Position Calibration Targets

English and Metric Measure

29 June 2009

Eric Hamilton

[1] $Header: d:/Binder2/Targets/TargetsC/RCS/GenTargt.c,v 1.5 2009-06-17 15:12:49-07 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:

$$\pi = 3.1415926$$

For English Measure:

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

For Metric Measure:

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

Where:

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

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.)

And 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.)

[2] `$Header: d:/Binder2/Targets/TargetsC/RCS/GenTargt.c,v 1.5 2009-06-17 15:12:49-07 Hamilton Exp Hamilton $`

1.1 How to use the targets

The included targets in this note are designed for use with English Measurements at ranges of $2 \rightarrow 11$ feet in full foot increments and from $12 \rightarrow 56$ feet in even foot increments, between the camera and the target[3]. For metric units the range is $1 \rightarrow 9.5$ in $\frac{1}{2}$ meter units and from $10 \rightarrow 20$ in full meter increments.

Each of the larger grids consists of a "large" and a "small" set of dots[4]. The large dots are 0.1° 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 $\pm$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 $\frac{1}{4}$ 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 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 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.)

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

[4]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.

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[5].

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

   To get an estimate of the amount of "printing error" that has been introduced to any given target, an inch rule has been provided on each edge of the target grid. If this inch 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 I have put a metric distance rule on the grids.

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. 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 many PTZ units, pan and tilt have different pivot points. This should be considered when making accurate close measurements.

[5] And the attitude of the author!

d_{ft}/d_m	a_{in}	a_{mm}	English Measure Grid	Metric Measure Grid
1.00	0.020944	0.174533	—	Figure 34, page 45
1.50	0.031416	0.261800	—	Figure 35, page 46
2.00	0.041888	0.349066	Figure 1, page 11	Figure 36, page 47
2.50	0.052360	0.436333	—	Figure 37, page 48
3.00	0.062832	0.523599	Figure 2, page 12	Figure 38, page 49
3.50	0.073304	0.610866	—	Figure 39, page 50
4.00	0.083776	0.698132	Figure 3, page 13	Figure 40, page 51
4.50	0.094248	0.785399	—	Figure 41, page 52
5.00	0.104720	0.872666	Figure 4, page 14	Figure 42, page 53
5.50	0.115192	0.959932	—	Figure 43, page 54
6.00	0.125664	1.047199	Figure 5, page 15	Figure 44, page 55
6.50	0.136136	1.134465	—	Figure 45, page 56
7.00	0.146608	1.221732	Figure 6, page 16	Figure 46, page 57
7.50	0.157080	1.308998	—	Figure 47, page 58
8.00	0.167552	1.396265	Figure 7, page 17	Figure 48, page 59
8.50	0.178024	1.483532	—	Figure 49, page 60
9.00	0.188496	1.570798	Figure 8, page 18	Figure 50, page 61
9.50	0.198968	1.658065	—	Figure 51, page 62
10.00	0.209440	1.745331	Figure 9, page 19	Figure 52, page 63
11.00	0.230384	1.919864	Figure 10, page 20	Figure 53, page 64
12.00	0.251328	2.094397	Figure 11, page 21	Figure 54, page 65
13.00	0.272272	2.268931	—	Figure 55, page 66
14.00	0.293216	2.443464	Figure 12, page 22	Figure 56, page 67
15.00	0.314160	2.617997	—	Figure 57, page 68
16.00	0.335104	2.792530	Figure 13, page 23	Figure 58, page 69
17.00	0.356048	2.967063	—	Figure 59, page 70
18.00	0.376992	3.141596	Figure 14, page 24	Figure 60, page 71
19.00	0.397936	3.316129	—	Figure 61, page 72
20.00	0.418879	3.490662	Figure 15, page 25	Figure 62, page 73
21.00	0.439823	3.665196	—	—
22.00	0.460767	3.839729	Figure 16, page 26	—
23.00	0.481711	4.014262	—	—
24.00	0.502655	4.188795	Figure 17, page 27	—
25.00	0.523599	4.363328	—	—
26.00	0.544543	4.537861	Figure 18, page 28	—
27.00	0.565487	4.712394	—	—
28.00	0.586431	4.886927	Figure 19, page 29	—
29.00	0.607375	5.061461	—	—
30.00	0.628319	5.235994	Figure 20, page 30	—
31.00	0.649263	5.410527	—	—
32.00	0.670207	5.585060	Figure 21, page 31	—
33.00	0.691151	5.759593	—	—
34.00	0.712095	5.934126	Figure 22, page 32	—
35.00	0.733039	6.108659	—	—
36.00	0.753983	6.283192	Figure 23, page 33	—
37.00	0.774927	6.457726	—	—
38.00	0.795871	6.632259	Figure 24, page 34	—

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d_{ft}/d_m	a_{in}	a_{mm}	English Measure Grid	Metric Measure Grid
39.00	0.816815	6.806792	—	—
40.00	0.837759	6.981325	Figure 25, page 35	—
41.00	0.858703	7.155858	—	—
42.00	0.879647	7.330391	Figure 26, page 36	—
43.00	0.900591	7.504924	—	—
44.00	0.921535	7.679457	Figure 27, page 37	—
45.00	0.942479	7.853991	—	—
46.00	0.963423	8.028524	Figure 28, page 38	—
47.00	0.984367	8.203057	—	—
48.00	1.005311	8.377590	Figure 29, page 39	—
49.00	1.026255	8.552123	—	—
50.00	1.047199	8.726656	Figure 30, page 40	—
51.00	1.068143	8.901189	—	—
52.00	1.089087	9.075722	Figure 31, page 41	—
53.00	1.110031	9.250255	—	—
54.00	1.130975	9.424789	Figure 32, page 42	—
55.00	1.151919	9.599322	—	—
56.00	1.172863	9.773855	—	—
57.00	1.193807	9.948388	—	—
58.00	1.214751	10.122921	—	—
59.00	1.235695	10.297454	—	—
60.00	1.256638	10.471987	—	—
61.00	1.277582	10.646520	—	—
62.00	1.298526	10.821054	—	—
63.00	1.319470	10.995587	—	—
64.00	1.340414	11.170120	—	—
65.00	1.361358	11.344653	—	—
66.00	1.382302	11.519186	—	—
67.00	1.403246	11.693719	—	—
68.00	1.424190	11.868252	—	—
69.00	1.445134	12.042785	—	—
70.00	1.466078	12.217319	—	—
71.00	1.487022	12.391852	—	—
72.00	1.507966	12.566385	—	—
73.00	1.528910	12.740918	—	—
74.00	1.549854	12.915451	—	—
75.00	1.570798	13.089984	—	—
76.00	1.591742	13.264517	—	—
77.00	1.612686	13.439050	—	—
78.00	1.633630	13.613584	—	—
79.00	1.654574	13.788117	—	—
80.00	1.675518	13.962650	—	—
81.00	1.696462	14.137183	—	—

1.2 English Measure Calibration Grids

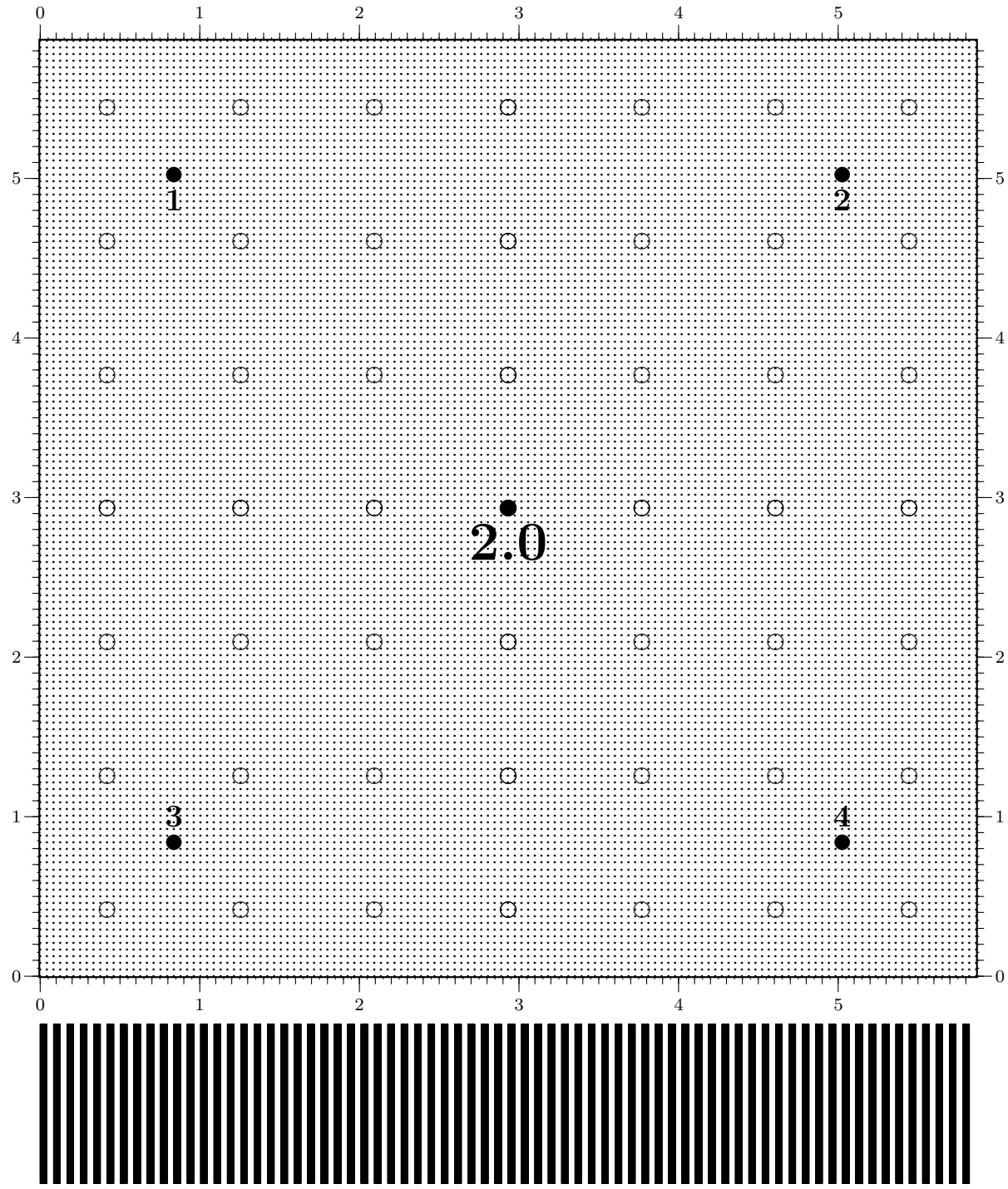

Figure 1: **0.1°at 2.0 feet is 0.041888 inch.**

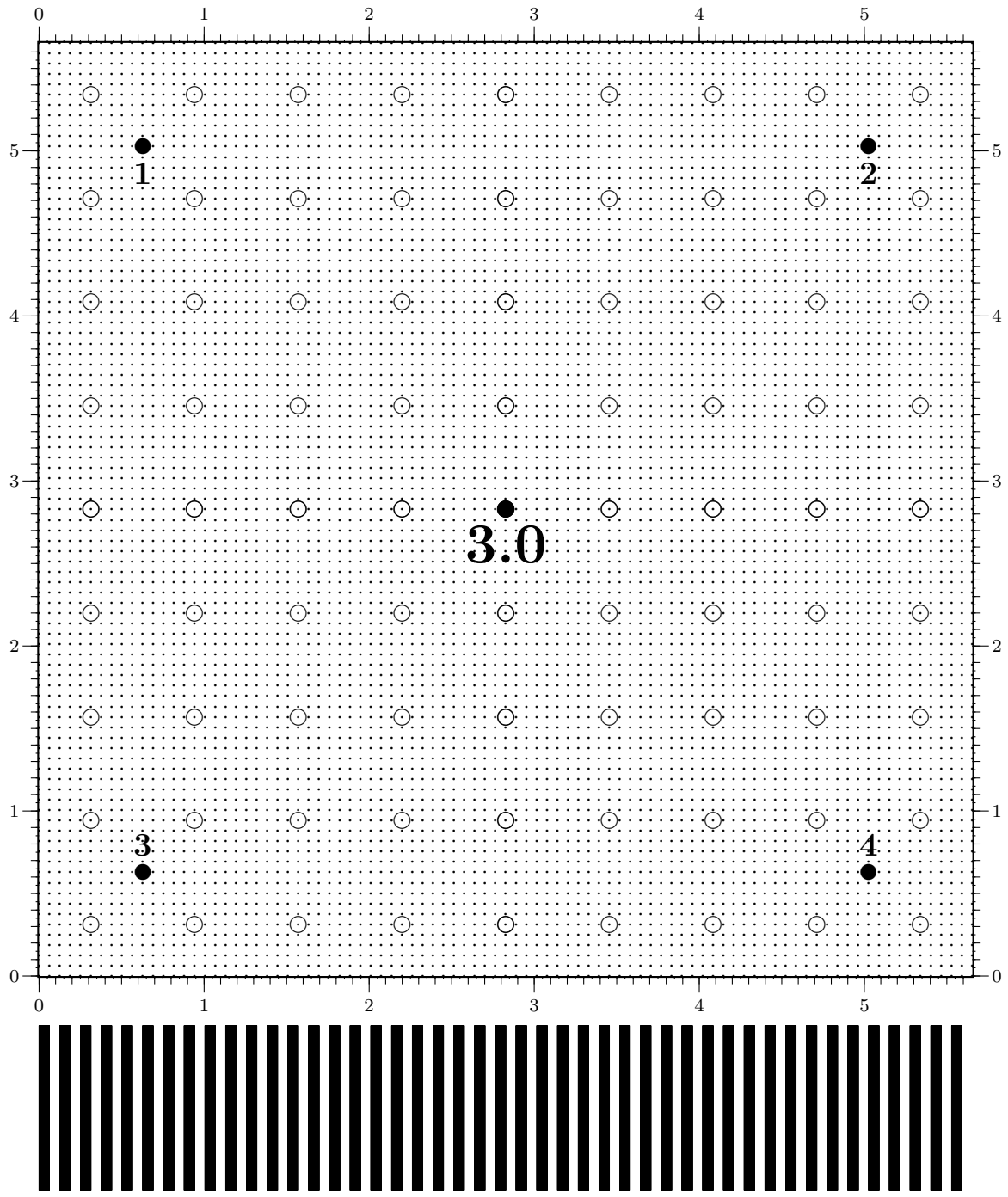

Figure 2: **0.1°at 3.0 feet is 0.062832 inch.**

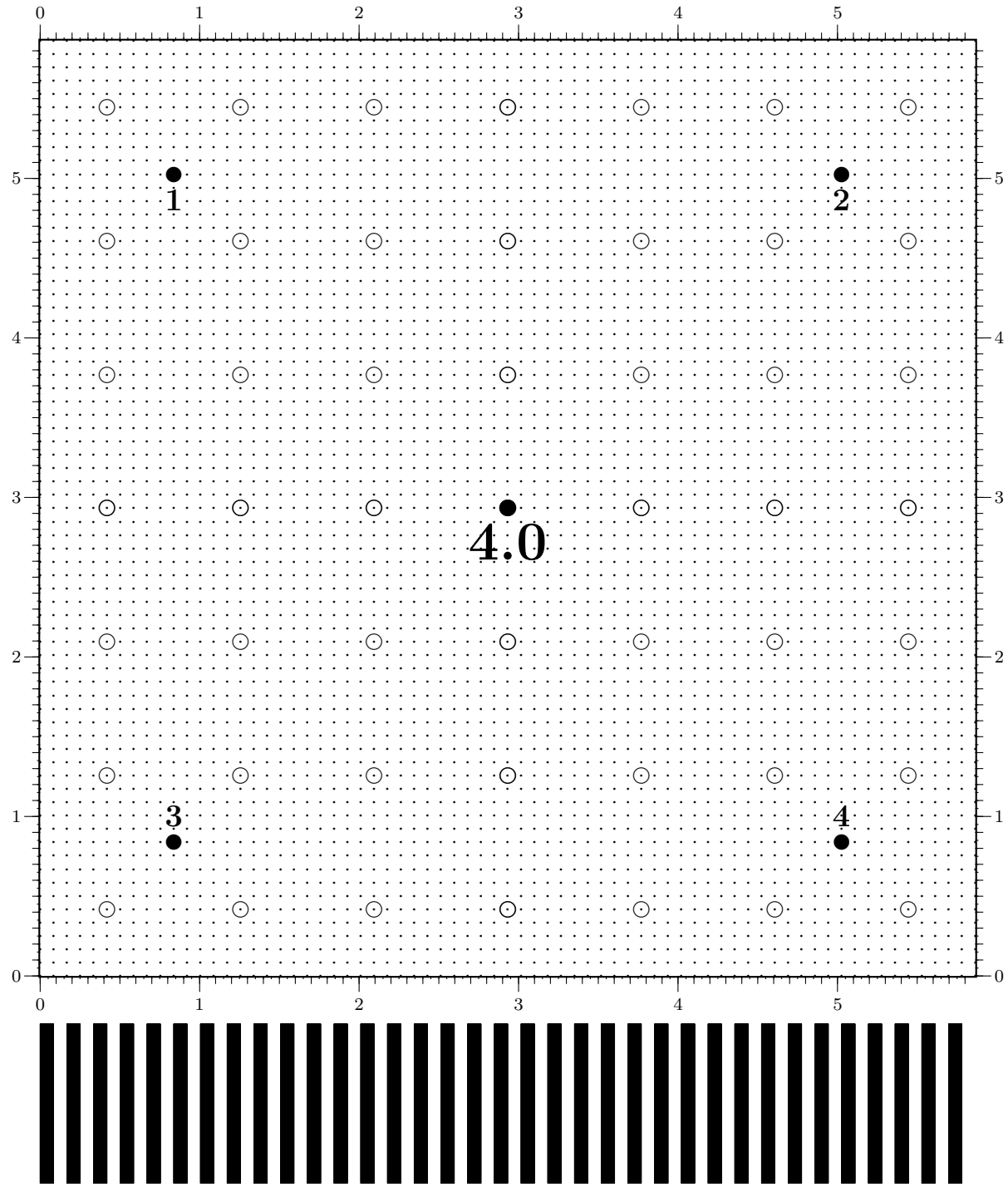

Figure 3: **0.1°at 4.0 feet is 0.083776 inch.**

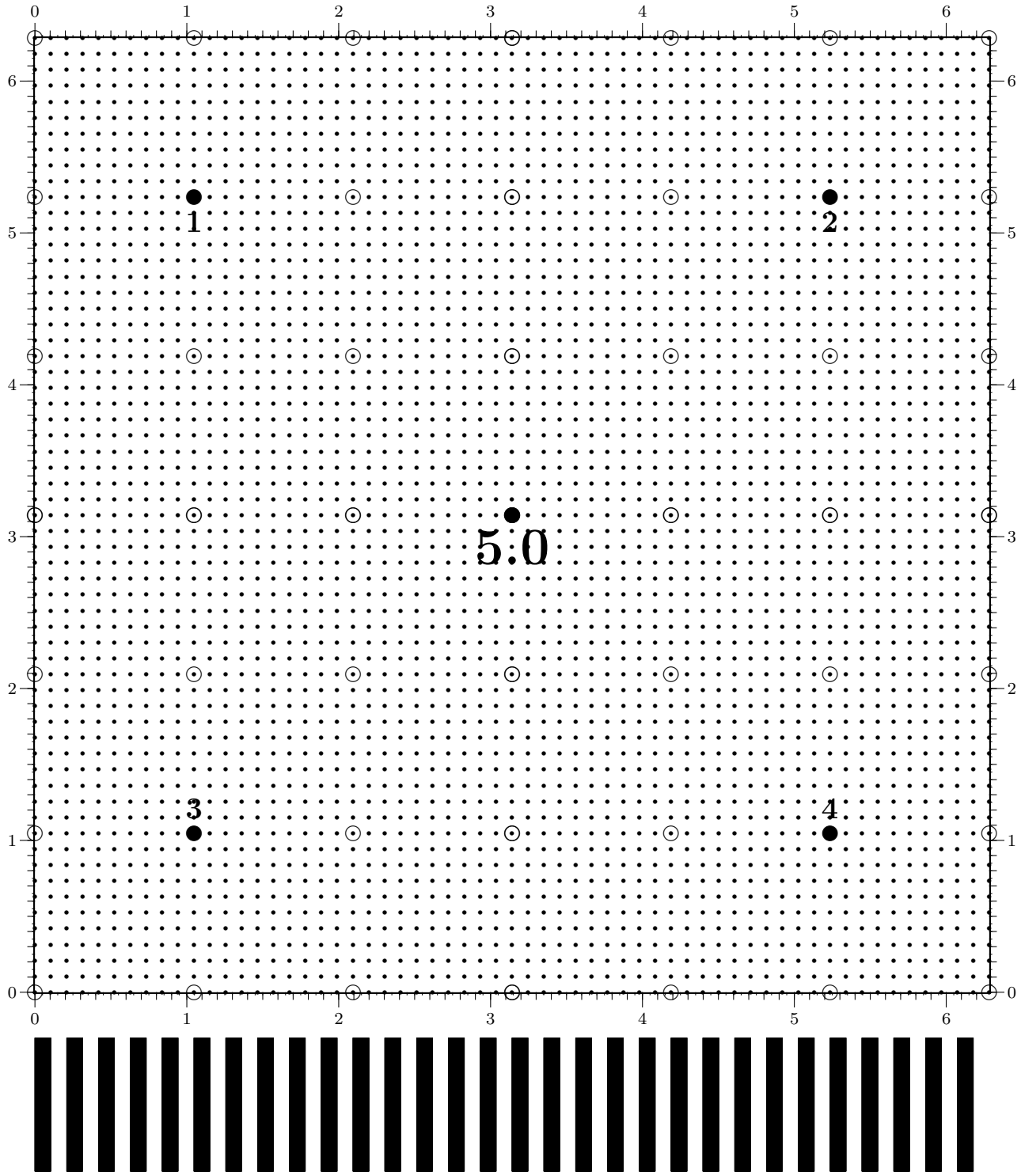

Figure 4: **0.1°at 5.0 feet is 0.104720 inch.**

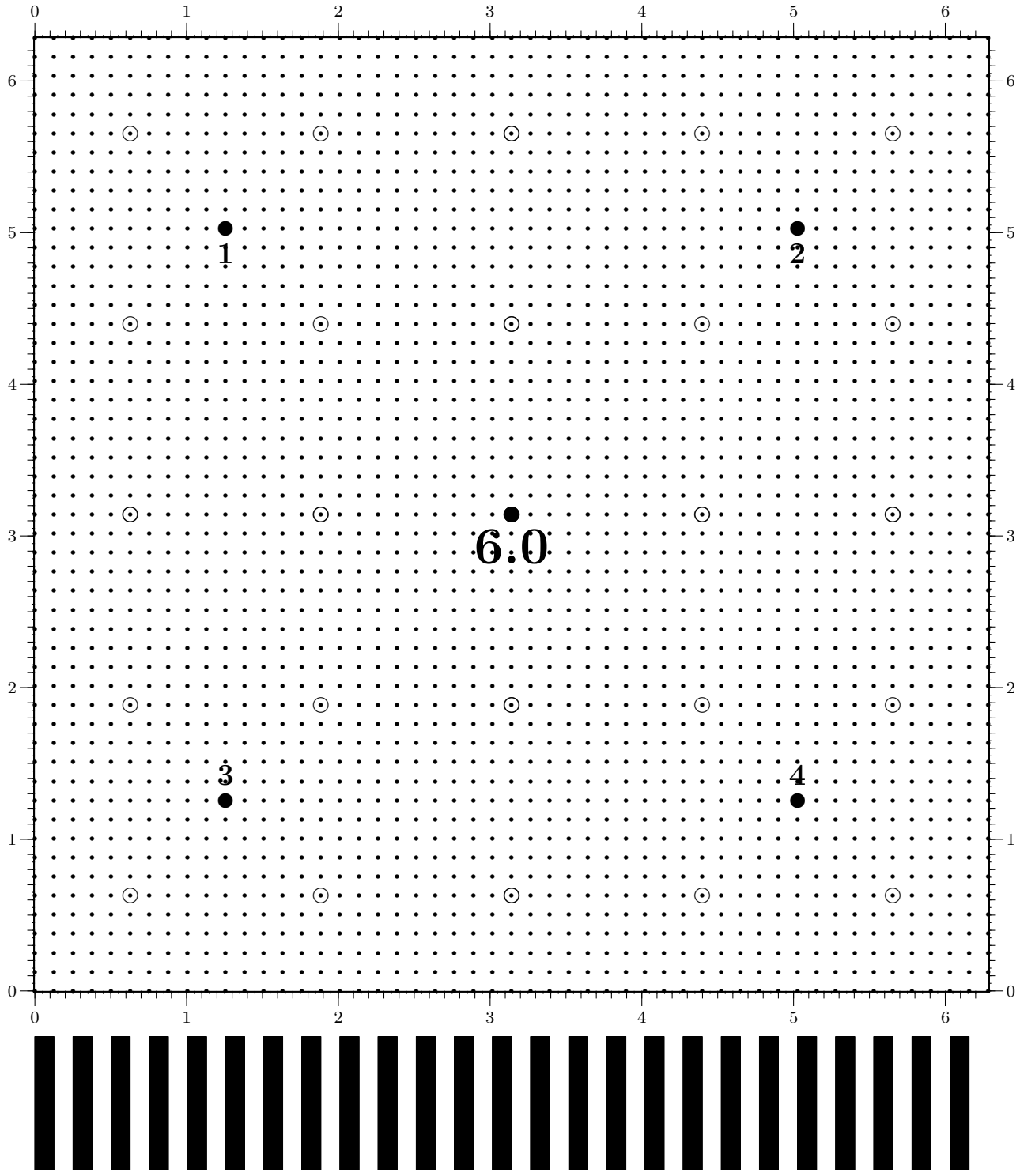

Figure 5: **0.1°at 6.0 feet is 0.125664 inch.**

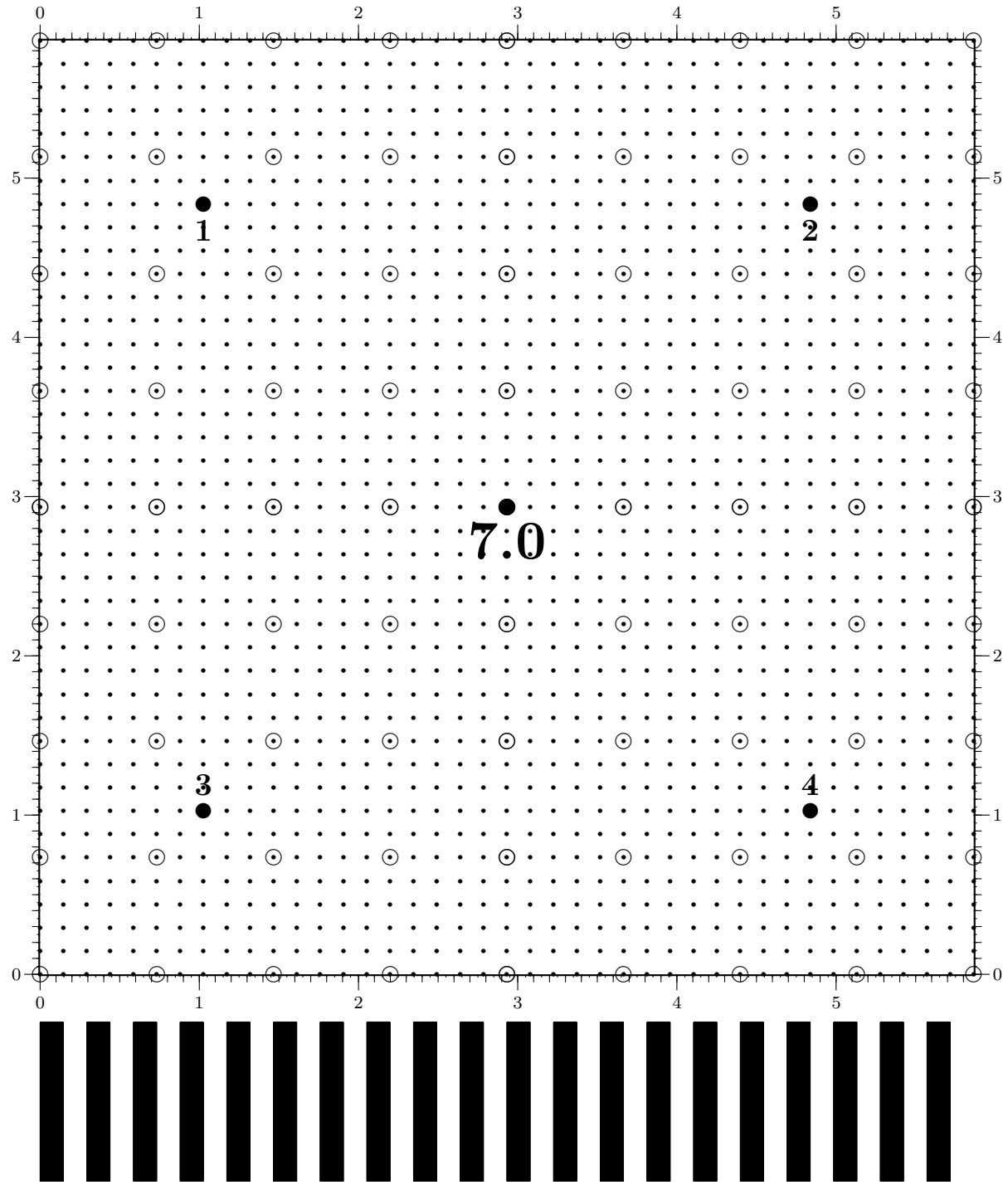

Figure 6: **0.1°at 7.0 feet is 0.146608 inch.**

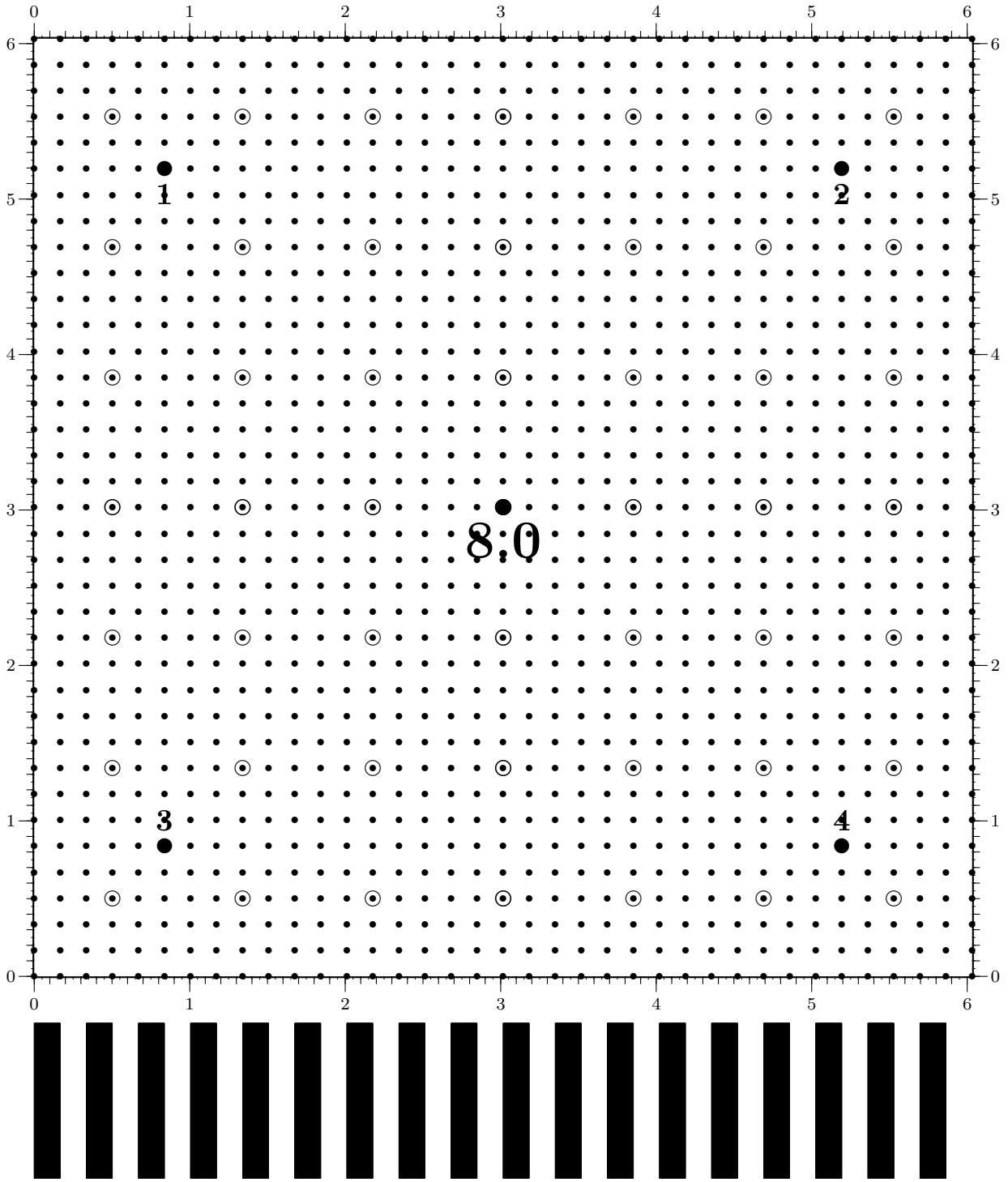

Figure 7: **0.1°at 8.0 feet is 0.167552 inch.**

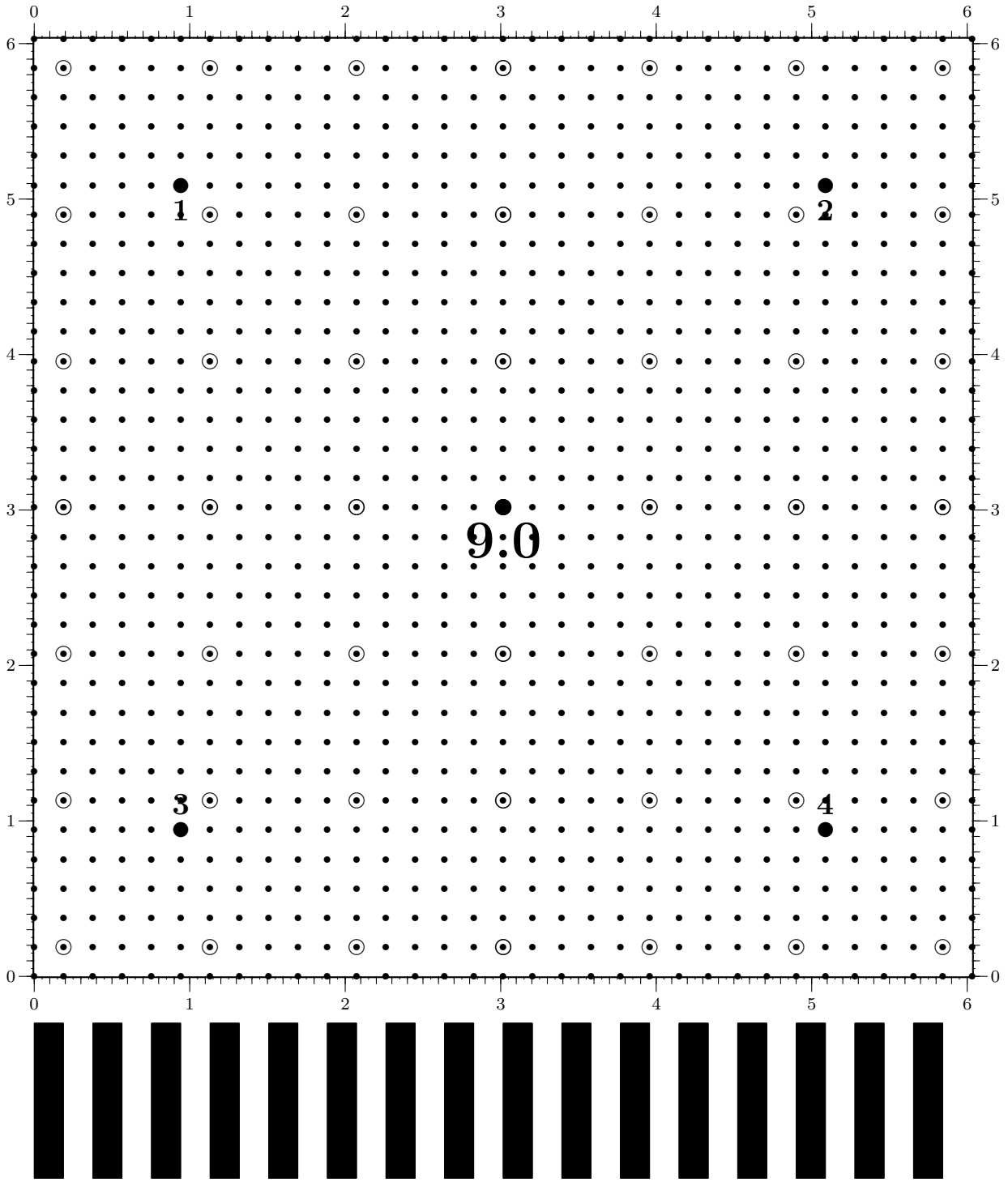

Figure 8: **0.1°at 9.0 feet is 0.188496 inch.**

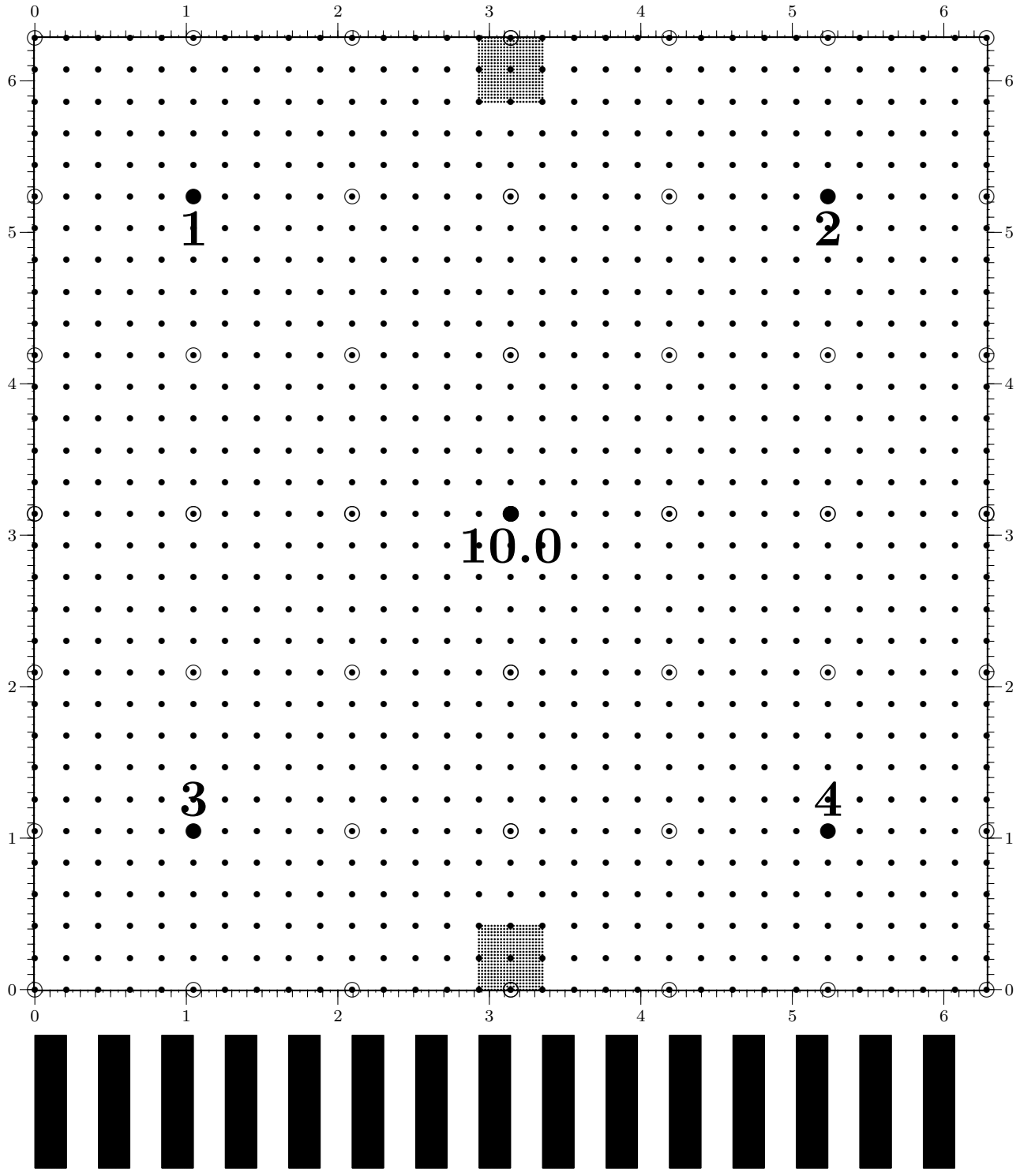

Figure 9: **0.1°at 10.0 feet is 0.209440 inch.**

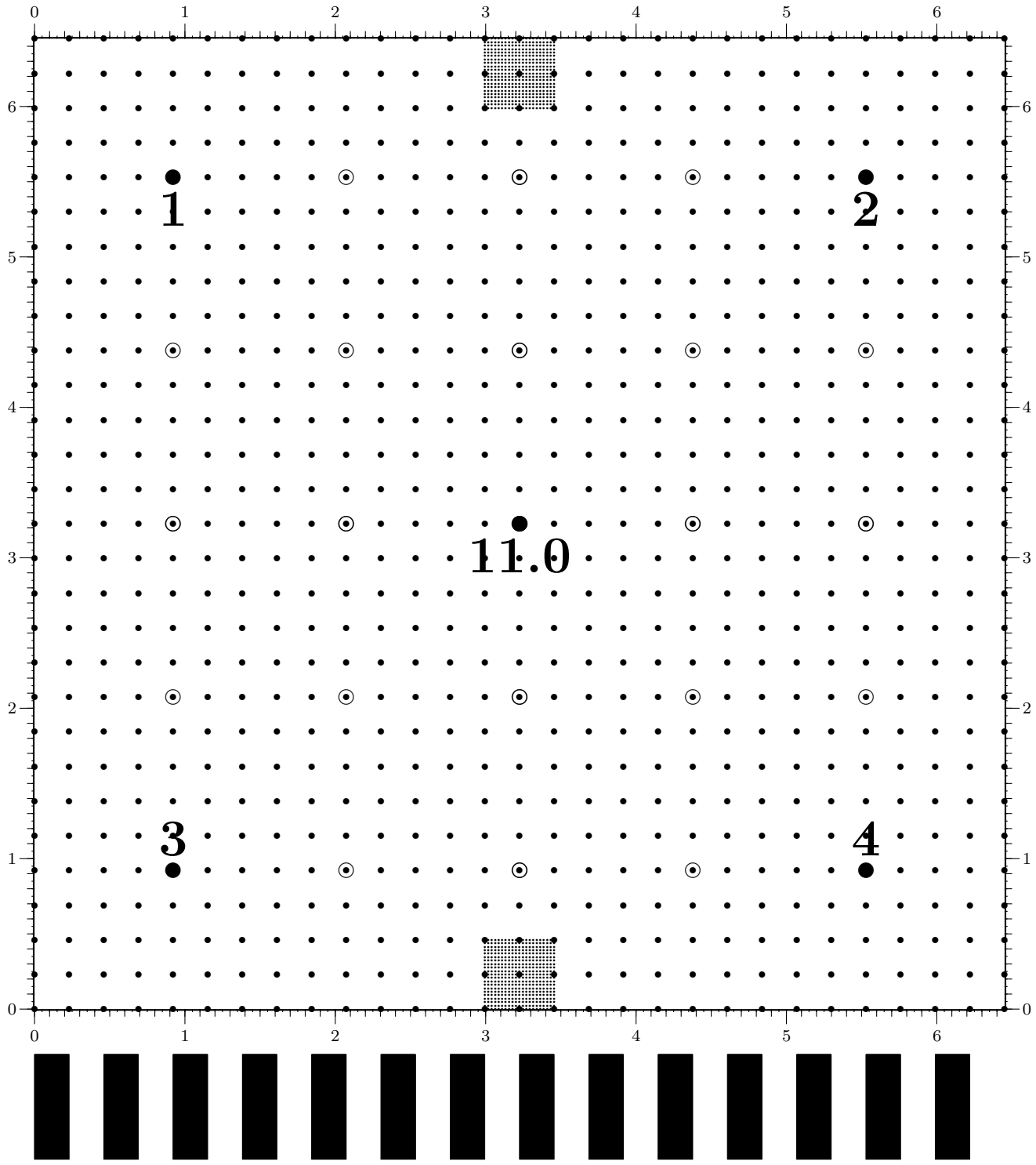

Figure 10: **0.1°at 11.0 feet is 0.230384 inch.**

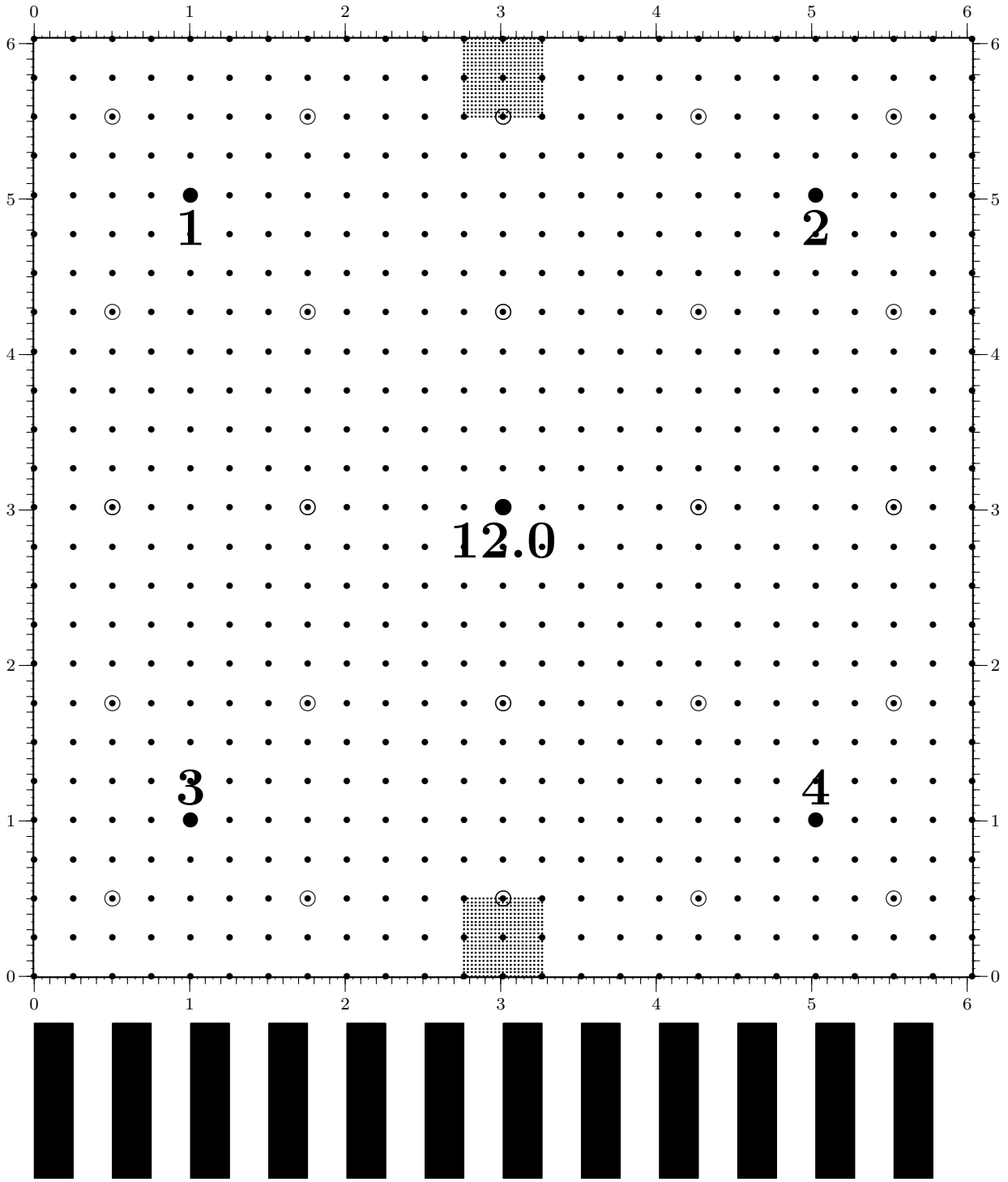

Figure 11: **0.1°at 12.0 feet is 0.251328 inch.**

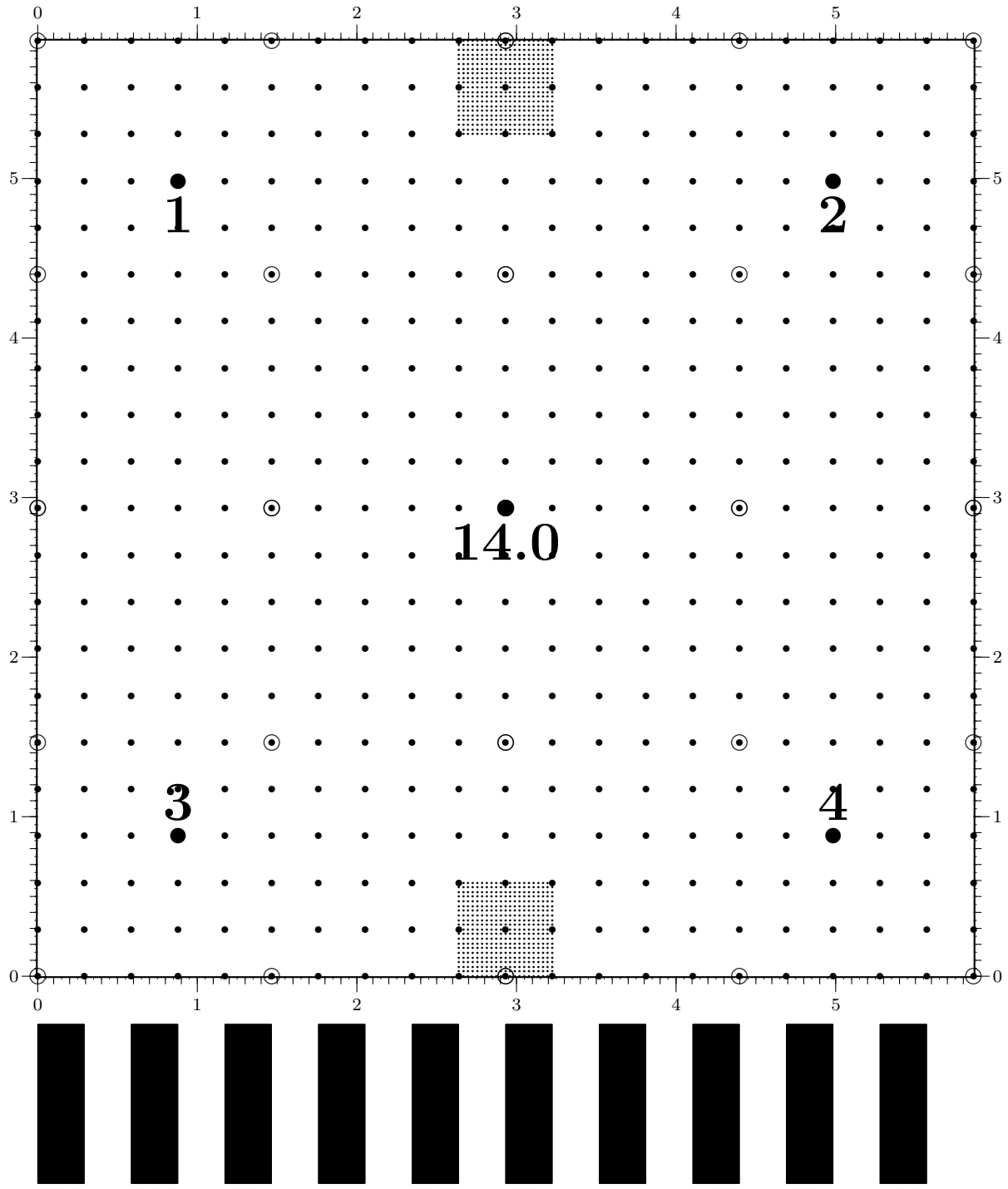

Figure 12: **0.1°at 14.0 feet is 0.293216 inch.**

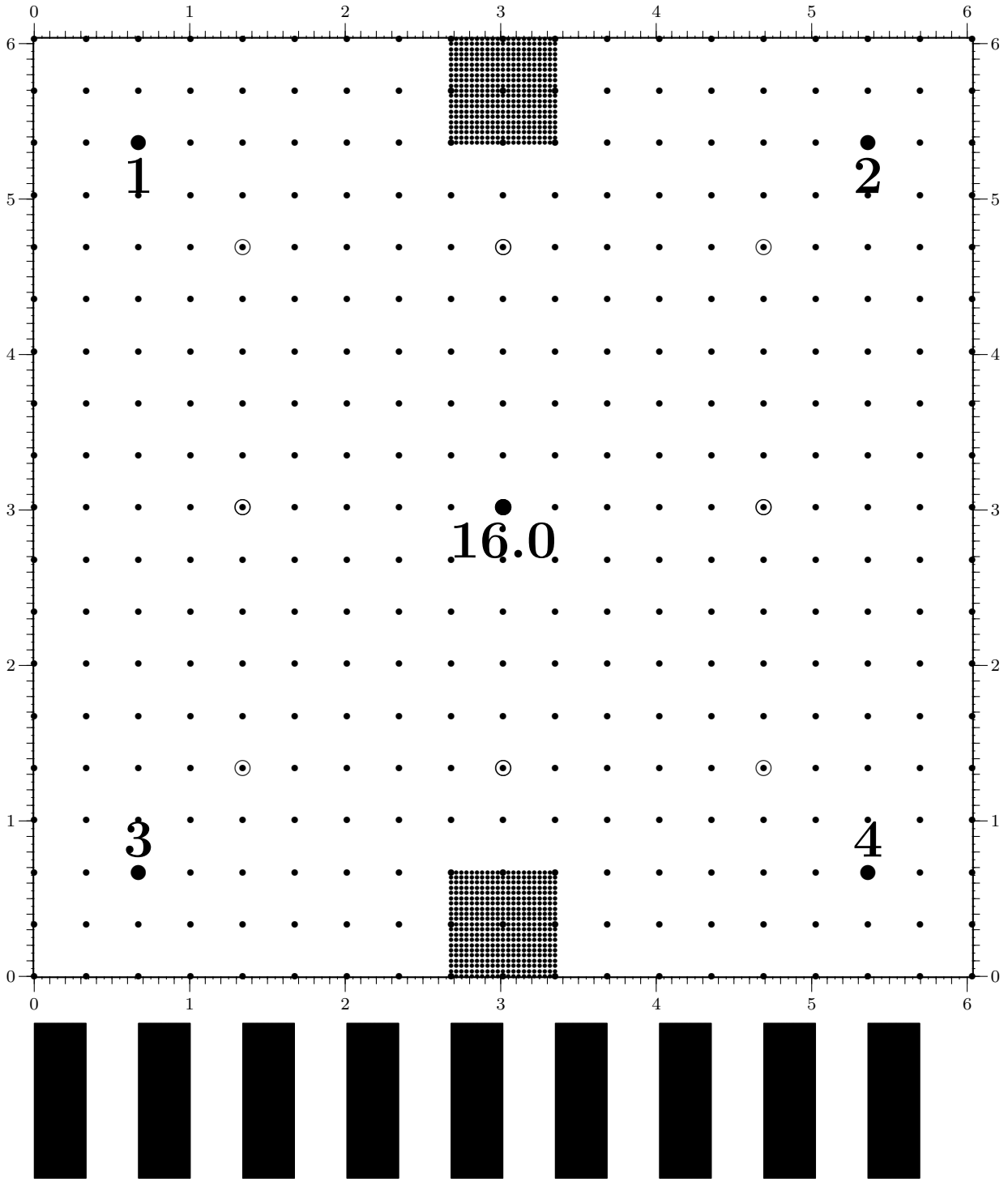

Figure 13: **0.1°at 16.0 feet is 0.335104 inch.**

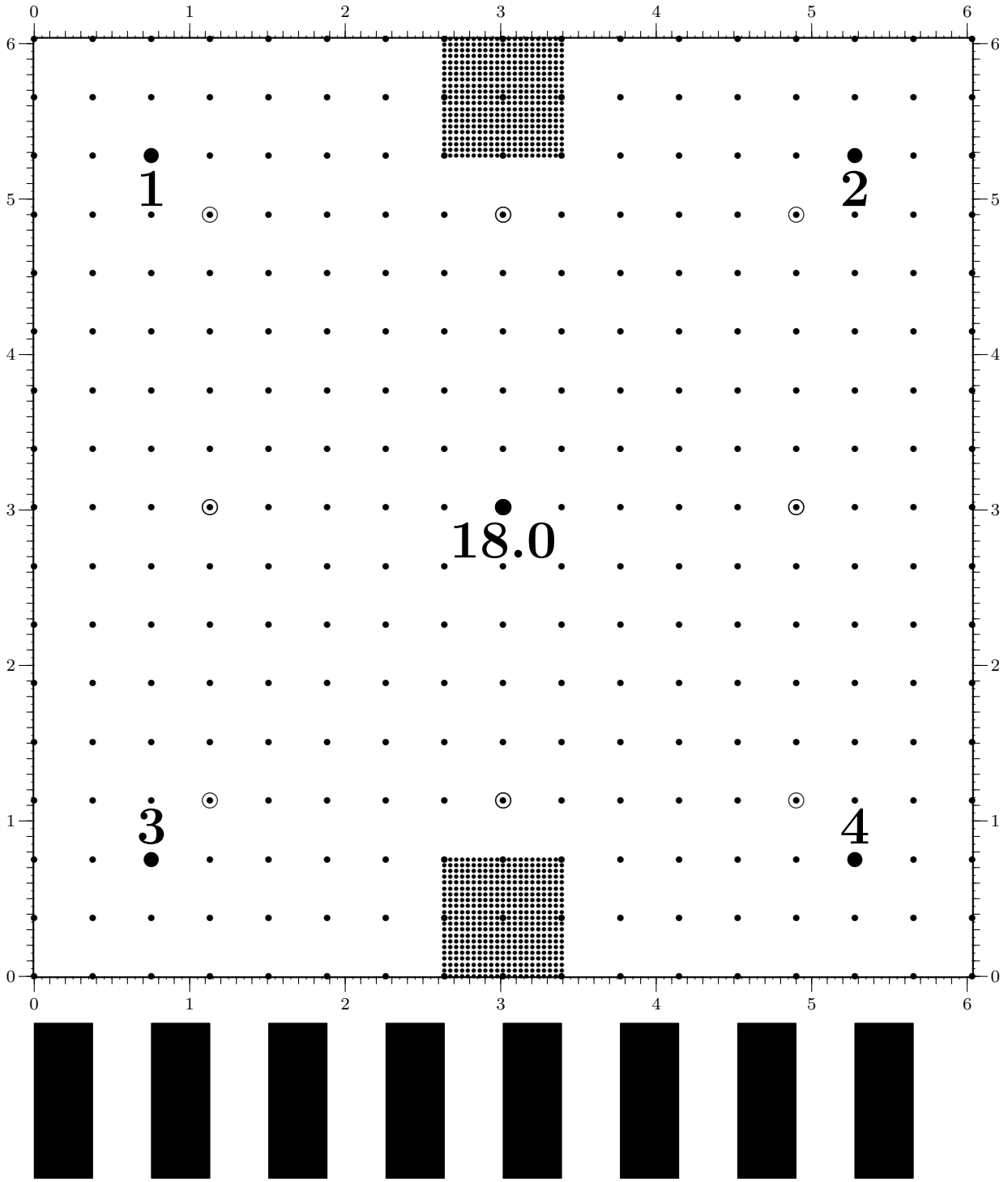

Figure 14: **0.1°at 18.0 feet is 0.376992 inch.**

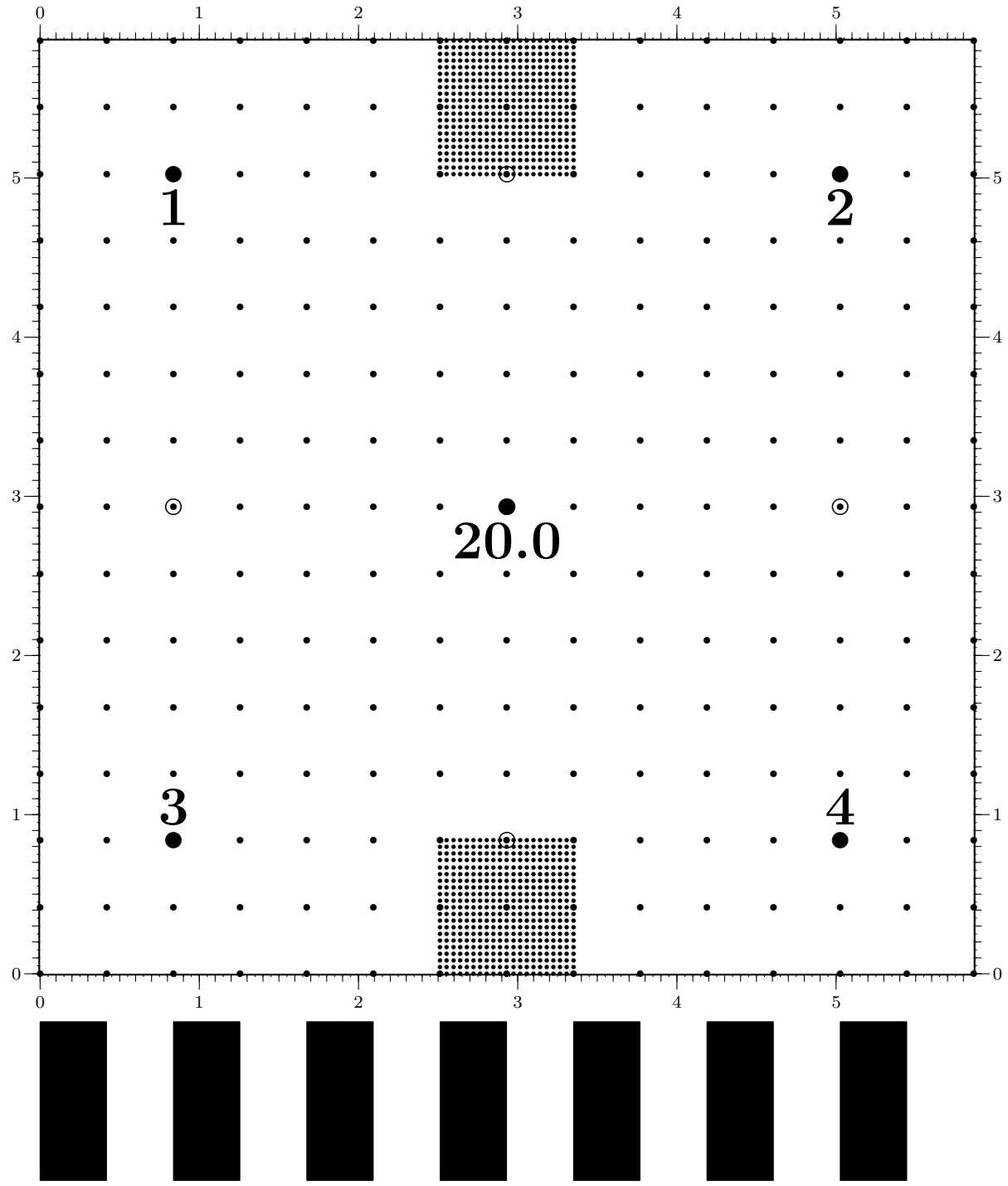

Figure 15: **0.1°at 20.0 feet is 0.418879 inch.**

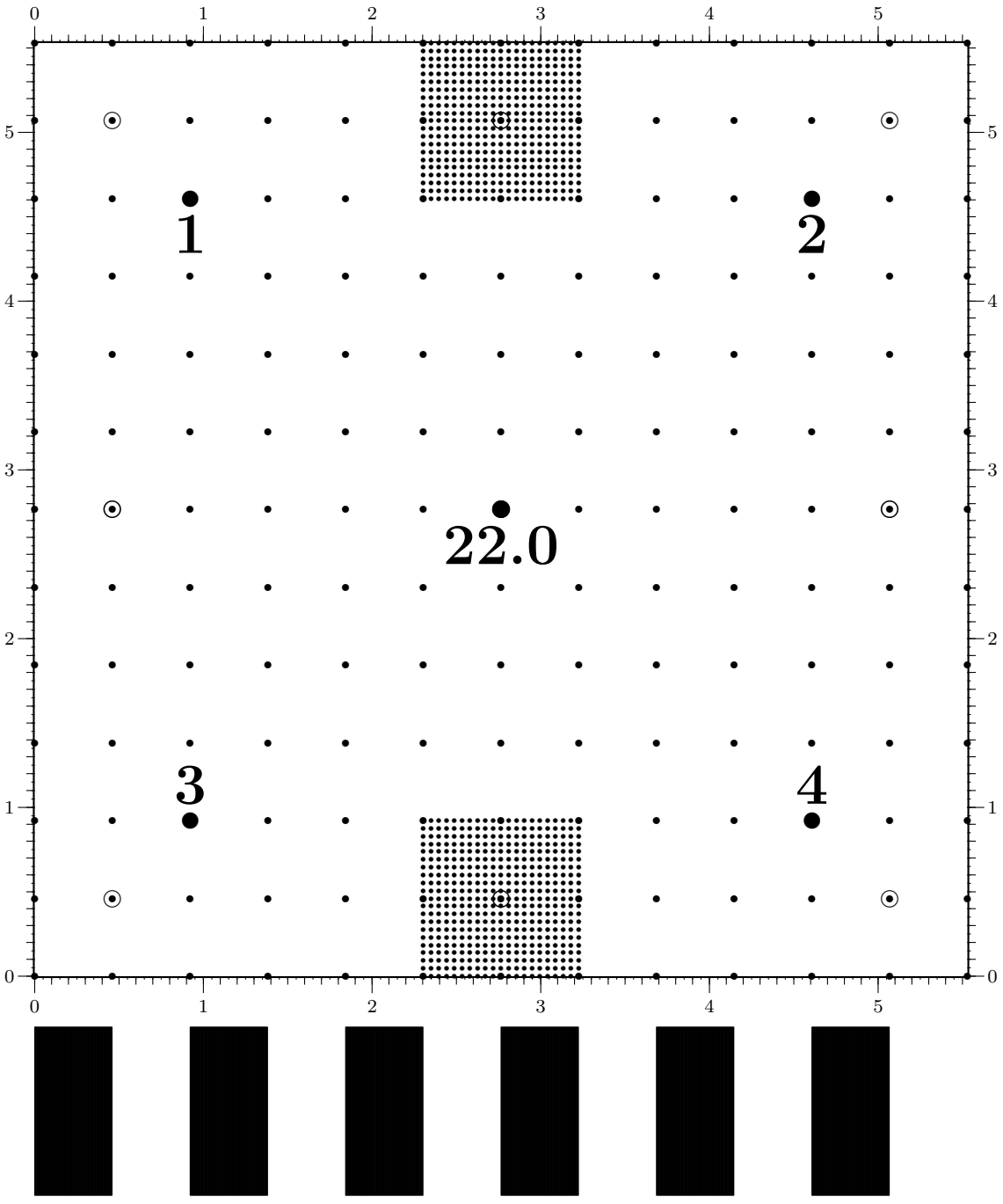

Figure 16: **0.1°at 22.0 feet is 0.460767 inch.**

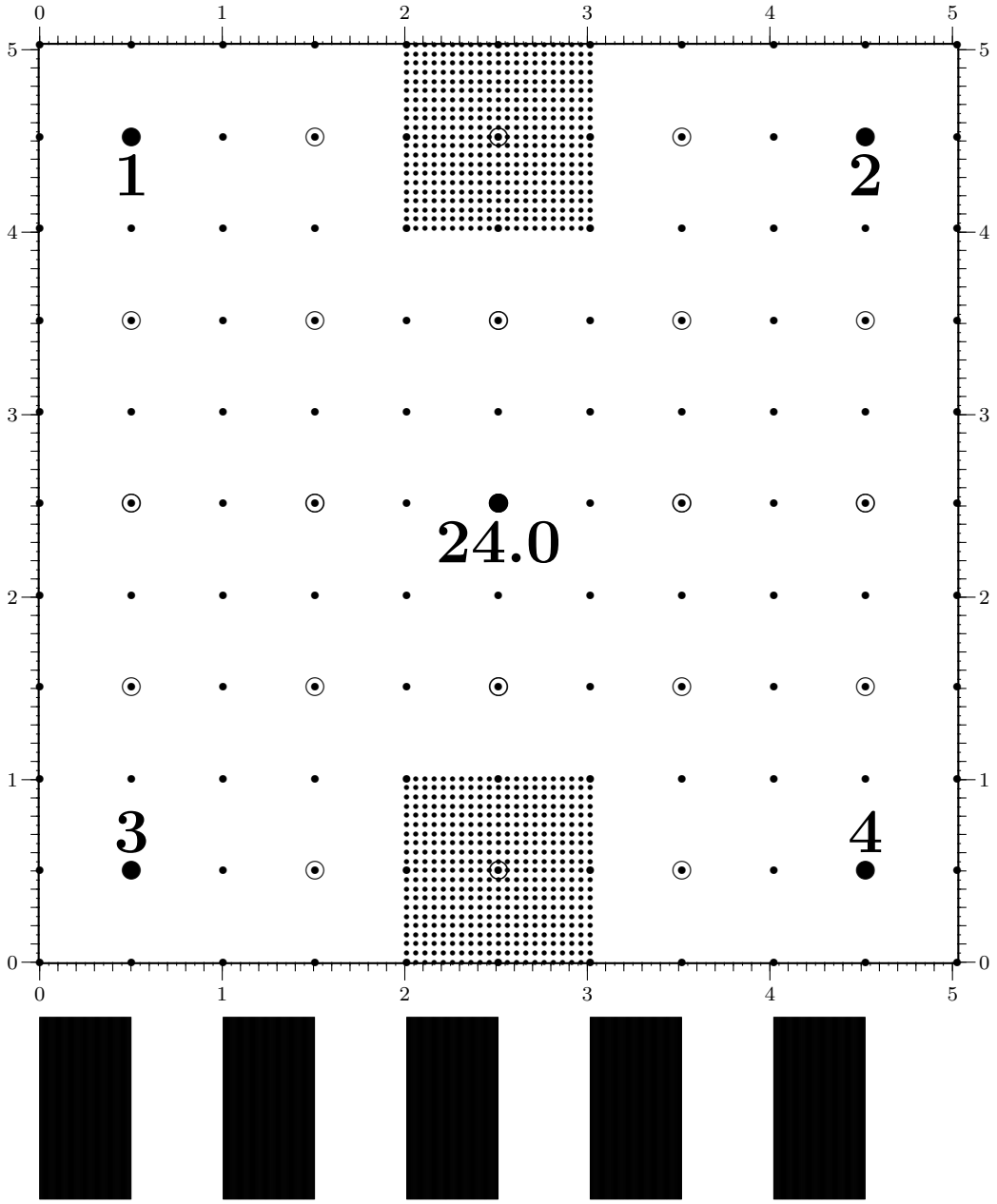

Figure 17: **0.1°at 24.0 feet is 0.502655 inch.**

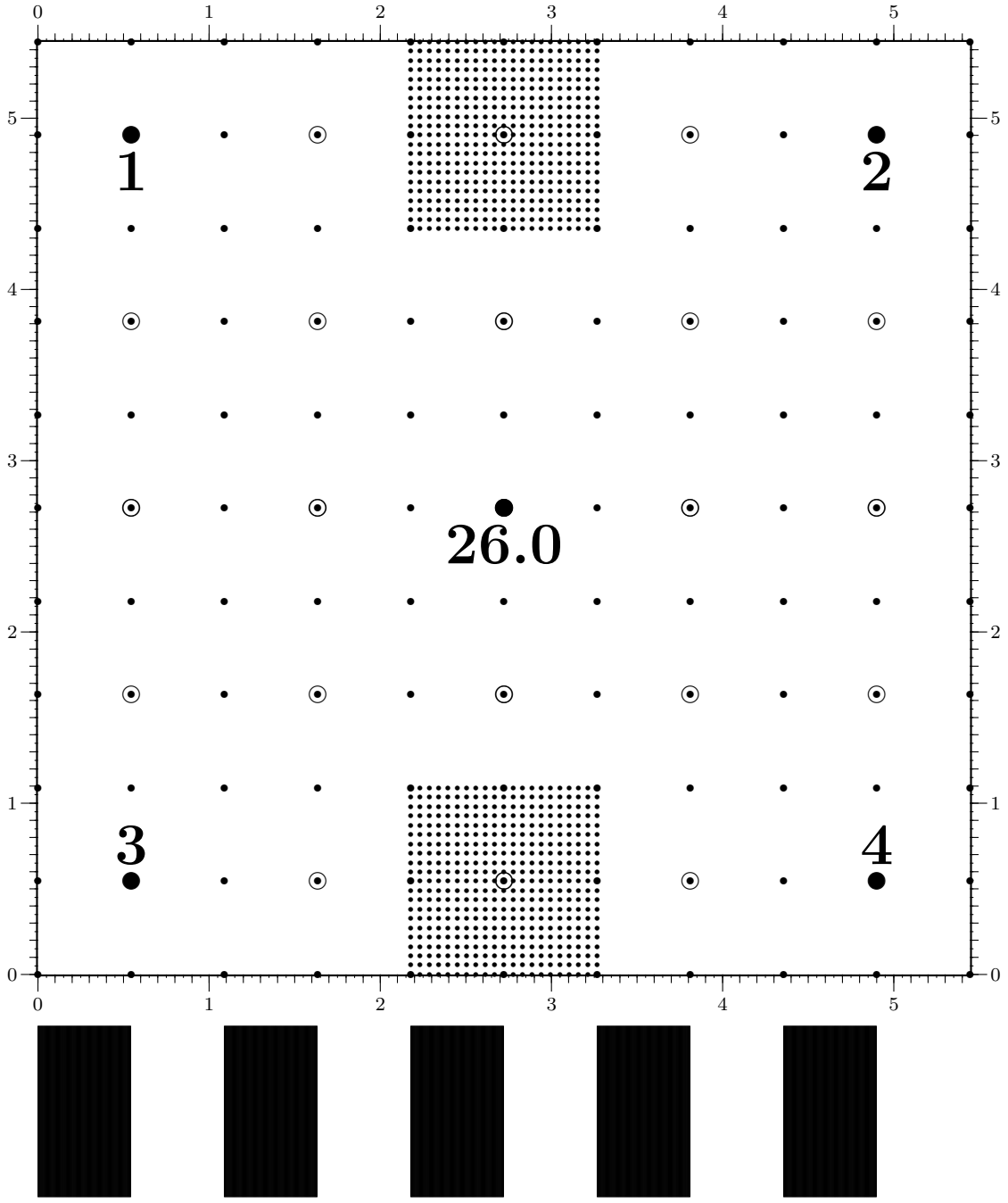

Figure 18: **0.1°at 26.0 feet is 0.544543 inch.**

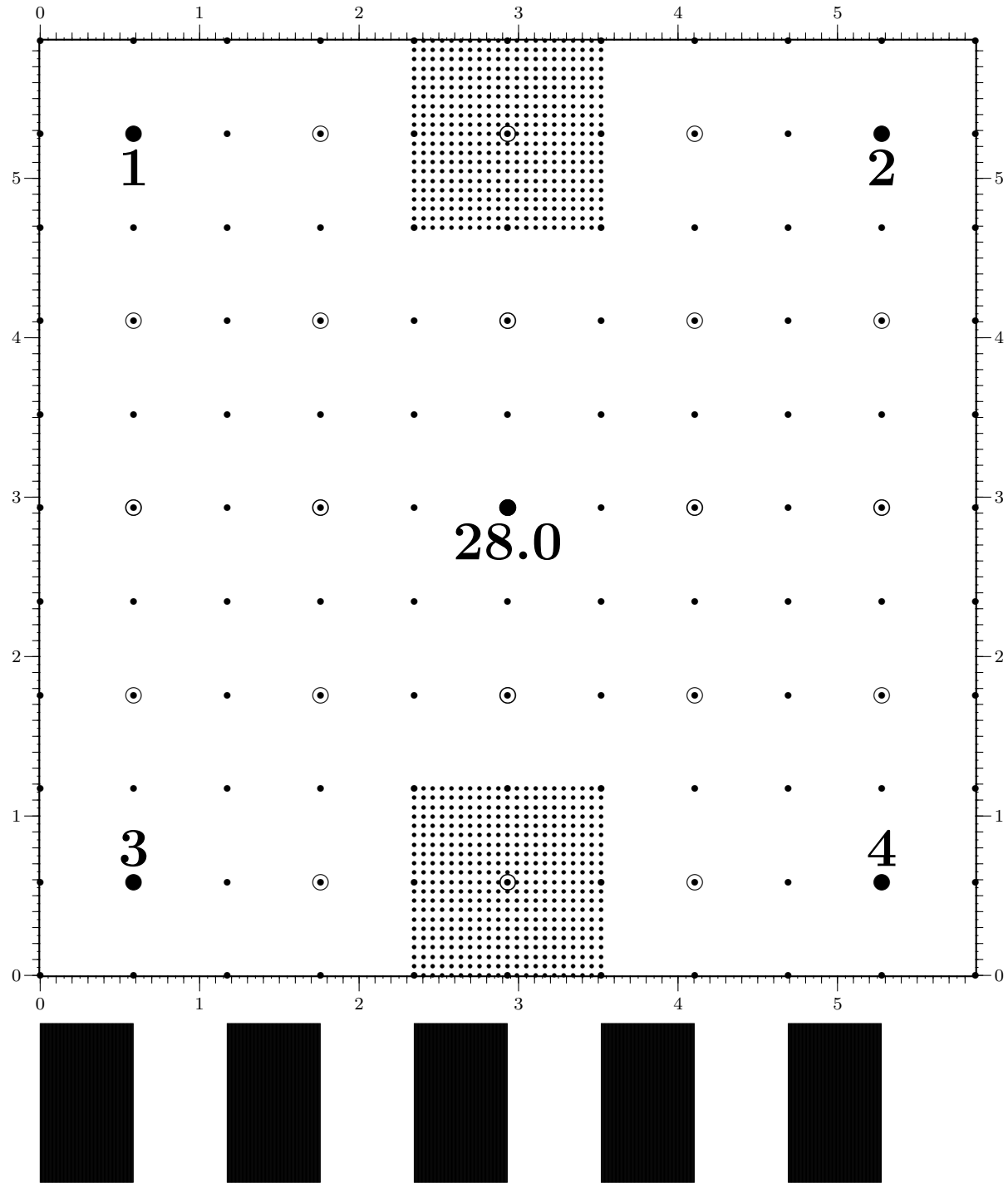

Figure 19: **0.1°at 28.0 feet is 0.586431 inch.**

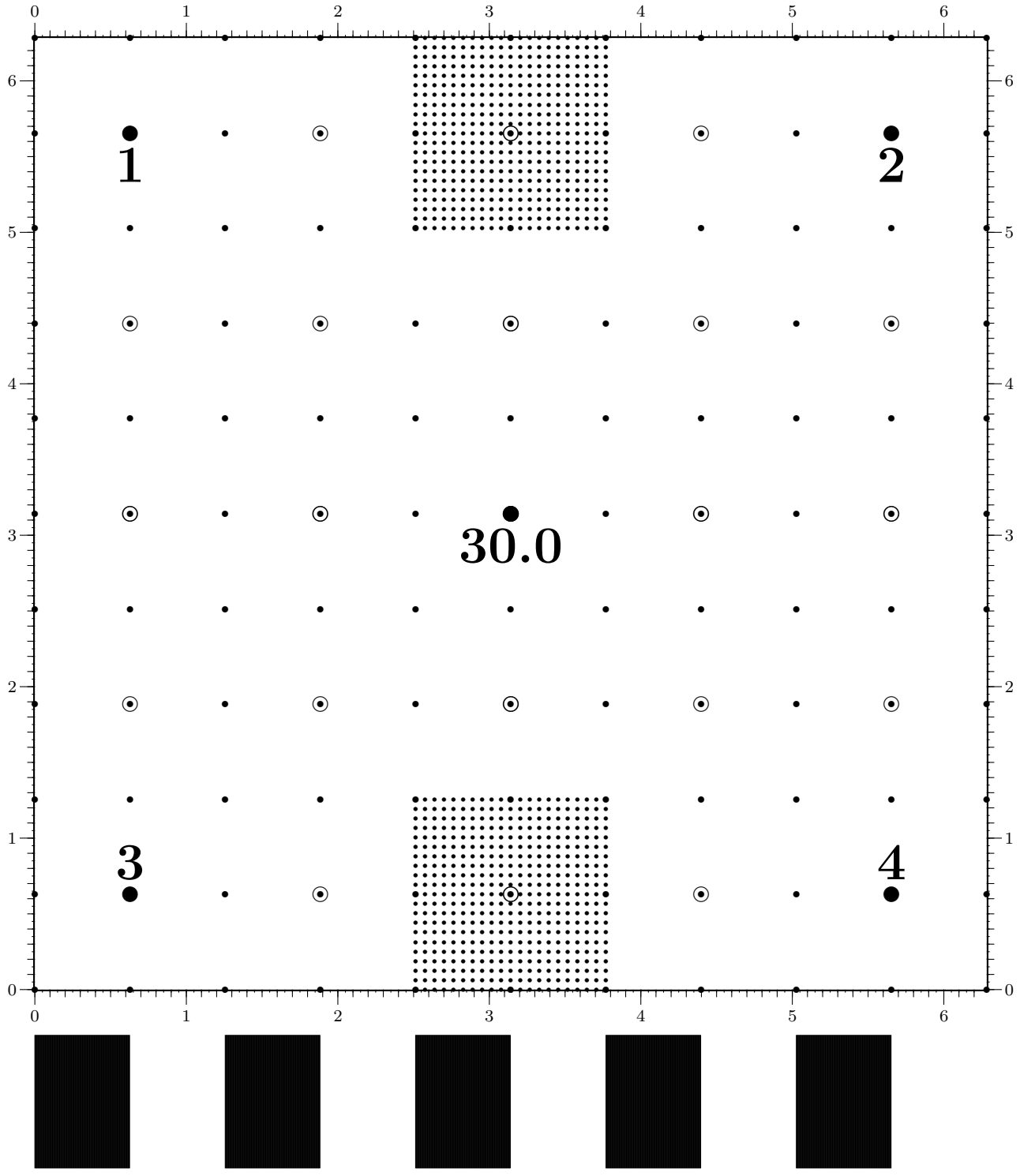

Figure 20: **0.1°at 30.0 feet is 0.628319 inch.**

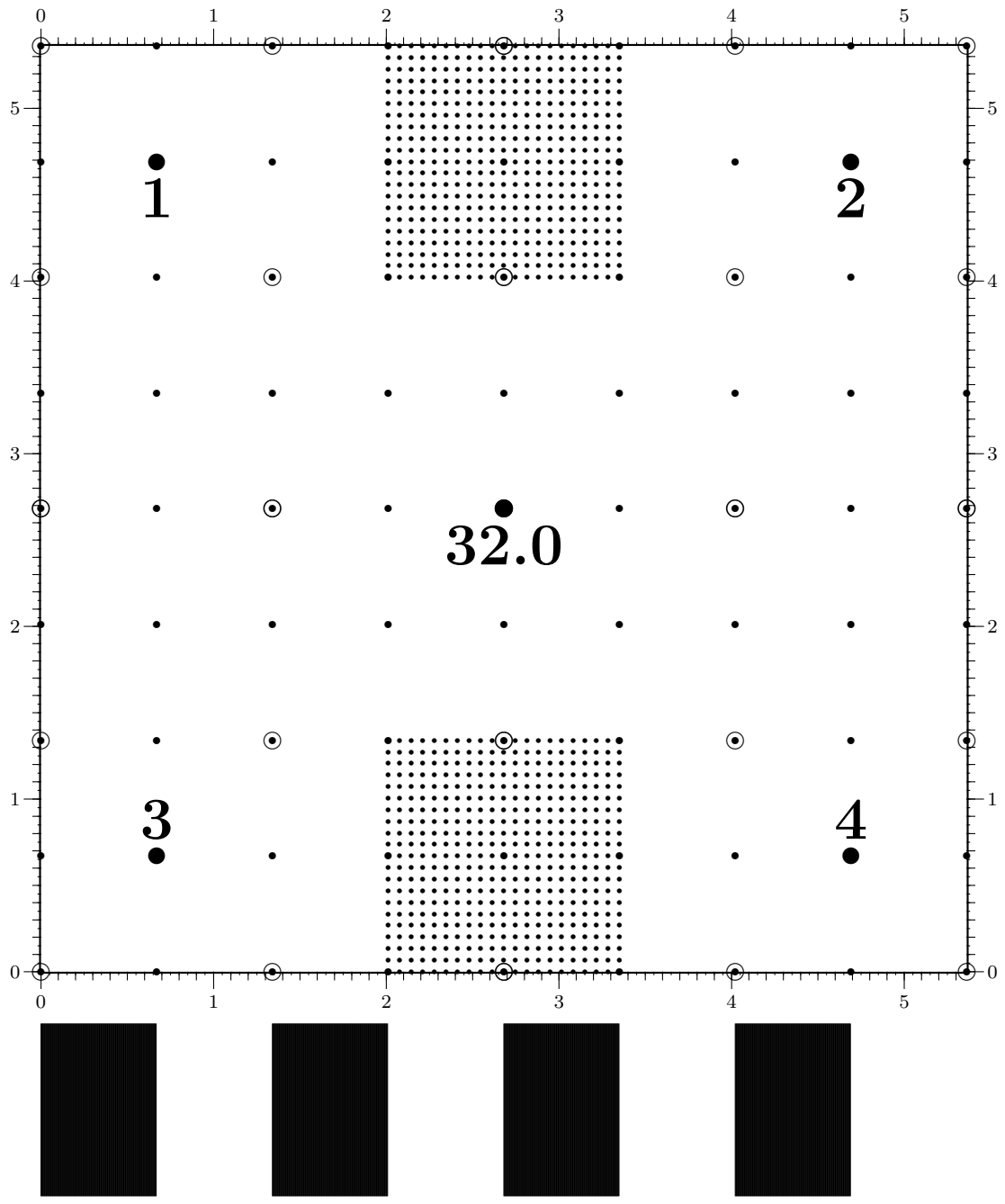

Figure 21: **0.1°at 32.0 feet is 0.670207 inch.**

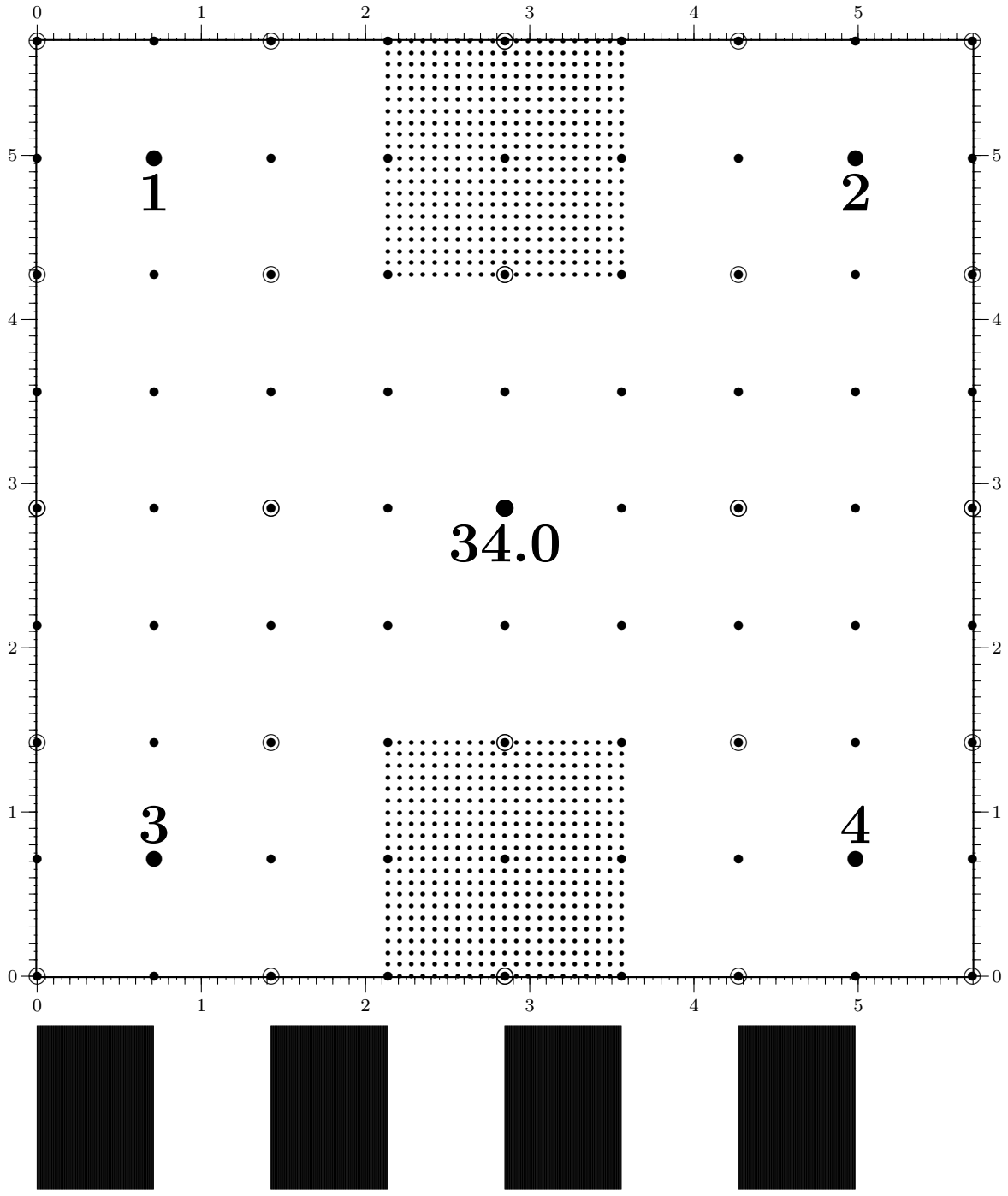

Figure 22: **0.1°at 34.0 feet is 0.712095 inch.**

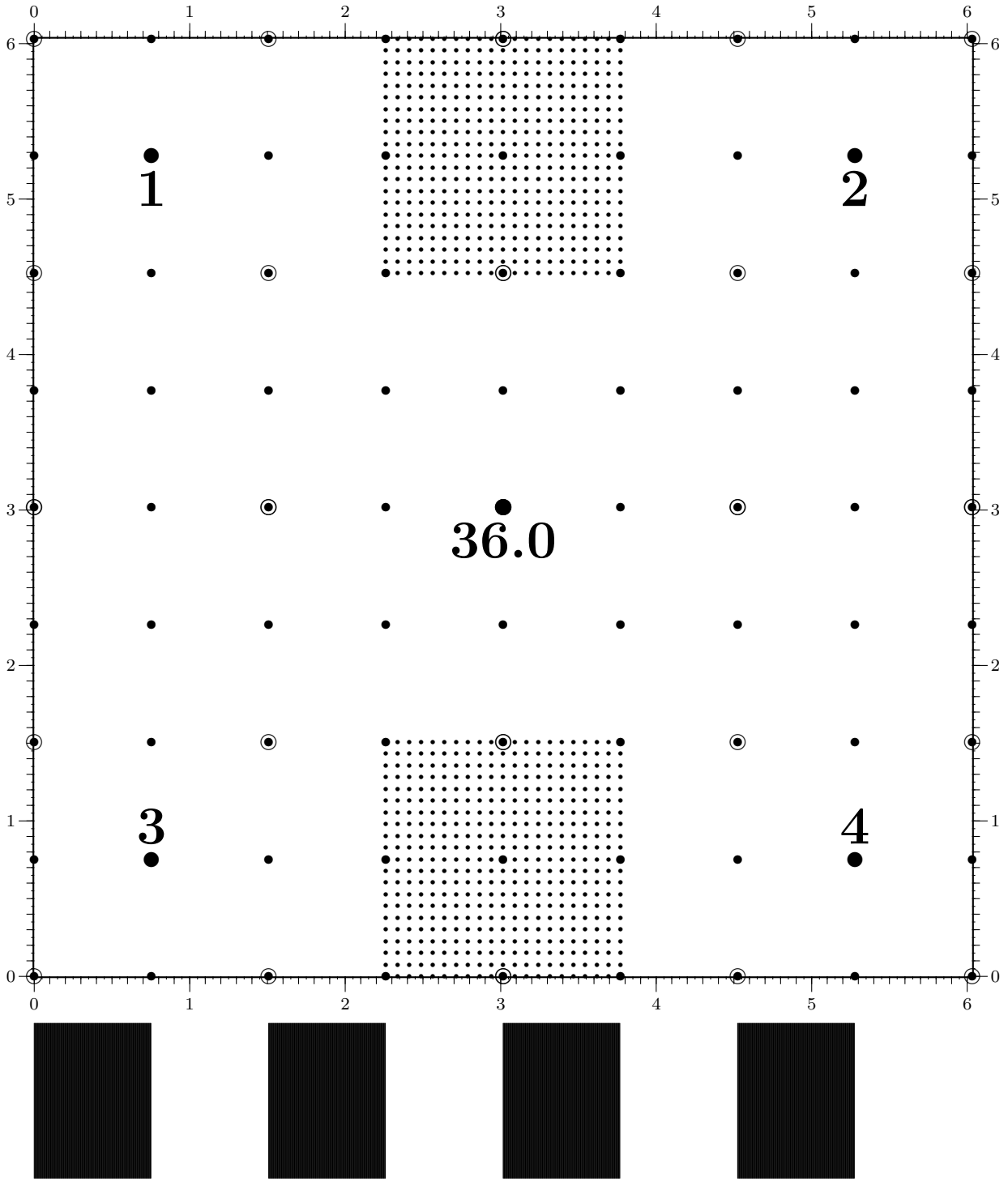

Figure 23: **0.1°at 36.0 feet is 0.753983 inch.**

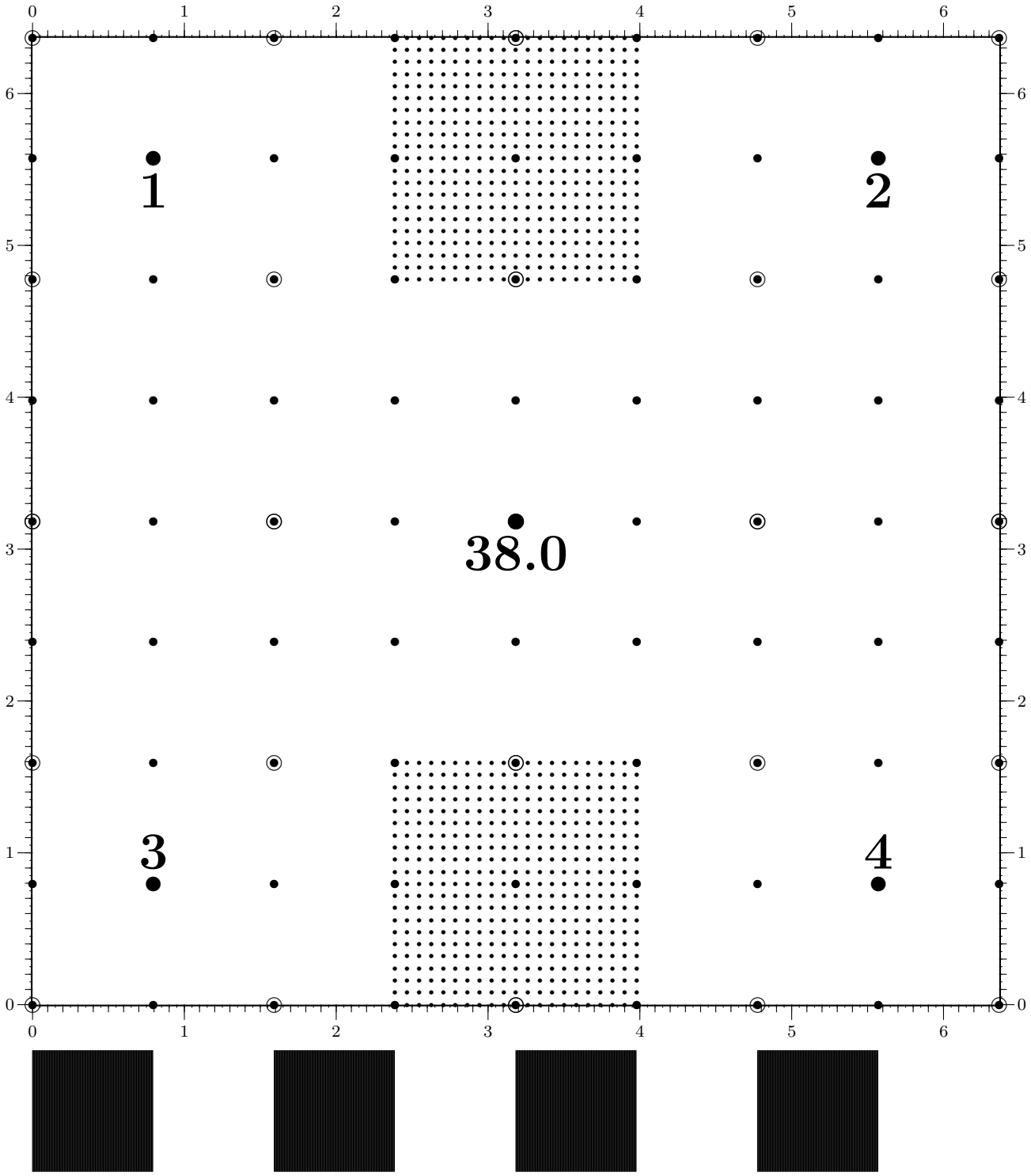

Figure 24: **0.1°at 38.0 feet is 0.795871 inch.**

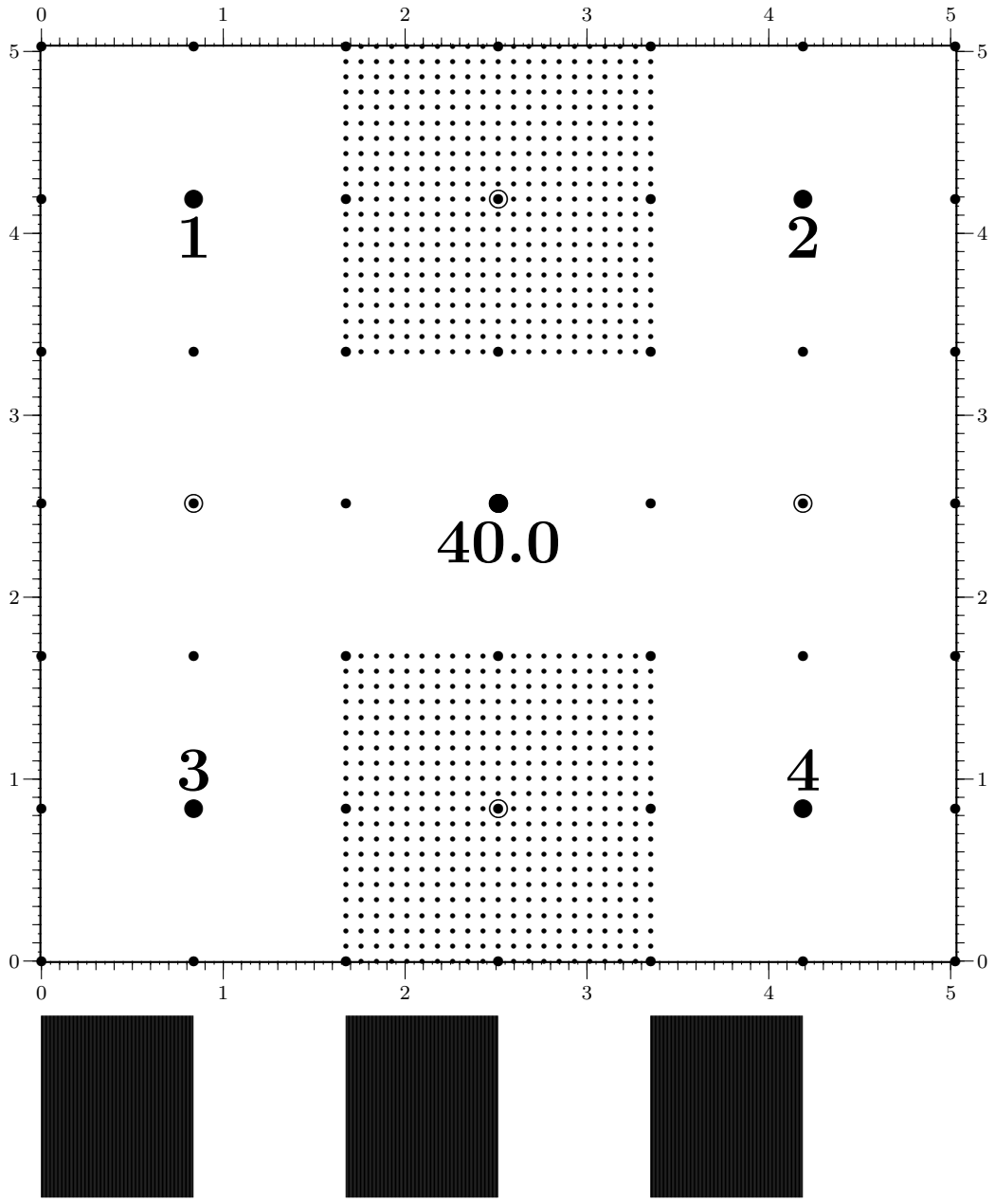

Figure 25: **0.1°at 40.0 feet is 0.837759 inch.**

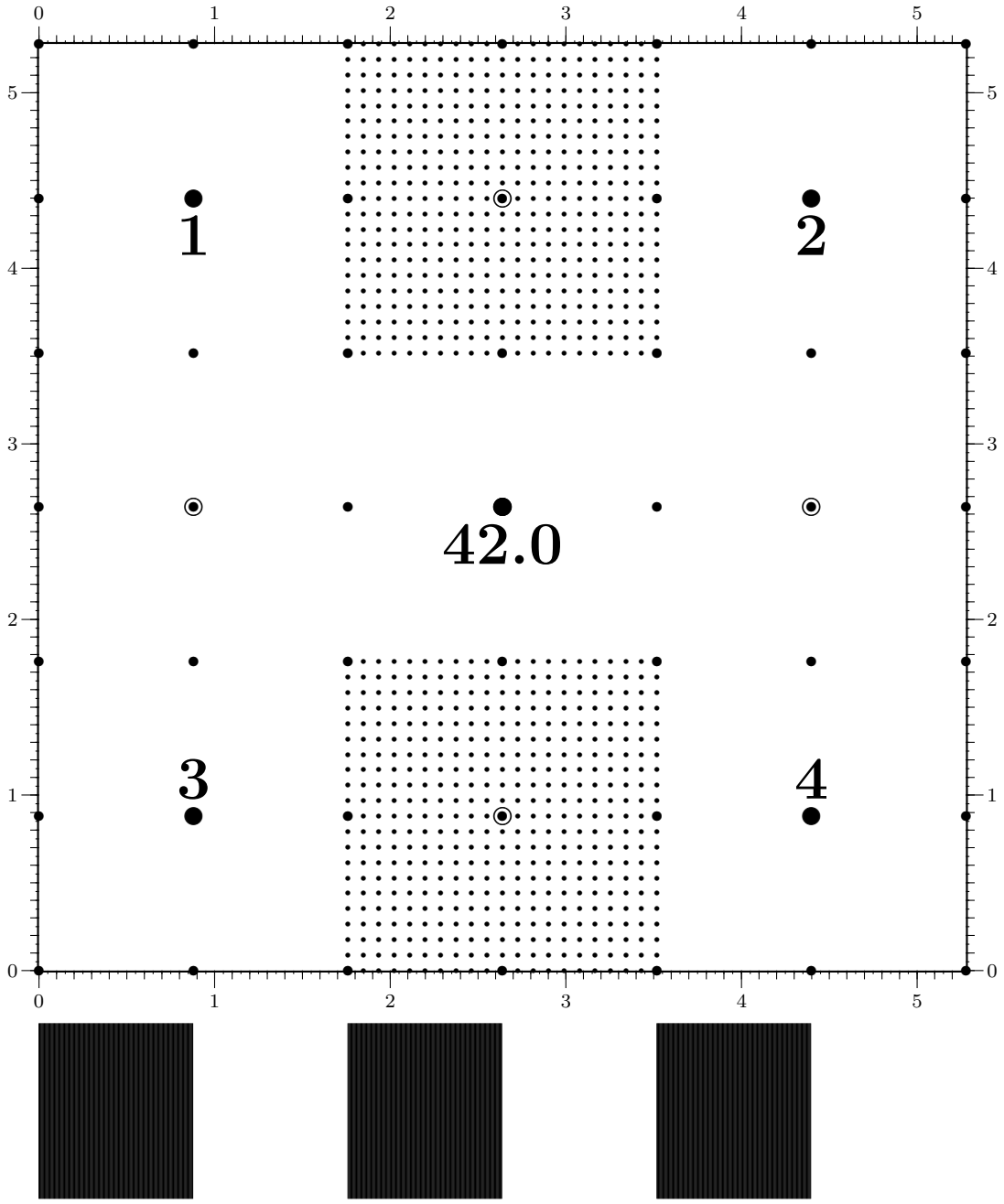

Figure 26: **0.1°at 42.0 feet is 0.879647 inch.**

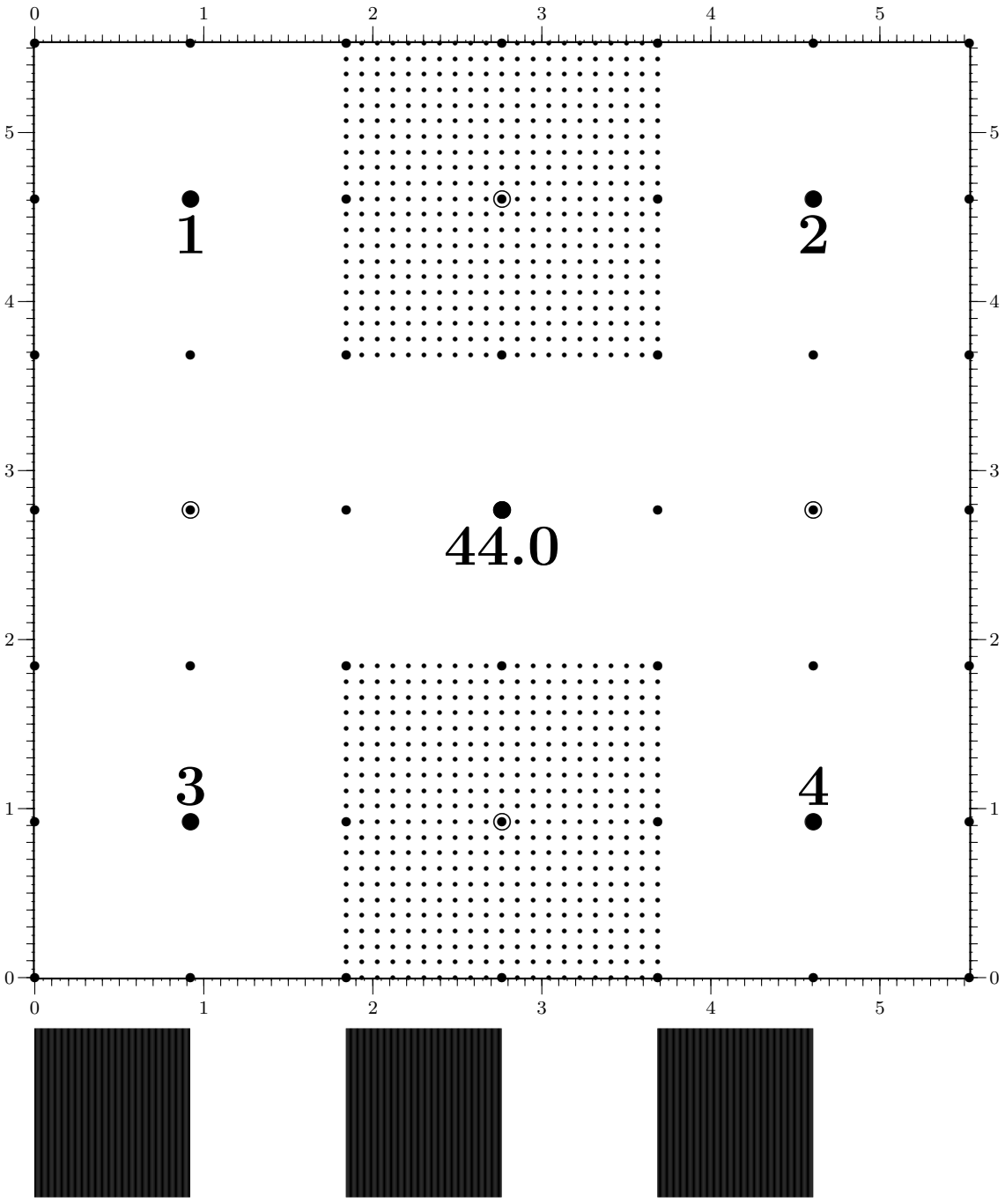

Figure 27: **0.1°at 44.0 feet is 0.921535 inch.**

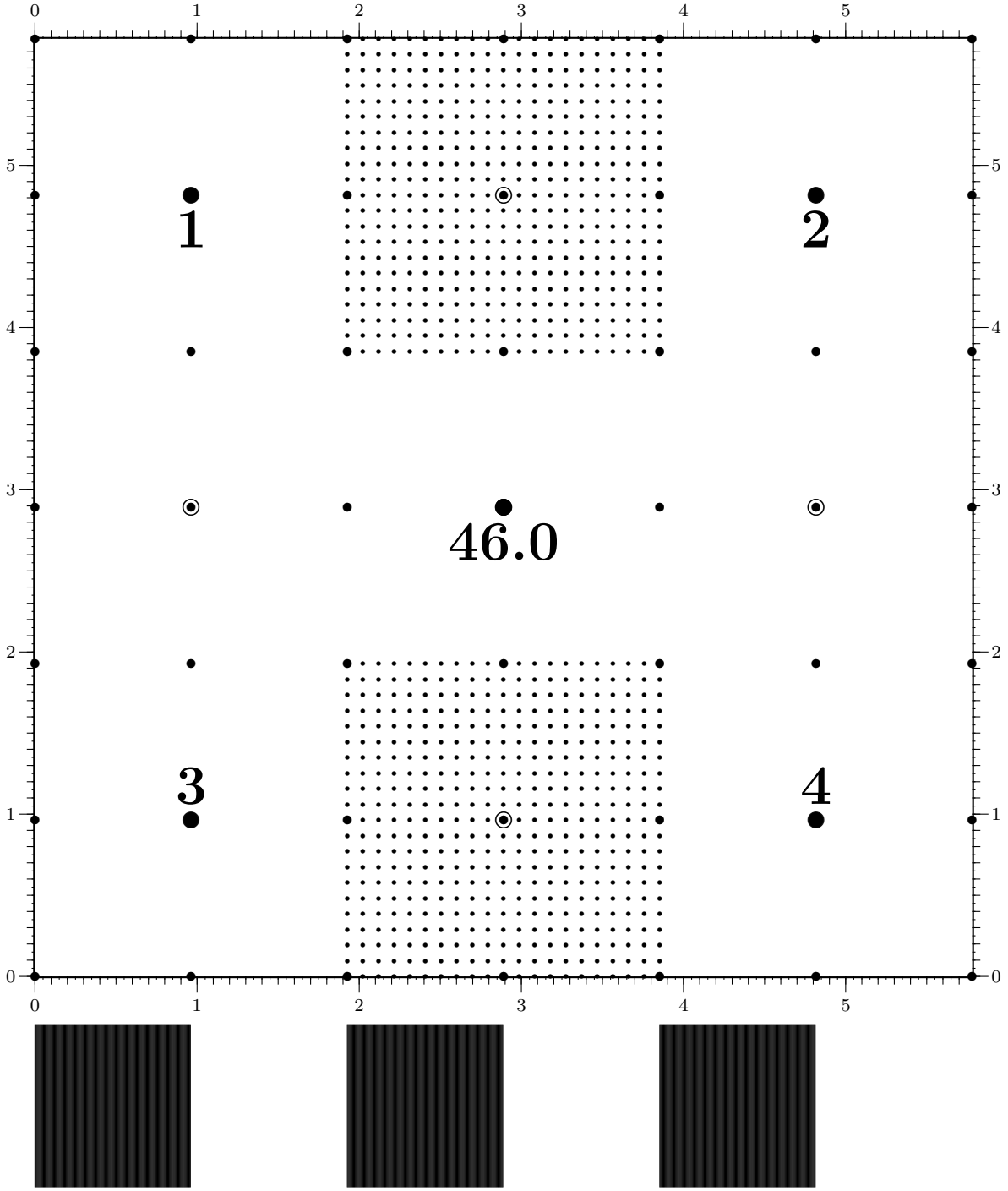

Figure 28: **0.1°at 46.0 feet is 0.963423 inch.**

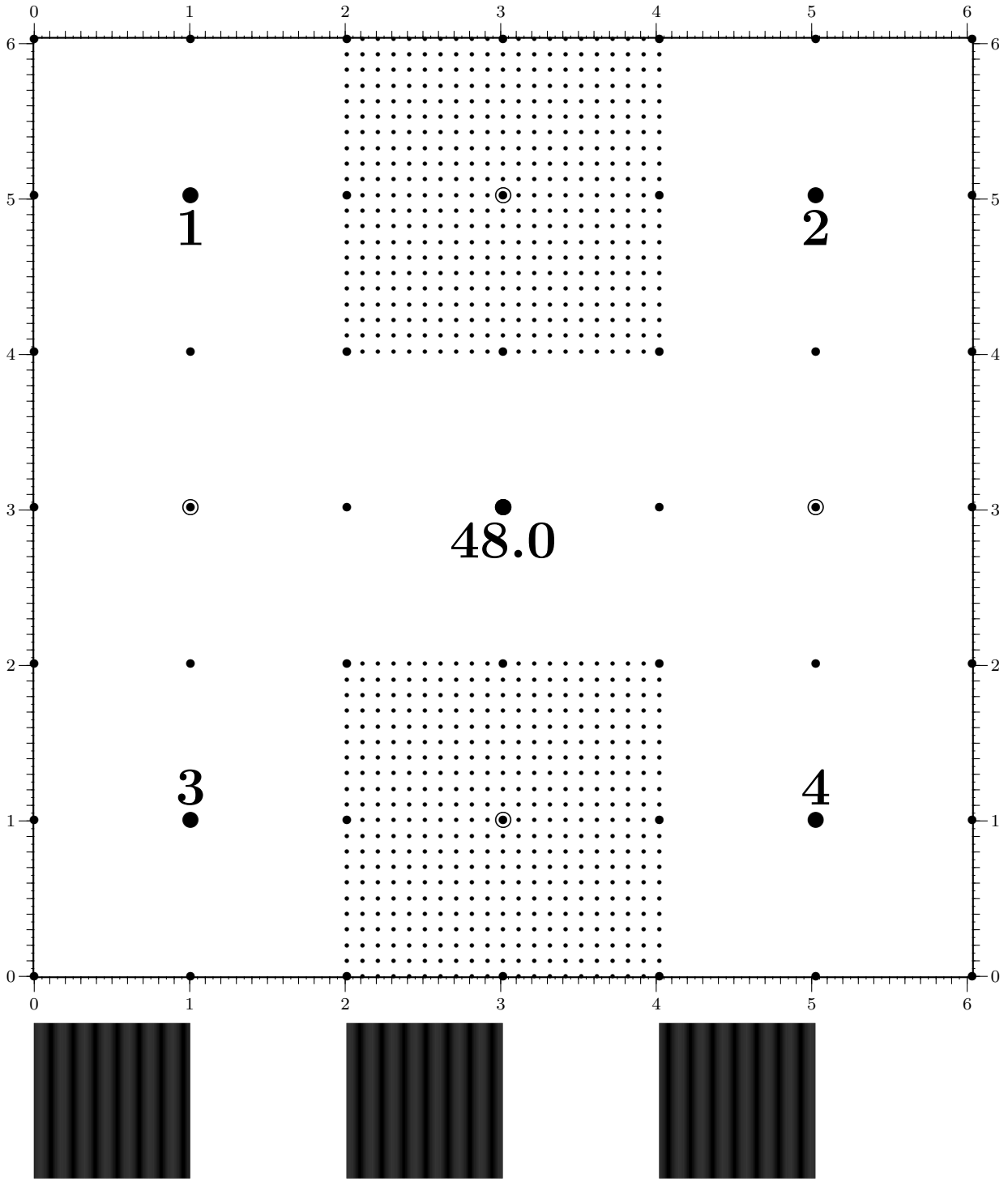

Figure 29: **0.1°at 48.0 feet is 1.005311 inch.**

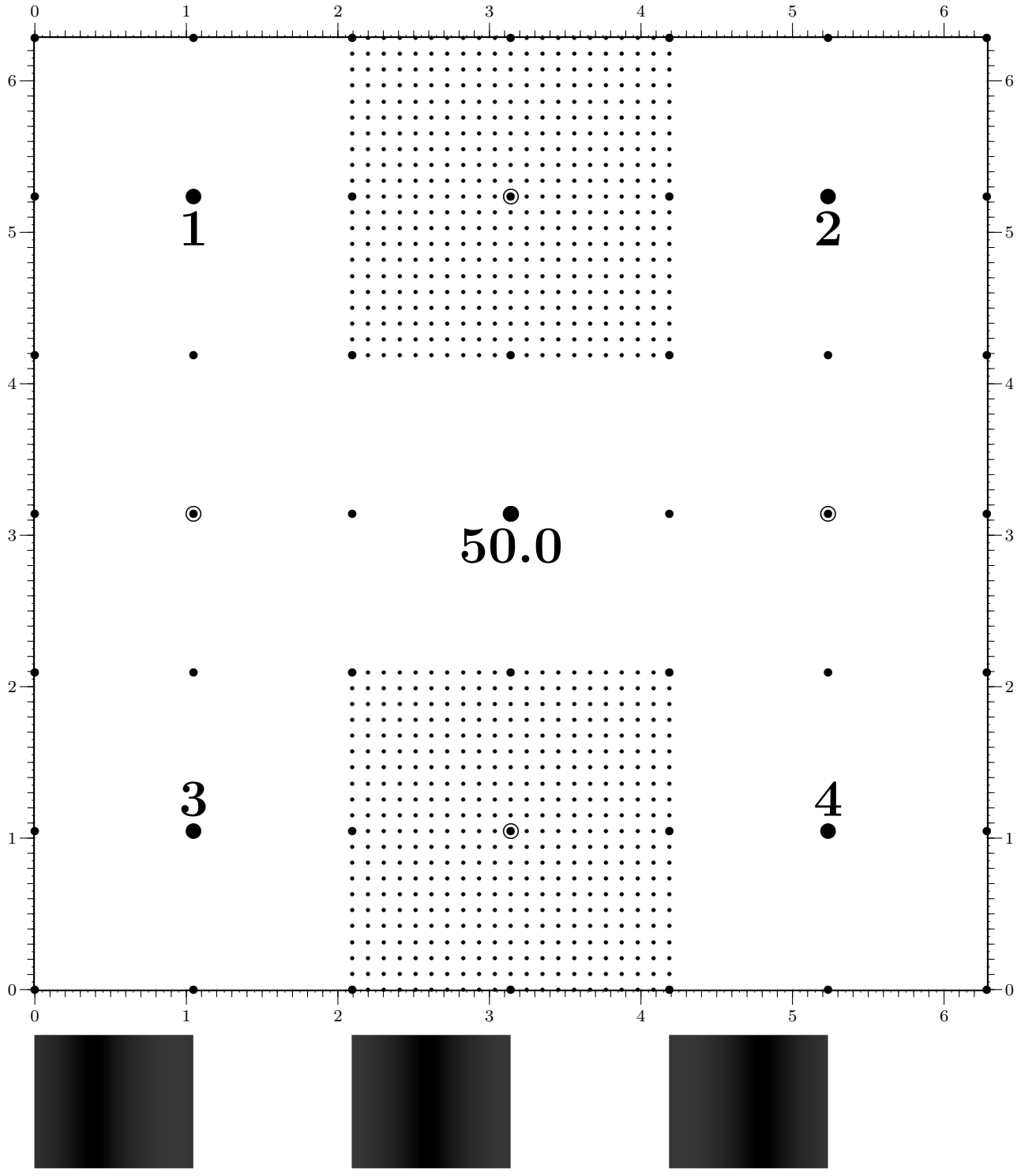

Figure 30: **0.1°at 50.0 feet is 1.047199 inch.**

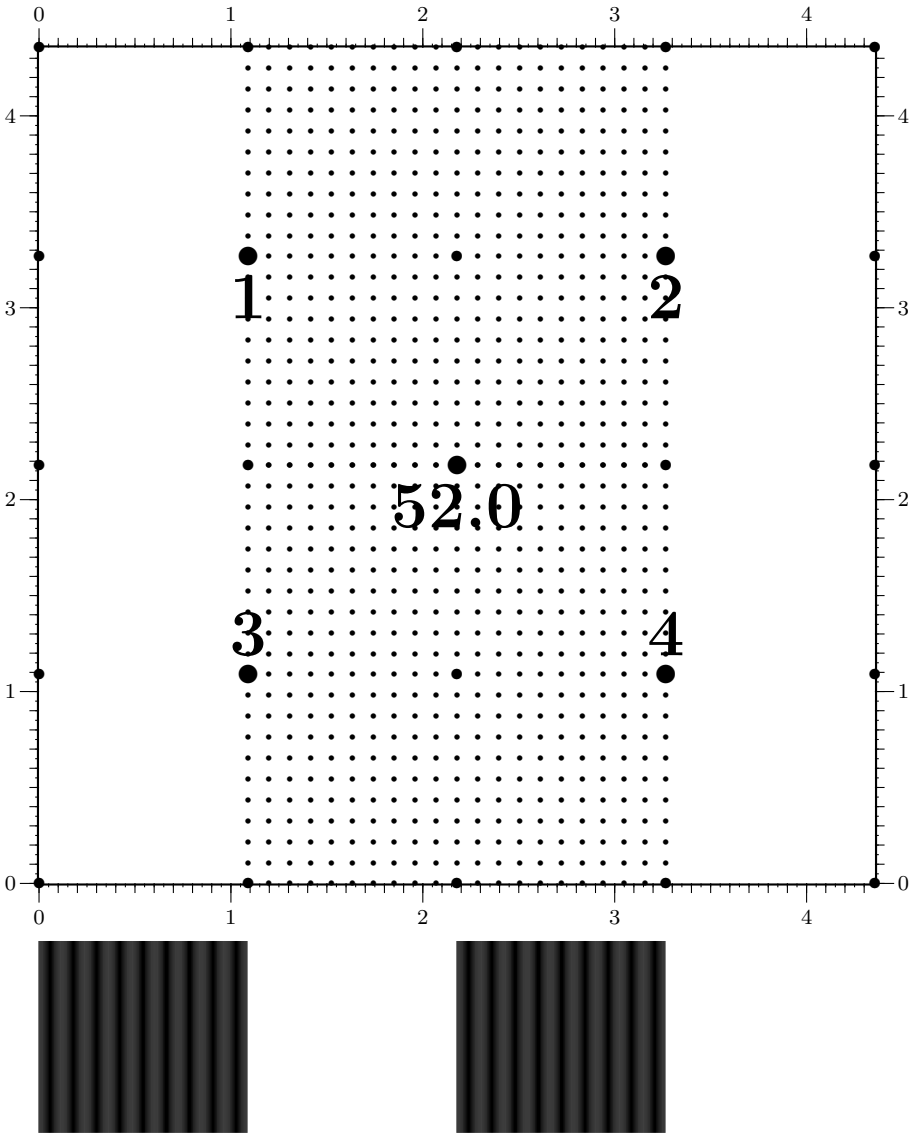

Figure 31: **0.1°at 52.0 feet is 1.089087 inch.**

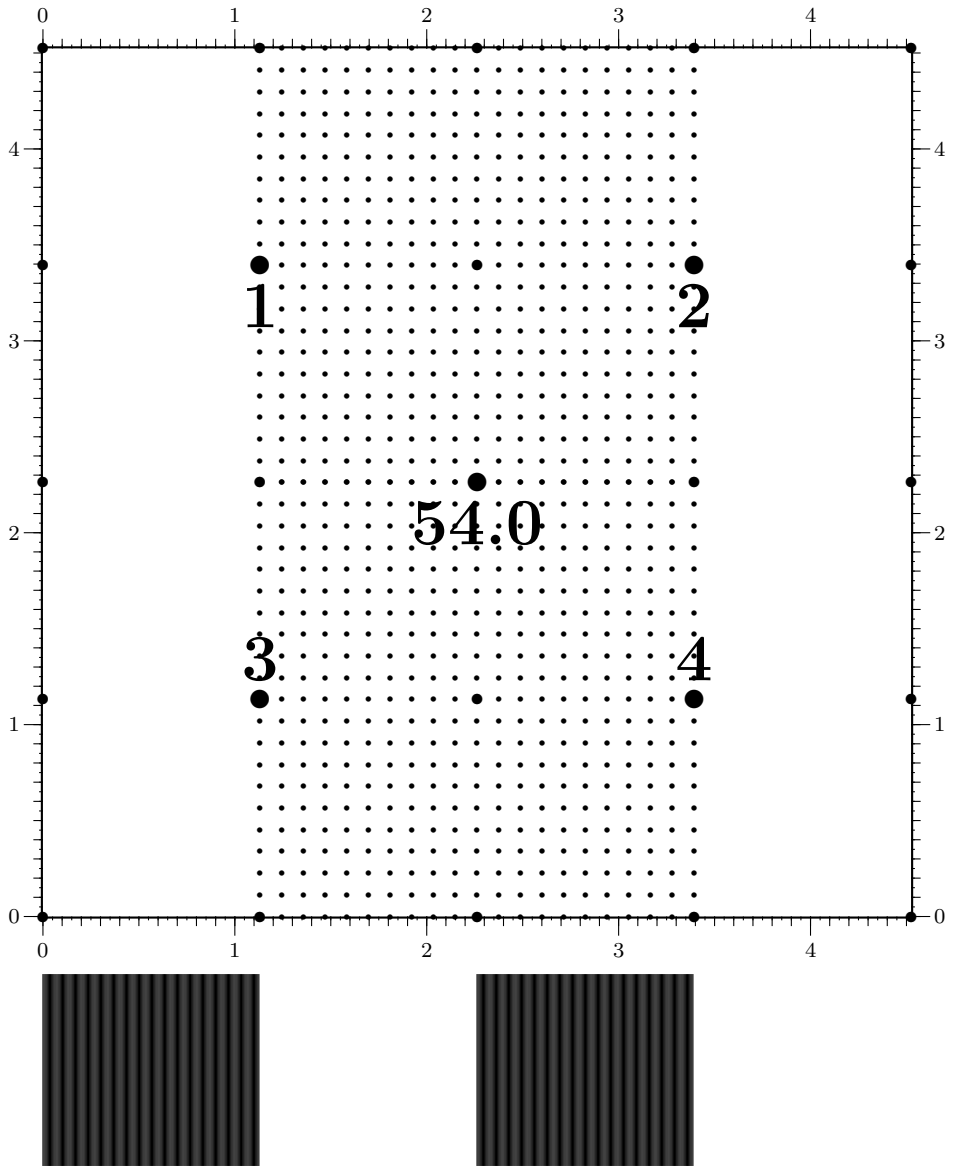

Figure 32: **0.1°at 54.0 feet is 1.130975 inch.**

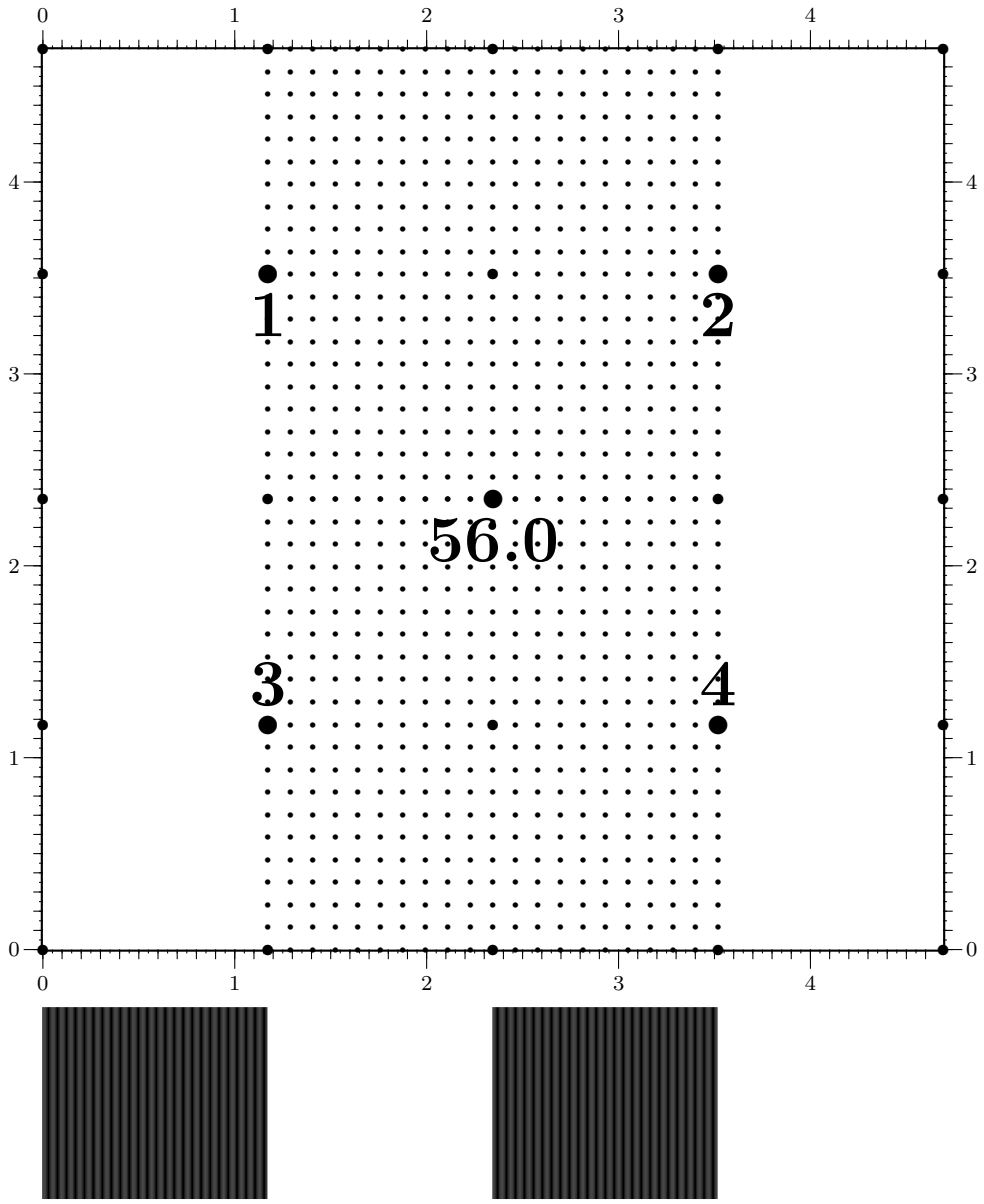

Figure 33: **0.1°at 56.0 feet is 1.172863 inch.**

1.3 Metric Calibration Grids

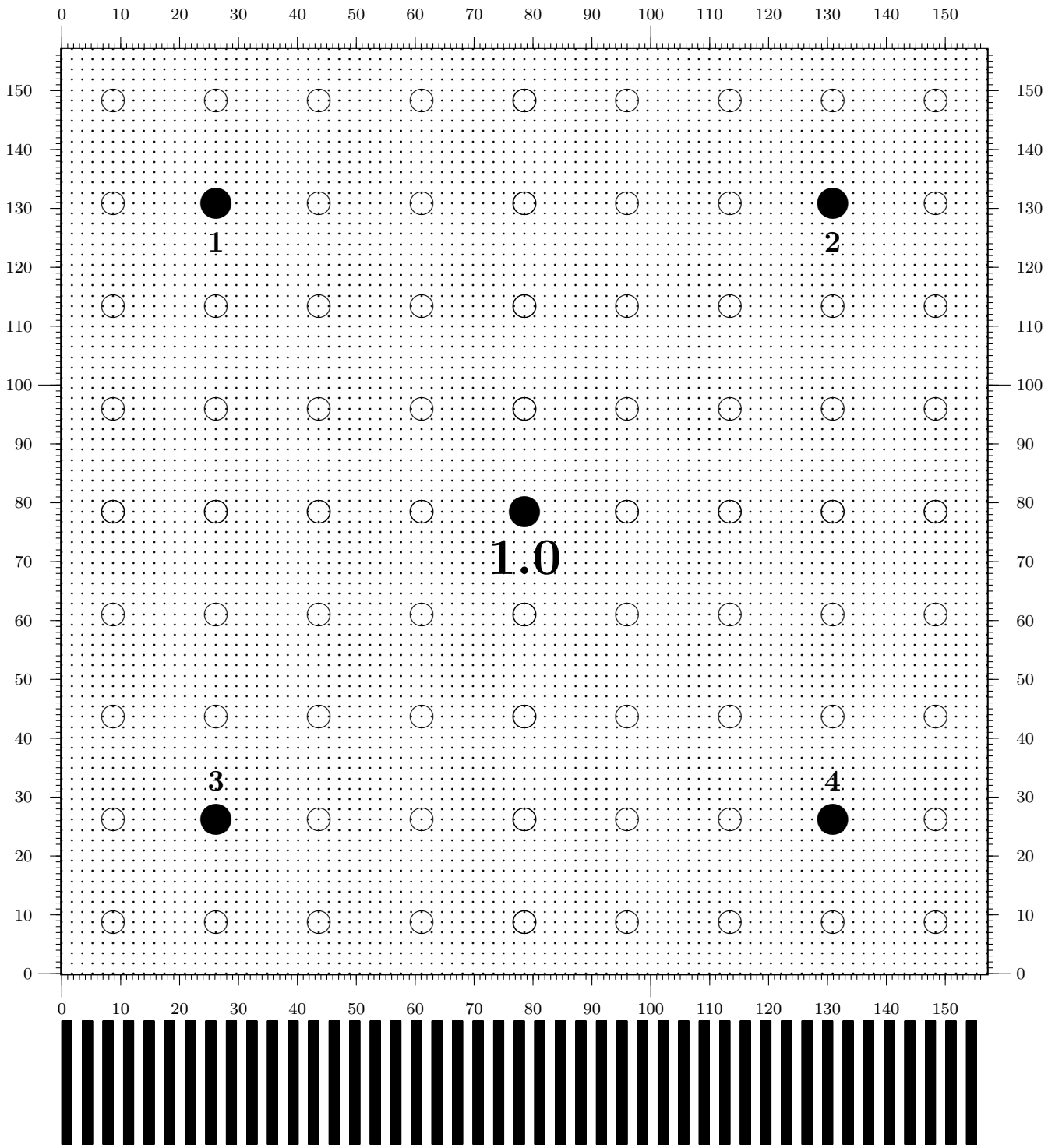

Figure 34: **0.1°at 1.0 meter is 1.745331 mm.**

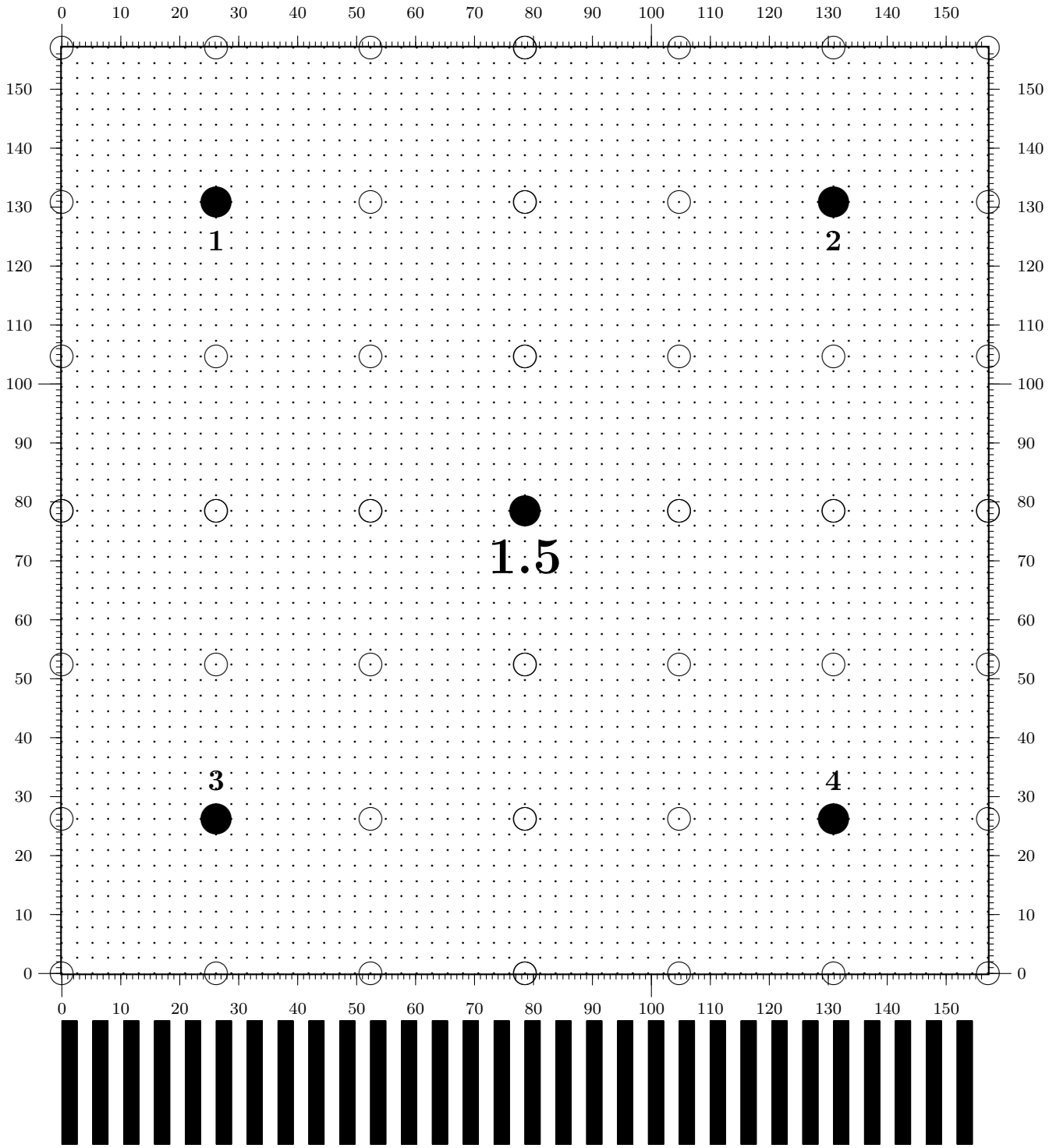

Figure 35: **0.1°at 1.5 meter is 2.617997 mm.**

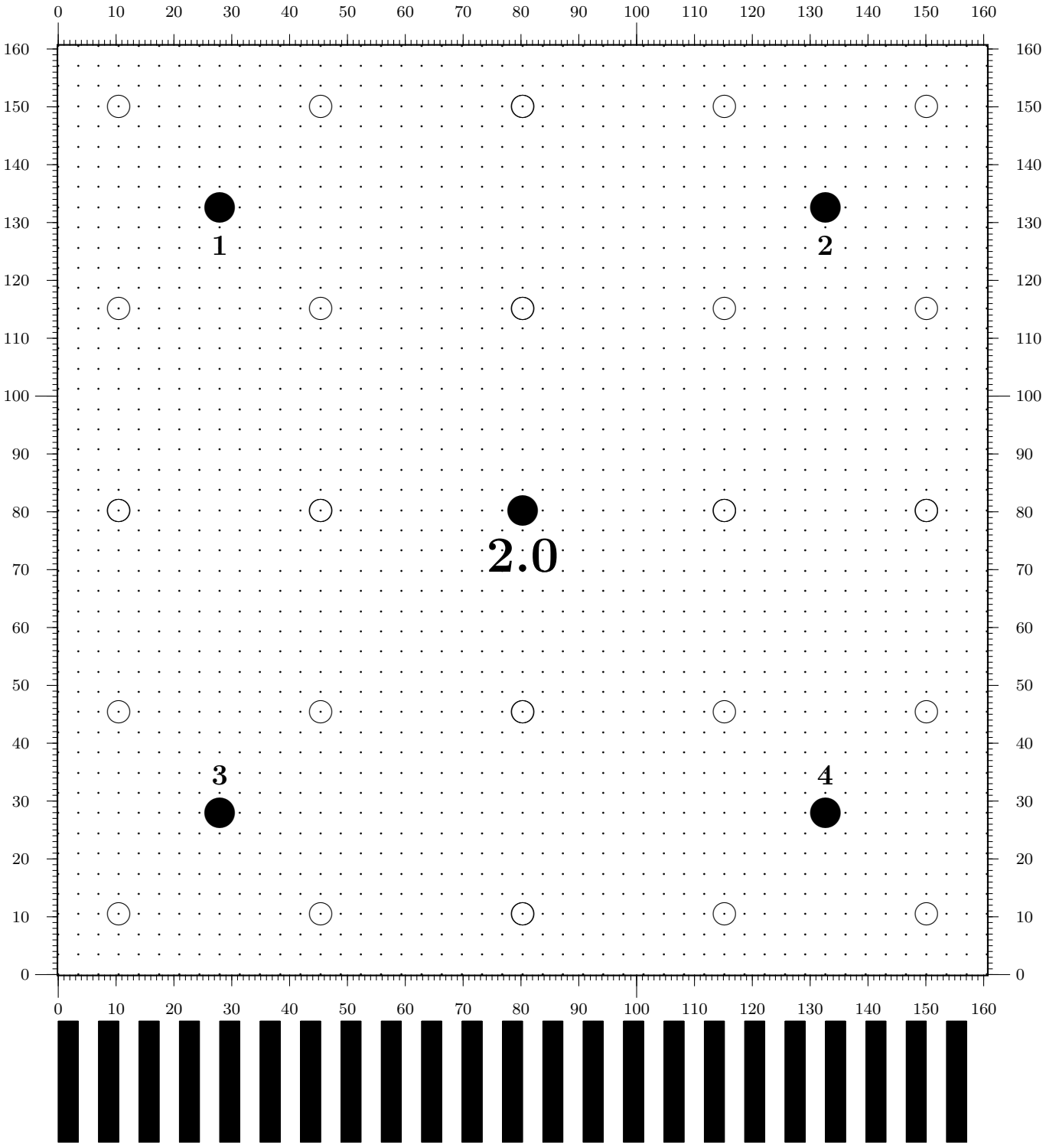

Figure 36: **0.1°at 2.0 meter is 3.490662 mm.**

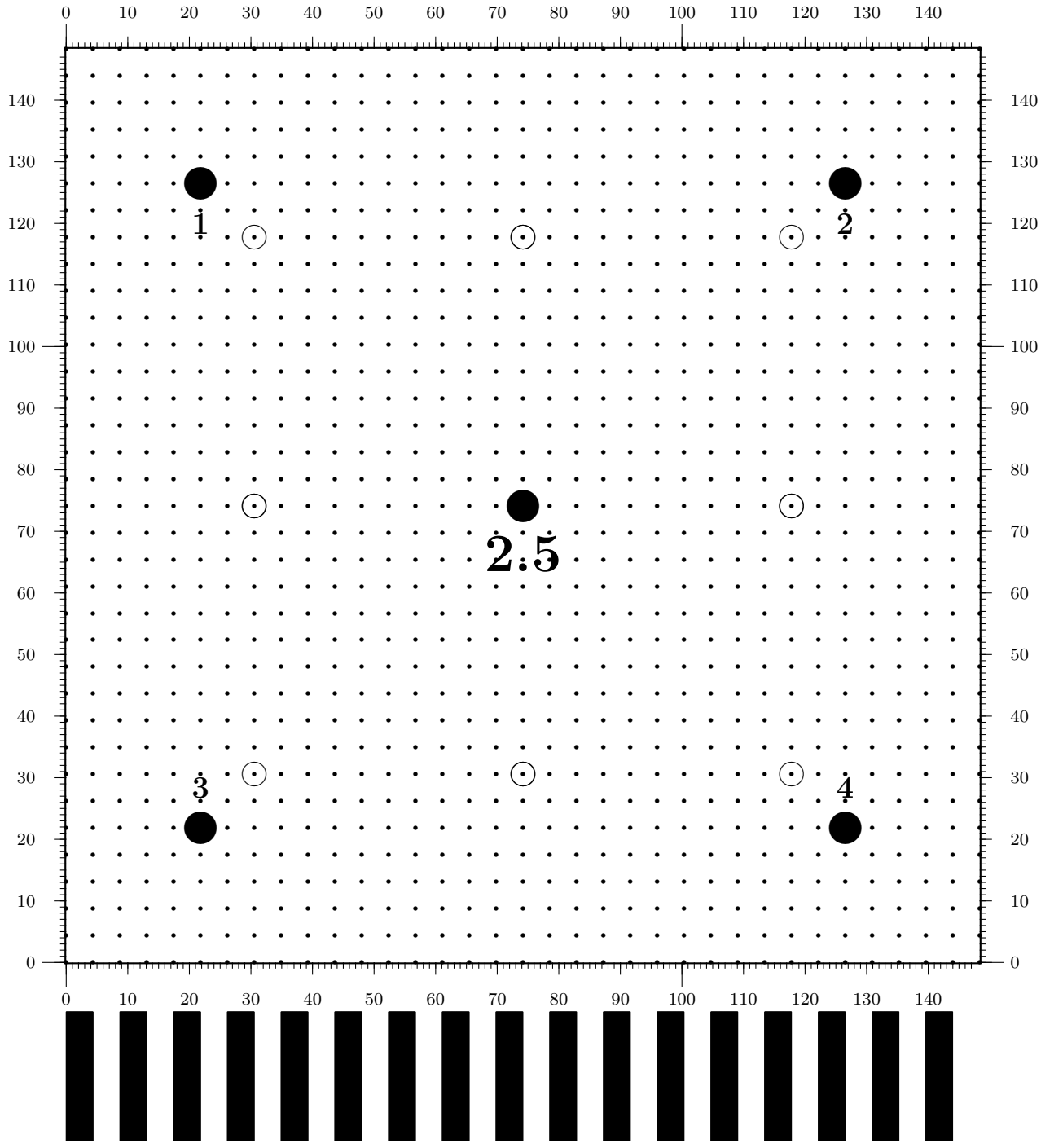

Figure 37: **0.1°at 2.5 meter is 4.363328 mm.**

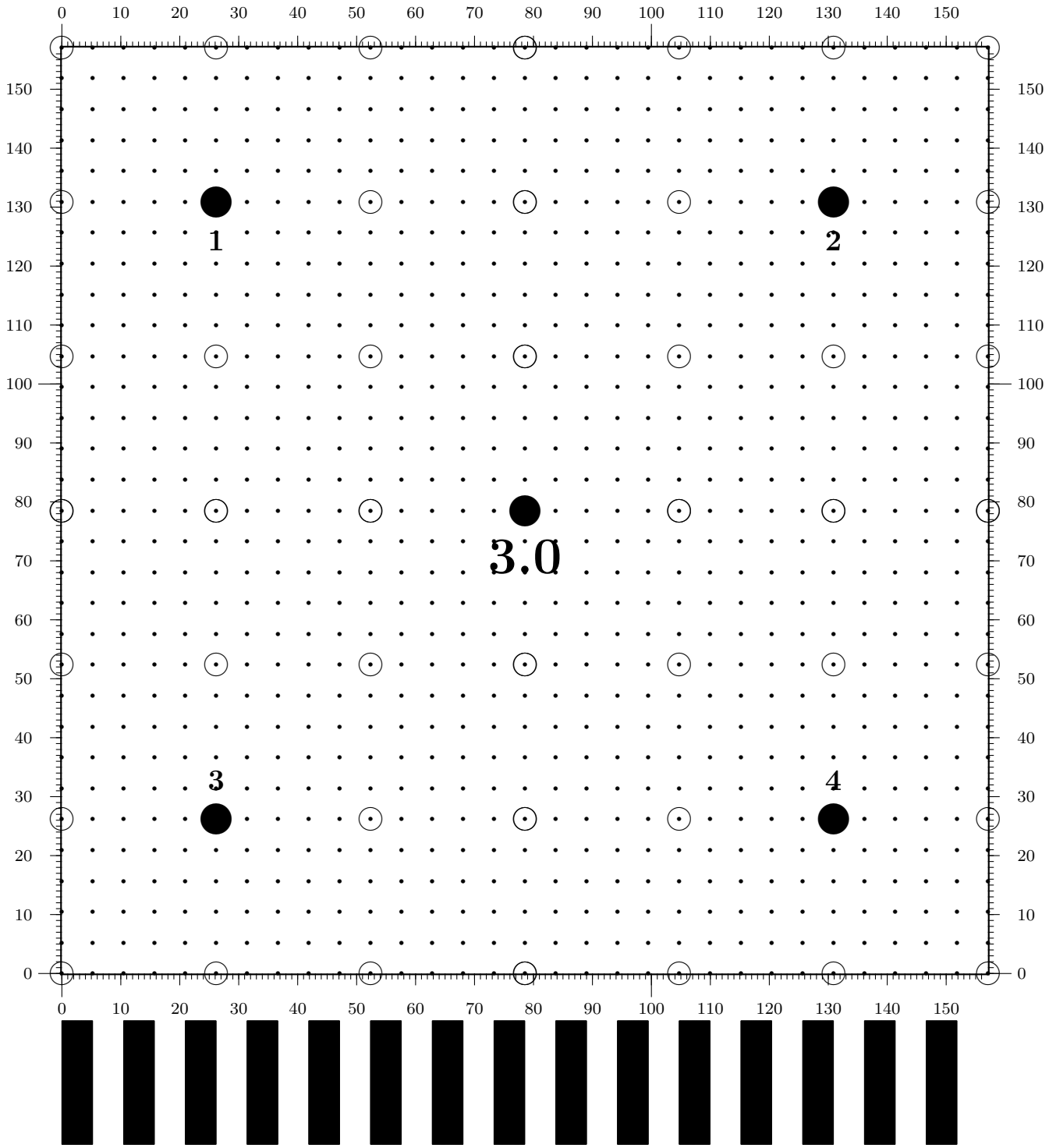

Figure 38: **0.1°at 3.0 meter is 5.235994 mm.**

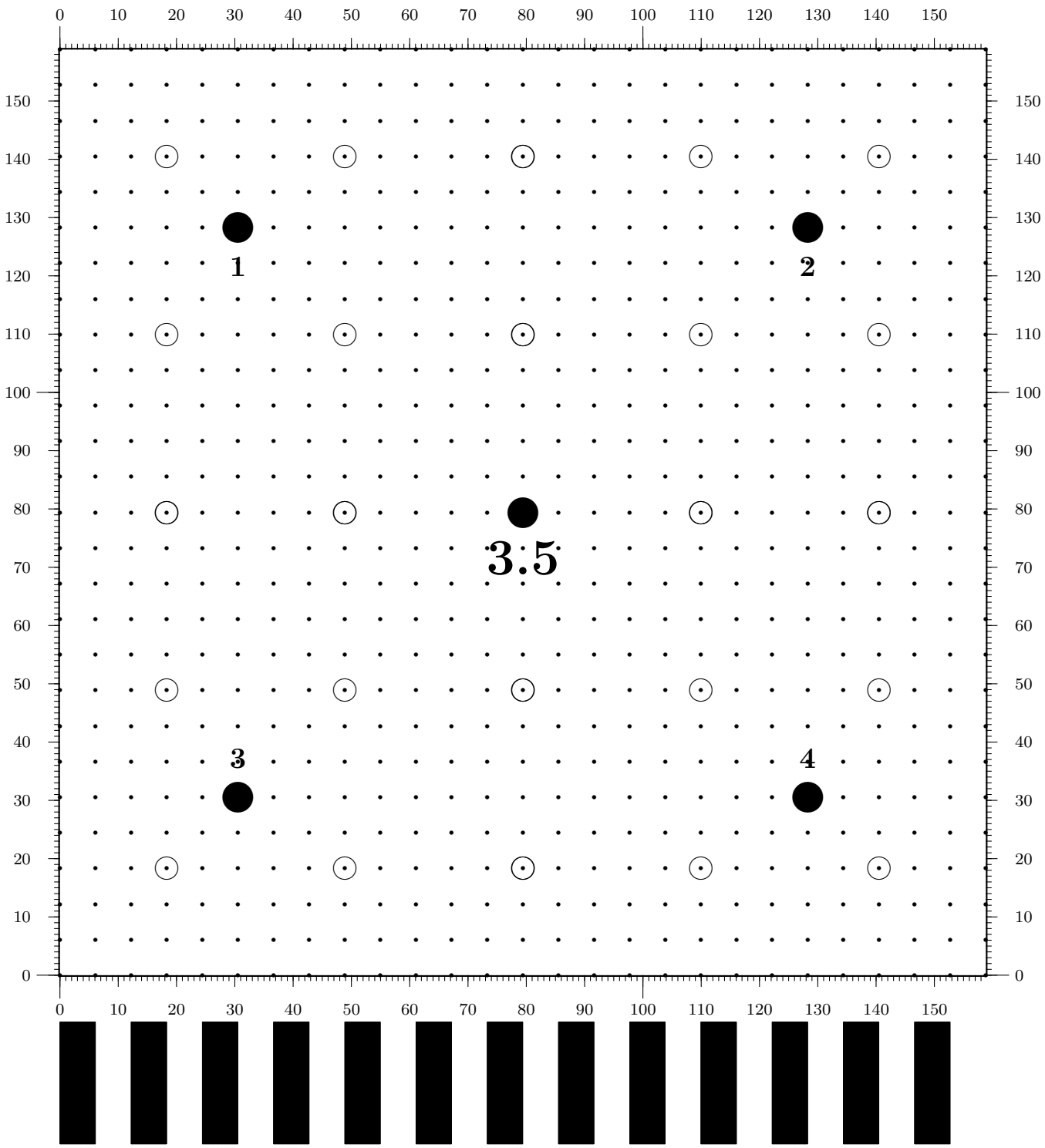

Figure 39: **0.1°at 3.5 meter is 6.108659 mm.**

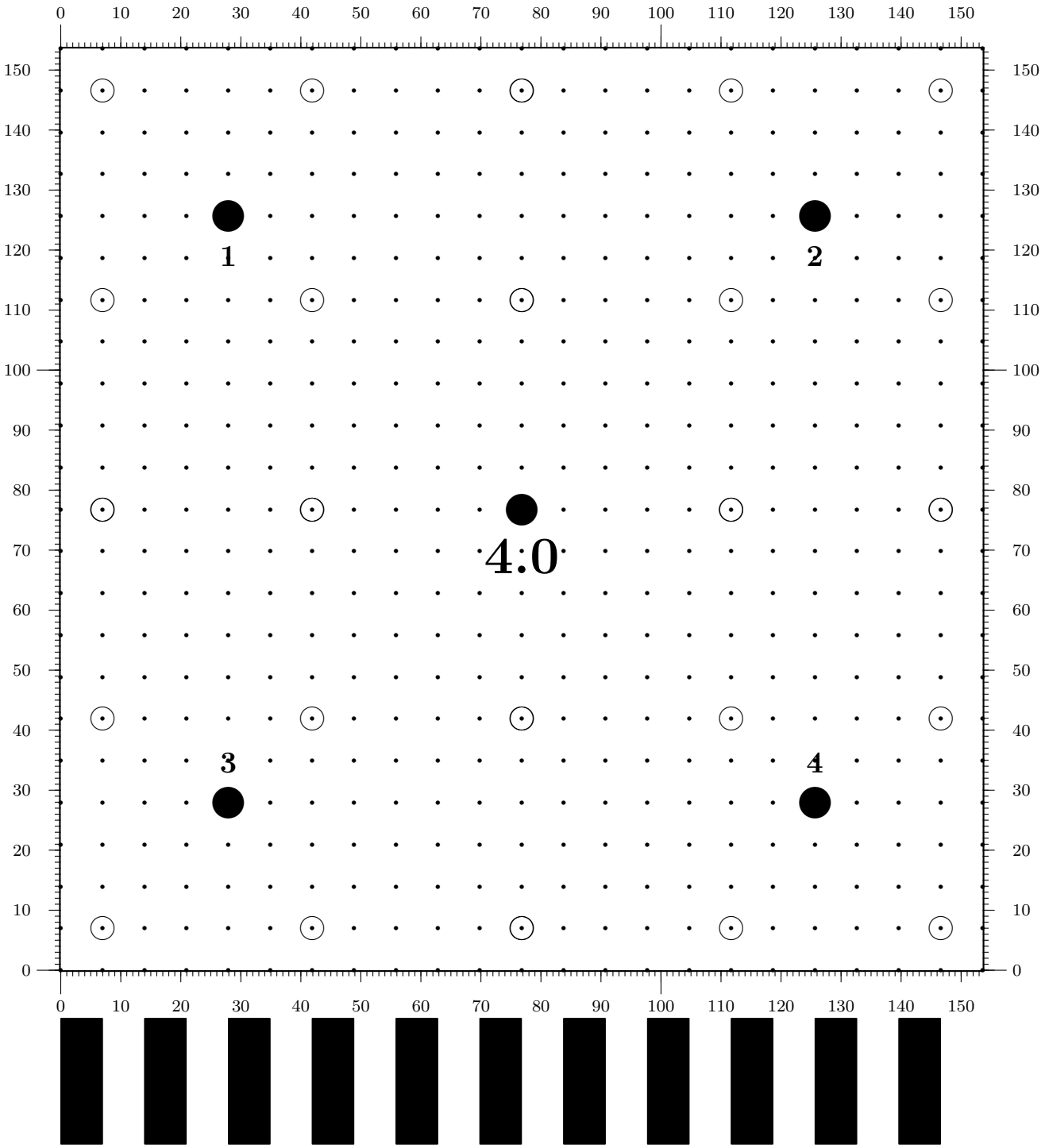

Figure 40: **0.1°at 4.0 meter is 6.981325 mm.**

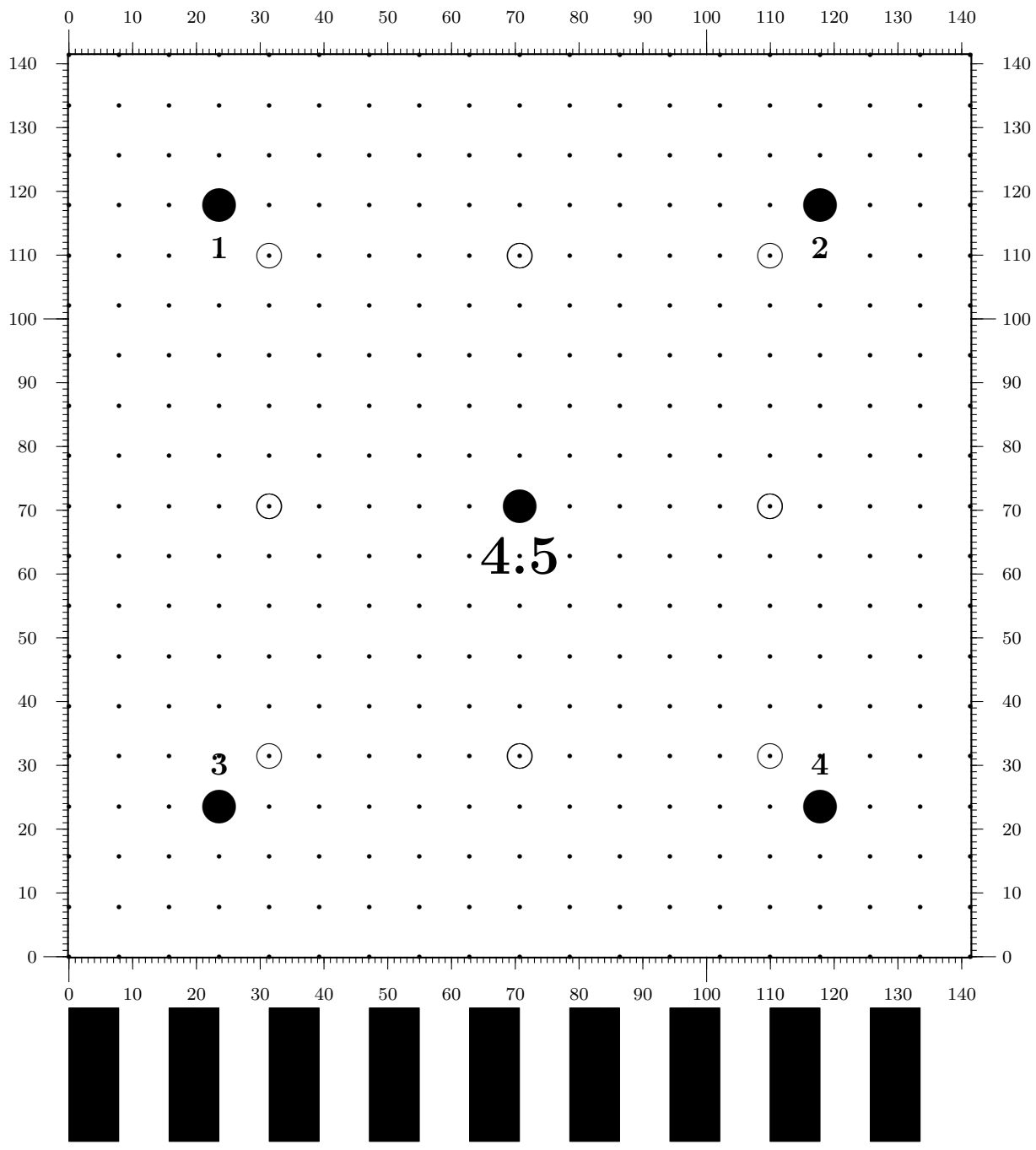

Figure 41: **0.1°at 4.5 meter is 7.853990 mm.**

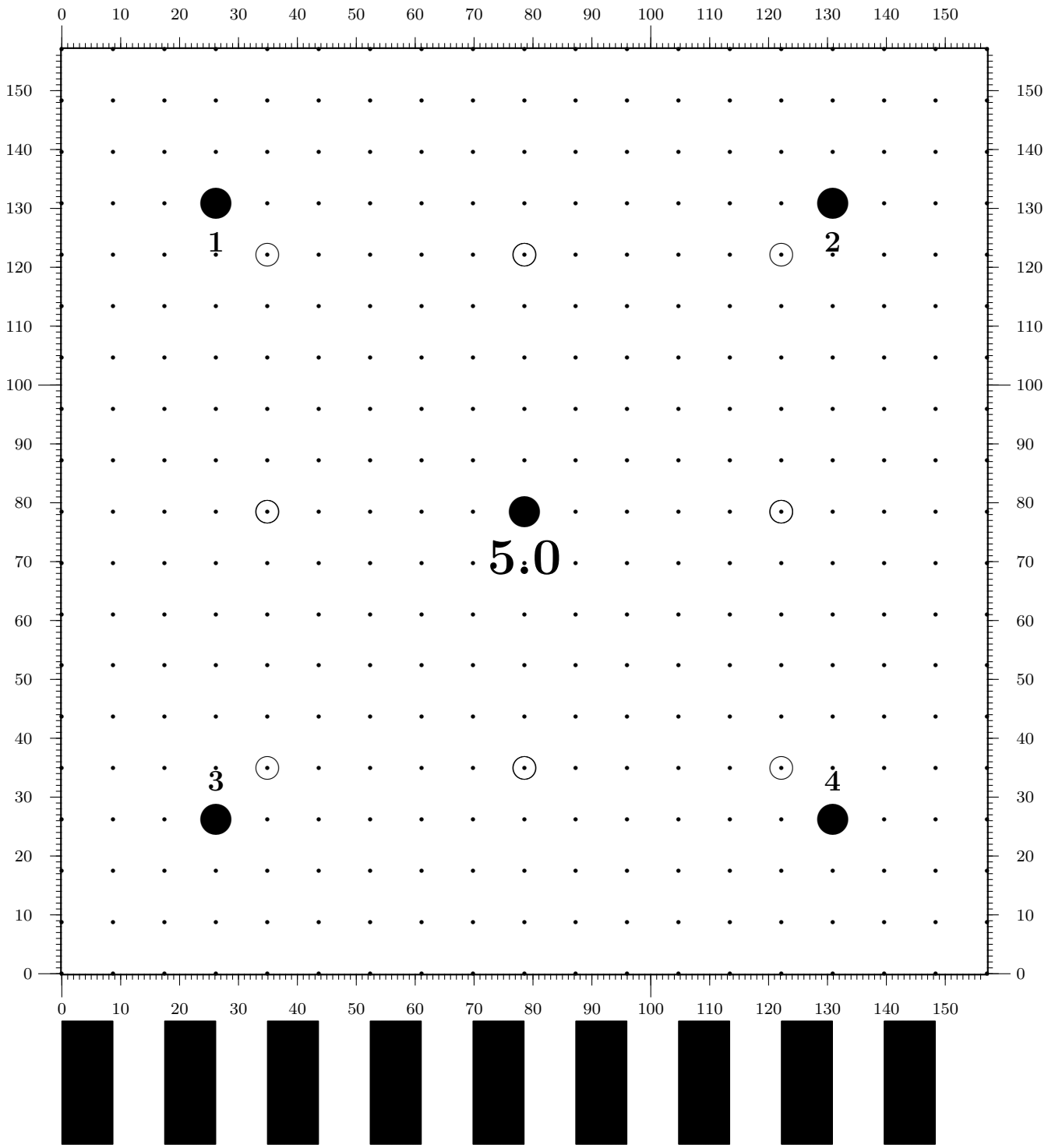

Figure 42: **0.1°at 5.0 meter is 8.726656 mm.**

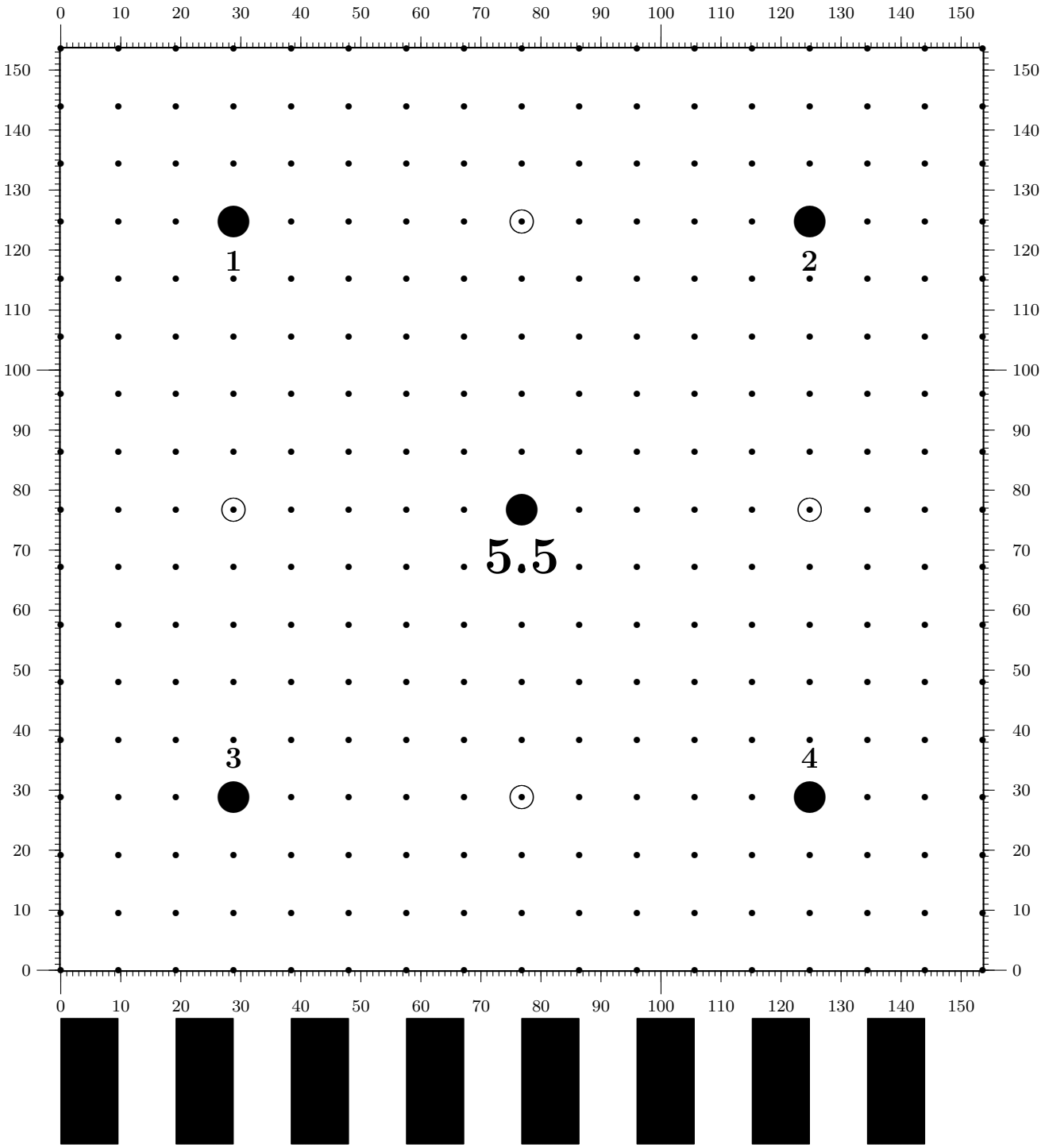

Figure 43: **0.1°at 5.5 meter is 9.599322 mm.**

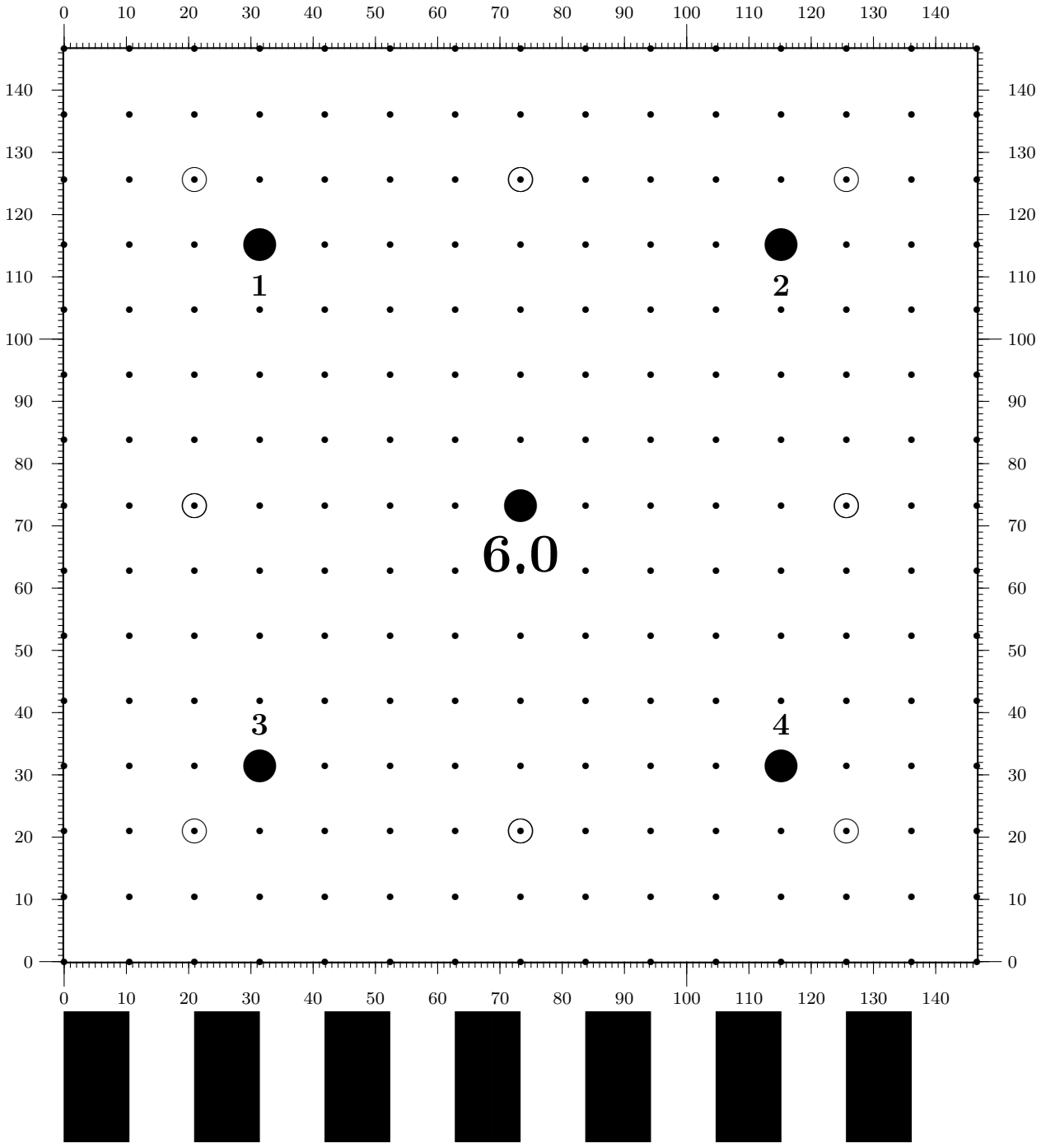

Figure 44: **0.1°at 6.0 meter is 10.471987 mm.**

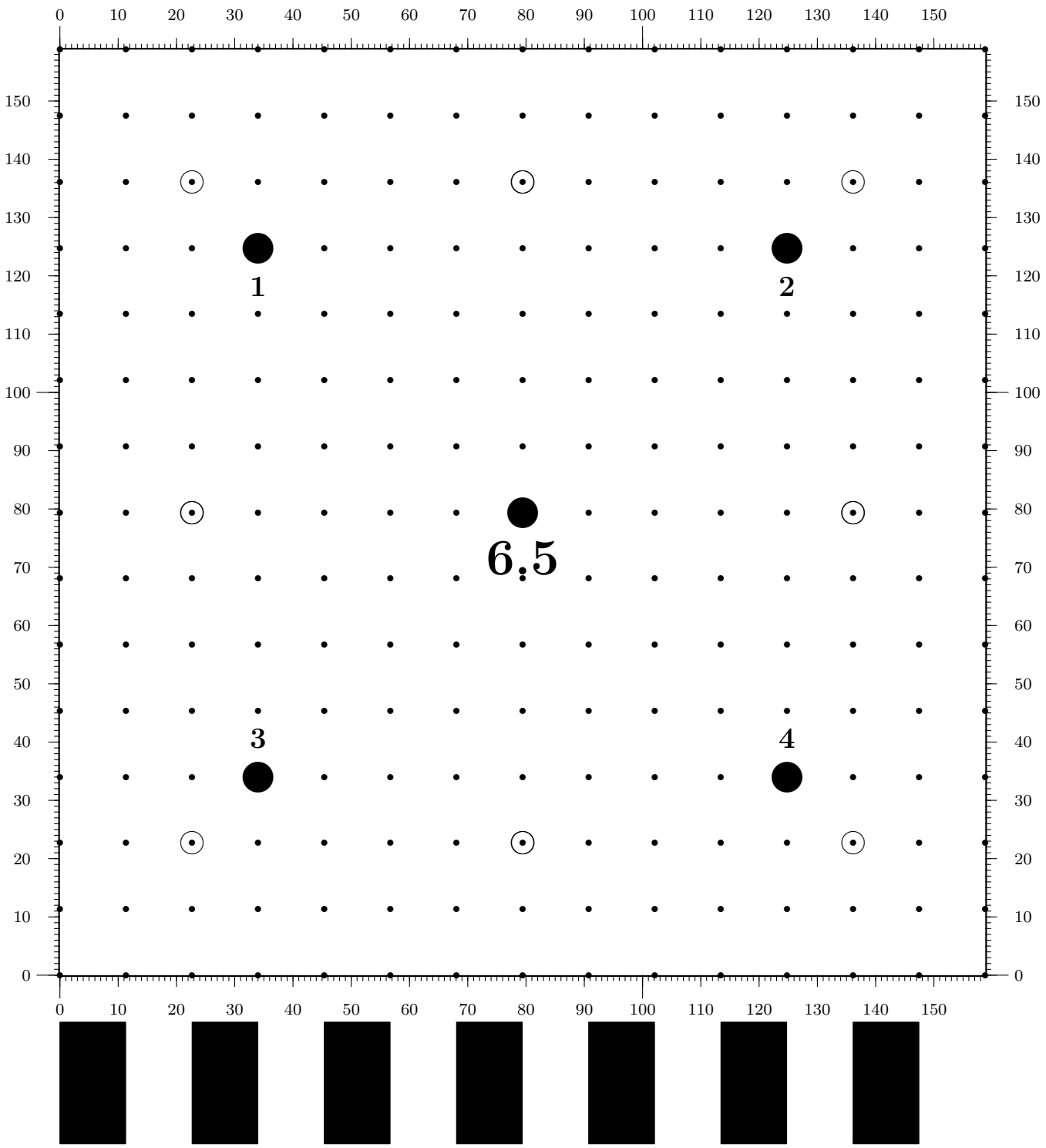

Figure 45: **0.1°at 6.5 meter is 11.344653 mm.**

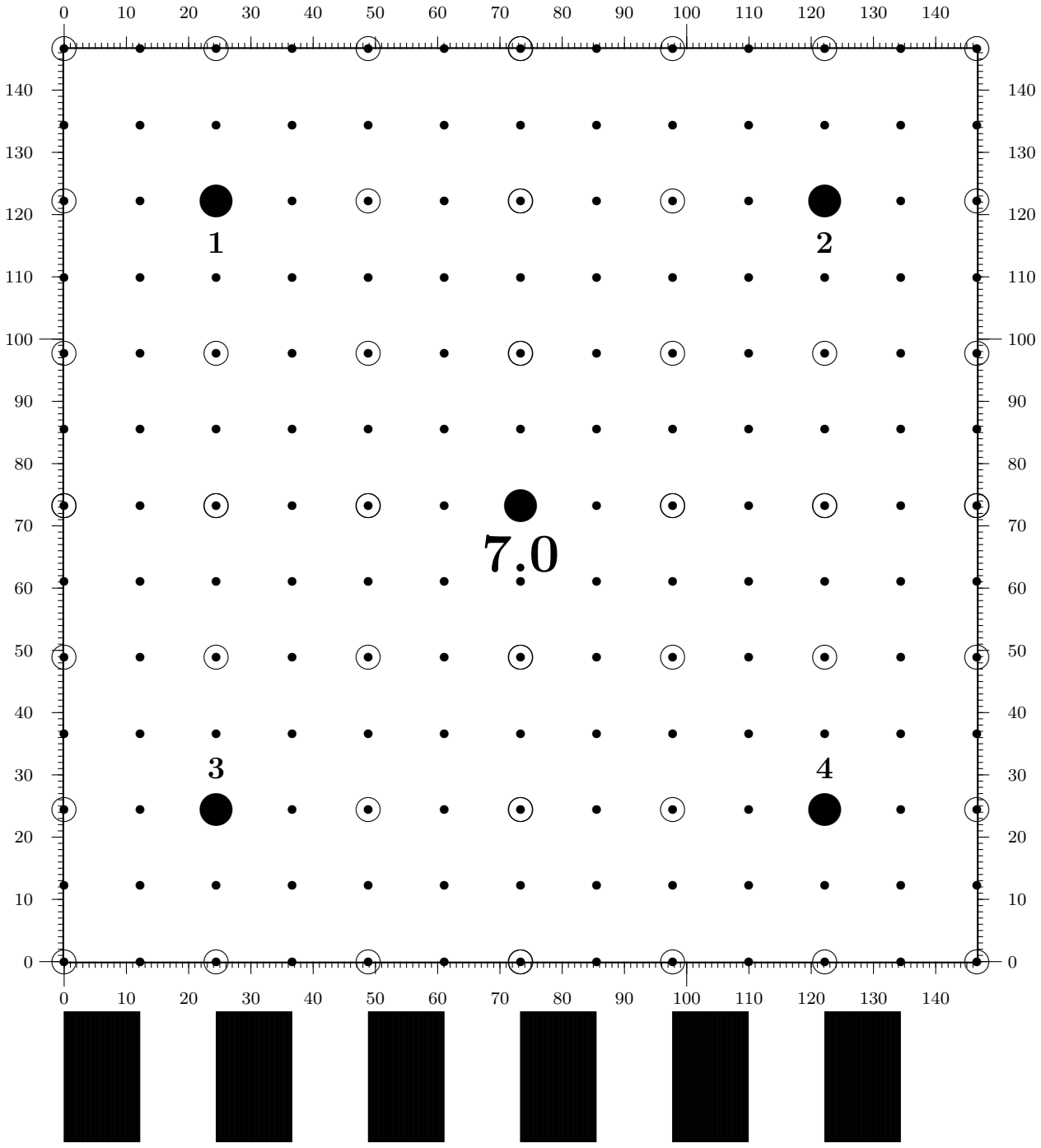

Figure 46: **0.1°at 7.0 meter is 12.217319 mm.**

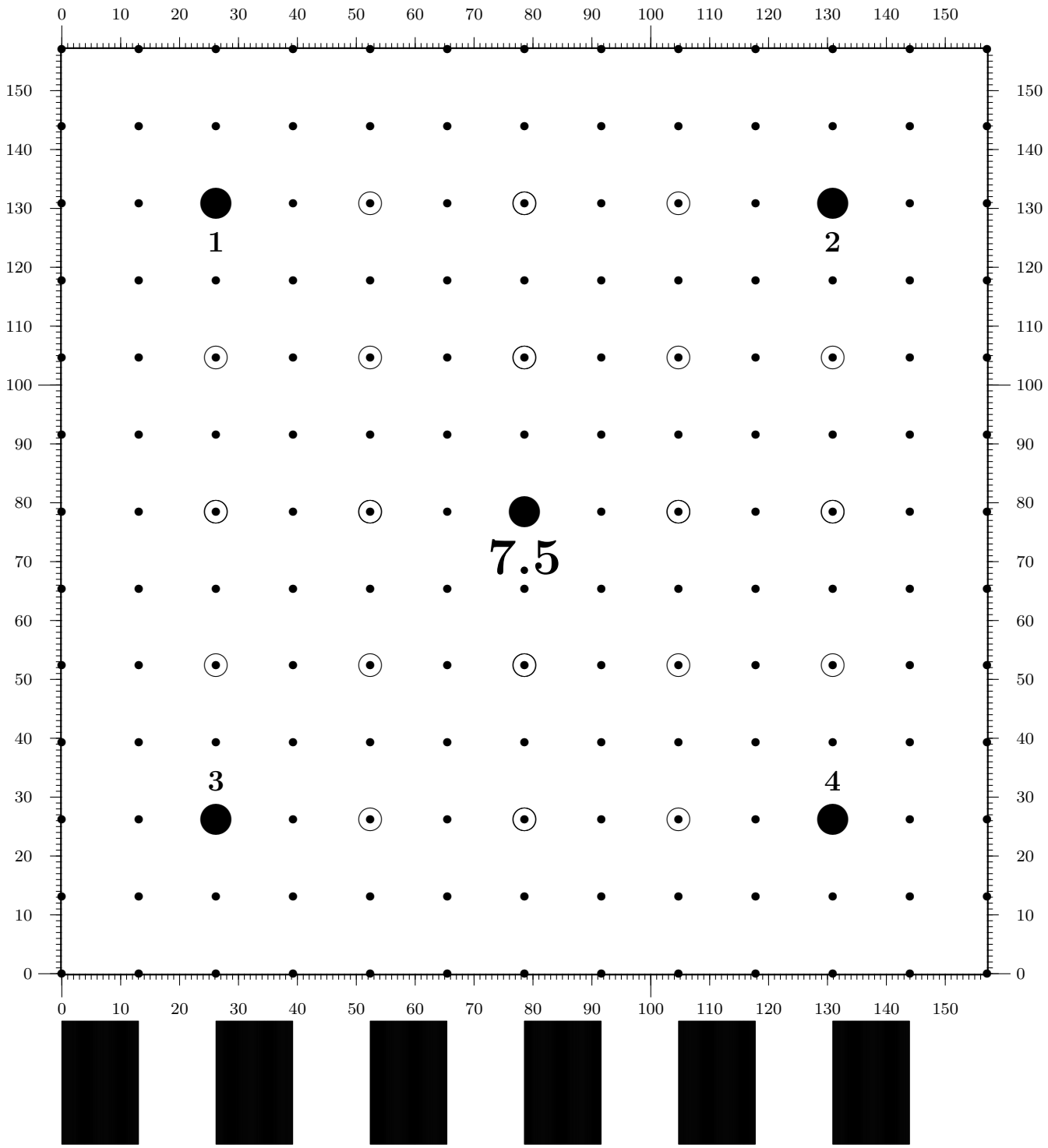

Figure 47: **0.1°at 7.5 meter is 13.089984 mm.**

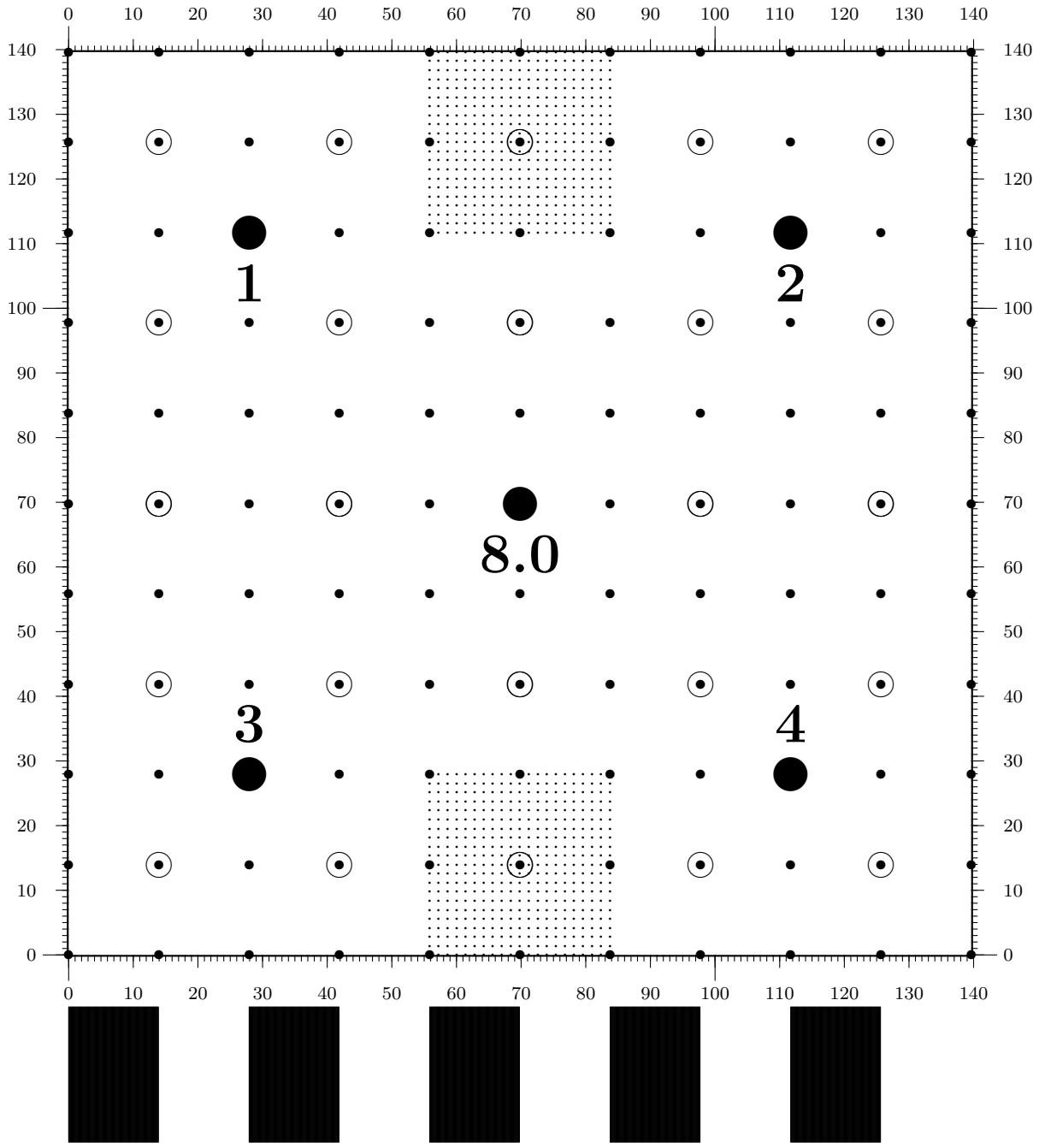

Figure 48: **0.1°at 8.0 meter is 13.962650 mm.**

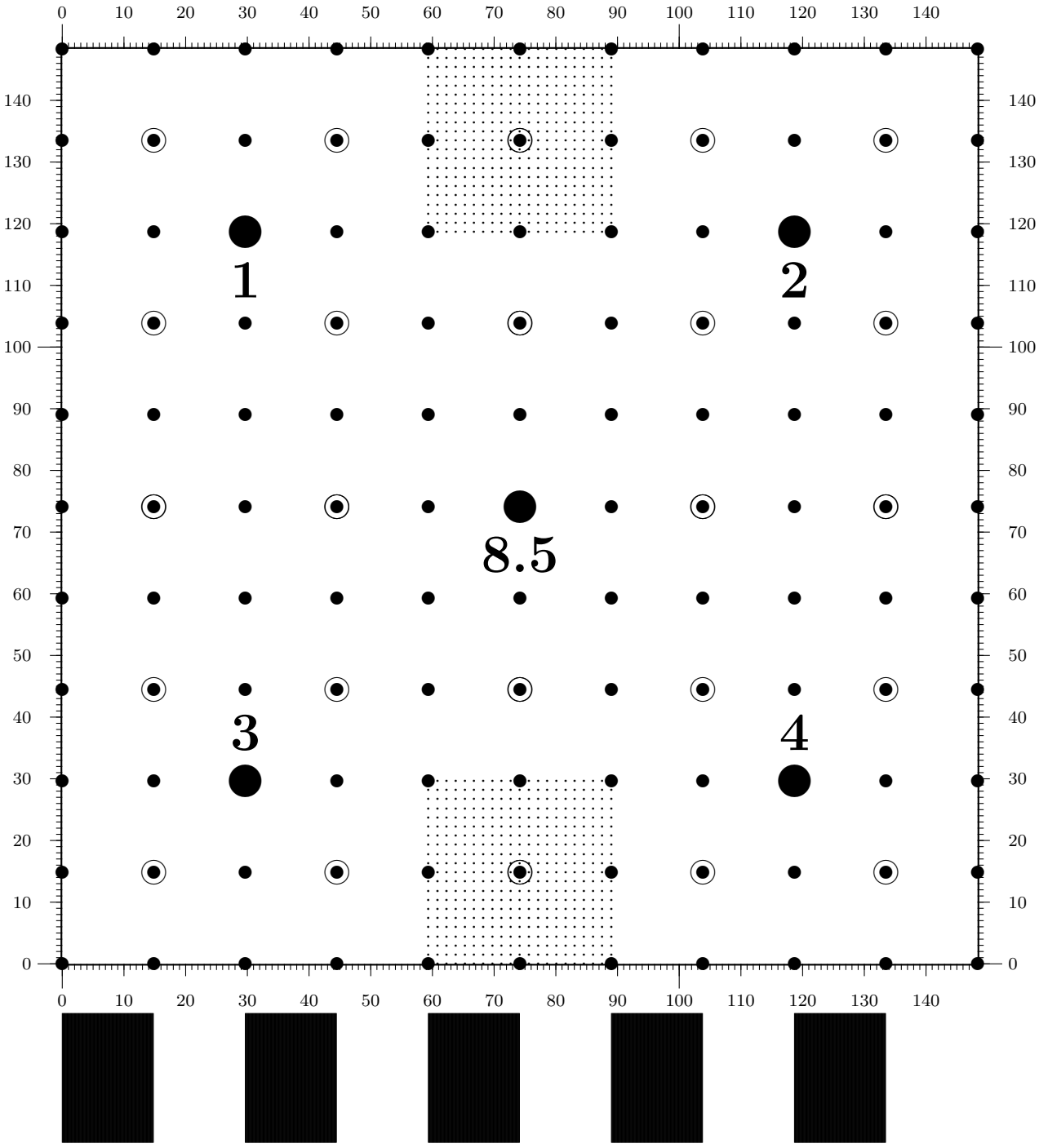

Figure 49: **0.1°at 8.5 meter is 14.835315 mm.**

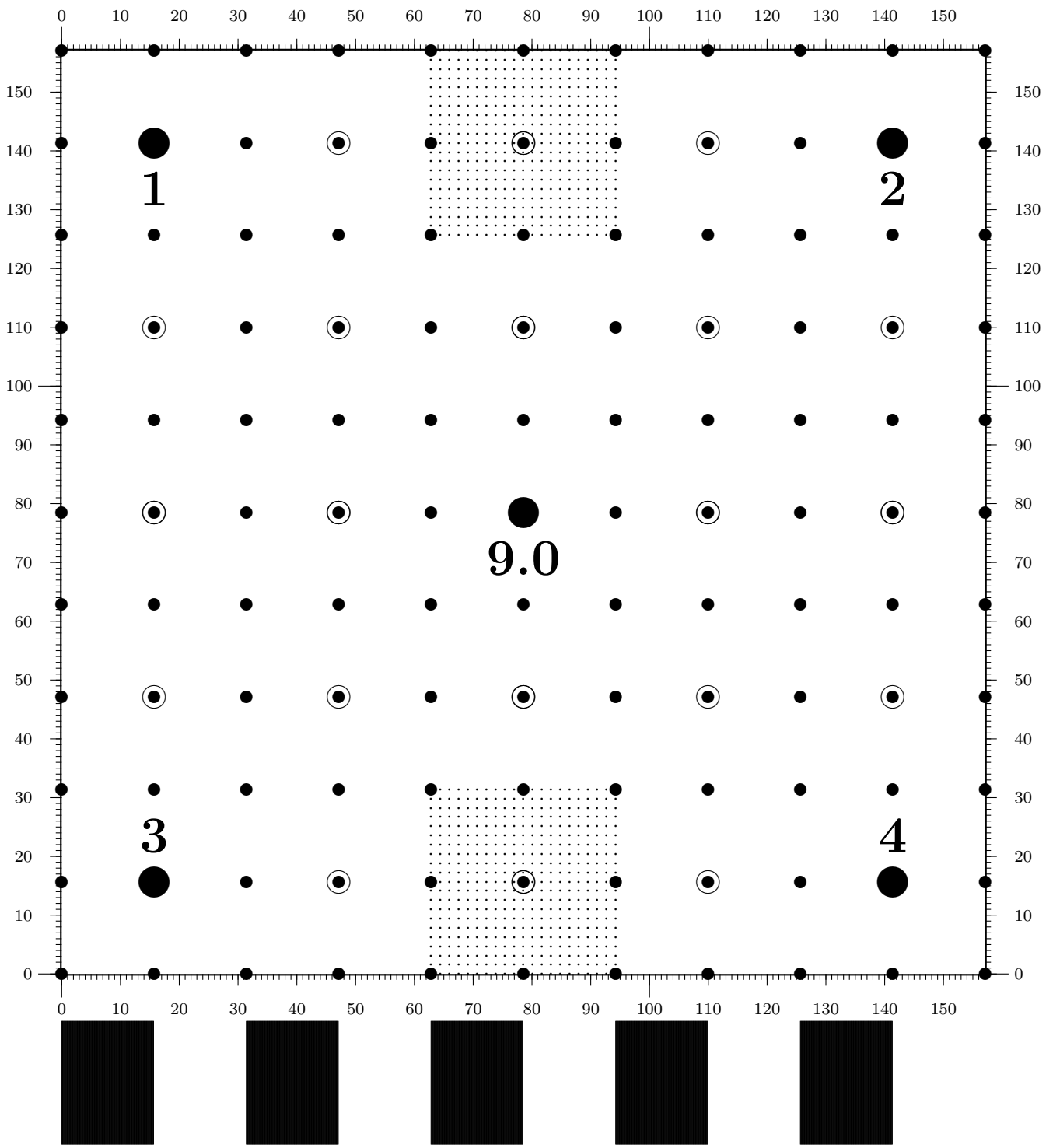

Figure 50: **0.1°at 9.0 meter is 15.707981 mm.**

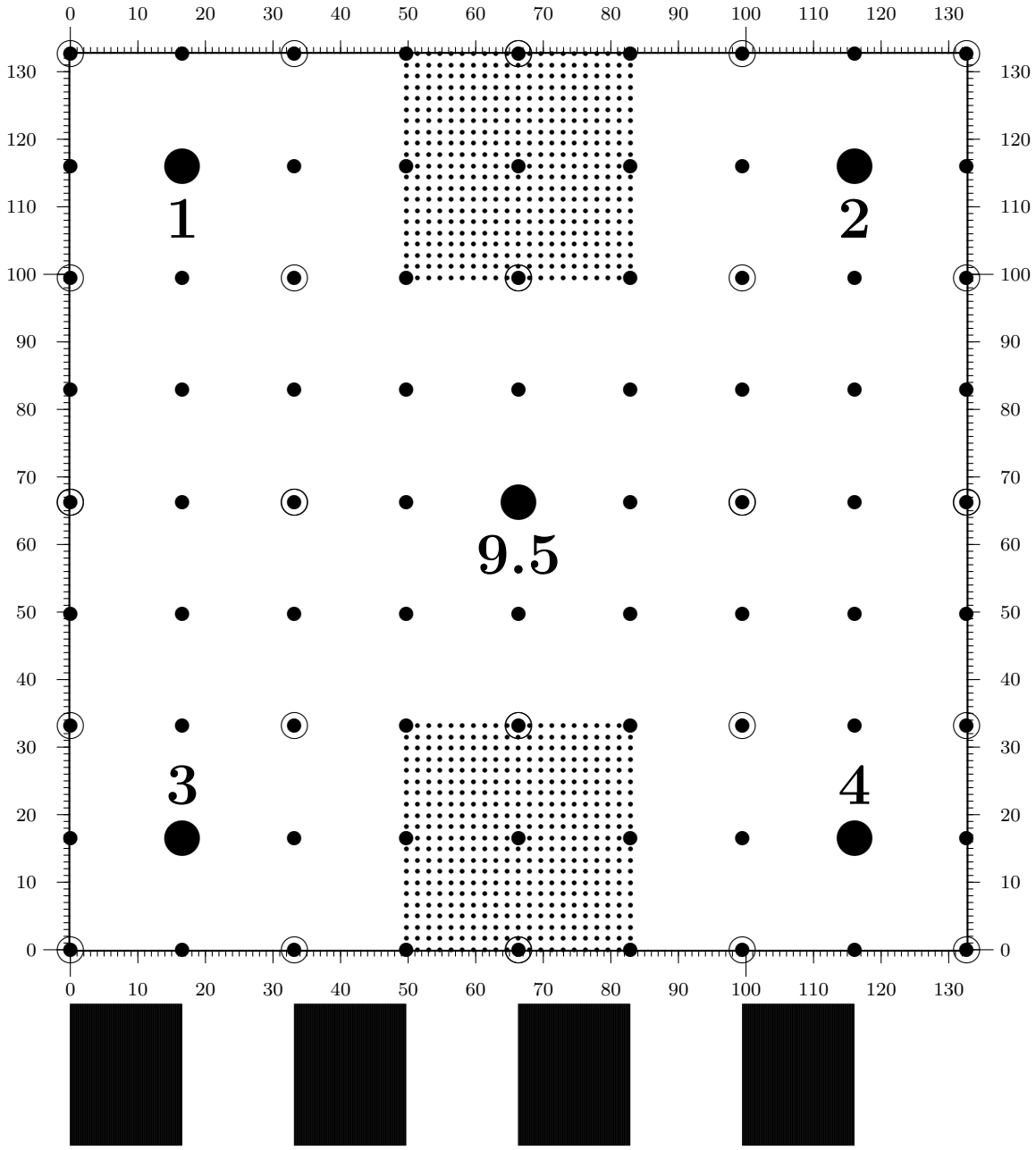

Figure 51: **0.1°at 9.5 meter is 16.580647 mm.**

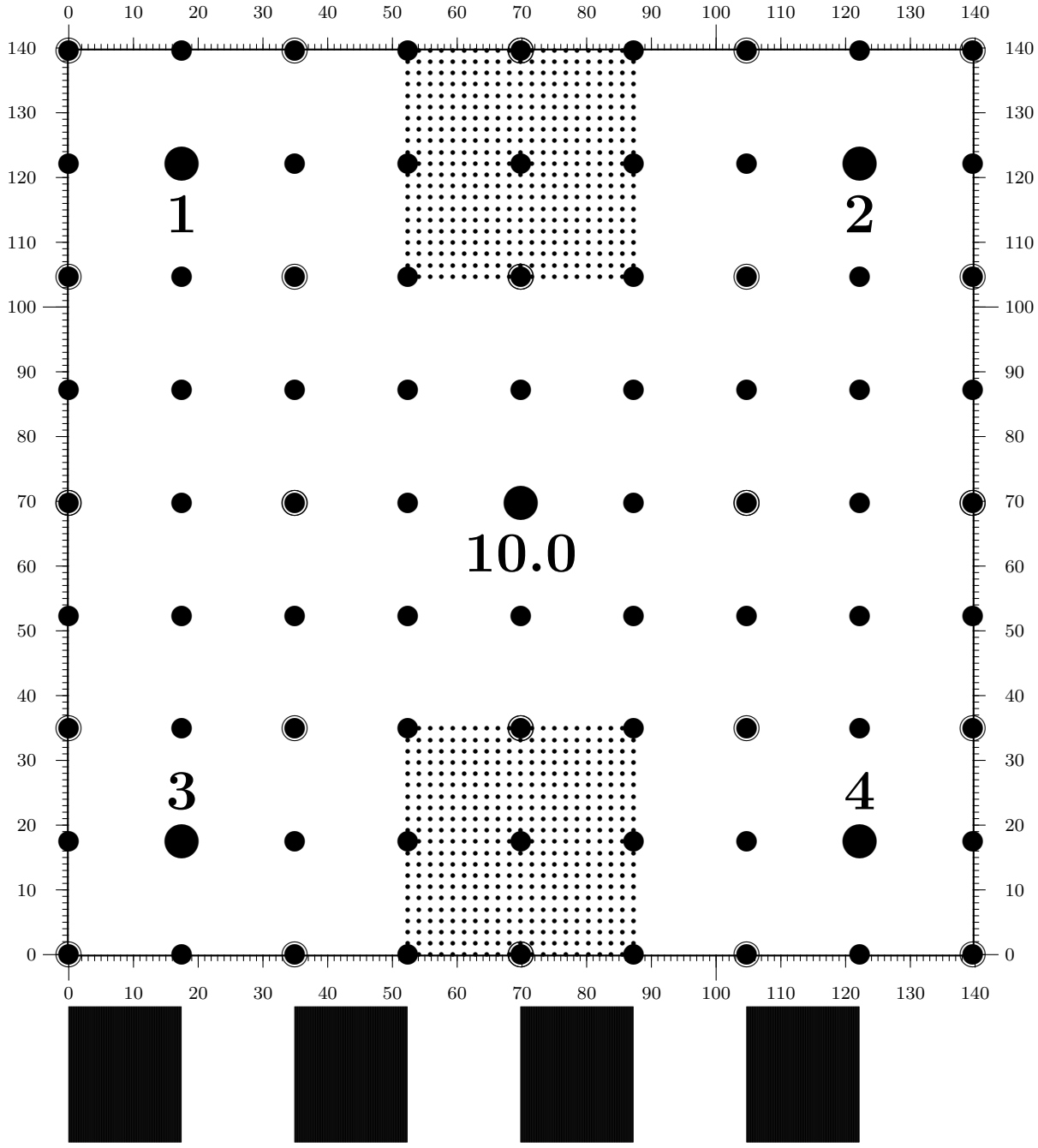

Figure 52: **0.1°at 10.0 meter is 17.453312 mm.**

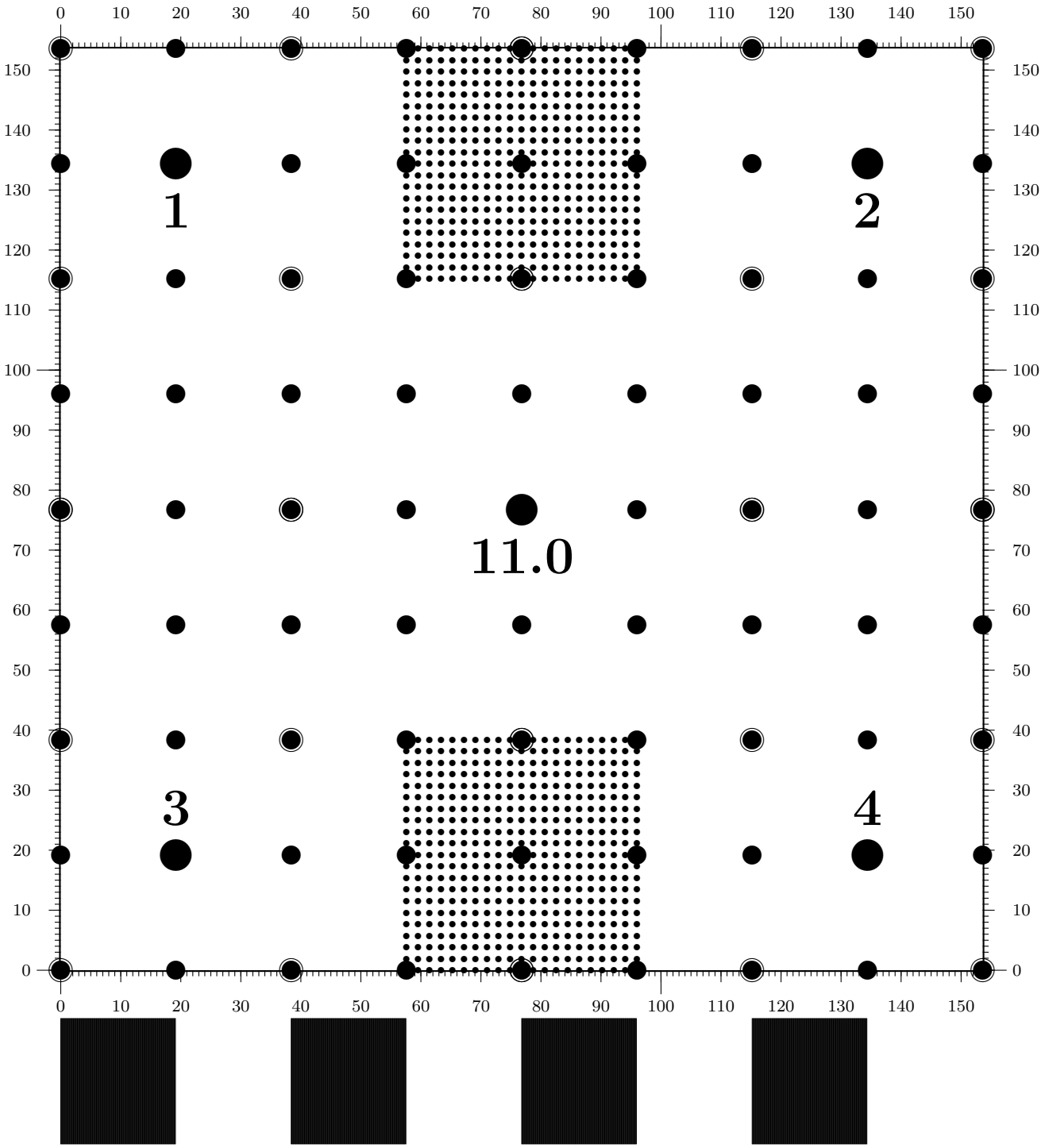

Figure 53: **0.1°at 11.0 meter is 19.198643 mm.**

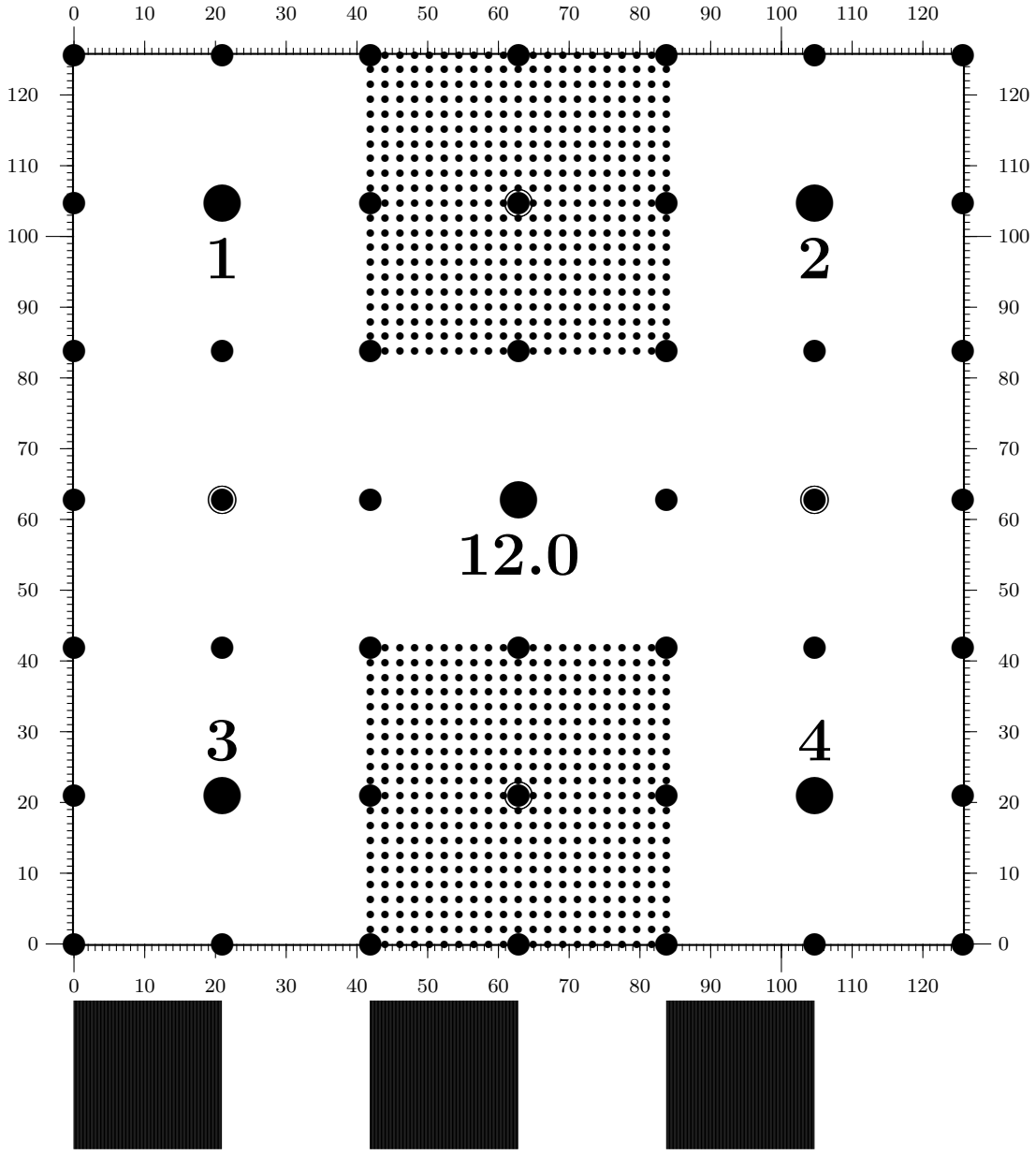

Figure 54: **0.1°at 12.0 meter is 20.943975 mm.**

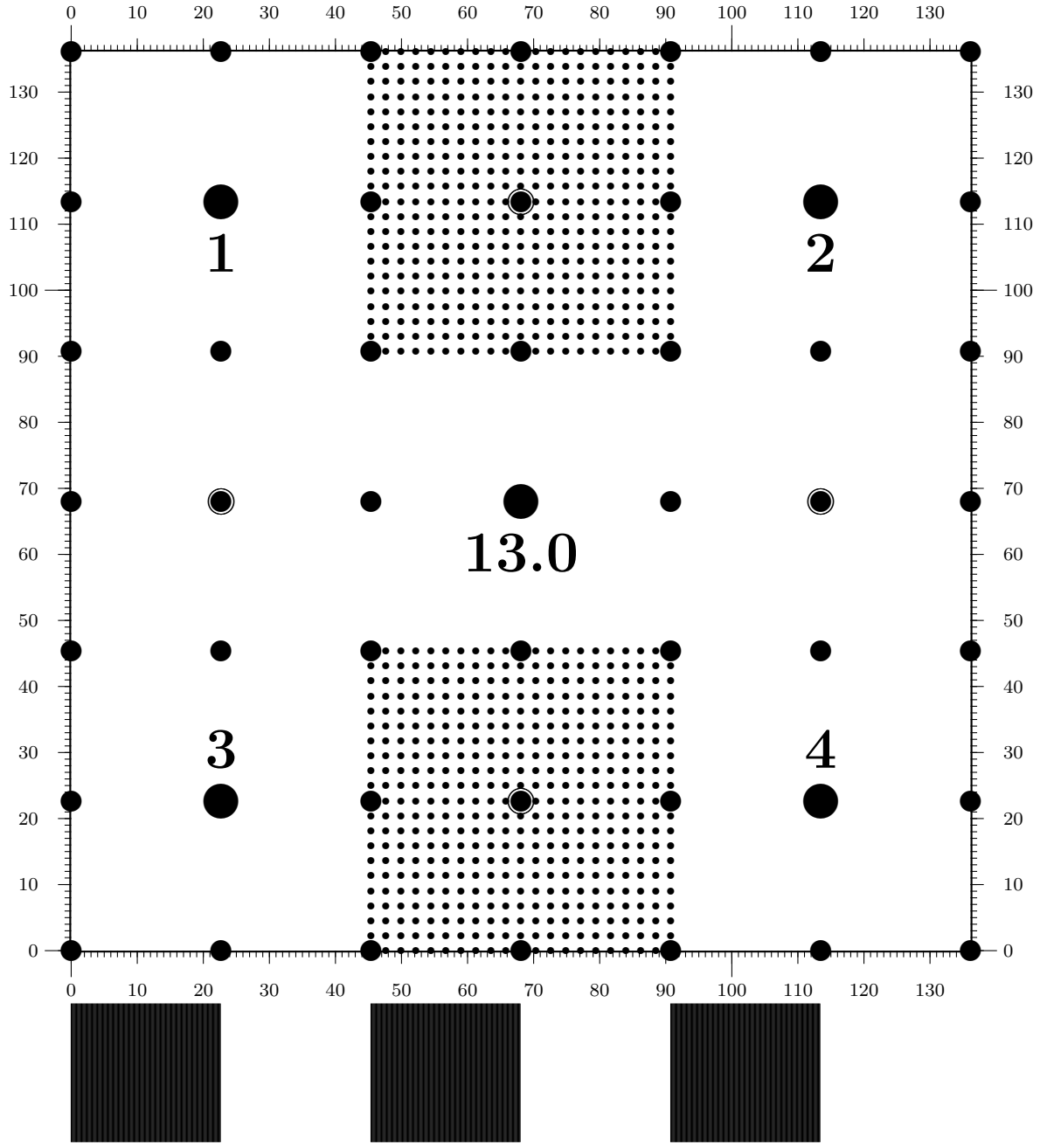

Figure 55: **0.1°at 13.0 meter is 22.689306 mm.**

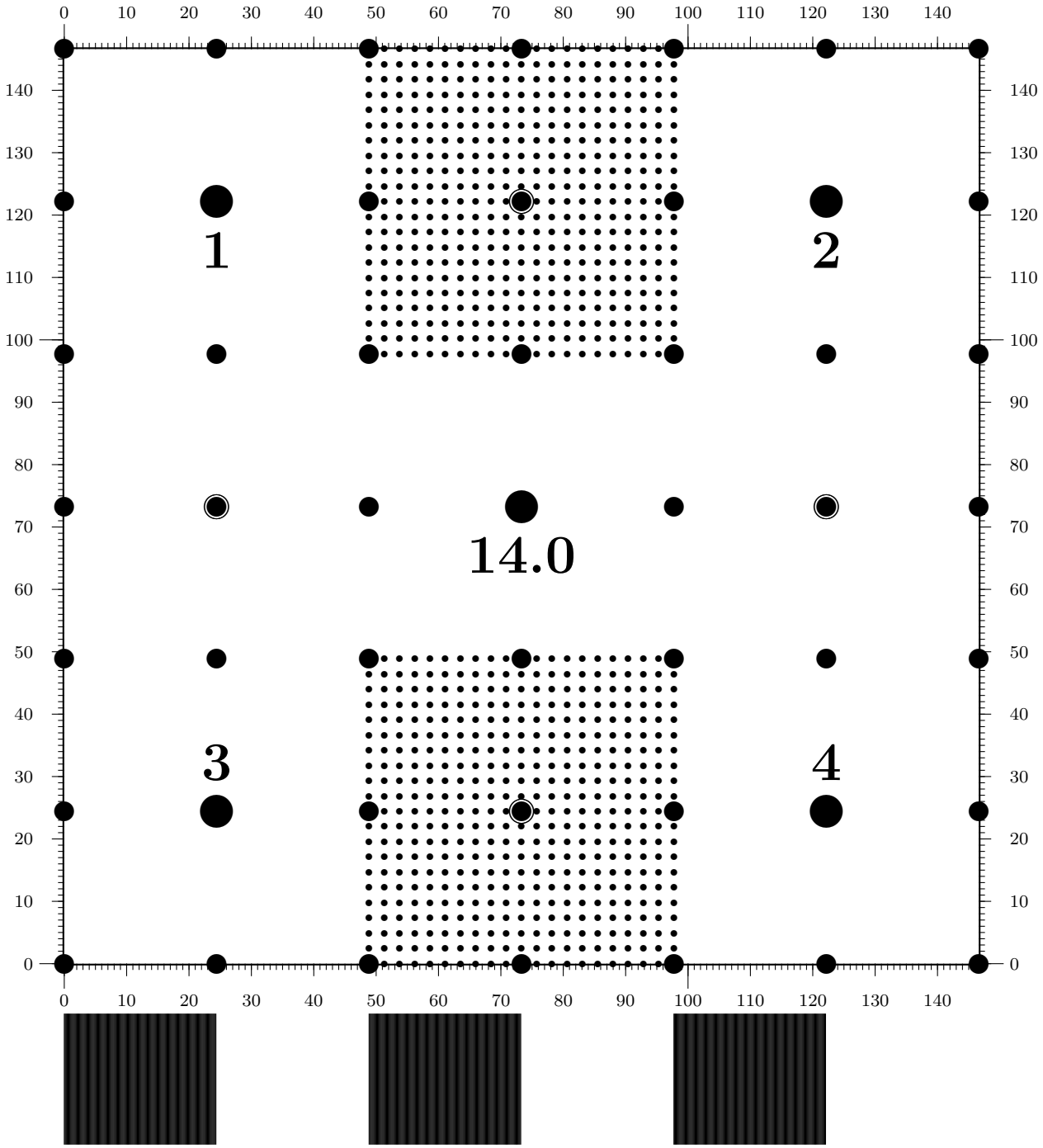

Figure 56: **0.1°at 14.0 meter is 24.434637 mm.**

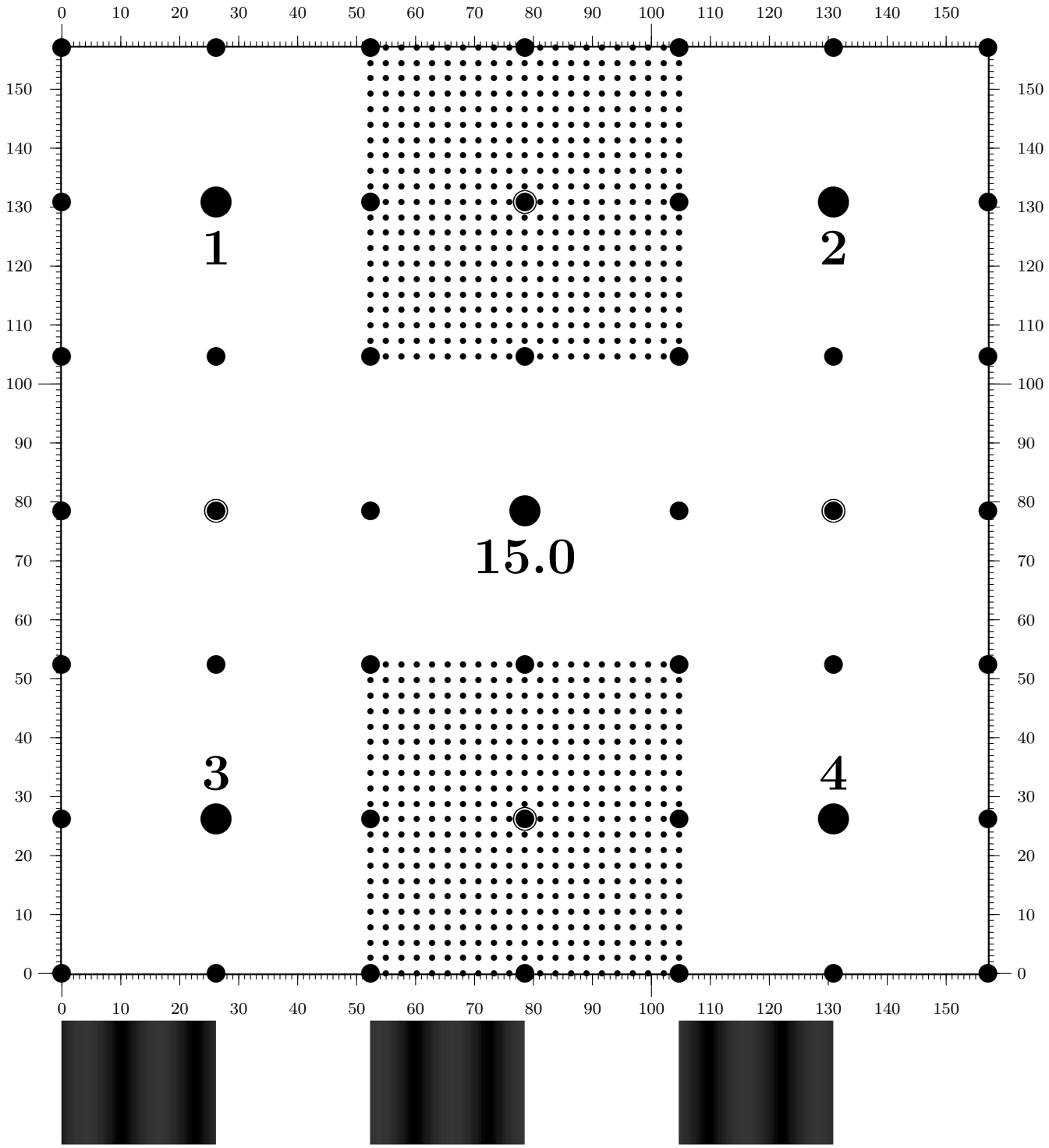

Figure 57: **0.1°at 15.0 meter is 26.179968 mm.**

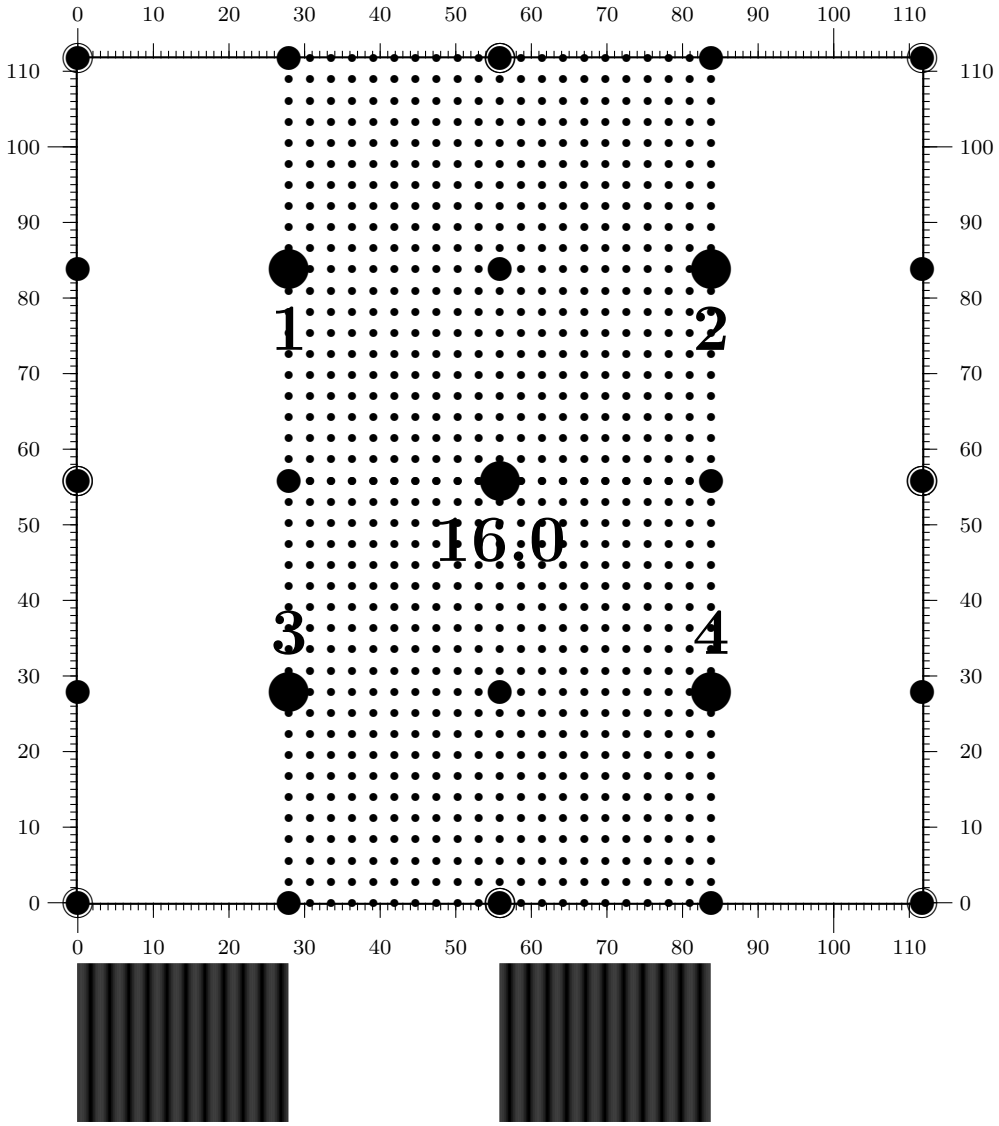

Figure 58: **0.1°at 16.0 meter is 27.925300 mm.**

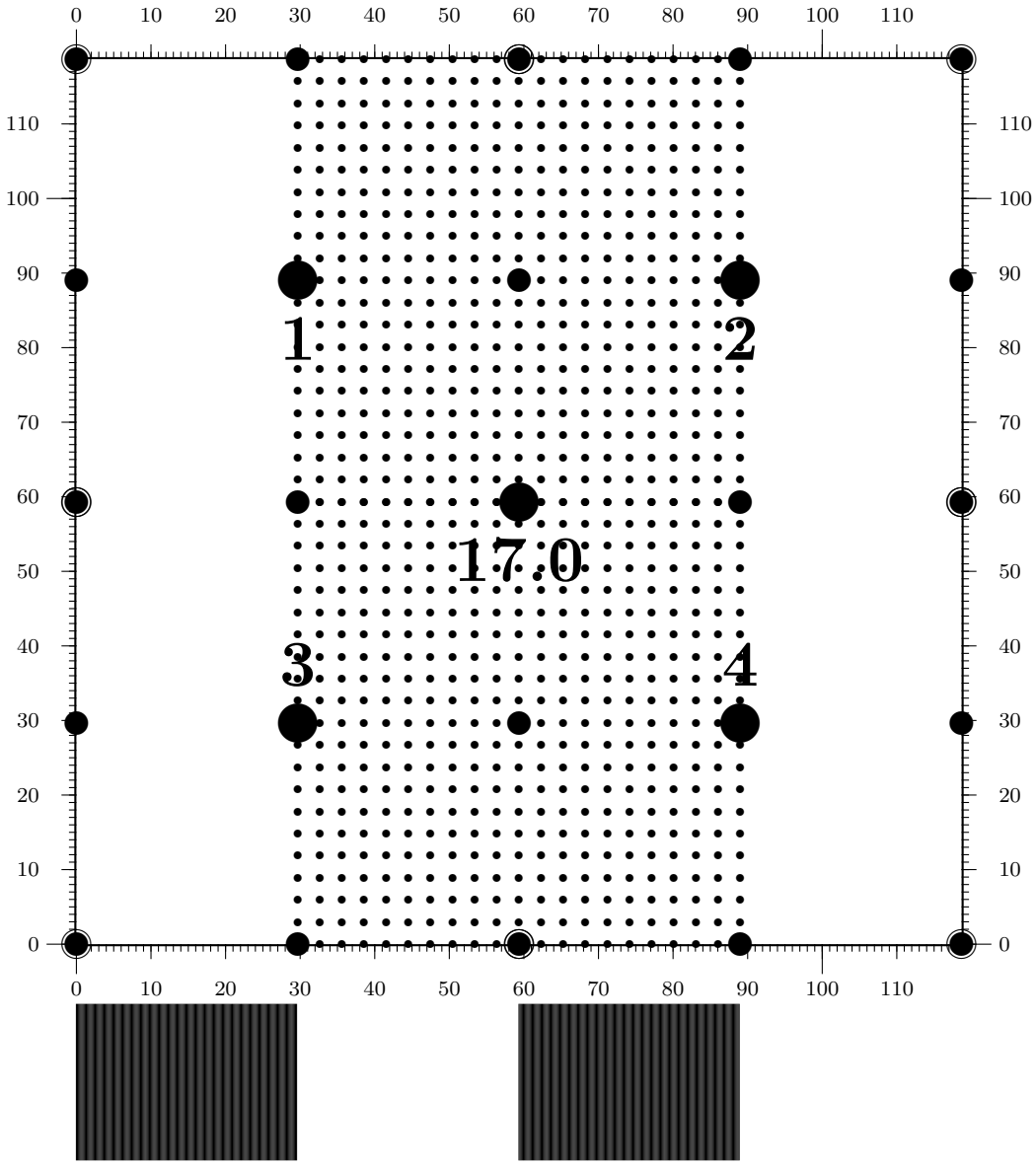

Figure 59: **0.1°at 17.0 meter is 29.670631 mm.**

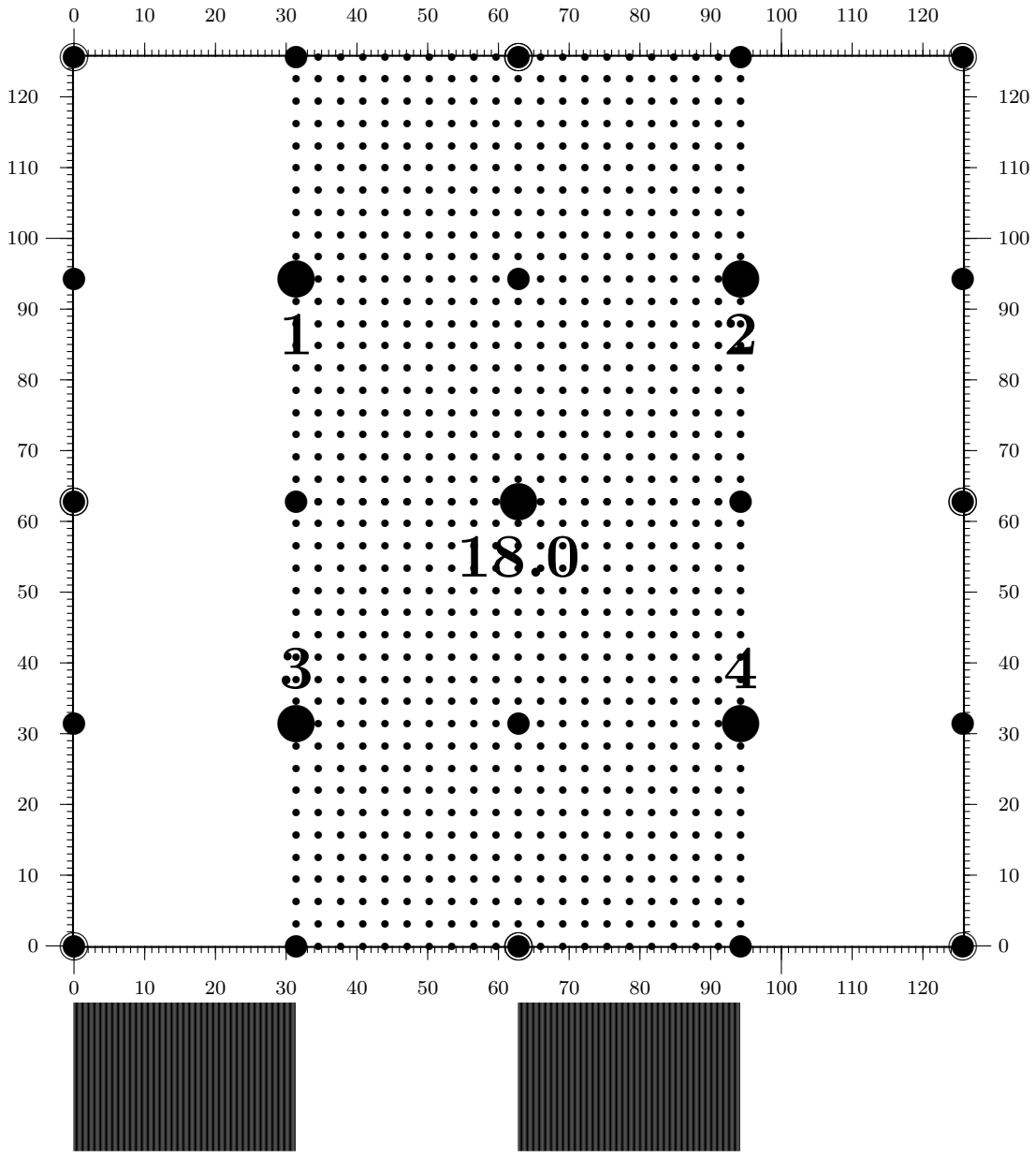

Figure 60: **0.1°at 18.0 meter is 31.415962 mm.**

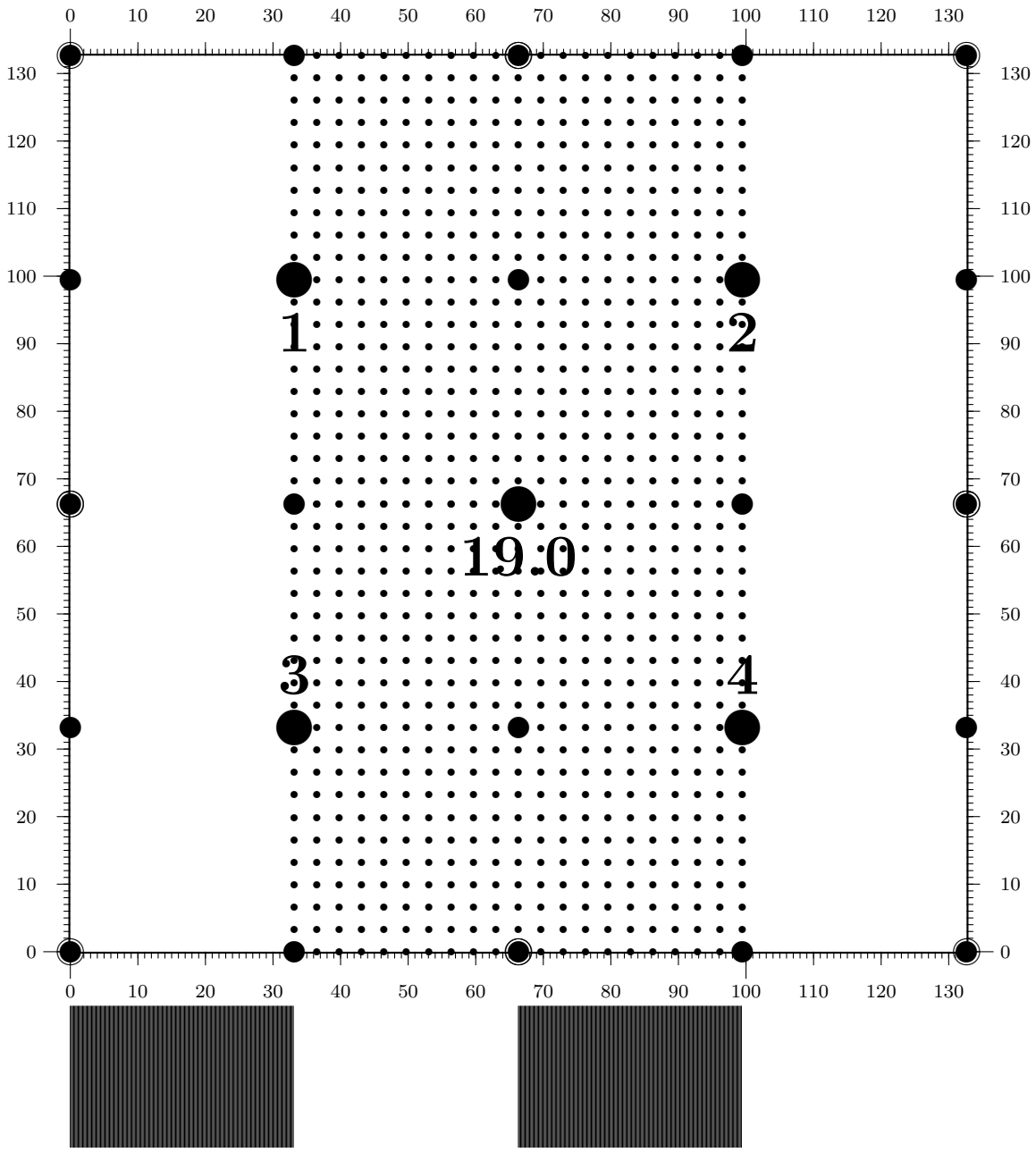

Figure 61: **0.1°at 19.0 meter is 33.161293 mm.**

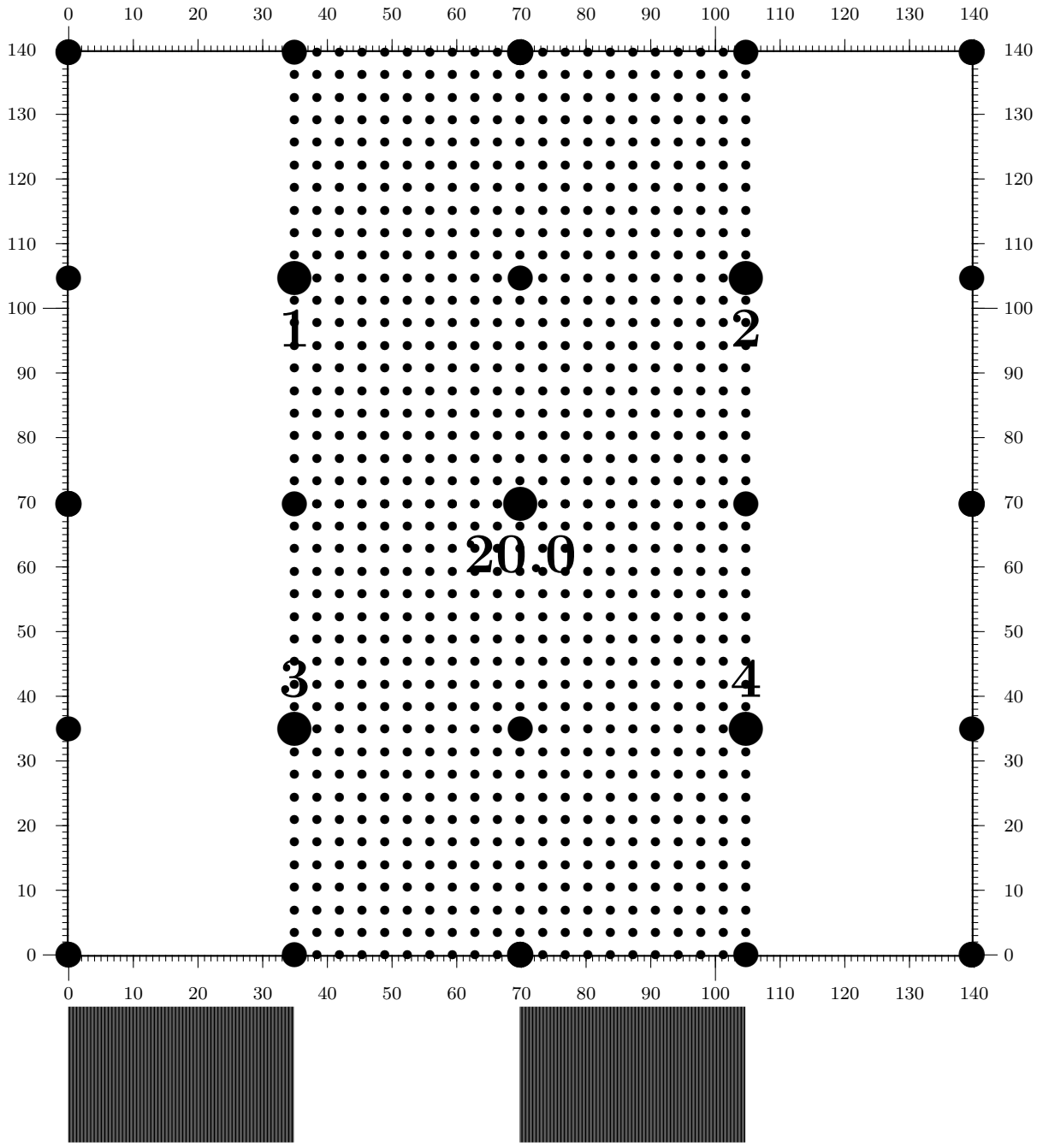

Figure 62: **0.1°at 20.0 meter is 34.906624 mm.**