0.1° Position Calibration Targets

English 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 1.4 2008-12-31 07:53:31-08 Hamilton Exp Hamilton $`

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List of Figures

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 foot distance targets generated

Target #	Marker °	Distance Feet	Step Size in	Step Size in	Page
12-31-2008 07:54:48					
1	10	2.0	0.04189	0.0	Figure 1, page 11
2	10	2.5	0.05236	0.1	Figure 2, page 12
3	10	3.0	0.06283	0.1	Figure 3, page 13
4	10	3.5	0.07330	0.1	Figure 4, page 14
5	10	4.0	0.08378	0.1	Figure 5, page 15
6	10	4.5	0.09425	0.1	Figure 6, page 16
7	5	5.0	0.10472	0.1	Figure 7, page 17
8	5	5.5	0.11519	0.1	Figure 8, page 18
9	5	6.0	0.12566	0.1	Figure 9, page 19
10	5	6.5	0.13614	0.1	Figure 10, page 20
11	5	7.0	0.14661	0.1	Figure 11, page 21
12	5	7.5	0.15708	0.2	Figure 12, page 22
13	5	8.0	0.16755	0.2	Figure 13, page 23
14	5	8.5	0.17802	0.2	Figure 14, page 24
15	5	9.0	0.18850	0.2	Figure 15, page 25
16	5	9.5	0.19897	0.2	Figure 16, page 26
17	5	10.0	0.20944	0.2	Figure 17, page 27
18	5	10.5	0.21991	0.2	Figure 18, page 28
19	2	11.0	0.23038	0.2	Figure 19, page 29
20	2	11.5	0.24086	0.2	Figure 20, page 30
21	2	12.0	0.25133	0.3	Figure 21, page 31
22	2	12.5	0.26180	0.3	Figure 22, page 32

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[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.

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Target #	Marker °	Distance Feet	Step Size in	Step Size in	Page
12-31-2008 07:54:48					
23	2	13.0	0.27227	0.3	Figure 23, page 33
24	2	13.5	0.28274	0.3	Figure 24, page 34
25	2	14.0	0.29322	0.3	Figure 25, page 35
26	2	14.5	0.30369	0.3	Figure 26, page 36
27	2	15.0	0.31416	0.3	Figure 27, page 37
28	2	15.5	0.32463	0.3	Figure 28, page 38
29	2	16.0	0.33510	0.3	Figure 29, page 39
30	2	16.5	0.34558	0.3	Figure 30, page 40
31	2	17.0	0.35605	0.4	Figure 31, page 41
32	2	17.5	0.36652	0.4	Figure 32, page 42
33	2	18.0	0.37699	0.4	Figure 33, page 43
34	2	18.5	0.38746	0.4	Figure 34, page 44
35	2	19.0	0.39794	0.4	Figure 35, page 45
36	2	19.5	0.40841	0.4	Figure 36, page 46
37	2	20.0	0.41888	0.4	Figure 37, page 47
38	2	21.0	0.43982	0.4	Figure 38, page 48
39	2	22.0	0.46077	0.5	Figure 39, page 49
40	2	23.0	0.48171	0.5	Figure 40, page 50
41	2	24.0	0.50266	0.5	Figure 41, page 51
42	2	25.0	0.52360	0.5	Figure 42, page 52
43	2	26.0	0.54454	0.5	Figure 43, page 53
44	2	27.0	0.56549	0.6	Figure 44, page 54
45	2	28.0	0.58643	0.6	Figure 45, page 55
46	2	29.0	0.60738	0.6	Figure 46, page 56
47	2	30.0	0.62832	0.6	Figure 47, page 57
48	2	31.0	0.64926	0.6	Figure 48, page 58
49	2	32.0	0.67021	0.7	Figure 49, page 59
50	2	33.0	0.69115	0.7	Figure 50, page 60
51	2	34.0	0.71210	0.7	Figure 51, page 61
52	2	35.0	0.73304	0.7	Figure 52, page 62
53	2	36.0	0.75398	0.8	Figure 53, page 63
54	2	37.0	0.77493	0.8	Figure 54, page 64
55	2	38.0	0.79587	0.8	Figure 55, page 65
56	2	39.0	0.81682	0.8	Figure 56, page 66

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Target #	Marker °	Distance Feet	Step Size in	Step Size in	Page
12-31-2008 07:54:48					
57	2	40.0	0.83776	0.8	Figure 57, page 67
58	2	41.0	0.85870	0.9	Figure 58, page 68
59	2	42.0	0.87965	0.9	Figure 59, page 69
60	2	43.0	0.90059	0.9	Figure 60, page 70
61	2	44.0	0.92153	0.9	Figure 61, page 71
62	2	45.0	0.94248	0.9	Figure 62, page 72
63	2	46.0	0.96342	1.0	Figure 63, page 73
64	2	47.0	0.98437	1.0	Figure 64, page 74
65	2	48.0	1.00531	1.0	Figure 65, page 75
66	2	49.0	1.02625	1.0	Figure 66, page 76
67	2	50.0	1.04720	1.0	Figure 67, page 77
68	2	51.0	1.06814	1.1	Figure 68, page 78
69	2	52.0	1.08909	1.1	Figure 69, page 79
70	2	53.0	1.11003	1.1	Figure 70, page 80
71	2	54.0	1.13097	1.1	Figure 71, page 81
72	2	55.0	1.15192	1.2	Figure 72, page 82
73	2	56.0	1.17286	1.2	Figure 73, page 83
74	2	57.0	1.19381	1.2	Figure 74, page 84
75	2	58.0	1.21475	1.2	Figure 75, page 85
76	2	59.0	1.23569	1.2	Figure 76, page 86
77	2	60.0	1.25664	1.3	Figure 77, page 87
78	2	61.0	1.27758	1.3	Figure 78, page 88
79	2	62.0	1.29853	1.3	Figure 79, page 89
80	2	63.0	1.31947	1.3	Figure 80, page 90
81	2	64.0	1.34041	1.3	Figure 81, page 91
82	2	65.0	1.36136	1.4	Figure 82, page 92
83	2	66.0	1.38230	1.4	Figure 83, page 93
84	2	67.0	1.40325	1.4	Figure 84, page 94
85	2	68.0	1.42419	1.4	Figure 85, page 95
86	2	69.0	1.44513	1.4	Figure 86, page 96
87	2	70.0	1.46608	1.5	Figure 87, page 97

1.3 Targets for foot distances

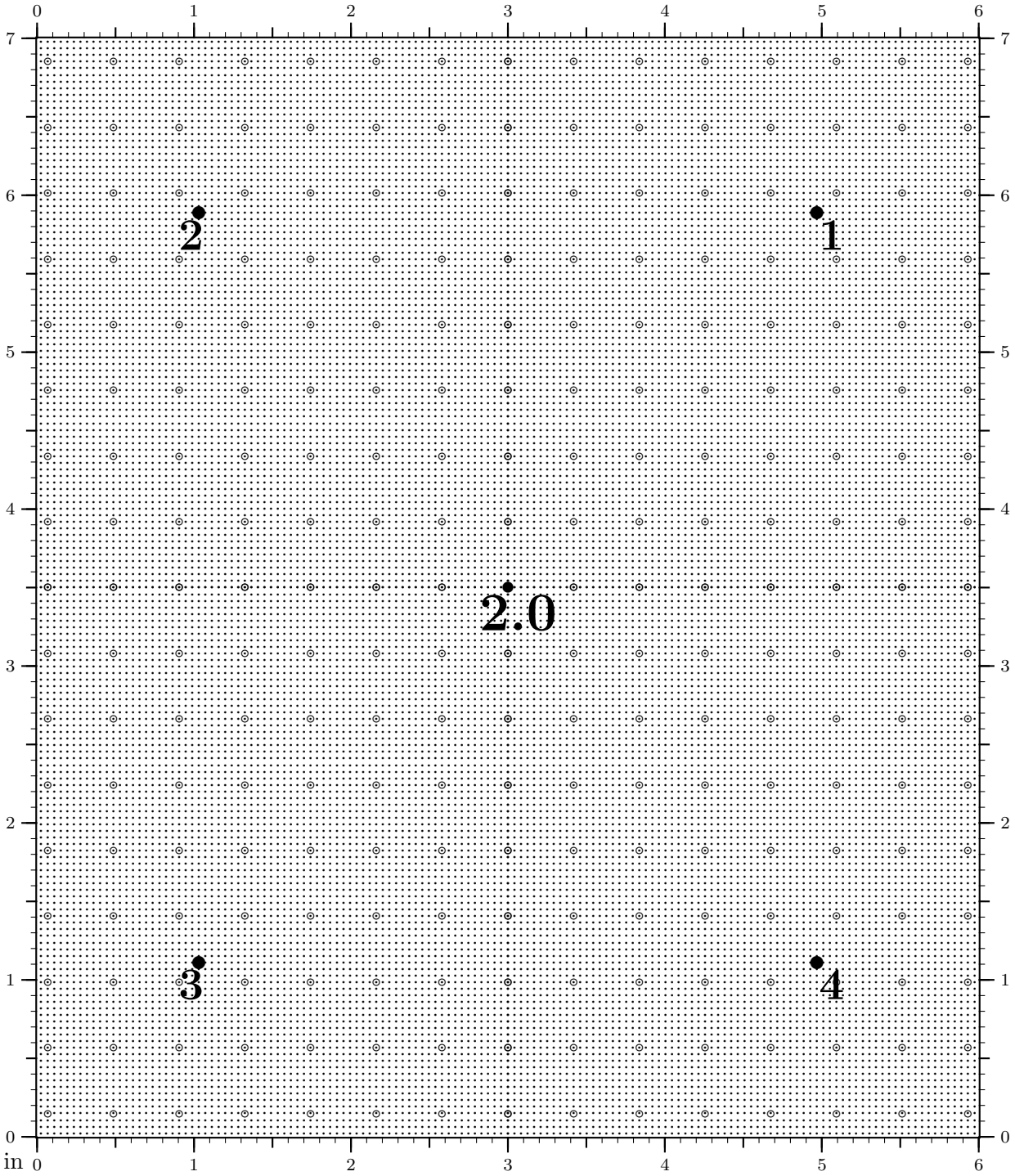

Figure 1: **0.1° at 2.0 feet is 0.041888 in.**

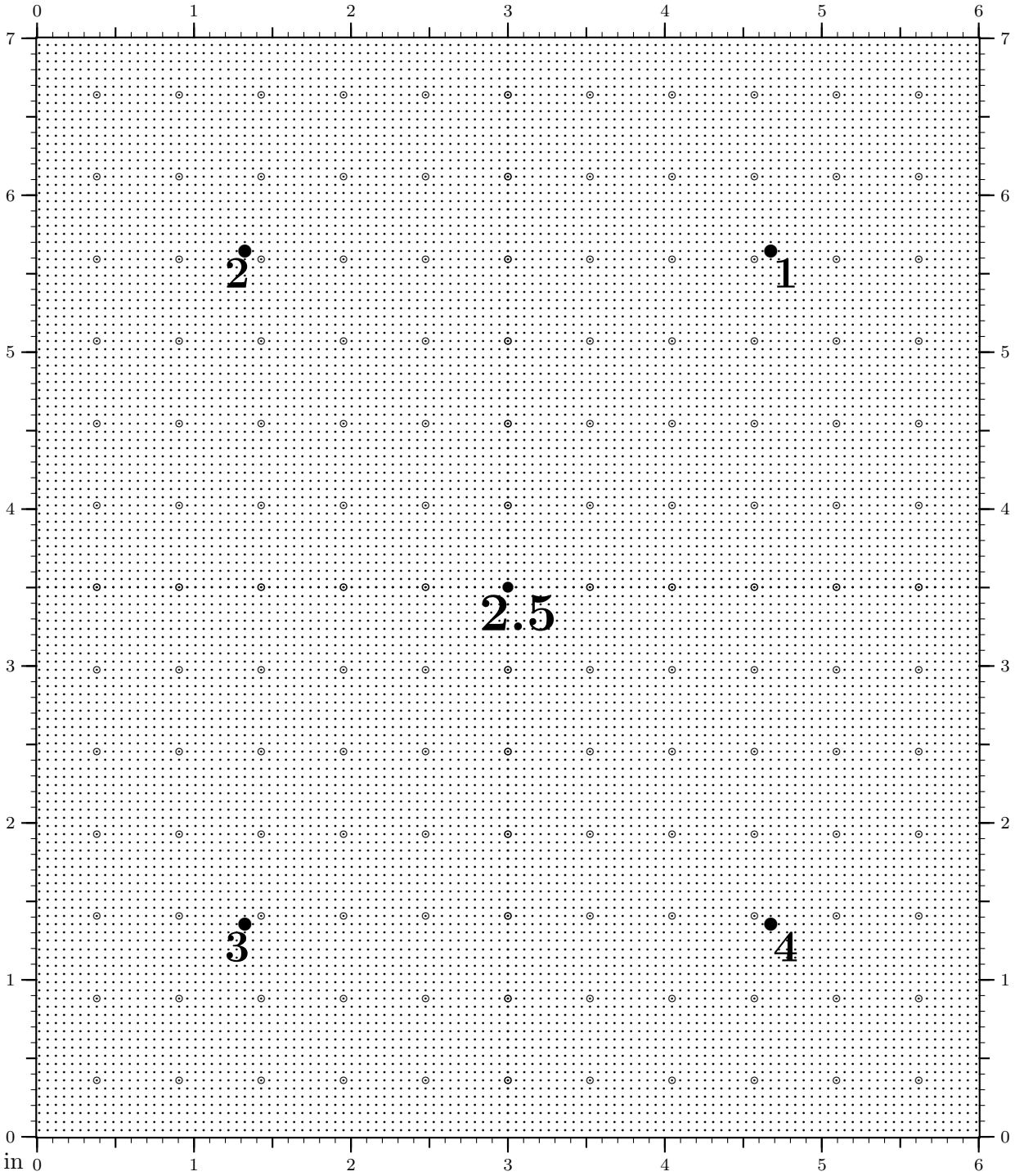

Figure 2: **0.1° at 2.5 feet is 0.052360 in.**

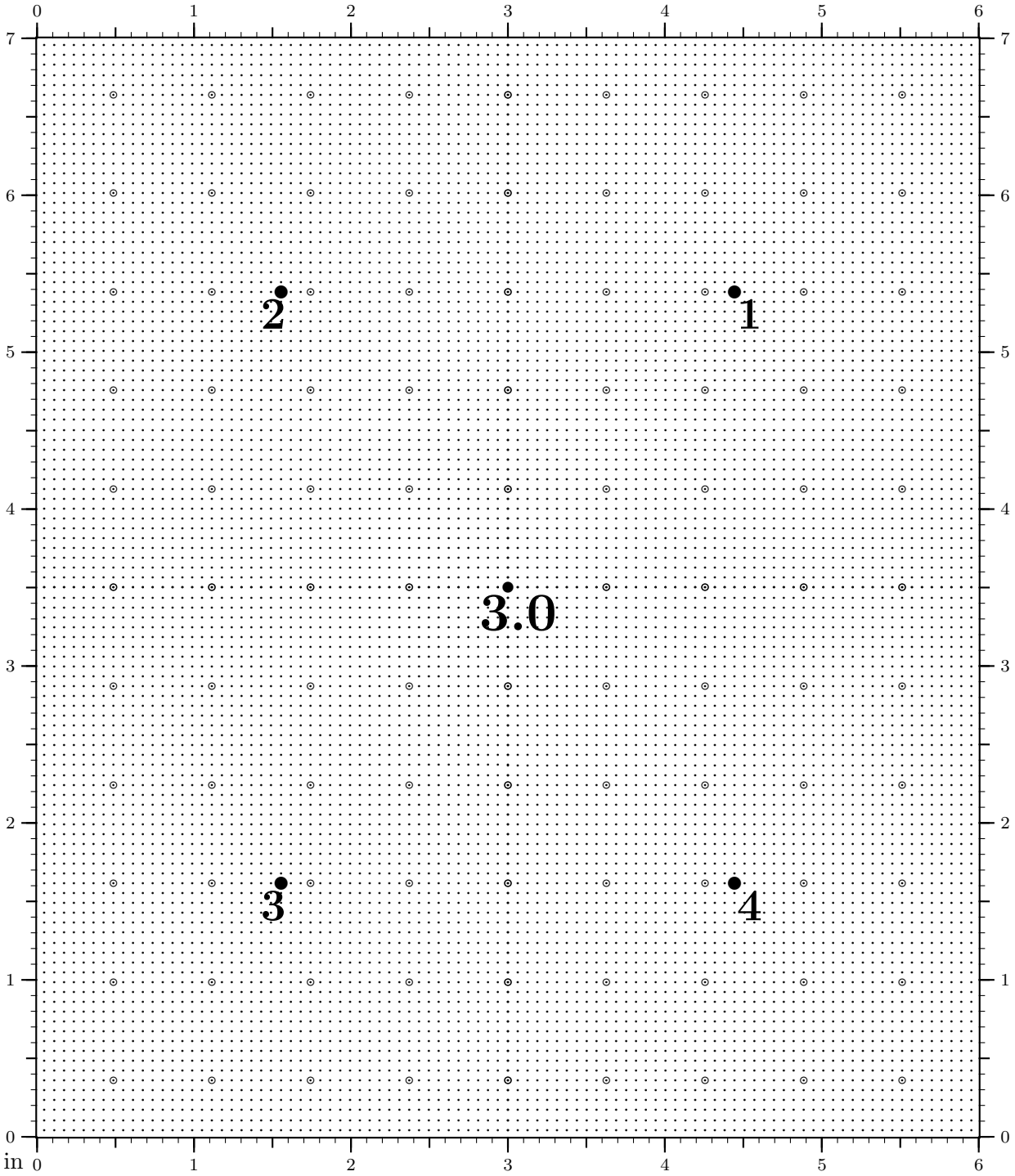

Figure 3: **0.1° at 3.0 feet is 0.062832 in.**

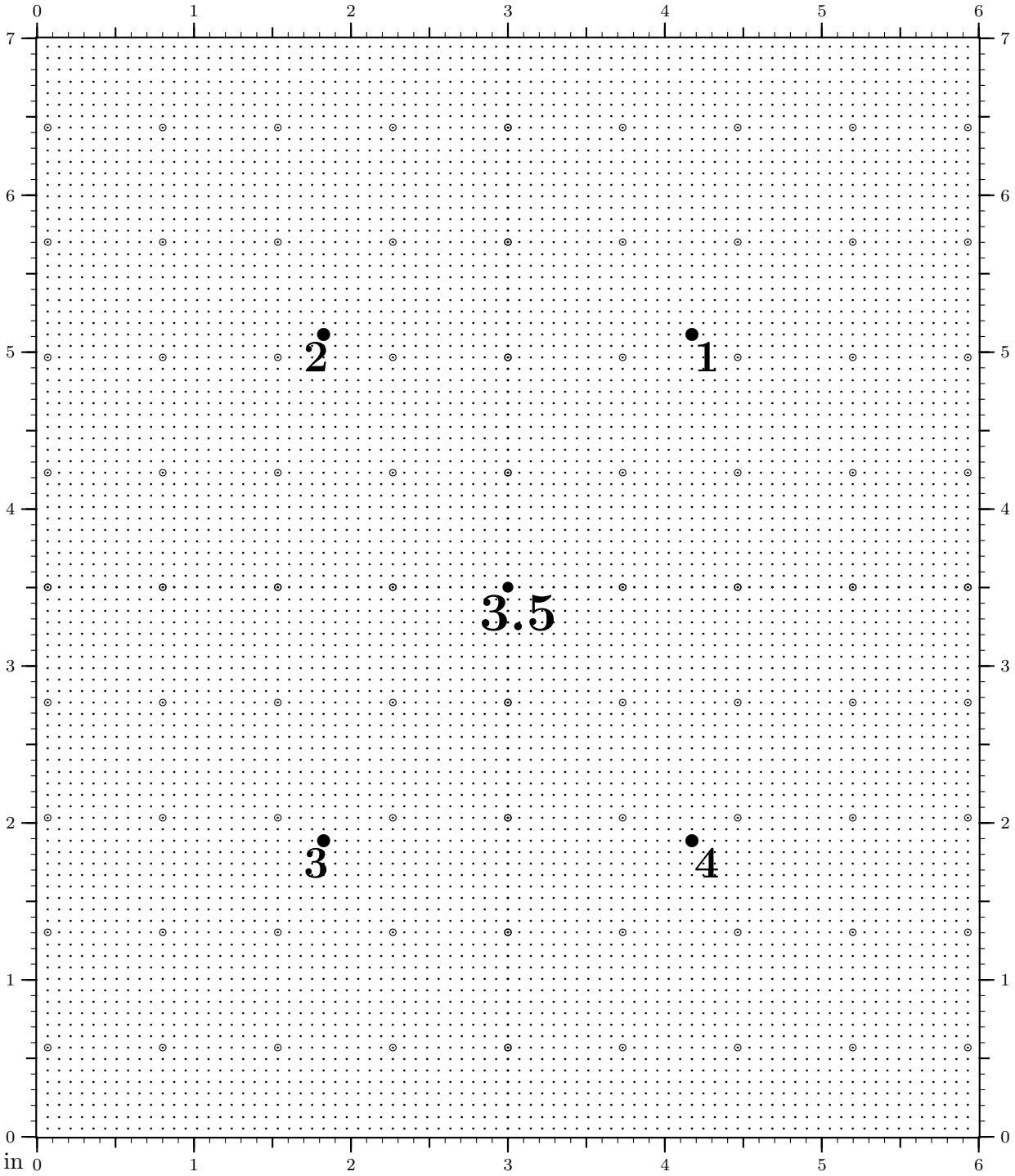

Figure 4: **0.1° at 3.5 feet is 0.073304 in.**

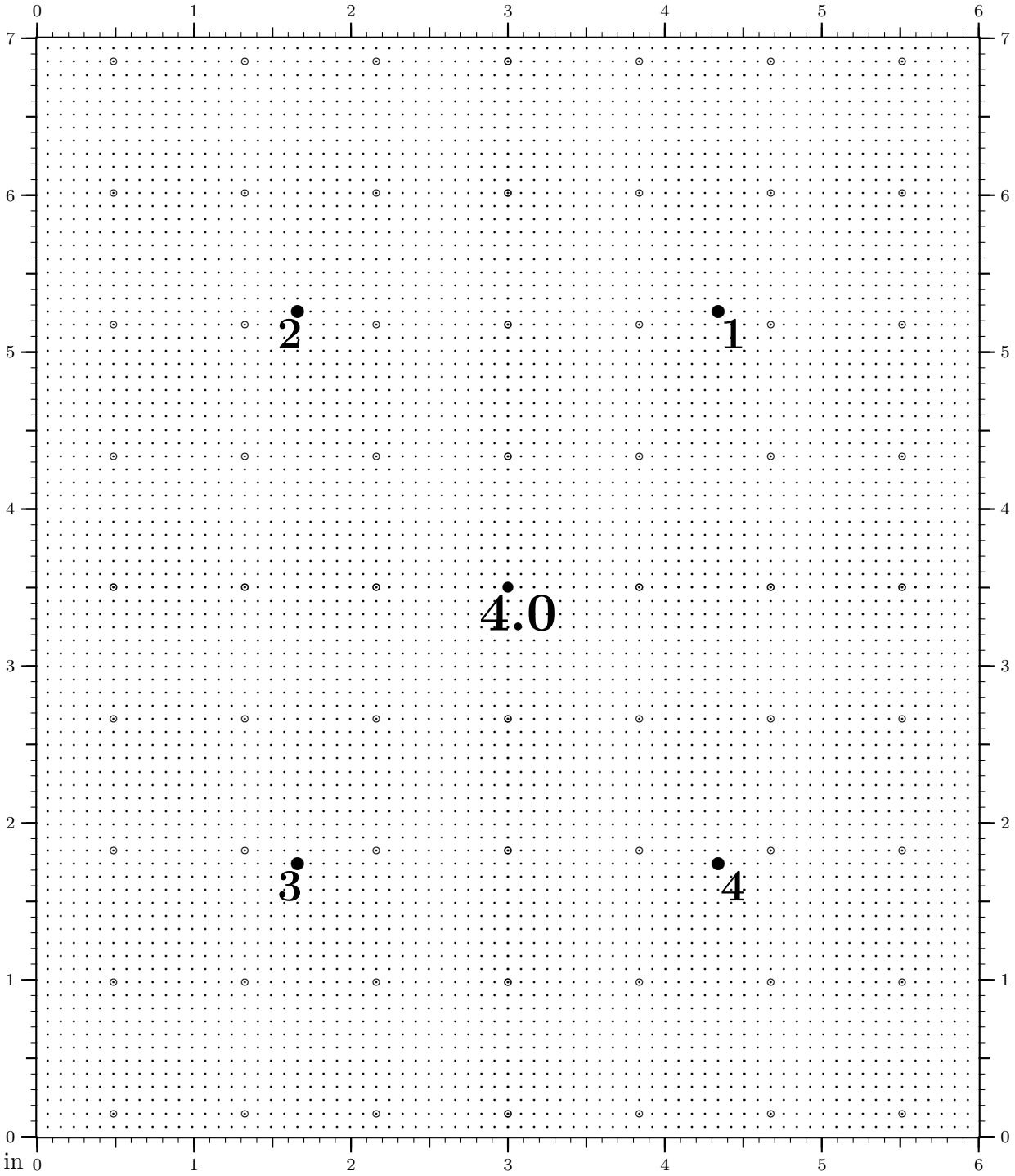

Figure 5: **0.1° at 4.0 feet is 0.083776 in.**

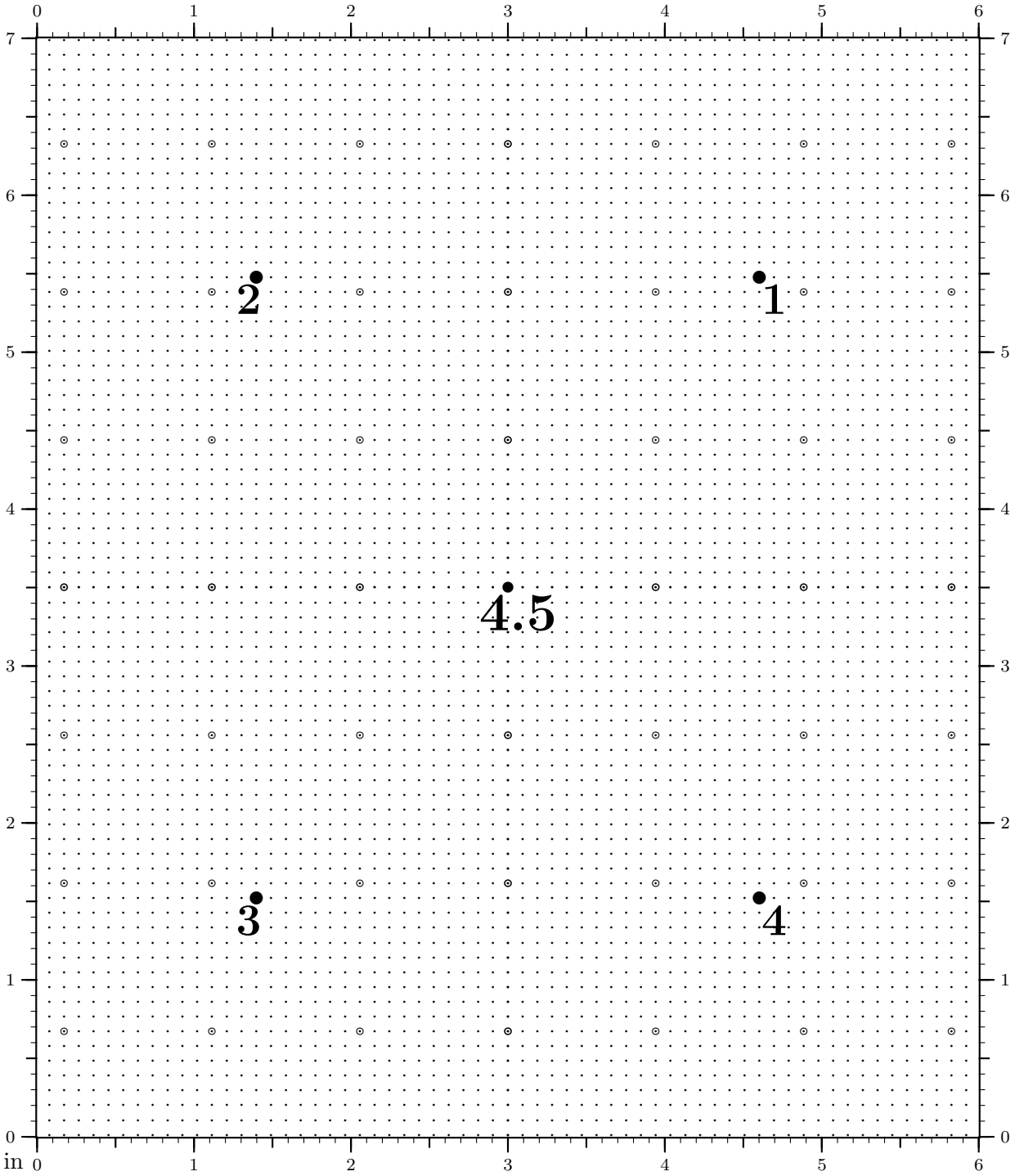

Figure 6: **0.1° at 4.5 feet is 0.094248 in.**

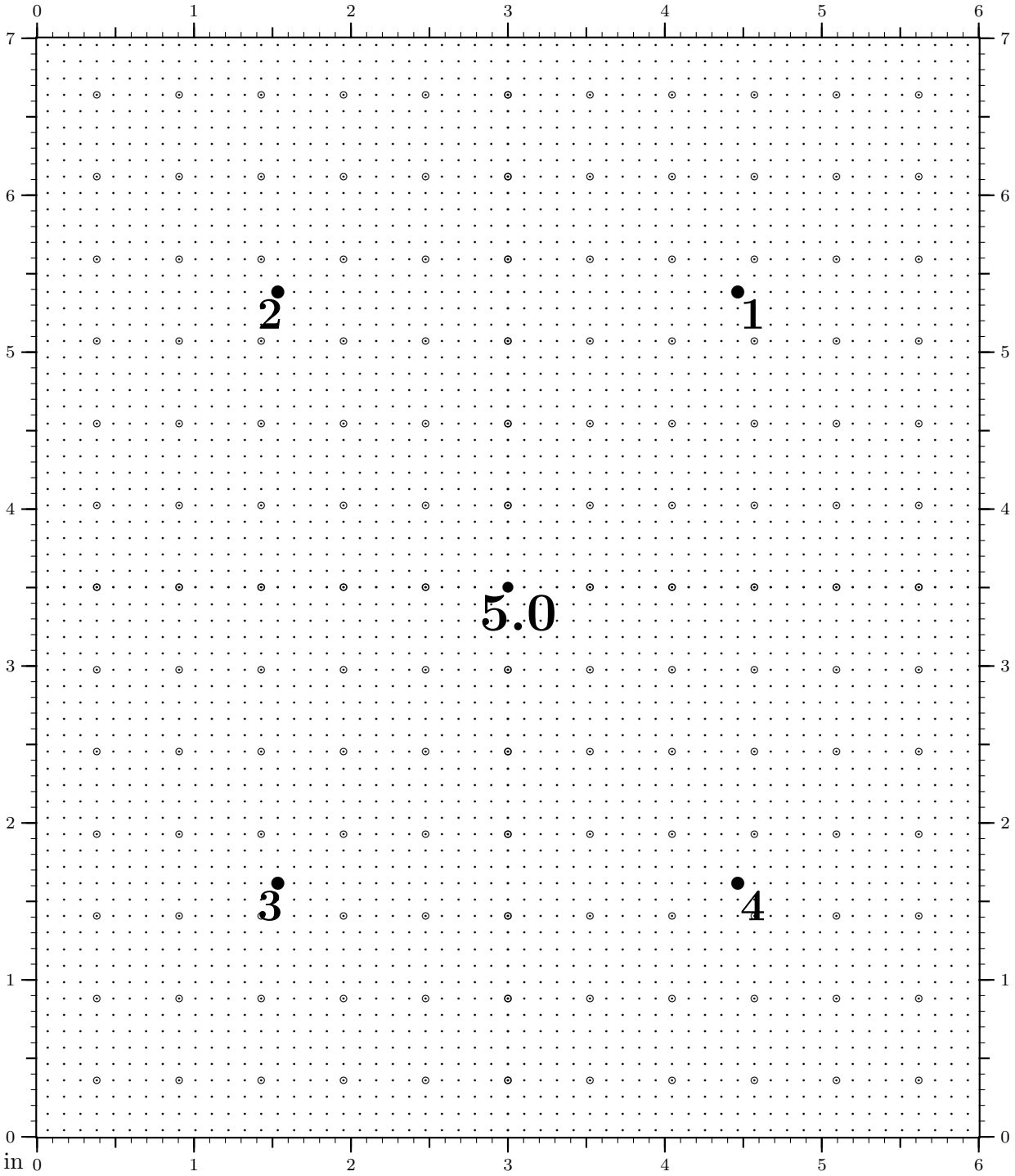

Figure 7: **0.1° at 5.0 feet is 0.104720 in.**

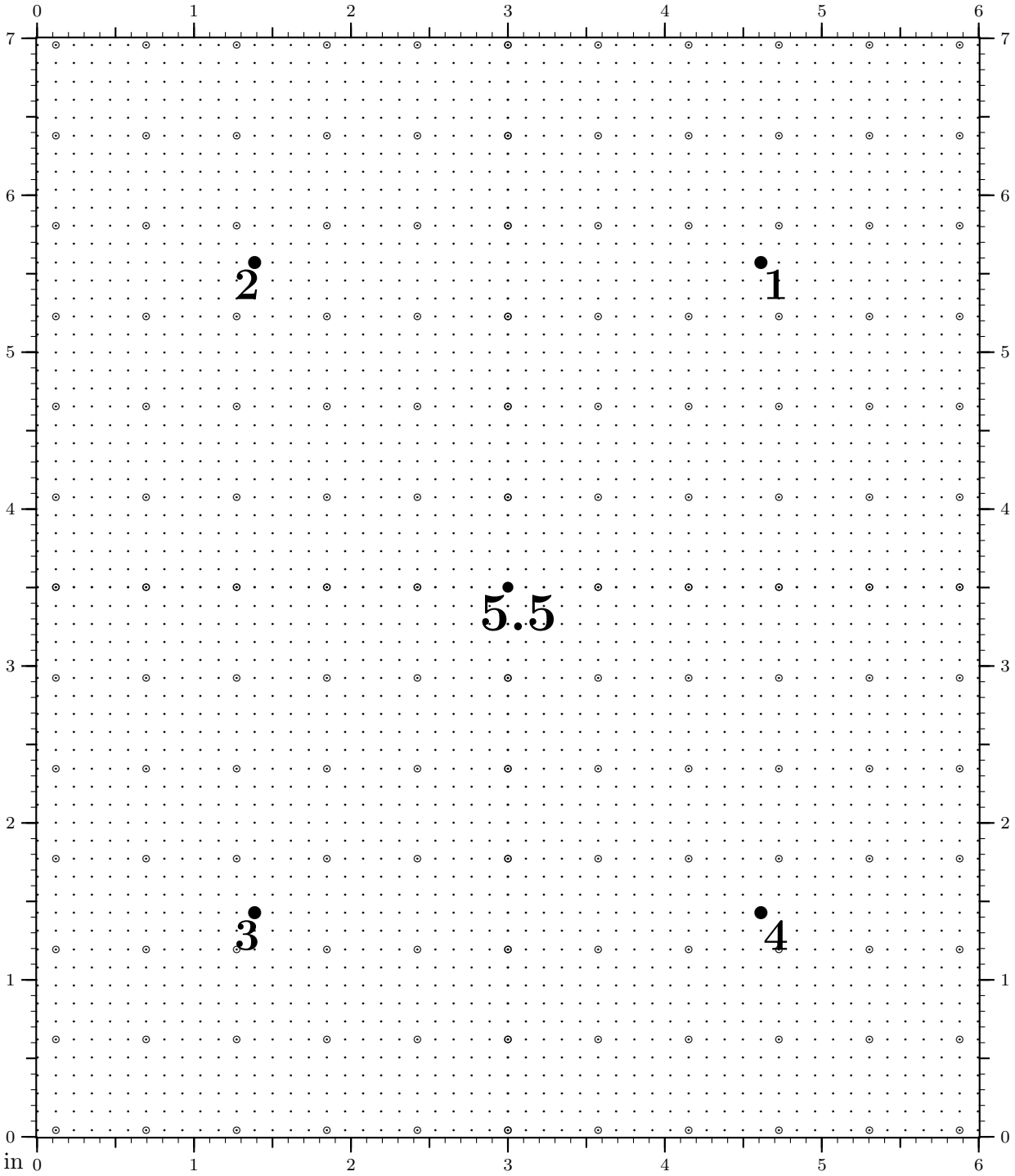

Figure 8: **0.1° at 5.5 feet is 0.115192 in.**

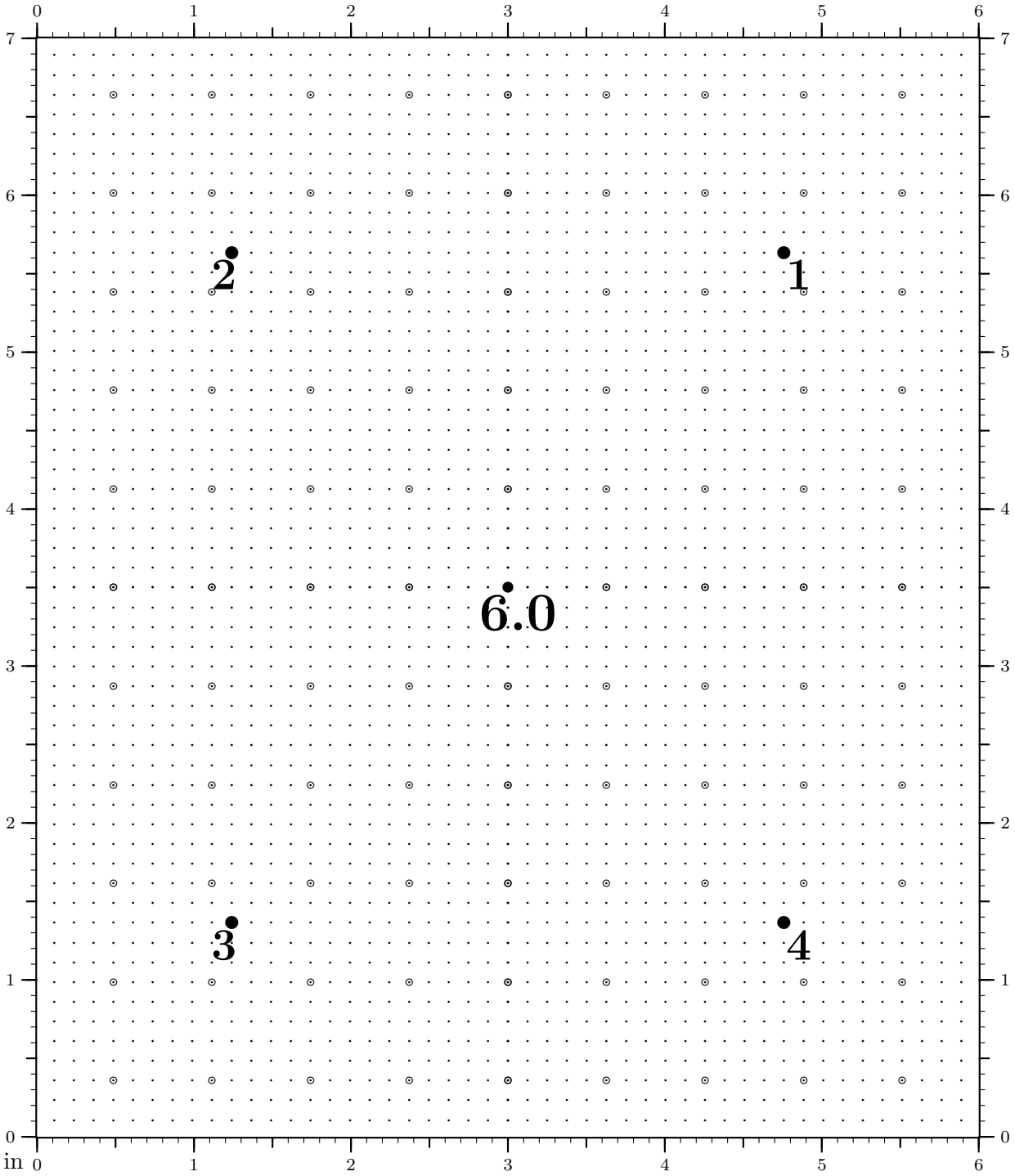

Figure 9: **0.1° at 6.0 feet is 0.125664 in.**

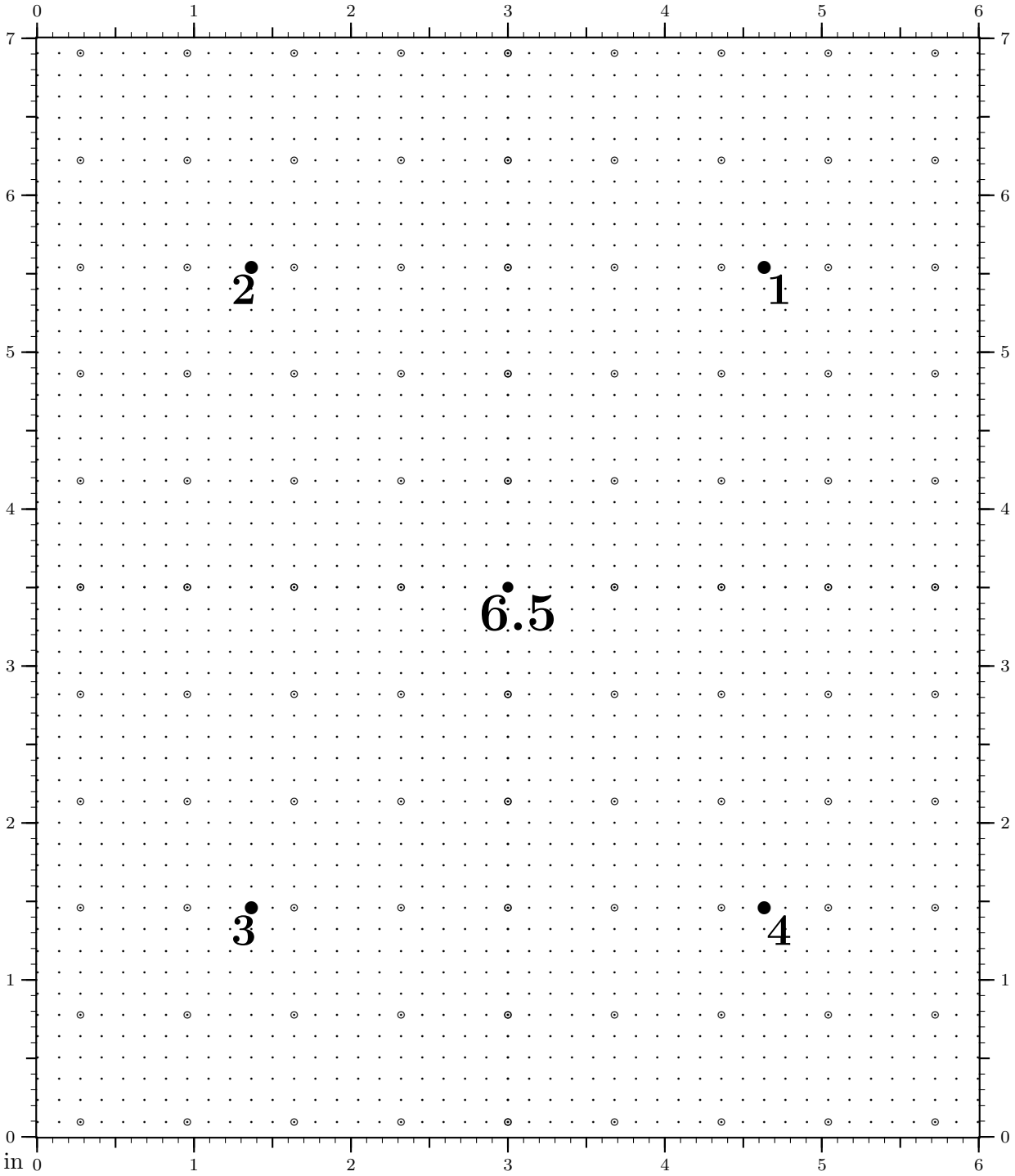

Figure 10: **0.1° at 6.5 feet is 0.136136 in.**

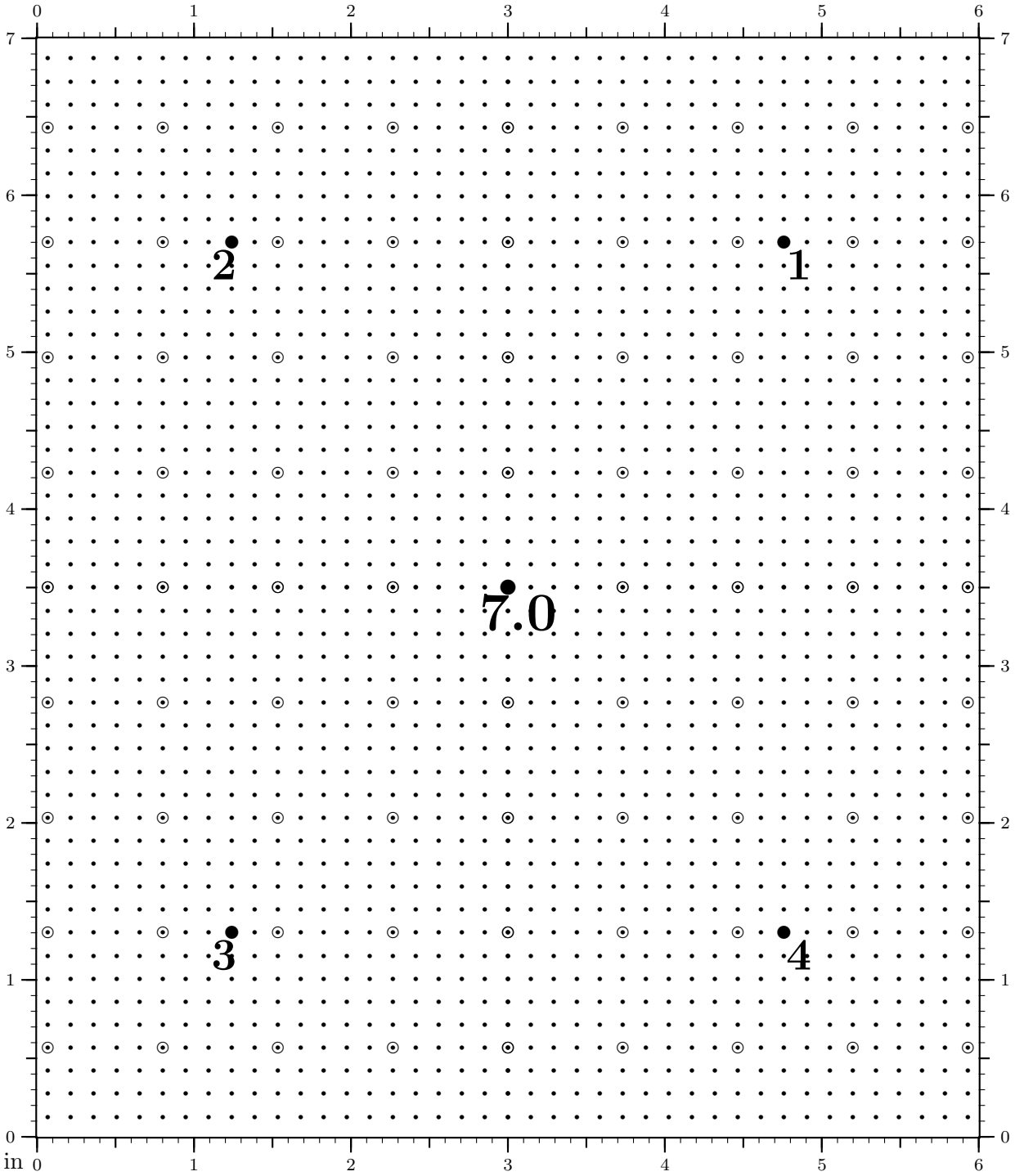

Figure 11: **0.1° at 7.0 feet is 0.146608 in.**

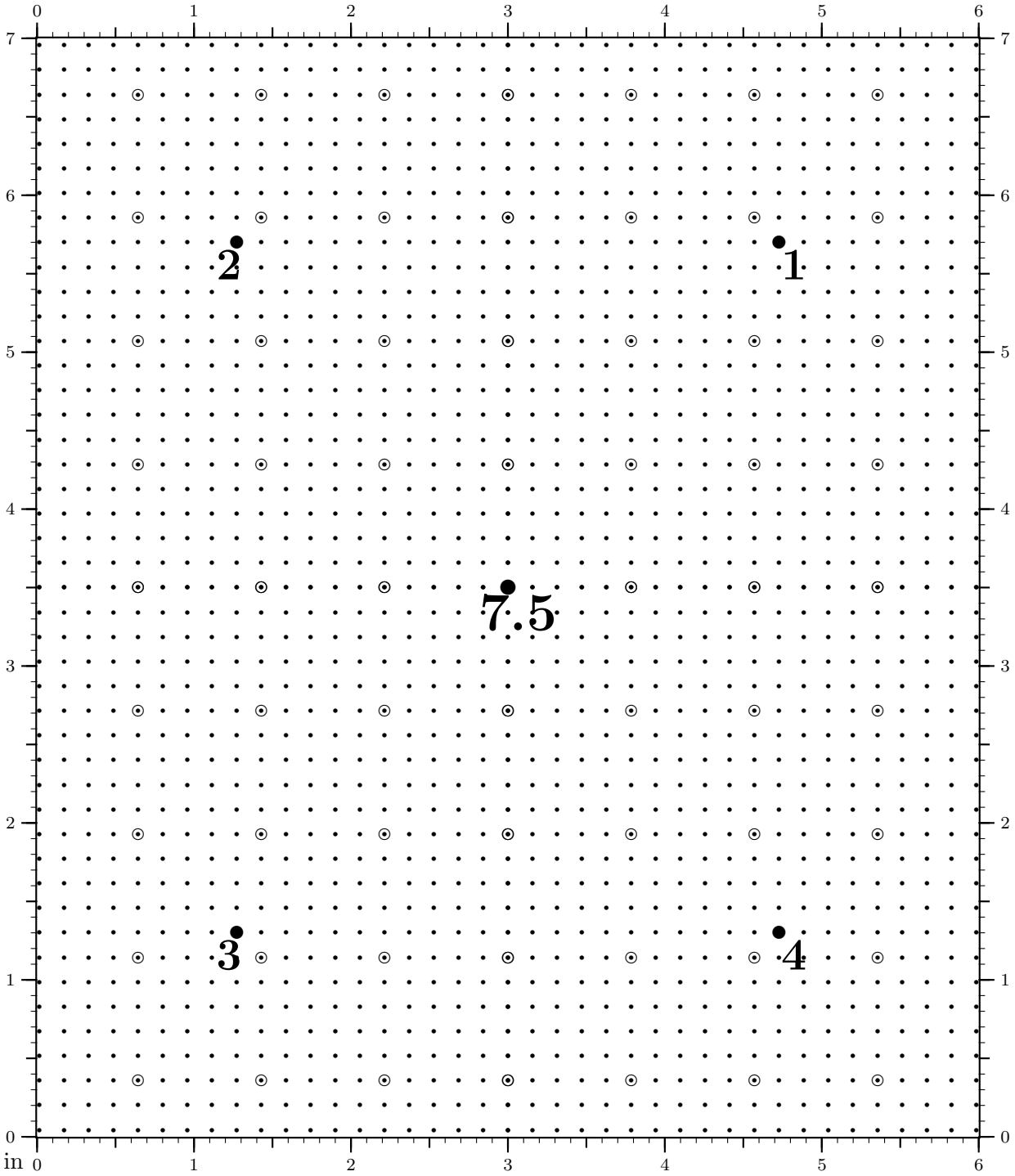

Figure 12: **0.1° at 7.5 feet is 0.157080 in.**

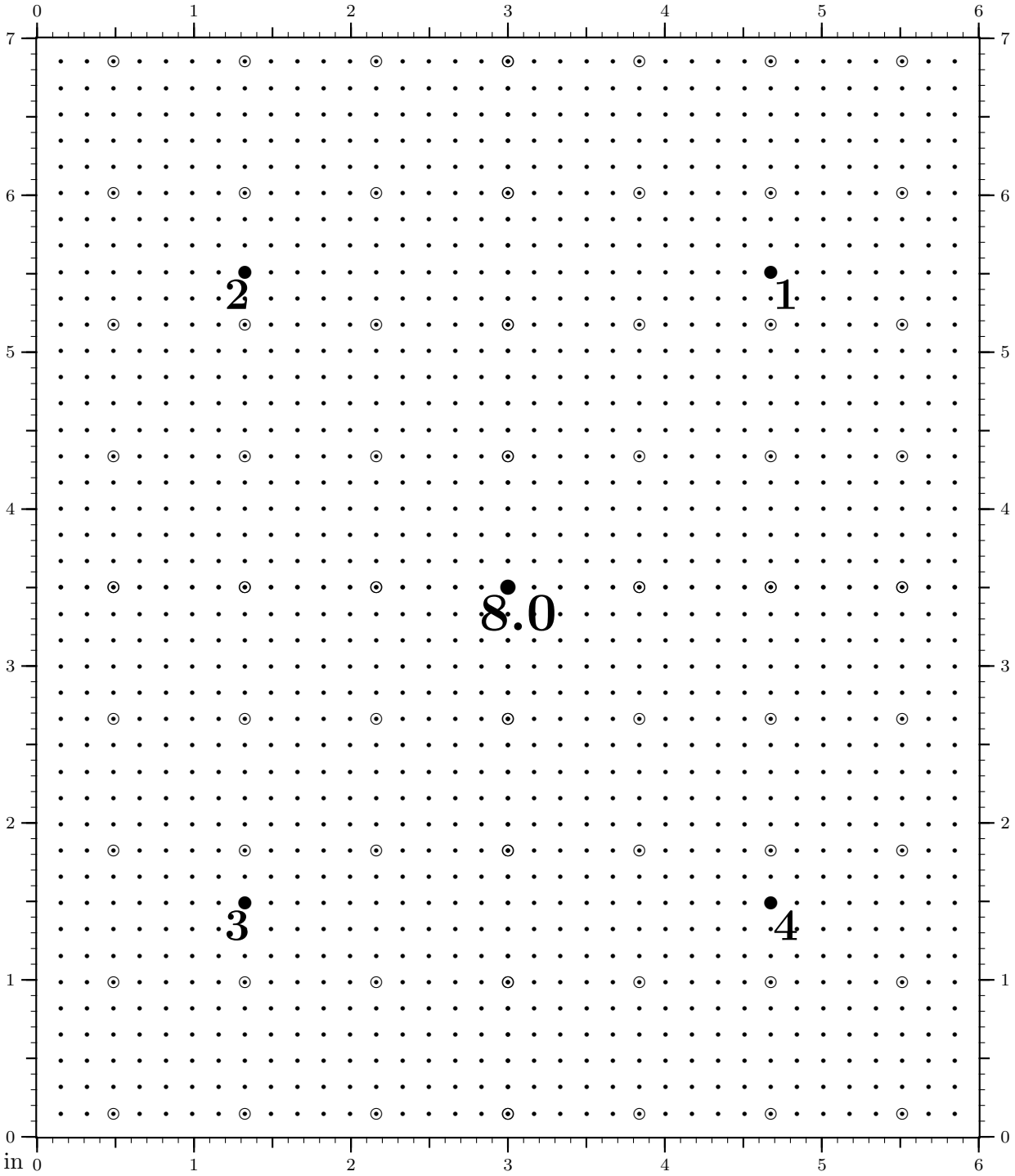

Figure 13: **0.1° at 8.0 feet is 0.167552 in.**

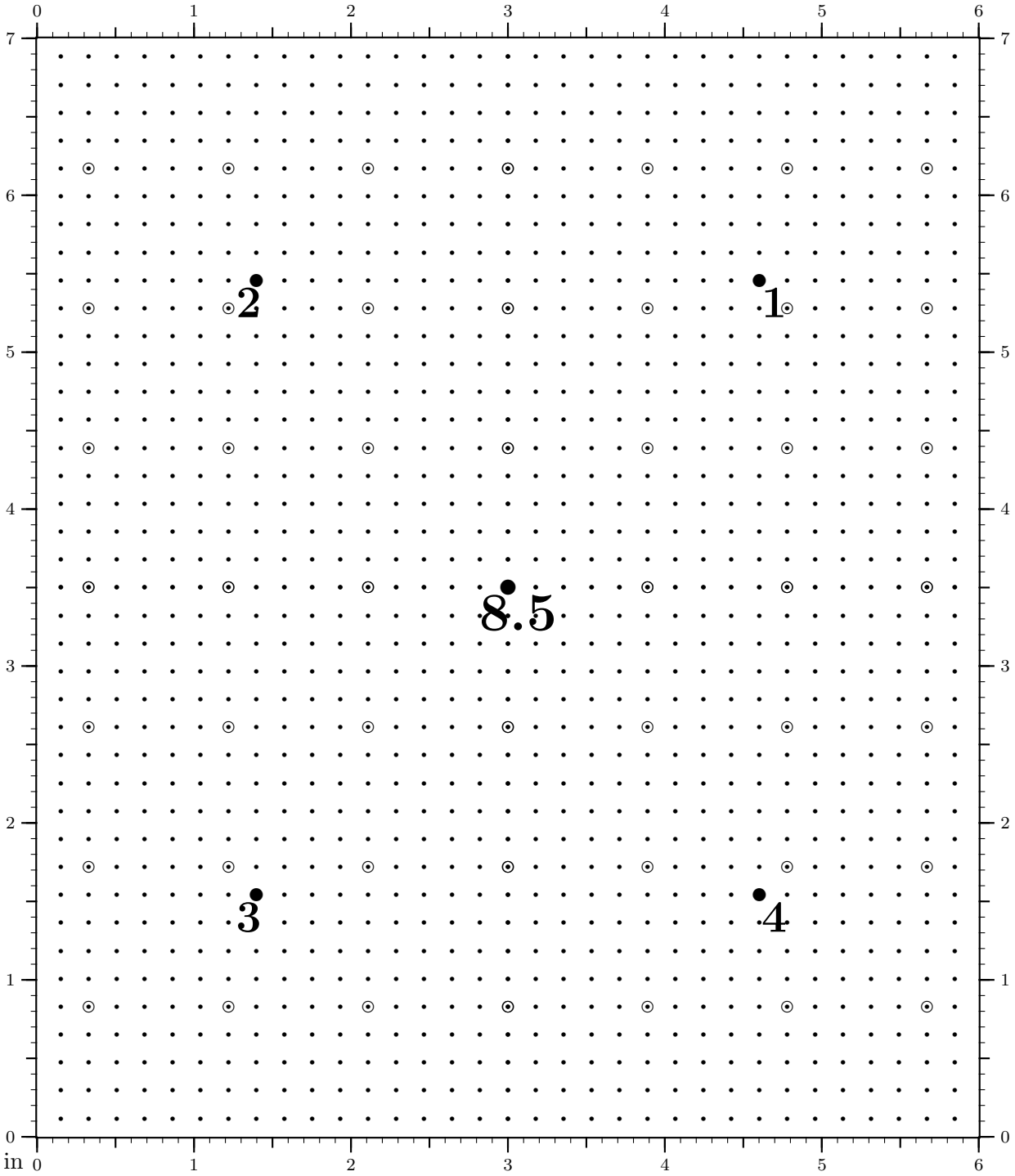

Figure 14: **0.1° at 8.5 feet is 0.178024 in.**

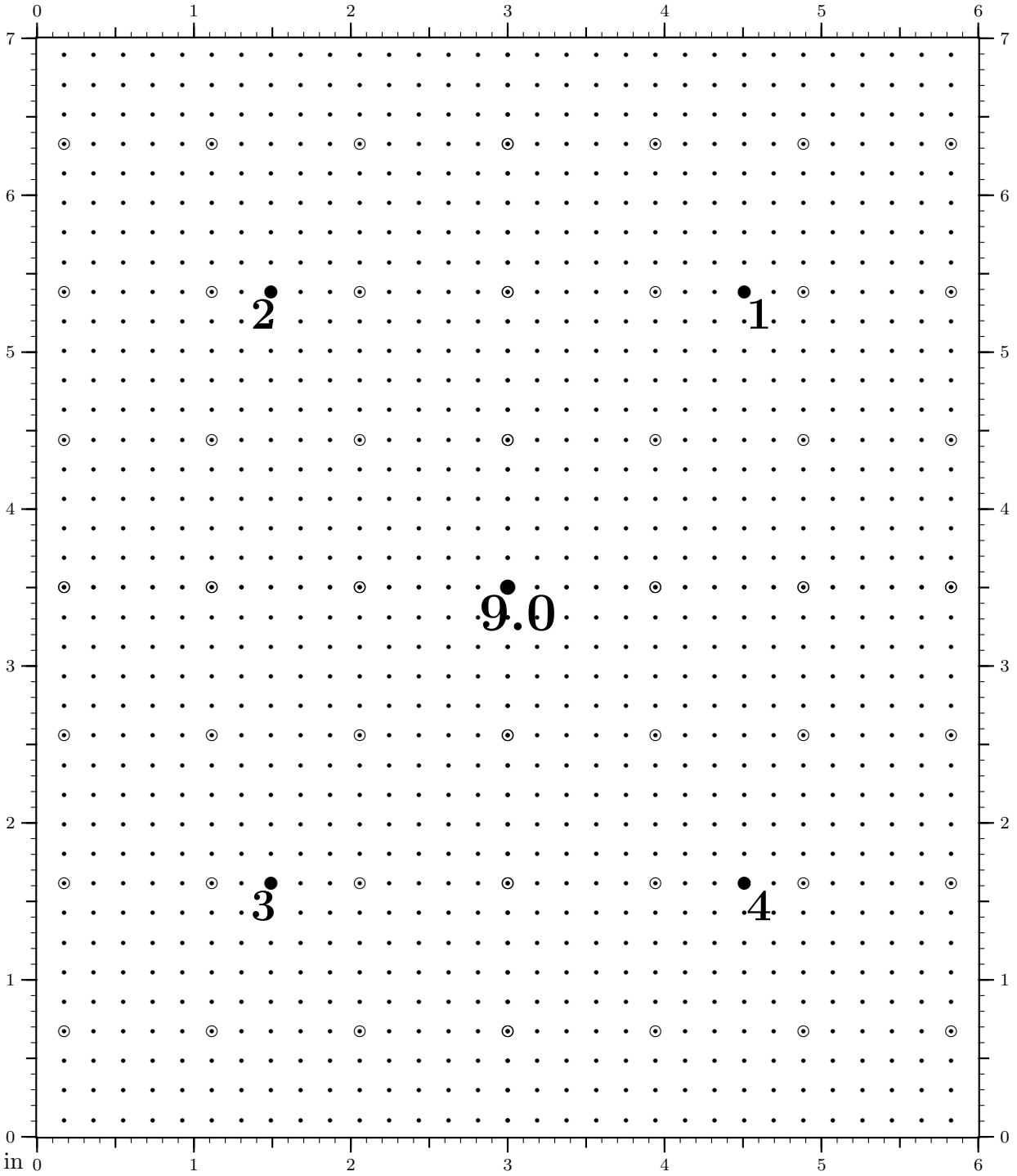

Figure 15: **0.1° at 9.0 feet is 0.188496 in.**

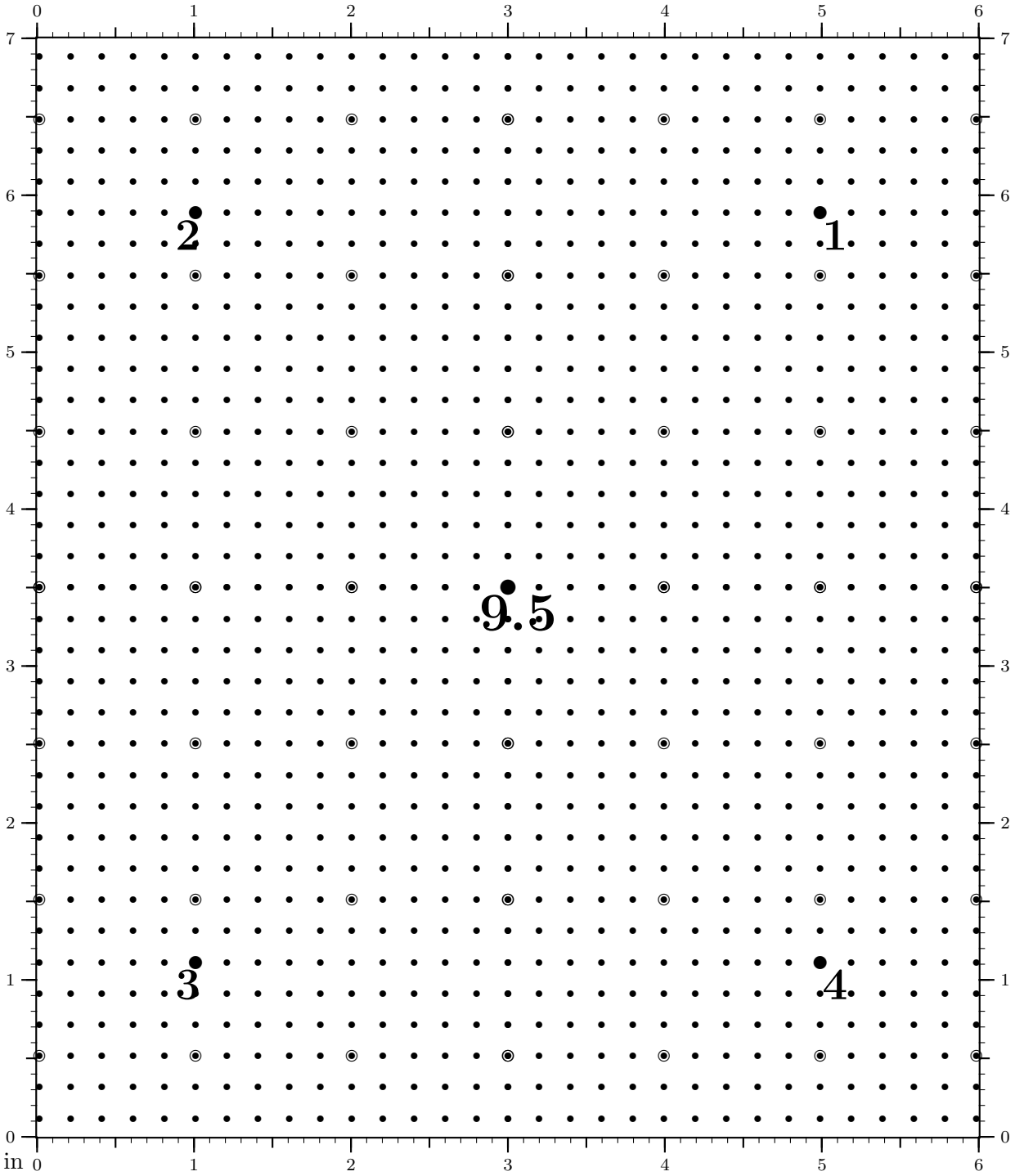

Figure 16: **0.1° at 9.5 feet is 0.198968 in.**

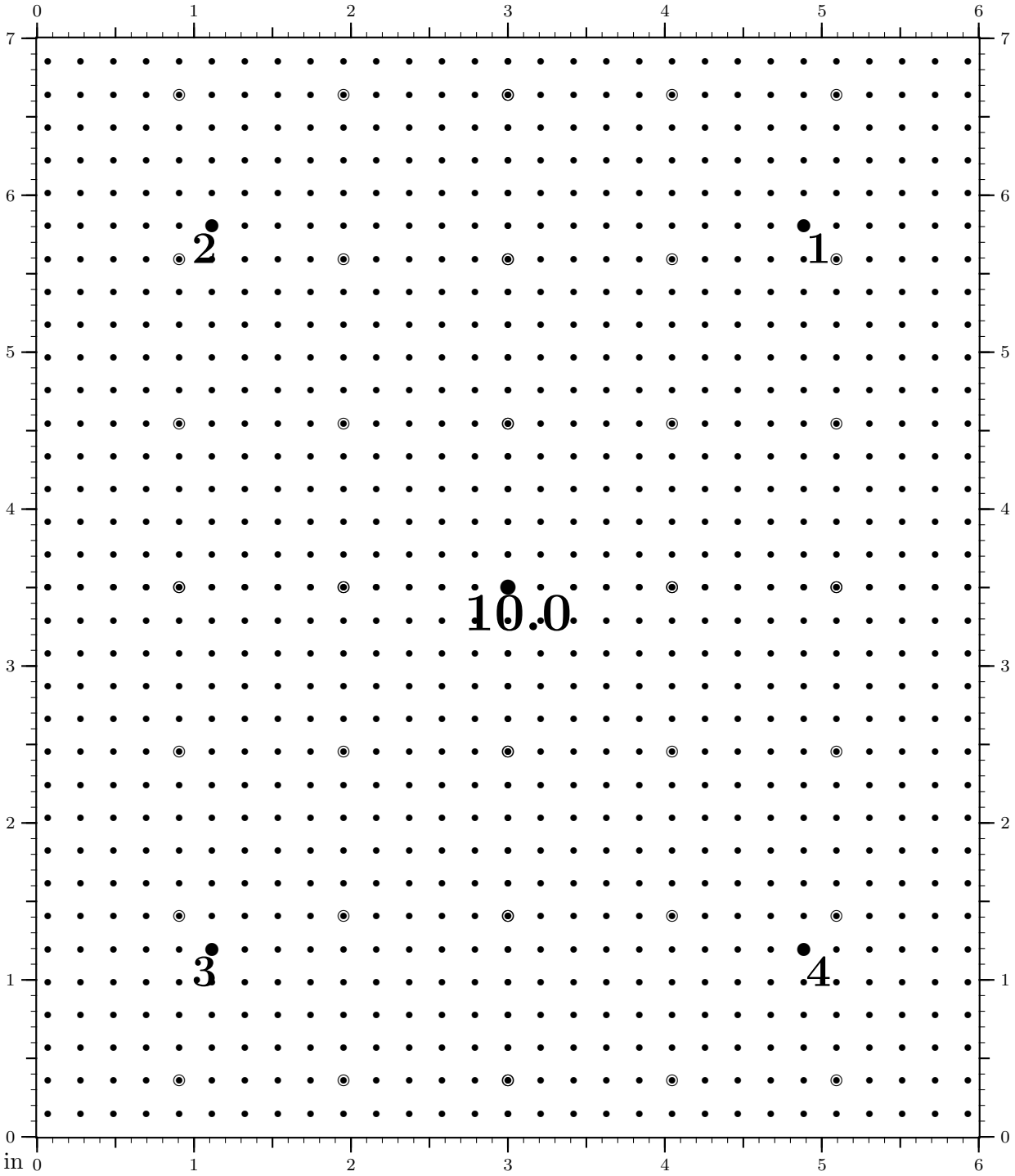

Figure 17: **0.1° at 10.0 feet is 0.209440 in.**

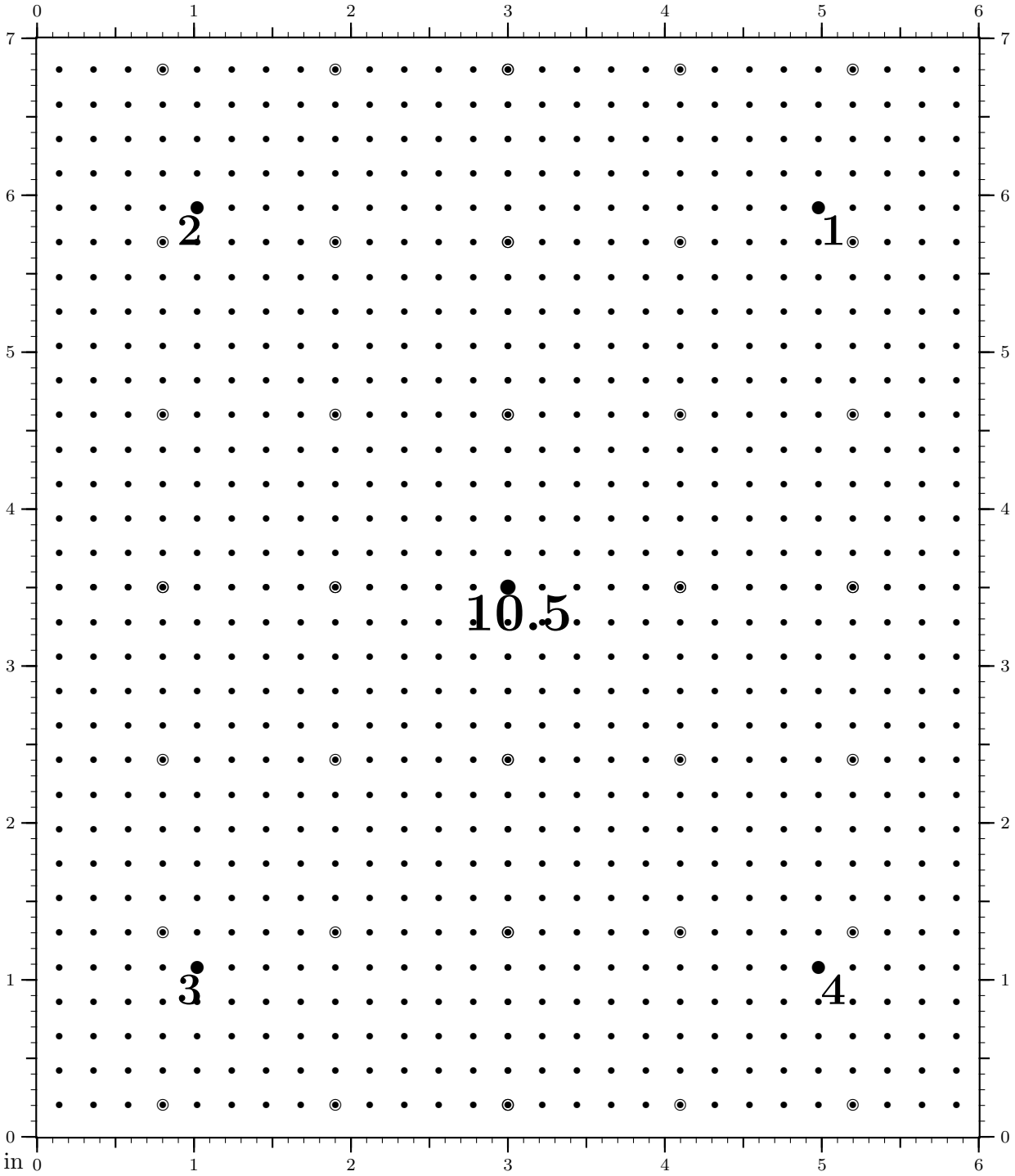

Figure 18: **0.1° at 10.5 feet is 0.219912 in.**

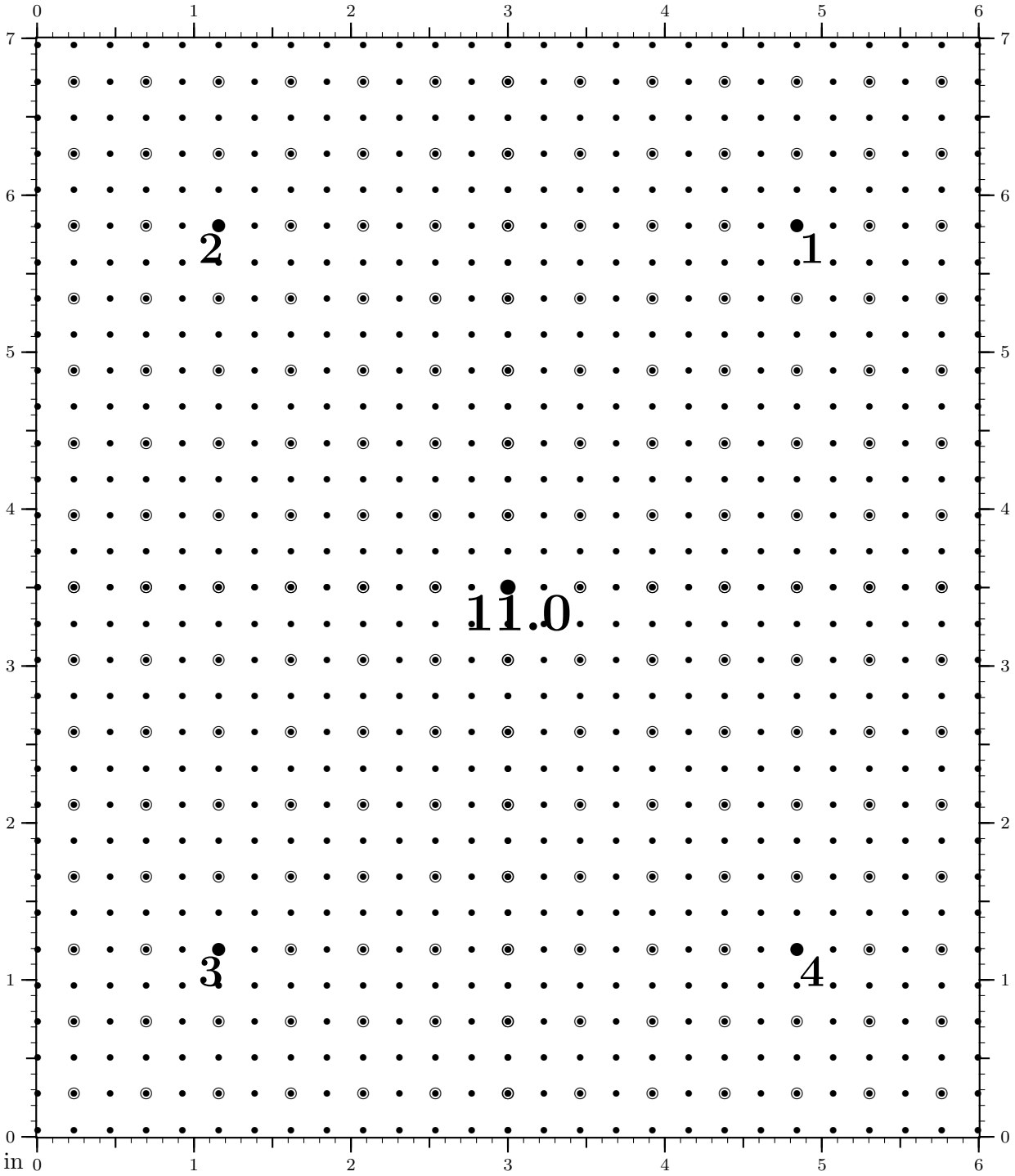

Figure 19: **0.1° at 11.0 feet is 0.230384 in.**

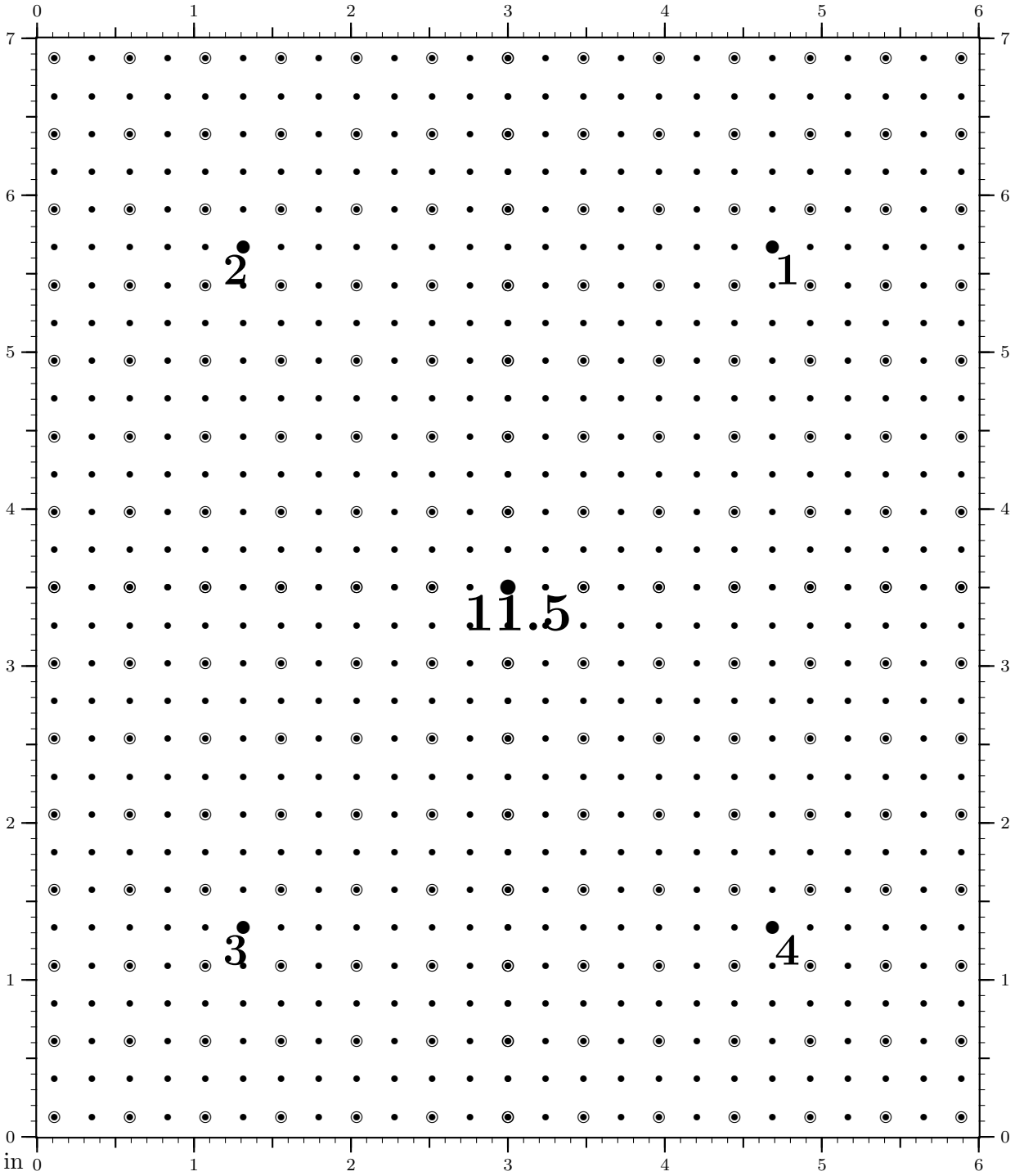

Figure 20: **0.1° at 11.5 feet is 0.240856 in.**

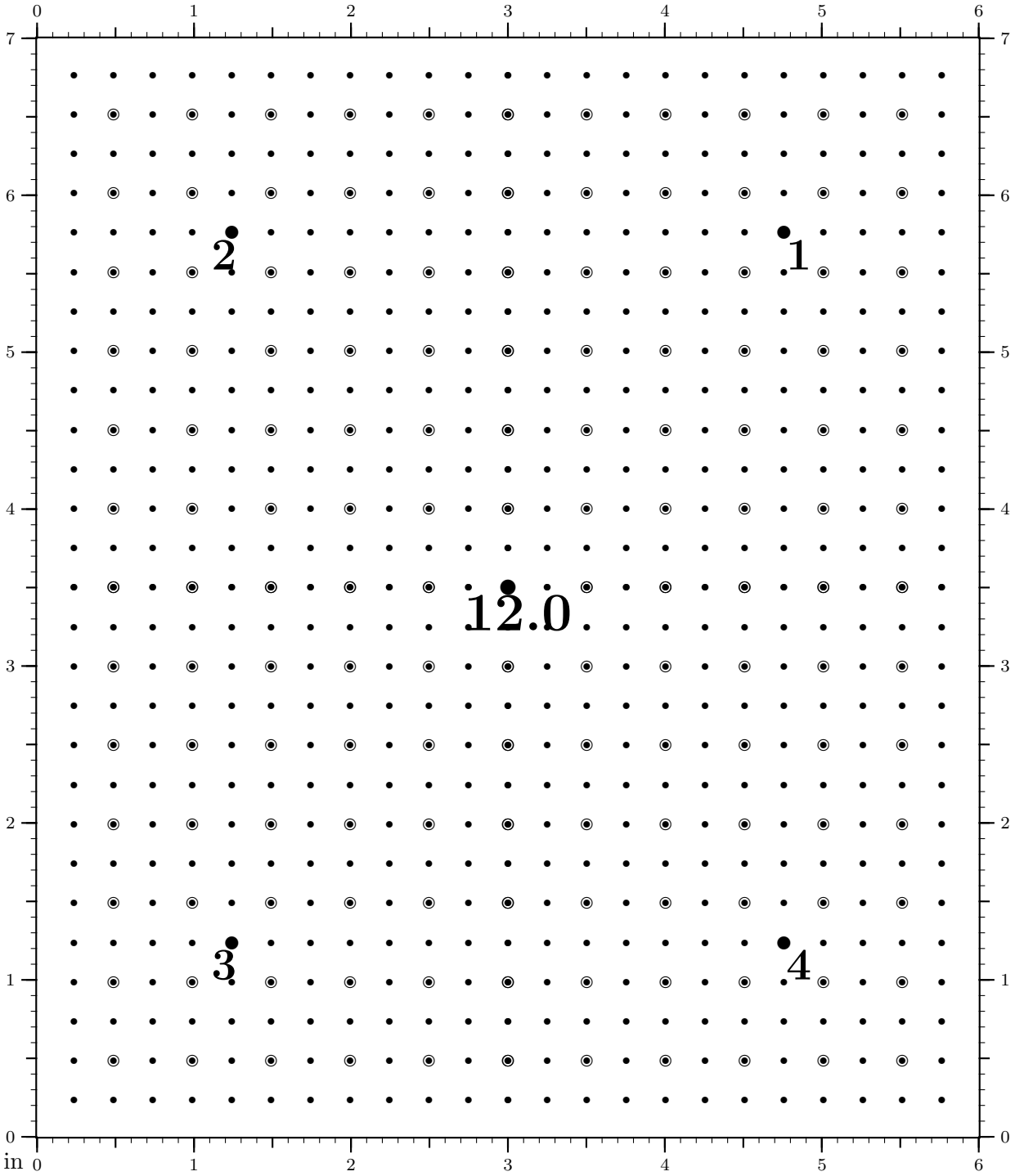

Figure 21: **0.1° at 12.0 feet is 0.251328 in.**

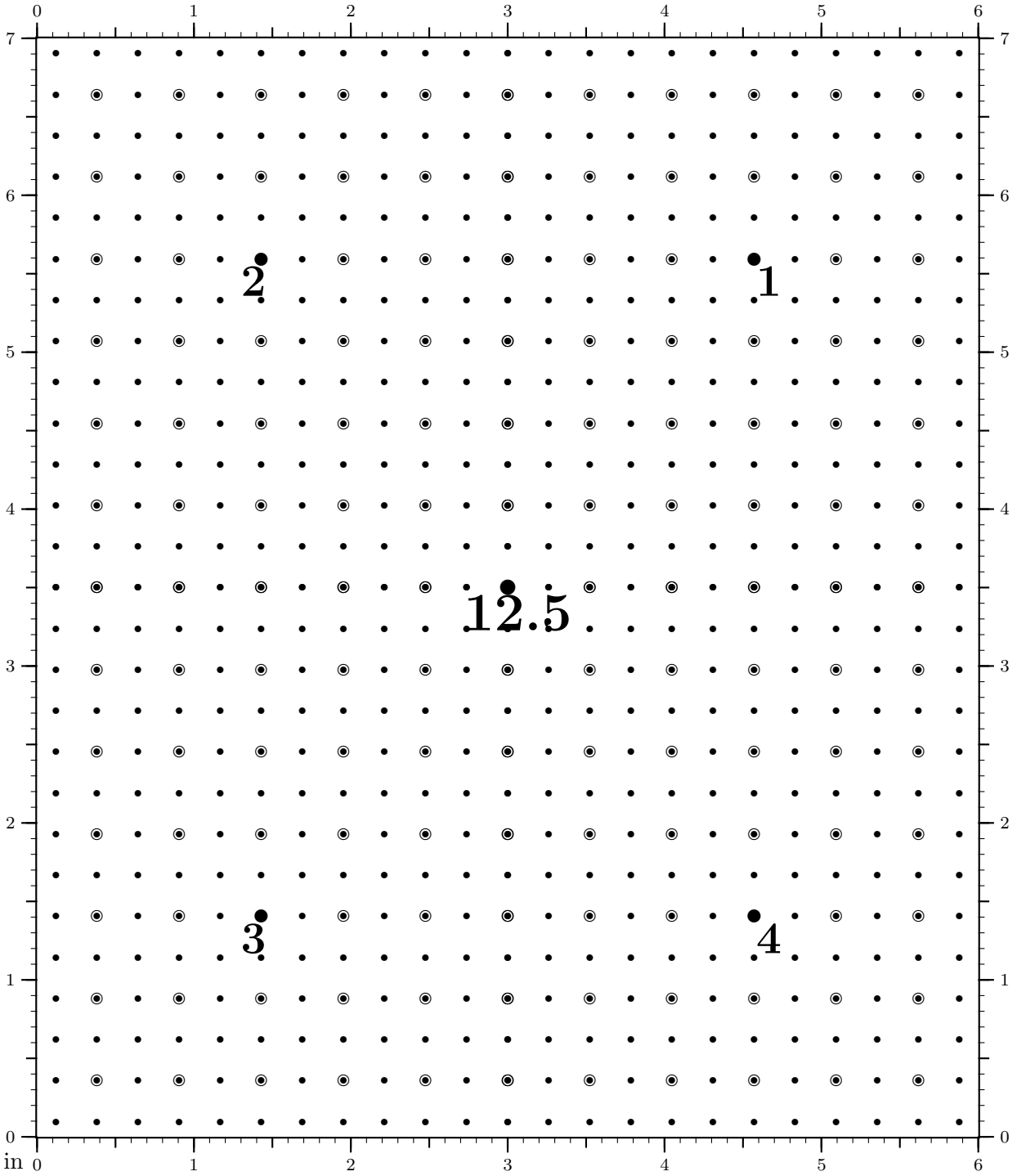

Figure 22: **0.1° at 12.5 feet is 0.261800 in.**

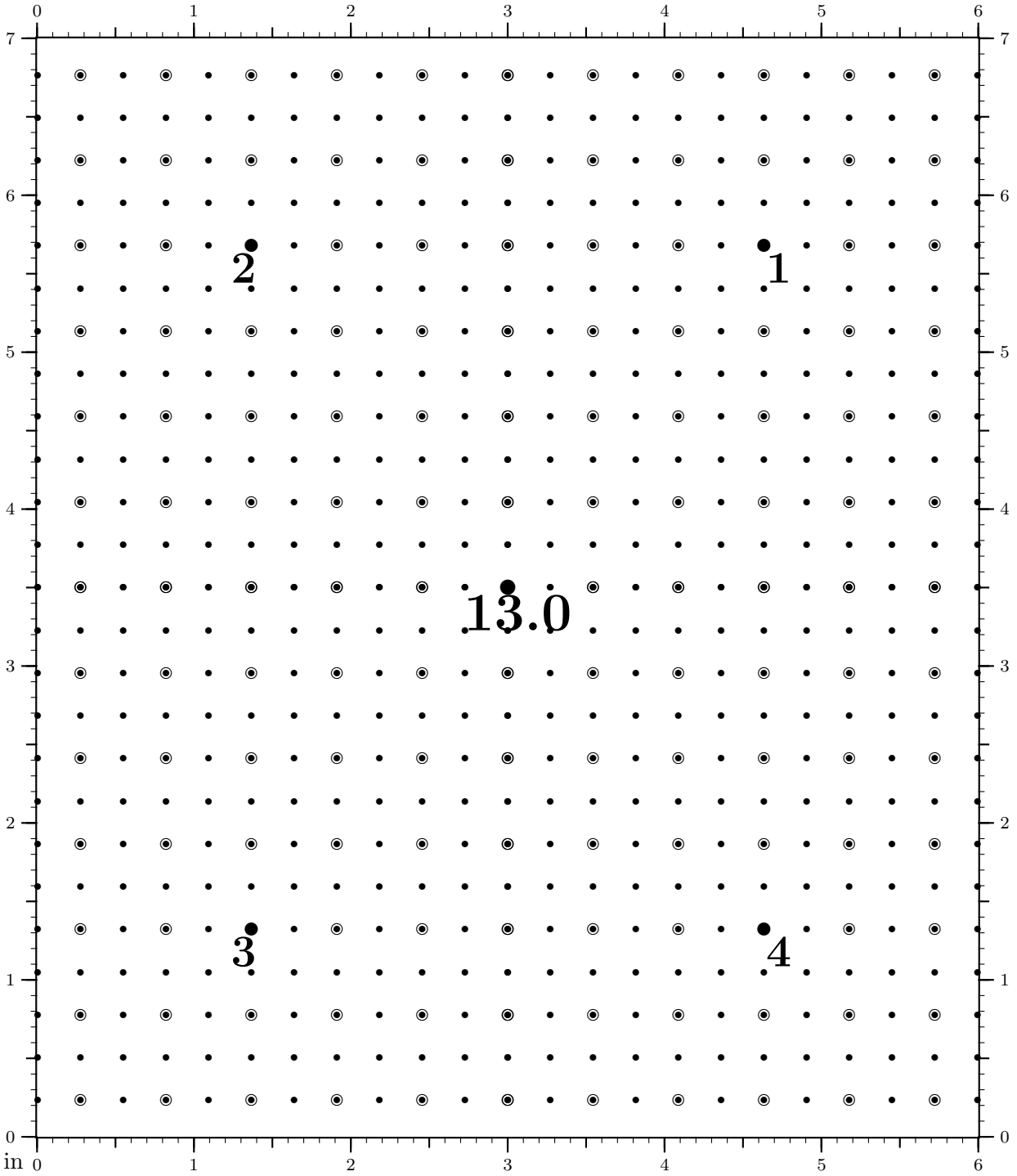

Figure 23: **0.1° at 13.0 feet is 0.272272 in.**

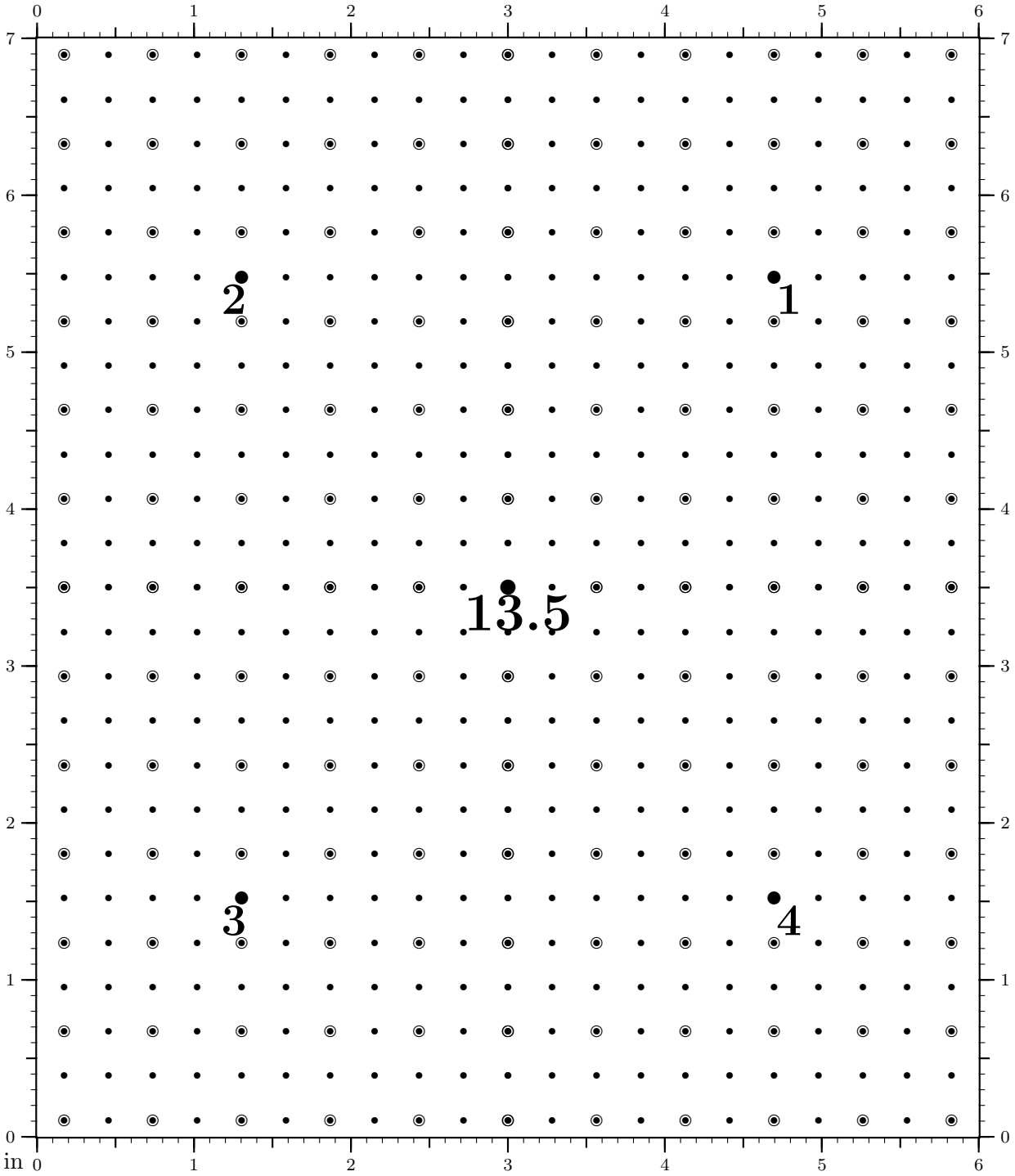

Figure 24: **0.1° at 13.5 feet is 0.282744 in.**

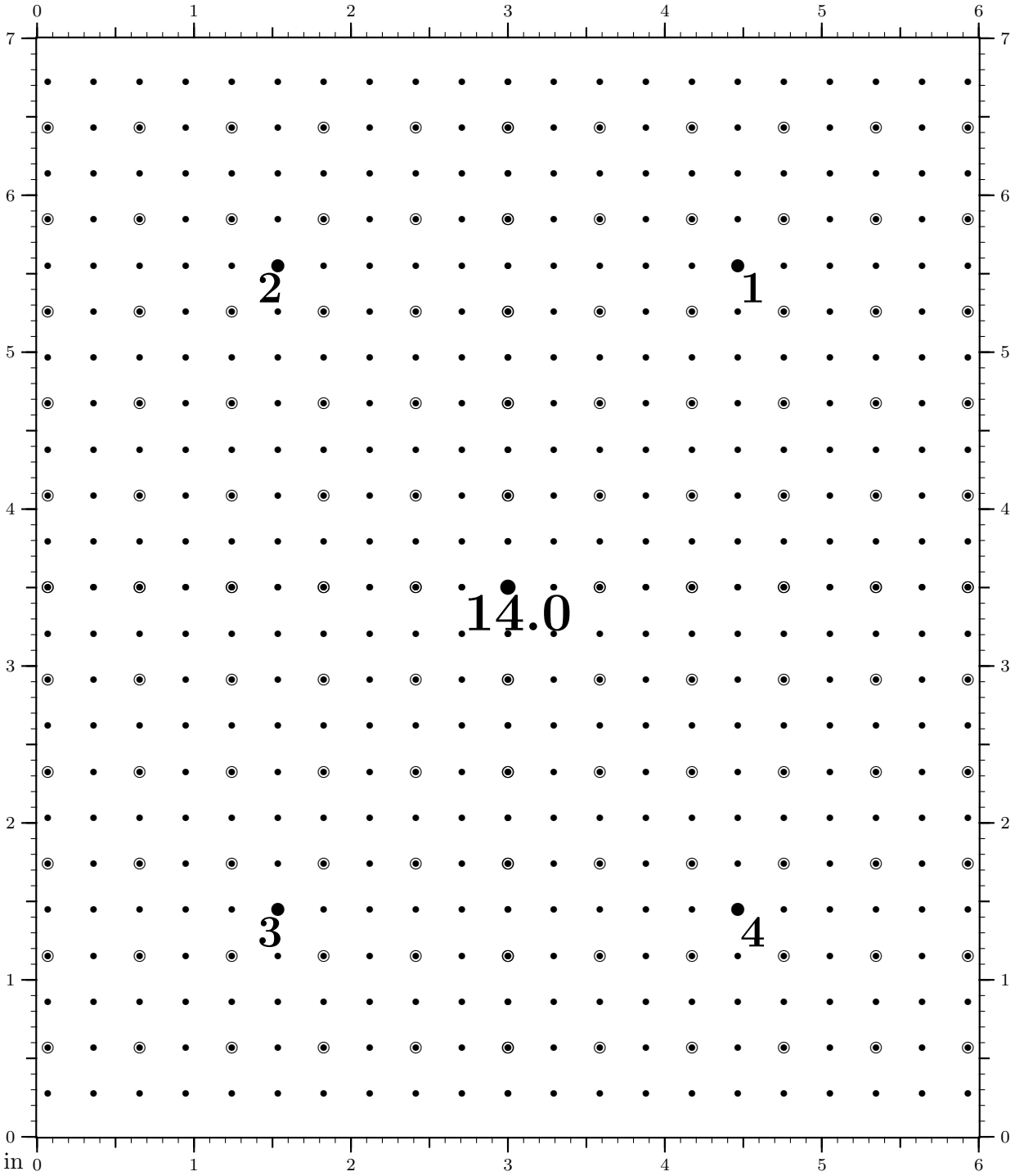

Figure 25: **0.1° at 14.0 feet is 0.293216 in.**

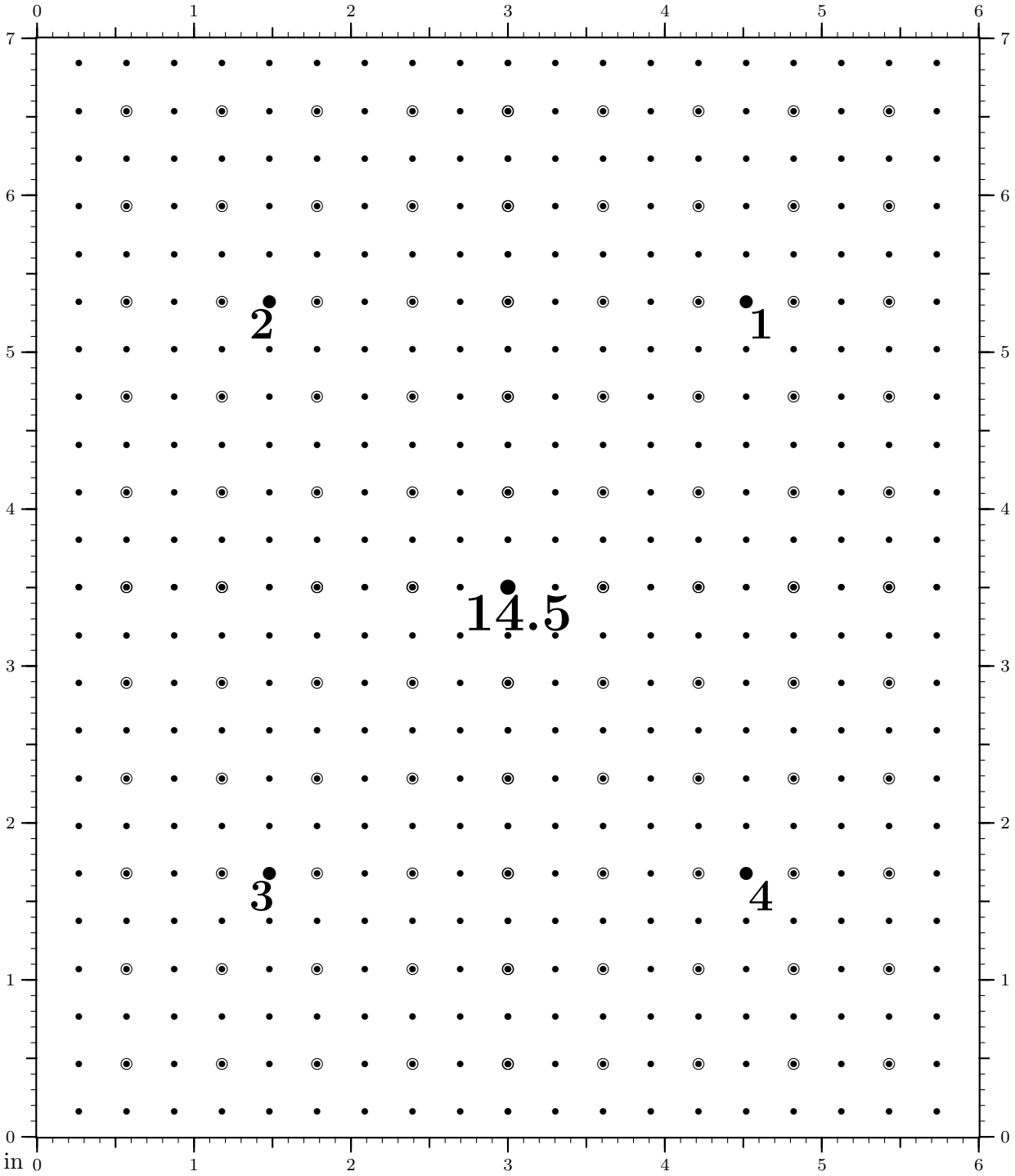

Figure 26: **0.1° at 14.5 feet is 0.303688 in.**

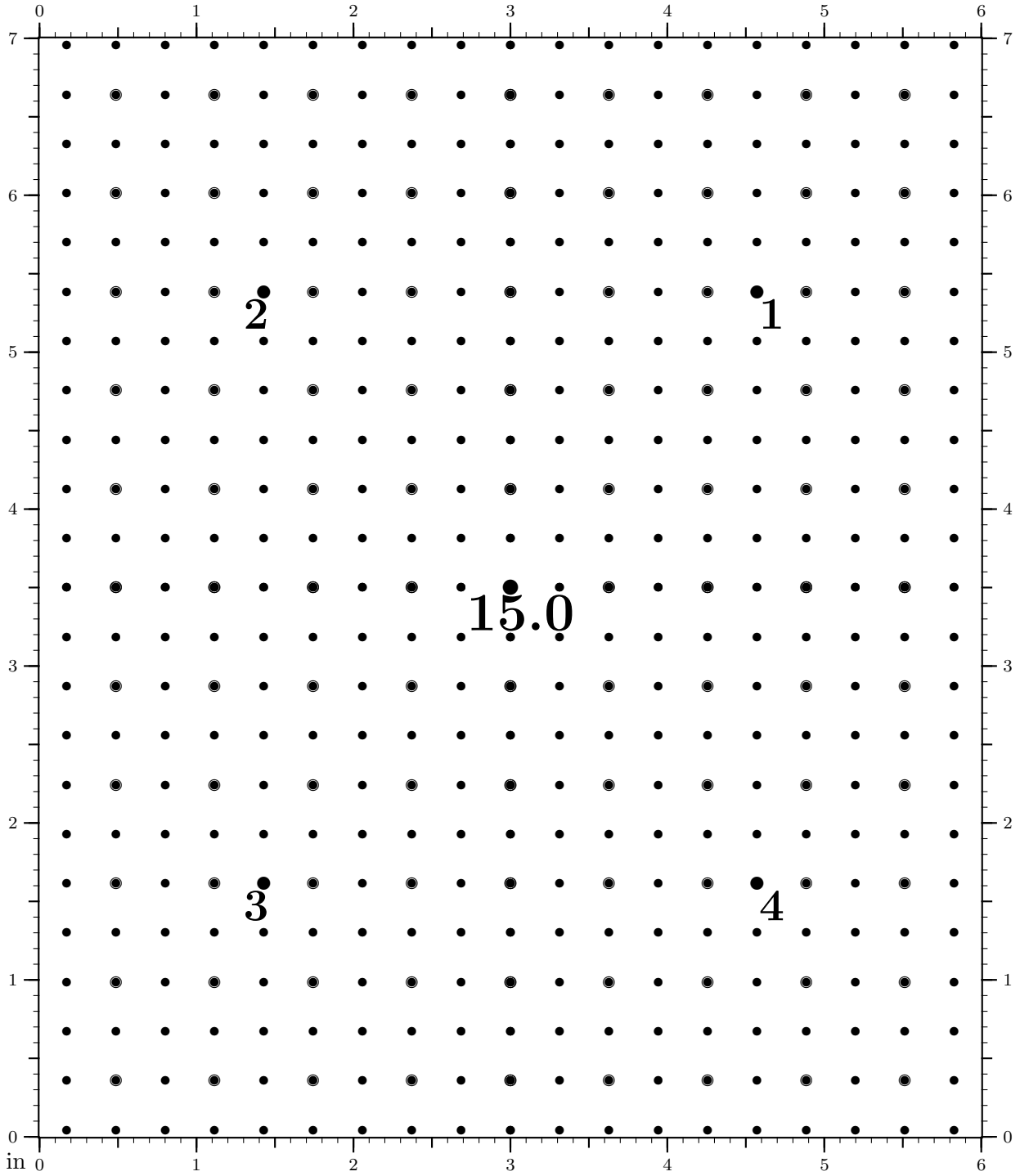

Figure 27: **0.1° at 15.0 feet is 0.314160 in.**

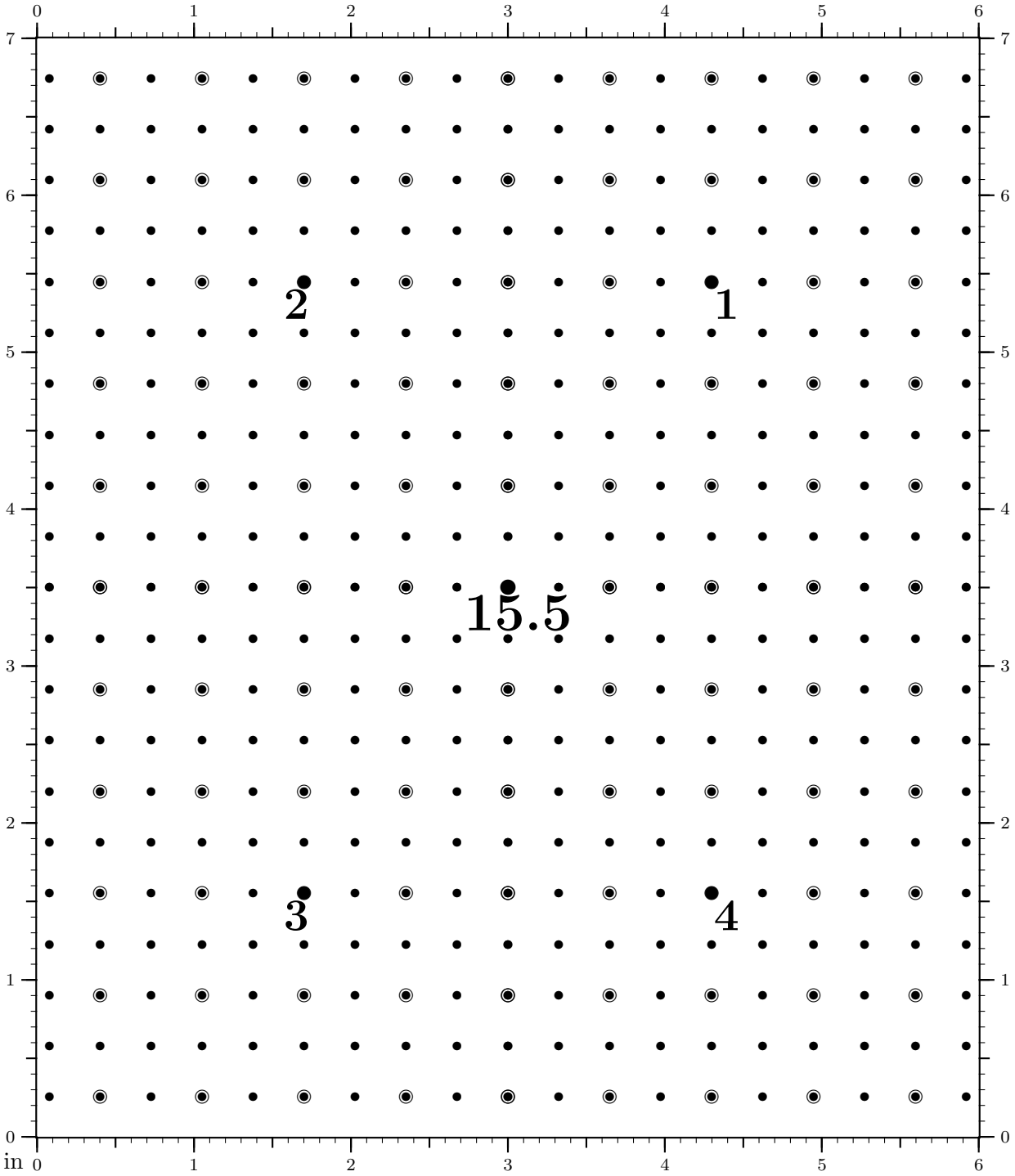

Figure 28: **0.1° at 15.5 feet is 0.324632 in.**

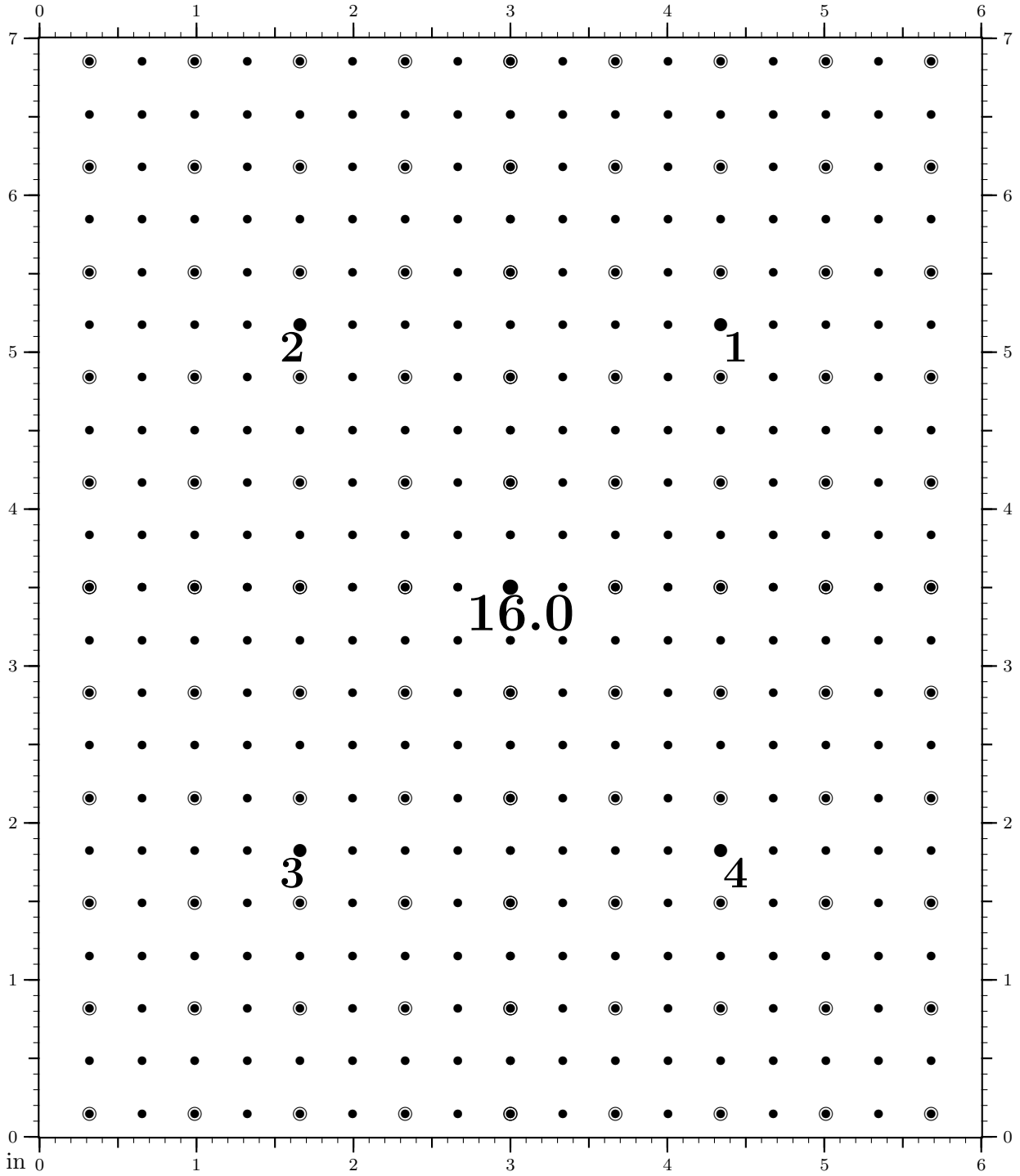

Figure 29: **0.1° at 16.0 feet is 0.335104 in.**

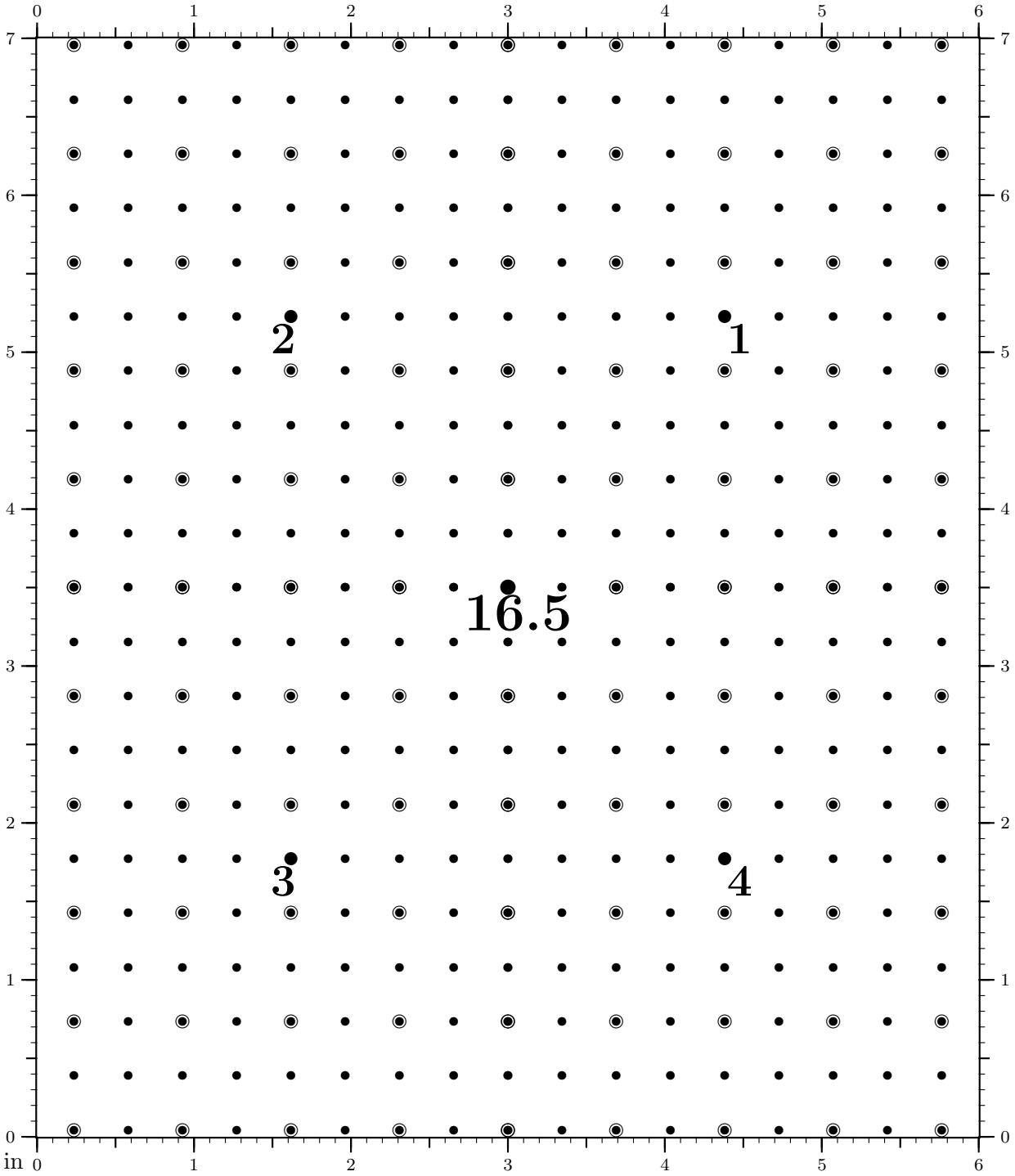

Figure 30: **0.1° at 16.5 feet is 0.345576 in.**

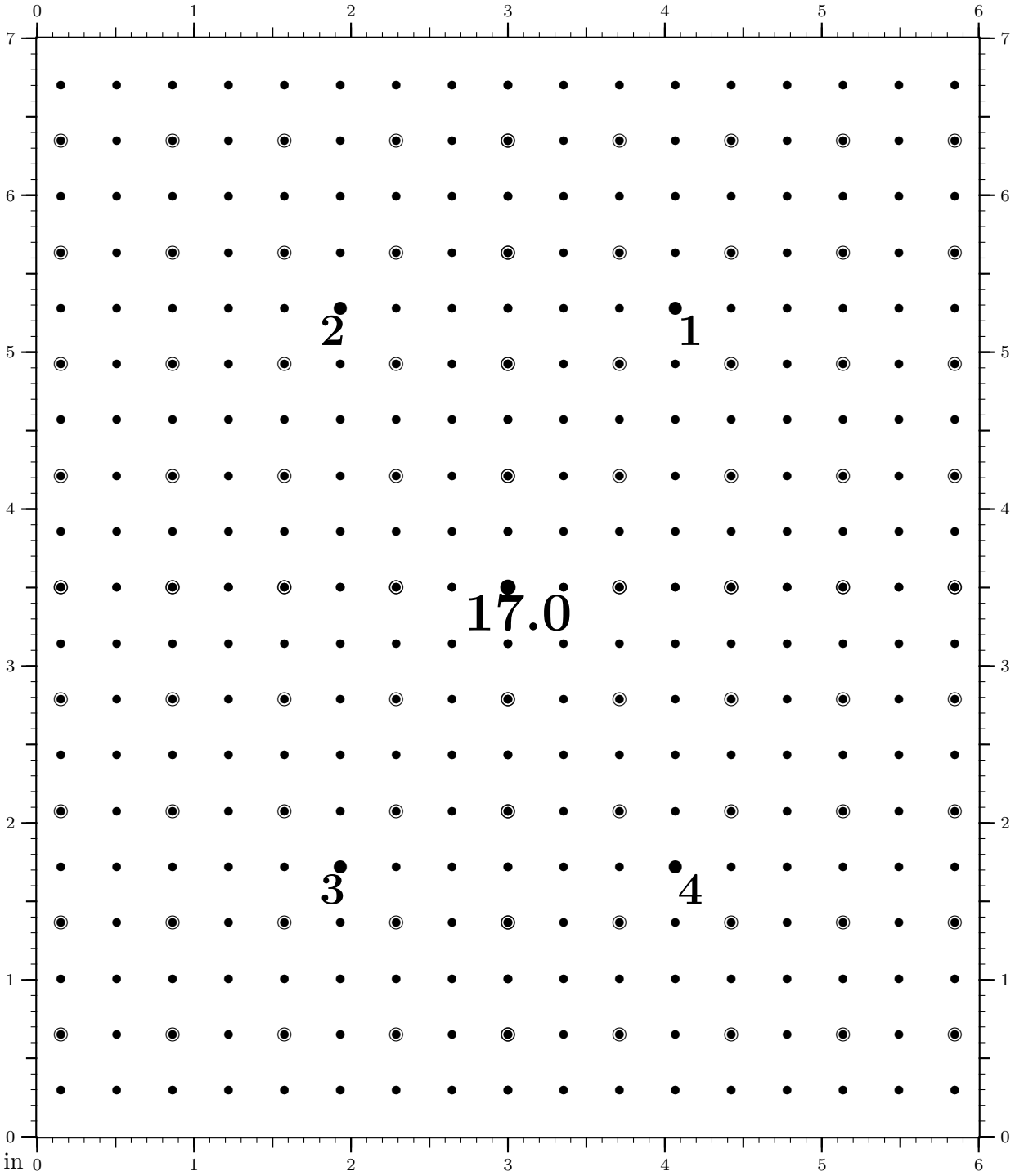

Figure 31: **0.1° at 17.0 feet is 0.356048 in.**

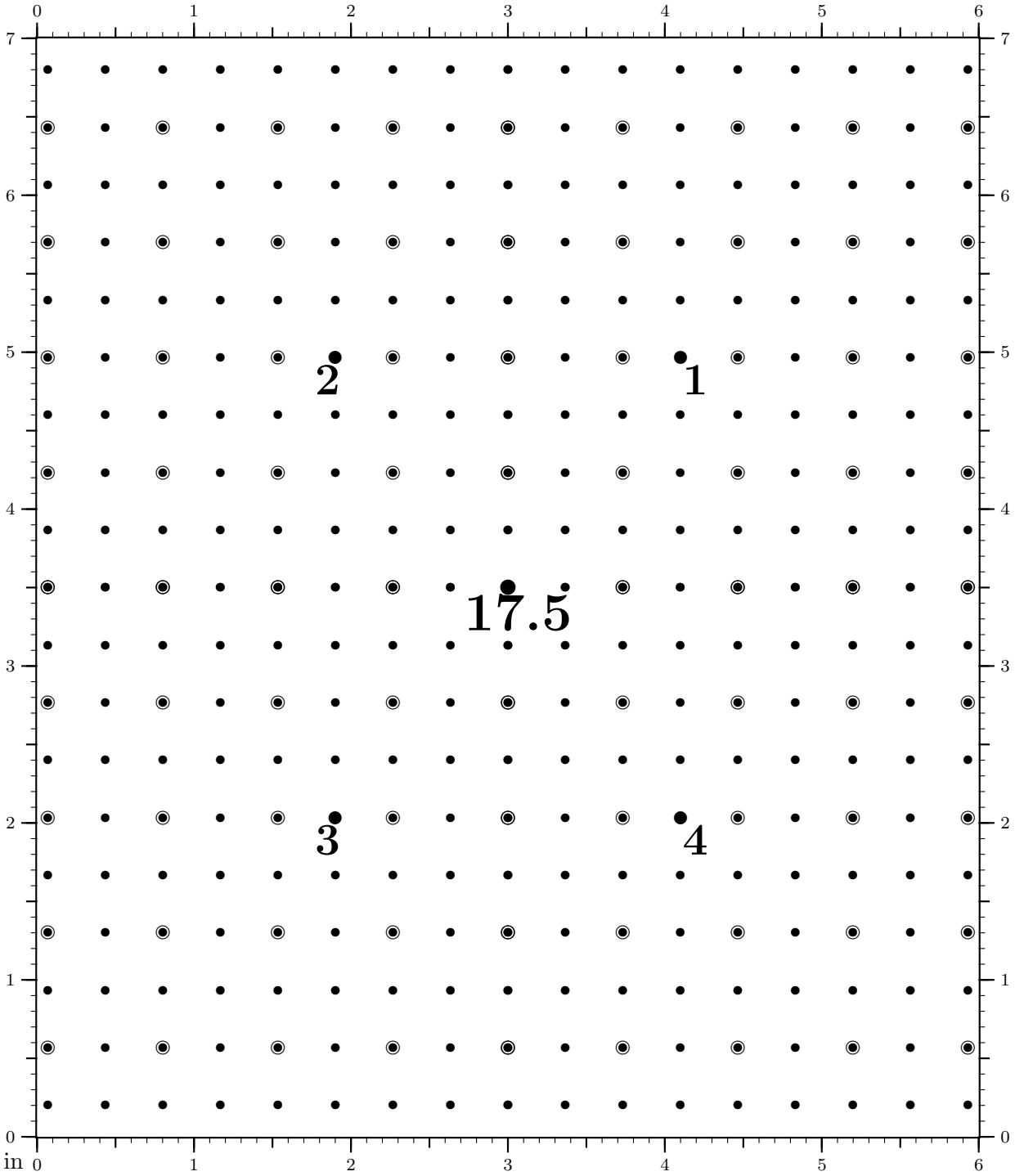

Figure 32: **0.1° at 17.5 feet is 0.366520 in.**

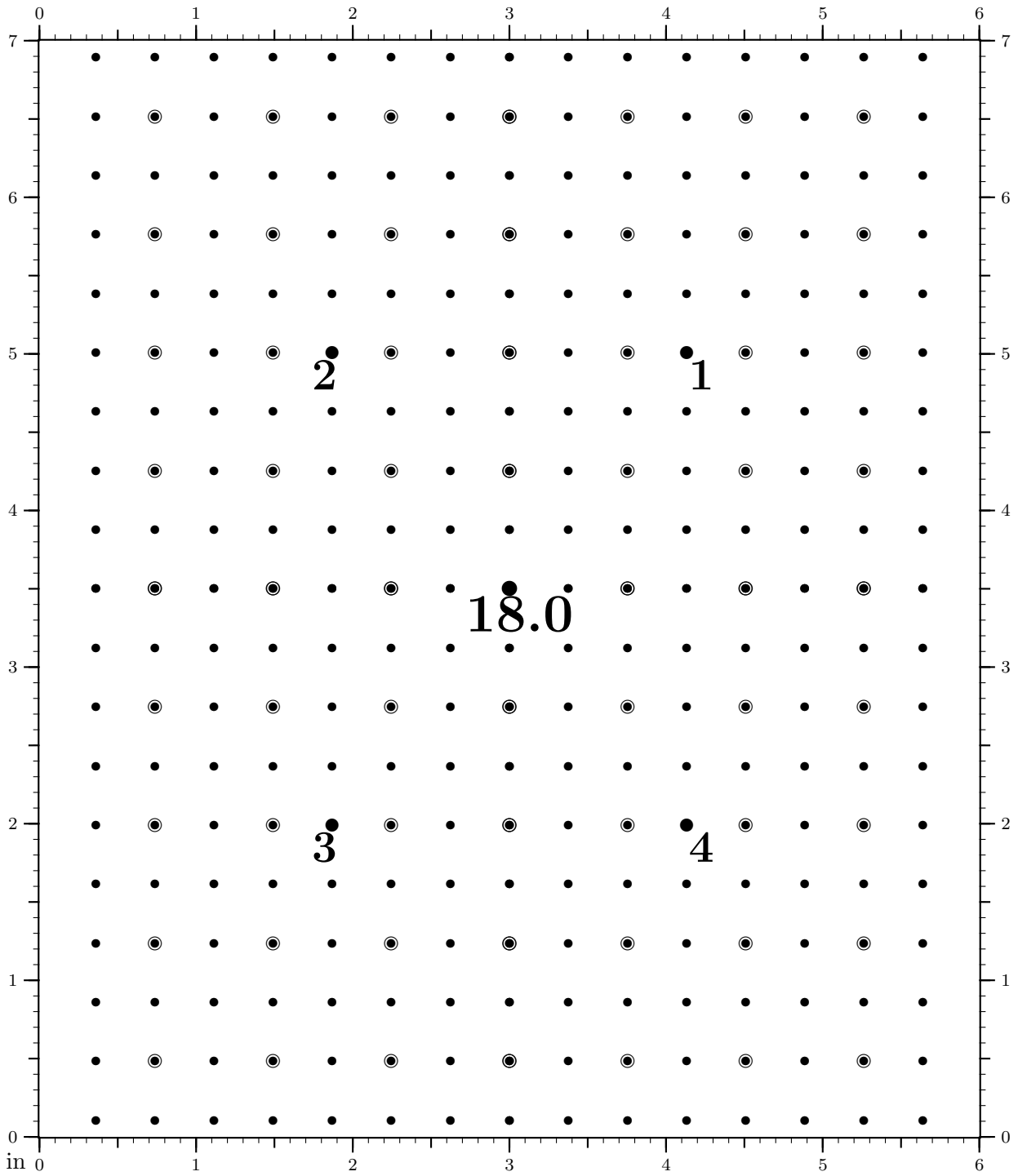

Figure 33: **0.1° at 18.0 feet is 0.376992 in.**

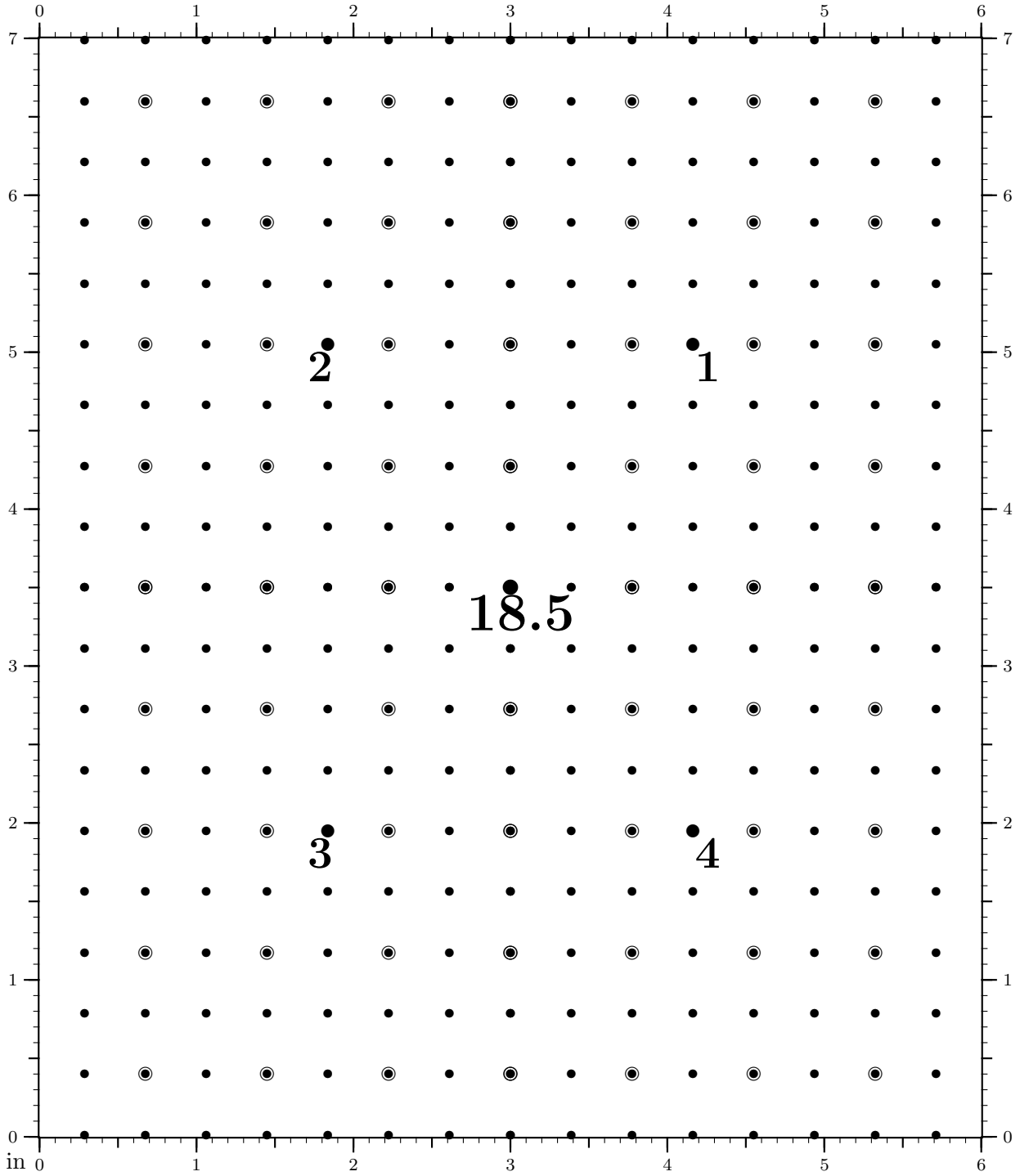

Figure 34: **0.1° at 18.5 feet is 0.387464 in.**

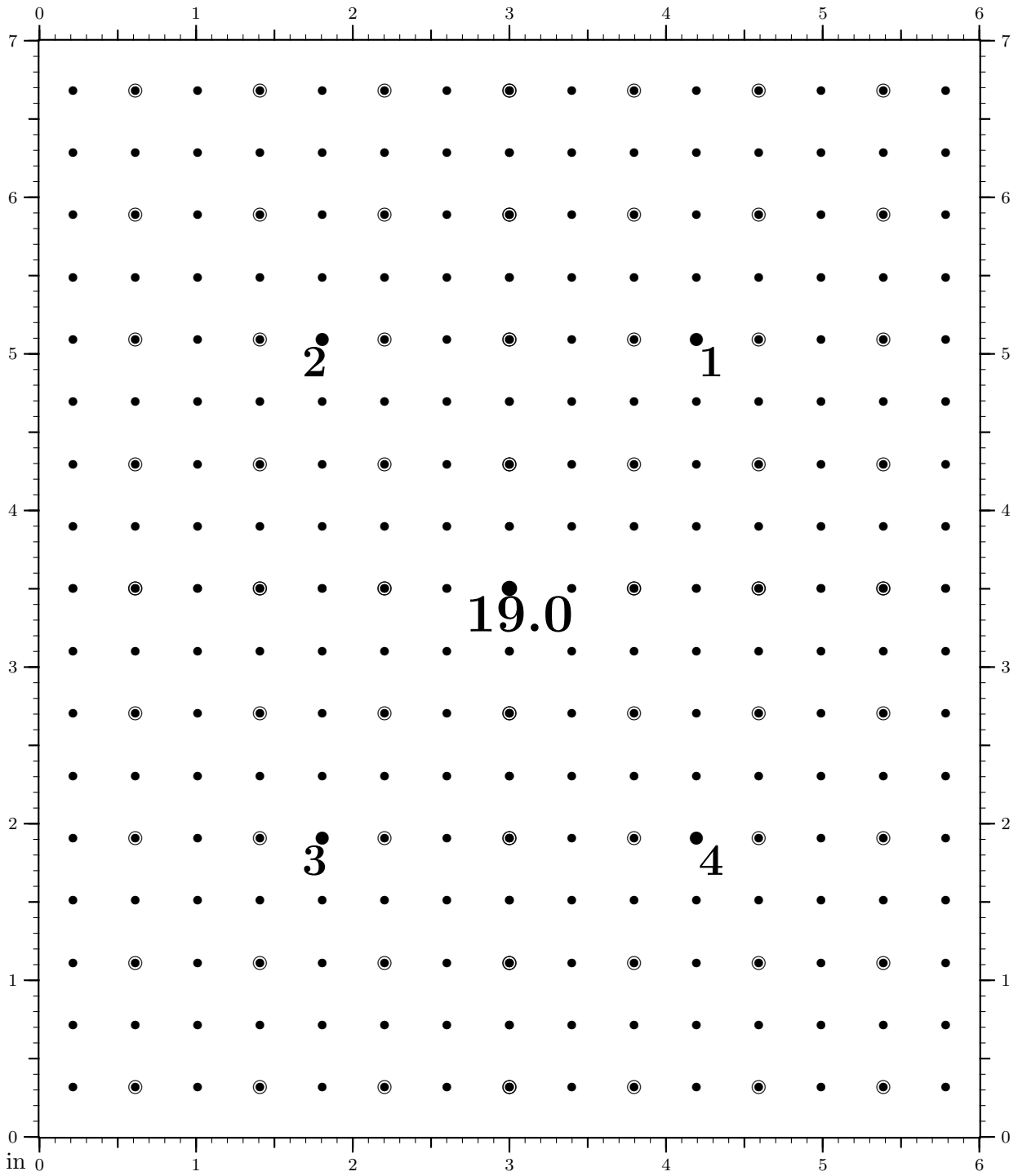

Figure 35: **0.1° at 19.0 feet is 0.397936 in.**

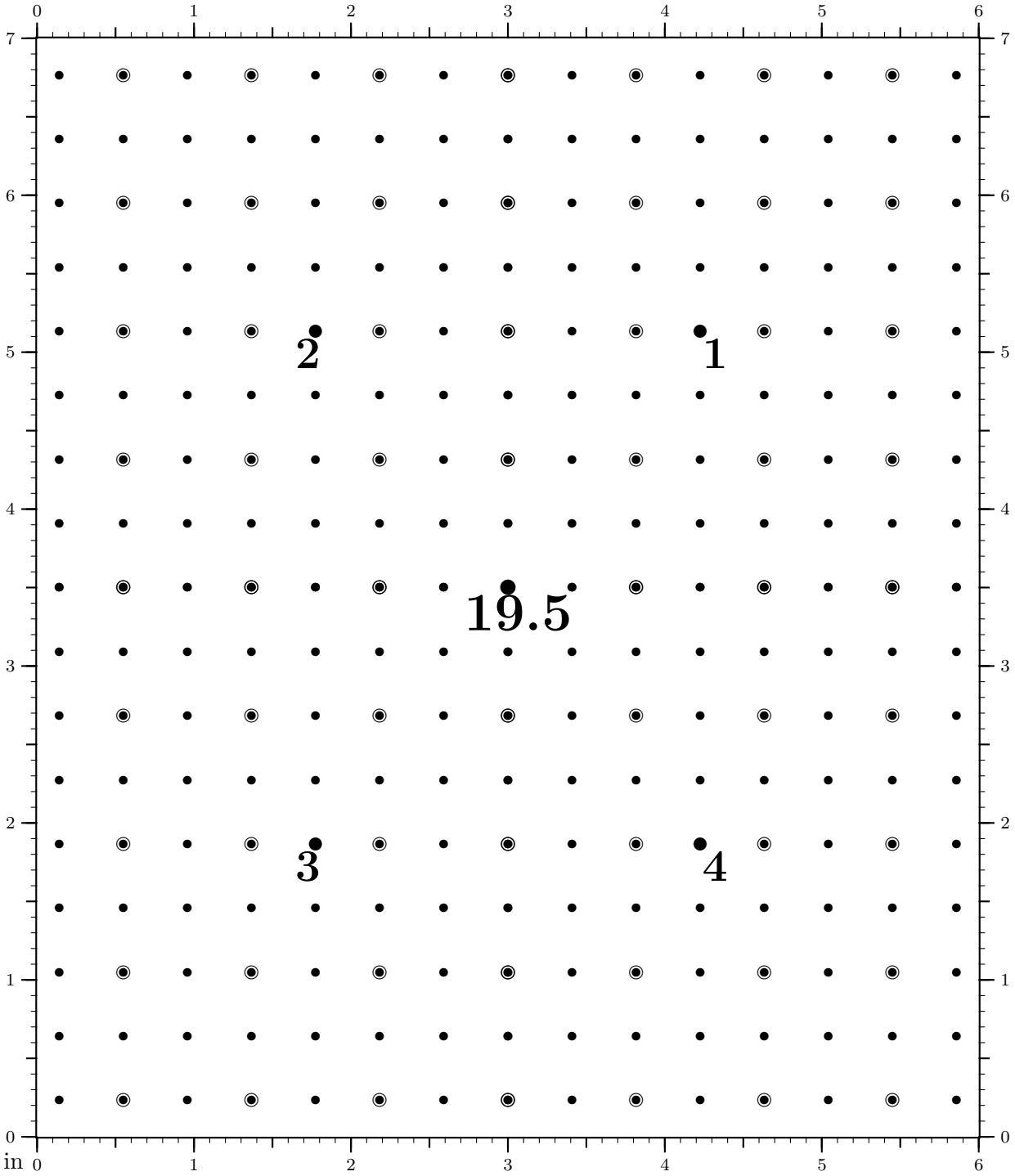

Figure 36: **0.1° at 19.5 feet is 0.408408 in.**

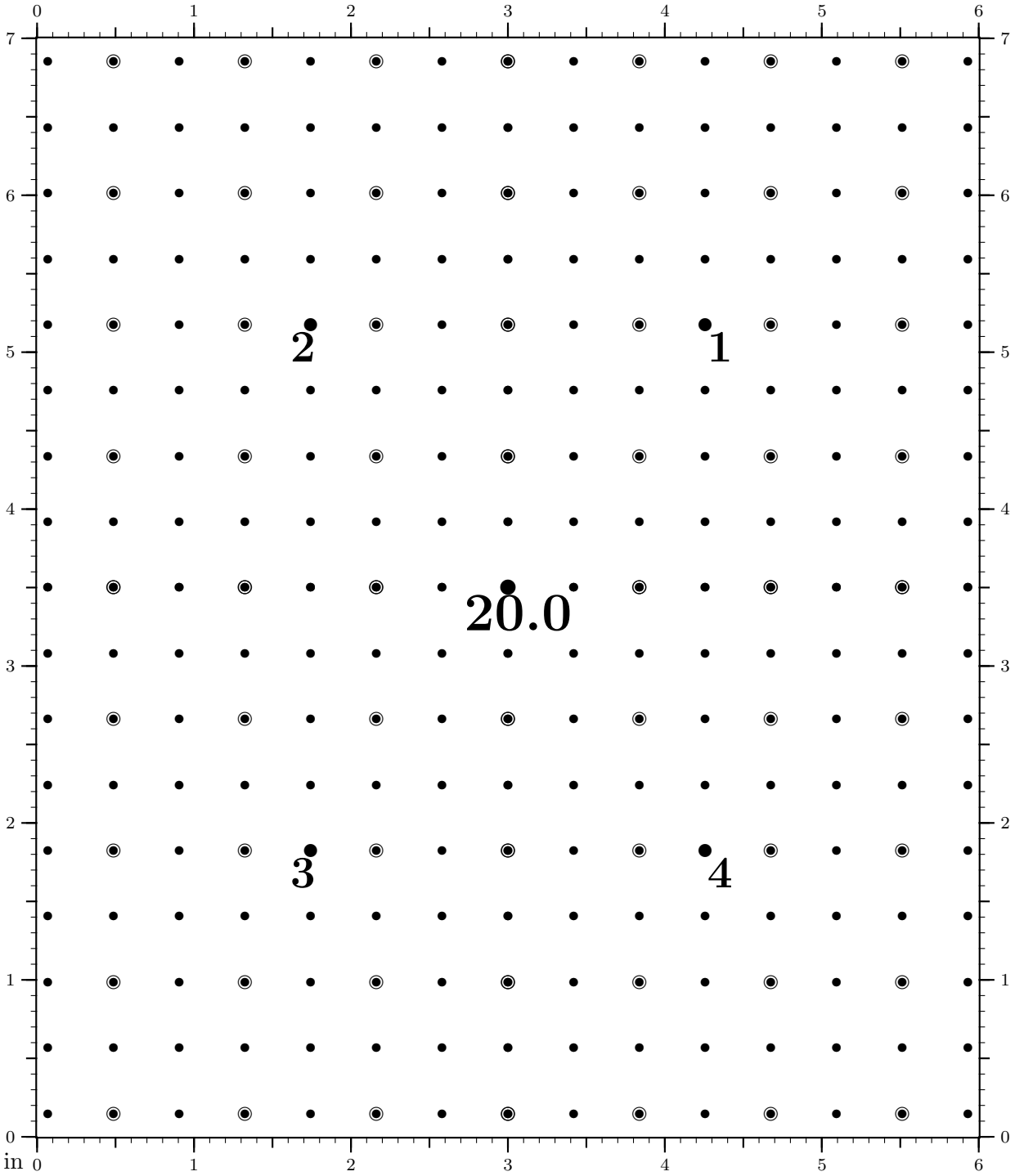

Figure 37: **0.1° at 20.0 feet is 0.418880 in.**

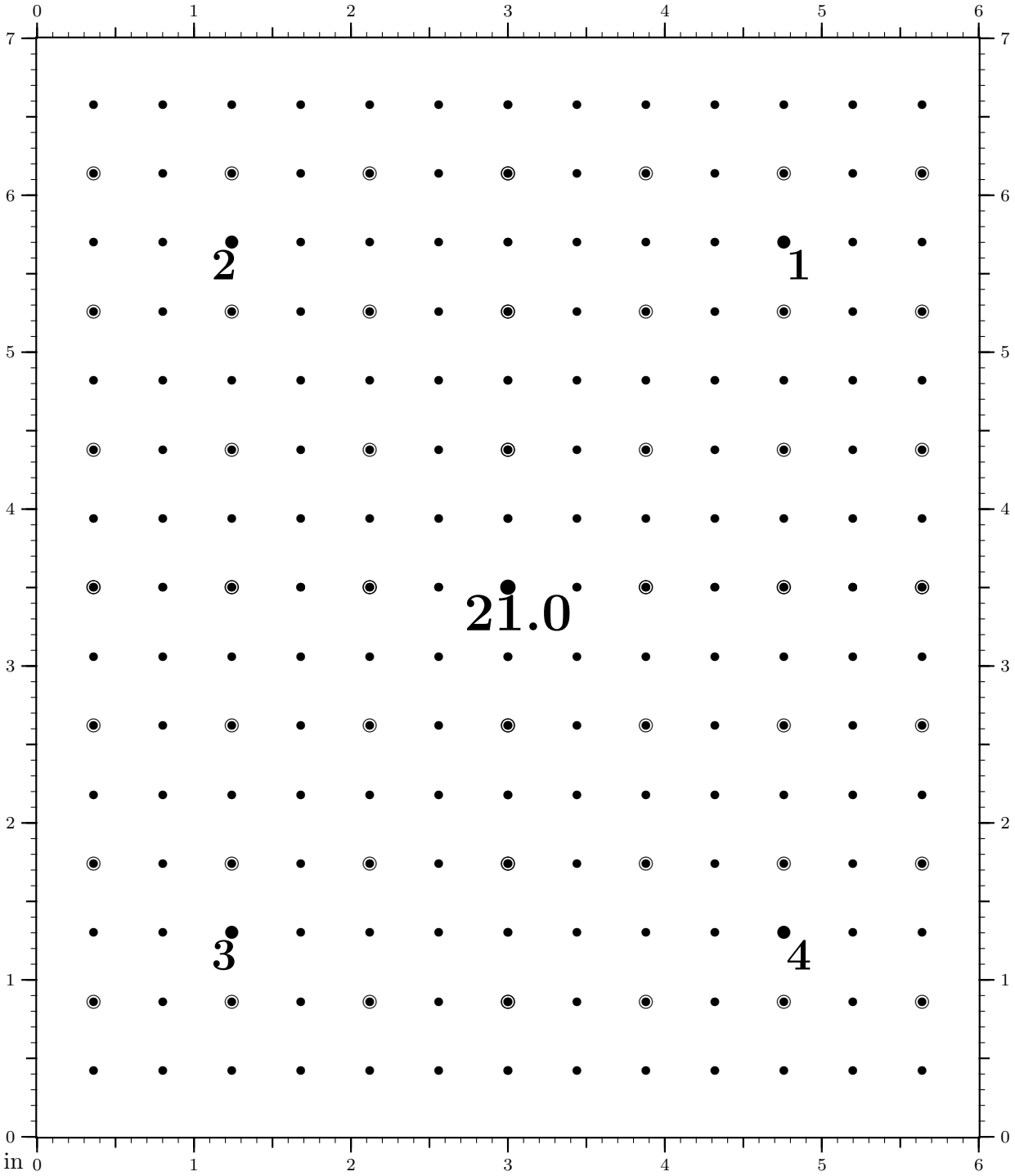

Figure 38: **0.1° at 21.0 feet is 0.439824 in.**

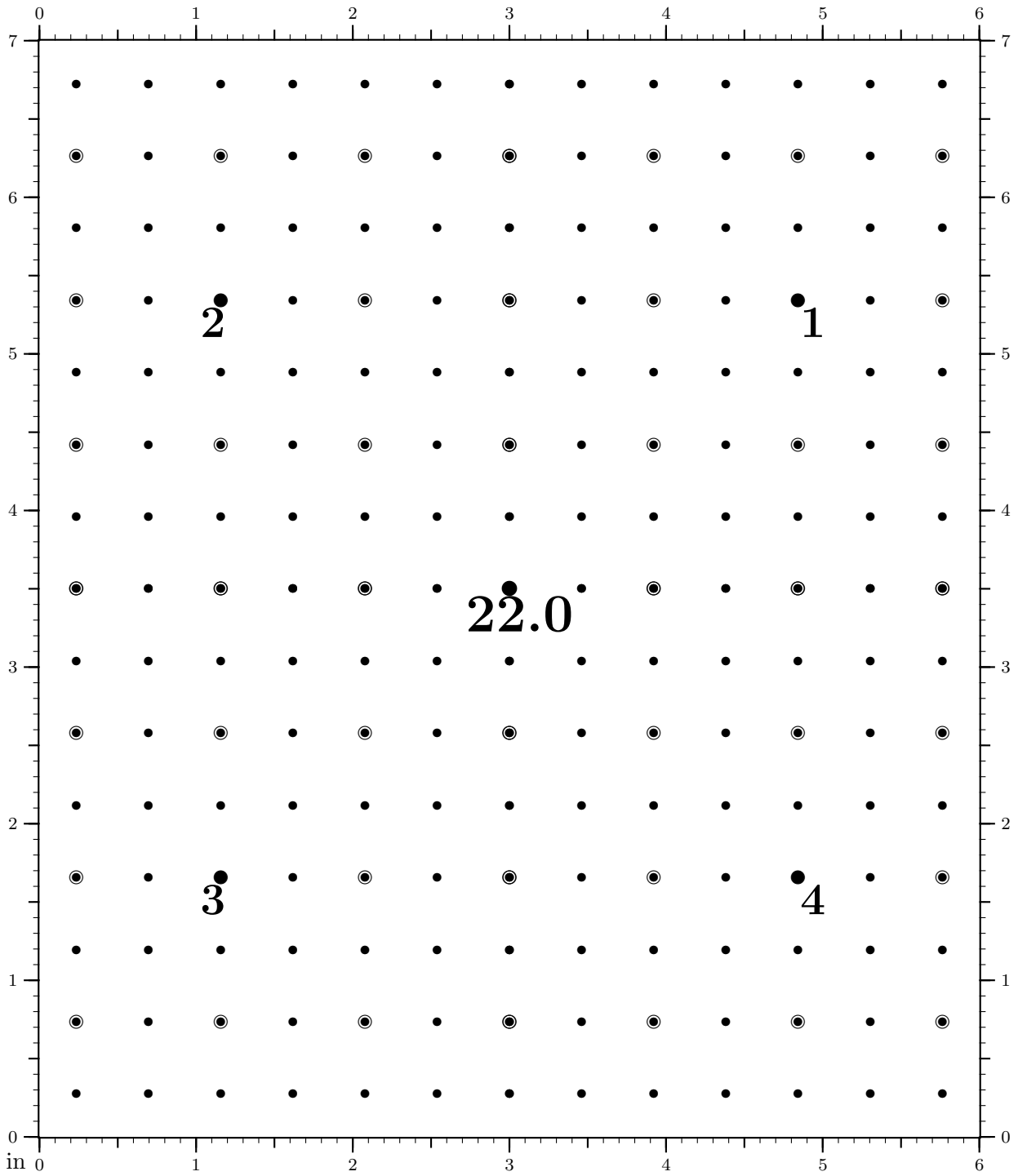

Figure 39: **0.1° at 22.0 feet is 0.460768 in.**

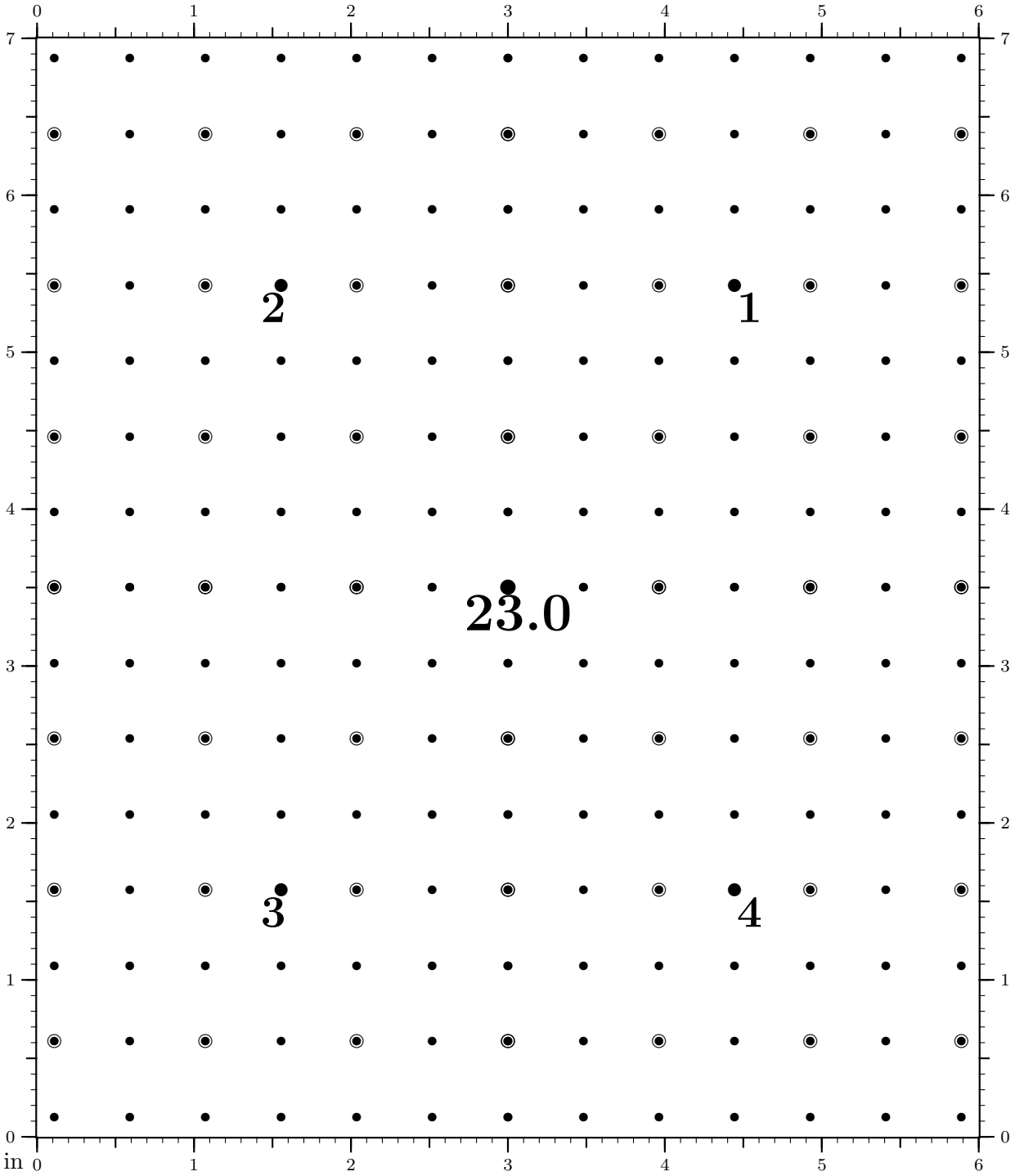

Figure 40: **0.1° at 23.0 feet is 0.481711 in.**

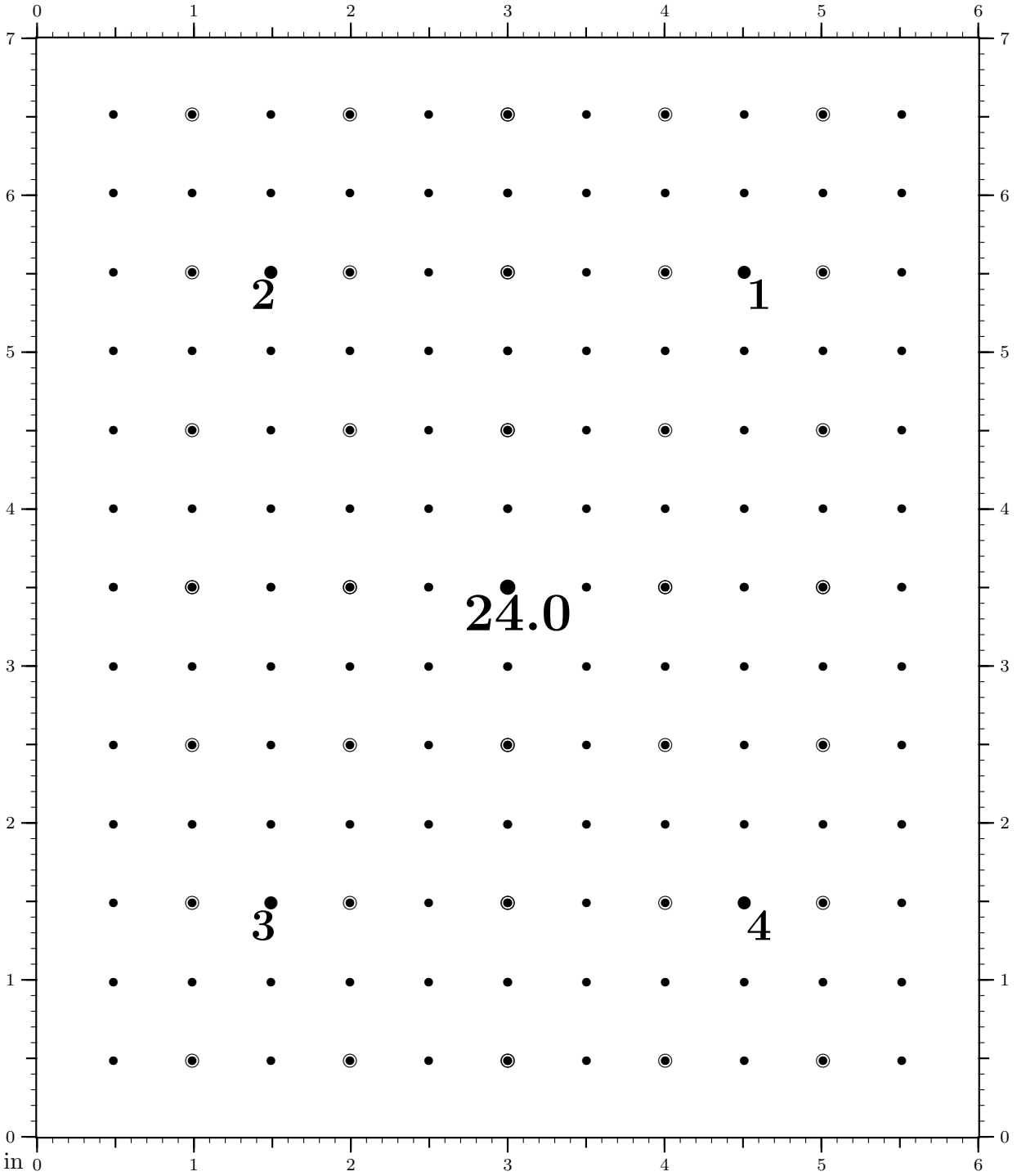

Figure 41: **0.1° at 24.0 feet is 0.502655 in.**

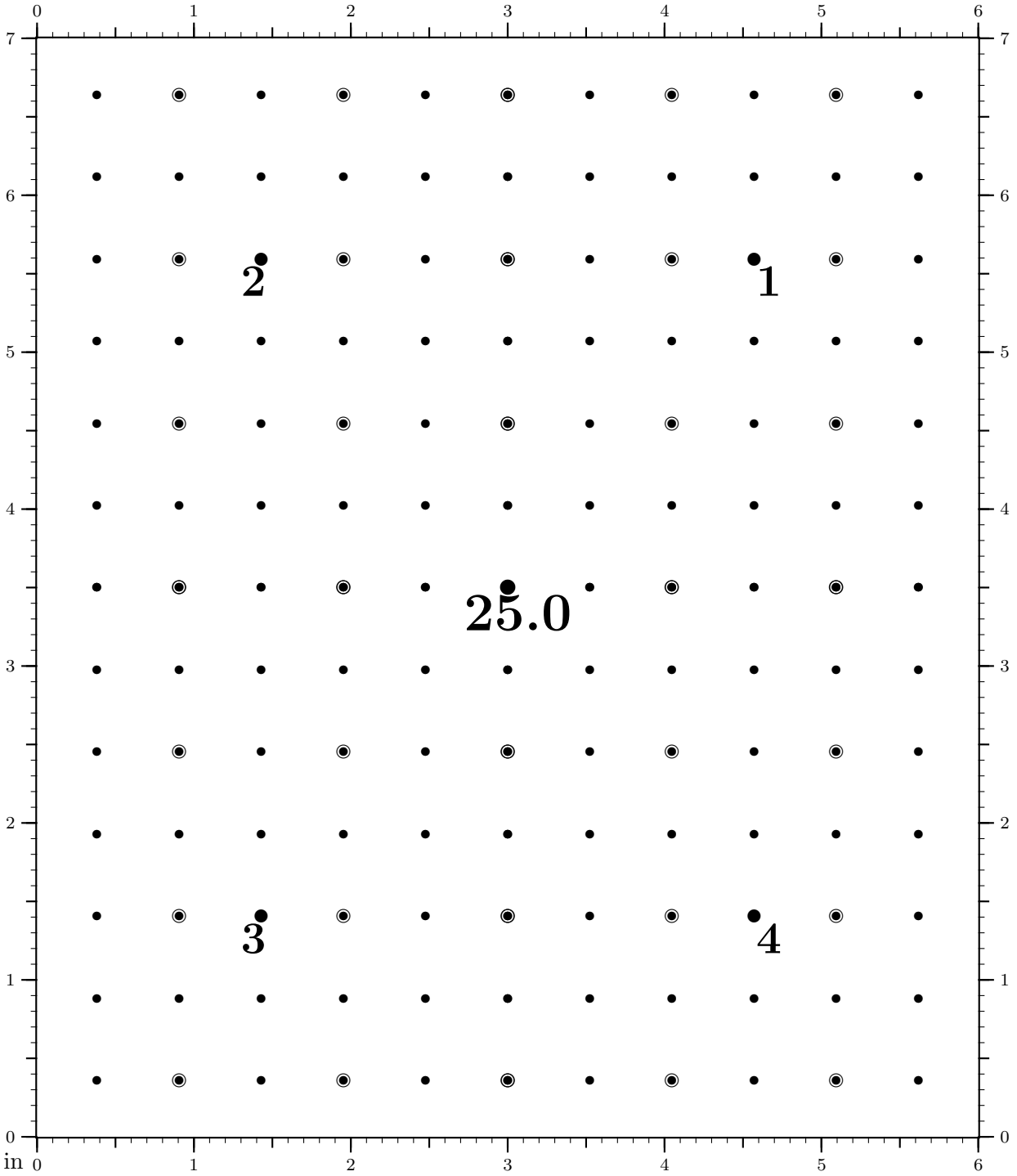

Figure 42: **0.1° at 25.0 feet is 0.523599 in.**

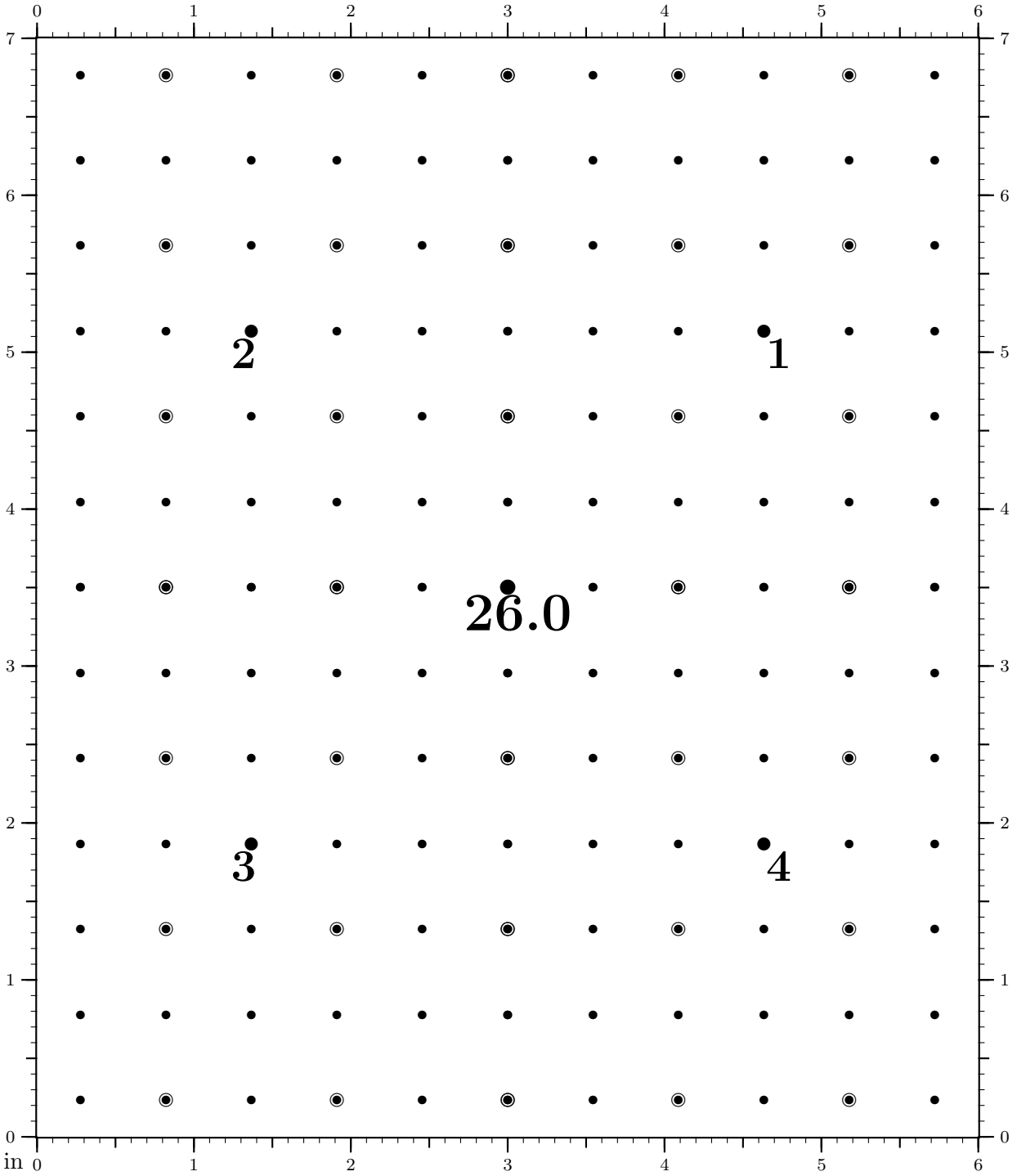

Figure 43: **0.1° at 26.0 feet is 0.544543 in.**

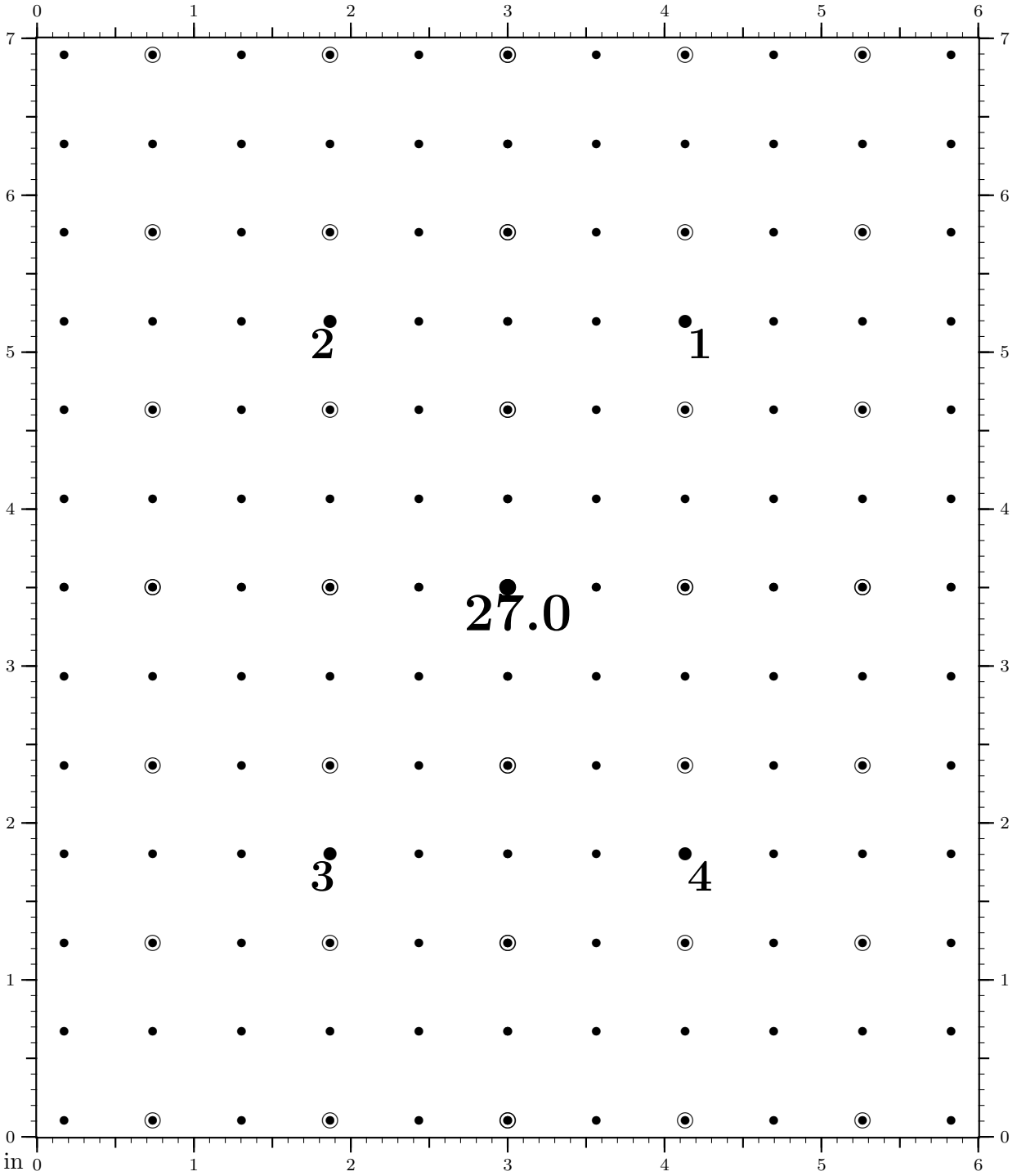

Figure 44: **0.1° at 27.0 feet is 0.565487 in.**

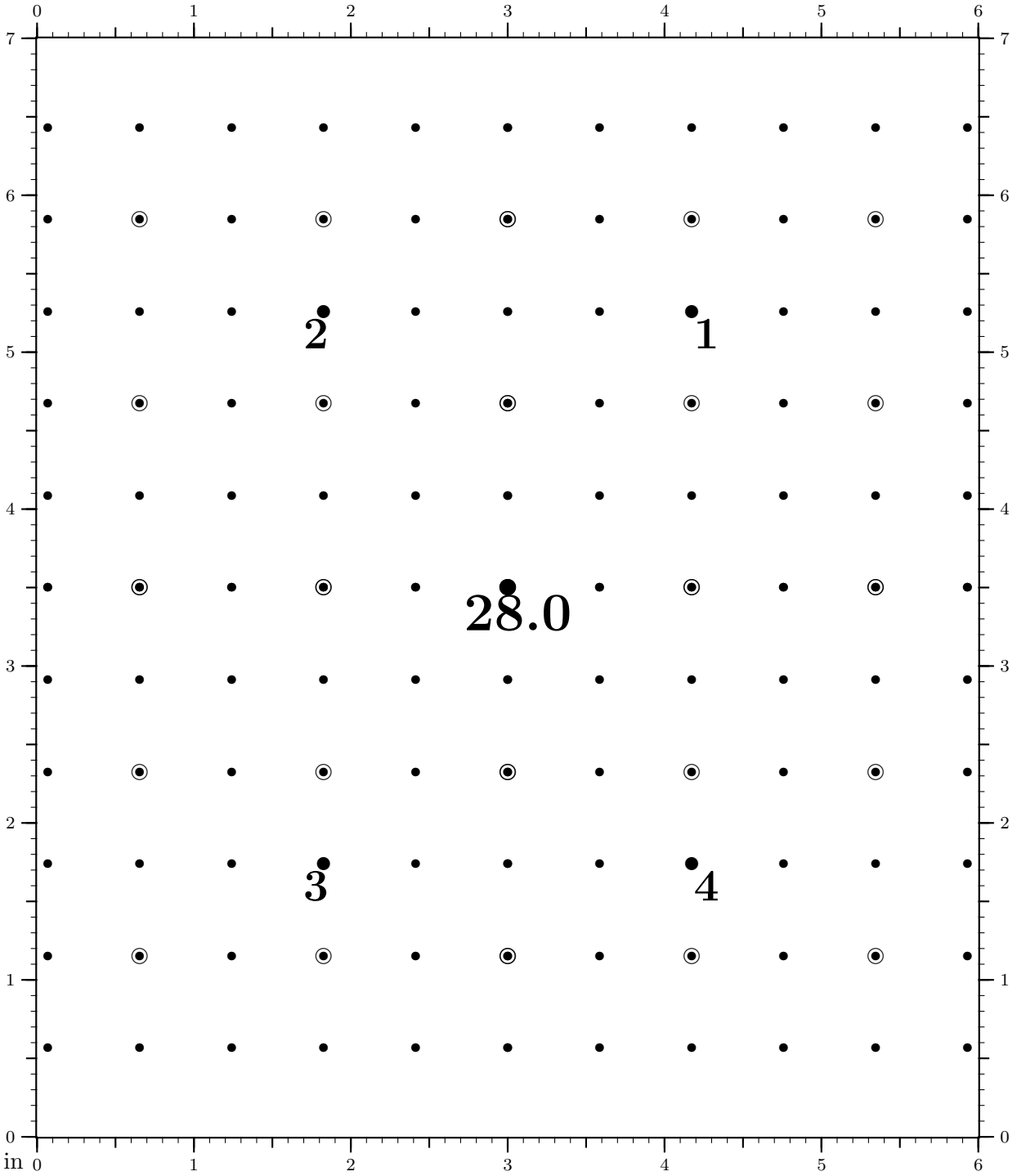

Figure 45: **0.1° at 28.0 feet is 0.586431 in.**

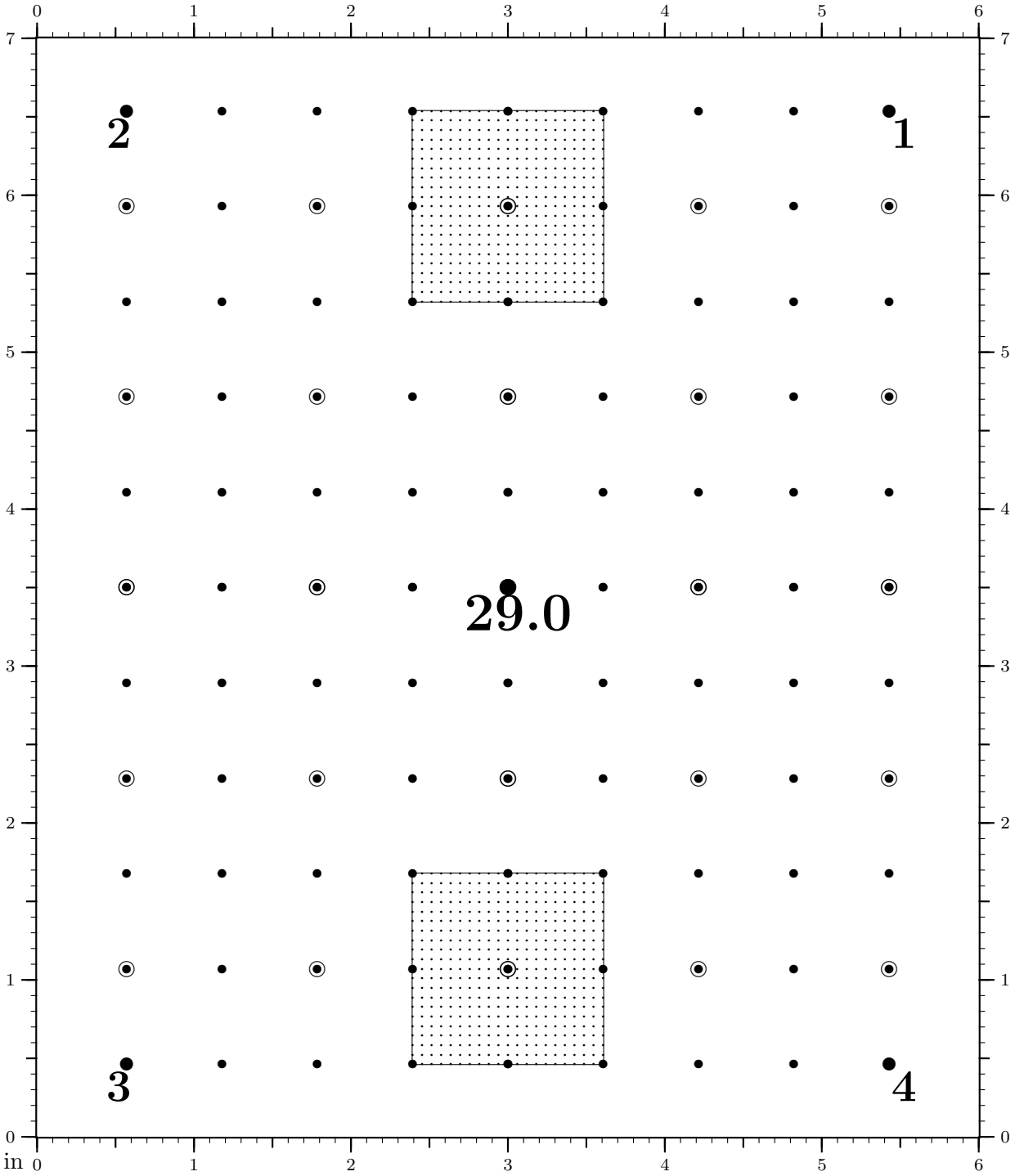

Figure 46: **0.1° at 29.0 feet is 0.607375 in.**

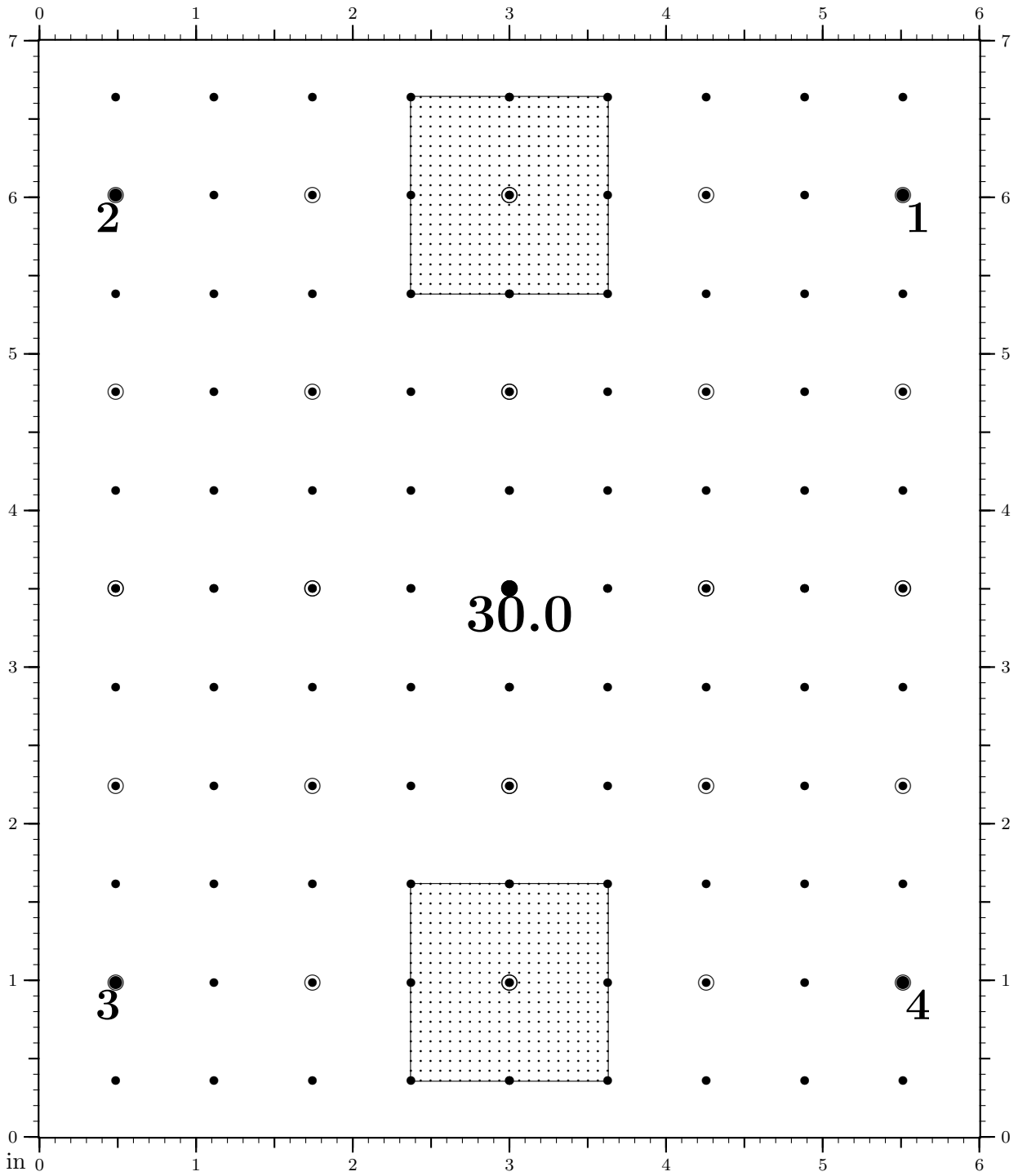

Figure 47: **0.1° at 30.0 feet is 0.628319 in.**

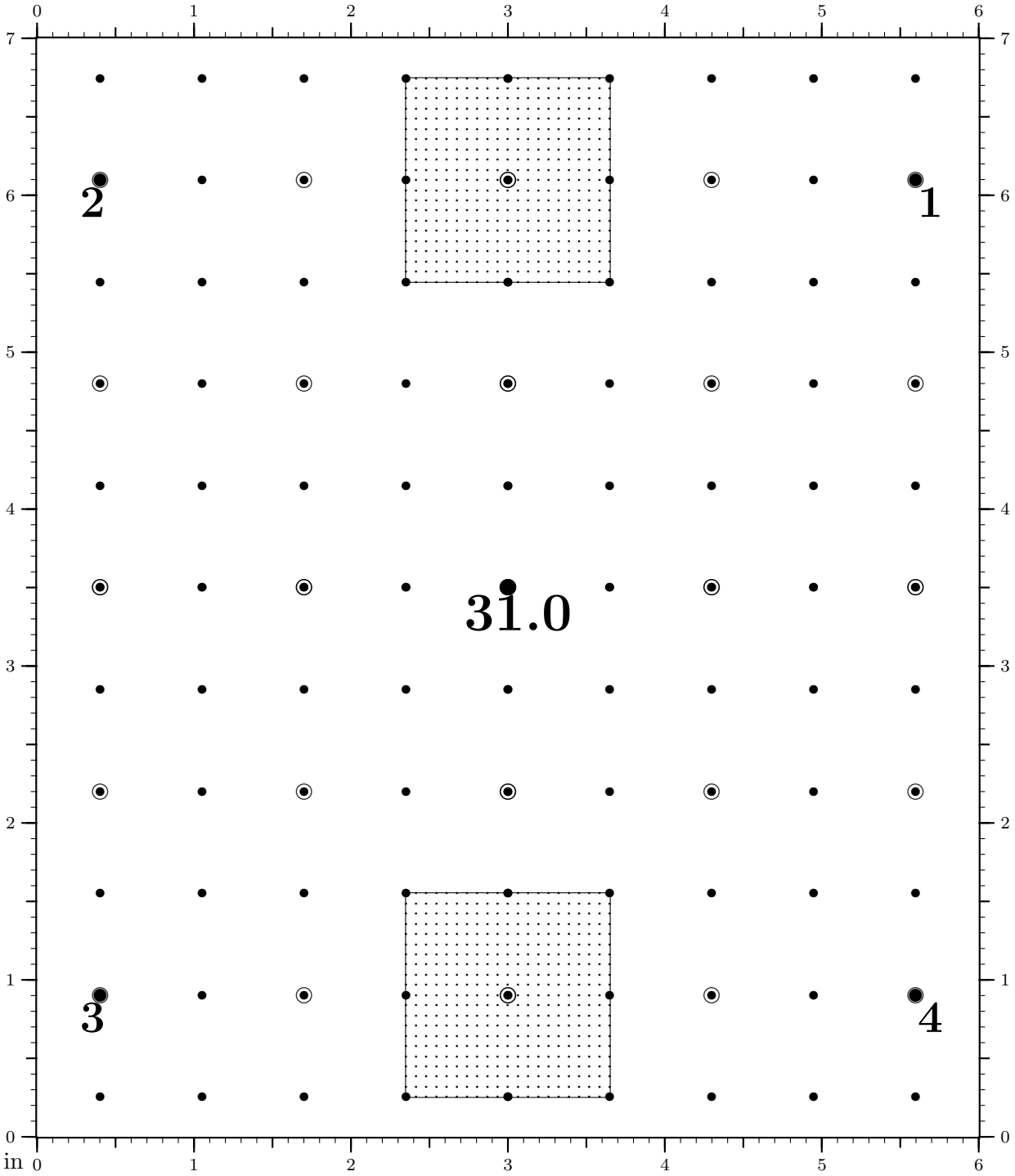

Figure 48: **0.1° at 31.0 feet is 0.649263 in.**

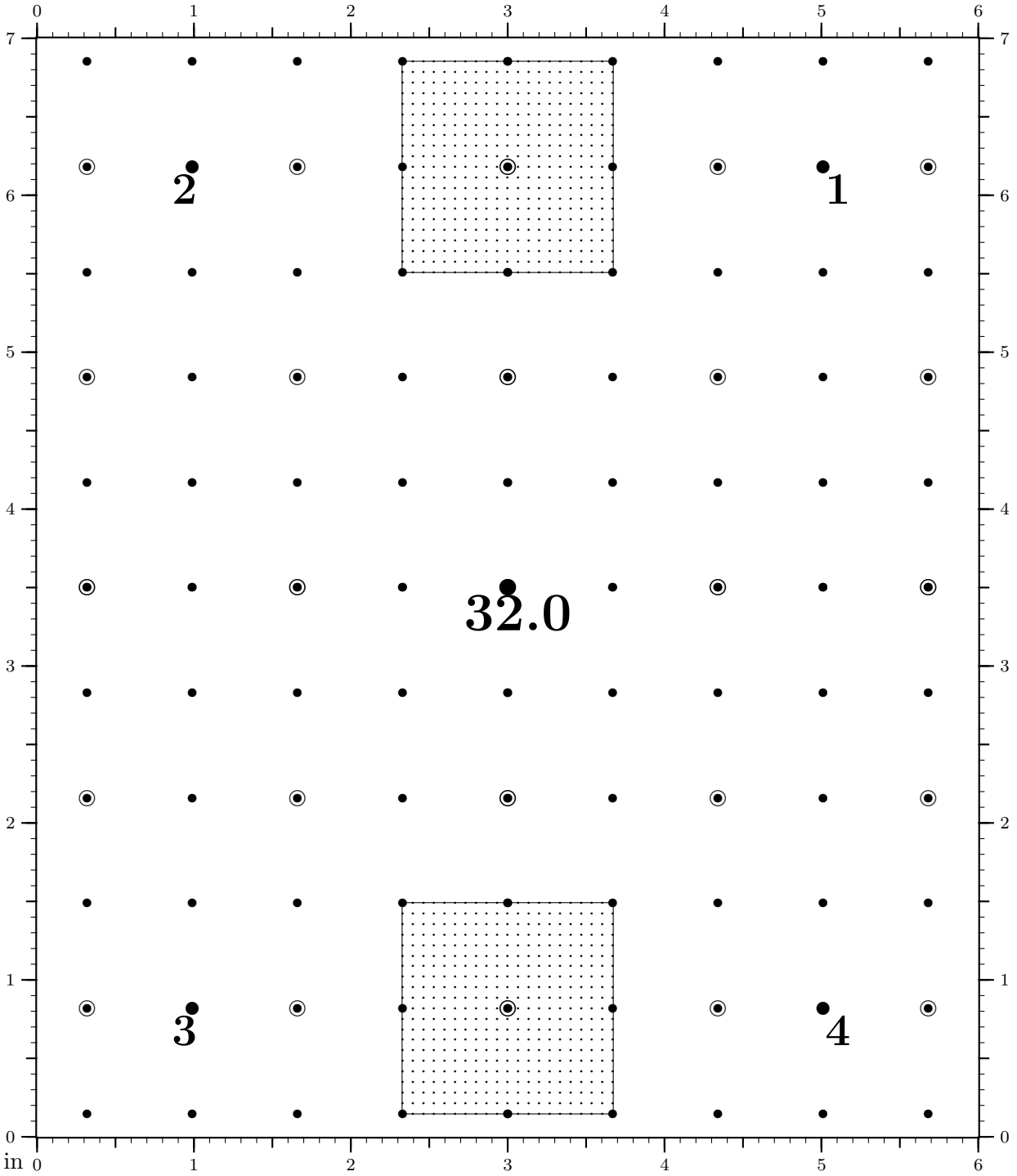

Figure 49: **0.1° at 32.0 feet is 0.670207 in.**

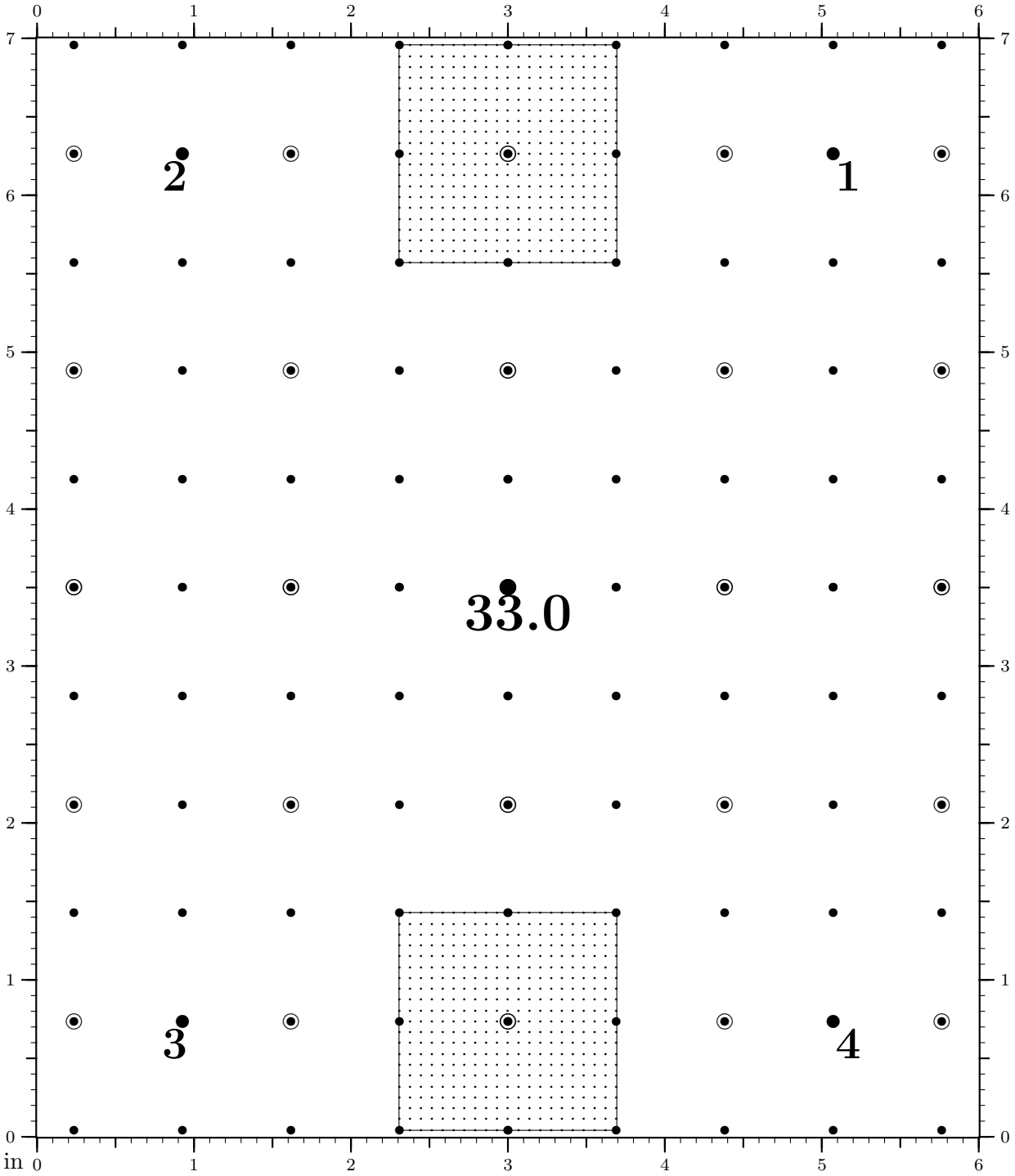

Figure 50: **0.1° at 33.0 feet is 0.691151 in.**

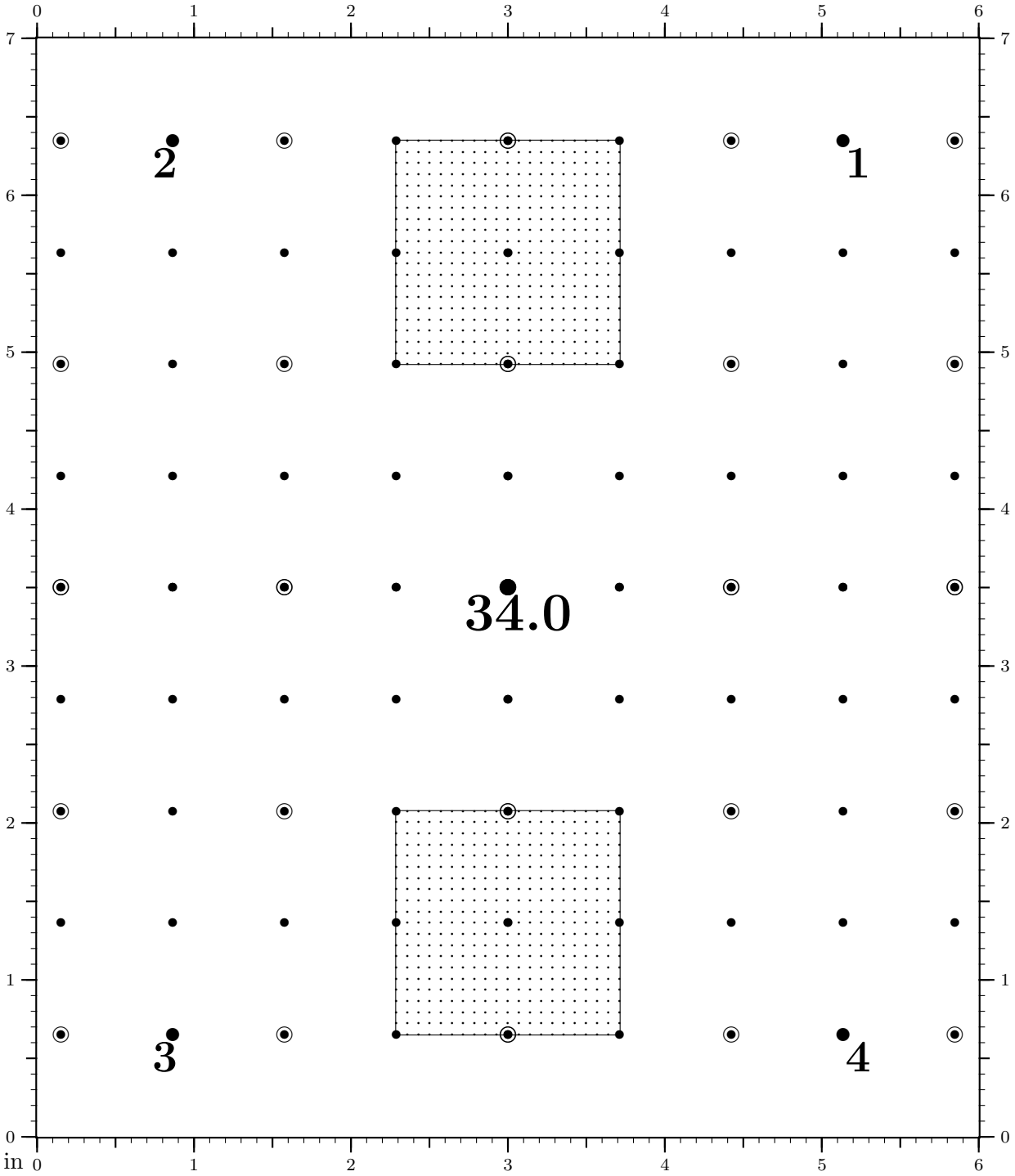

Figure 51: **0.1° at 34.0 feet is 0.712095 in.**

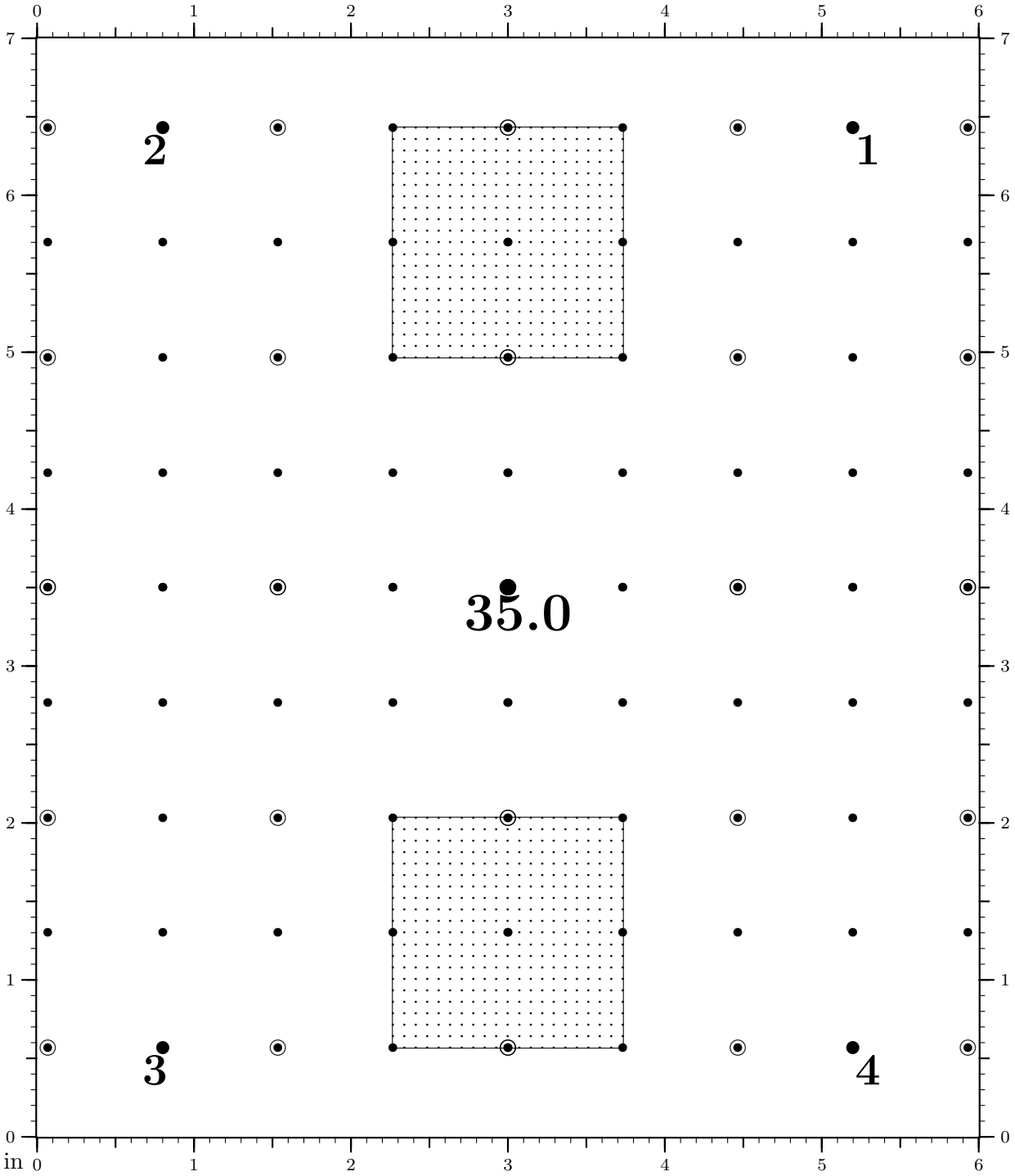

Figure 52: **0.1° at 35.0 feet is 0.733039 in.**

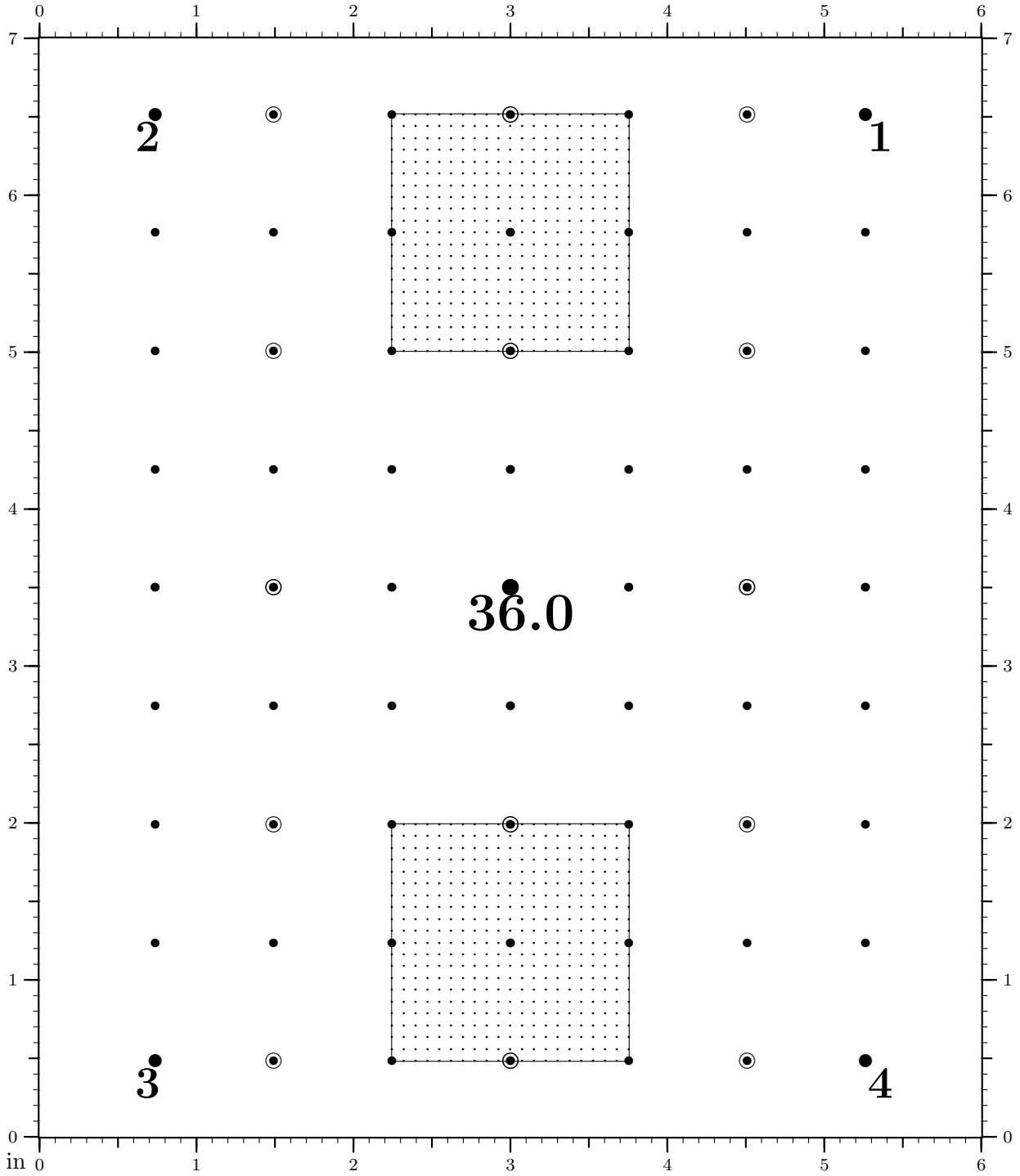

Figure 53: **0.1° at 36.0 feet is 0.753983 in.**

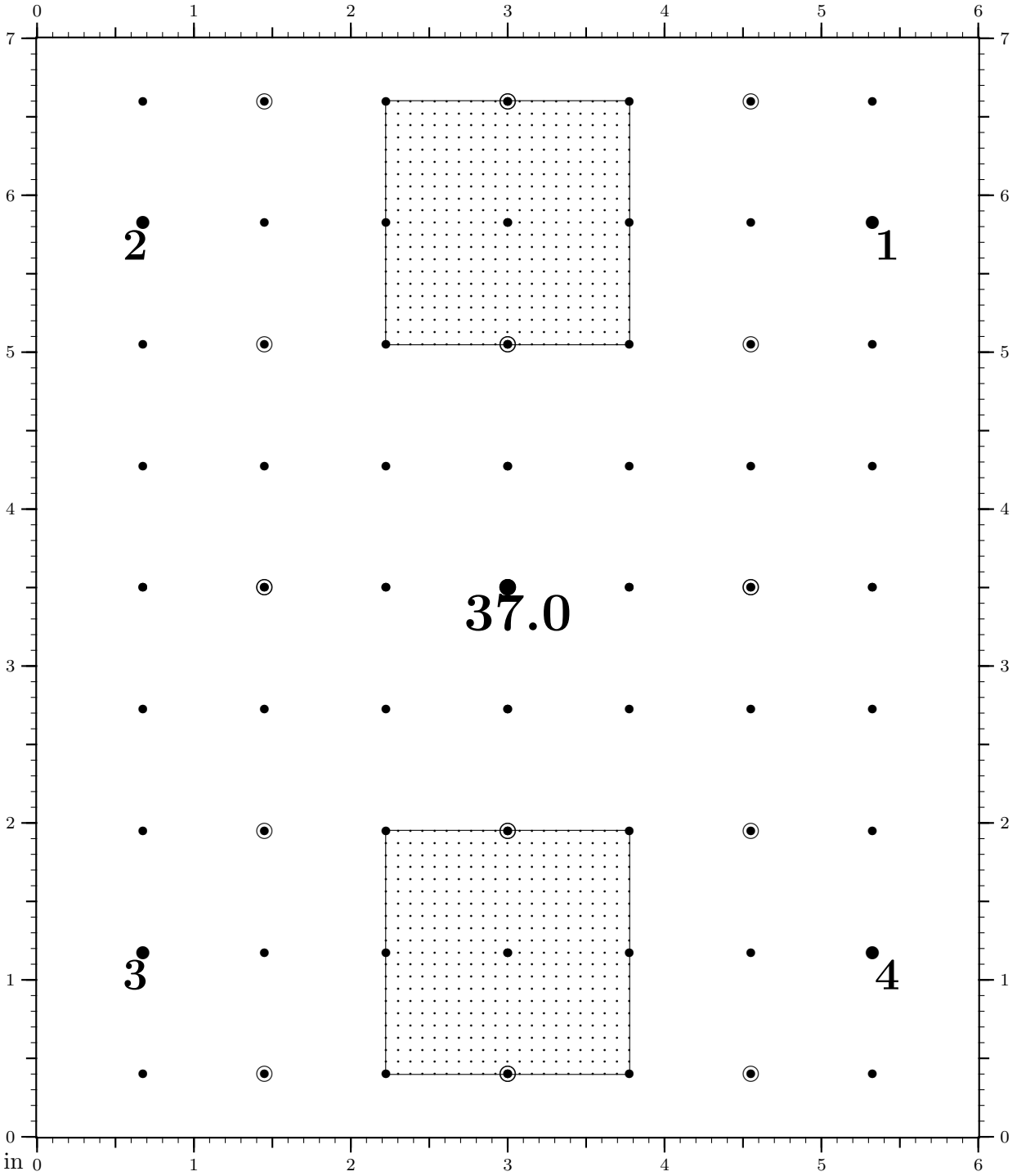

Figure 54: **0.1° at 37.0 feet is 0.774927 in.**

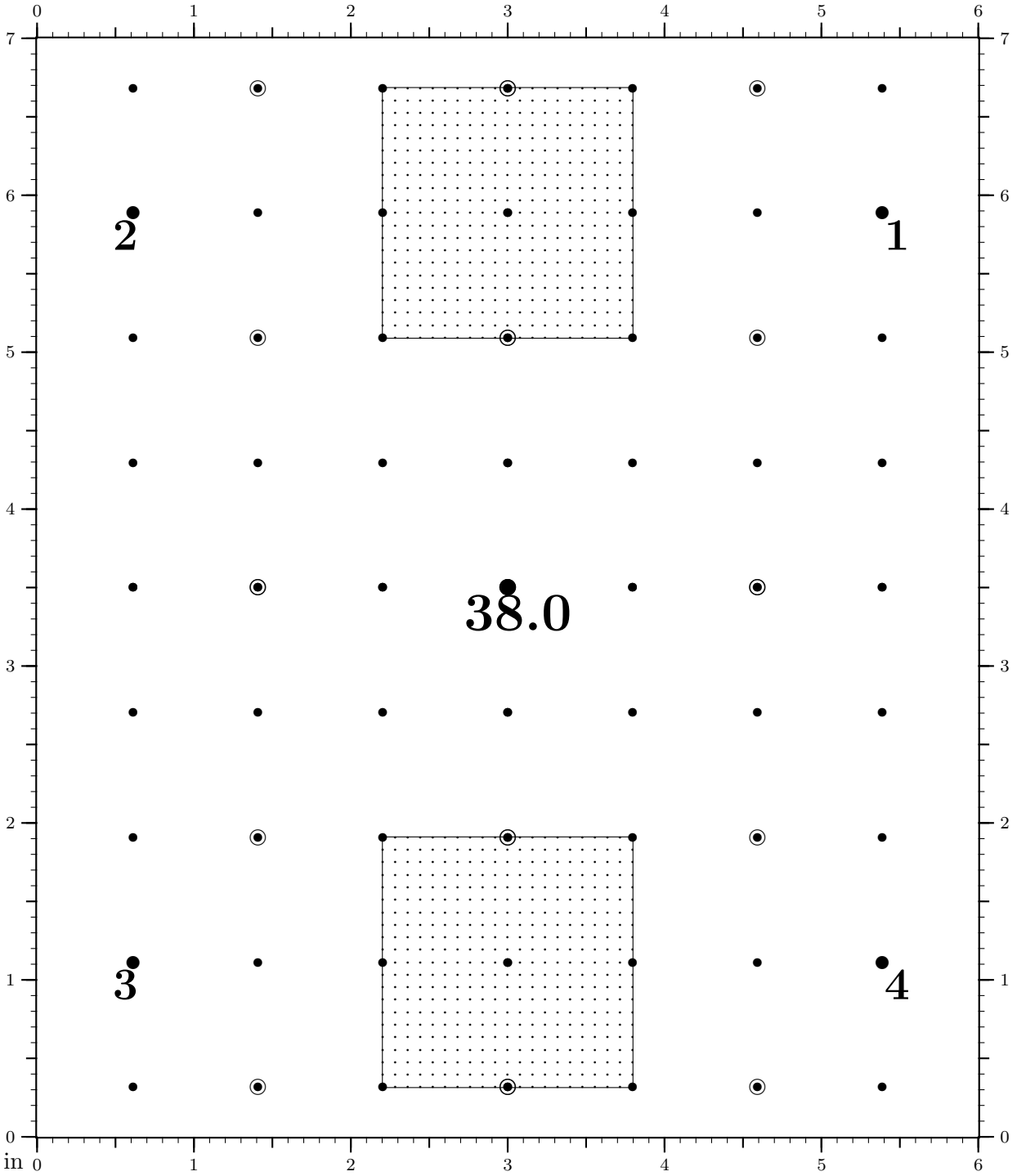

Figure 55: **0.1° at 38.0 feet is 0.795871 in.**

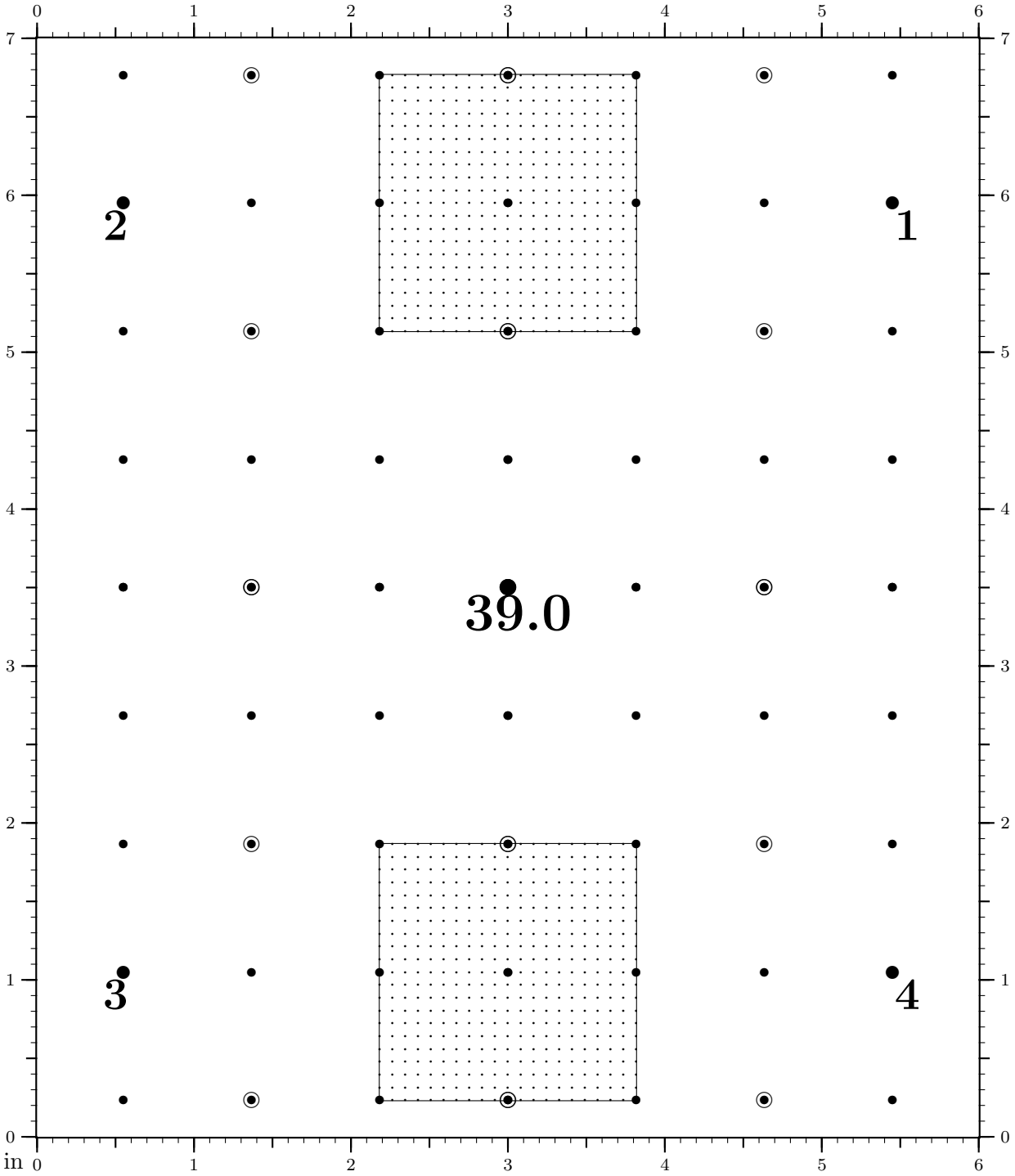

Figure 56: **0.1° at 39.0 feet is 0.816815 in.**

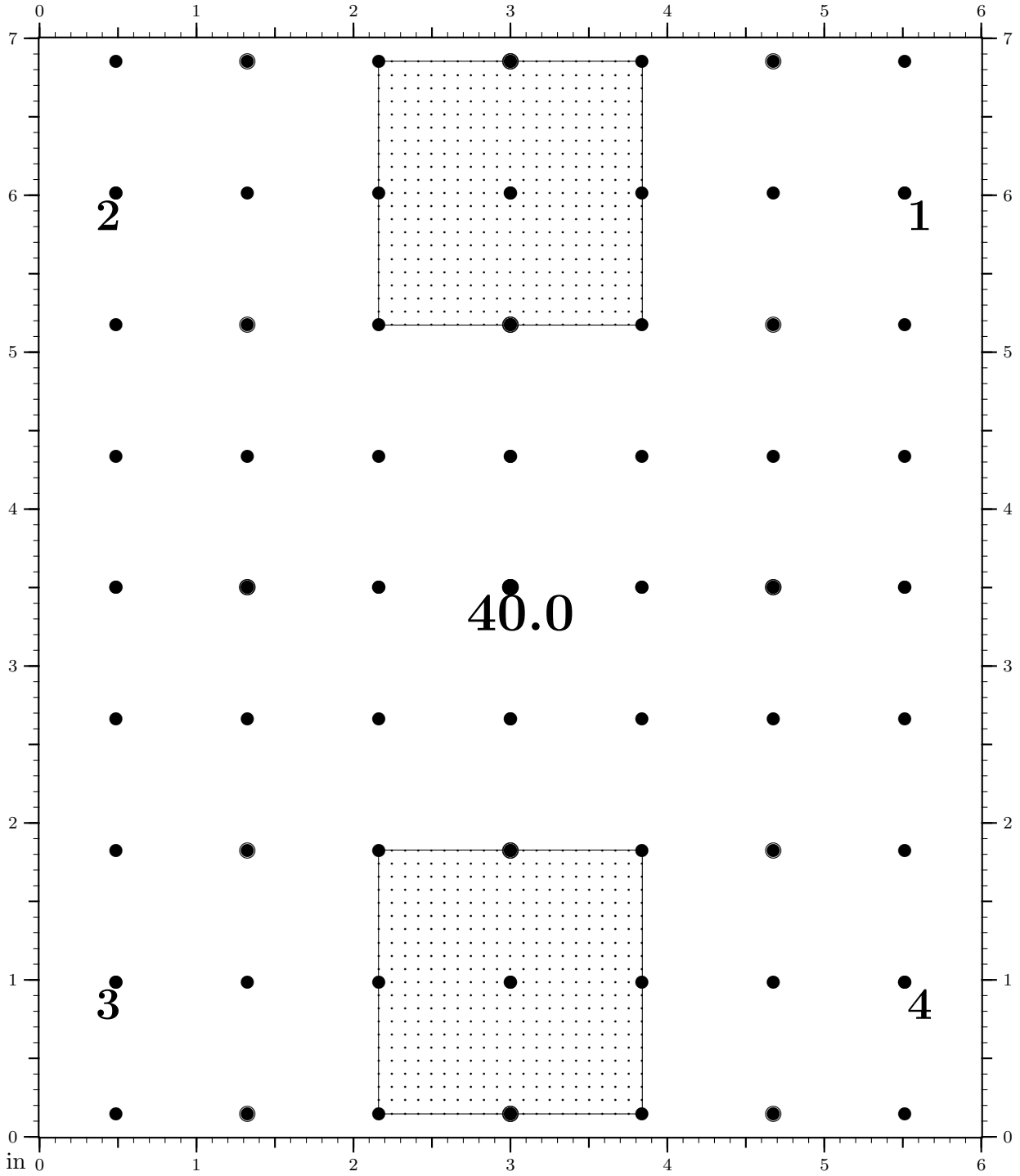

Figure 57: **0.1° at 40.0 feet is 0.837759 in.**

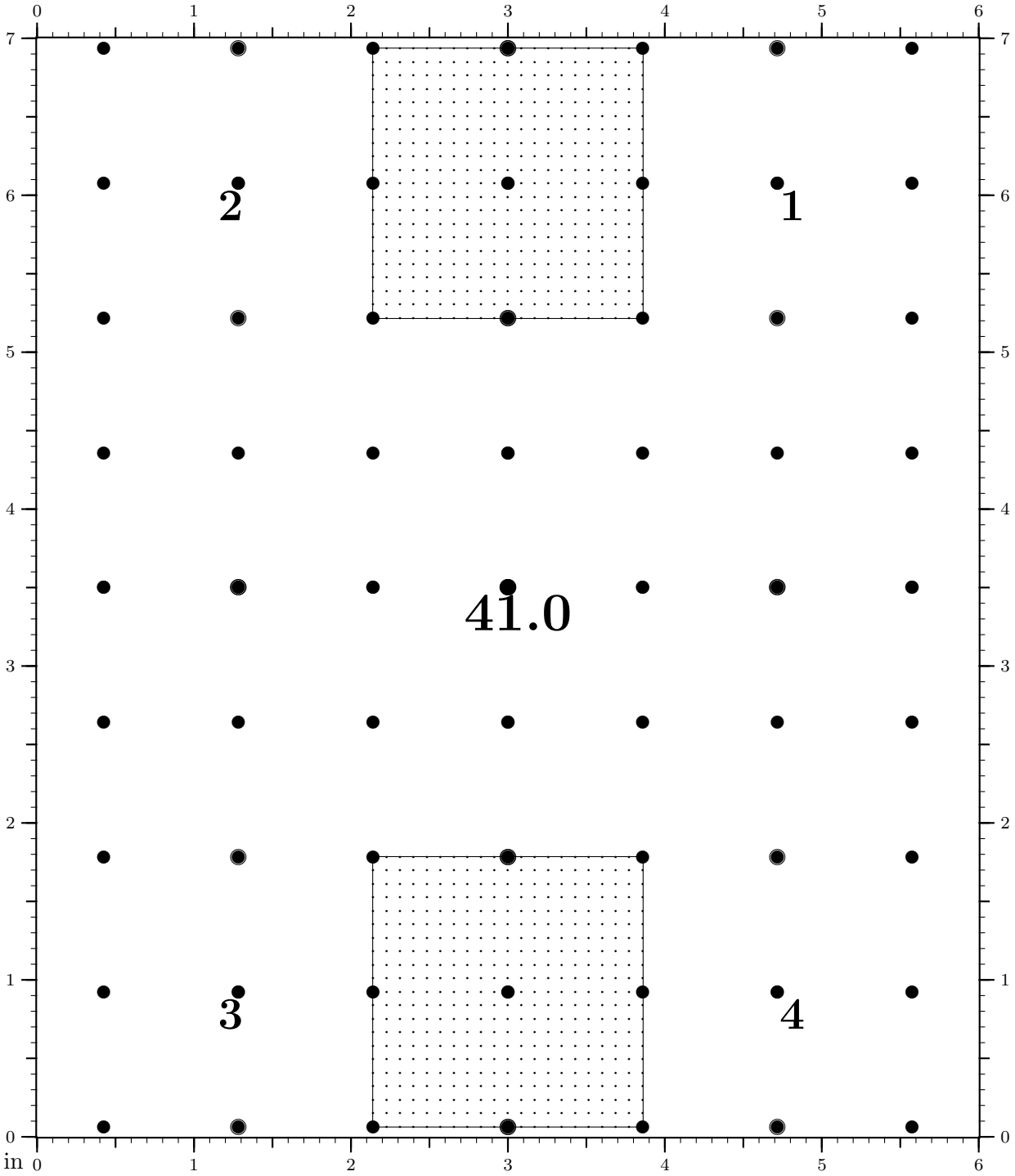

Figure 58: **0.1° at 41.0 feet is 0.858703 in.**

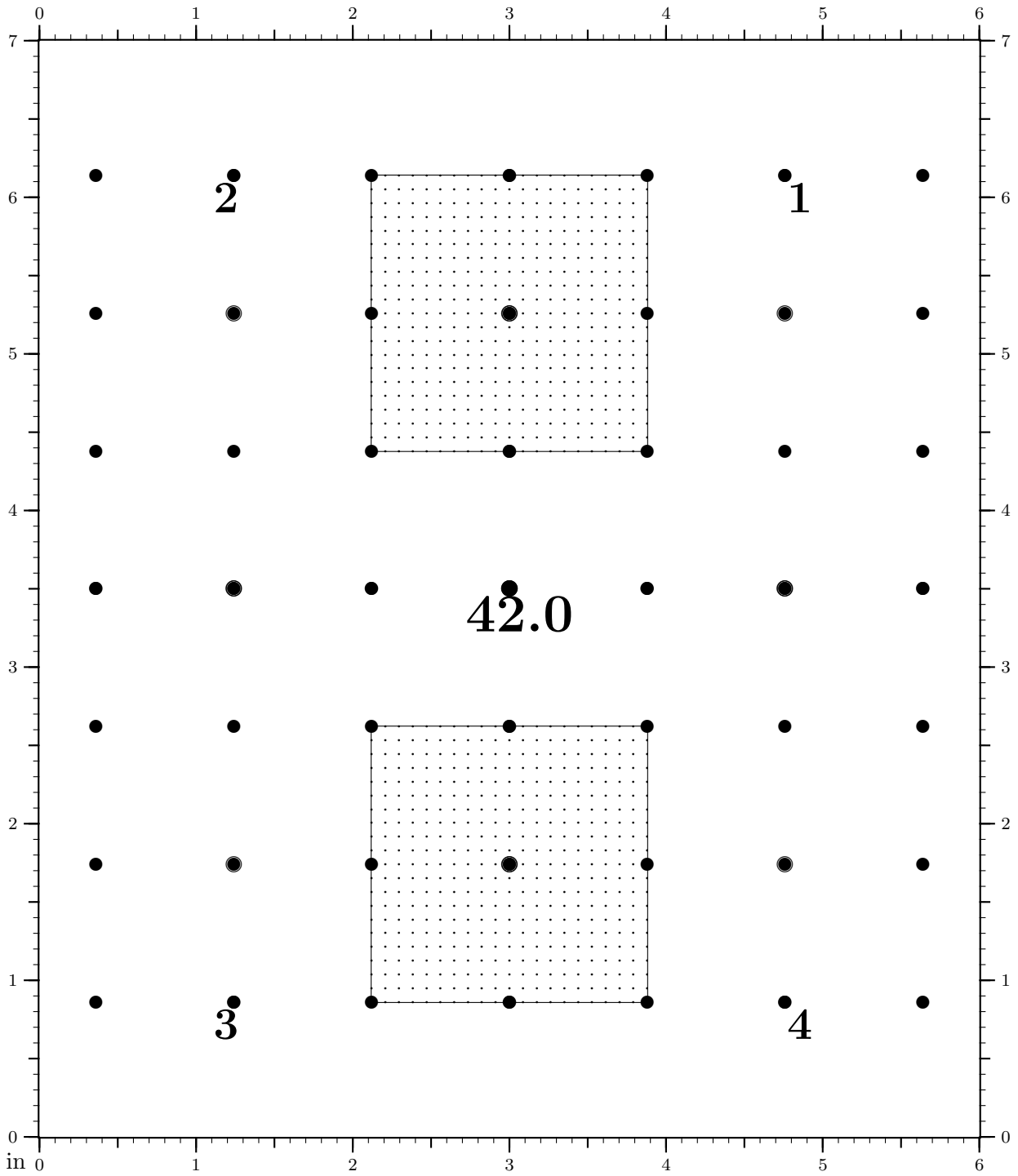

Figure 59: **0.1° at 42.0 feet is 0.879647 in.**

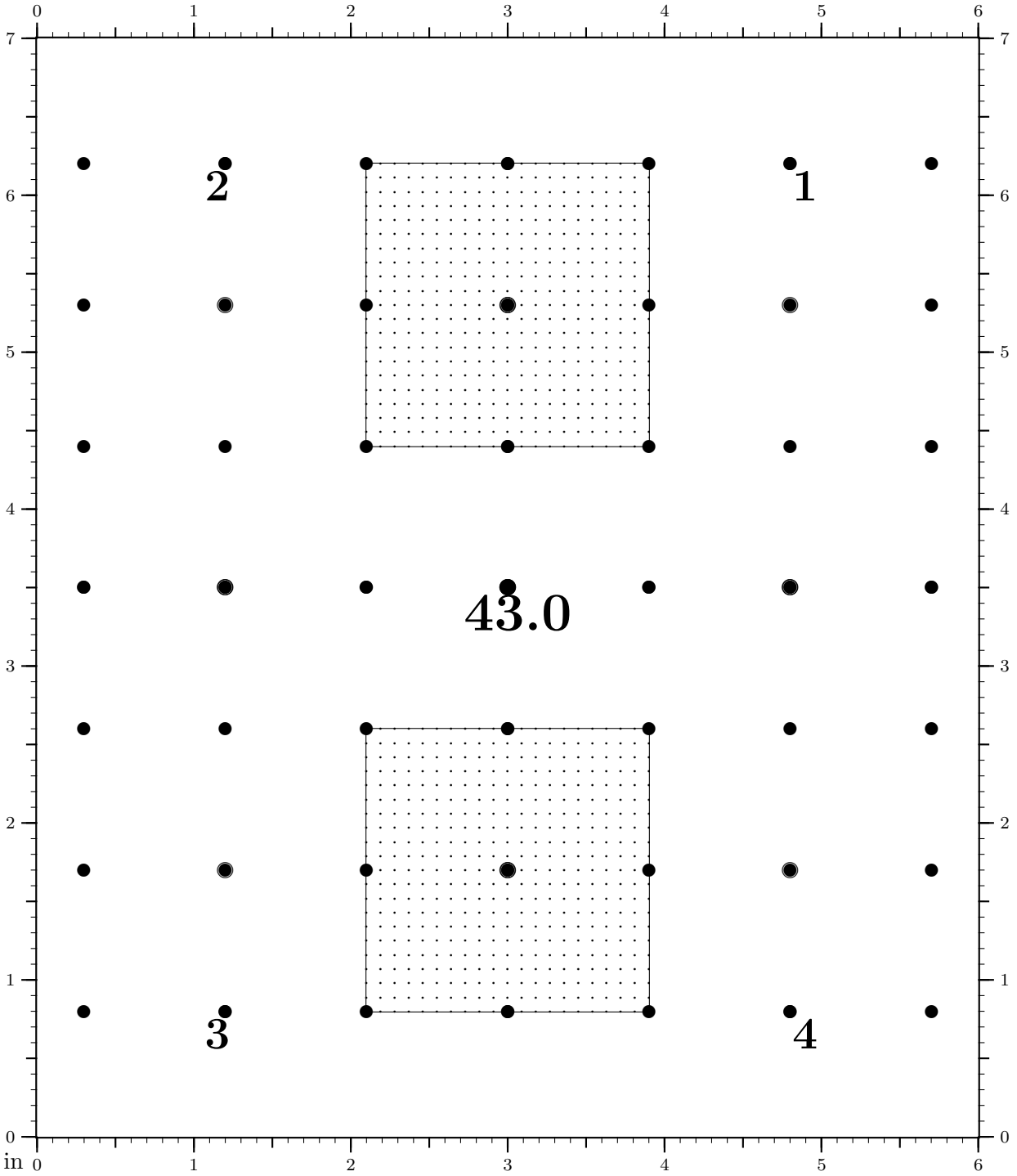

Figure 60: **0.1° at 43.0 feet is 0.900591 in.**

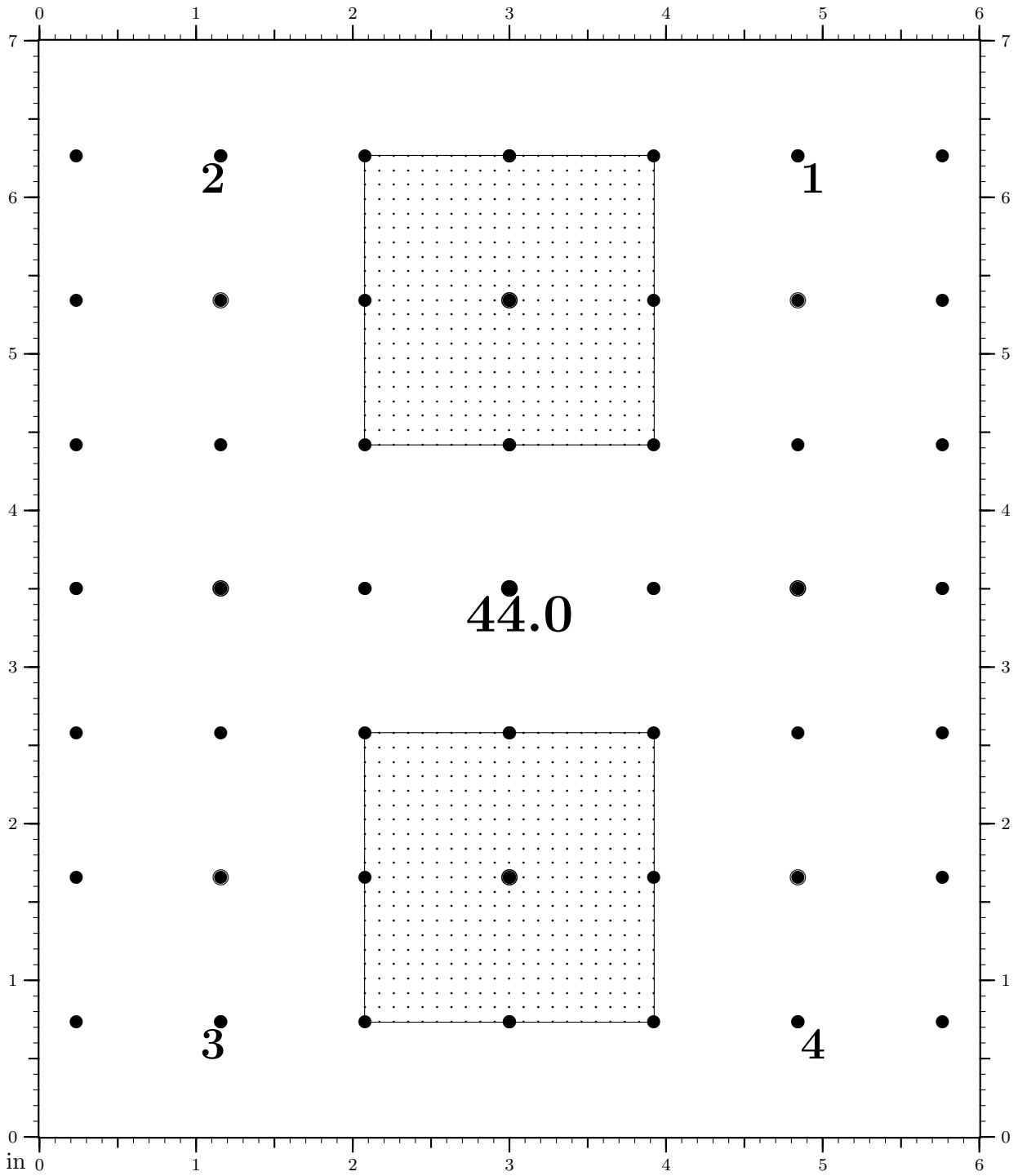

Figure 61: **0.1° at 44.0 feet is 0.921535 in.**

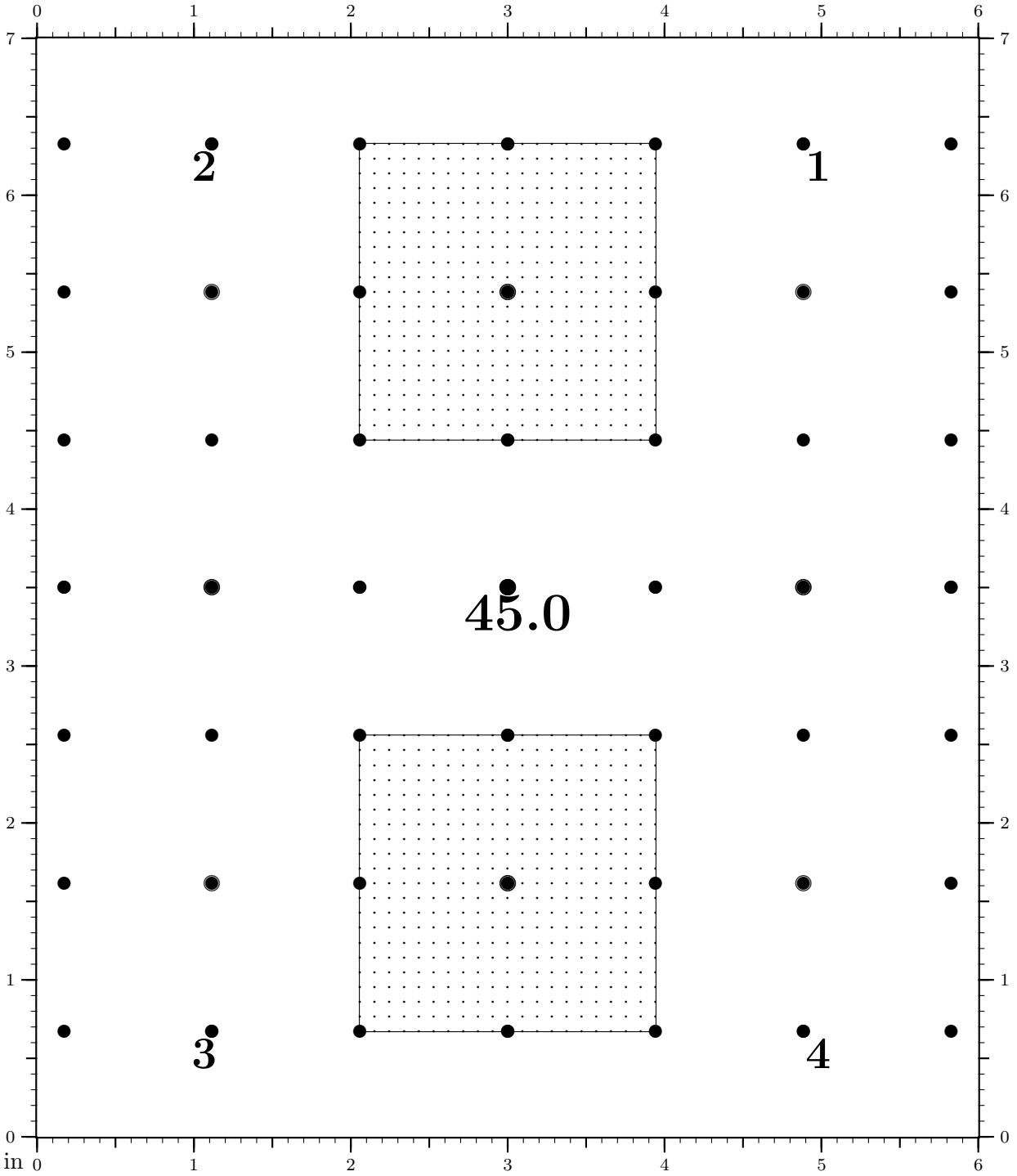

Figure 62: **0.1° at 45.0 feet is 0.942479 in.**

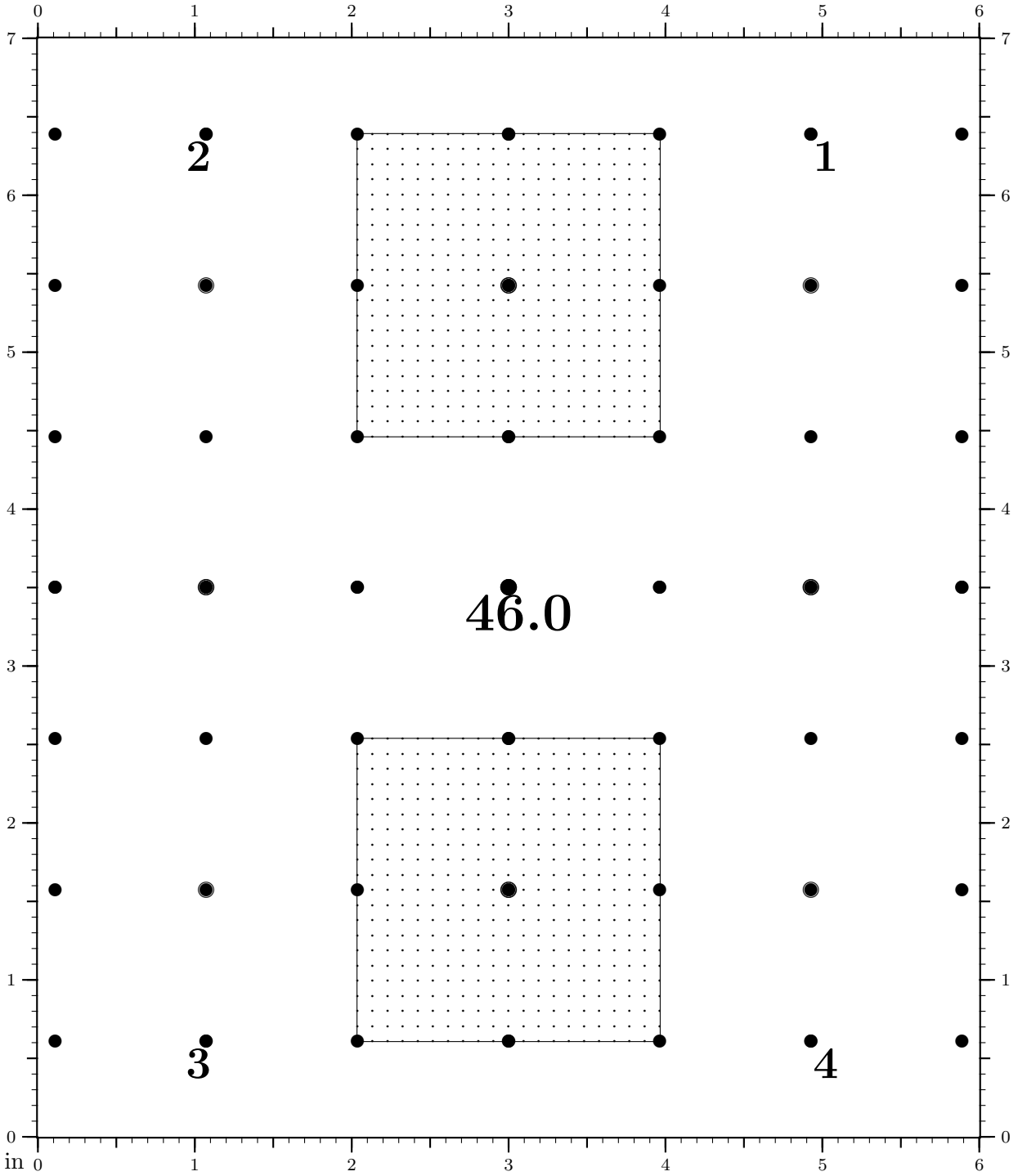

Figure 63: **0.1° at 46.0 feet is 0.963423 in.**

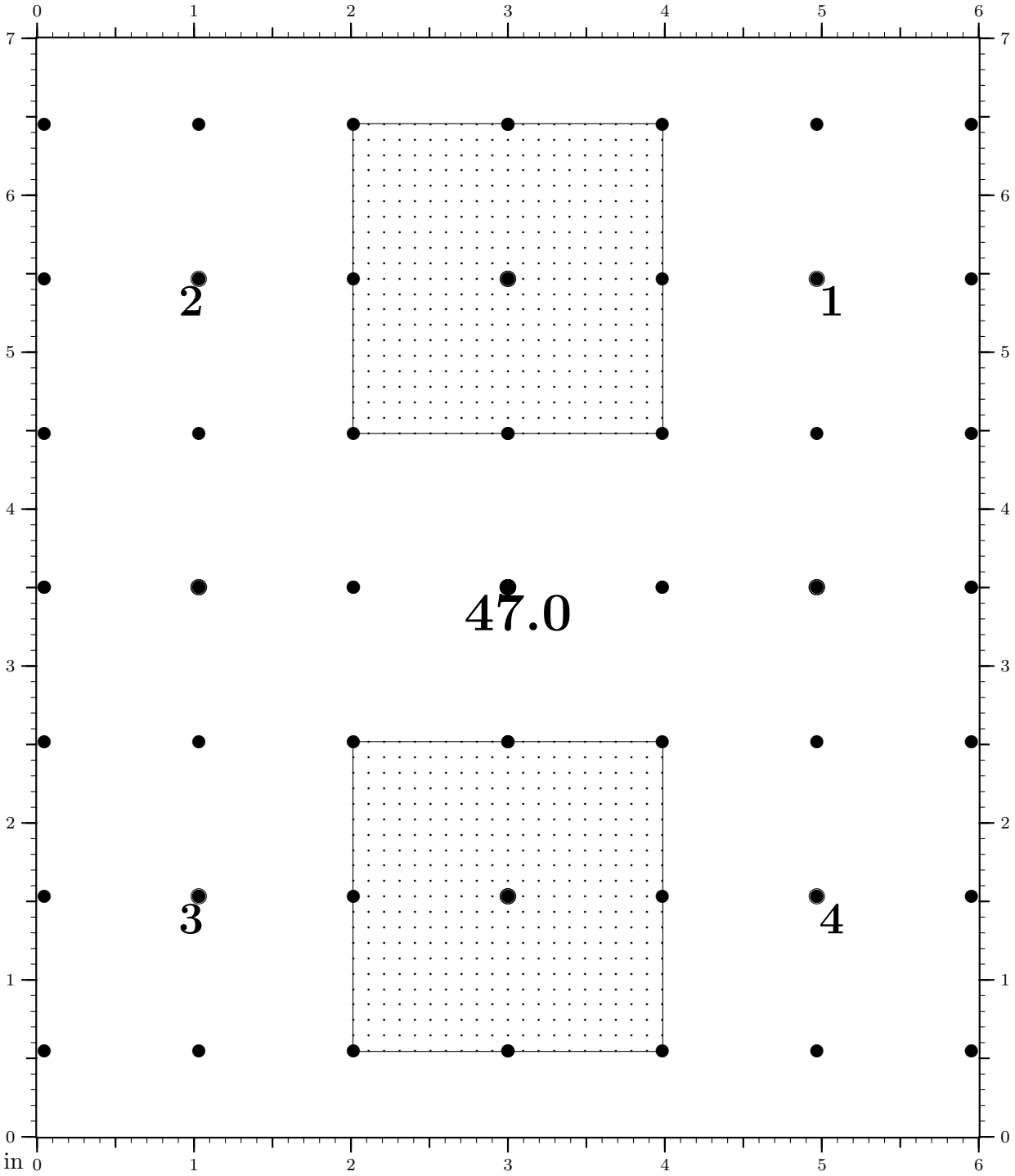

Figure 64: **0.1° at 47.0 feet is 0.984367 in.**

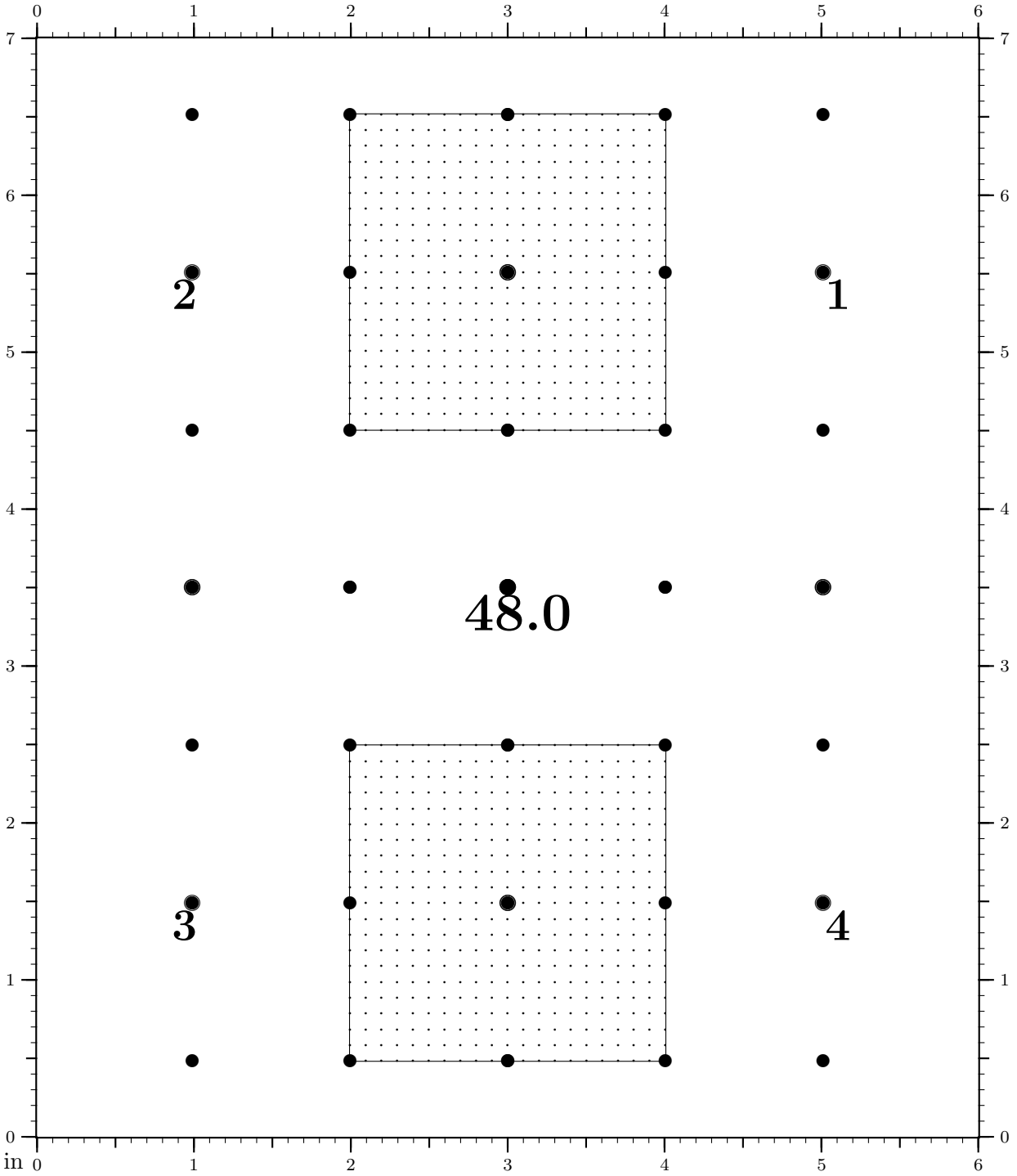

Figure 65: **0.1° at 48.0 feet is 1.005311 in.**

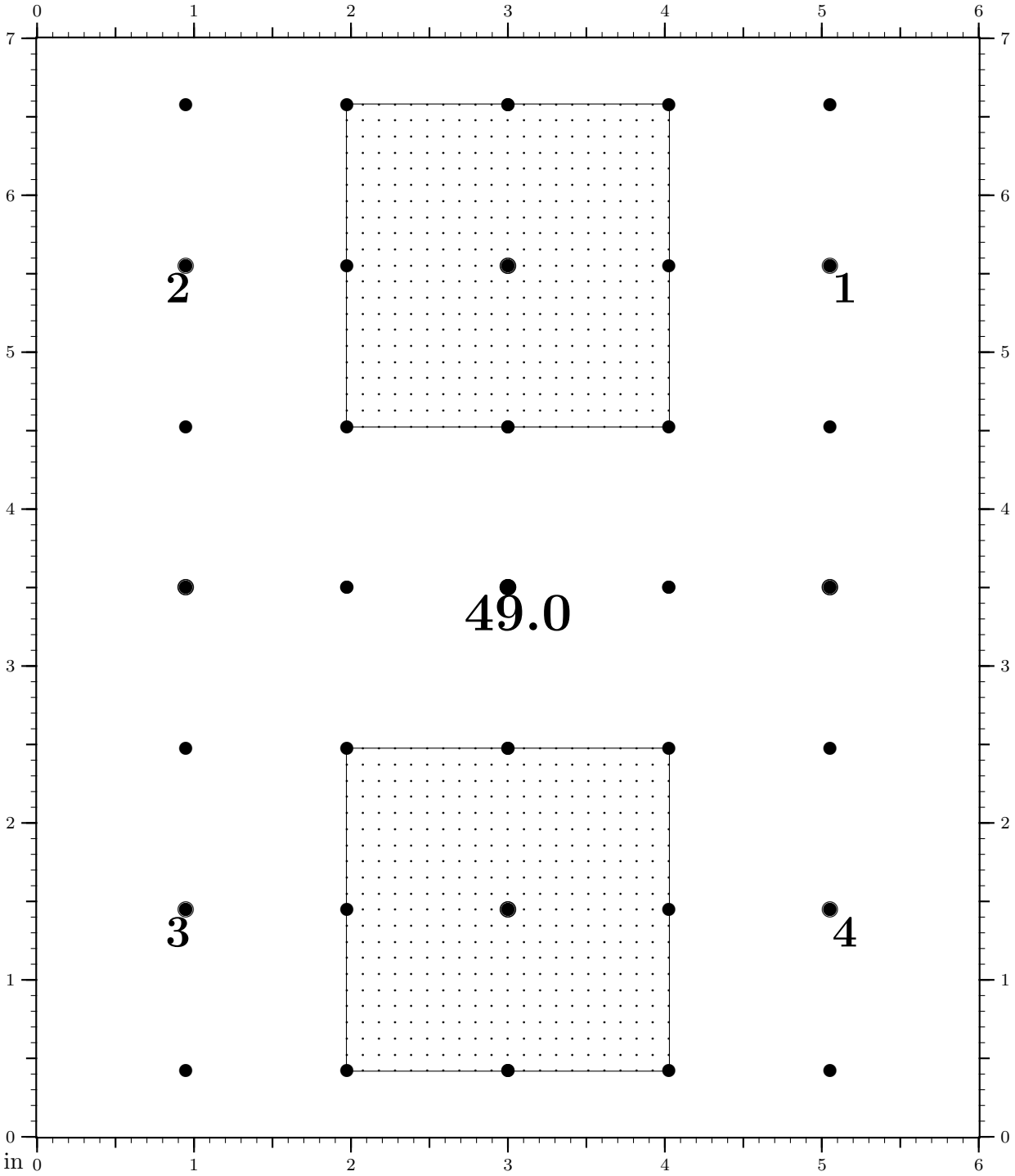

Figure 66: **0.1° at 49.0 feet is 1.026255 in.**

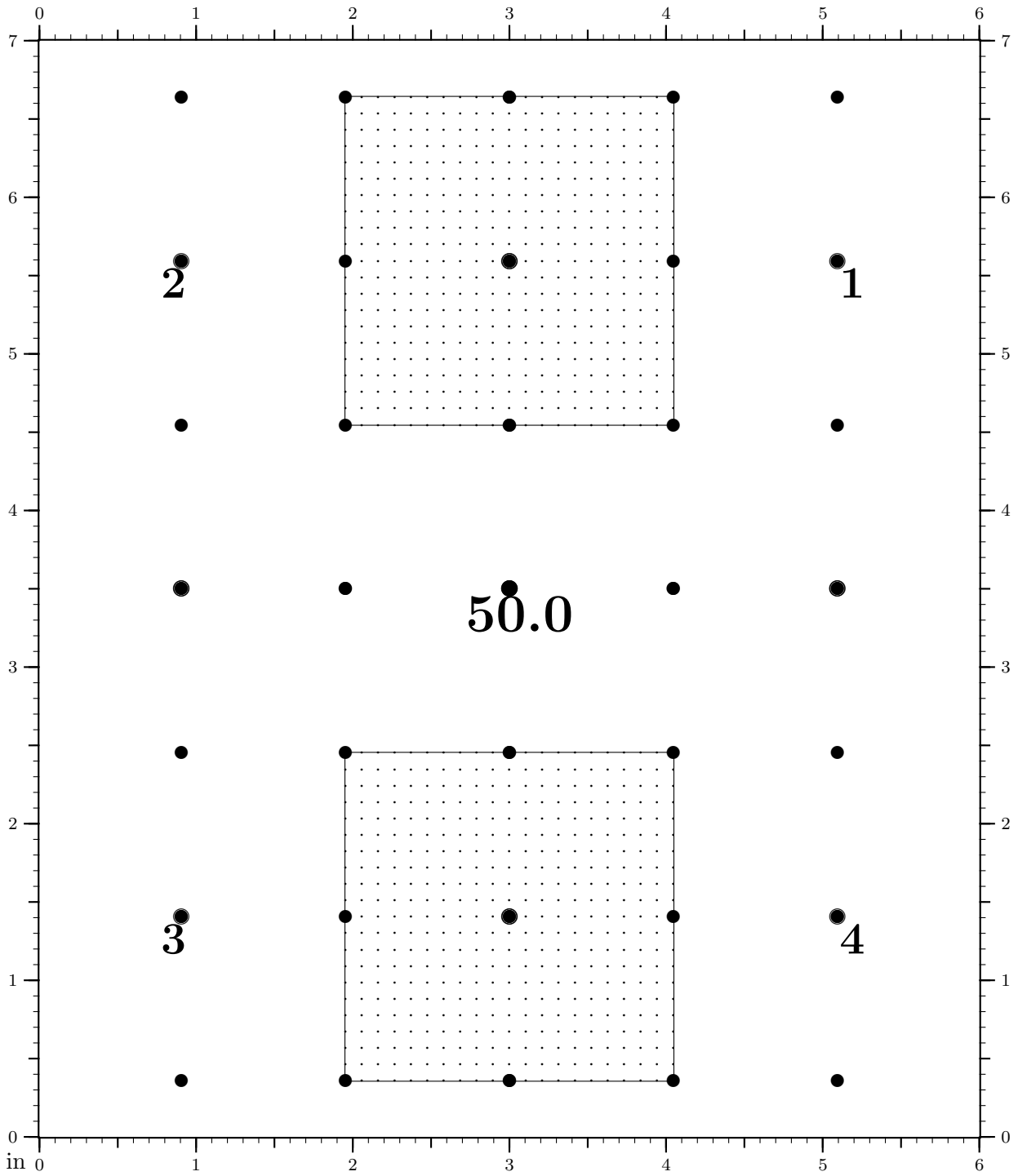

Figure 67: **0.1° at 50.0 feet is 1.047199 in.**

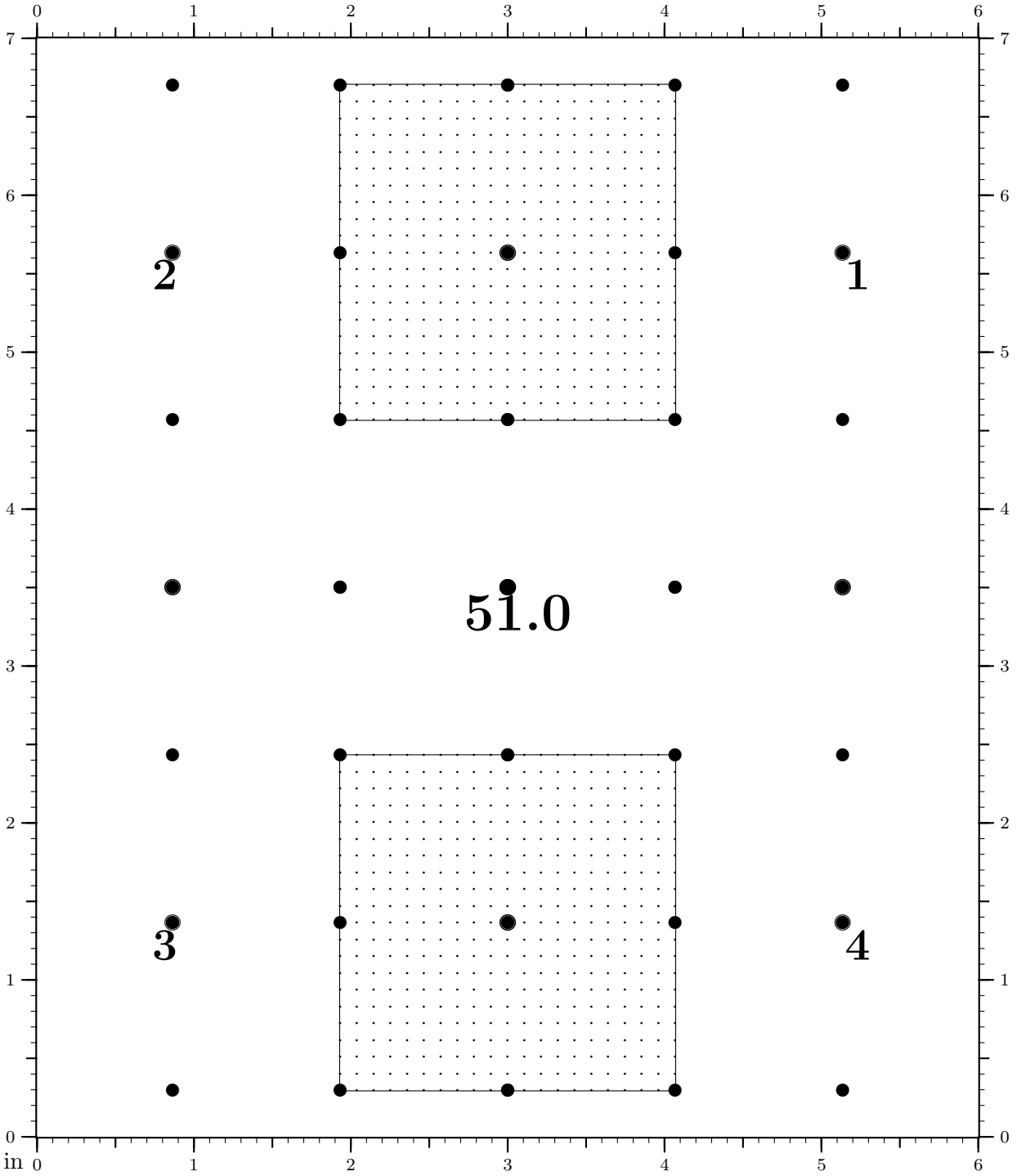

Figure 68: **0.1° at 51.0 feet is 1.068143 in.**

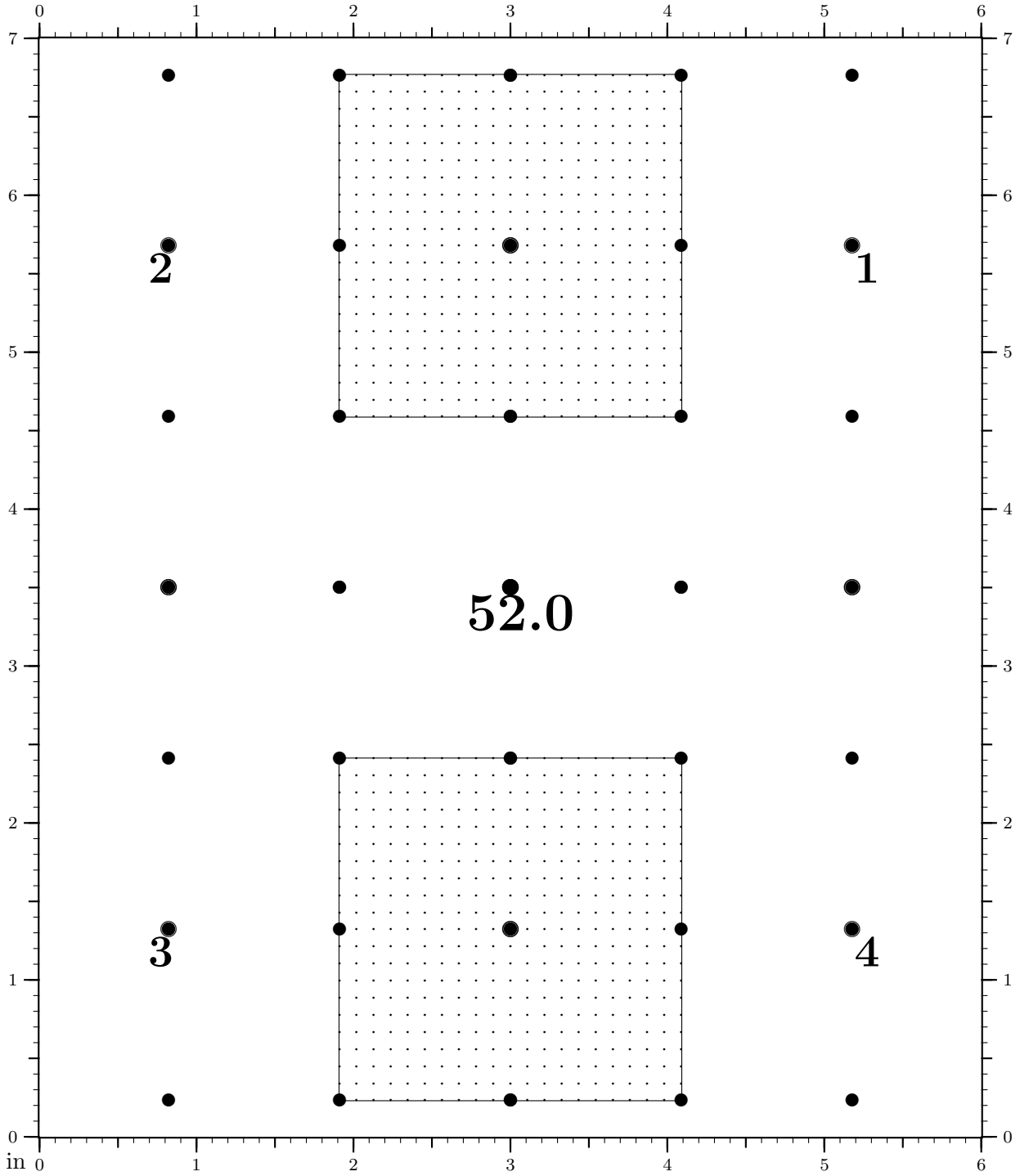

Figure 69: **0.1° at 52.0 feet is 1.089087 in.**

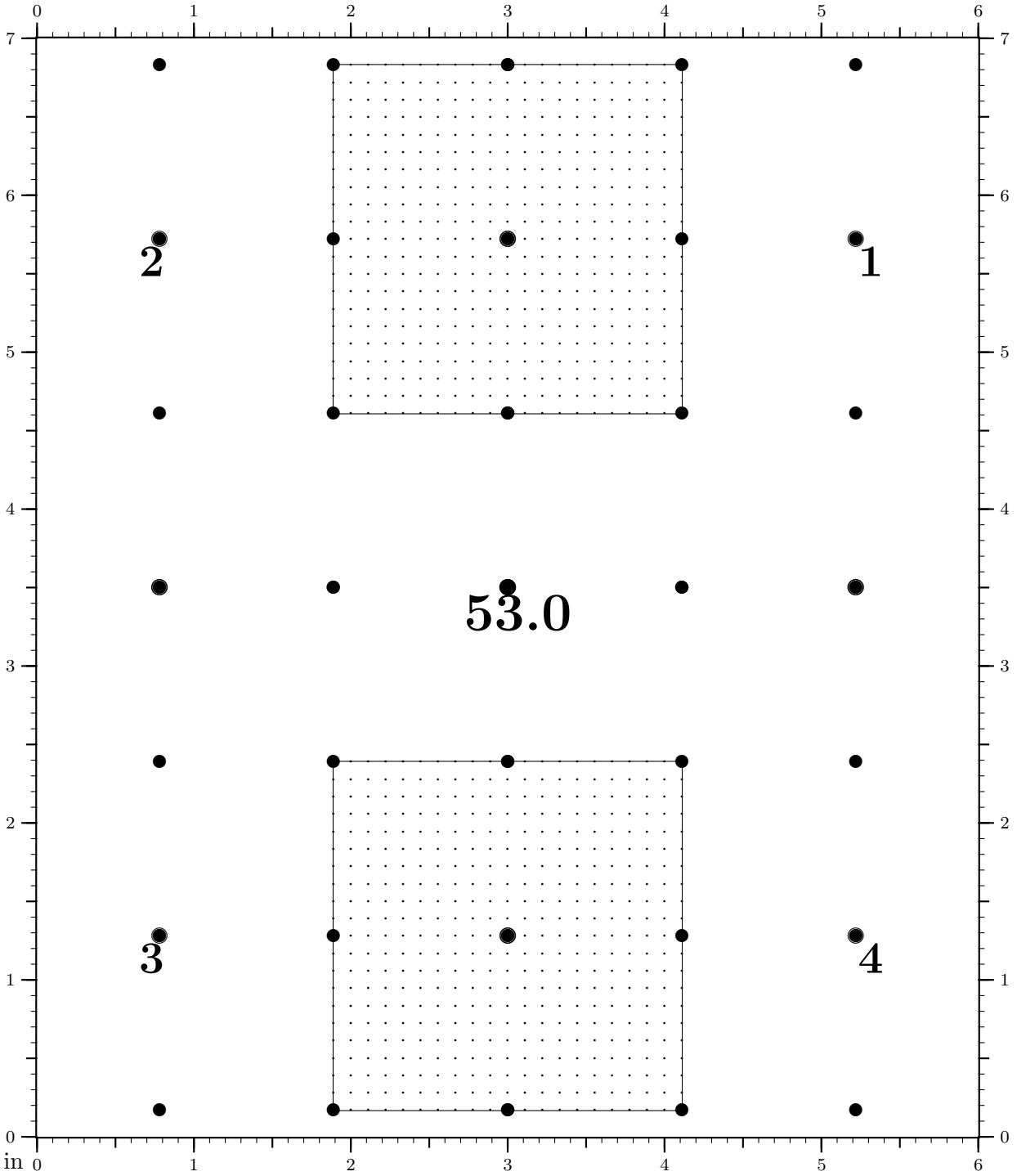

Figure 70: **0.1° at 53.0 feet is 1.110031 in.**

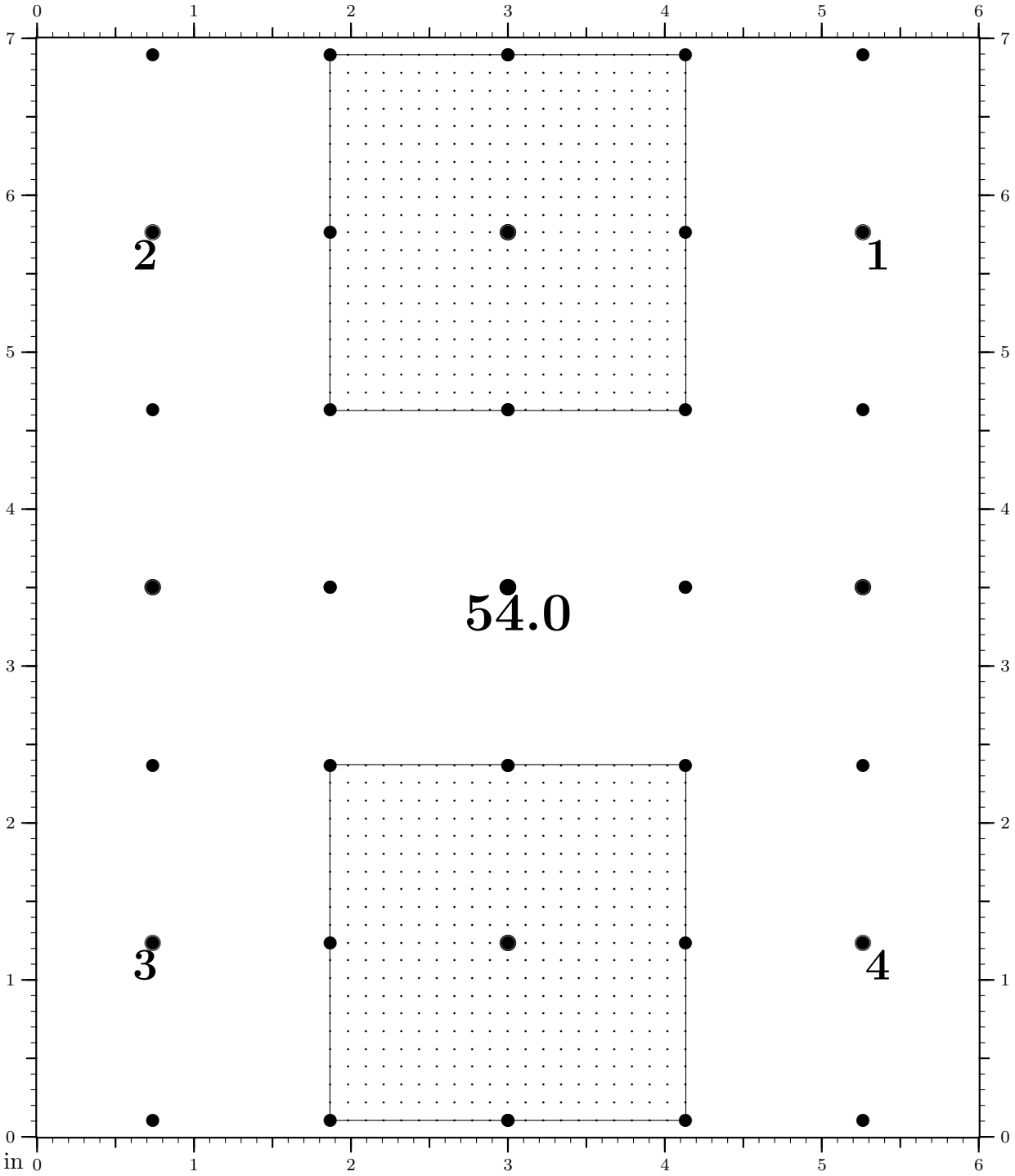

Figure 71: **0.1° at 54.0 feet is 1.130975 in.**

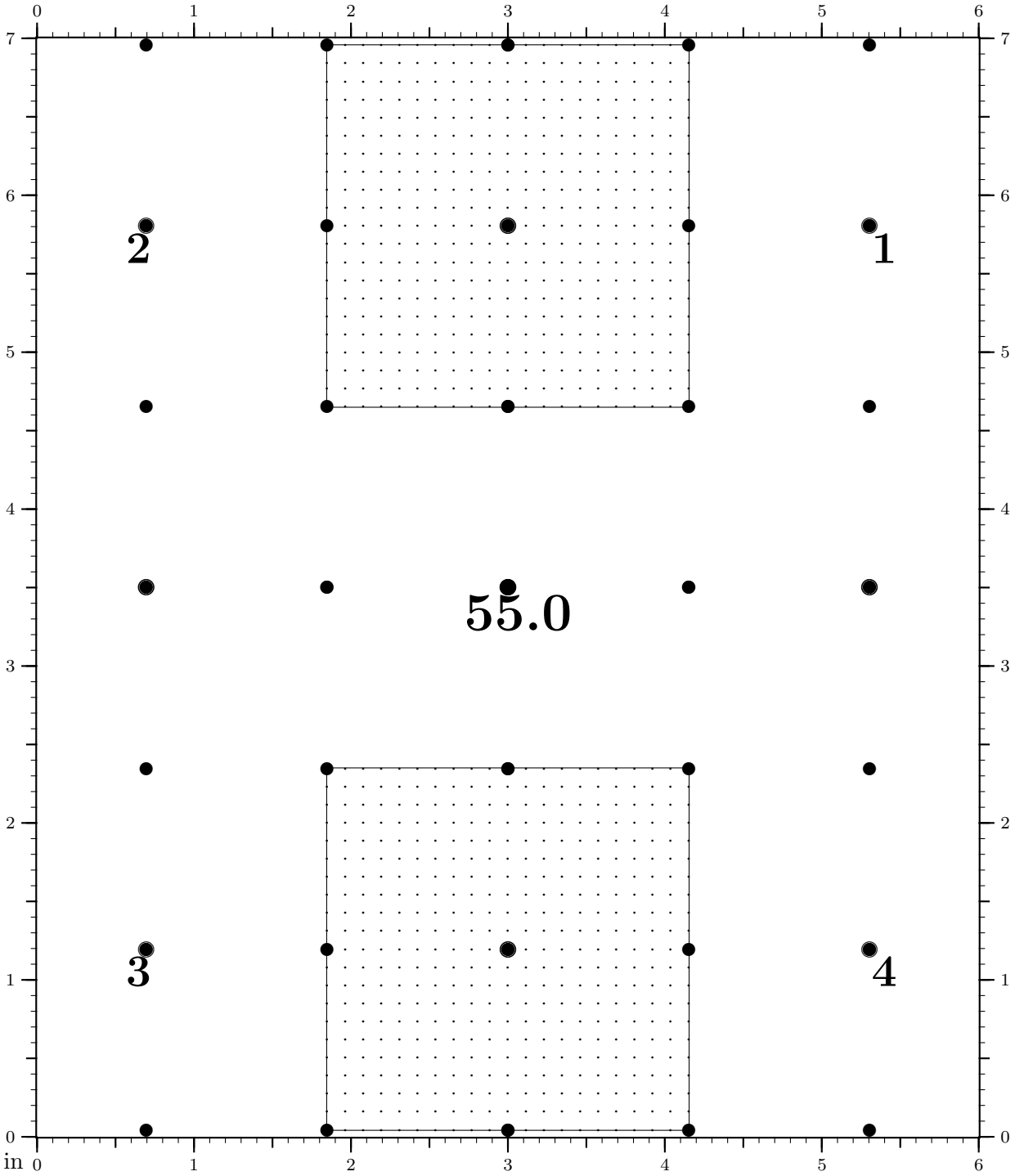

Figure 72: **0.1° at 55.0 feet is 1.151919 in.**

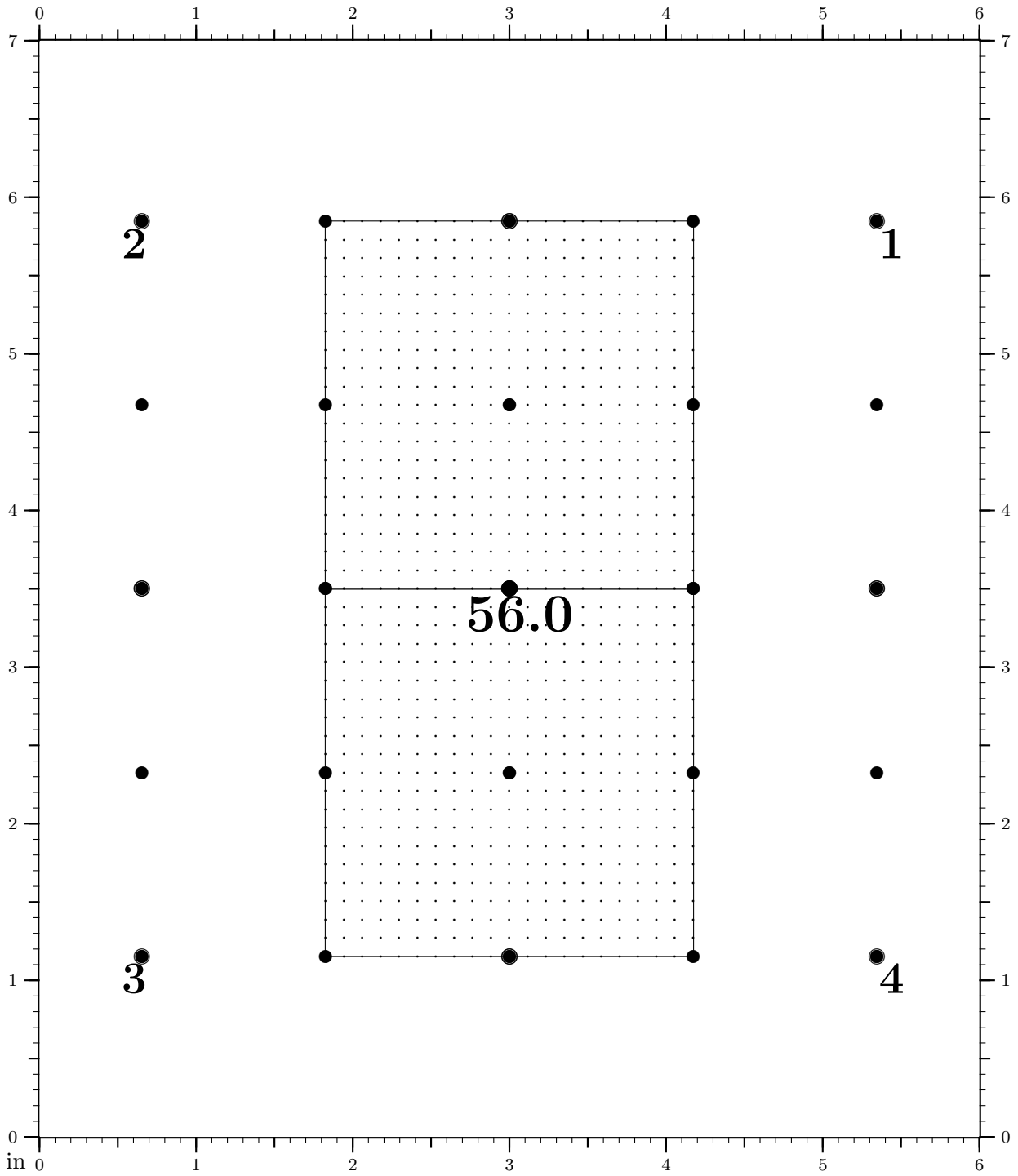

Figure 73: **0.1° at 56.0 feet is 1.172863 in.**

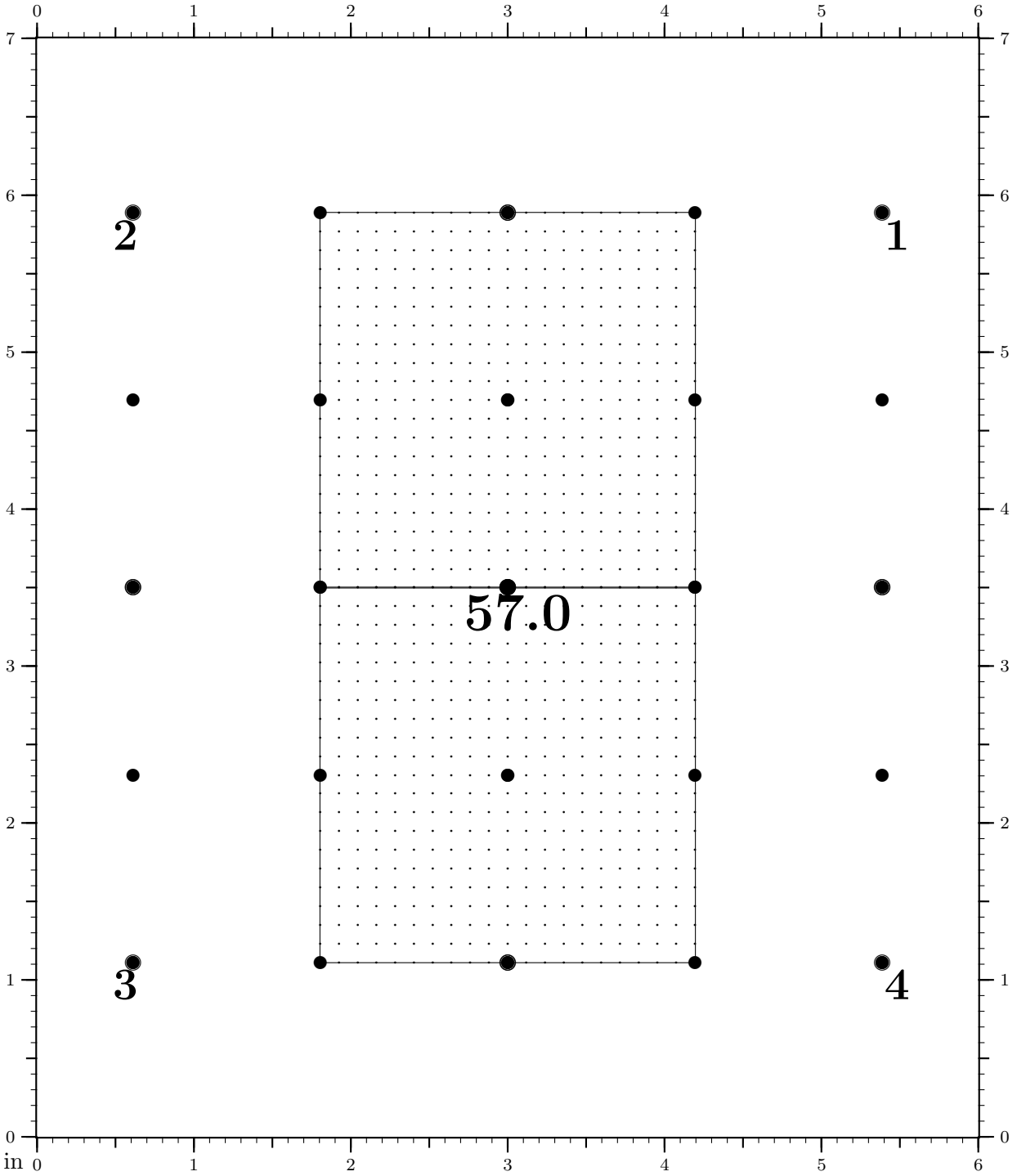

Figure 74: **0.1° at 57.0 feet is 1.193807 in.**

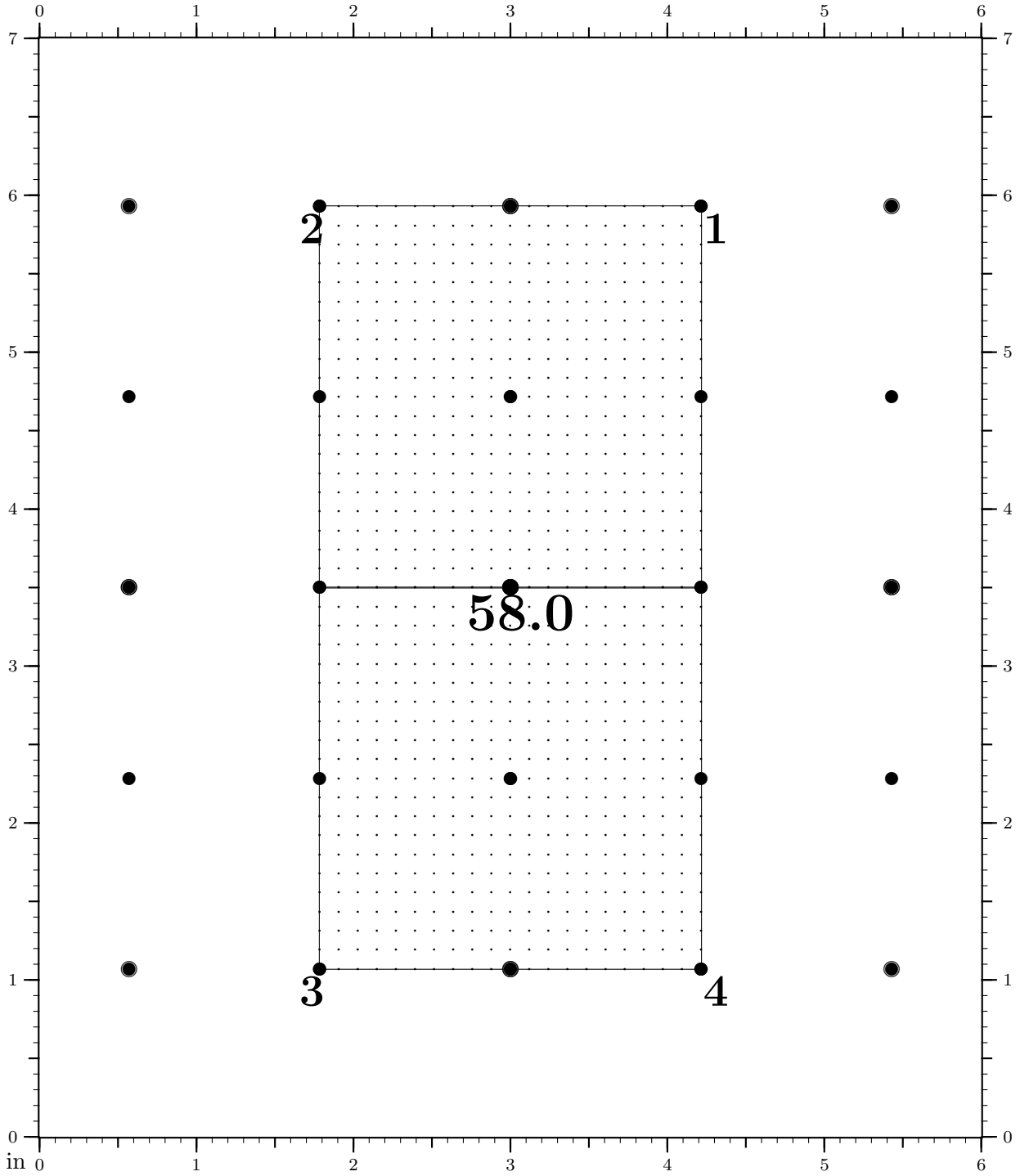

Figure 75: **0.1° at 58.0 feet is 1.214751 in.**

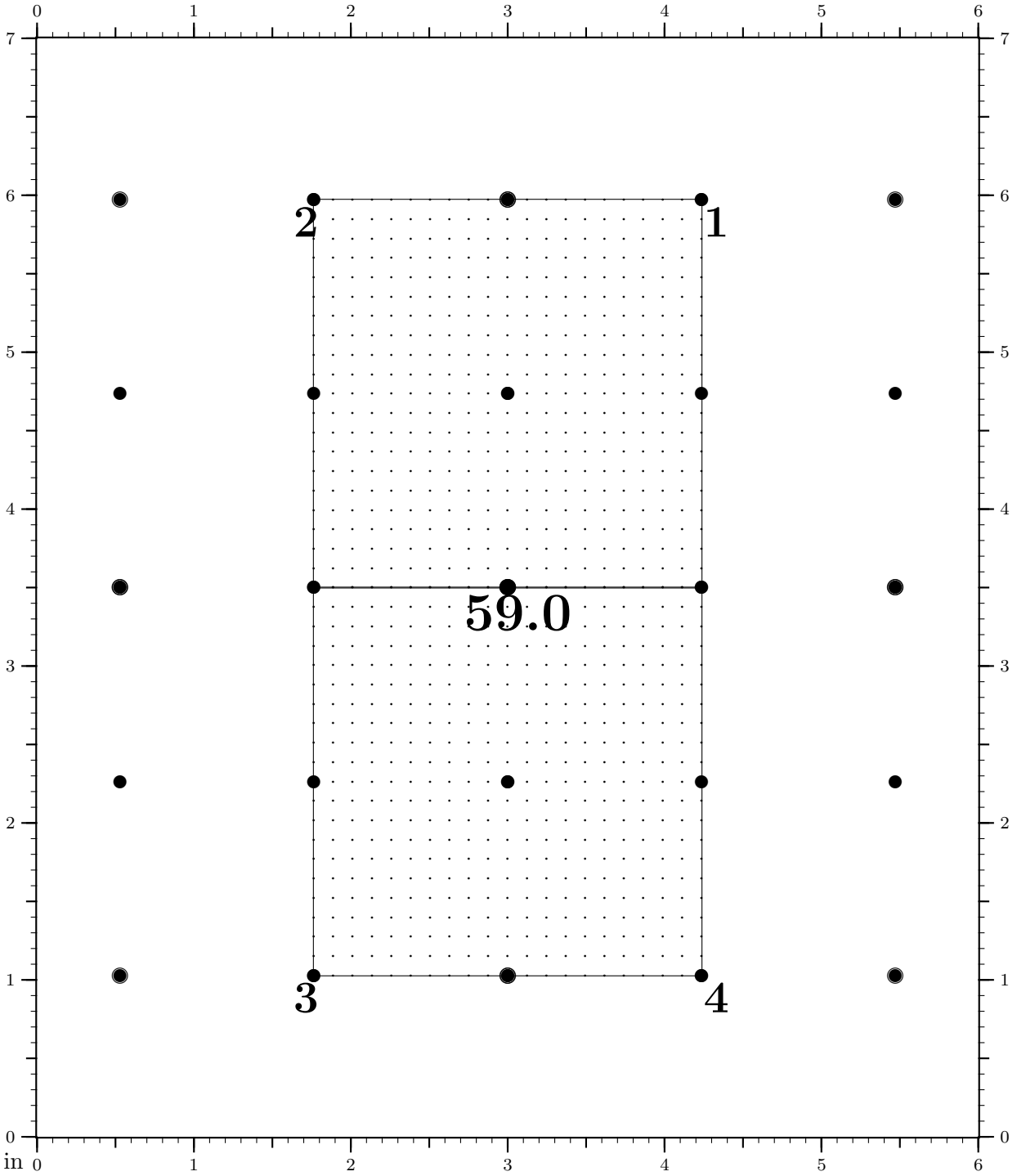

Figure 76: **0.1° at 59.0 feet is 1.235695 in.**

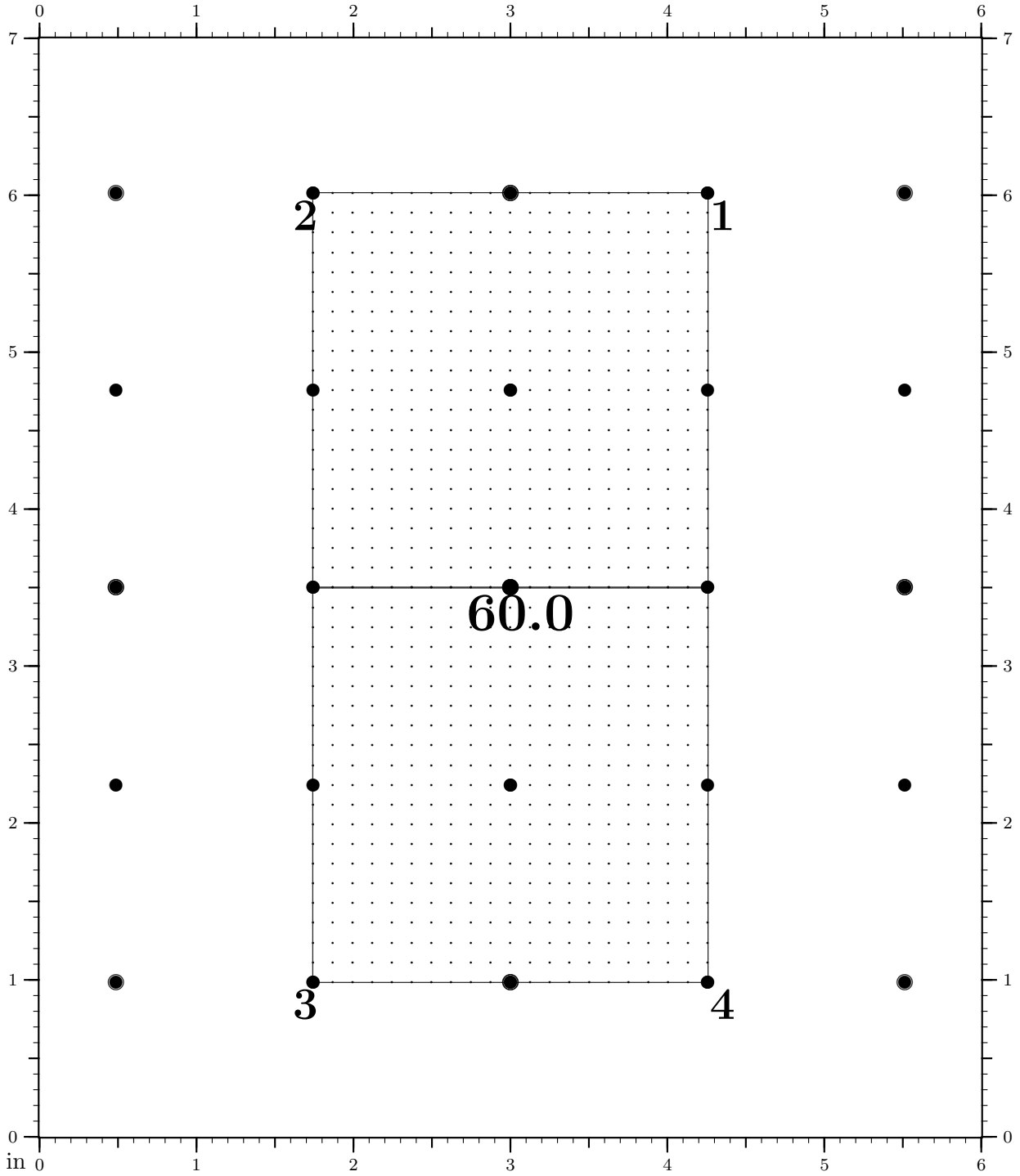

Figure 77: **0.1° at 60.0 feet is 1.256638 in.**

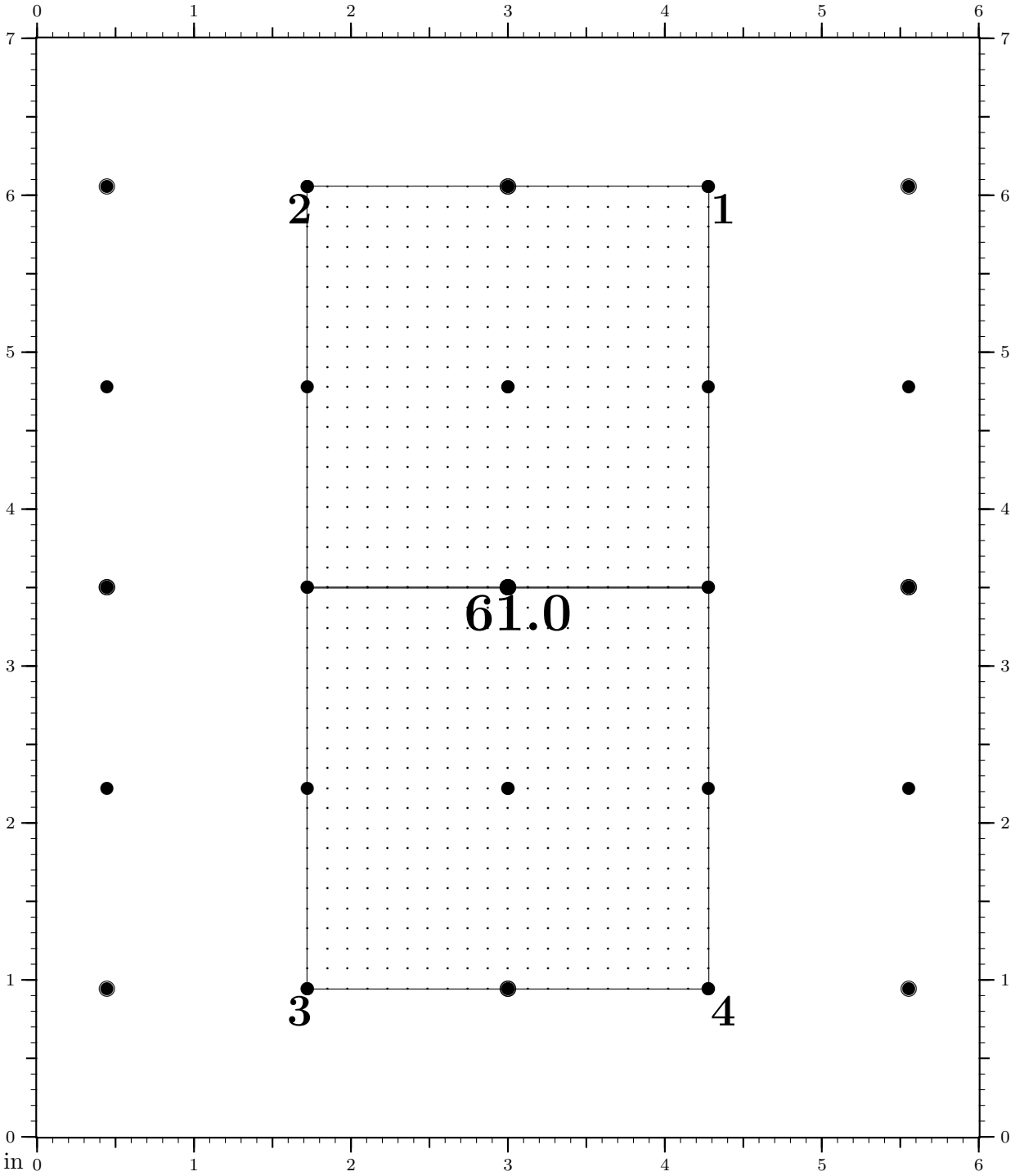

Figure 78: **0.1° at 61.0 feet is 1.277582 in.**

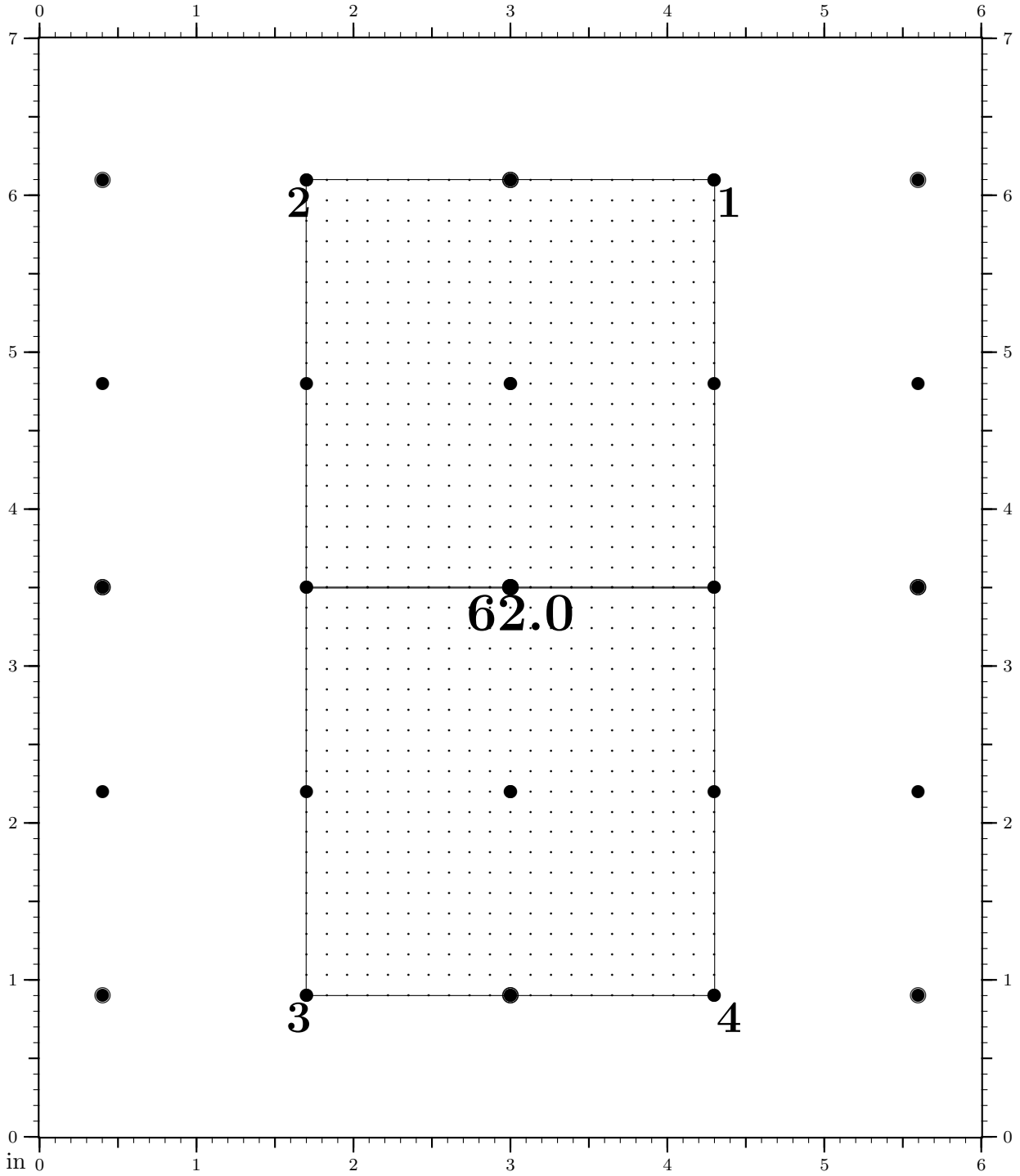

Figure 79: **0.1° at 62.0 feet is 1.298527 in.**

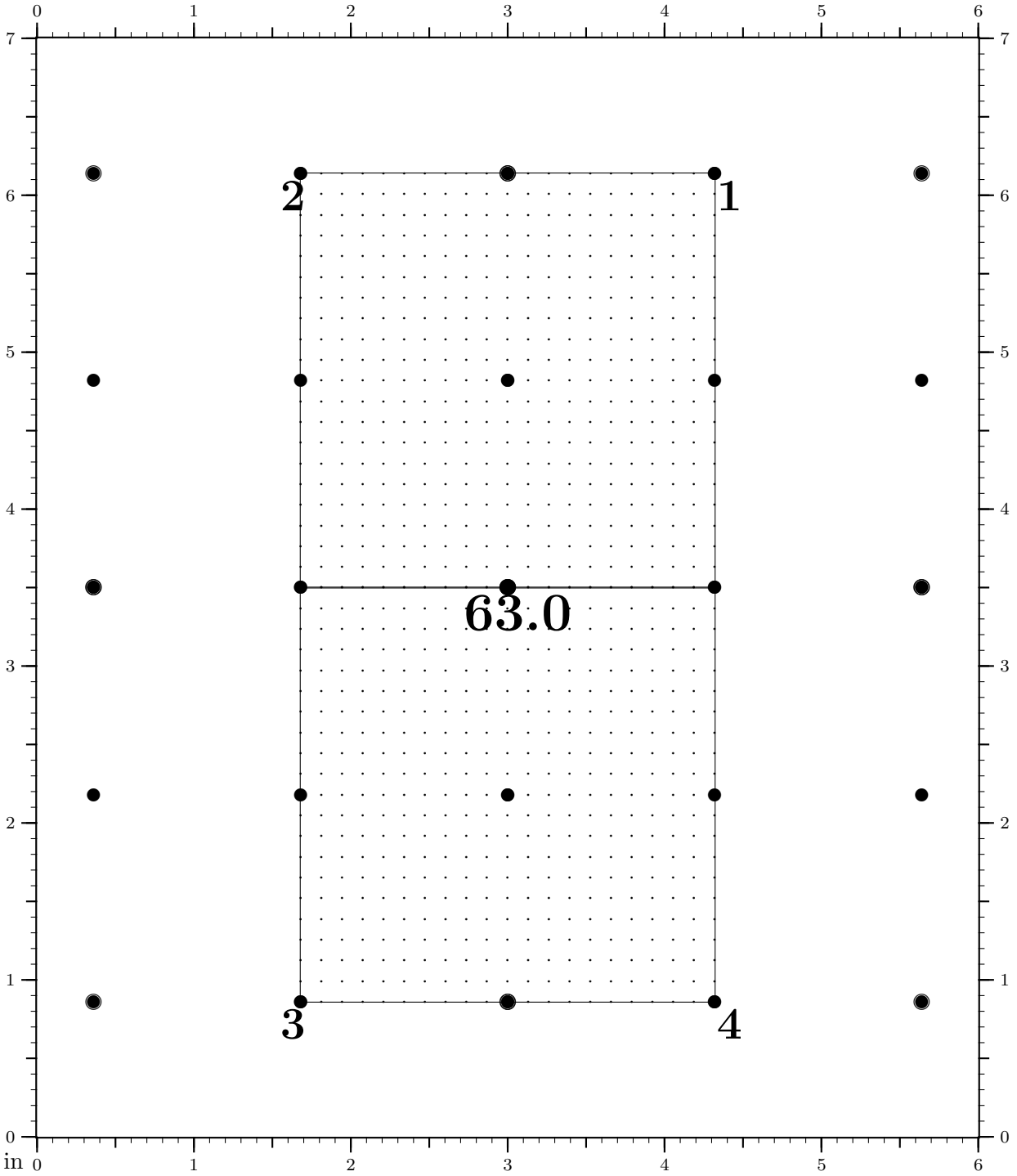

Figure 80: **0.1° at 63.0 feet is 1.319471 in.**

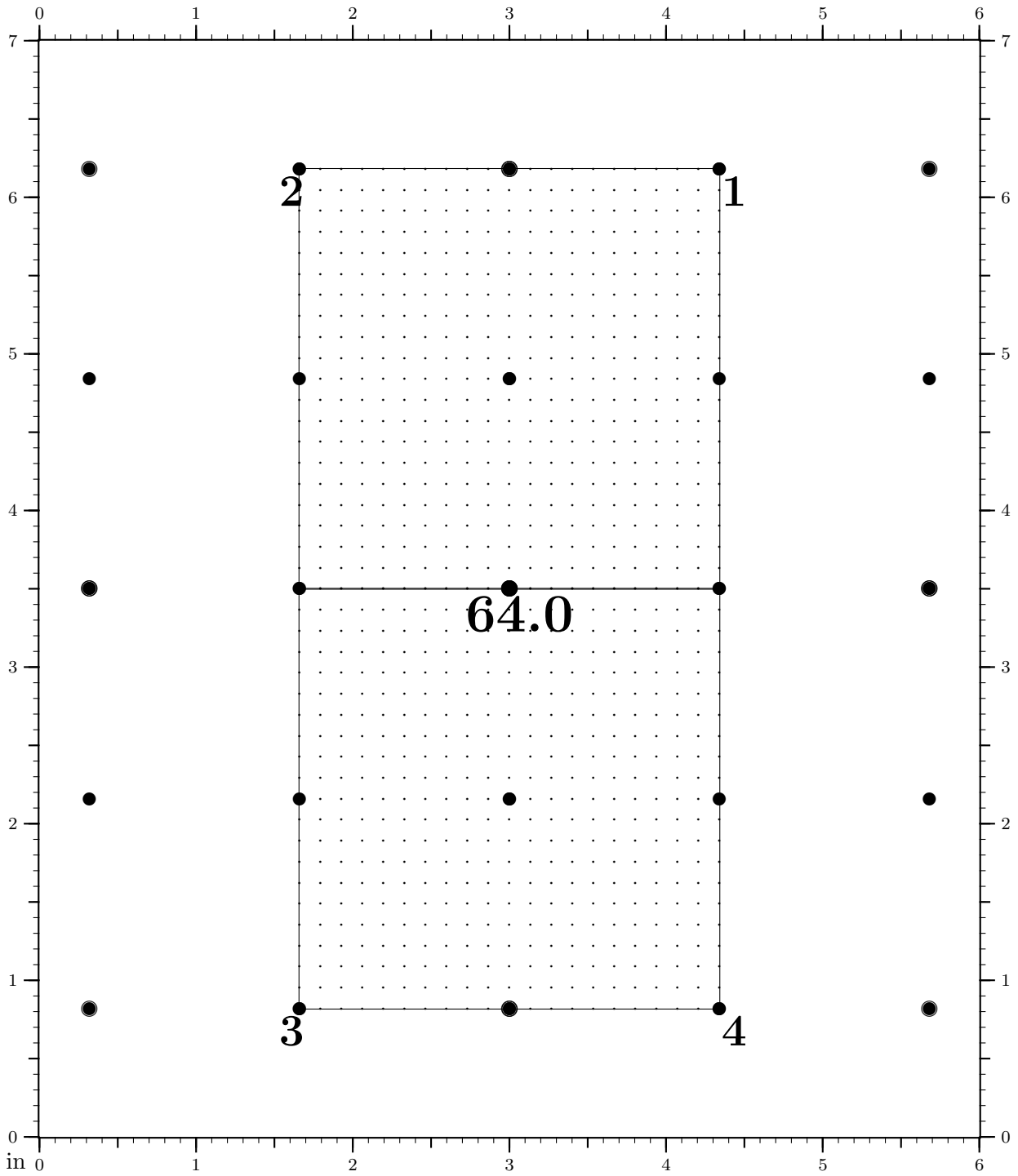

Figure 81: **0.1° at 64.0 feet is 1.340415 in.**

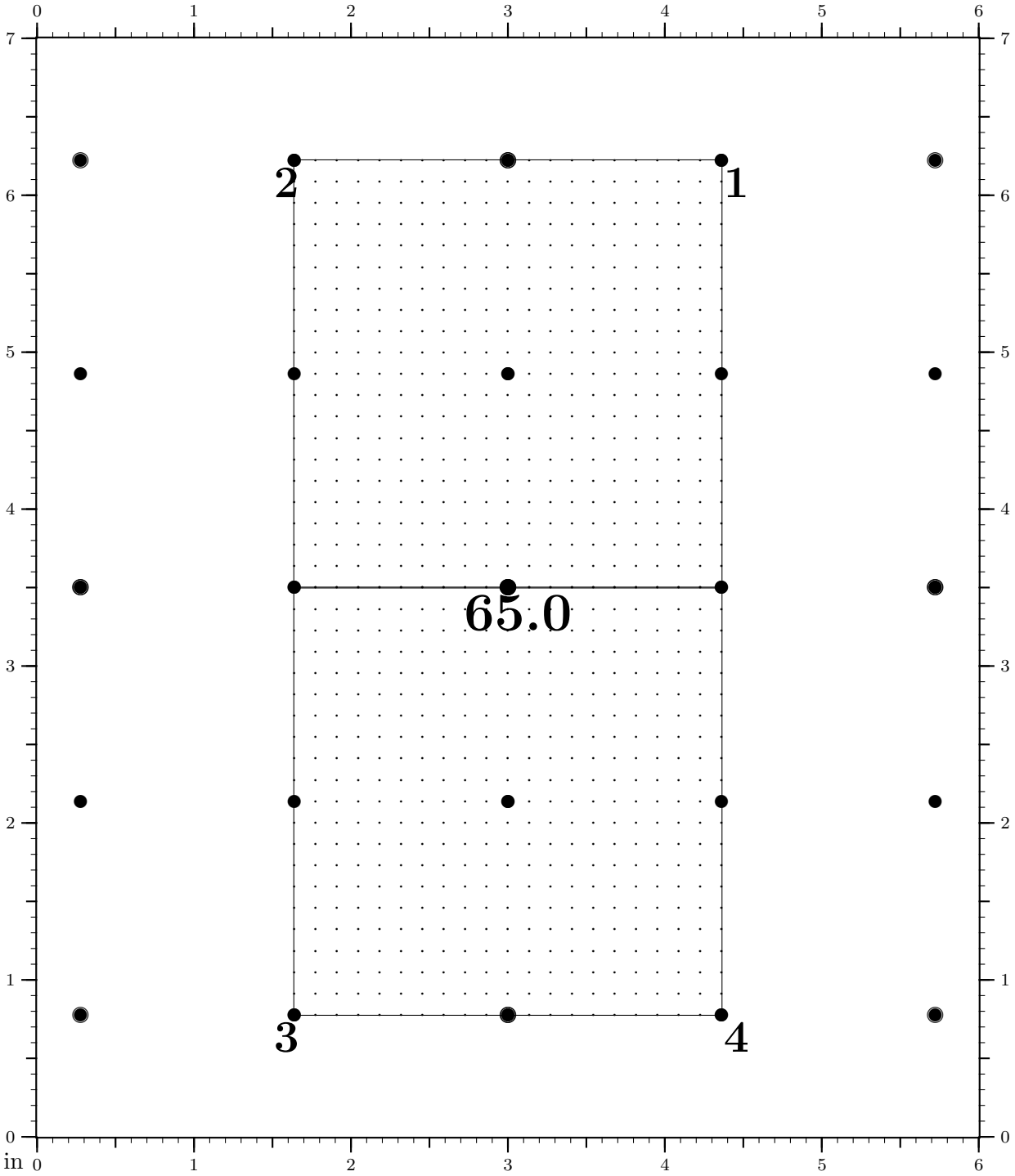

Figure 82: **0.1° at 65.0 feet is 1.361359 in.**

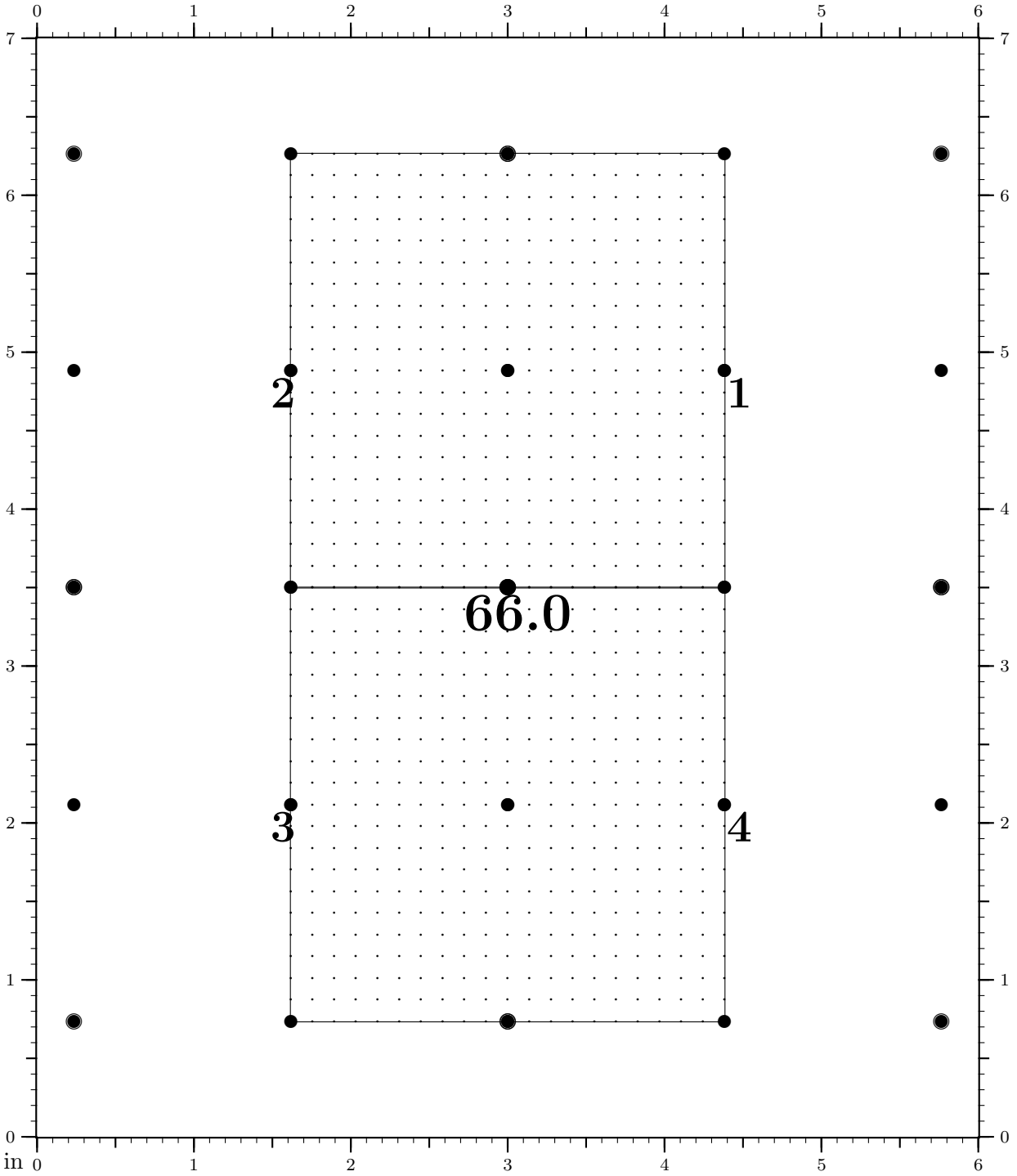

Figure 83: **0.1° at 66.0 feet is 1.382302 in.**

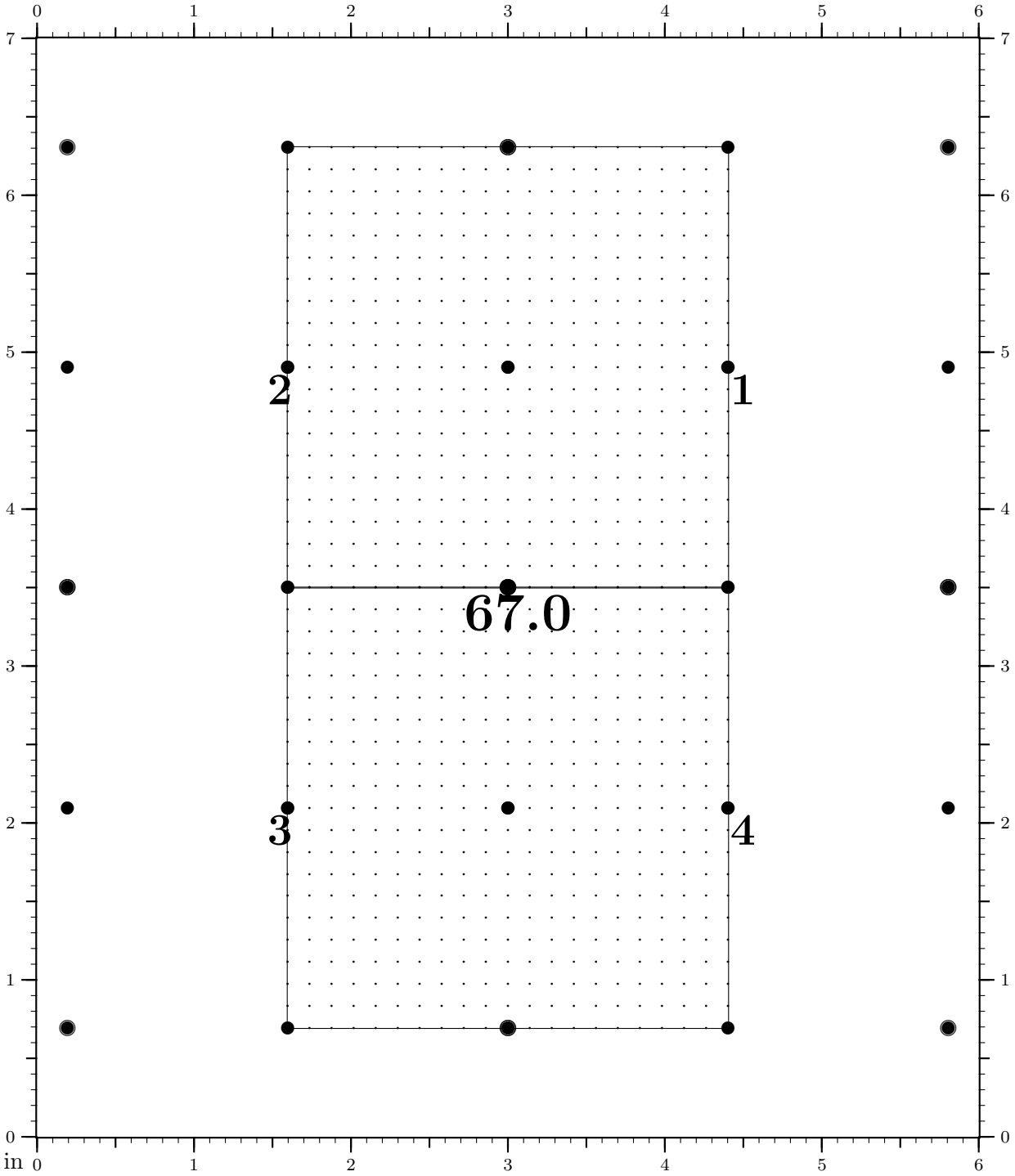

Figure 84: **0.1° at 67.0 feet is 1.403246 in.**

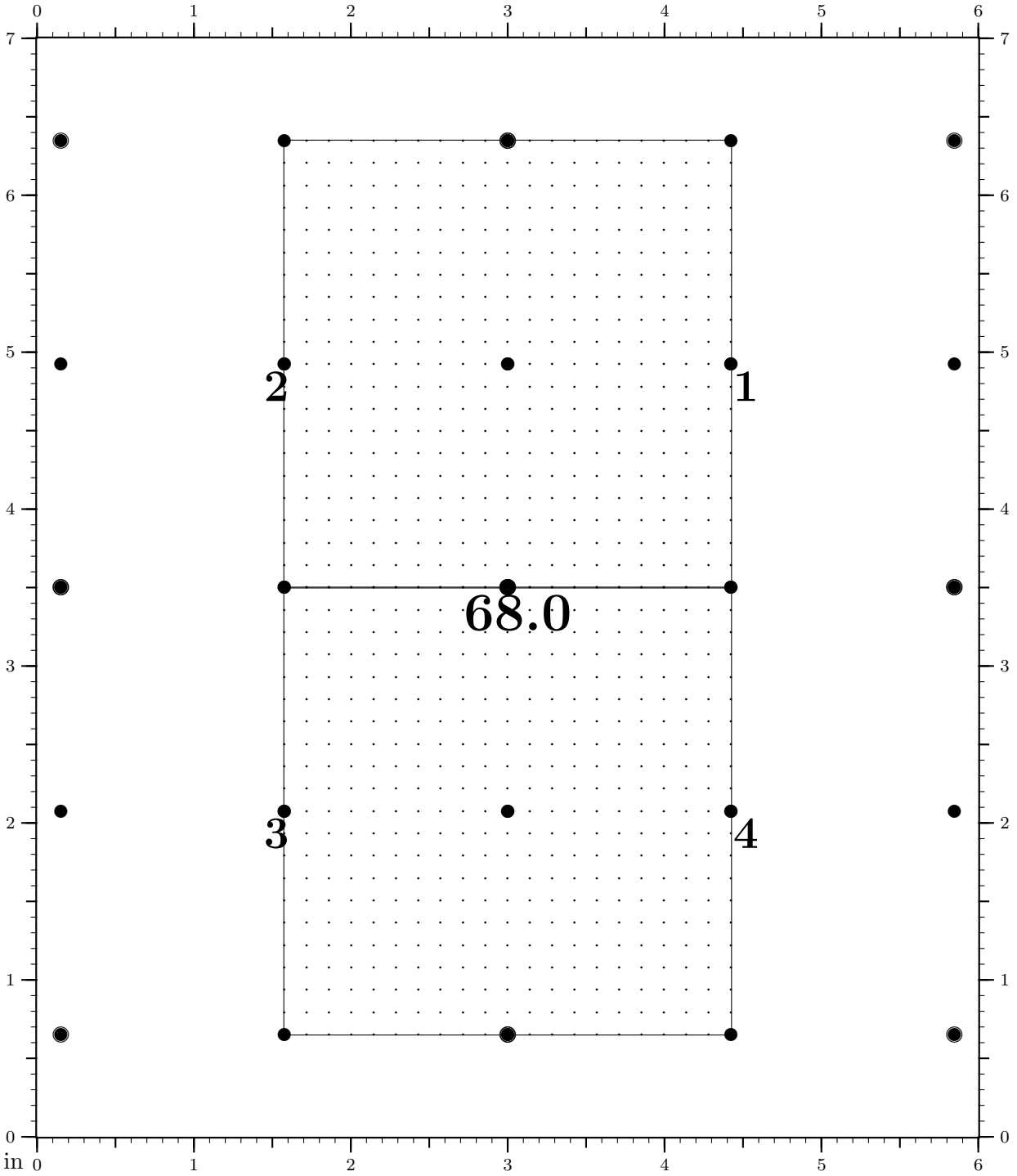

Figure 85: **0.1° at 68.0 feet is 1.424190 in.**

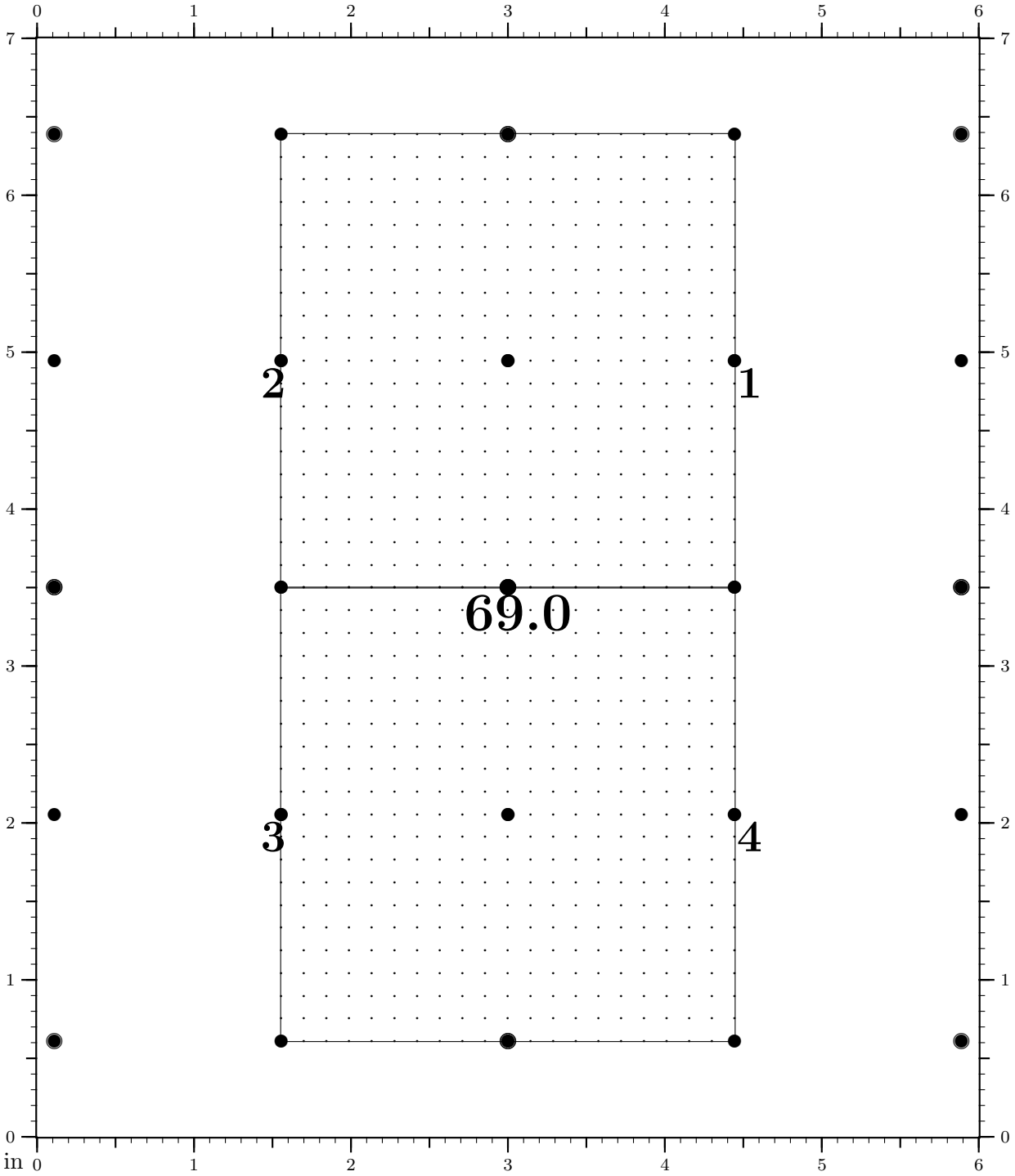

Figure 86: **0.1° at 69.0 feet is 1.445134 in.**

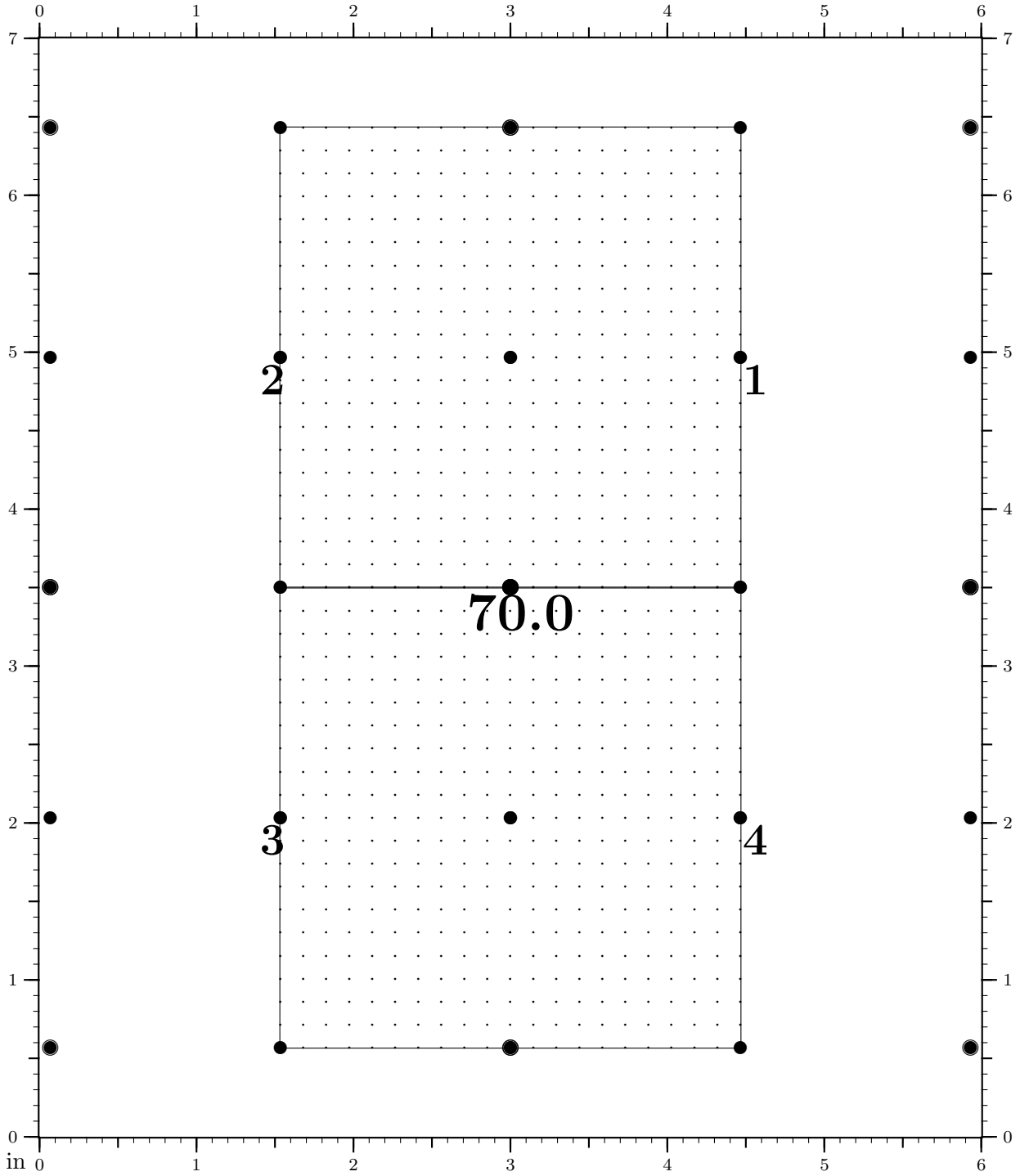

Figure 87: **0.1° at 70.0 feet is 1.466078 in.**

1.4 `EFrame1.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.*