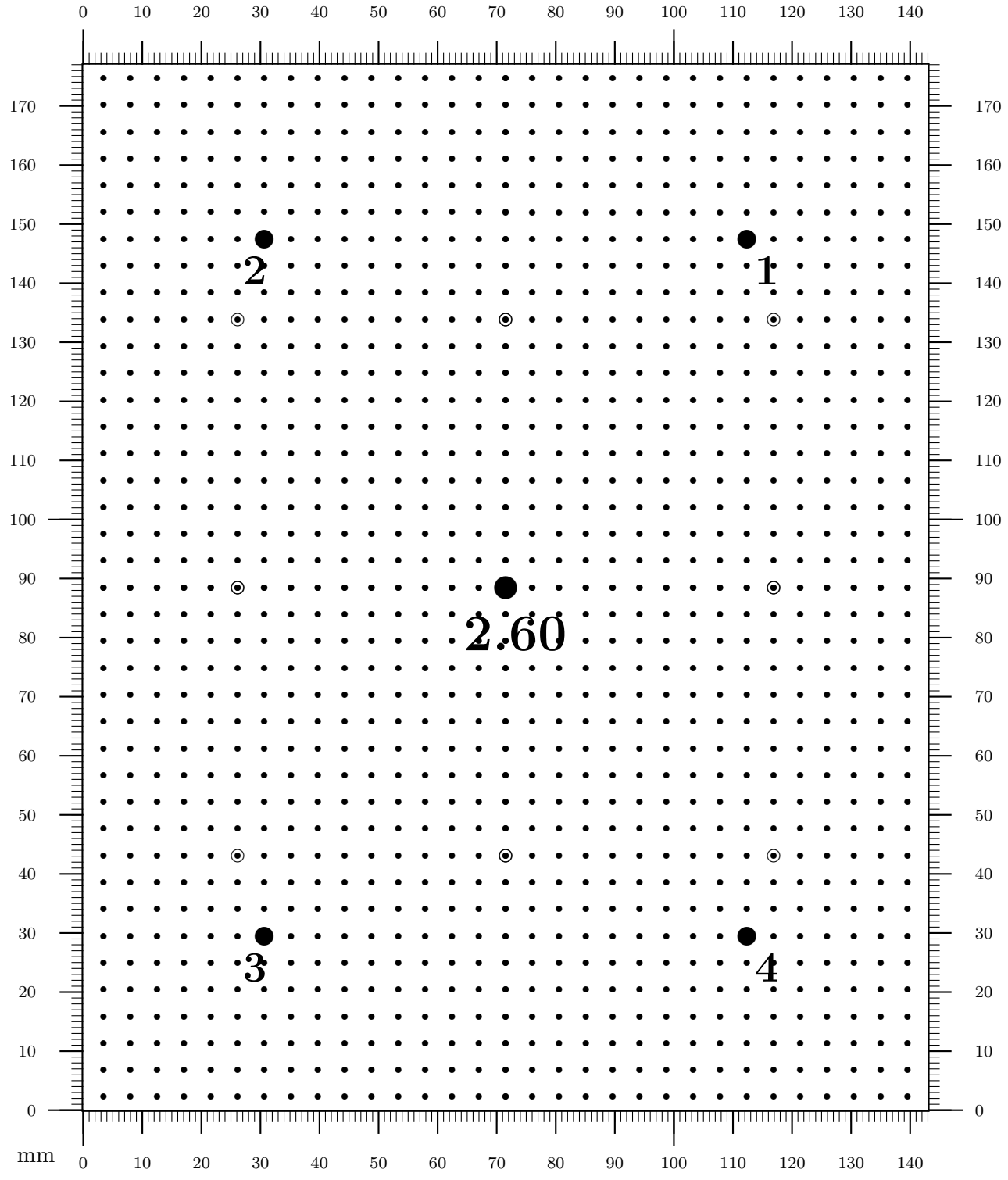

Figure 7: **0.1° at 2.60 meters is 4.537860 mm.**

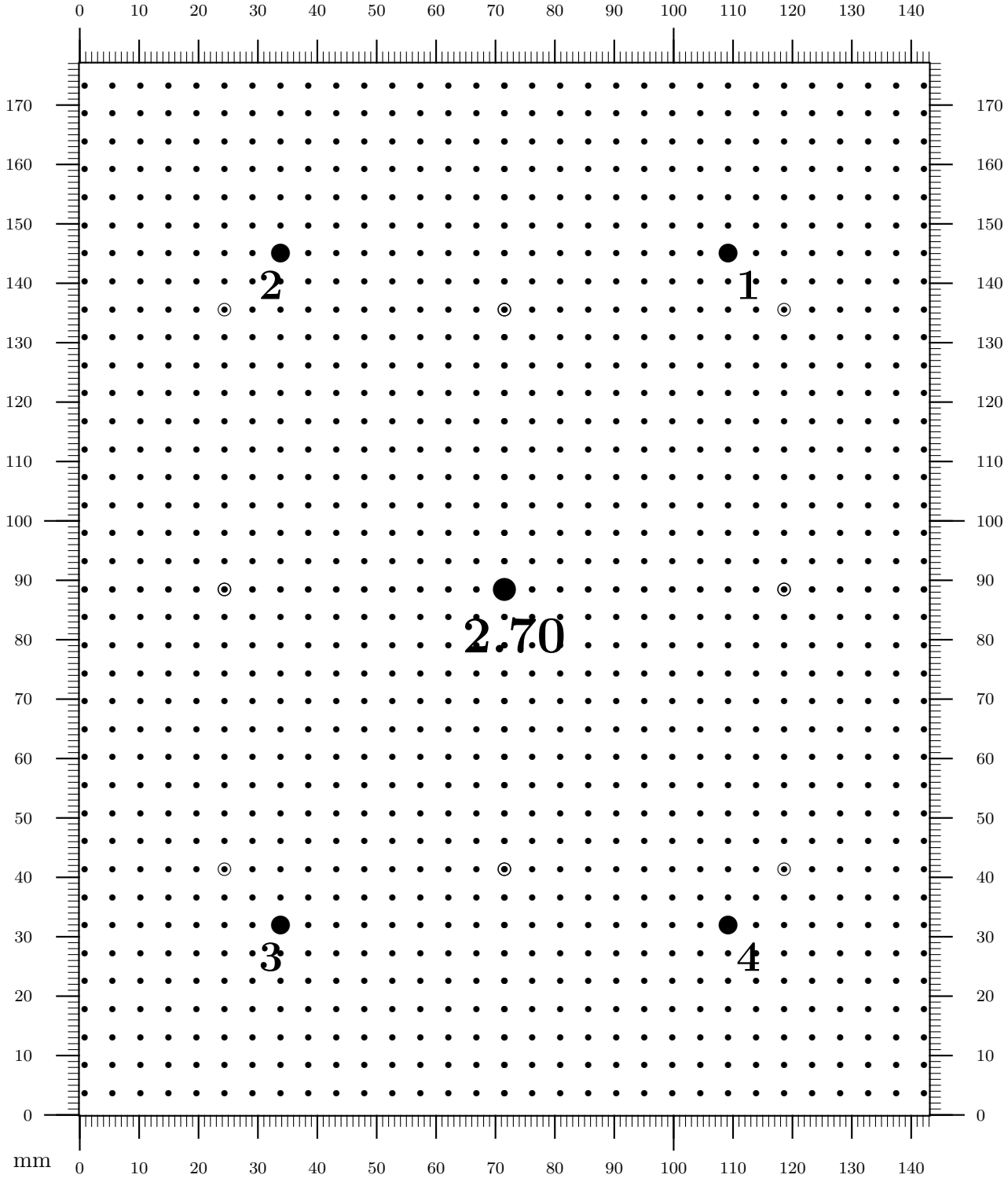

Figure 8: **0.1° at 2.70 meters is 4.712394 mm.**

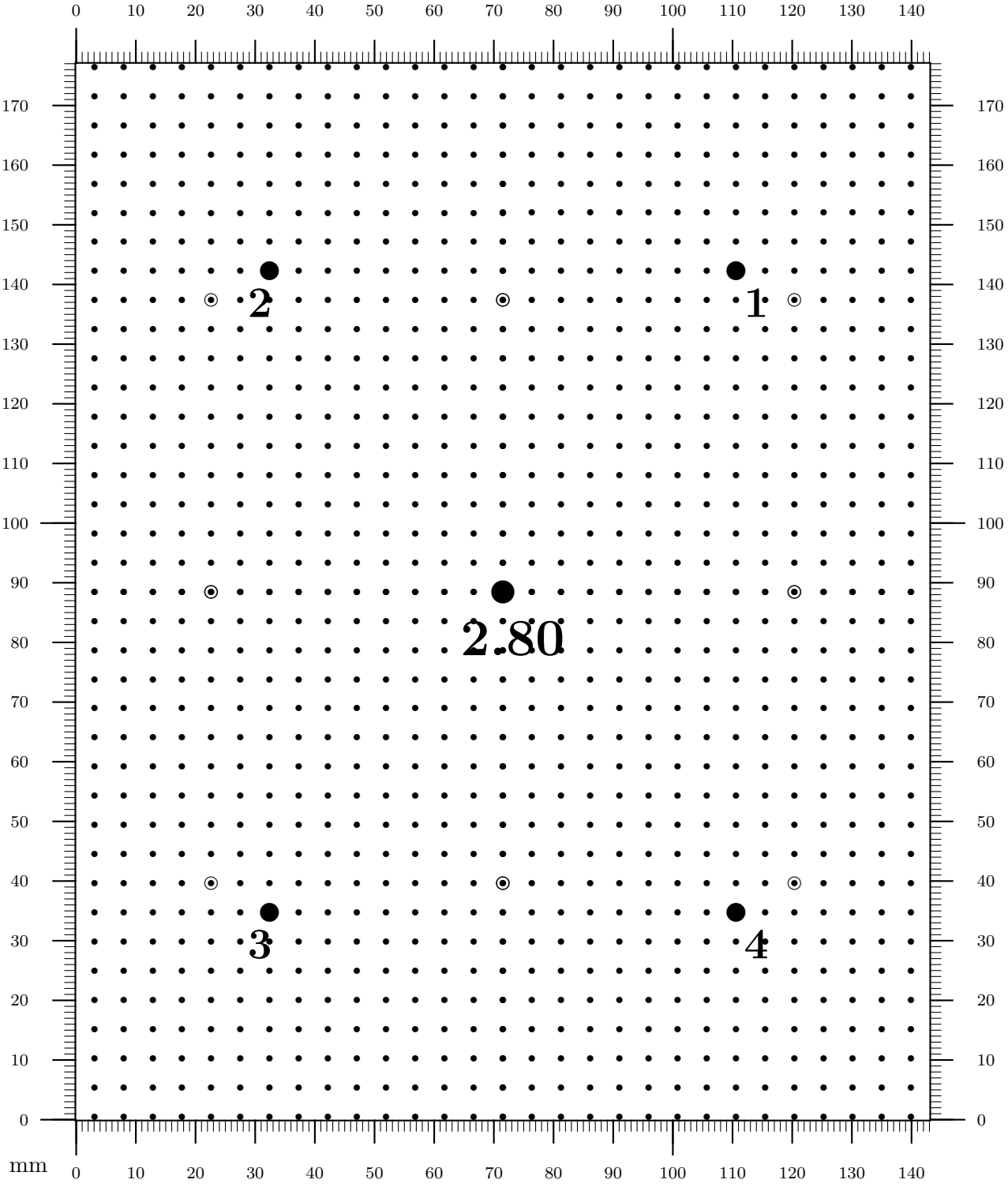

Figure 9: **0.1° at 2.80 meters is 4.886926 mm.**

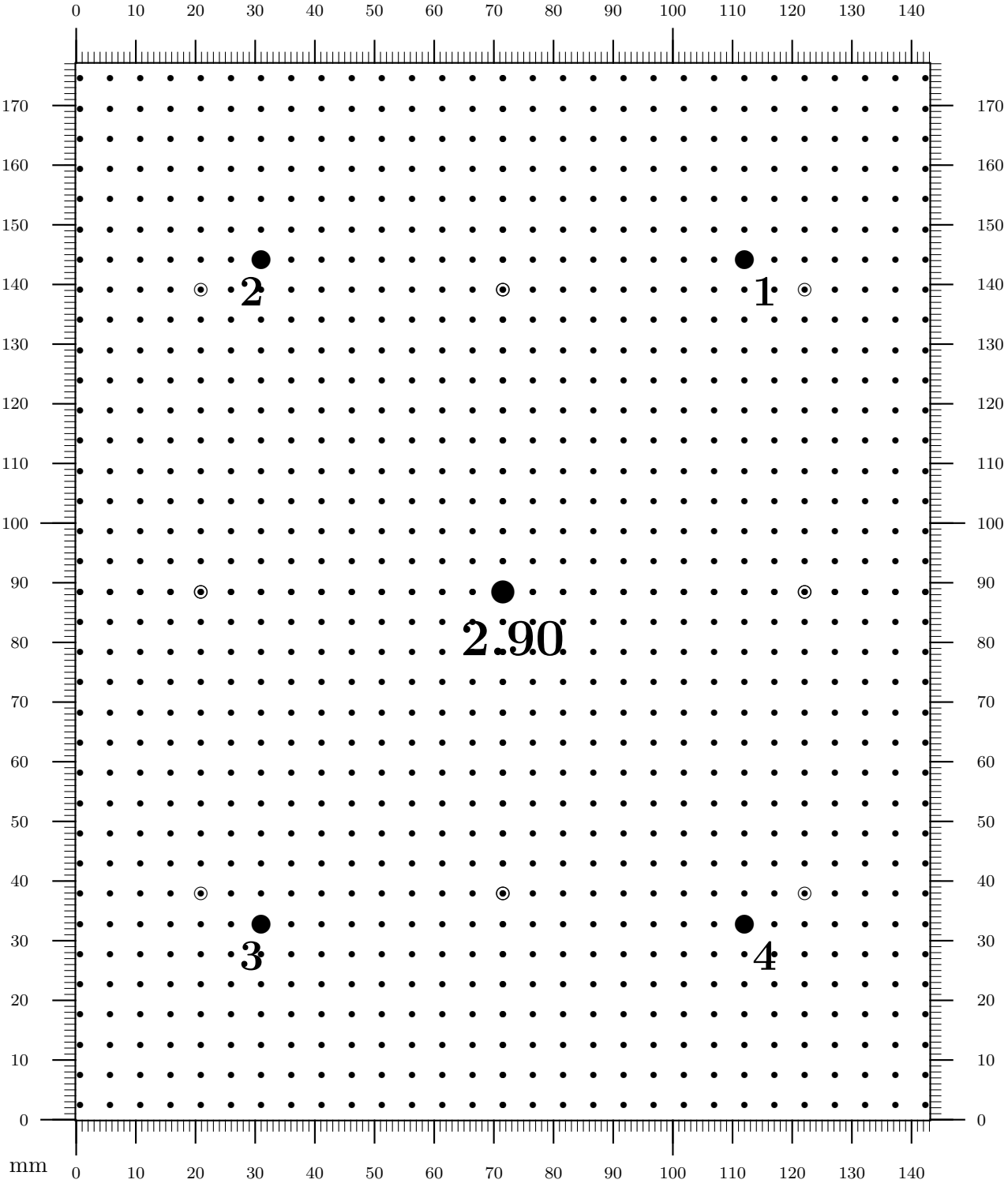

Figure 10: **0.1° at 2.90 meters is 5.061459 mm.**

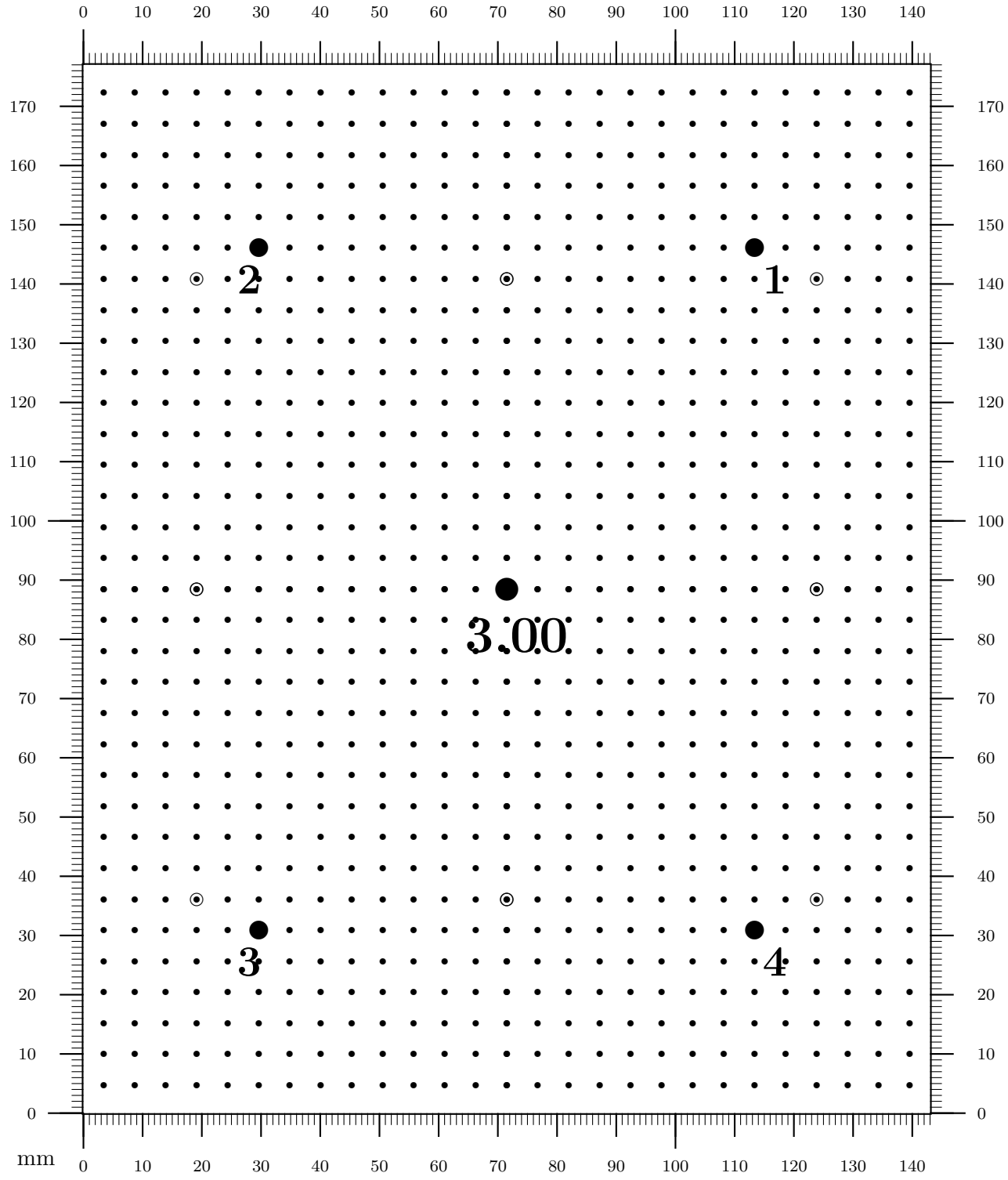

Figure 11: **0.1° at 3.00 meters is 5.235992 mm.**

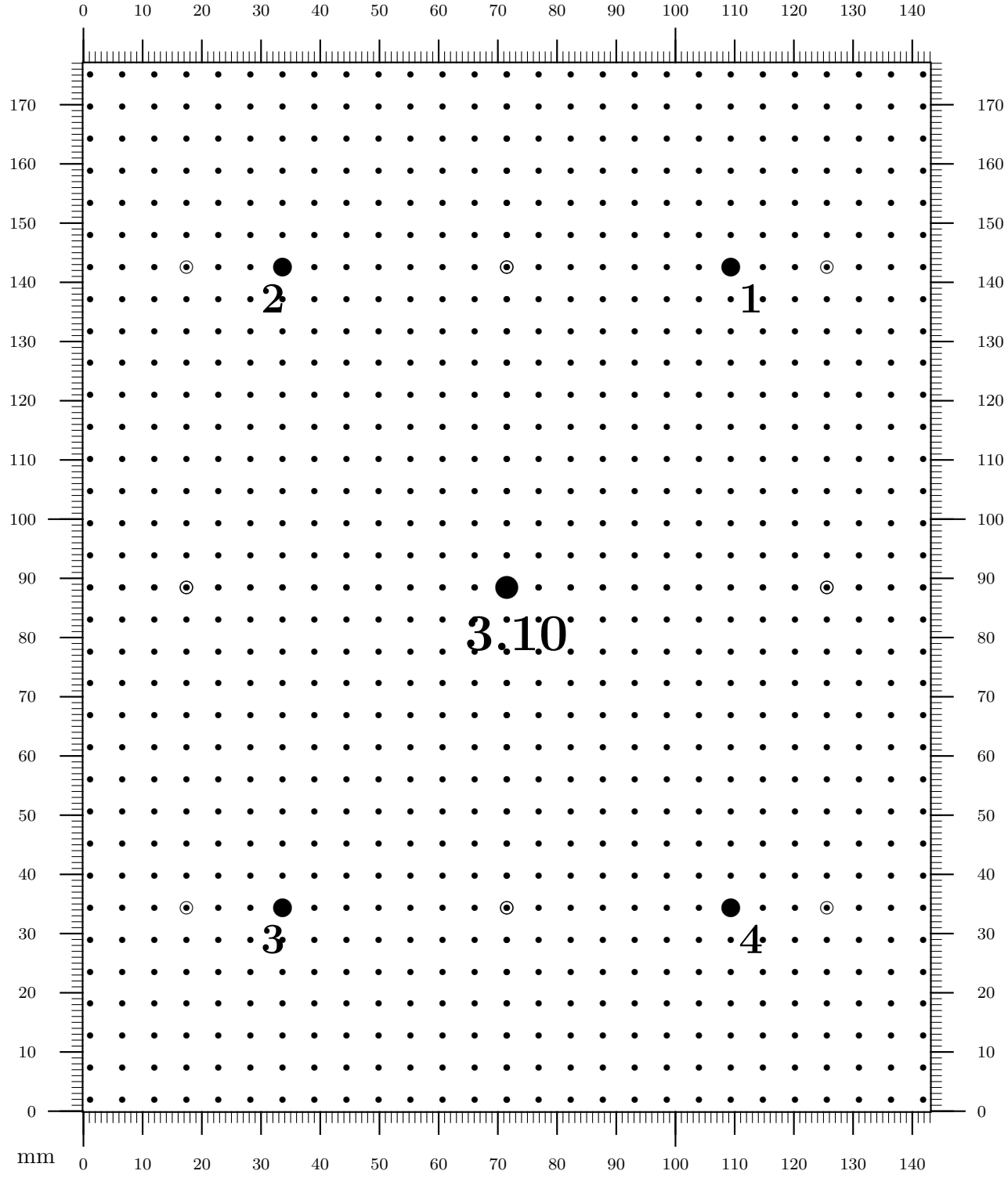

Figure 12: **0.1° at 3.10 meters is 5.410525 mm.**

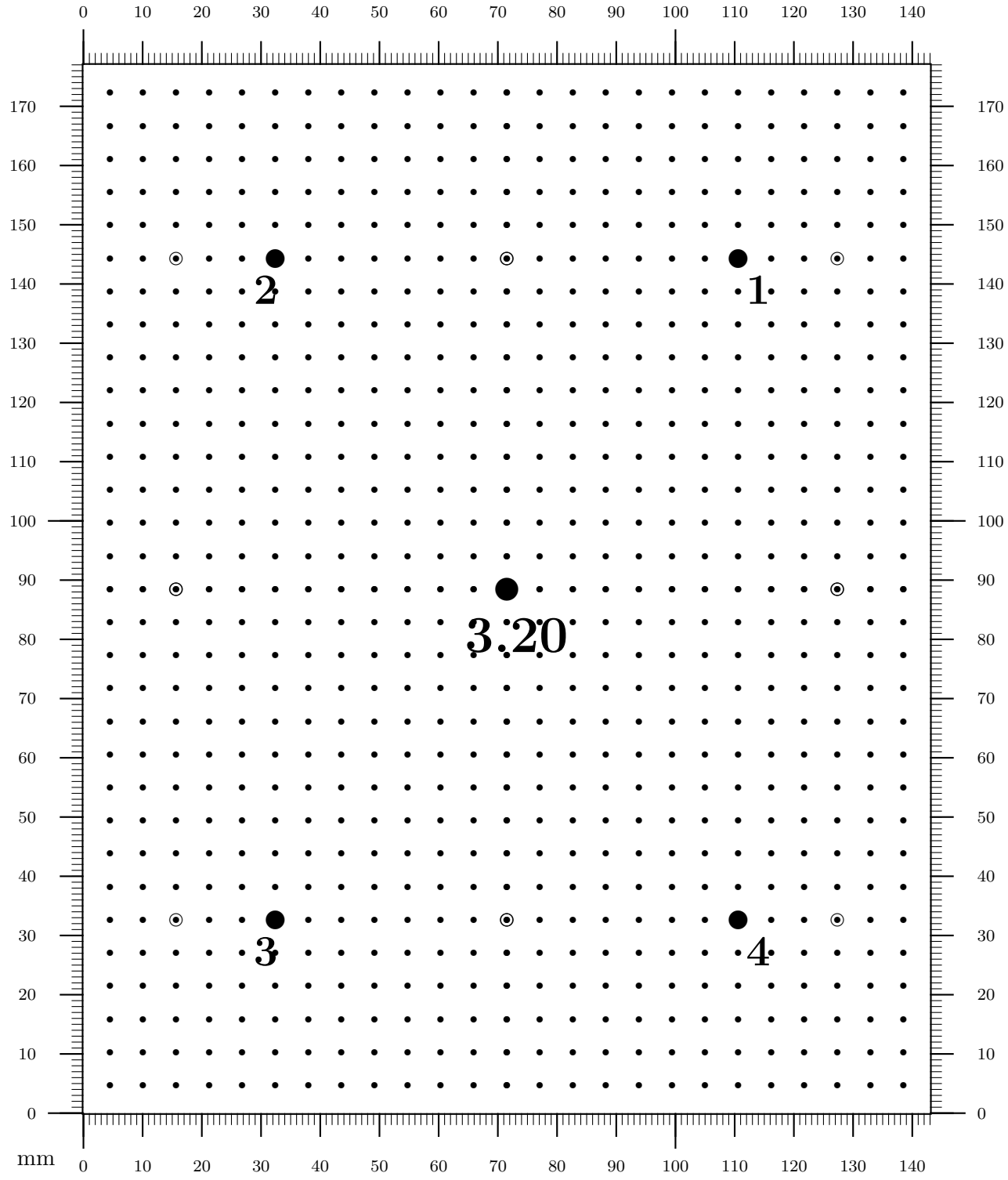

Figure 13: **0.1° at 3.20 meters is 5.585058 mm.**

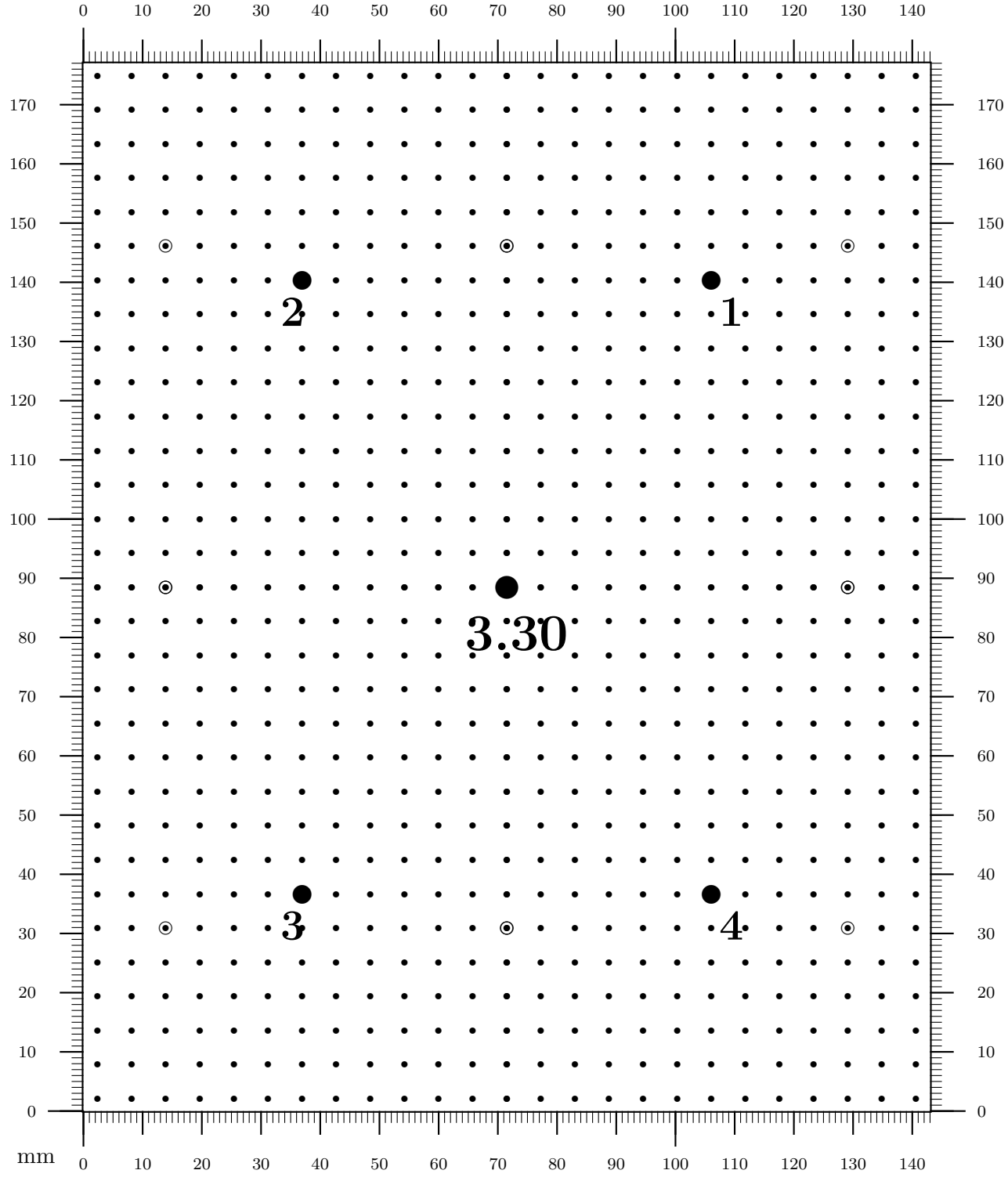

Figure 14: **0.1° at 3.30 meters is 5.759591 mm.**

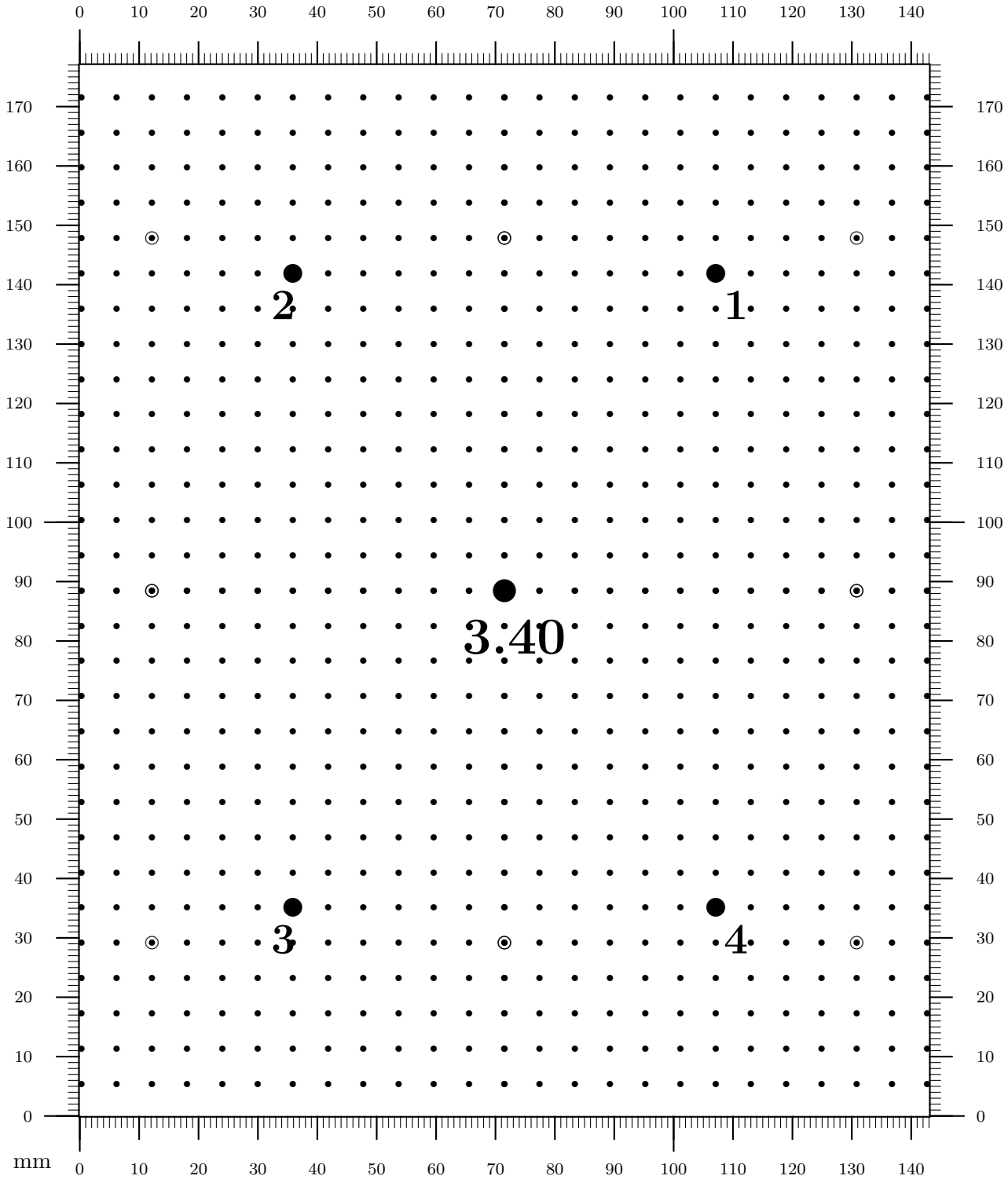

Figure 15: **0.1° at 3.40 meters is 5.934124 mm.**

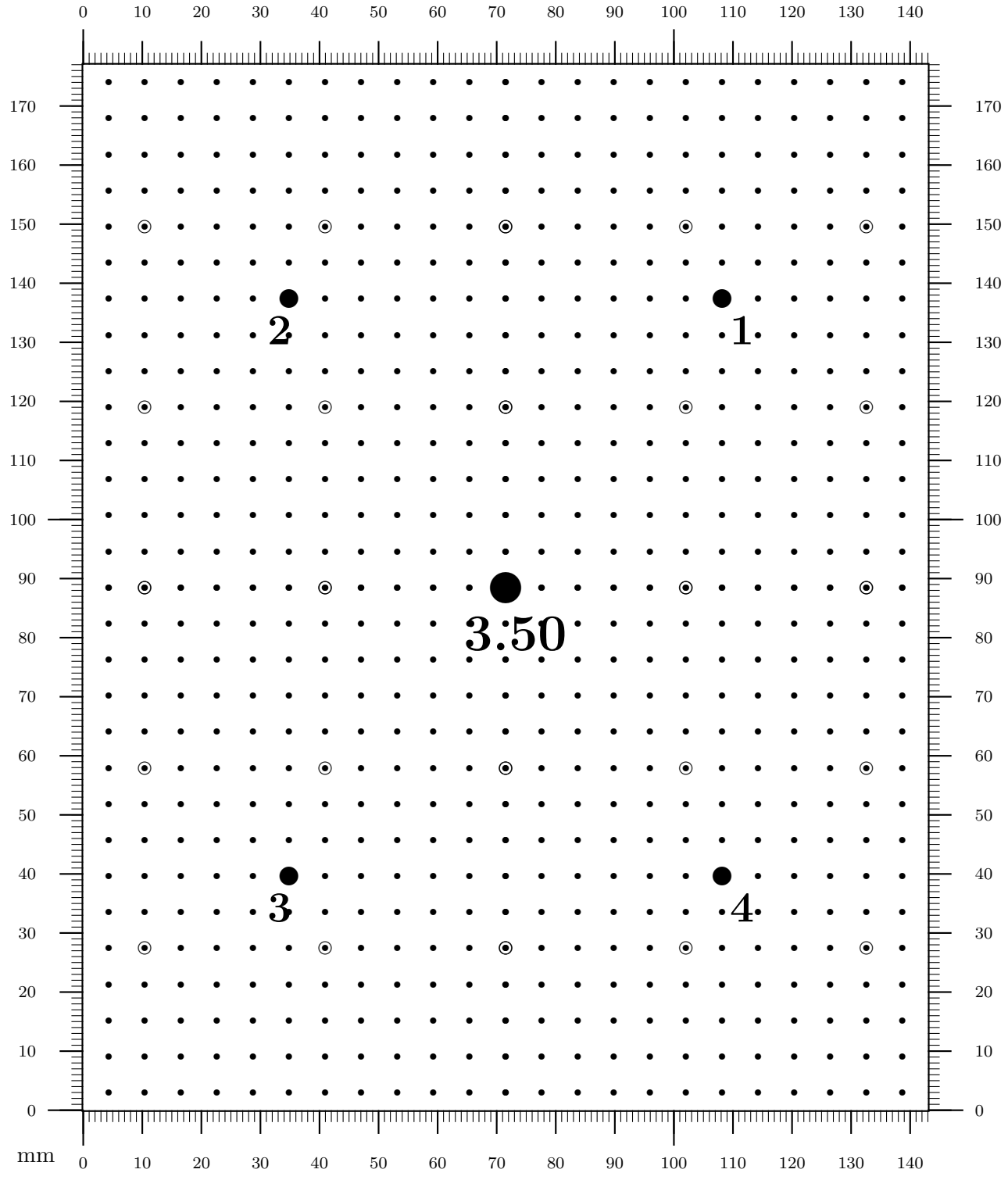

Figure 16: **0.1° at 3.50 meters is 6.108657 mm.**

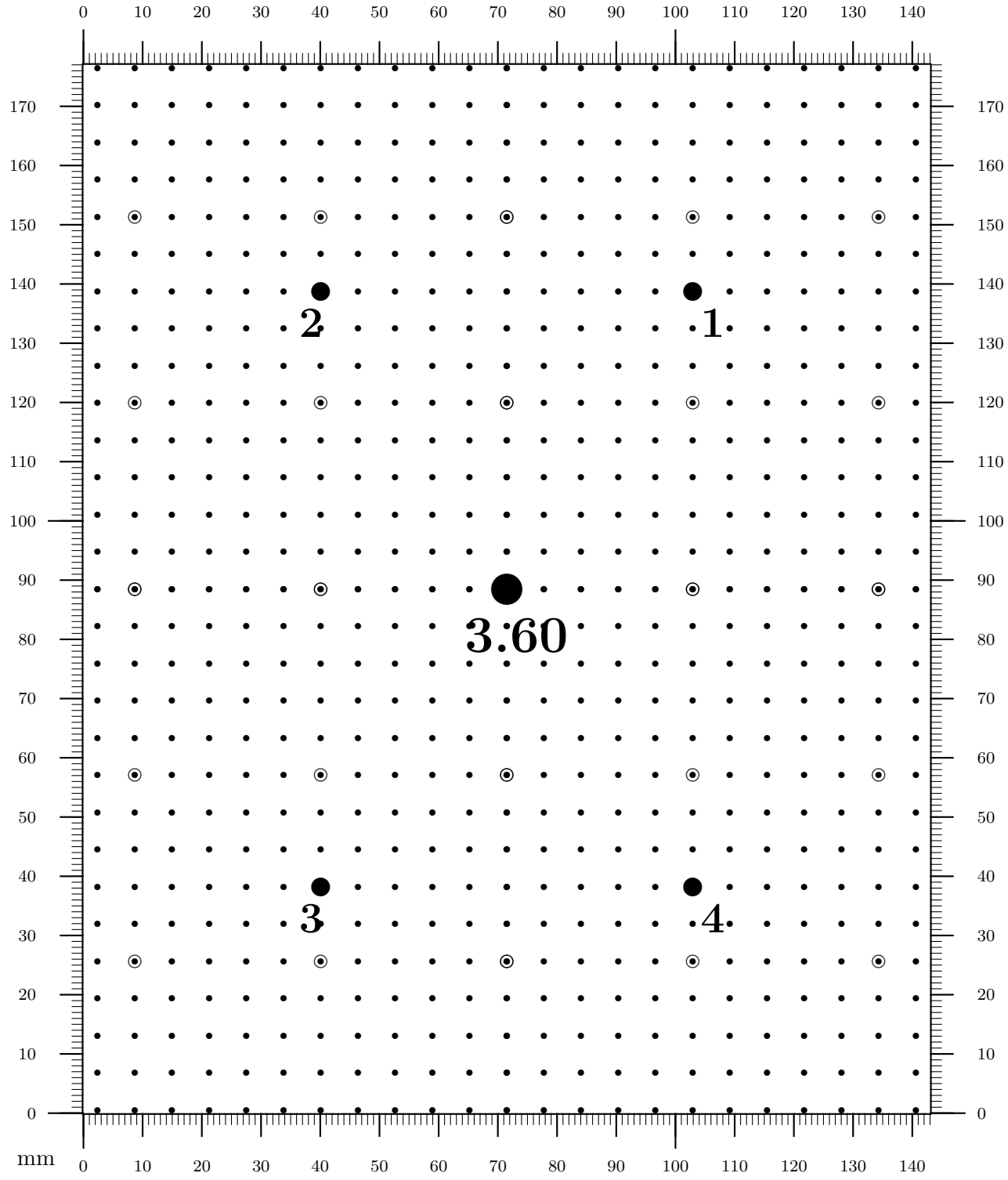

Figure 17: **0.1° at 3.60 meters is 6.283191 mm.**

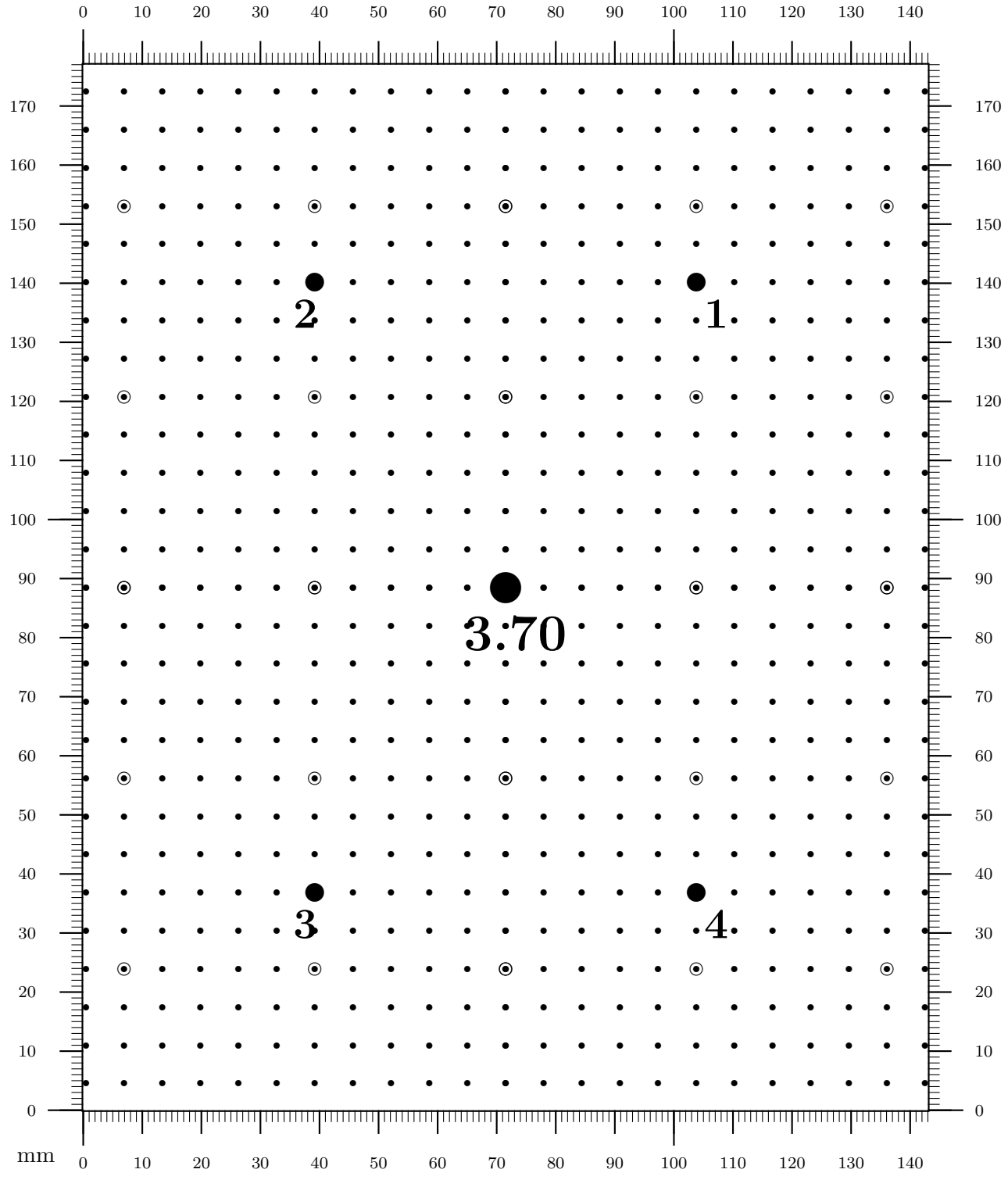

Figure 18: **0.1° at 3.70 meters is 6.457723 mm.**

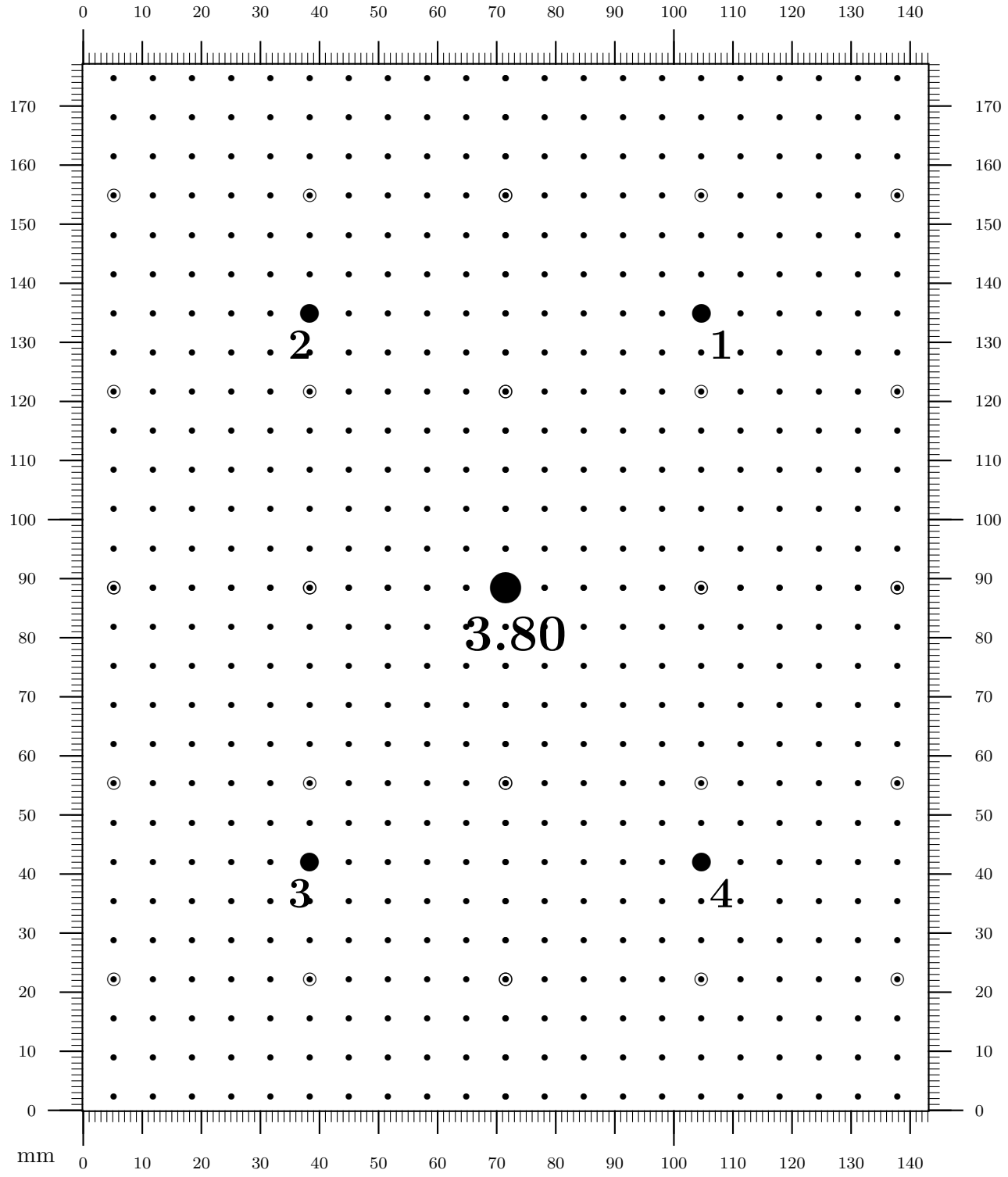

Figure 19: **0.1° at 3.80 meters is 6.632256 mm.**

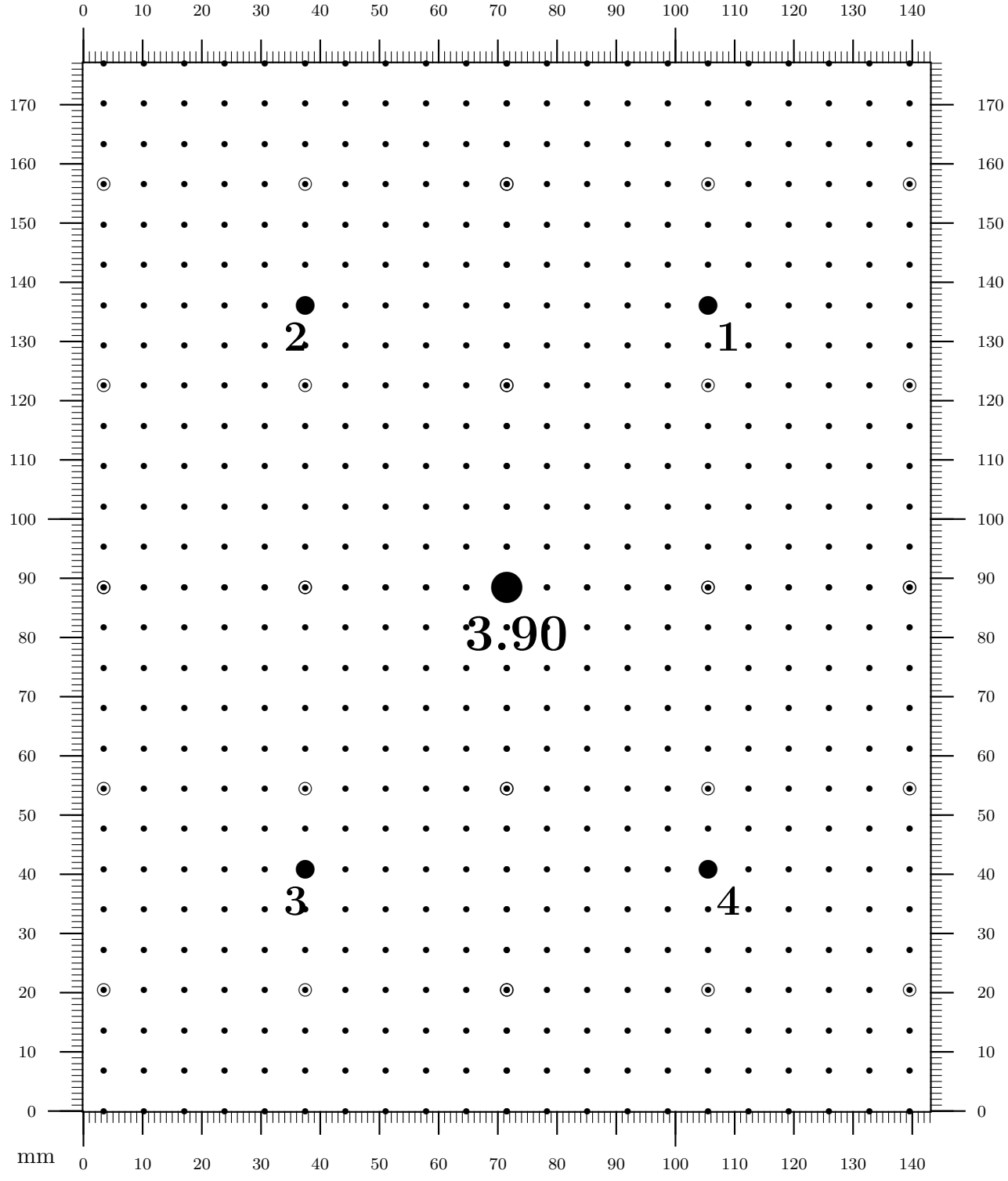

Figure 20: **0.1° at 3.90 meters is 6.806790 mm.**

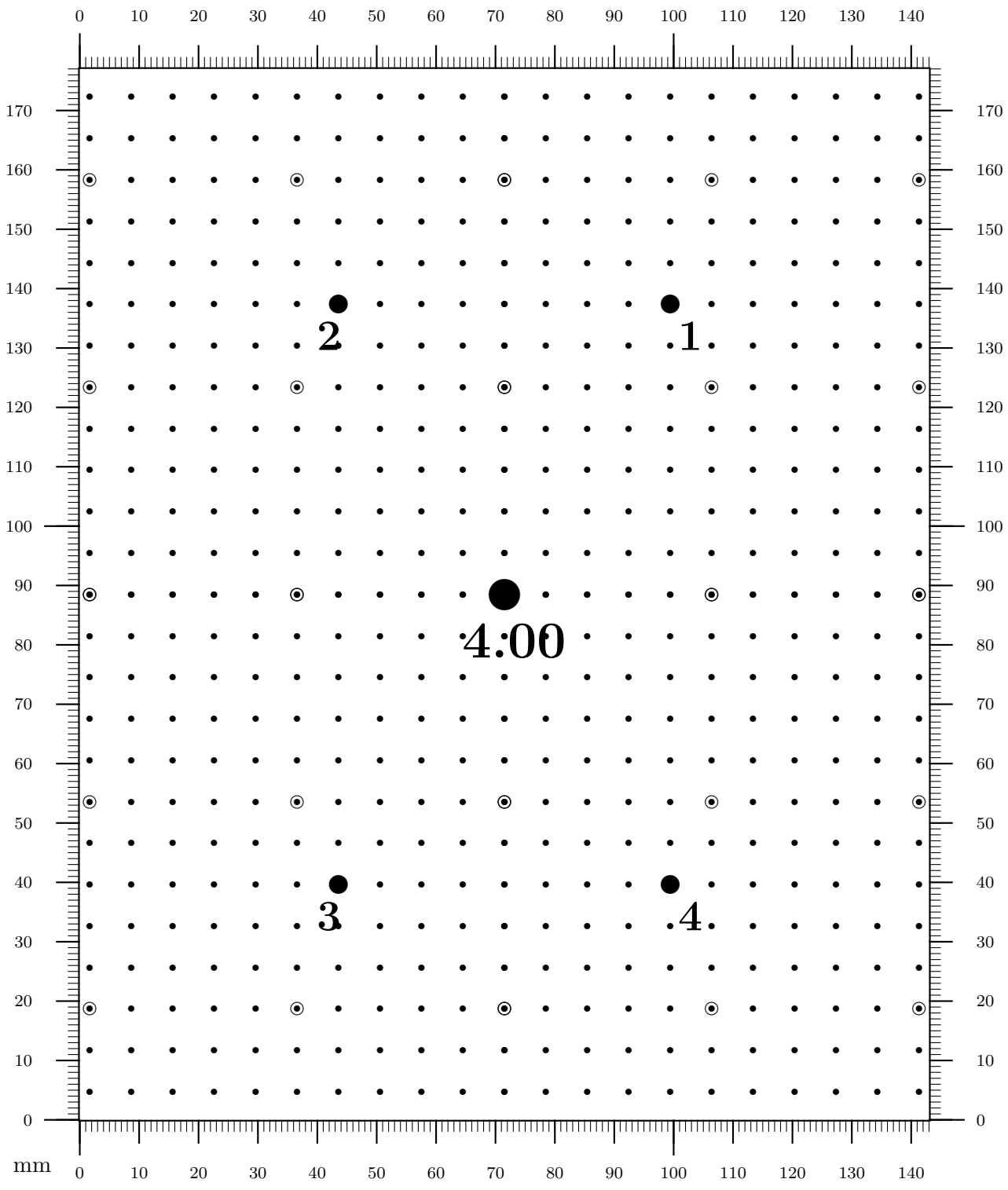

Figure 21: **0.1° at 4.00 meters is 6.981323 mm.**

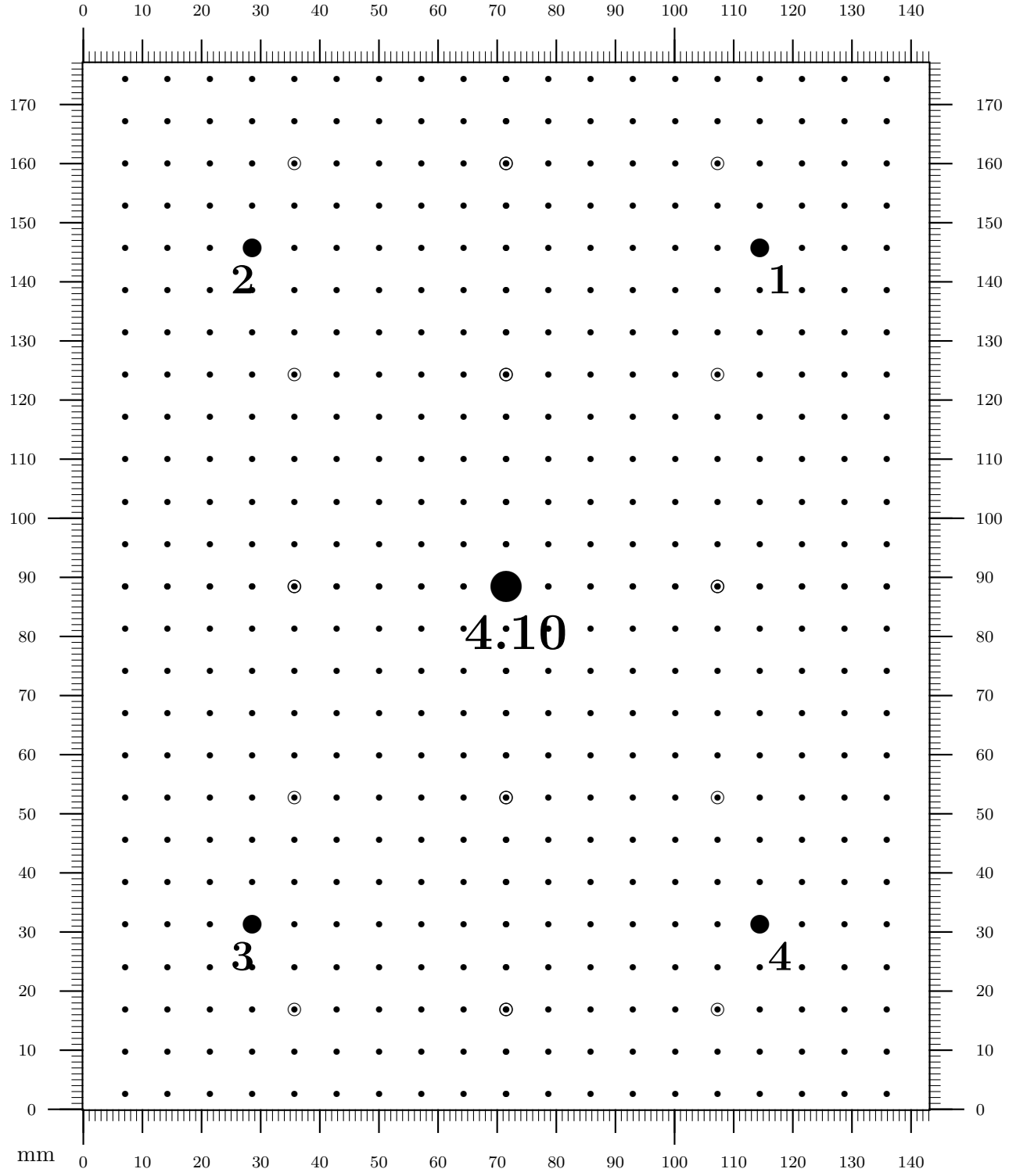

Figure 22: **0.1° at 4.10 meters is 7.155855 mm.**

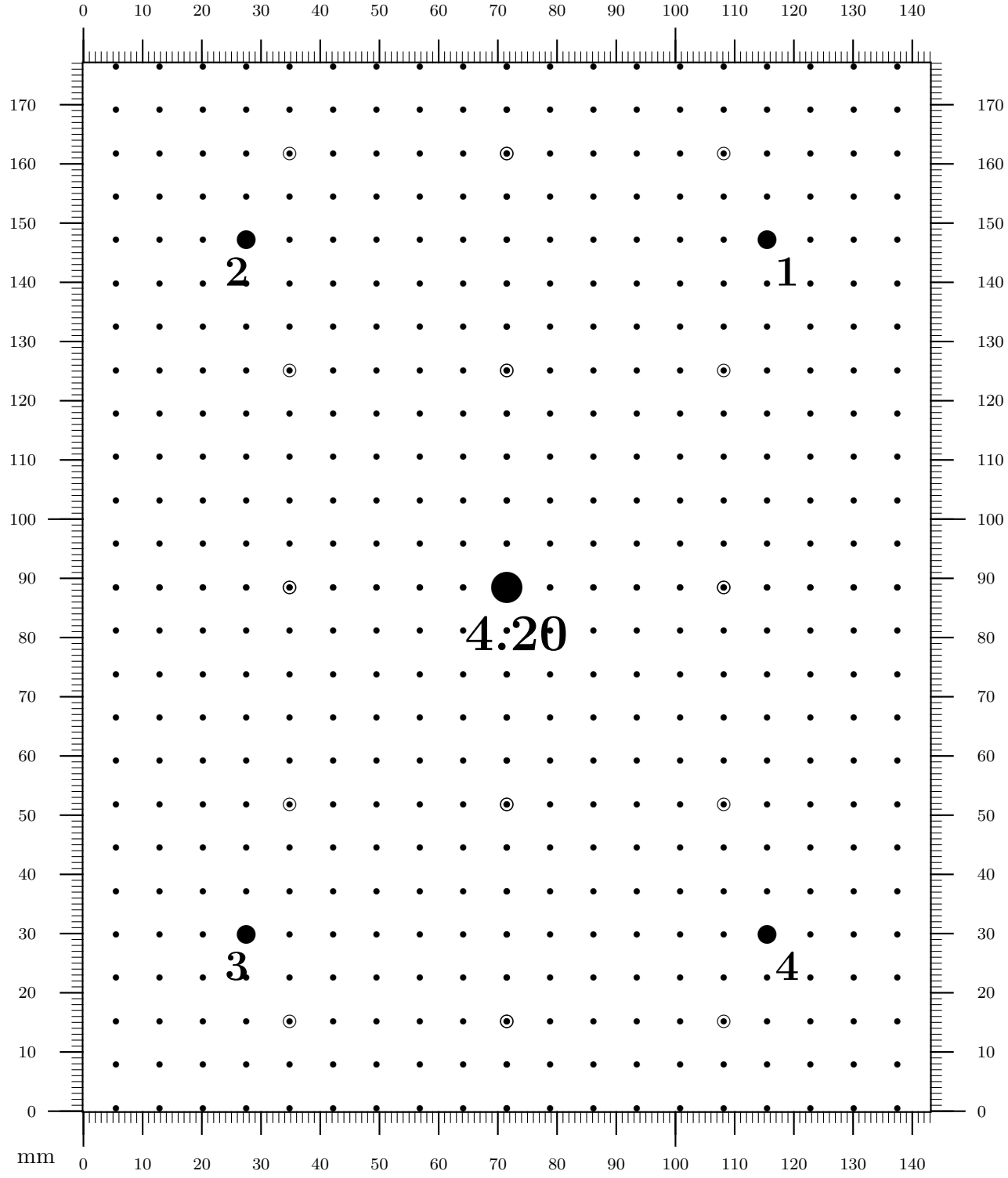

Figure 23: **0.1° at 4.20 meters is 7.330388 mm.**

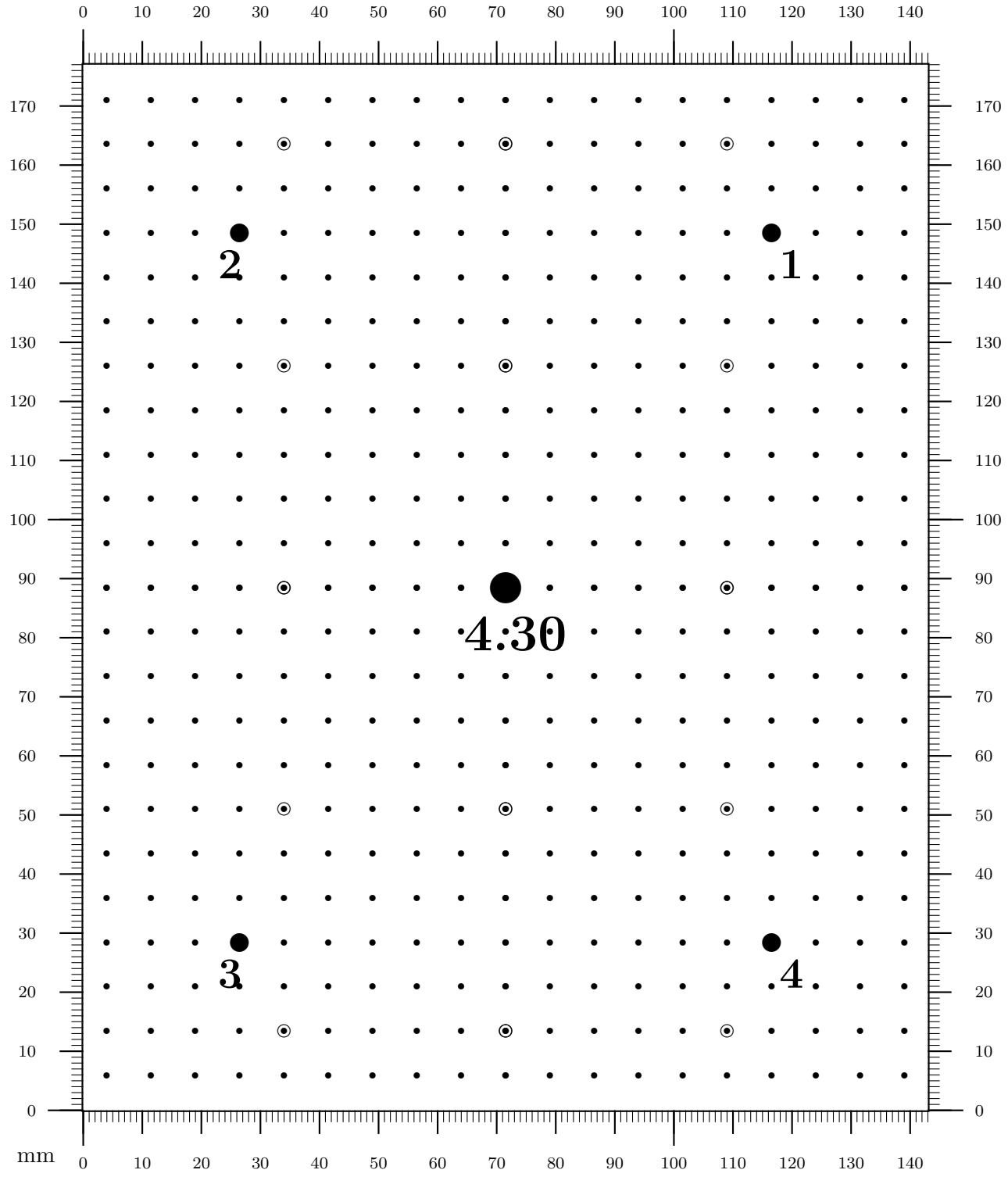

Figure 24: **0.1° at 4.30 meters is 7.504921 mm.**

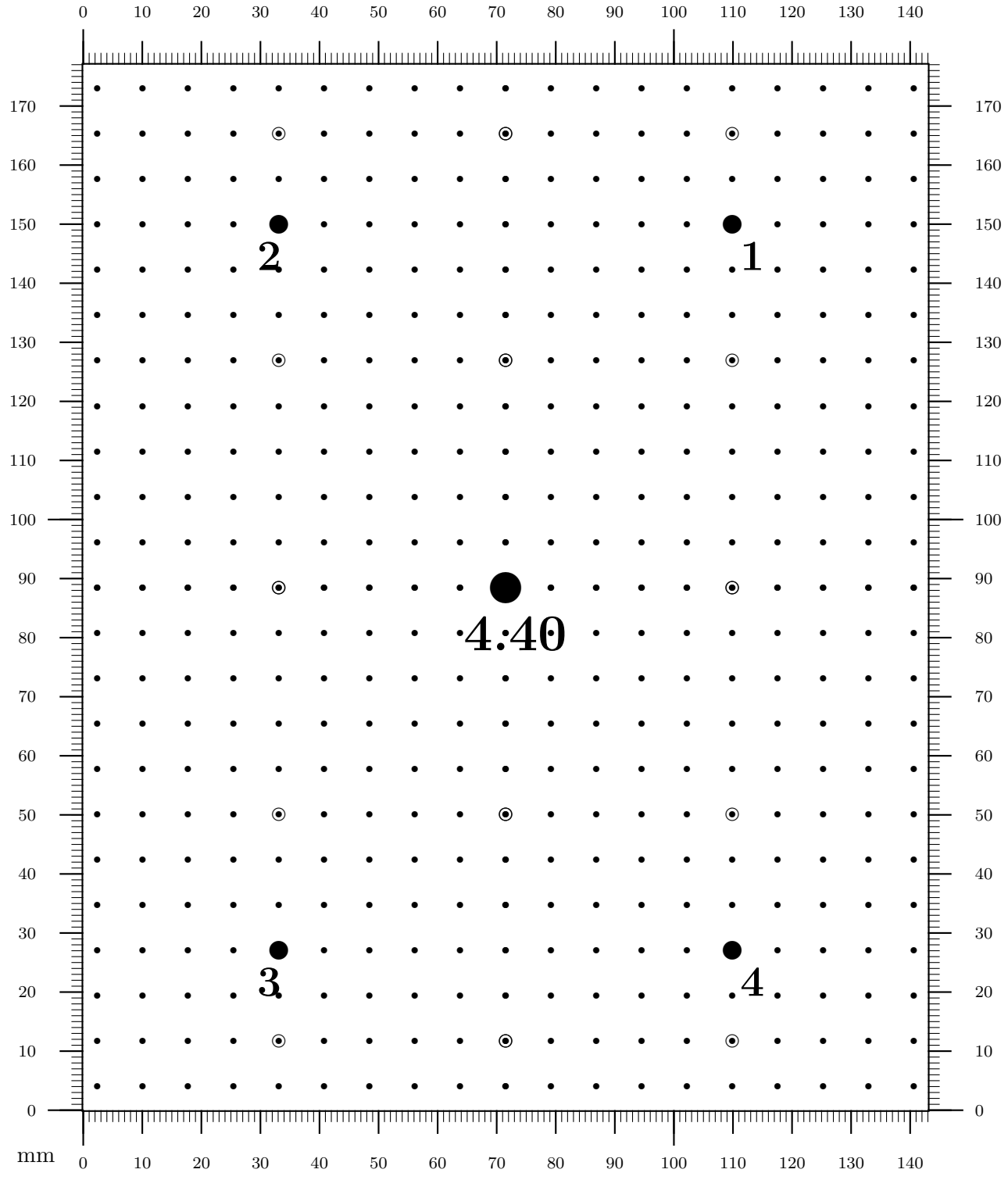

Figure 25: **0.1° at 4.40 meters is 7.679454 mm.**

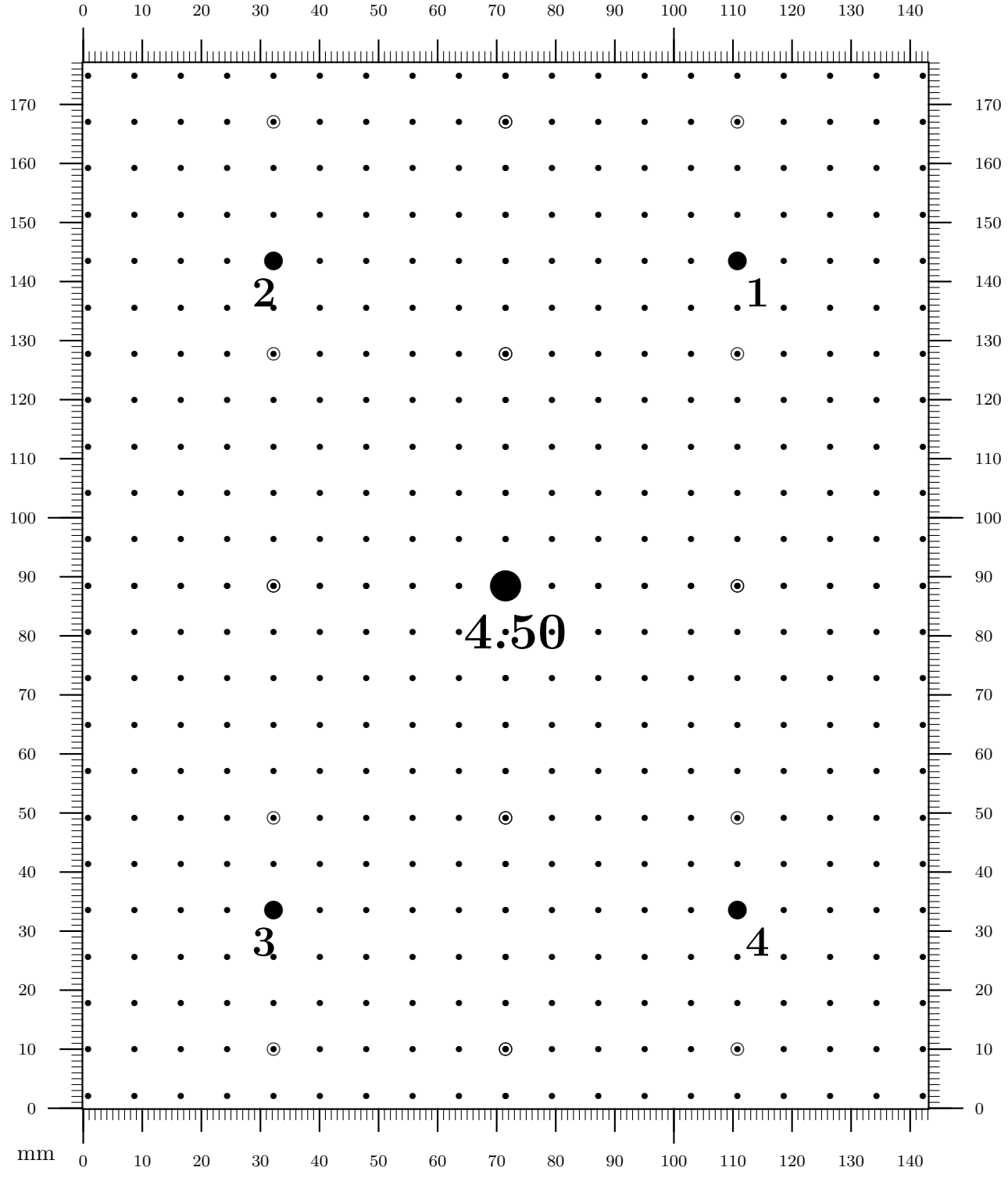

Figure 26: **0.1° at 4.50 meters is 7.853987 mm.**

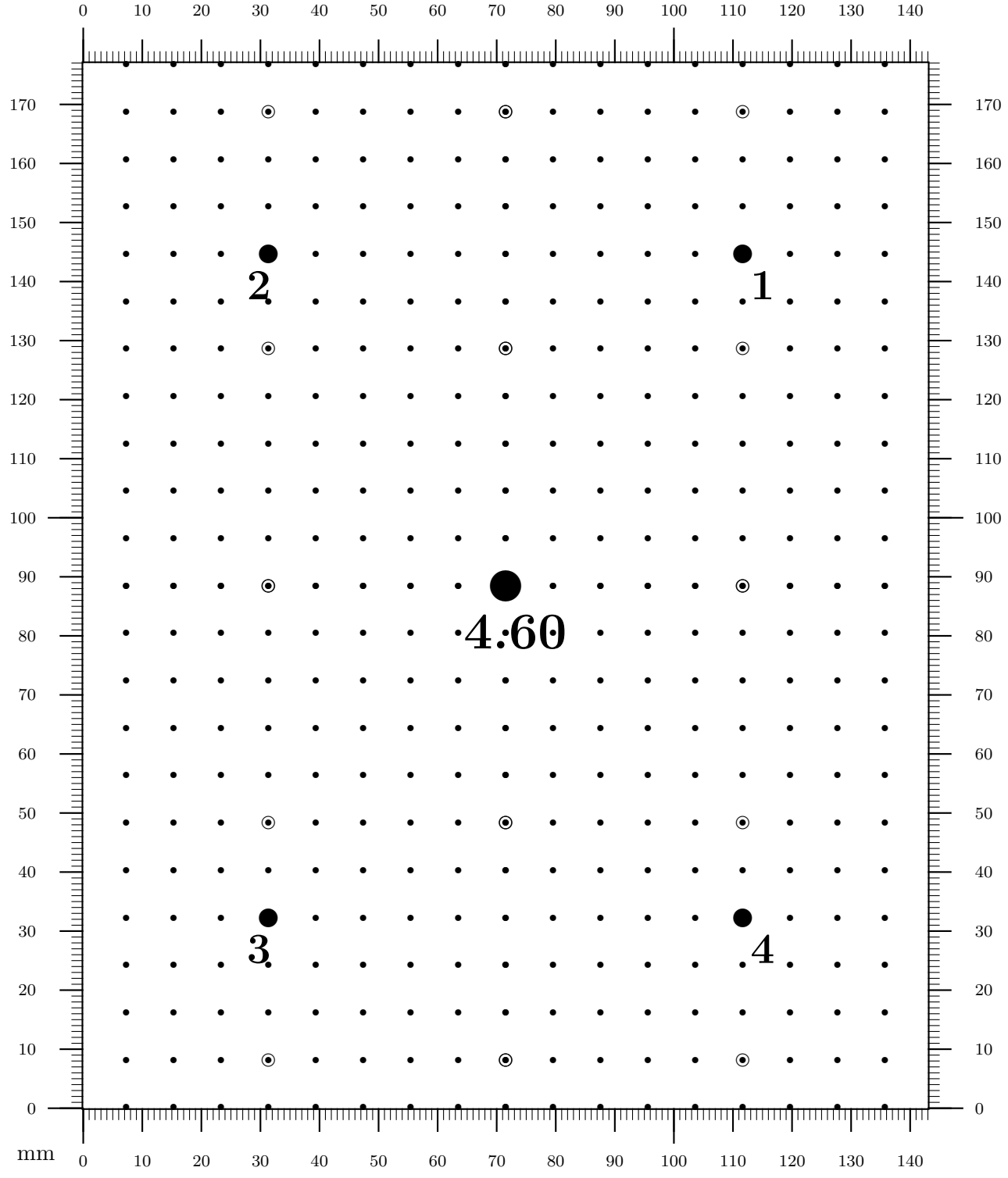

Figure 27: **0.1° at 4.60 meters is 8.028519 mm.**

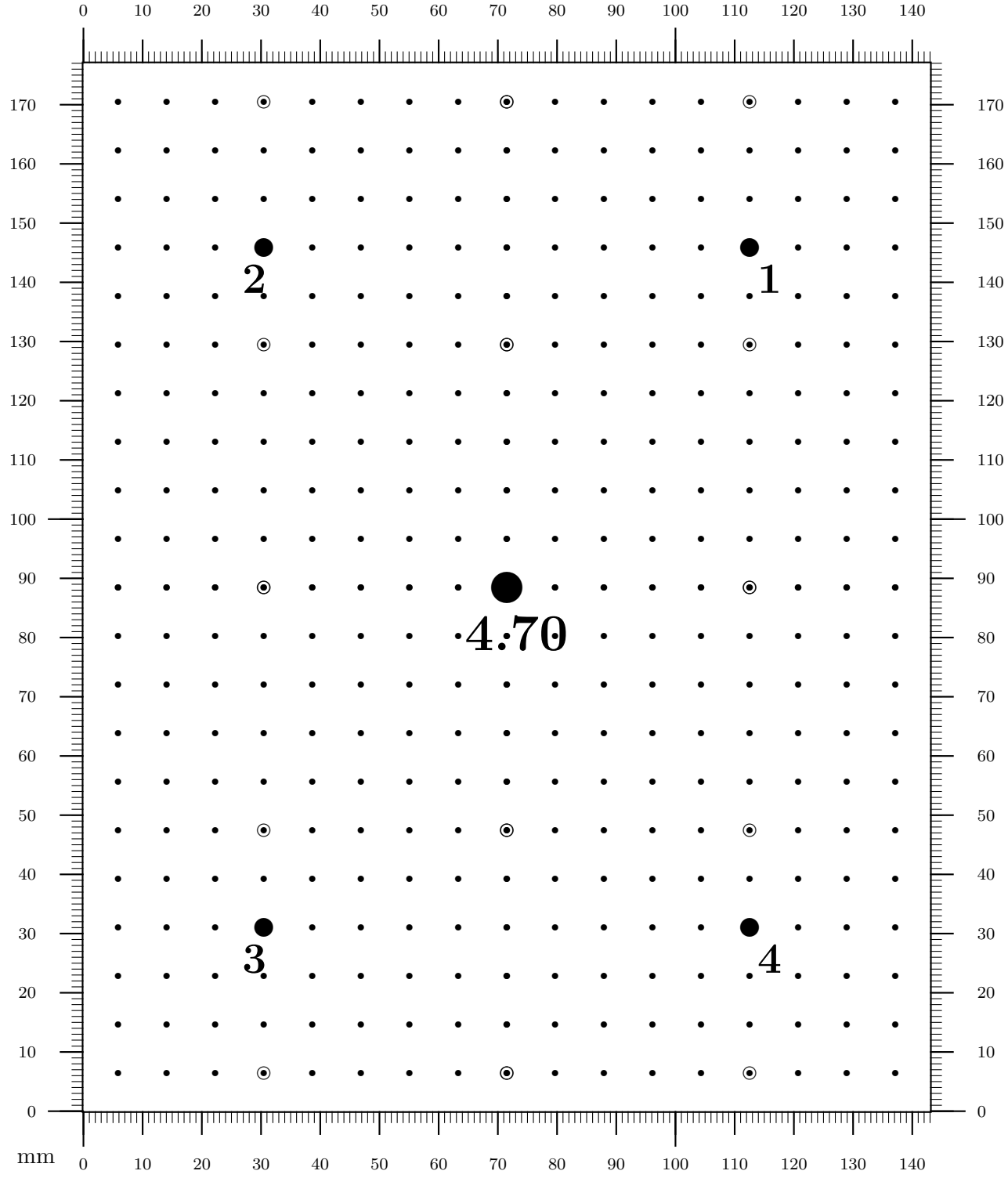

Figure 28: **0.1° at 4.70 meters is 8.203053 mm.**

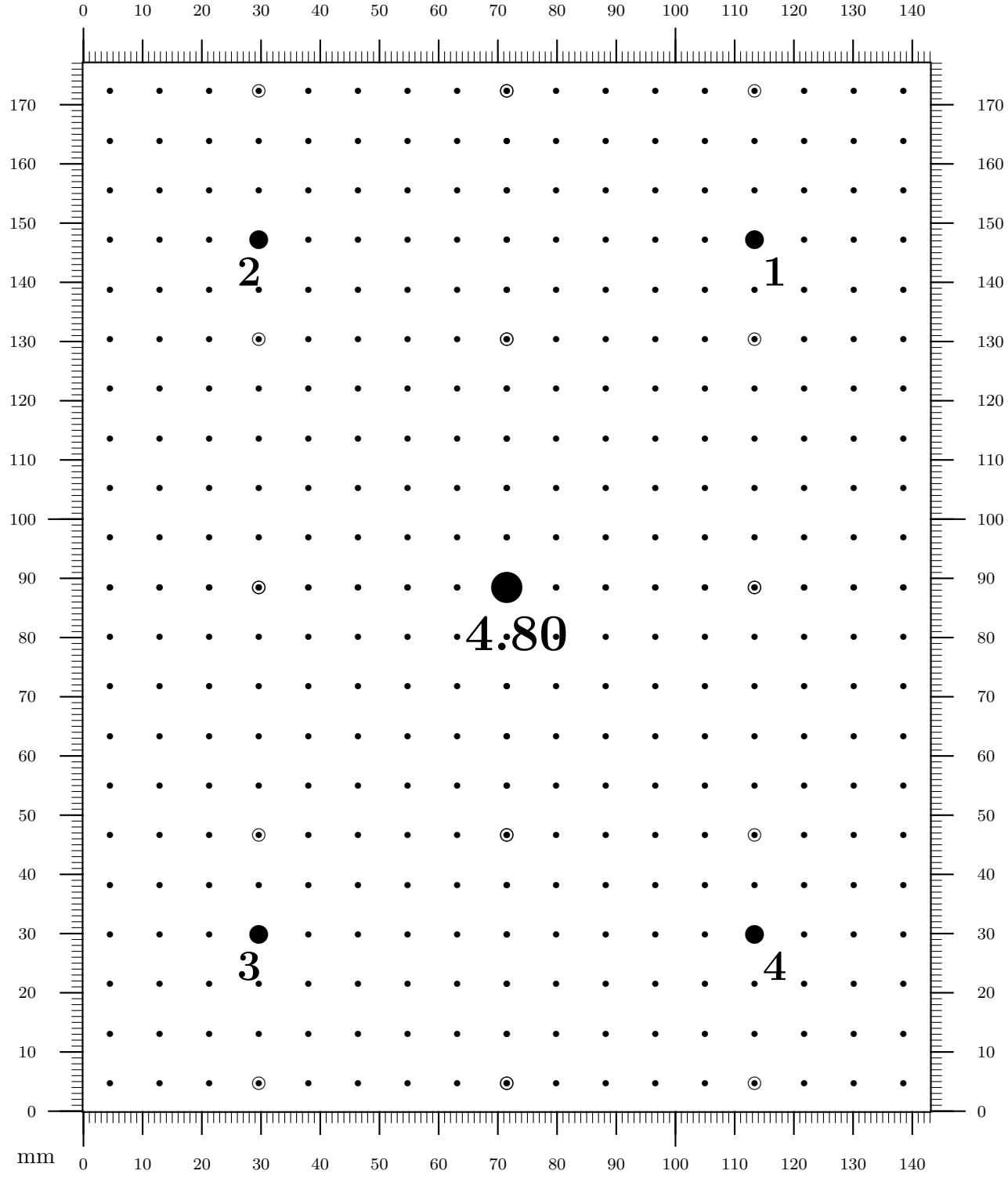

Figure 29: **0.1° at 4.80 meters is 8.377586 mm.**

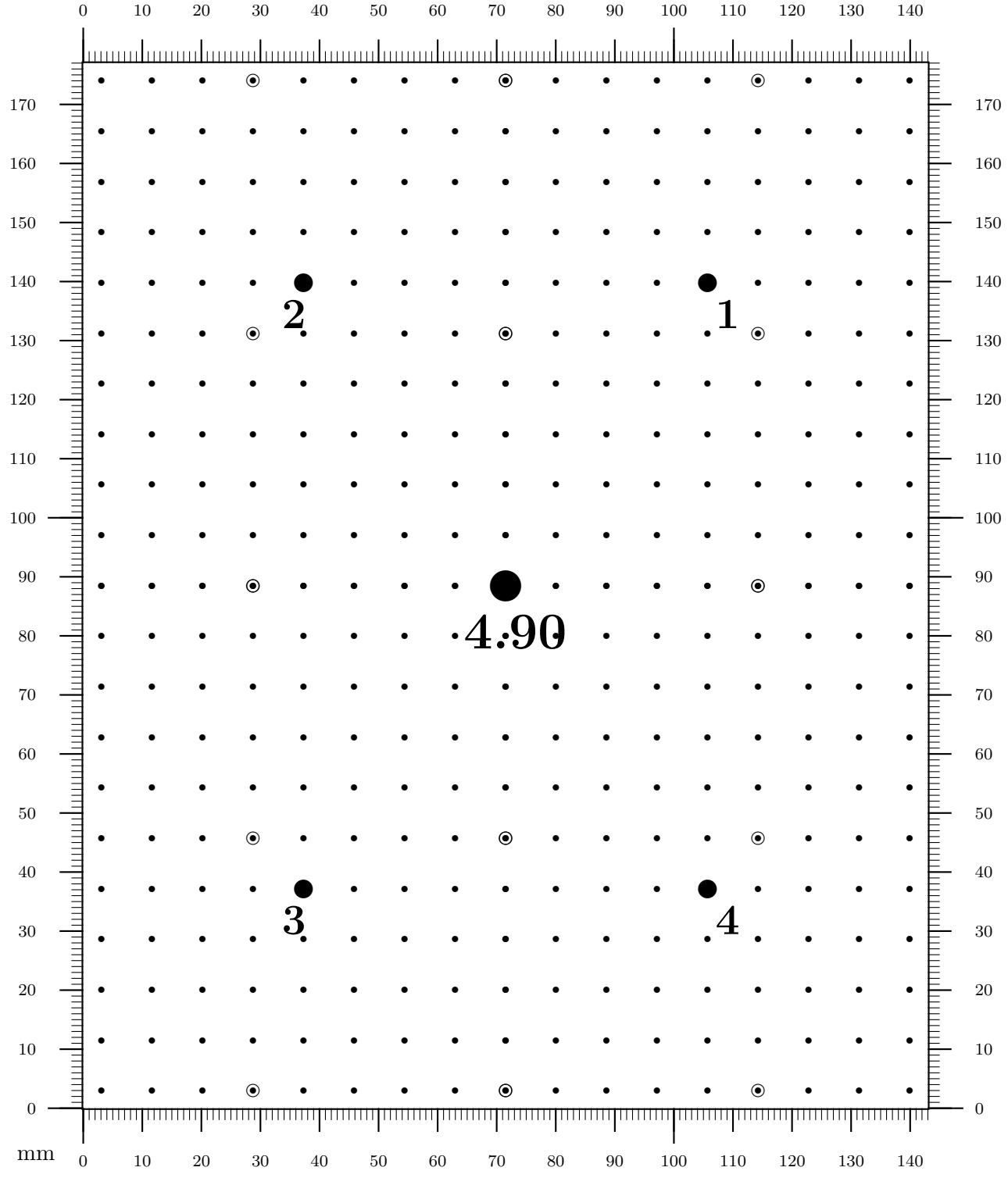

Figure 30: **0.1° at 4.90 meters is 8.552118 mm.**

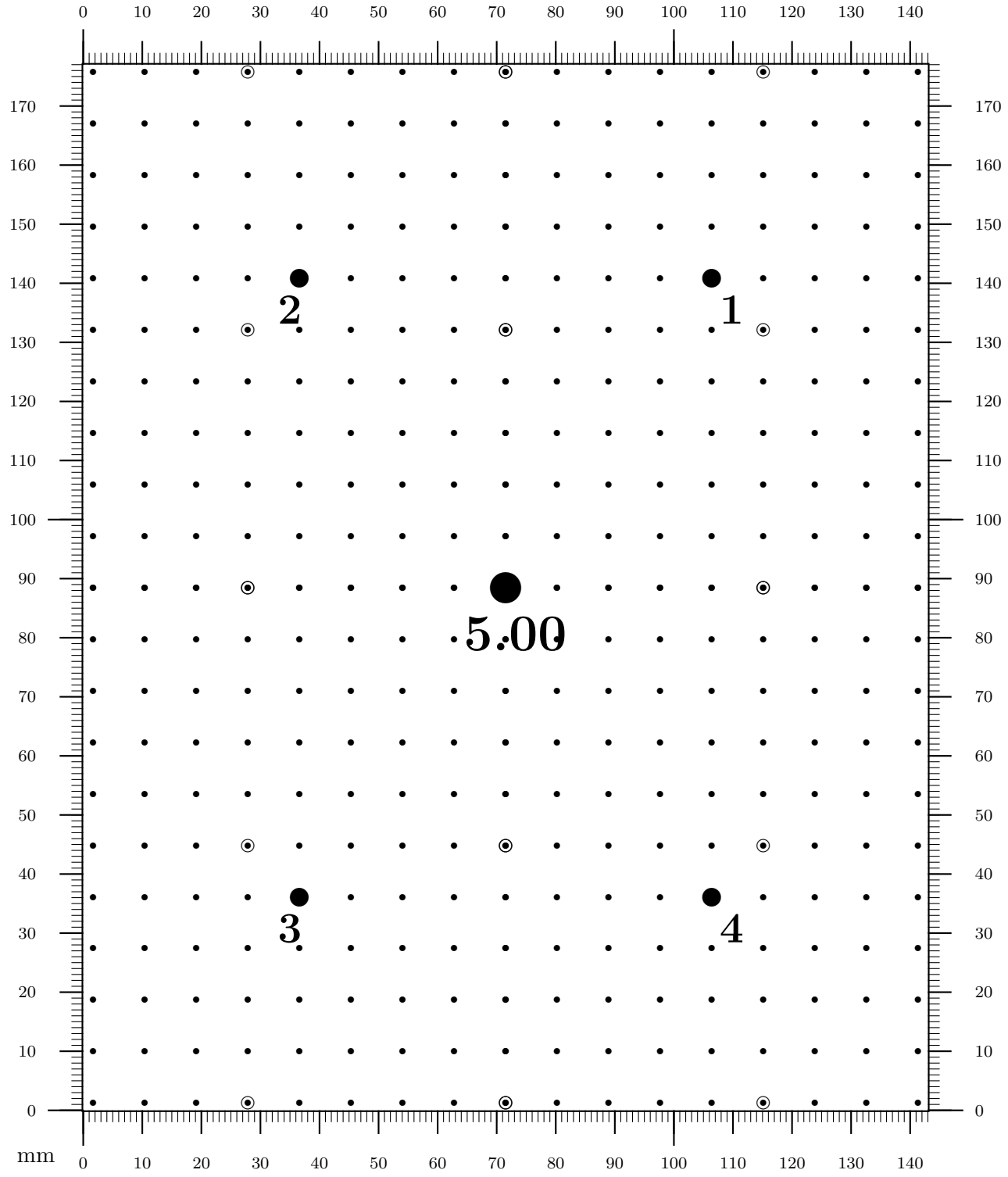

Figure 31: **0.1° at 5.00 meters is 8.726651 mm.**

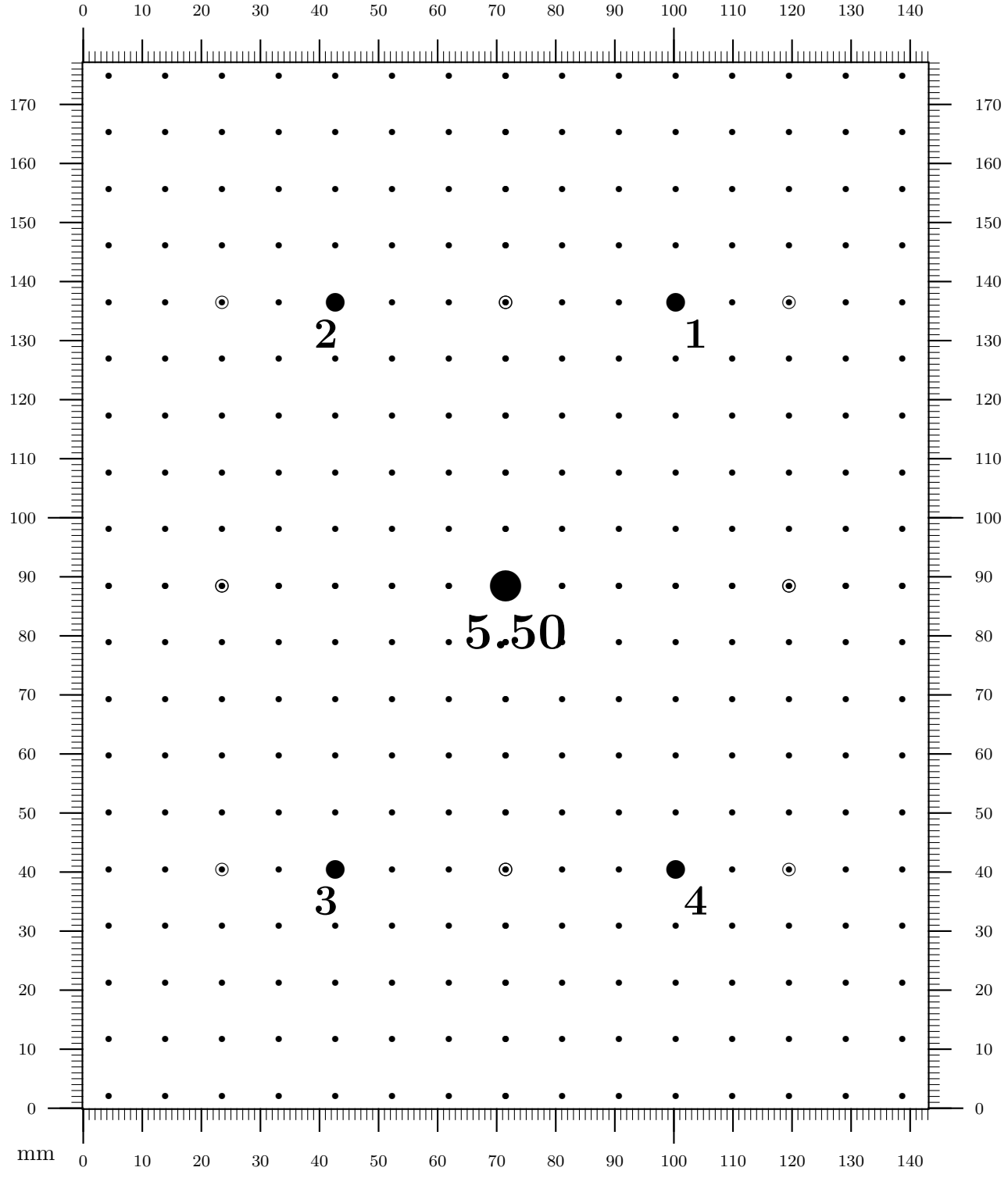

Figure 32: **0.1° at 5.50 meters is 9.599322 mm.**

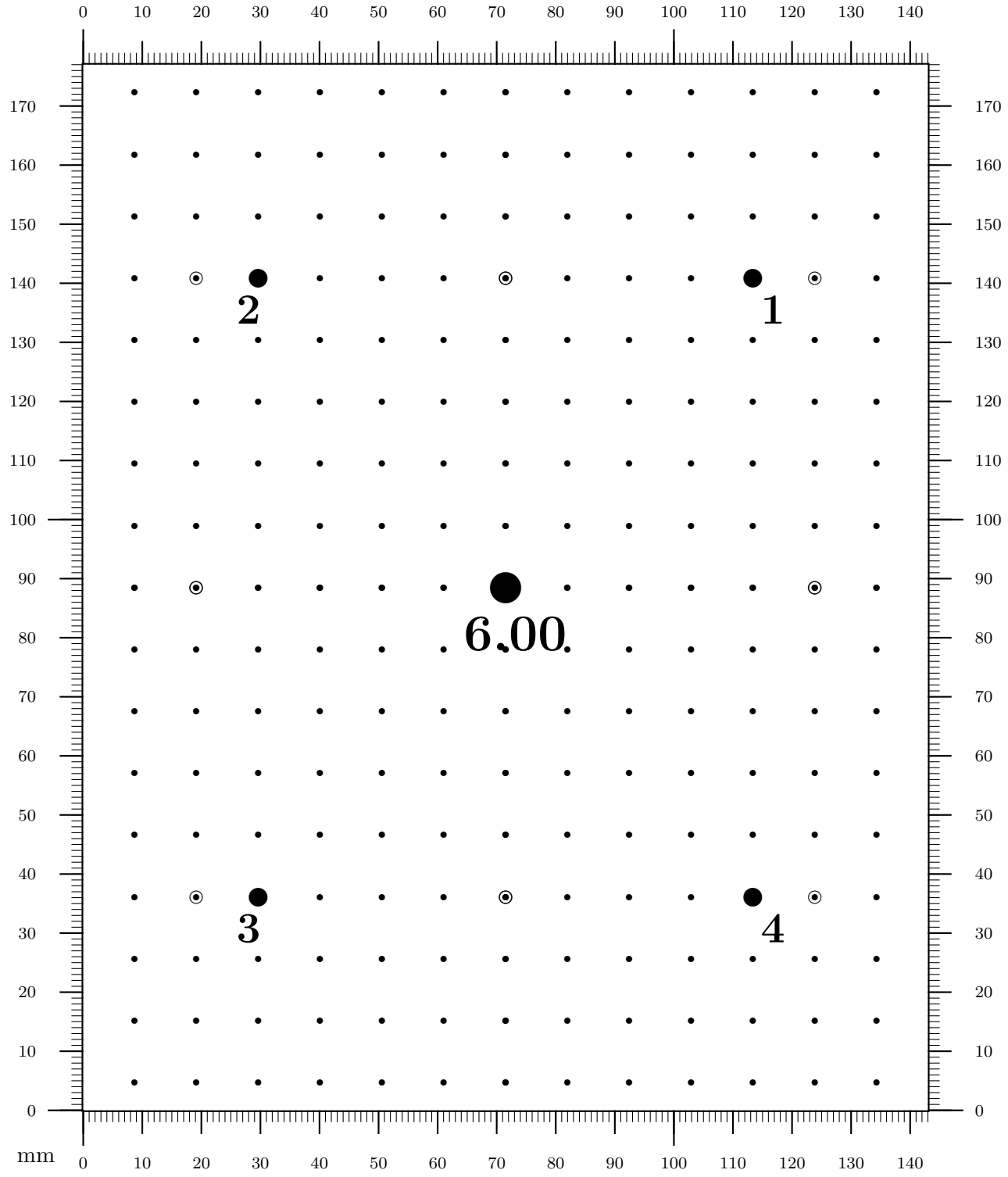

Figure 33: **0.1° at 6.00 meters is 10.471990 mm.**

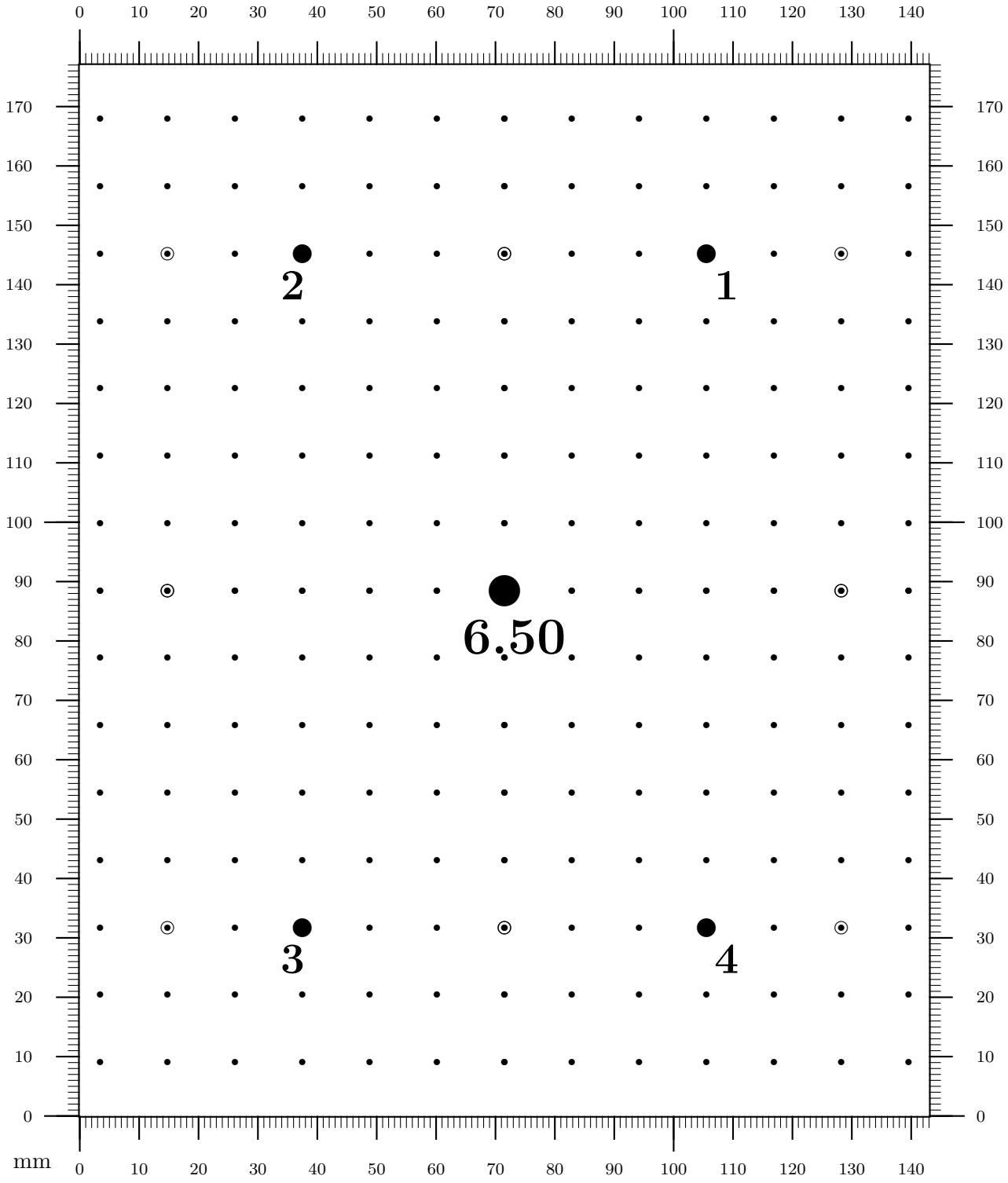

Figure 34: **0.1° at 6.50 meters is 11.344650 mm.**

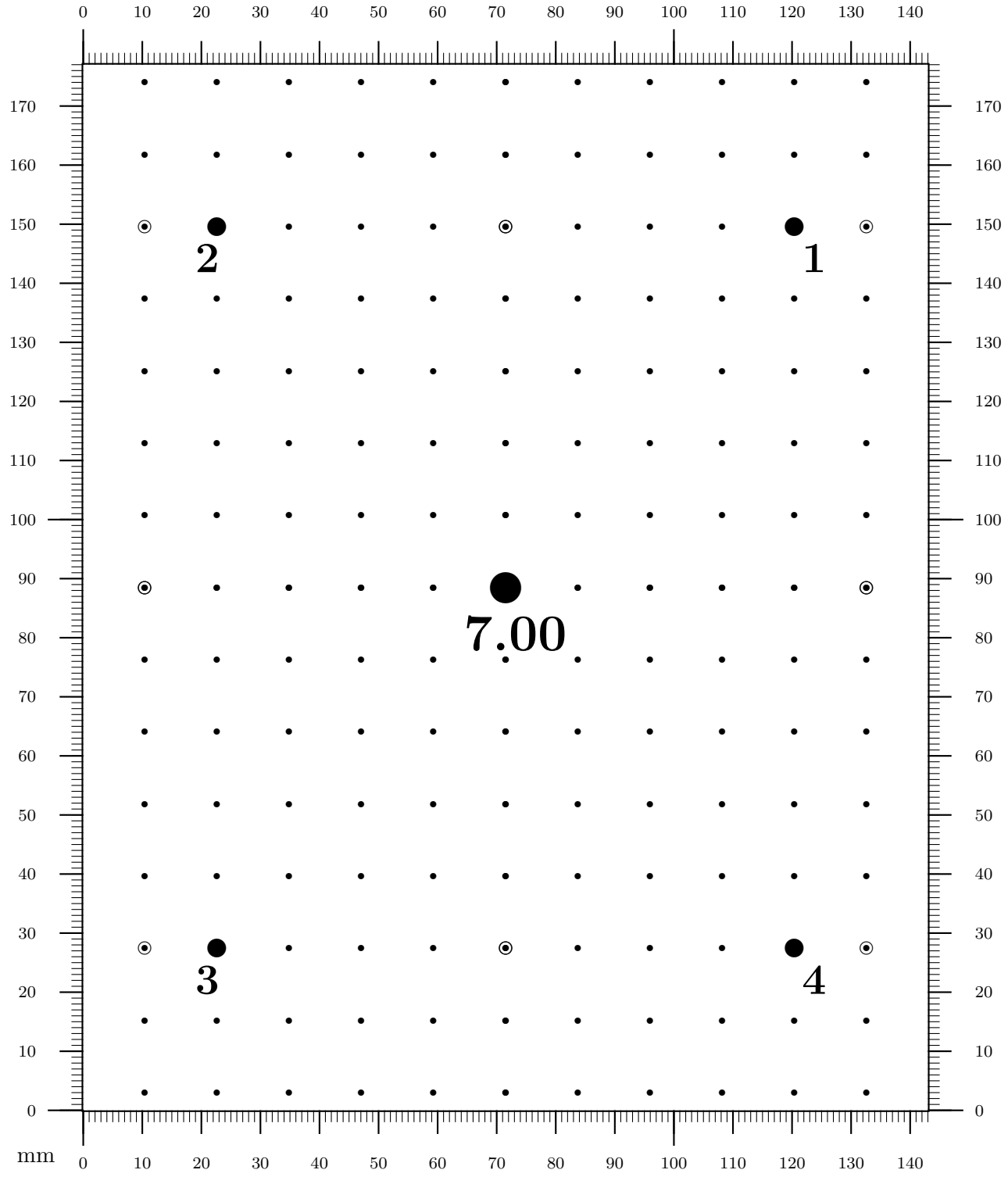

Figure 35: **0.1° at 7.00 meters is 12.217320 mm.**

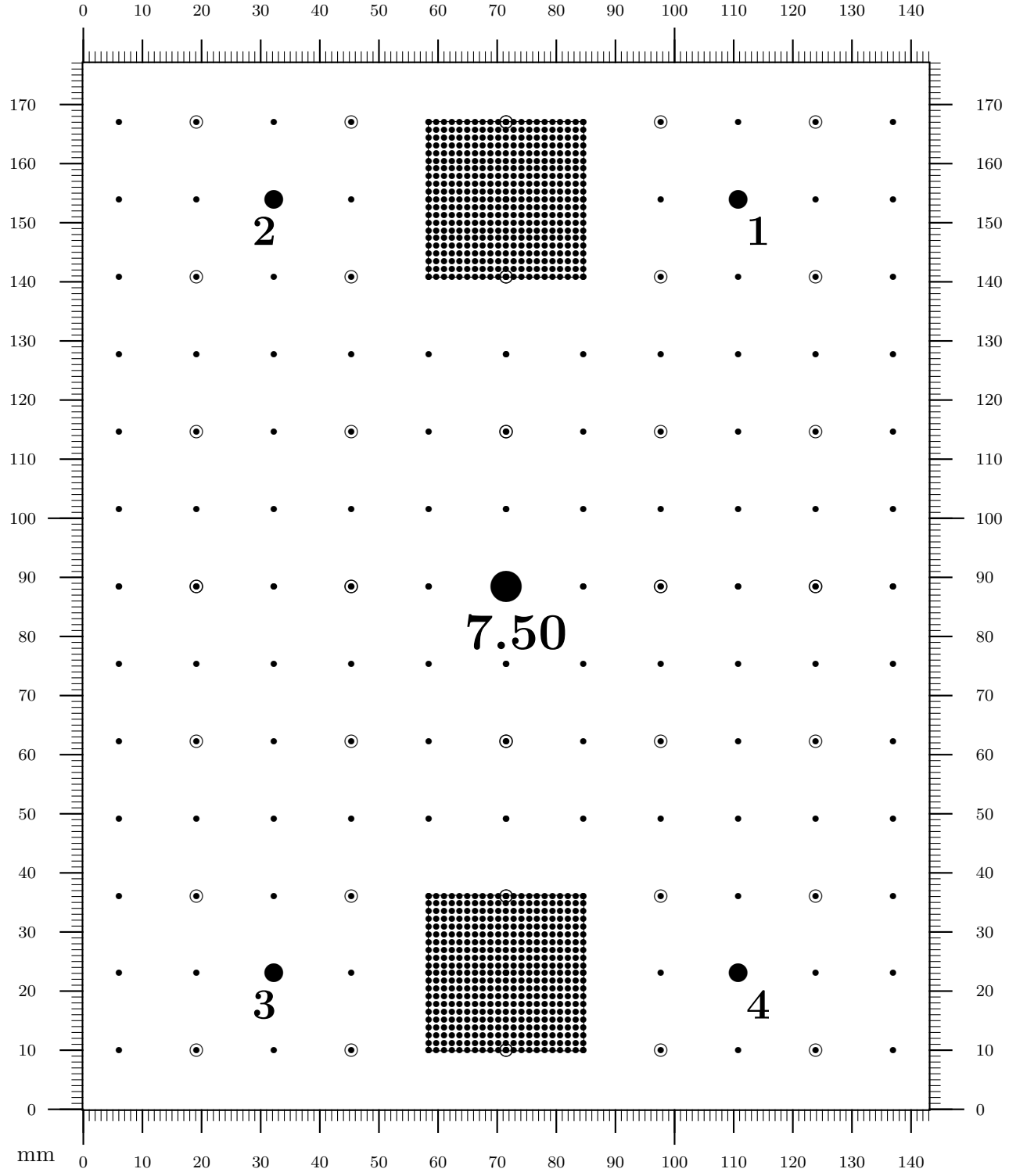

Figure 36: **0.1° at 7.50 meters is 13.089990 mm.**

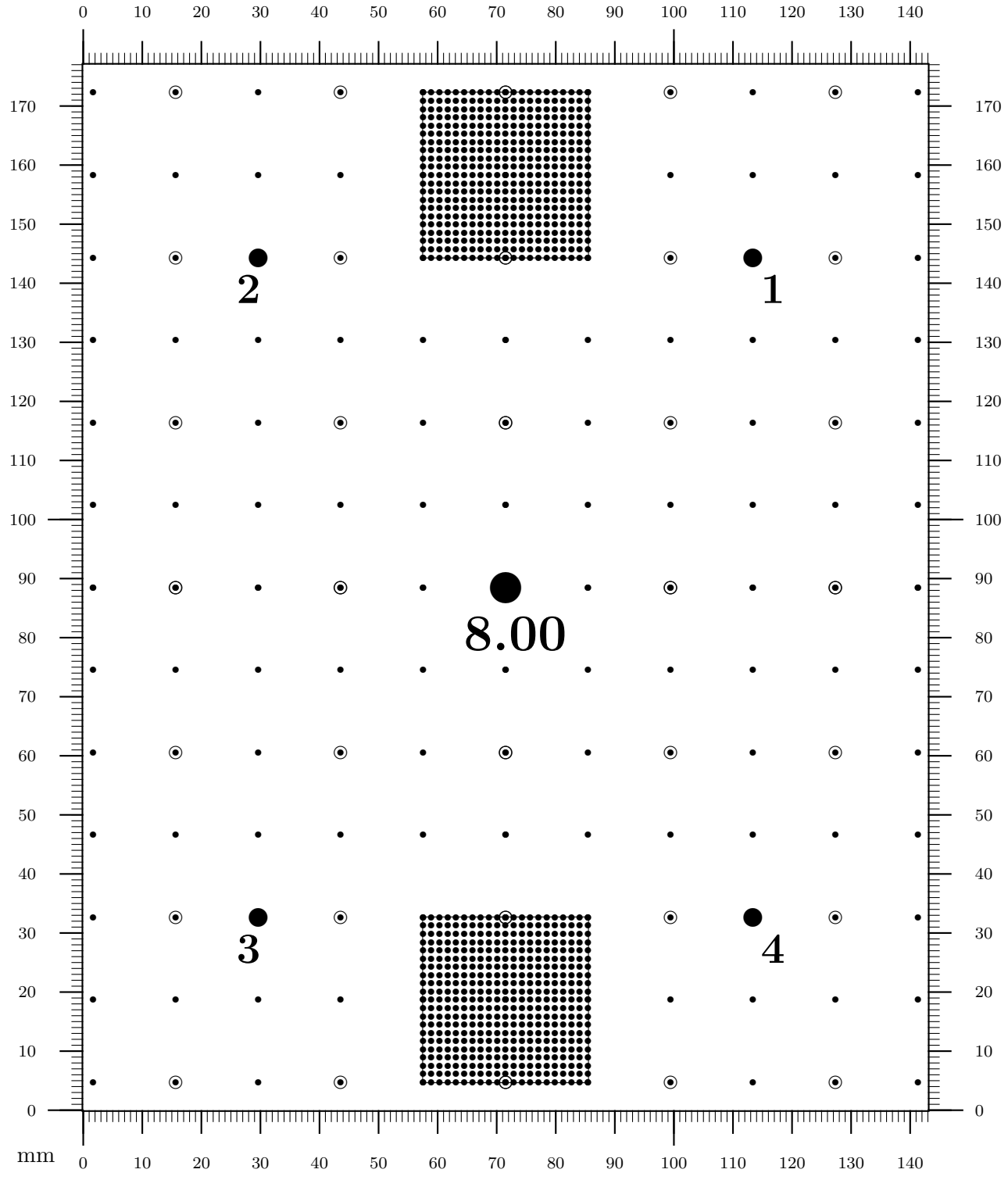

Figure 37: **0.1° at 8.00 meters is 13.962650 mm.**

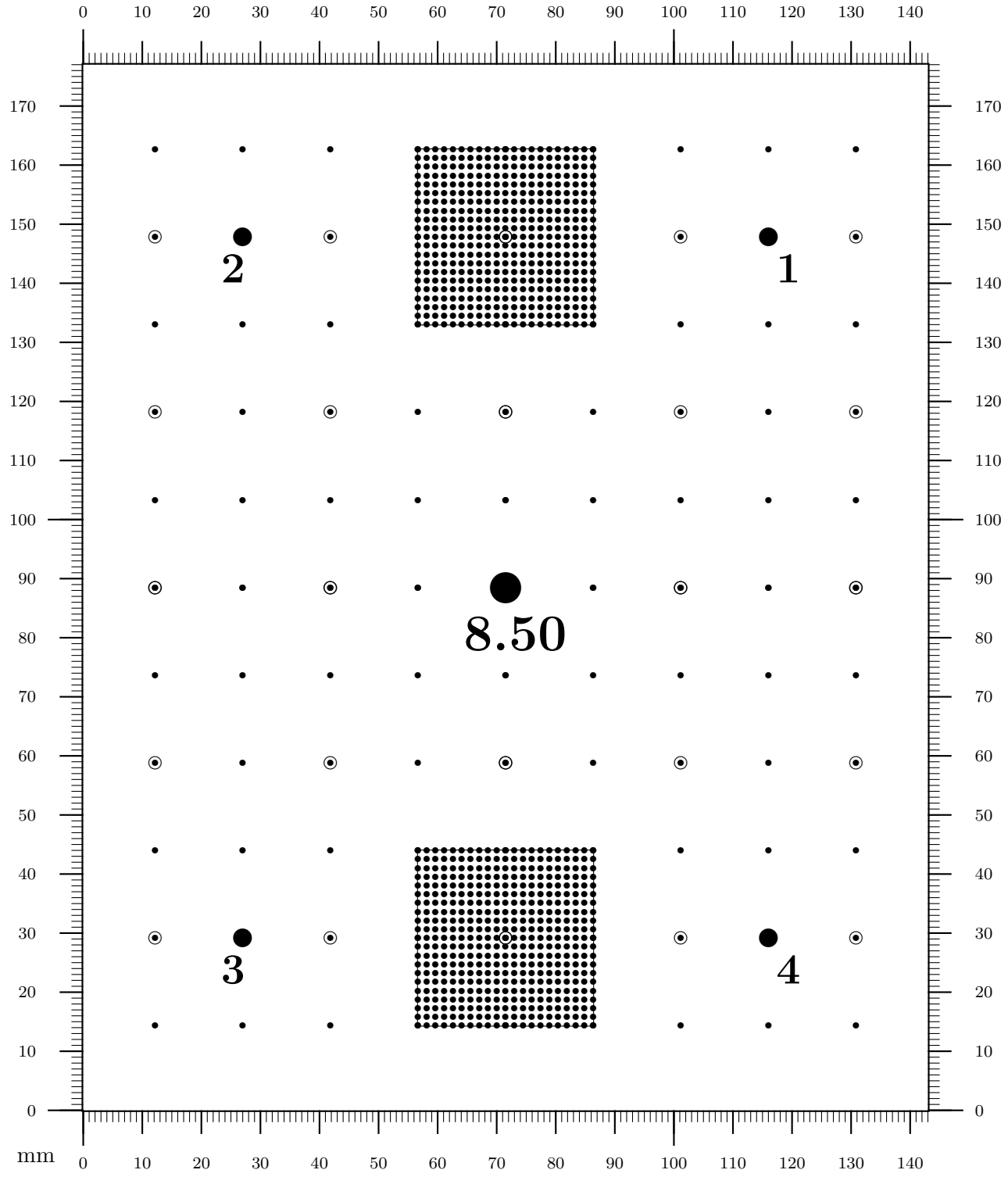

Figure 38: **0.1° at 8.50 meters is 14.835320 mm.**

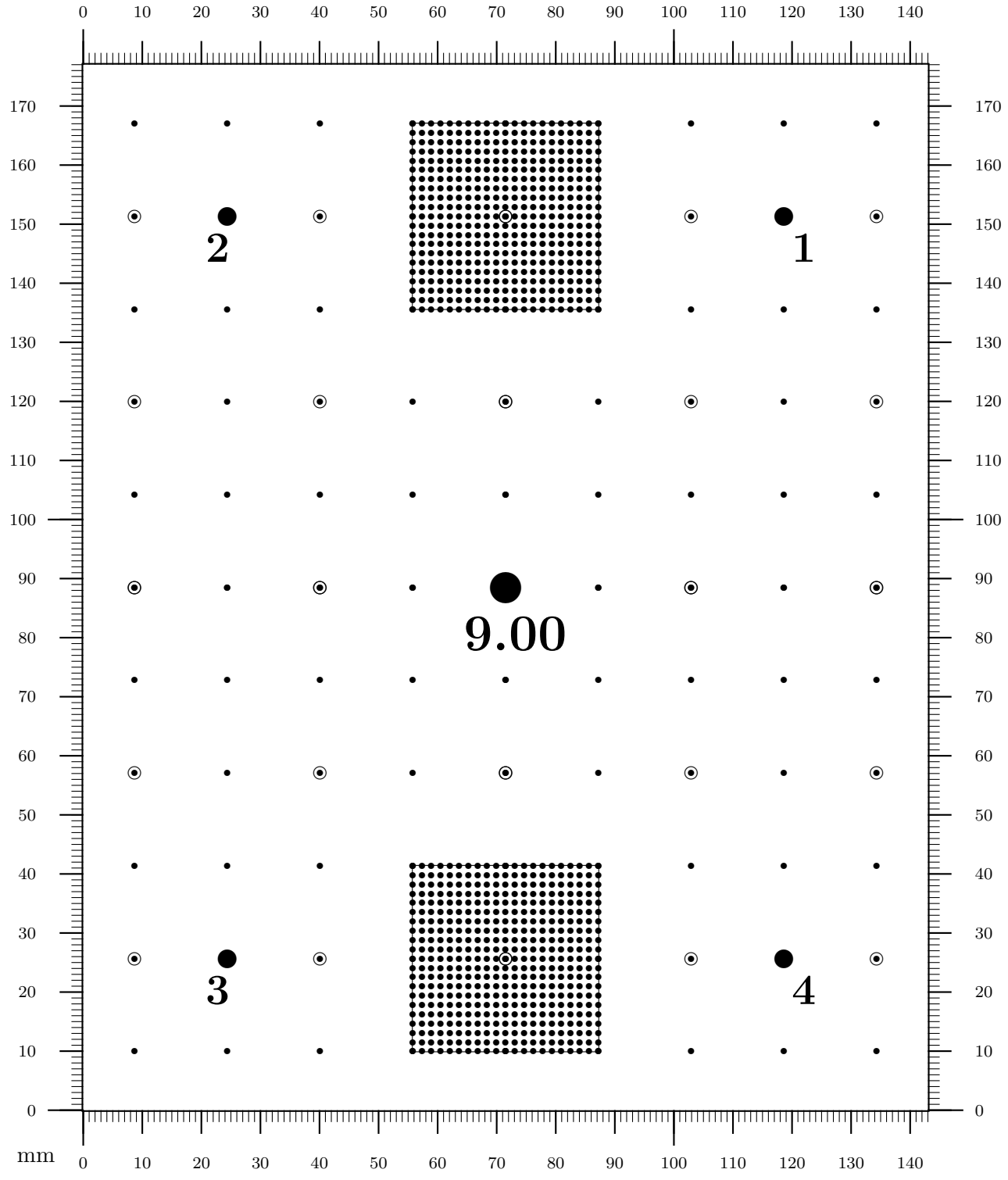

Figure 39: **0.1° at 9.00 meters is 15.707980 mm.**

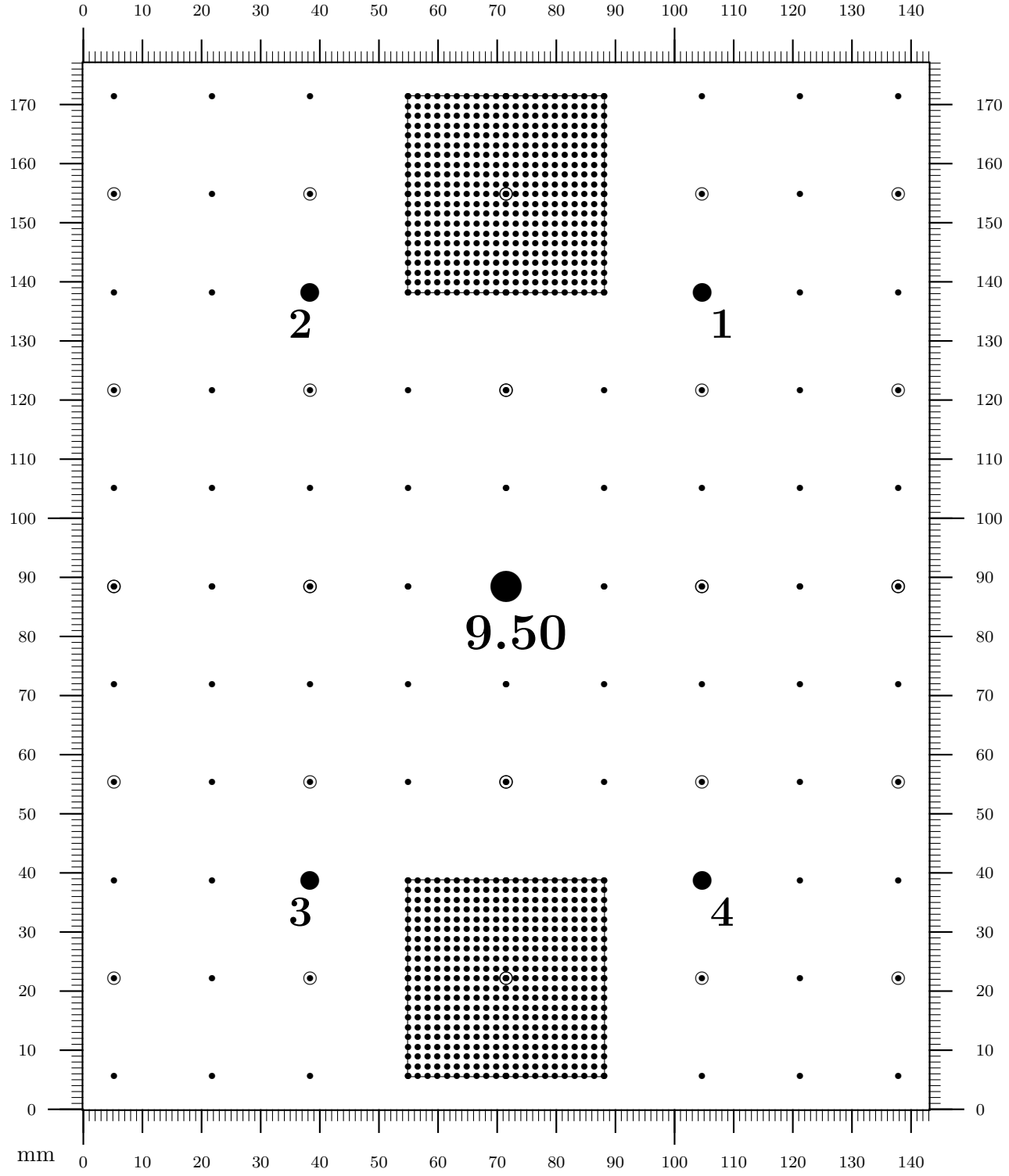

Figure 40: **0.1° at 9.50 meters is 16.580650 mm.**

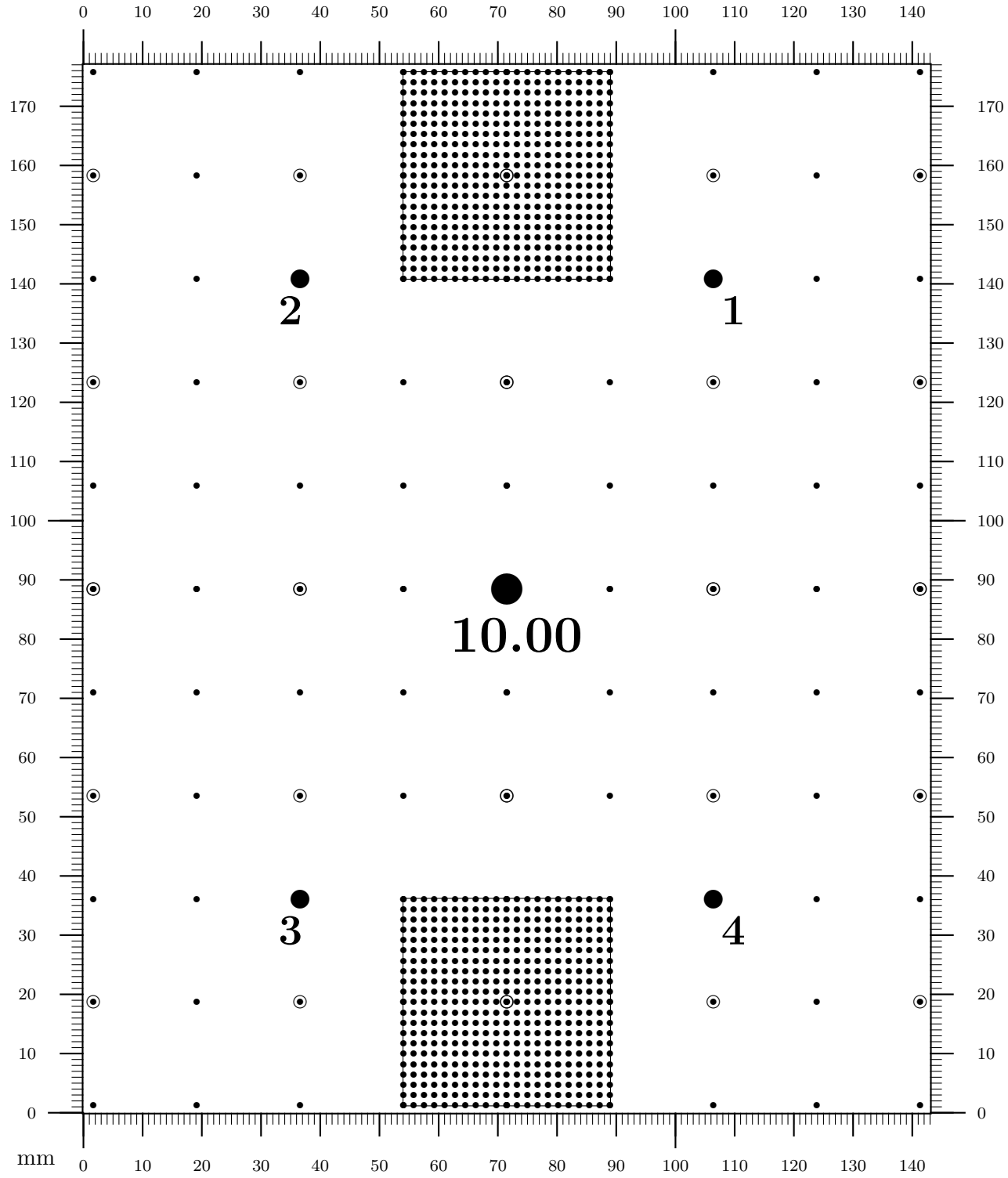

Figure 41: **0.1° at 10.00 meters is 17.453310 mm.**

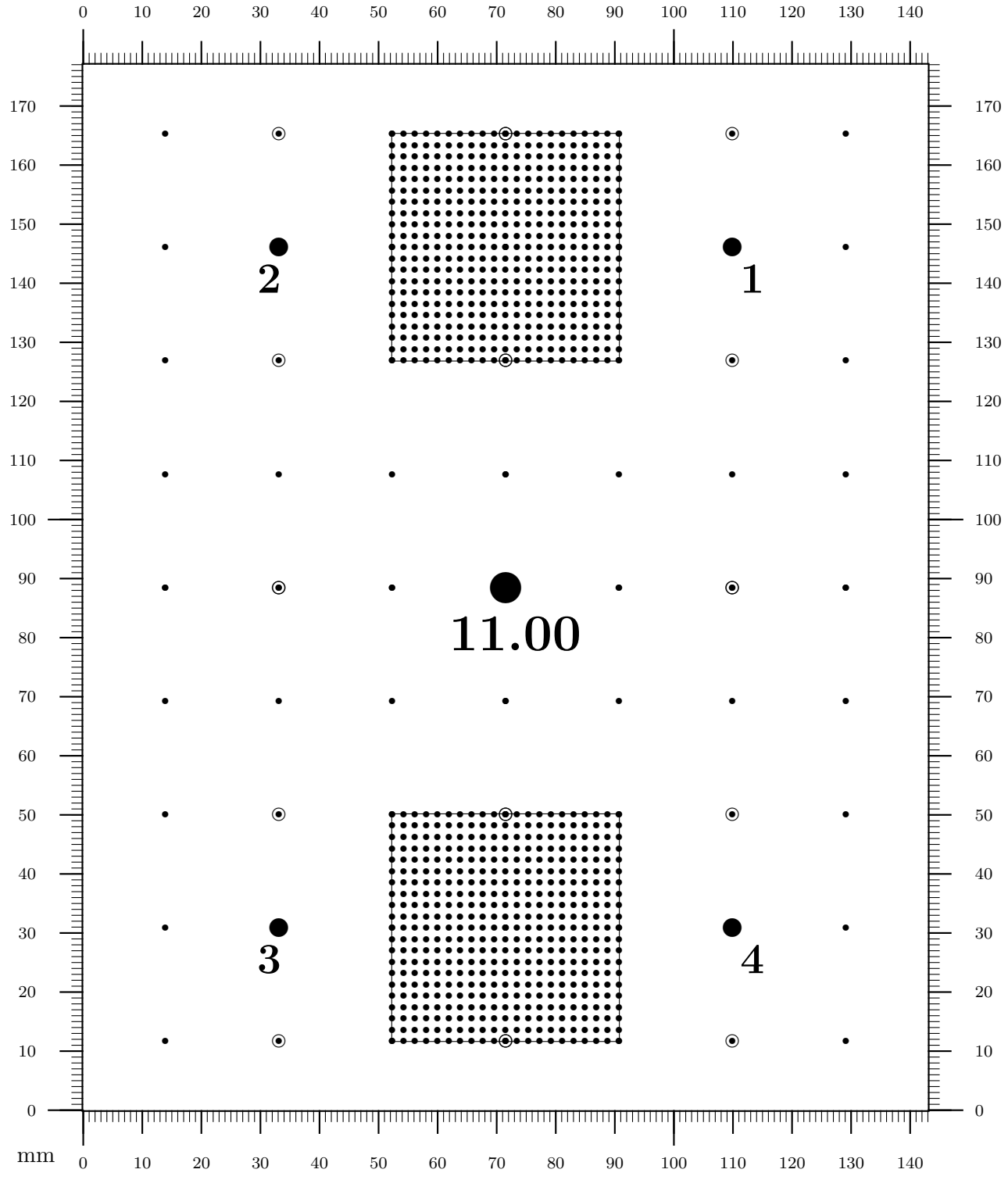

Figure 42: **0.1° at 11.00 meters is 19.198650 mm.**

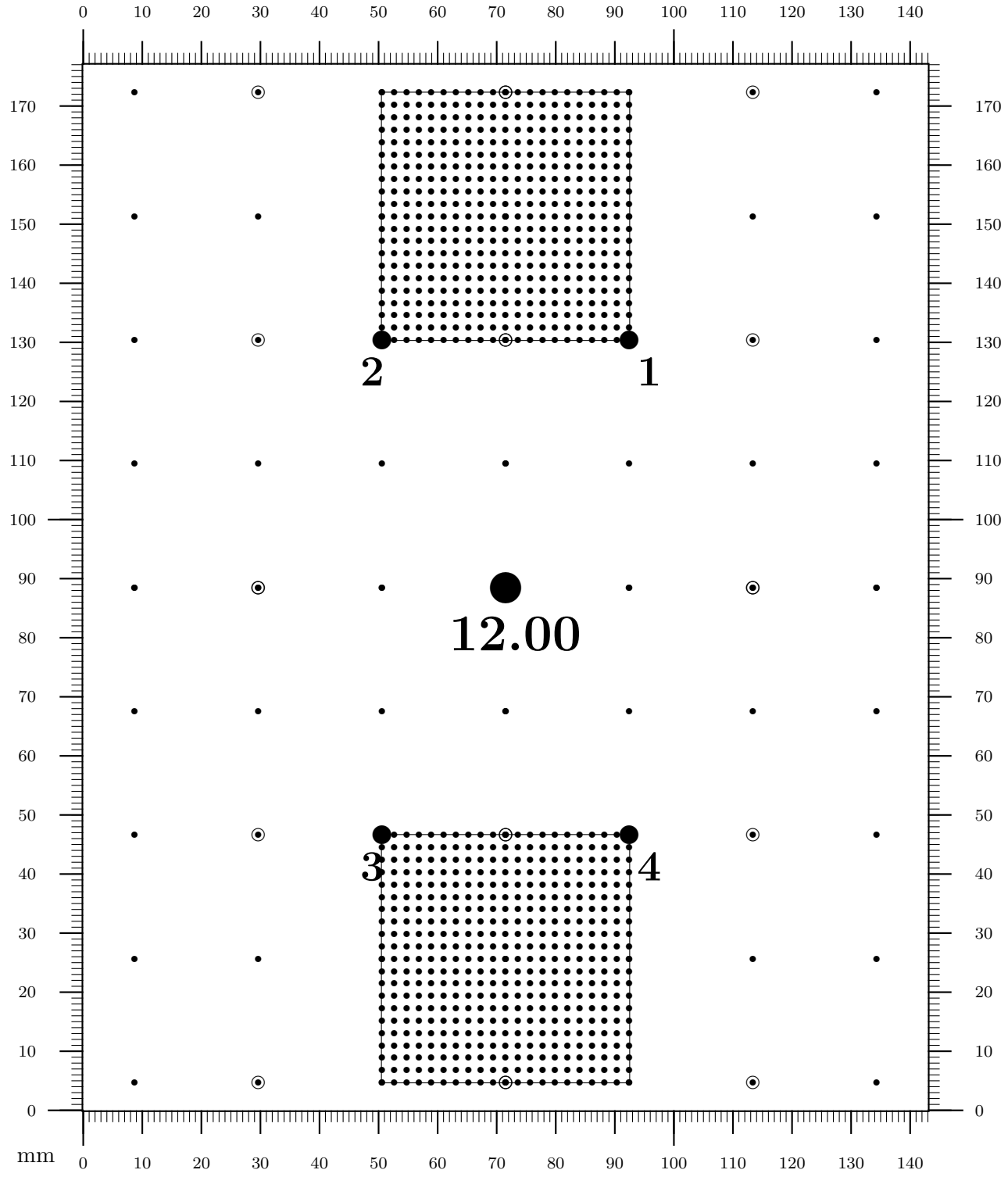

Figure 43: **0.1° at 12.00 meters is 20.943980 mm.**

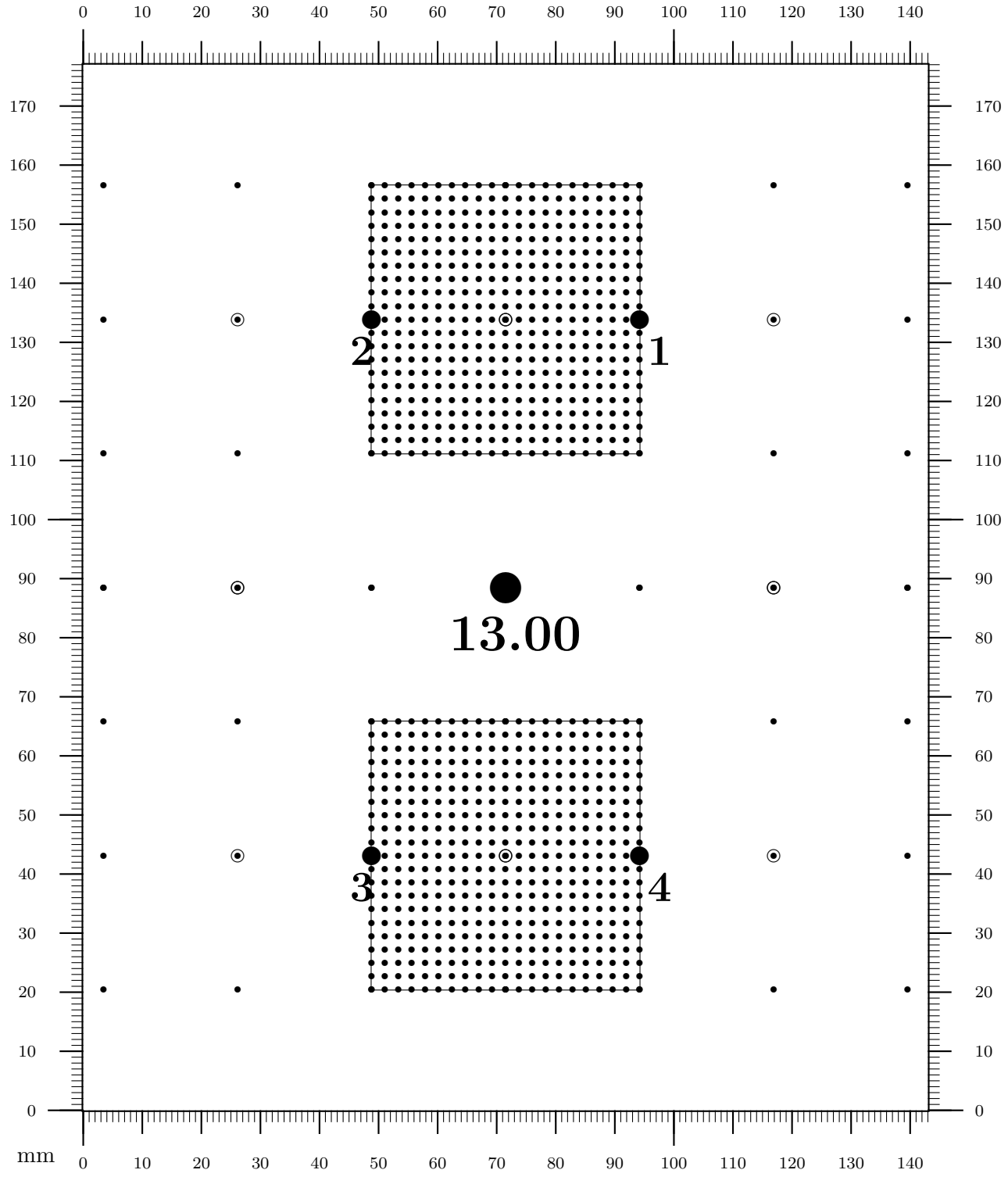

Figure 44: **0.1° at 13.00 meters is 22.689310 mm.**

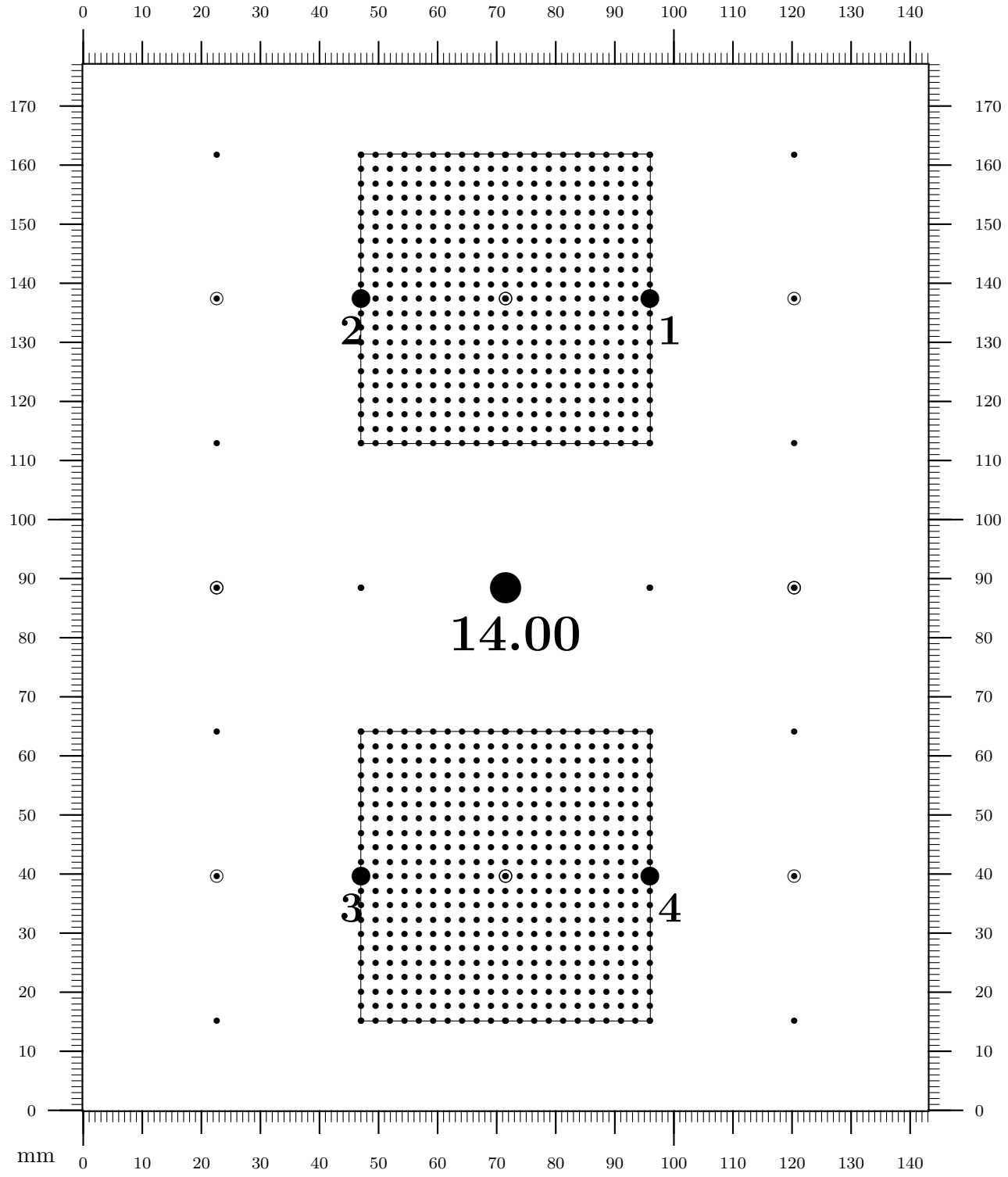

Figure 45: **0.1° at 14.00 meters is 24.434640 mm.**

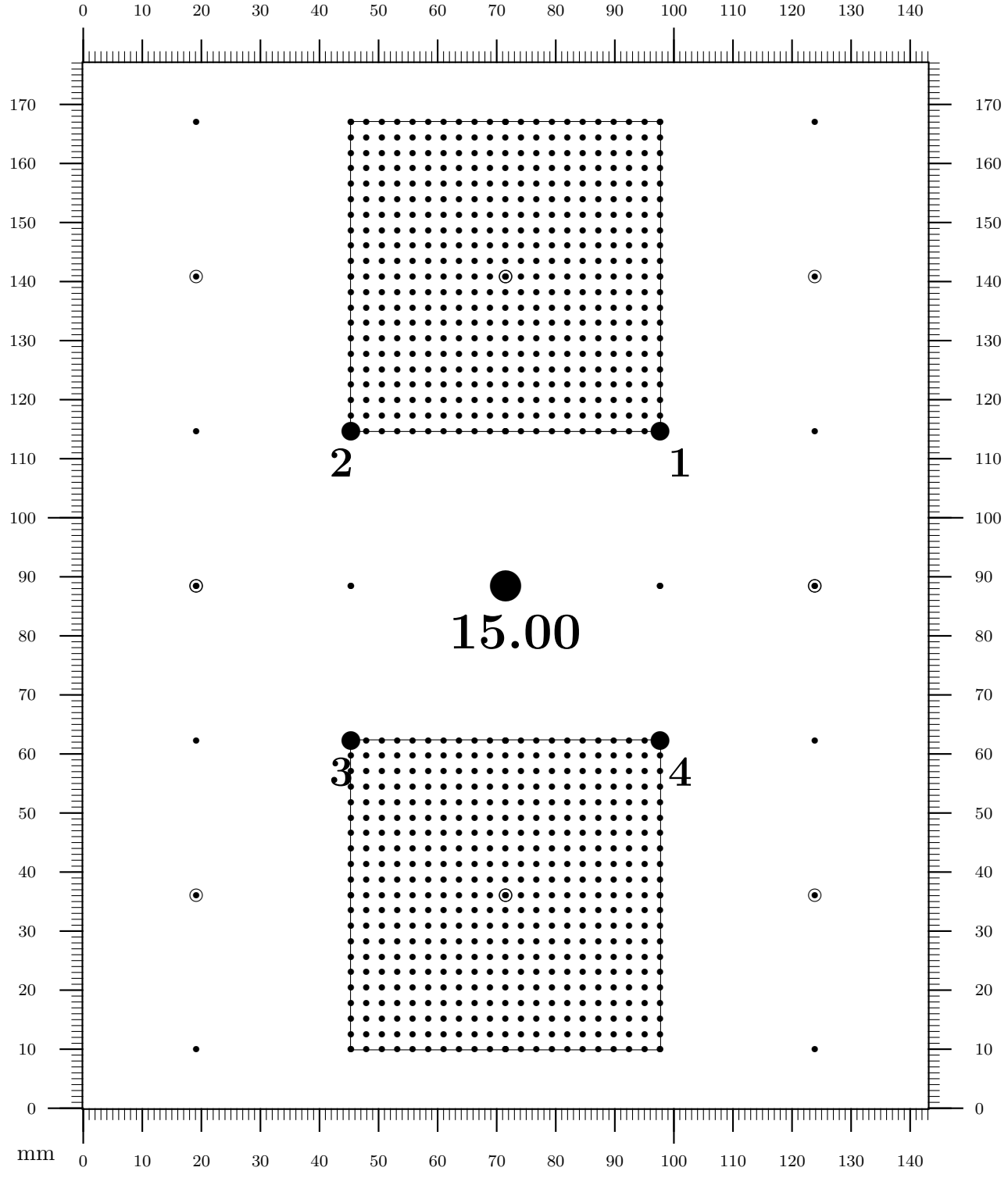

Figure 46: **0.1° at 15.00 meters is 26.179970 mm.**

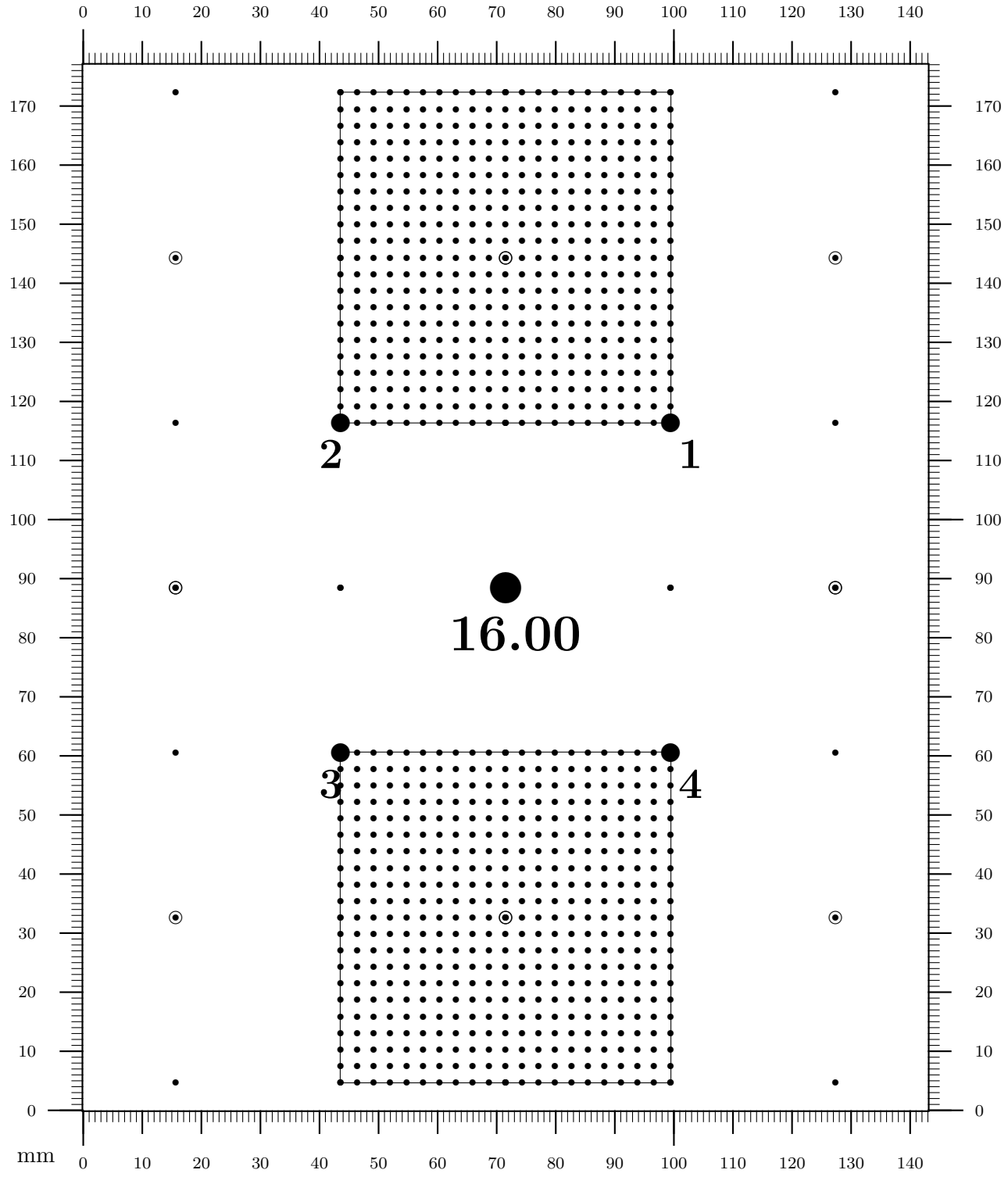

Figure 47: **0.1° at 16.00 meters is 27.925300 mm.**

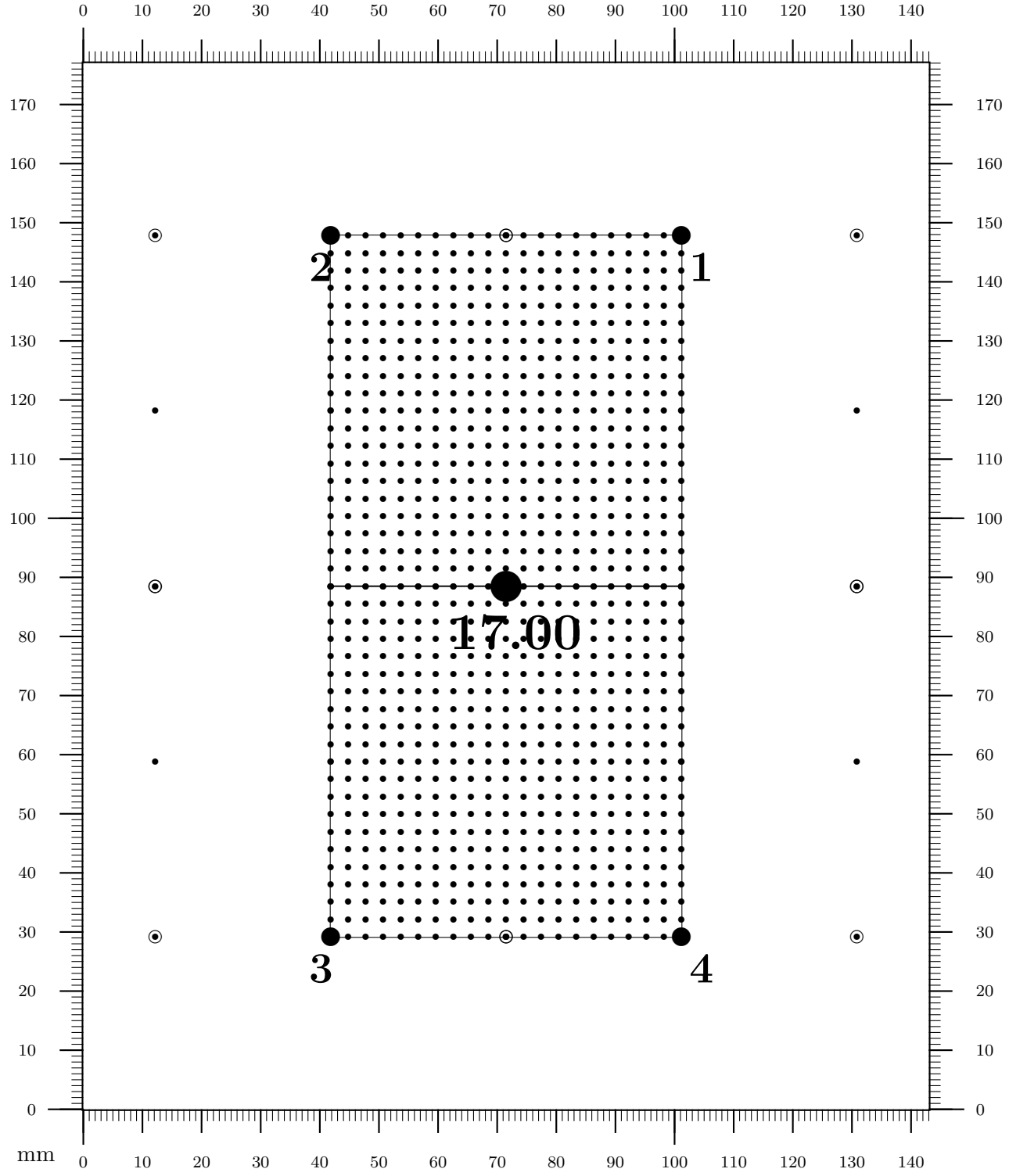

Figure 48: **0.1° at 17.00 meters is 29.670630 mm.**

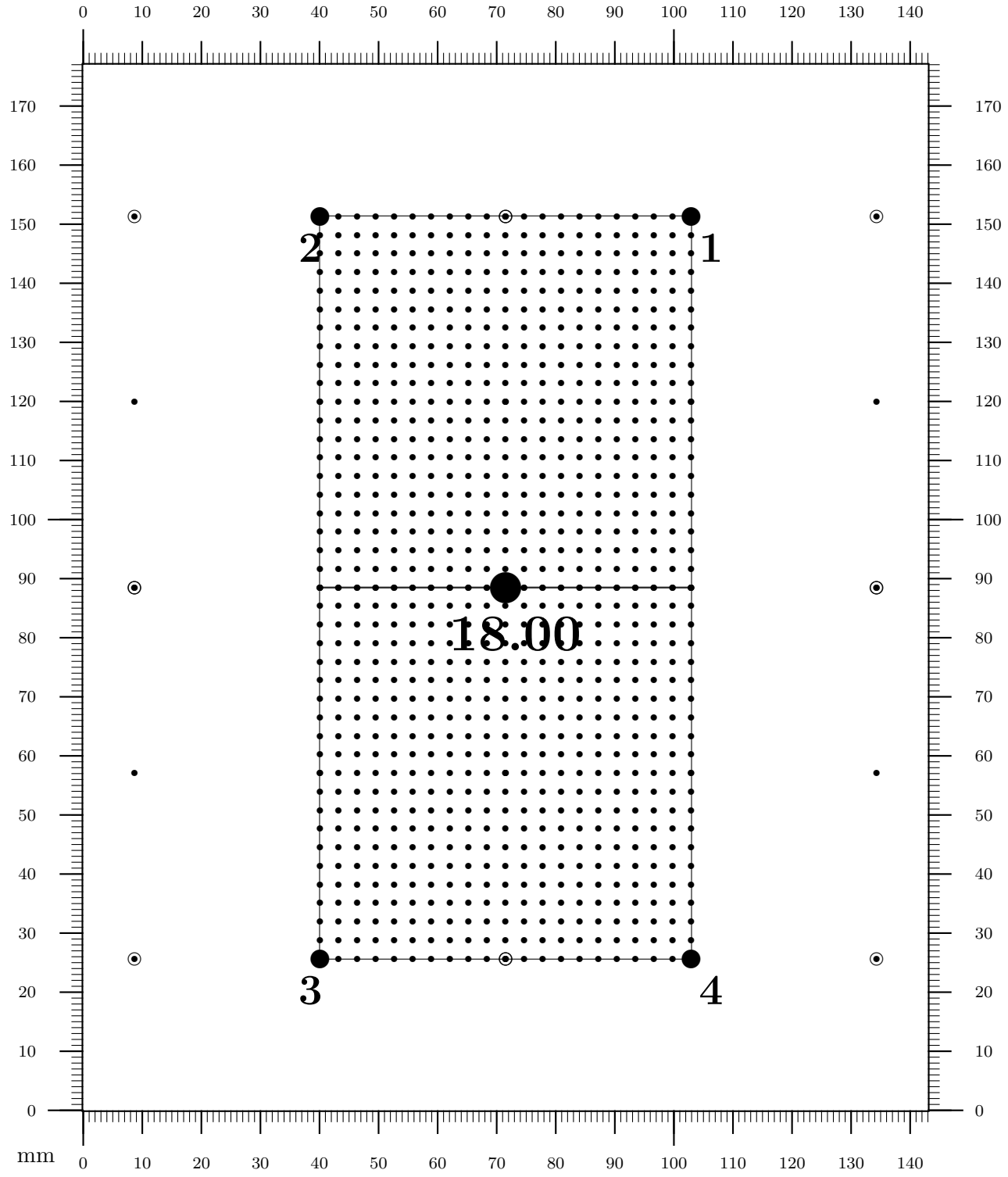

Figure 49: **0.1° at 18.00 meters is 31.415960 mm.**

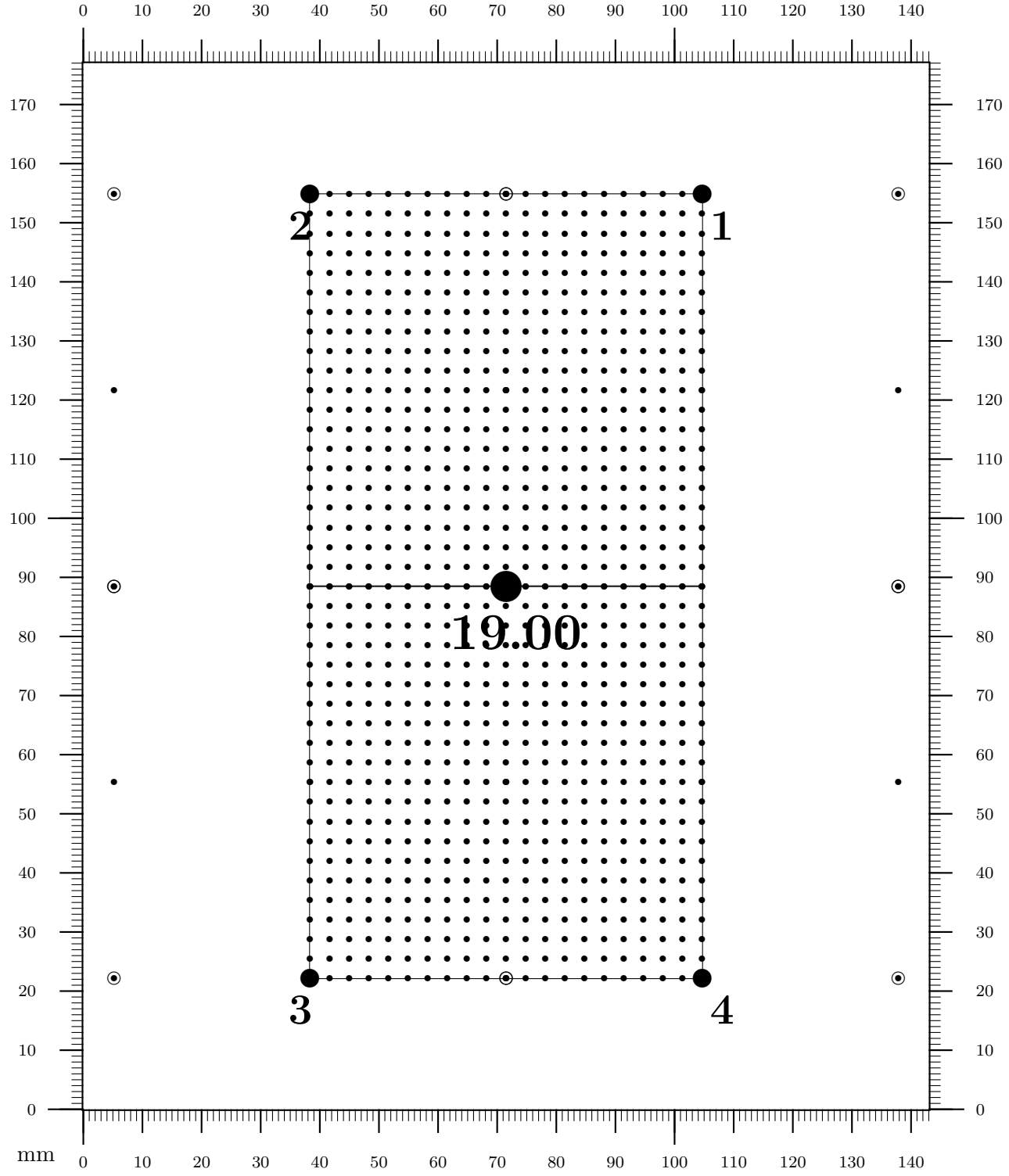

Figure 50: **0.1° at 19.00 meters is 33.161290 mm.**

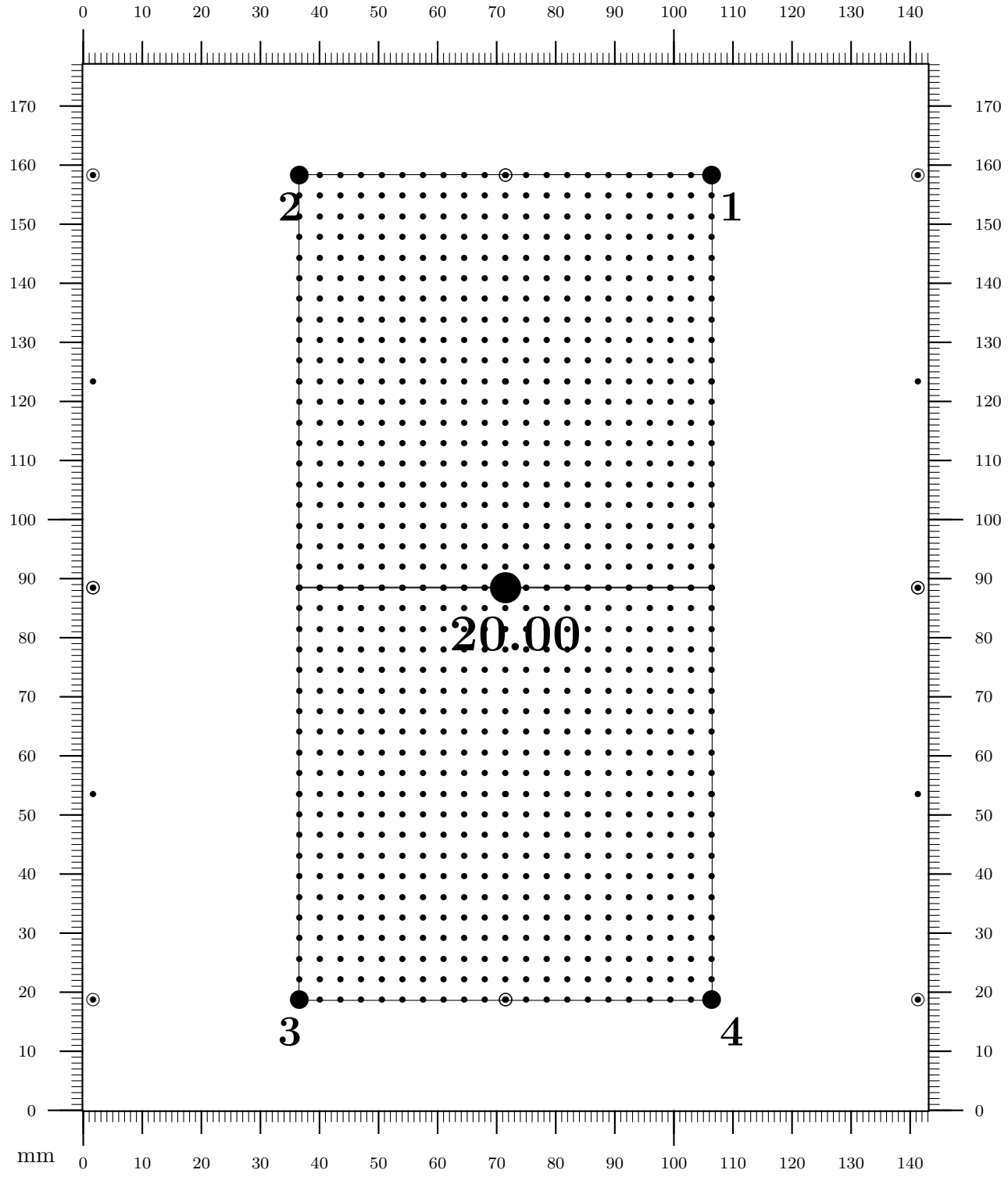

Figure 51: **0.1° at 20.00 meters is 34.906630 mm.**

1.4 `MFrame1.bas` Routines

A short program written in GW-BASIC was developed to generate the LaTeXplot files used in making the actual targets. *This has been temporarily deleted.*