Position Calibration Targets

English and Metric Measure

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[1] $Header: d:/Binder2/Targets/RCS/TargetA4.tex,v 1.2 2008-09-12 07:26:05-07 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^o and 0.01^o 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^o 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^o width in inches.
- a_m = Arc of 0.1^o 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^o 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^o of angular distance is .0061 meters (or .61 cm) long. (Or 0.610866 cm, if more accuracy is needed.)

[2] `$Header: d:/Binder2/Targets/RCS/TargetA4.tex,v 1.2 2008-09-12 07:26:05-07 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^o apart and the small dots are 0.01^o 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 that it is reasonable to point a camera at which 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, 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.

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.

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

A note on the accuracy of the targets

Accuracy in the generation of the grid is controlled by the quality of the printer used to print it out 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.

[5] And the attitude of the author!

d_{ft}	a_{in}	d_{ft}	a_{in}	d_{ft}	a_{in}	d_{ft}	a_{in}
2	**0.041887501**	**34**	**0.712087523**	66	1.382287544	98	2.052487565
4	**0.083775003**	**36**	**0.753975024**	68	1.424175045	100	2.094375067
6	**0.125662504**	**38**	**0.795862525**	70	1.466062547	102	2.136262568
8	**0.167550005**	**40**	**0.837750027**	72	1.507950048	104	2.178150069
10	**0.209437507**	**42**	**0.879637528**	74	1.549837549	106	2.220037571
12	**0.251325008**	**44**	**0.921525029**	76	1.591725051	108	2.261925072
14	**0.293212509**	**46**	**0.963412531**	78	1.633612552	110	2.303812573
16	**0.335100011**	**48**	**1.005300032**	80	1.675500053	112	2.345700075
18	**0.376987512**	**50**	**1.047187533**	82	1.717387555	114	2.387587576
20	**0.418875013**	**52**	**1.089075035**	84	1.759275056	116	2.429475077
22	**0.460762515**	**54**	**1.130962536**	86	1.801162557	118	2.471362579
24	**0.502650016**	**56**	**1.172850037**	88	1.843050059	120	2.513250080
26	**0.544537517**	58	1.214737539	90	1.884937560	122	2.555137581
28	**0.586425019**	60	1.256625040	92	1.926825061	124	2.597025083
30	**0.628312520**	62	1.298512541	94	1.968712563	126	2.638912584
32	**0.670200021**	64	1.340400043	96	2.010600064	128	2.680800085

Table 1: Full Table of 0.1^o widths for English Measure

d_{ft}	a_{in}	d_{ft}	a_{in}	d_{ft}	a_{in}	d_{ft}	a_{in}
2	0.042	34	0.71	66	1.38	98	2.05
4	0.084	36	0.75	68	1.42	100	2.09
6	0.126	38	0.80	70	1.47	102	2.14
8	0.168	40	0.84	72	1.51	104	2.18
10	0.209	42	0.88	74	1.55	106	2.22
12	0.251	44	0.92	76	1.59	108	2.26
14	0.293	46	0.96	78	1.63	110	2.30
16	0.335	48	1.01	80	1.68	112	2.35
18	0.377	50	1.05	82	1.72	114	2.39
20	0.419	52	1.09	84	1.76	116	2.41
22	0.461	54	1.13	86	1.80	118	2.47
24	0.503	56	1.17	88	1.84	120	2.51
26	0.545	58	1.21	90	1.88	122	2.56
28	0.586	60	1.26	92	1.92	124	2.60
30	0.628	62	1.30	94	1.97	126	2.64
32	0.670	64	1.34	96	2.01	128	2.68

Table 2: Rounded Values of 0.1^o widths for English Measure

Full				Rounded			
d_m	a_{mm}	d_m	a_{mm}	d_m	a_{mm}	d_m	a_{mm}
1.0	1.745331	8.5	14.835320	1.0	1.75	8.5	14.84
1.5	2.617997	9.0	15.707980	1.5	2.62	9.0	15.71
2.0	3.490663	9.5	16.580650	2.0	3.49	9.5	16.58
2.5	4.363328	10.0	17.453310	2.5	4.36	10.0	17.45
3.0	5.235995	11.0	19.198650	3.0	5.26	11.0	19.20
3.5	6.108660	12.0	20.943980	3.5	6.11	12.0	20.94
4.0	6.981325	13.0	22.689310	4.0	6.98	13.0	22.69
4.5	7.853991	14.0	24.434640	4.5	7.85	14.0	24.43
5.0	8.726656	15.0	26.179970	5.0	8.73	15.0	26.18
5.5	9.599322	16.0	27.925300	5.5	9.60	16.0	27.93
6.0	10.471990	17.0	29.670630	6.0	10.47	17.0	29.67
6.5	11.344650	18.0	31.415960	6.5	11.34	18.0	31.41
7.0	12.217320	19.0	33.161290	7.0	12.21	19.0	33.16
7.5	13.089990	20.0	34.906630	7.5	13.90	20.0	34.91
8.0	13.962650	—	—	8.0	13.96	—	—

Table 3: Full, and rounded, Table of 0.1^o widths for Metric Measure

1.2 English Measure Calibration Grids

Distance	Page
2	Figure 1, page 11
3	Figure 2, page 12
4	Figure 3, page 13
5	Figure 4, page 14
6	Figure 5, page 15
7	Figure 6, page 16
8	Figure 7, page 17
9	Figure 8, page 18
10	Figure 9, page 19
11	Figure 10, page 20
12	Figure 11, page 21
14	Figure 12, page 22
16	Figure 13, page 23
18	Figure 14, page 24
20	Figure 15, page 25
22	Figure 16, page 26
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28	Figure 19, page 29
30	Figure 20, page 30
32	Figure 21, page 31
34	Figure 22, page 32
36	Figure 23, page 33
38	Figure 24, page 34
40	Figure 25, page 35
42	Figure 26, page 36
44	Figure 27, page 37
46	Figure 28, page 38
48	Figure 29, page 39
50	Figure 30, page 40
52	Figure 31, page 41
54	Figure 32, page 42
56	Figure 33, page 43

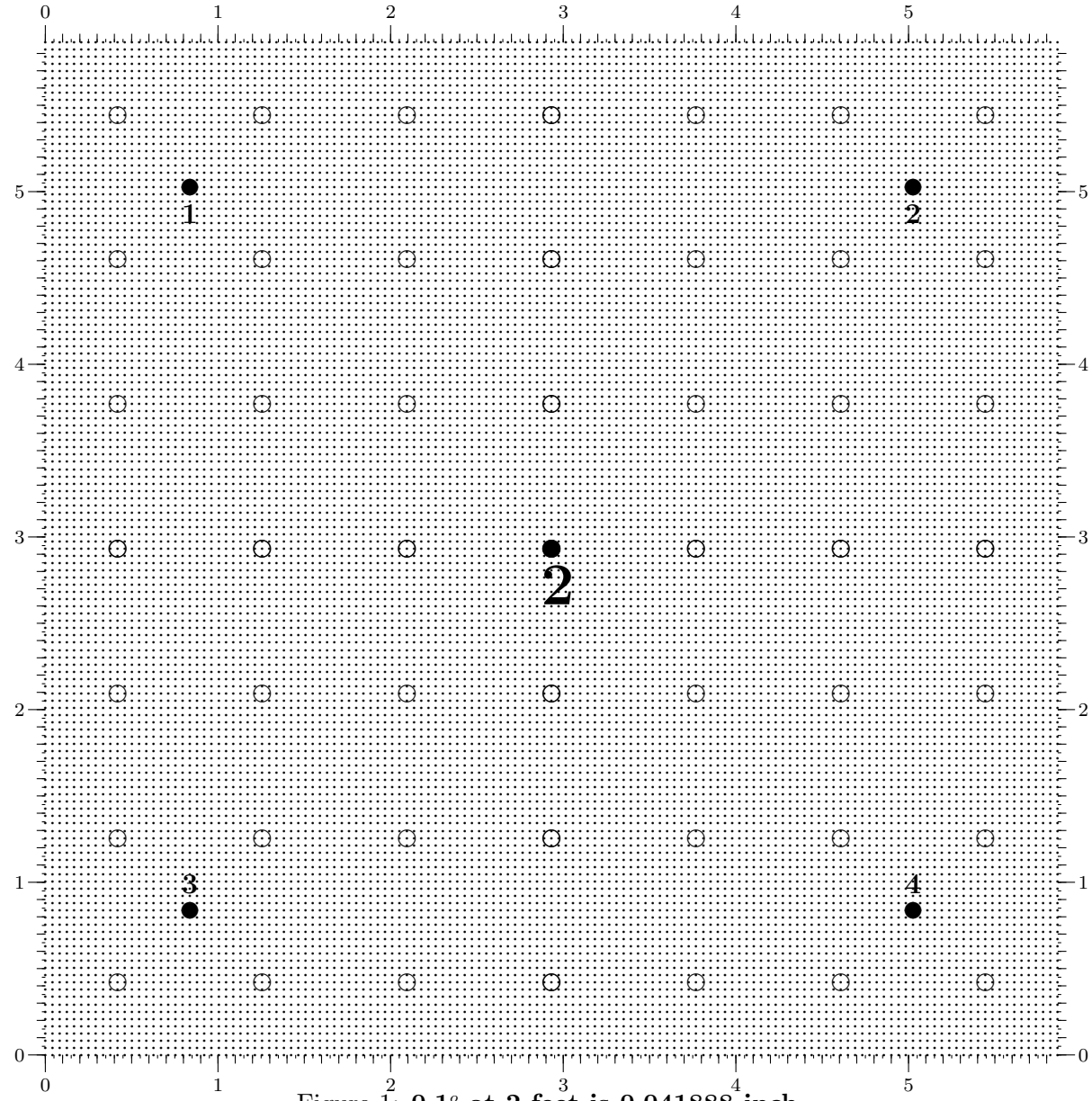

Figure 1: **0.1^o at 2 feet is 0.041888 inch.**

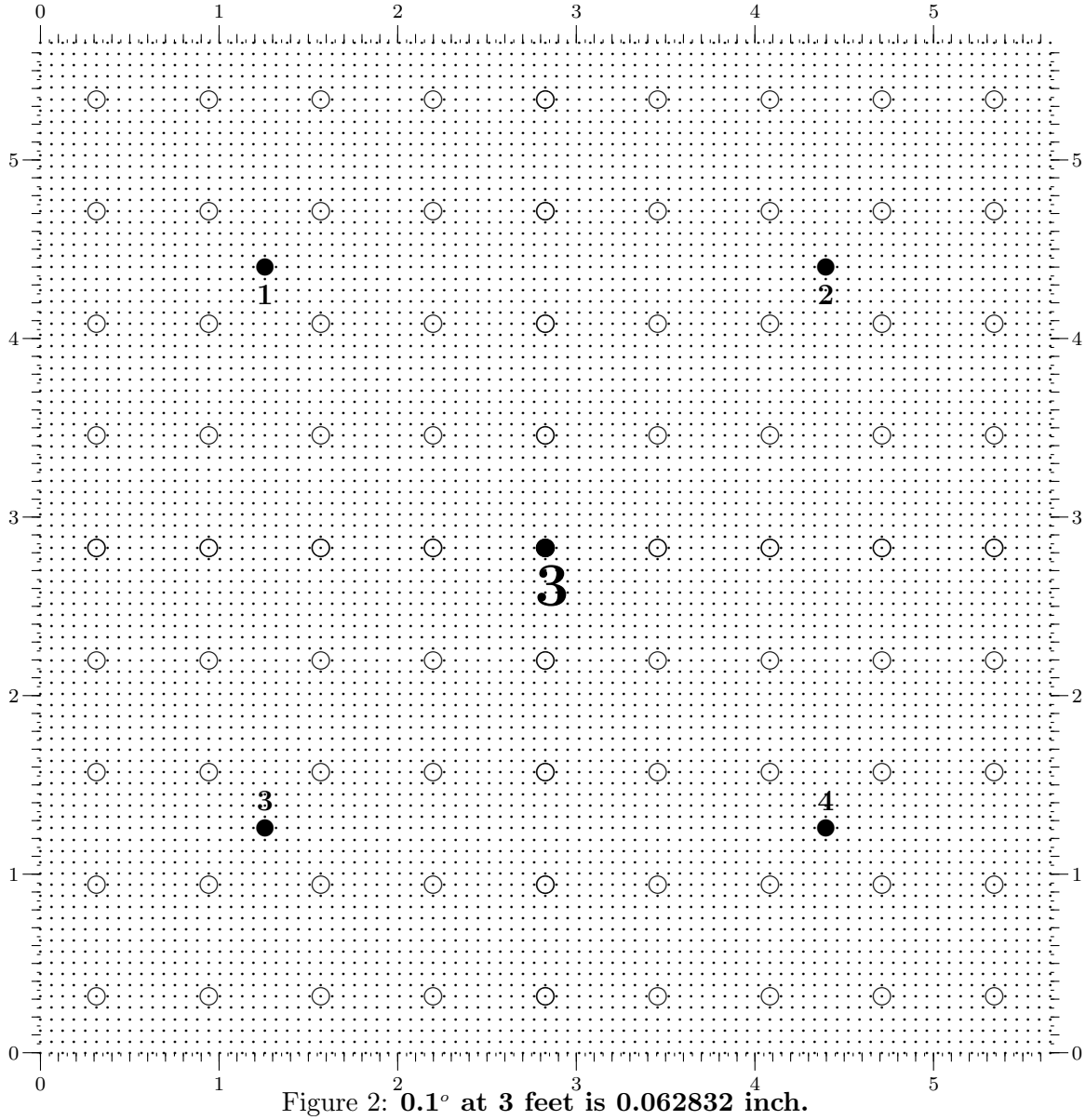

Figure 2: **0.1° at 3 feet is 0.062832 inch.**

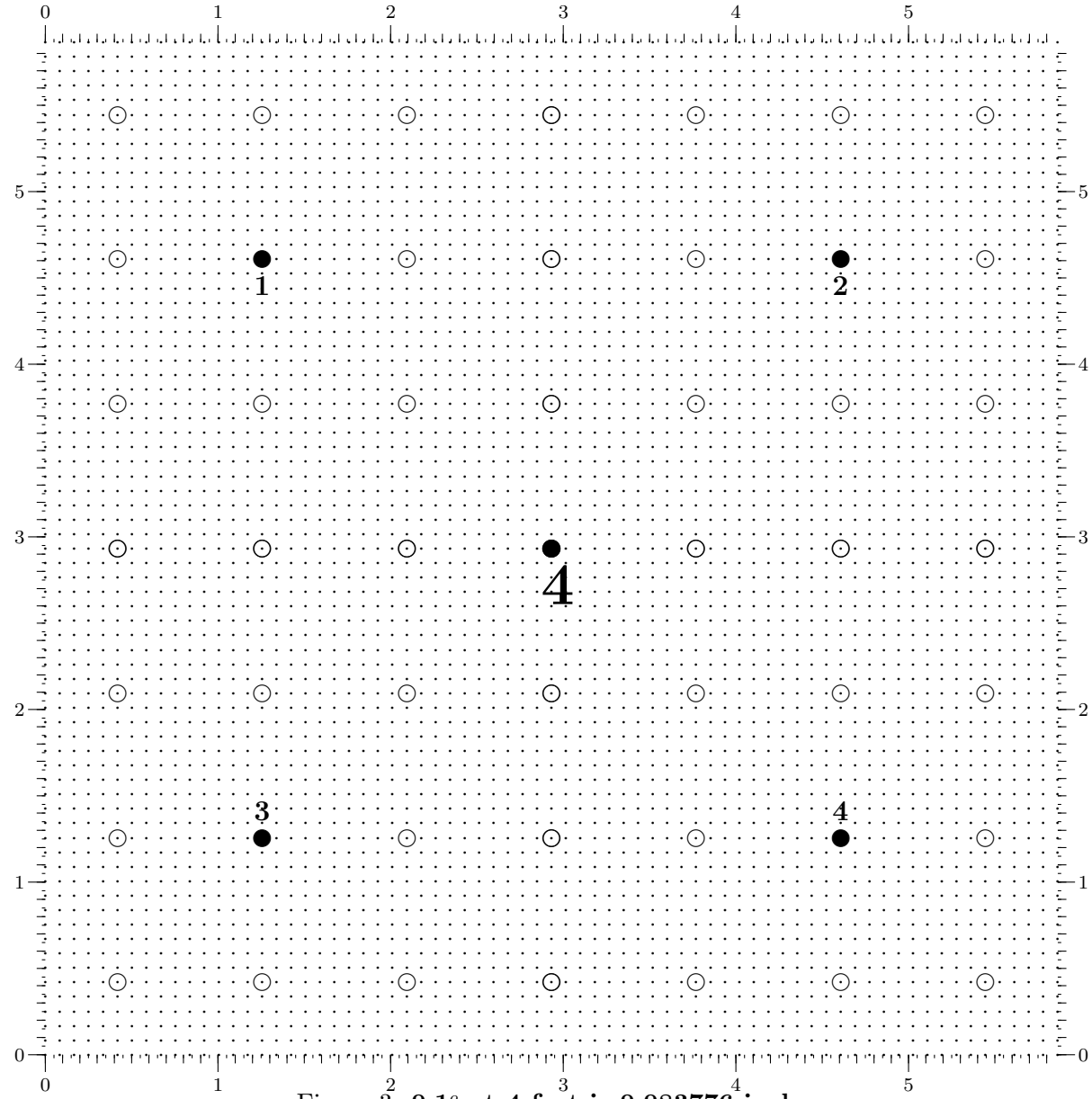

Figure 3: **0.1° at 4 feet is 0.083776 inch.**

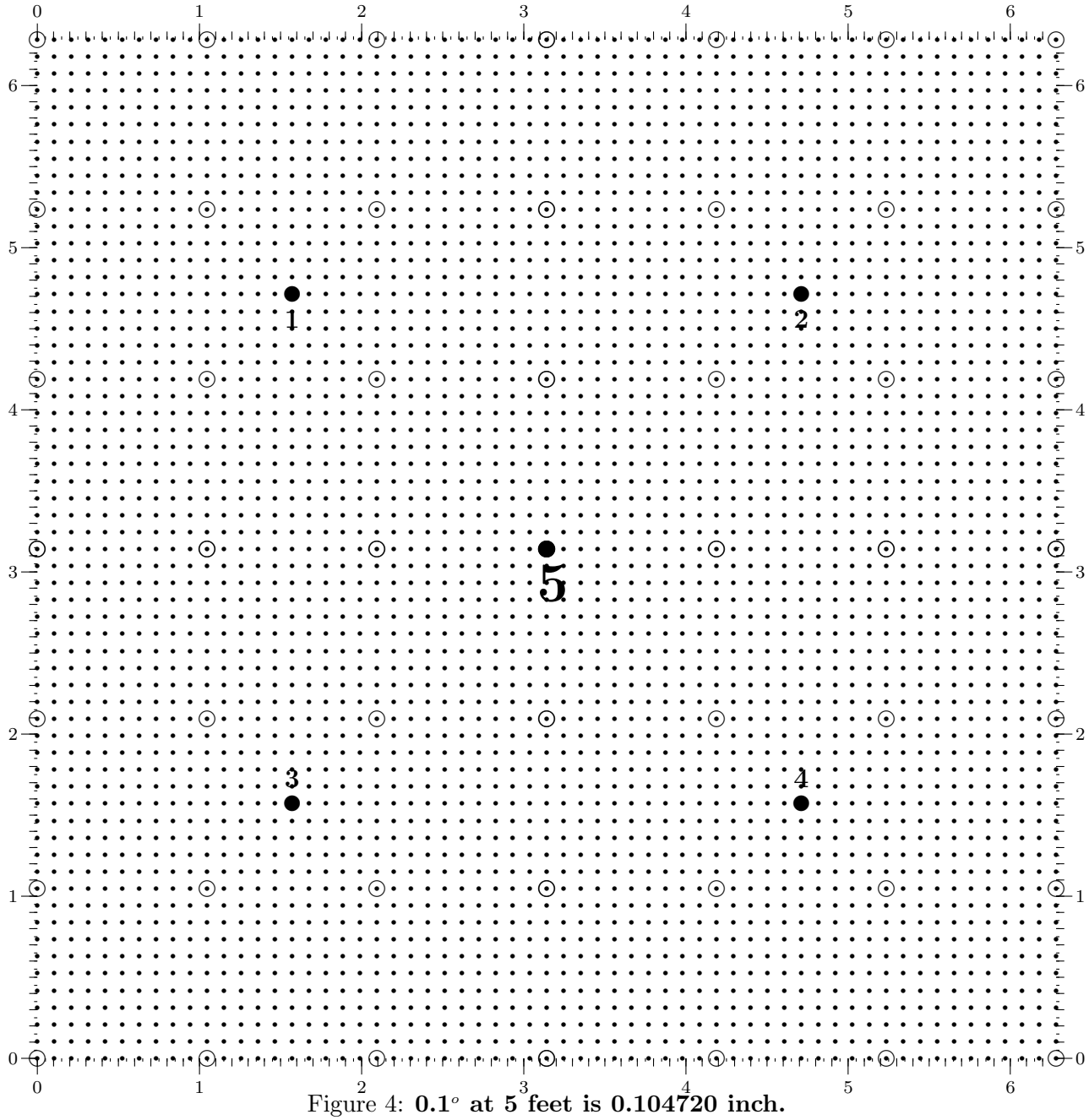

Figure 4: **0.1^o at 5 feet is 0.104720 inch.**

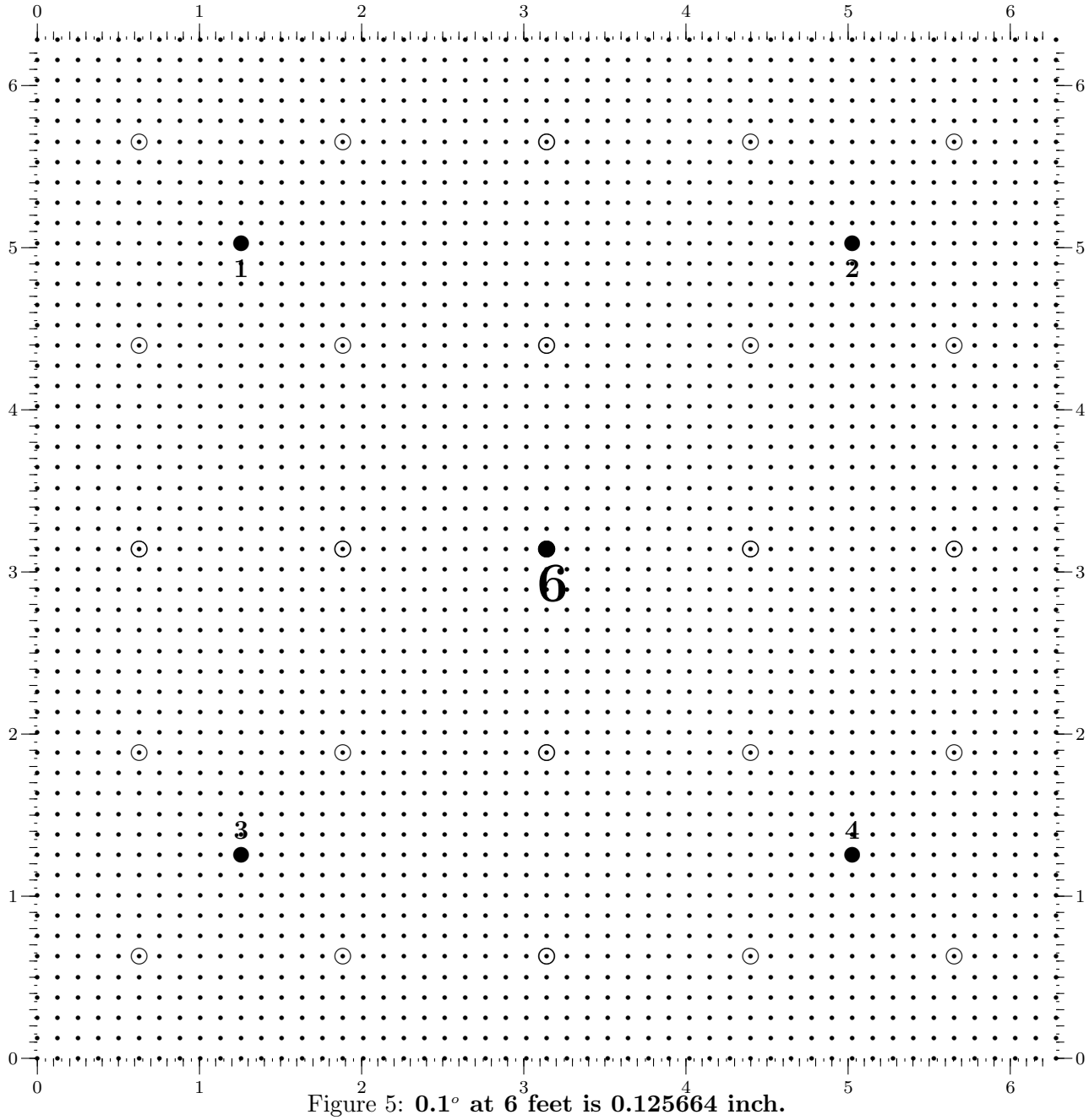

Figure 5: **0.1^o at 6 feet is 0.125664 inch.**

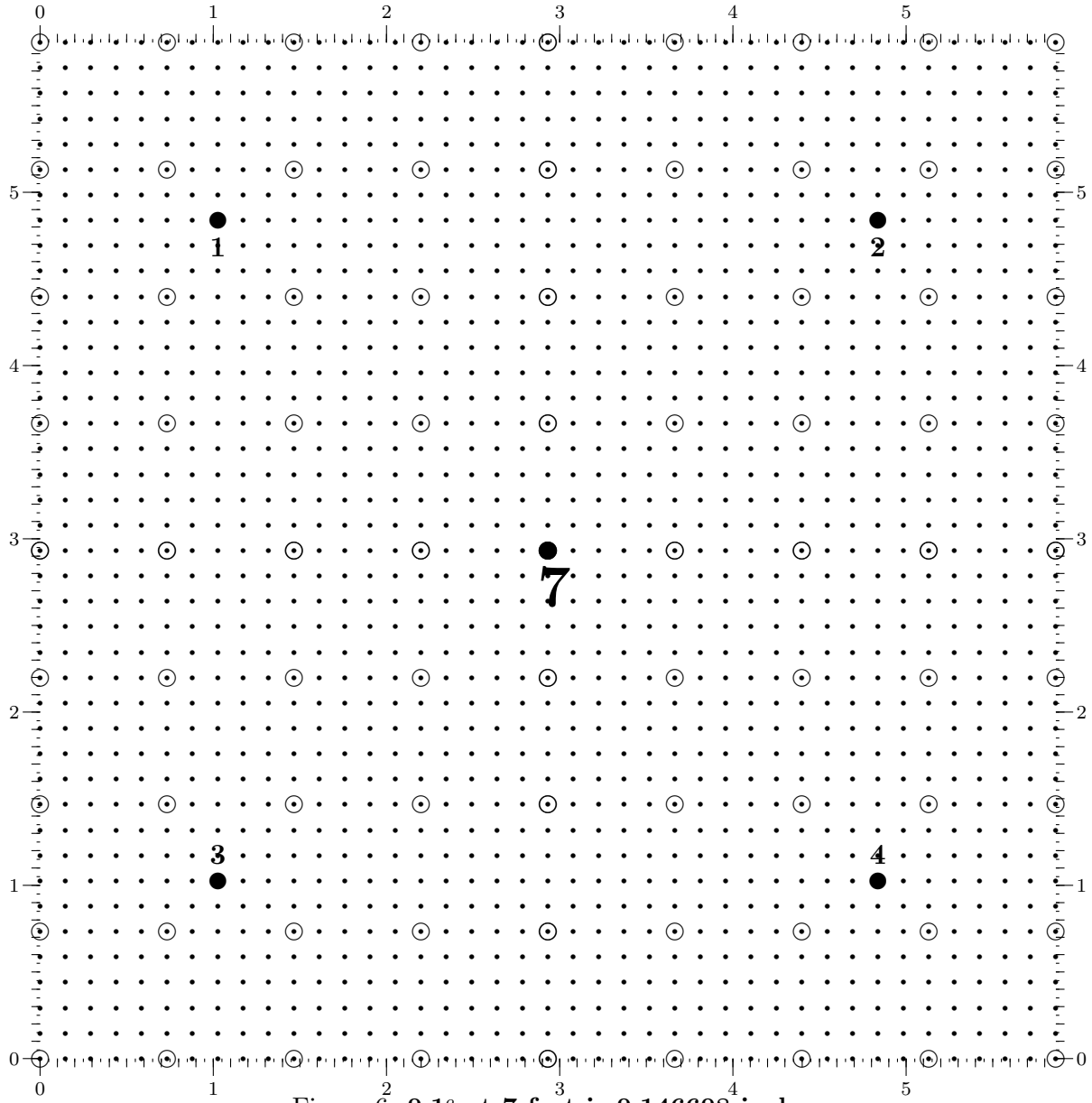

Figure 6: **0.1° at 7 feet is 0.146608 inch.**

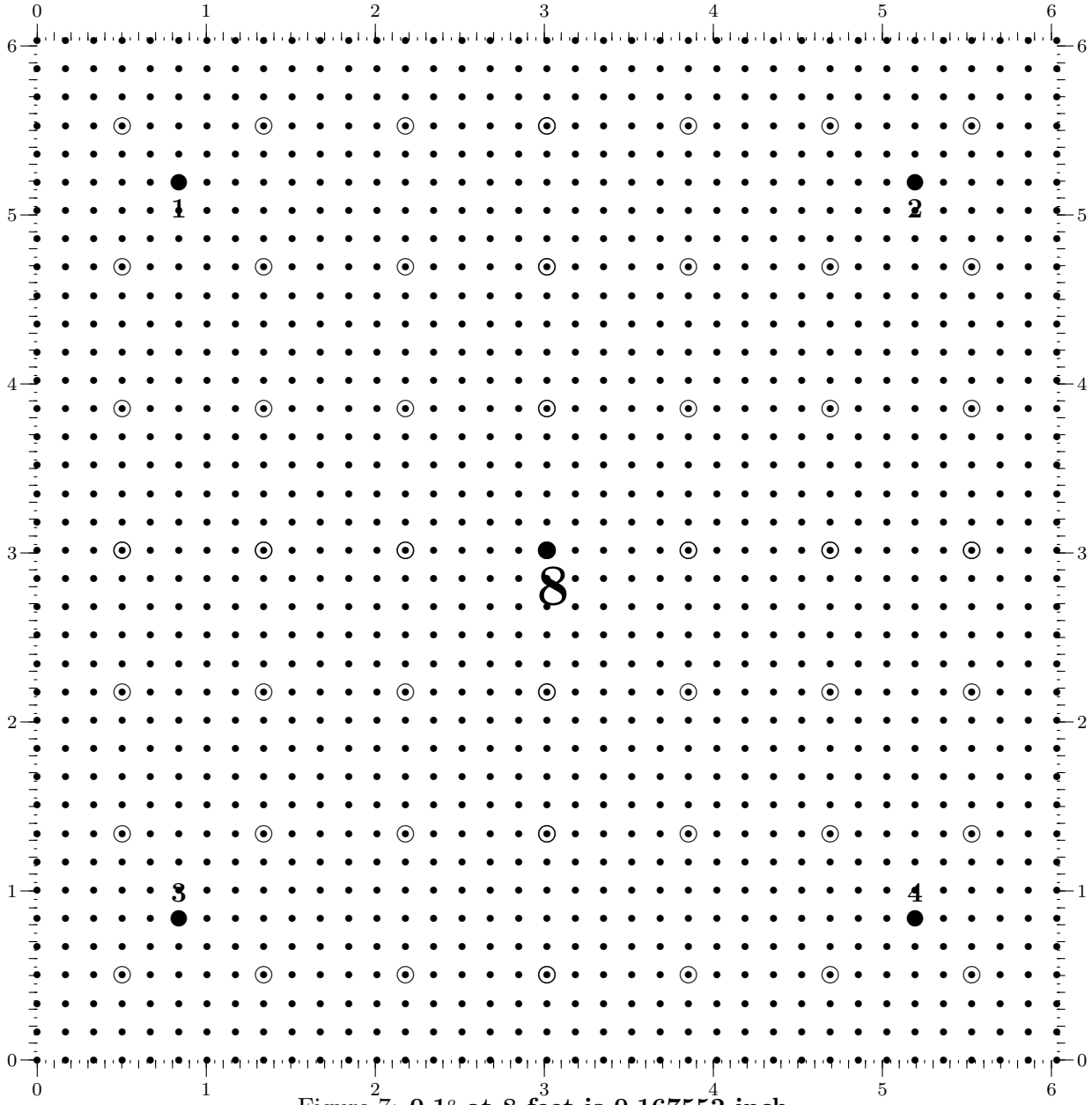

Figure 7: **0.1^{o} at 8 feet is 0.167552 inch.**

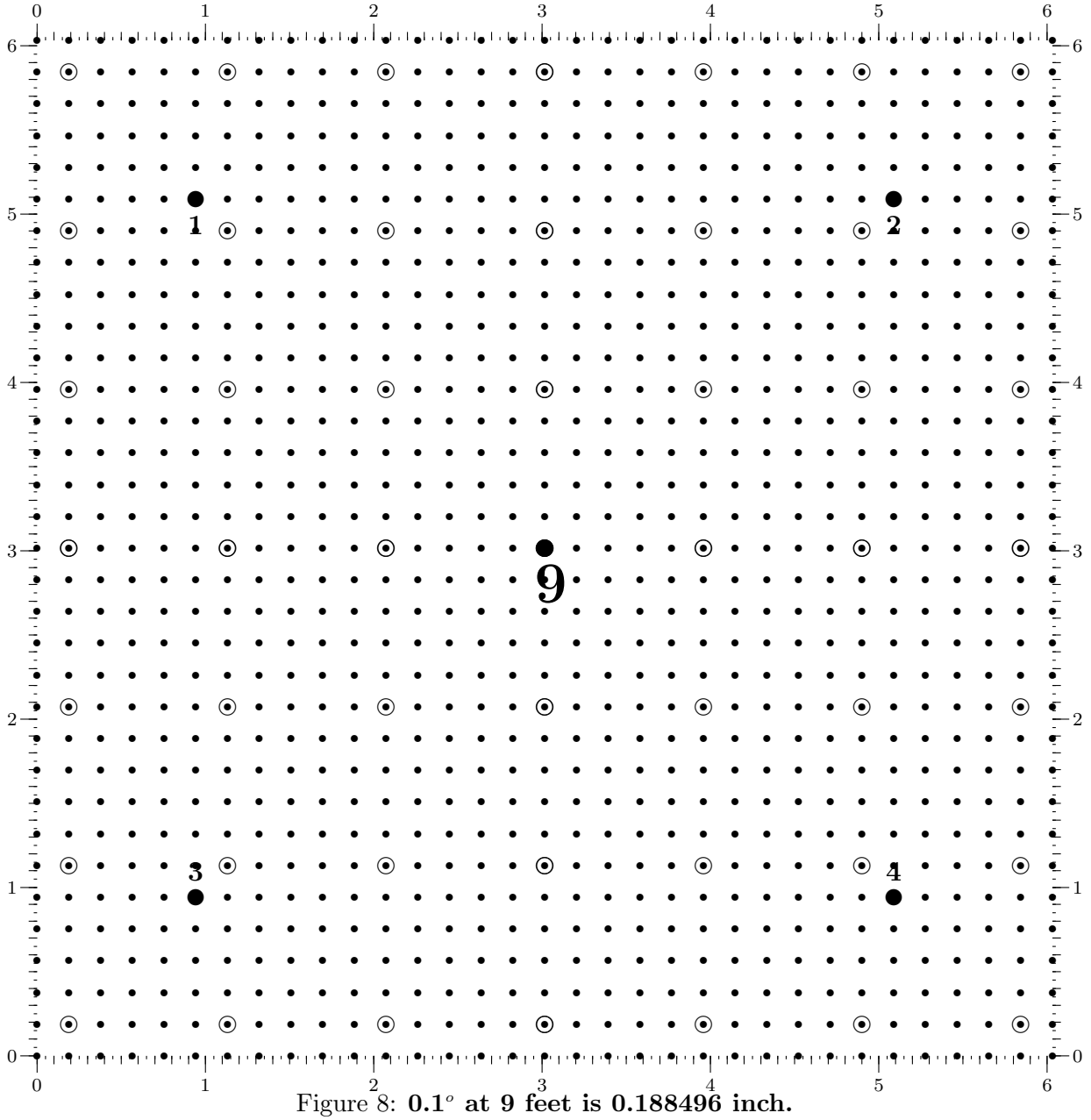

Figure 8: **0.1^o at 9 feet is 0.188496 inch.**

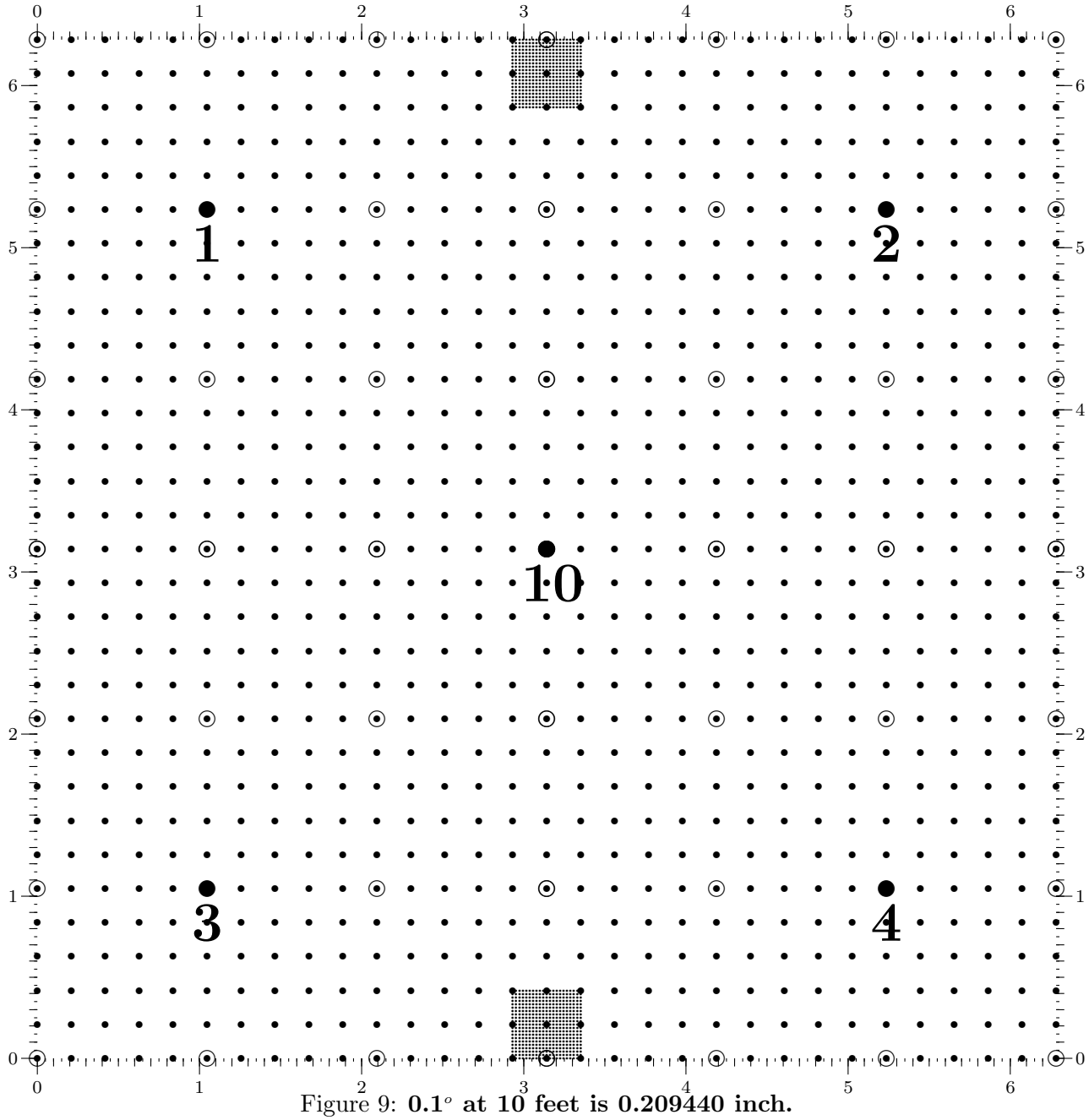

Figure 9: **0.1° at 10 feet is 0.209440 inch.**

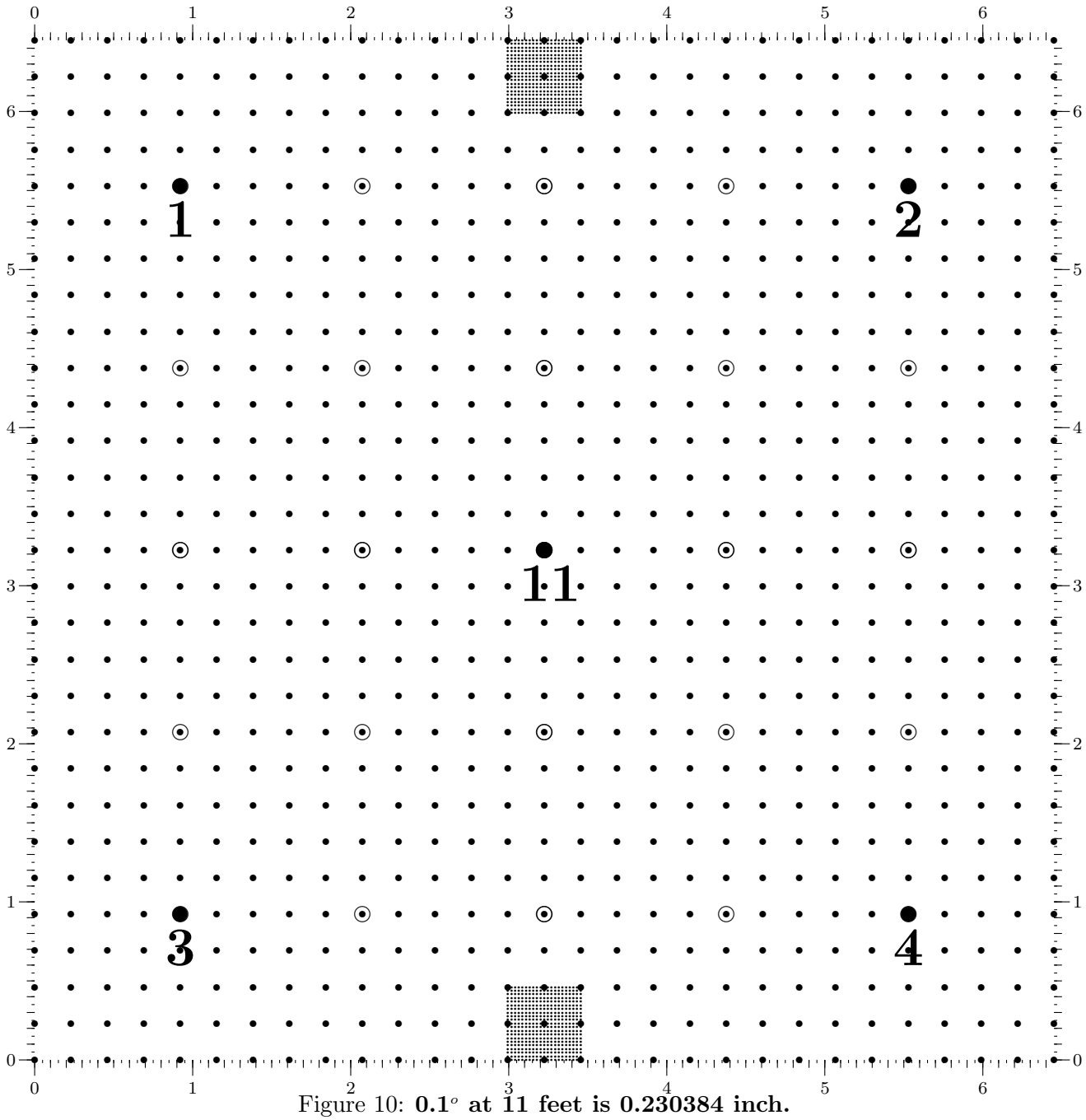

Figure 10: **0.1° at 11 feet is 0.230384 inch.**

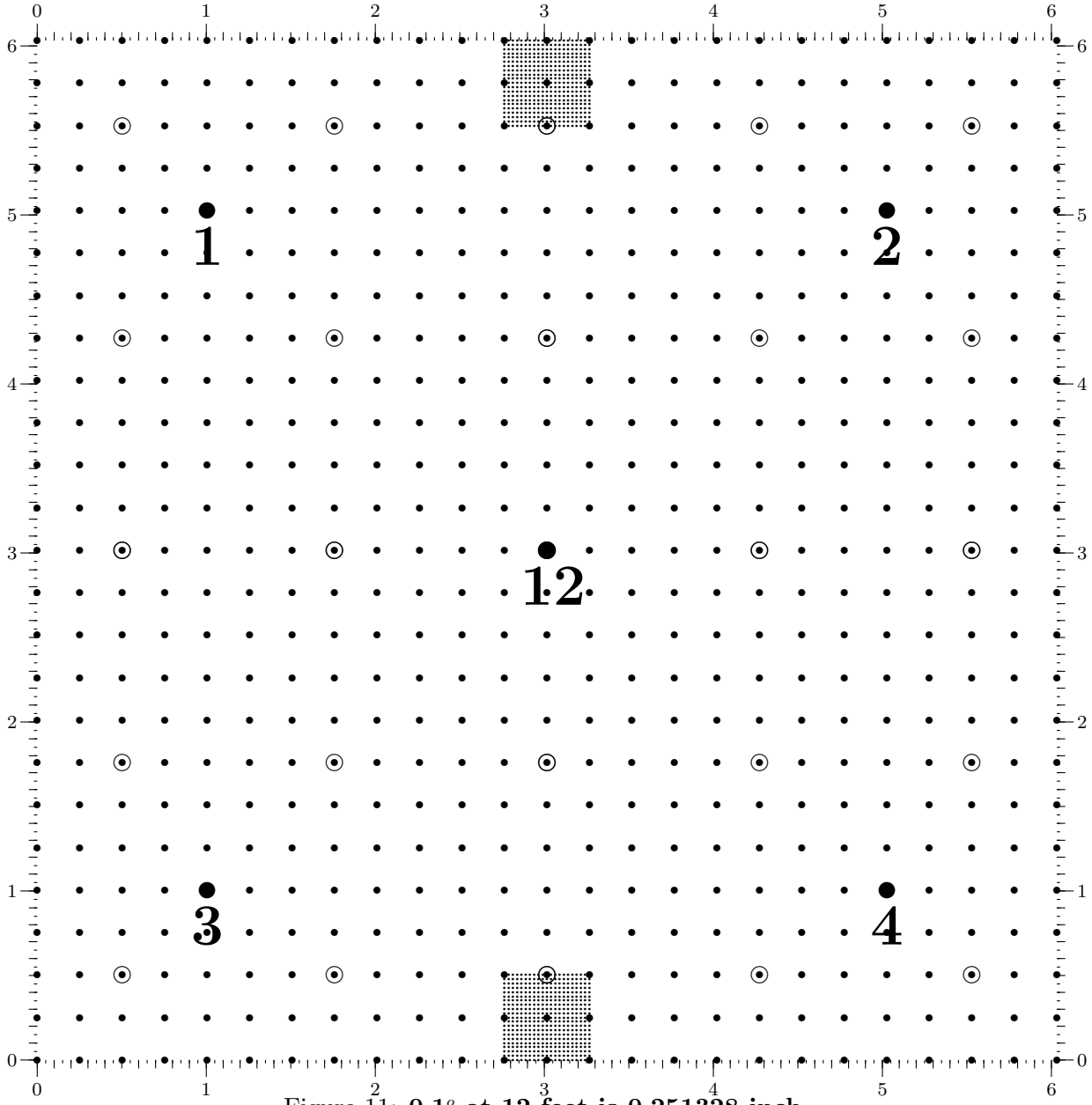

Figure 11: **0.1^o at 12 feet is 0.251328 inch.**

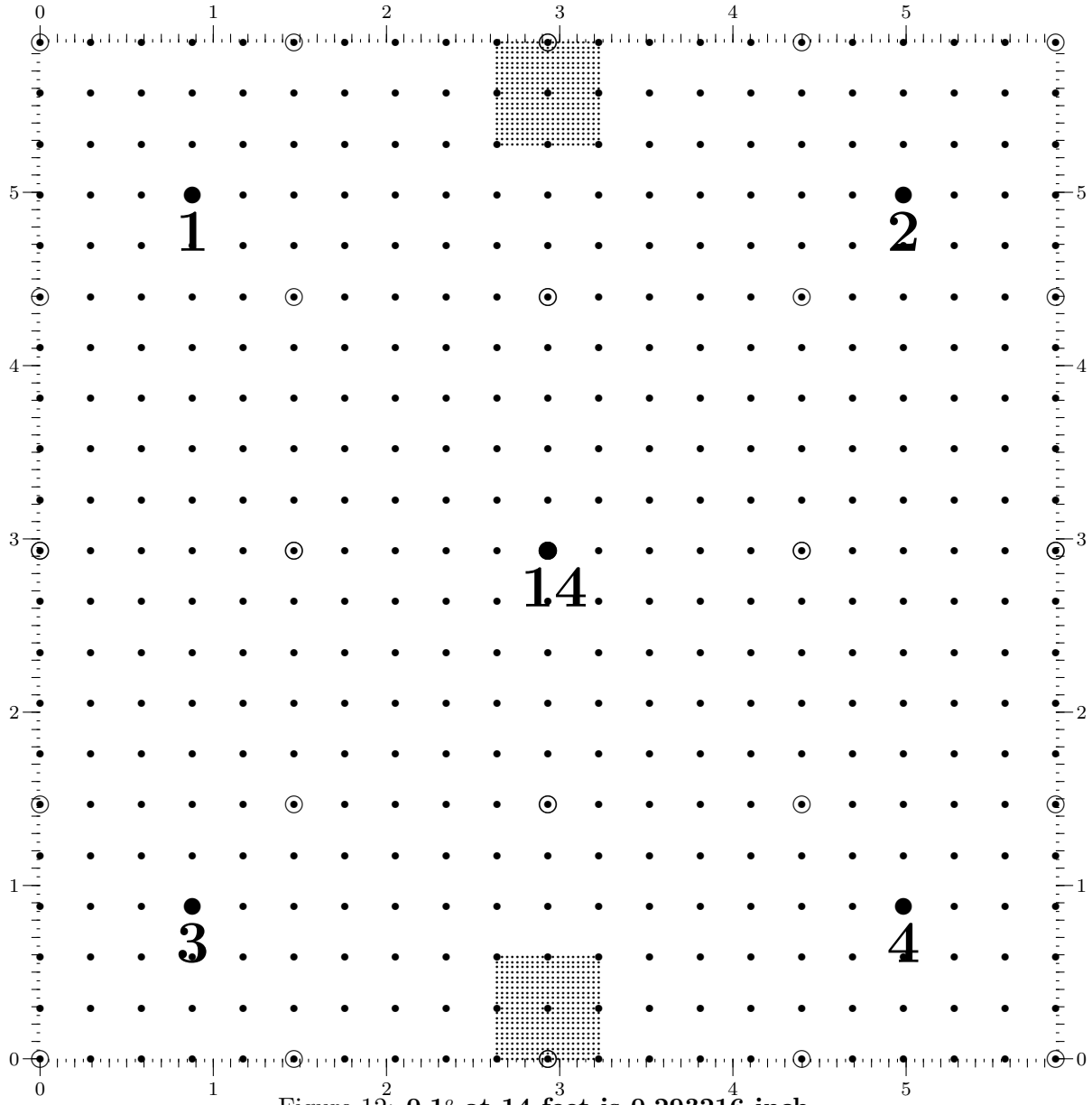

Figure 12: **0.1° at 14 feet is 0.293216 inch.**

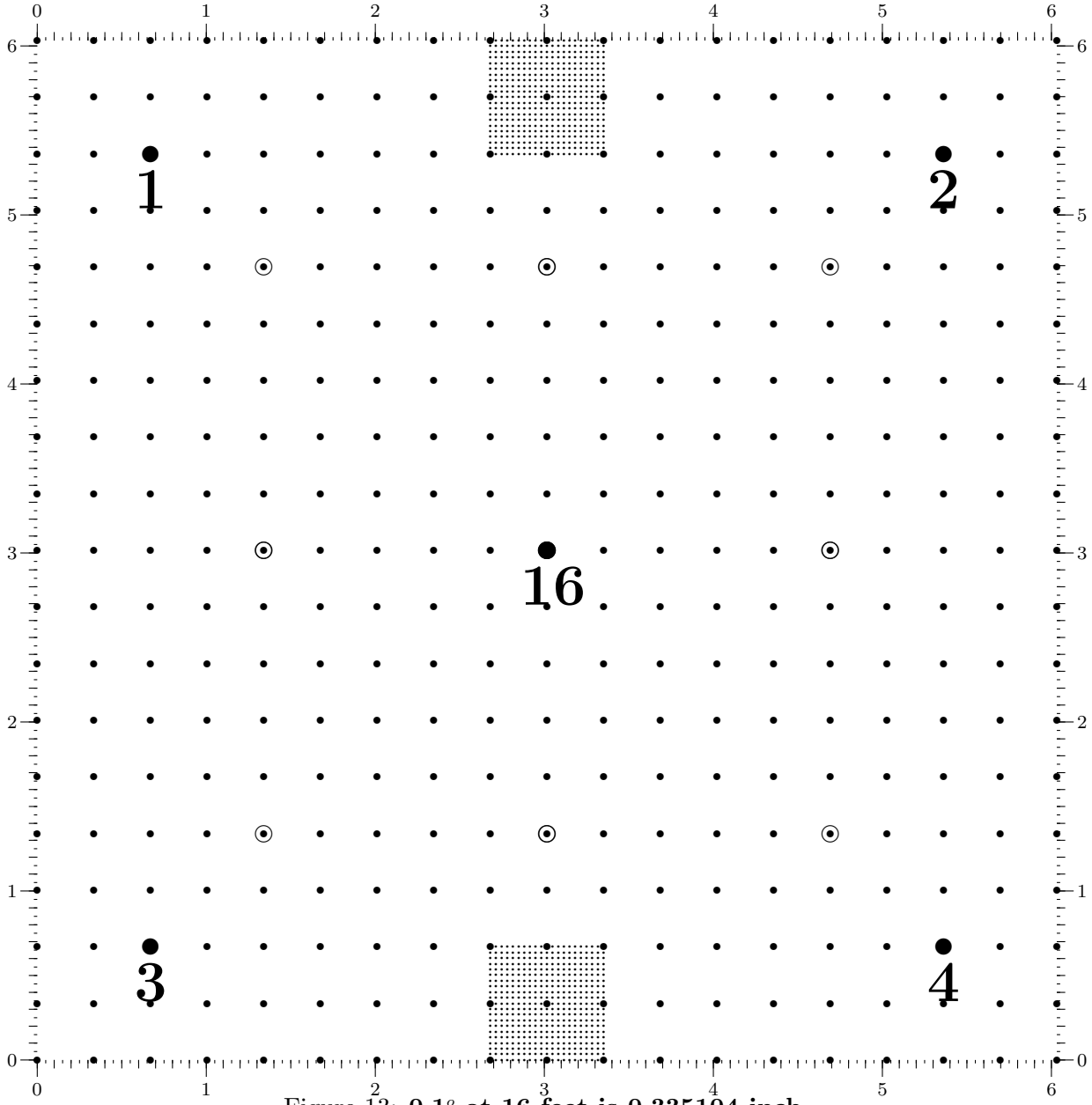

Figure 13: **0.1^o at 16 feet is 0.335104 inch.**

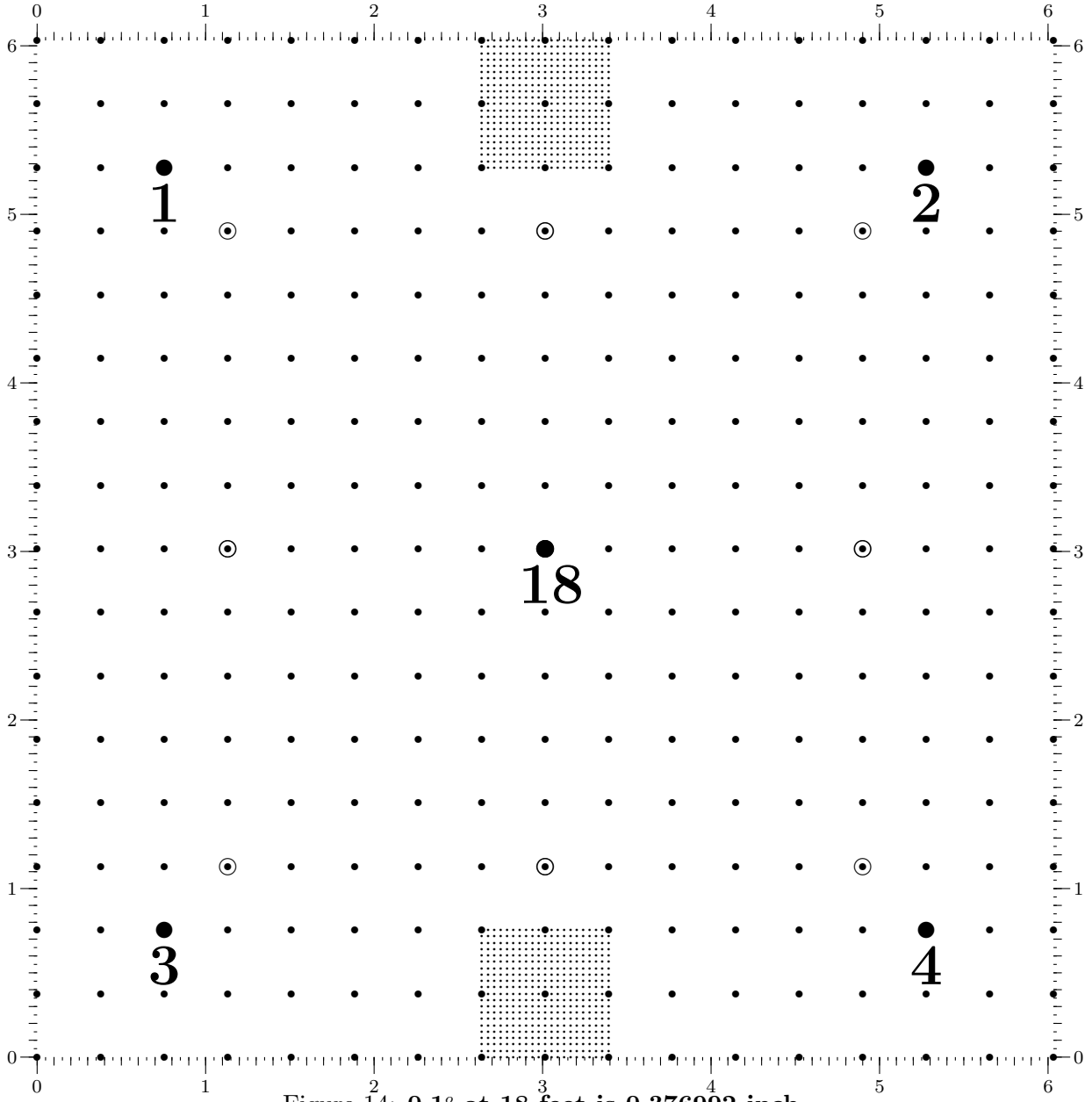

Figure 14: **0.1^o at 18 feet is 0.376992 inch.**

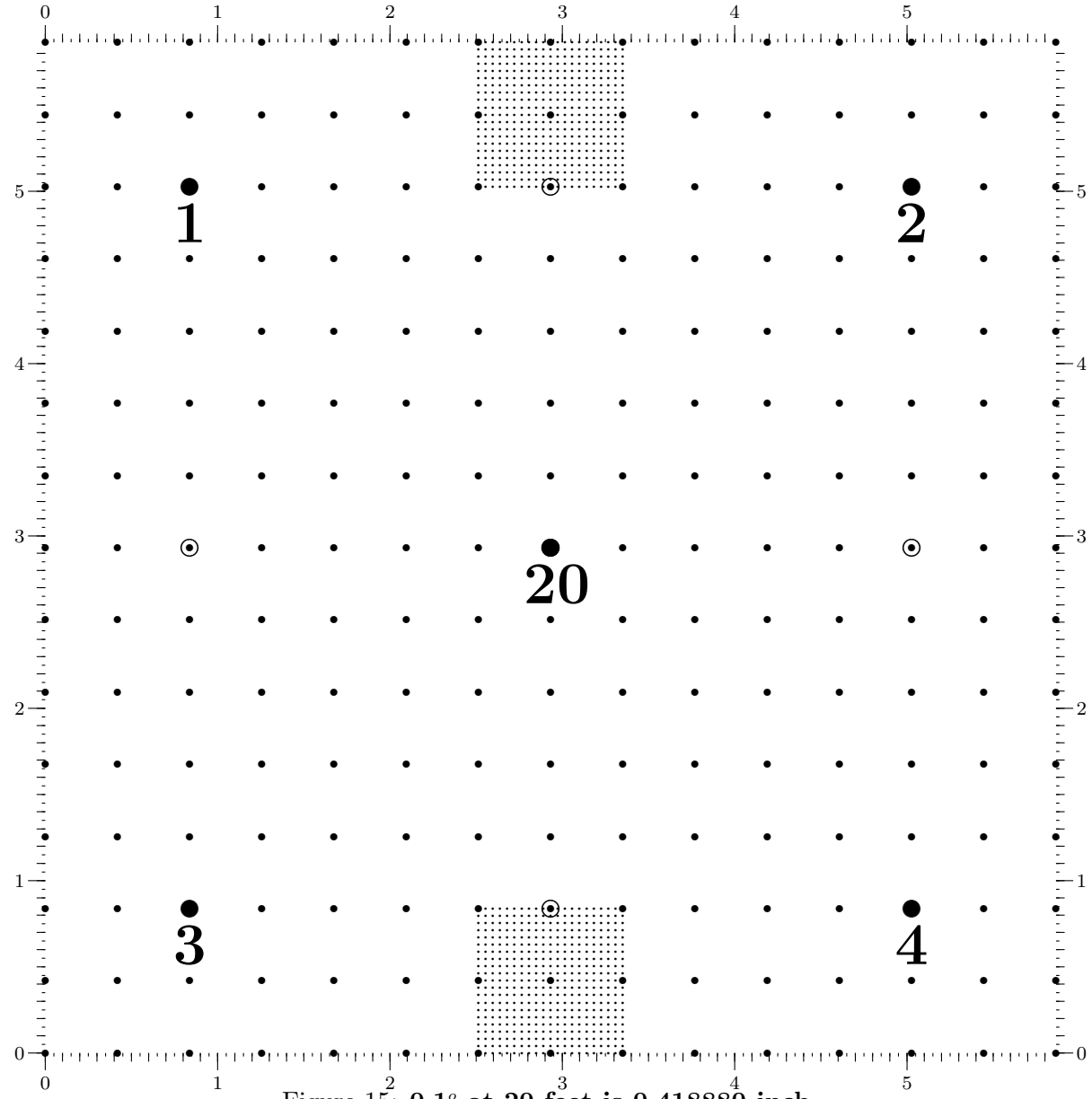

Figure 15: **0.1° at 20 feet is 0.418880 inch.**

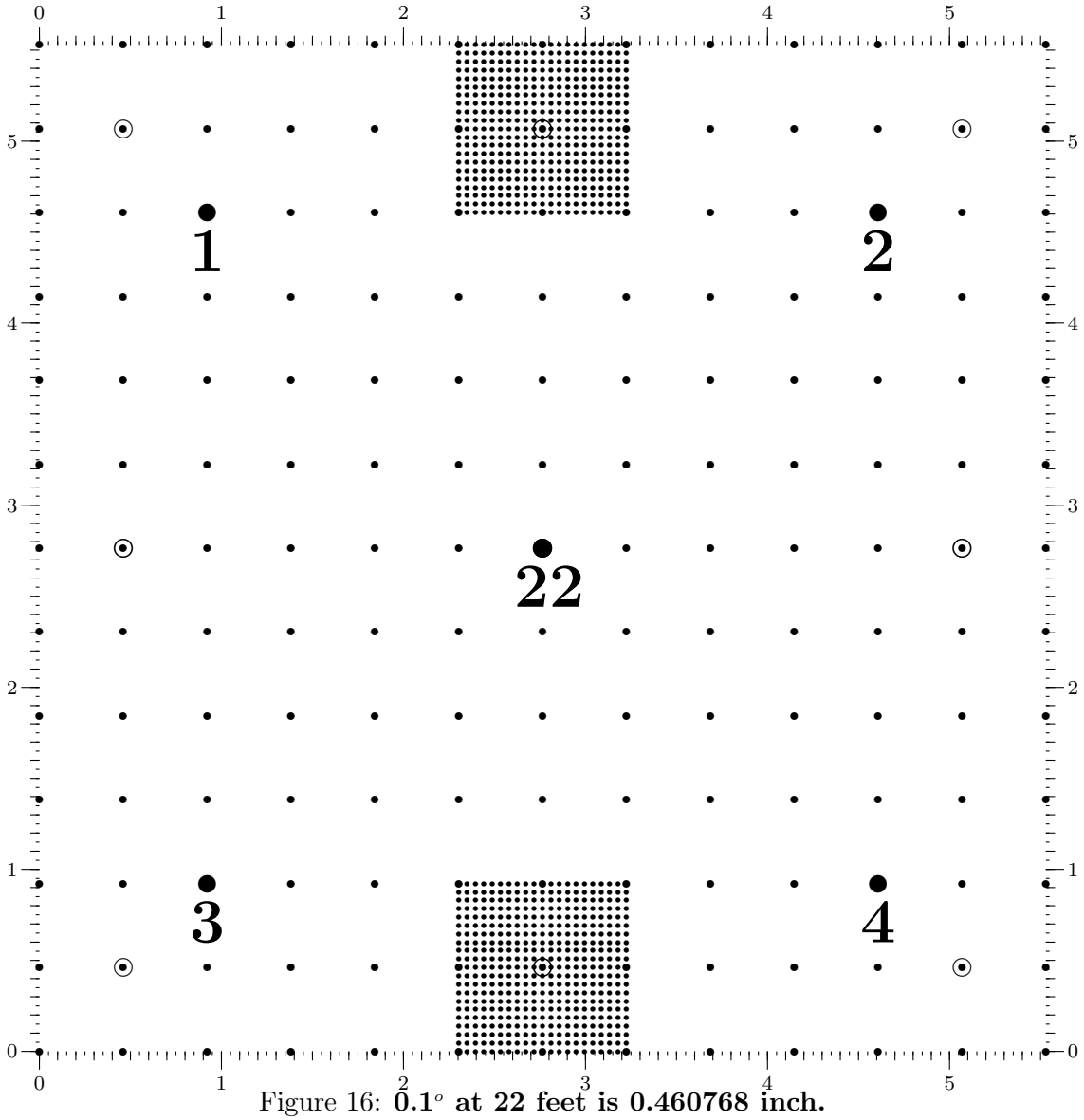

Figure 16: **0.1^o at 22 feet is 0.460768 inch.**

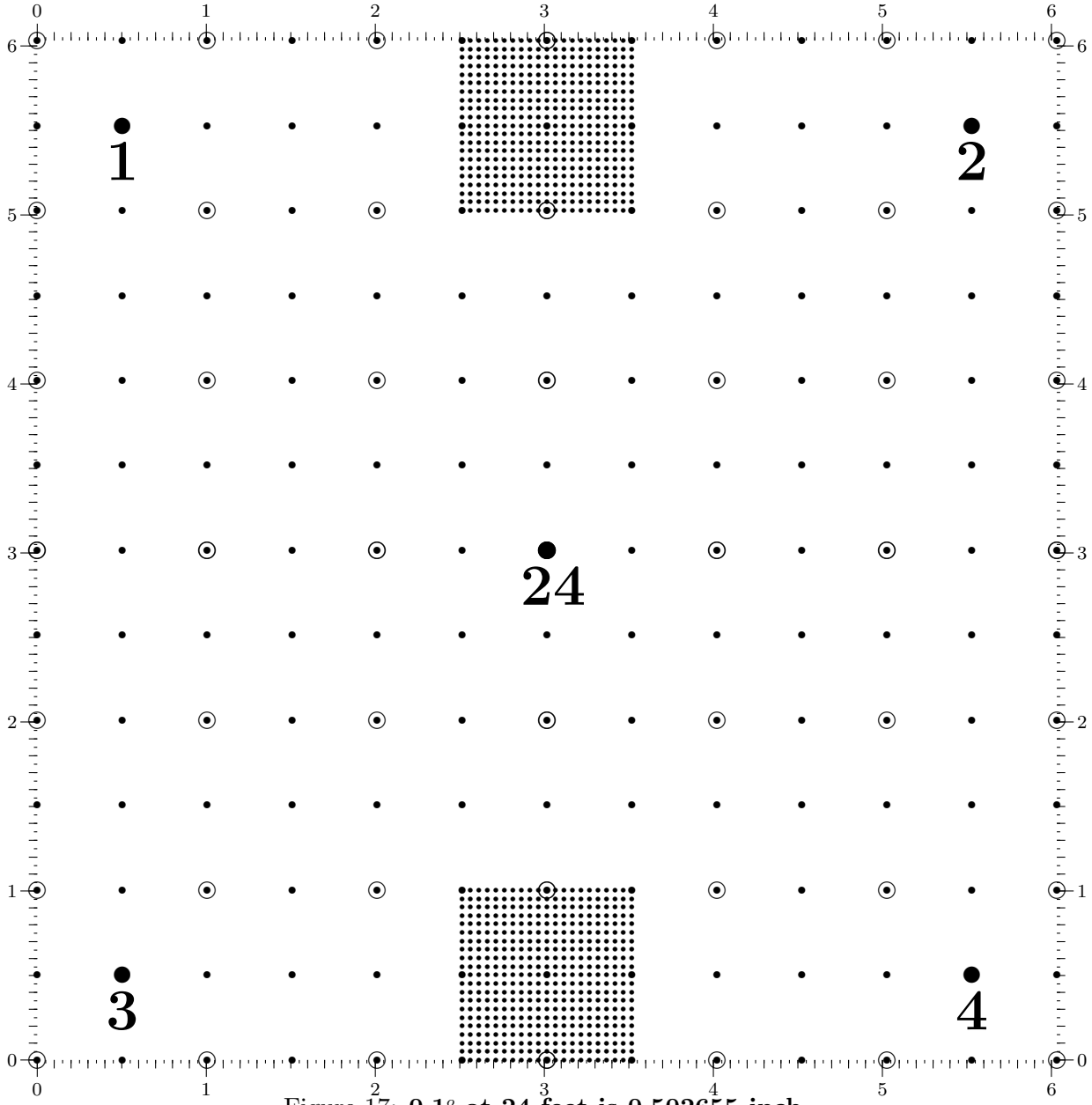

Figure 17: **0.1^o at 24 feet is 0.502655 inch.**

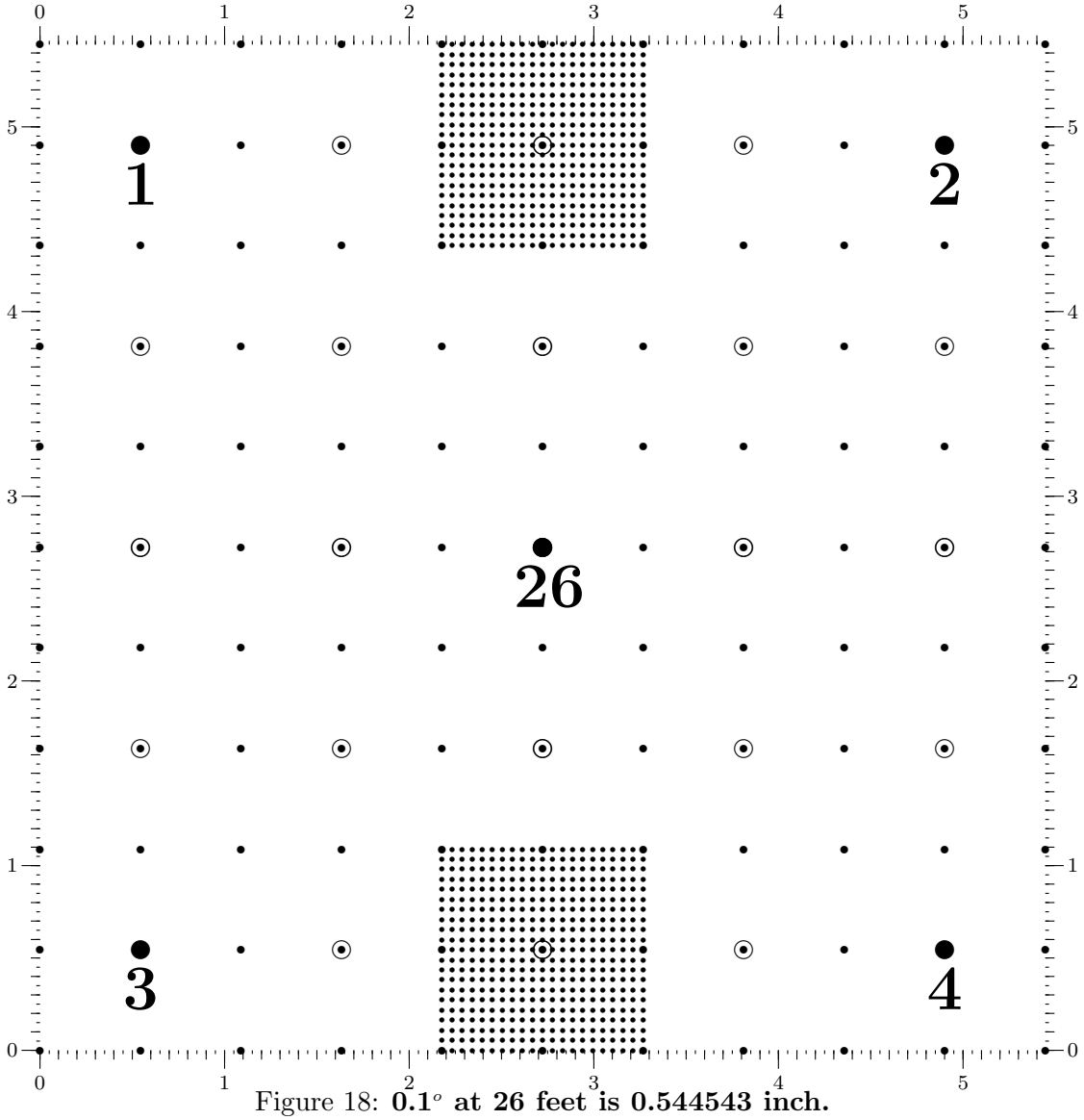

Figure 18: **0.1° at 26 feet is 0.544543 inch.**

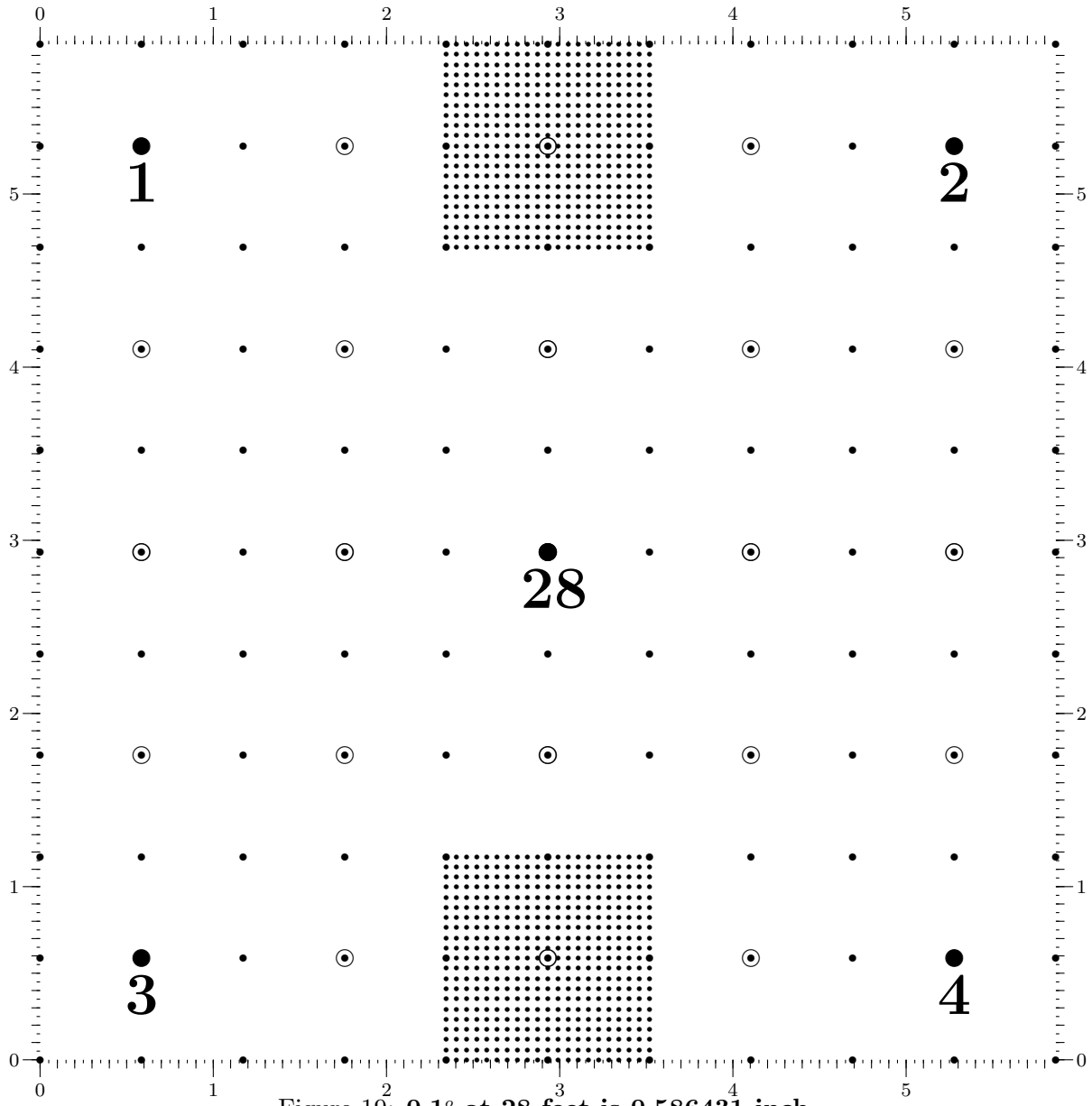

Figure 19: **0.1° at 28 feet is 0.586431 inch.**

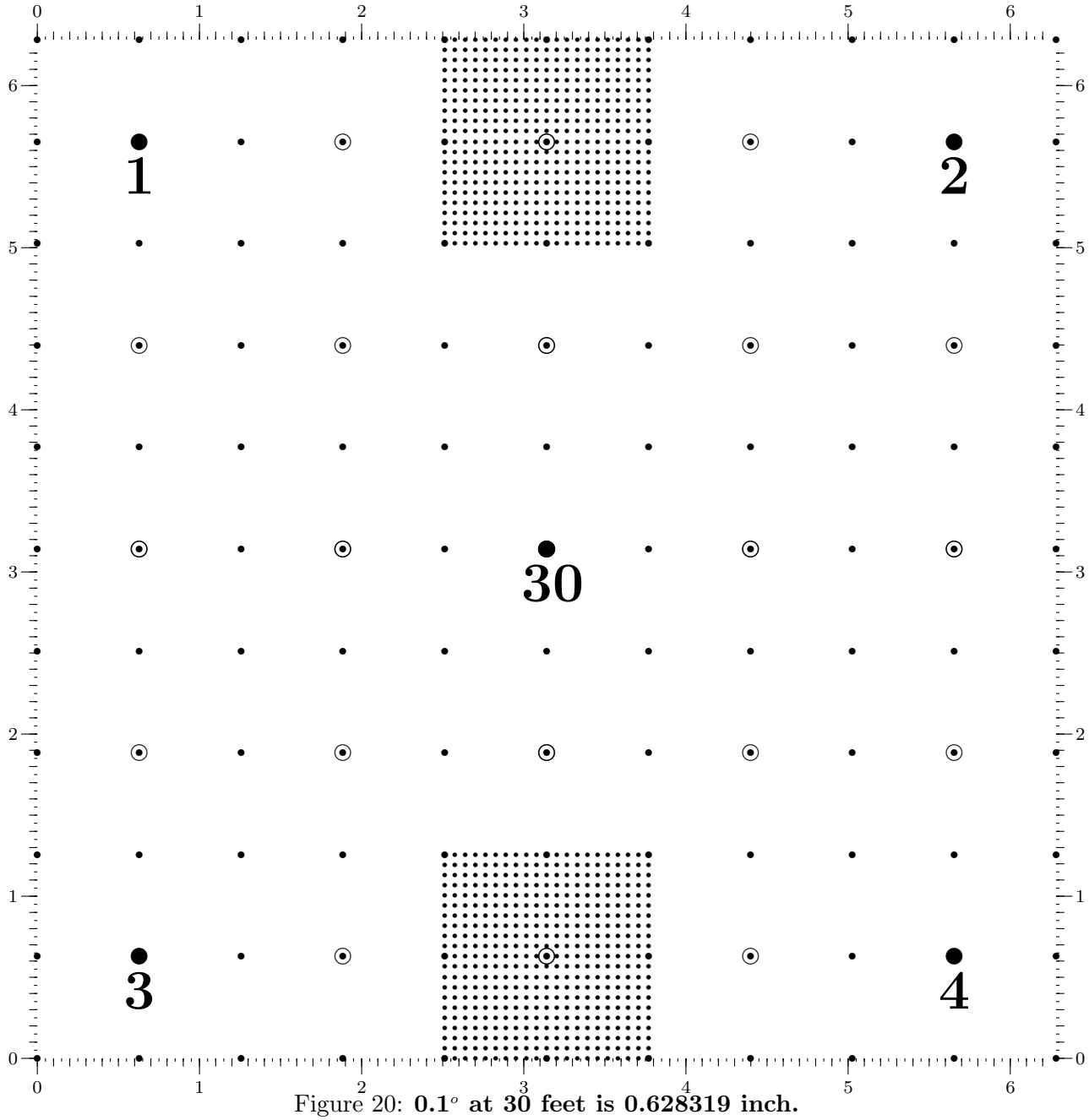

Figure 20: **0.1^o at 30 feet is 0.628319 inch.**

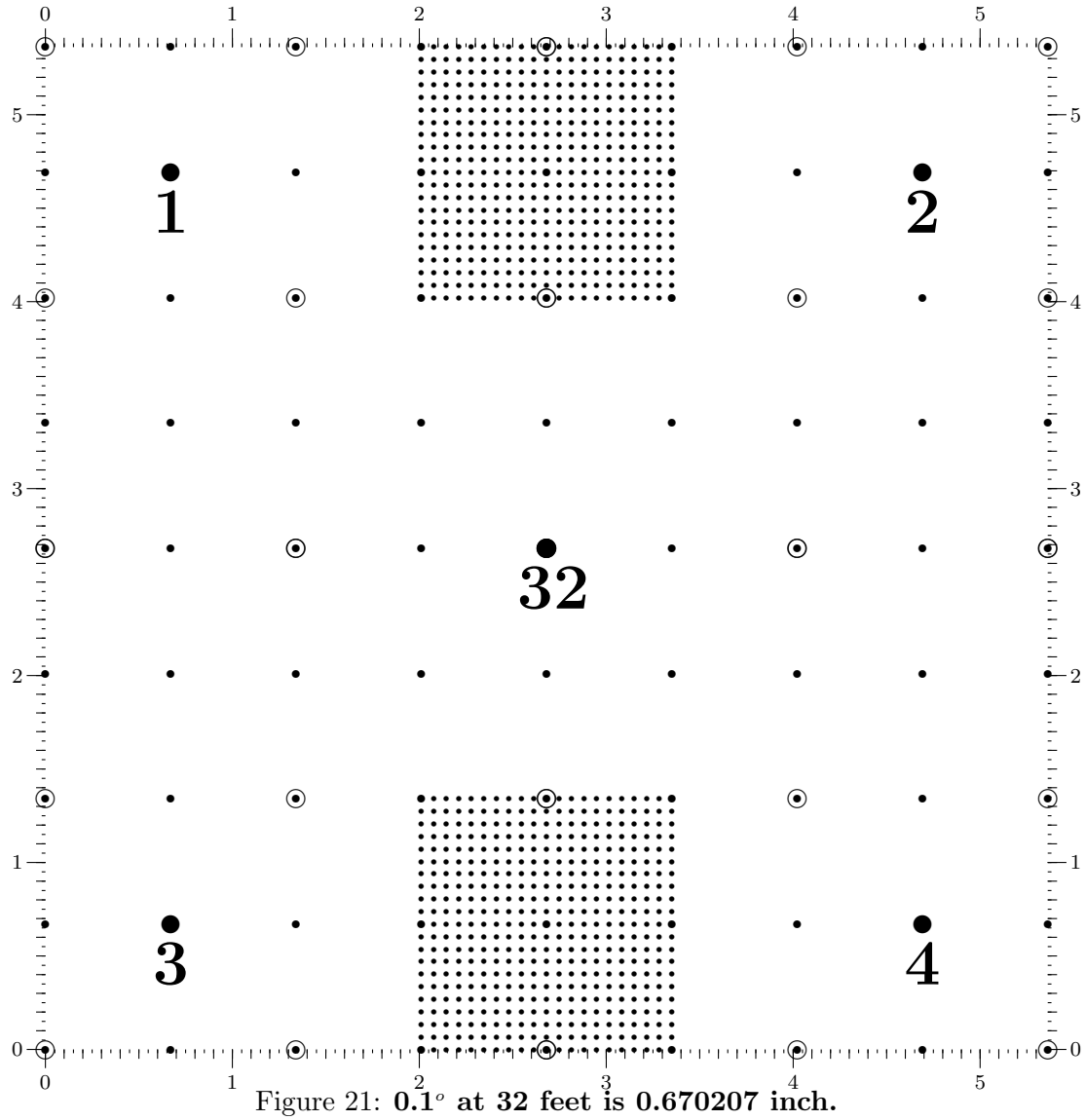

Figure 21: **0.1^o at 32 feet is 0.670207 inch.**

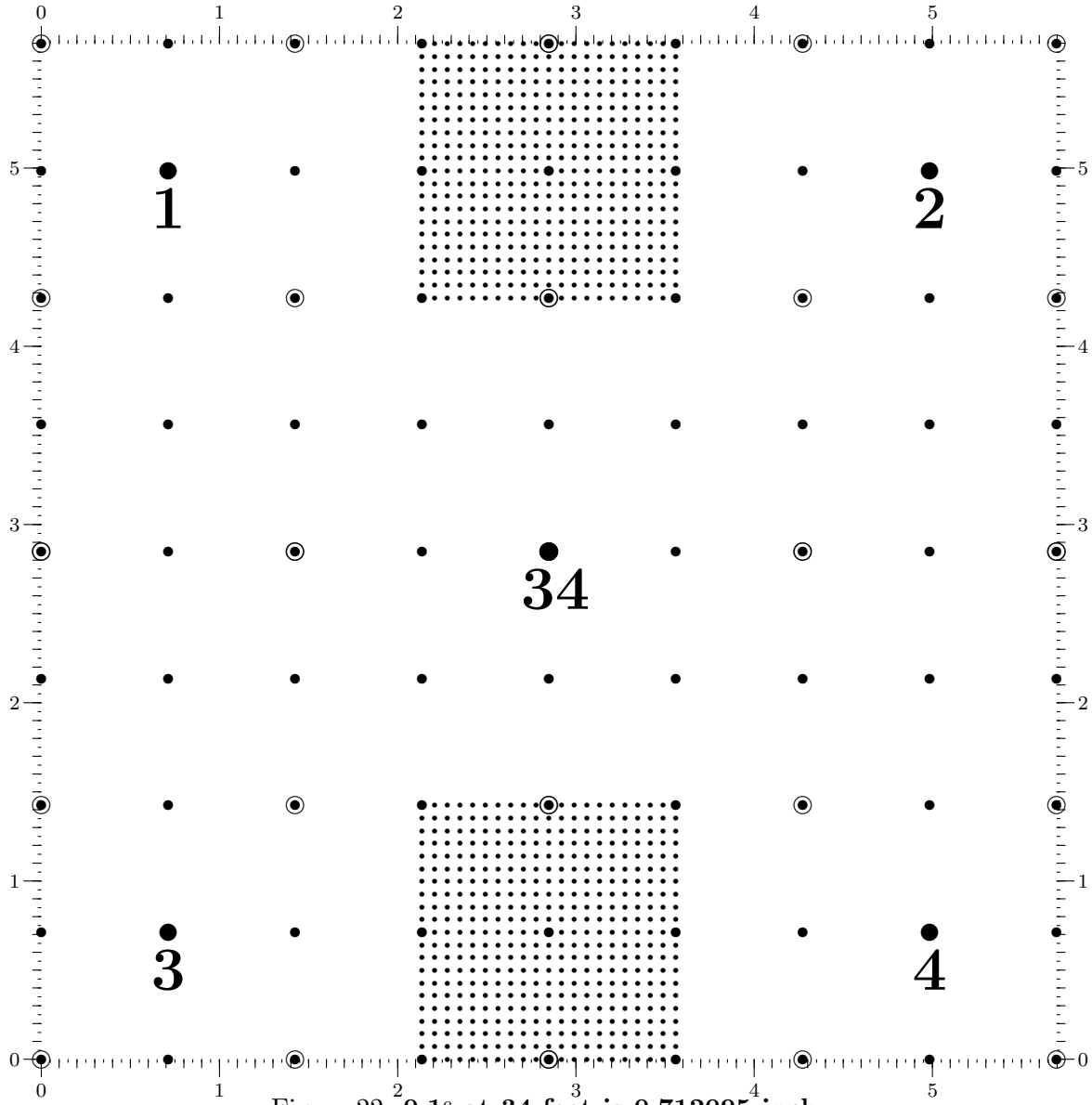

Figure 22: **0.1° at 34 feet is 0.712095 inch.**

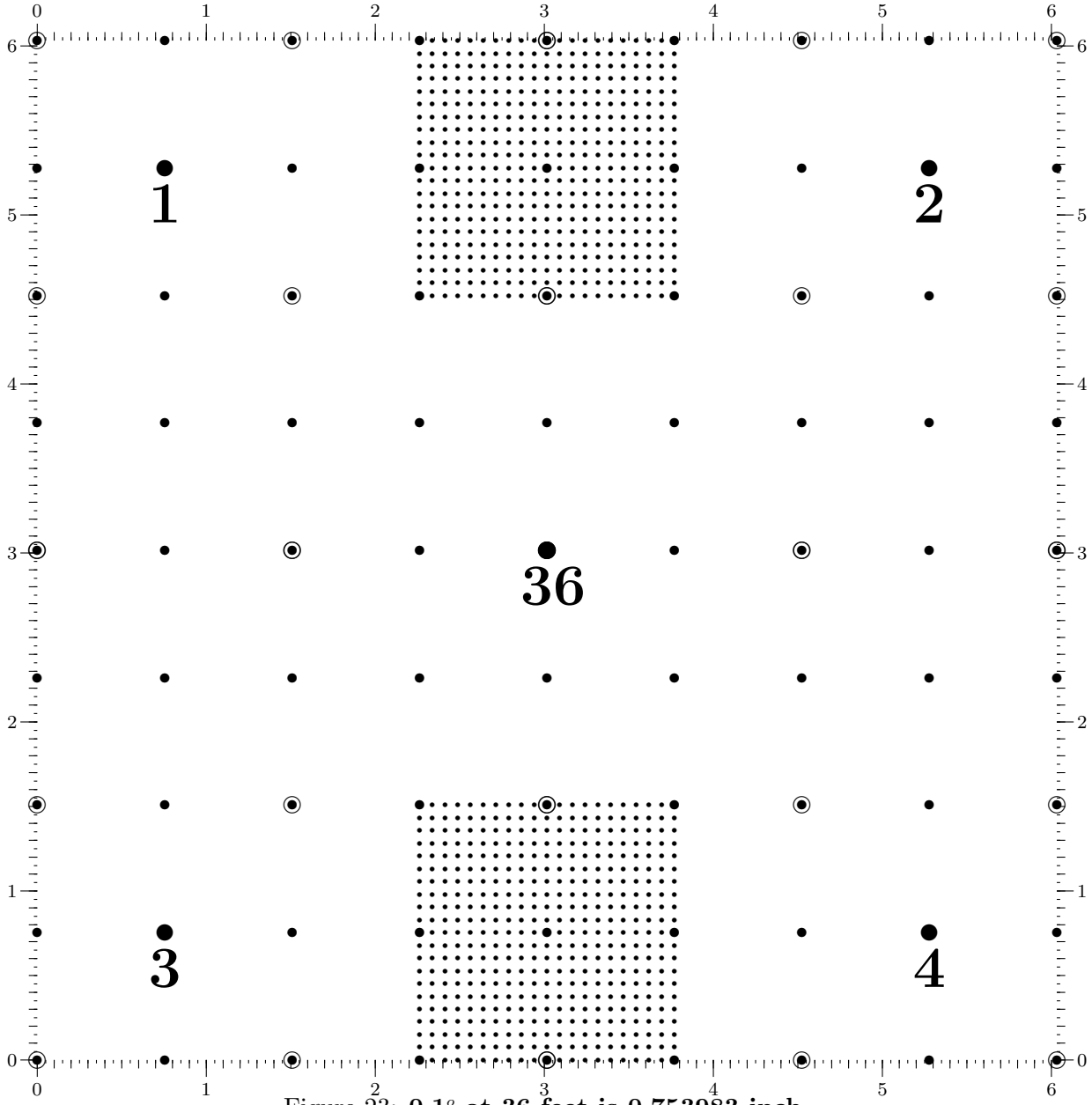

Figure 23: **0.1^o at 36 feet is 0.753983 inch.**

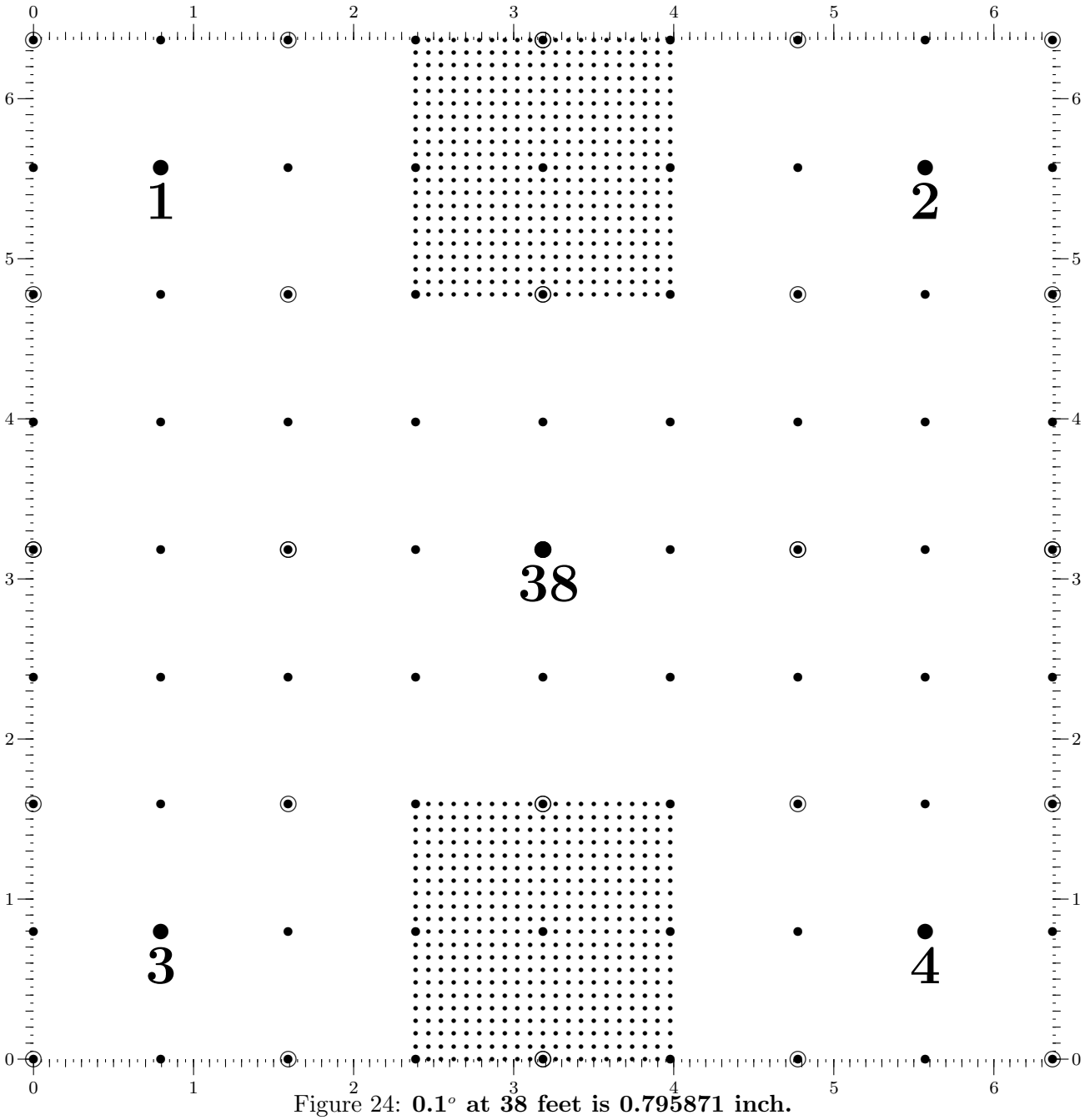

Figure 24: **0.1^o at 38 feet is 0.795871 inch.**

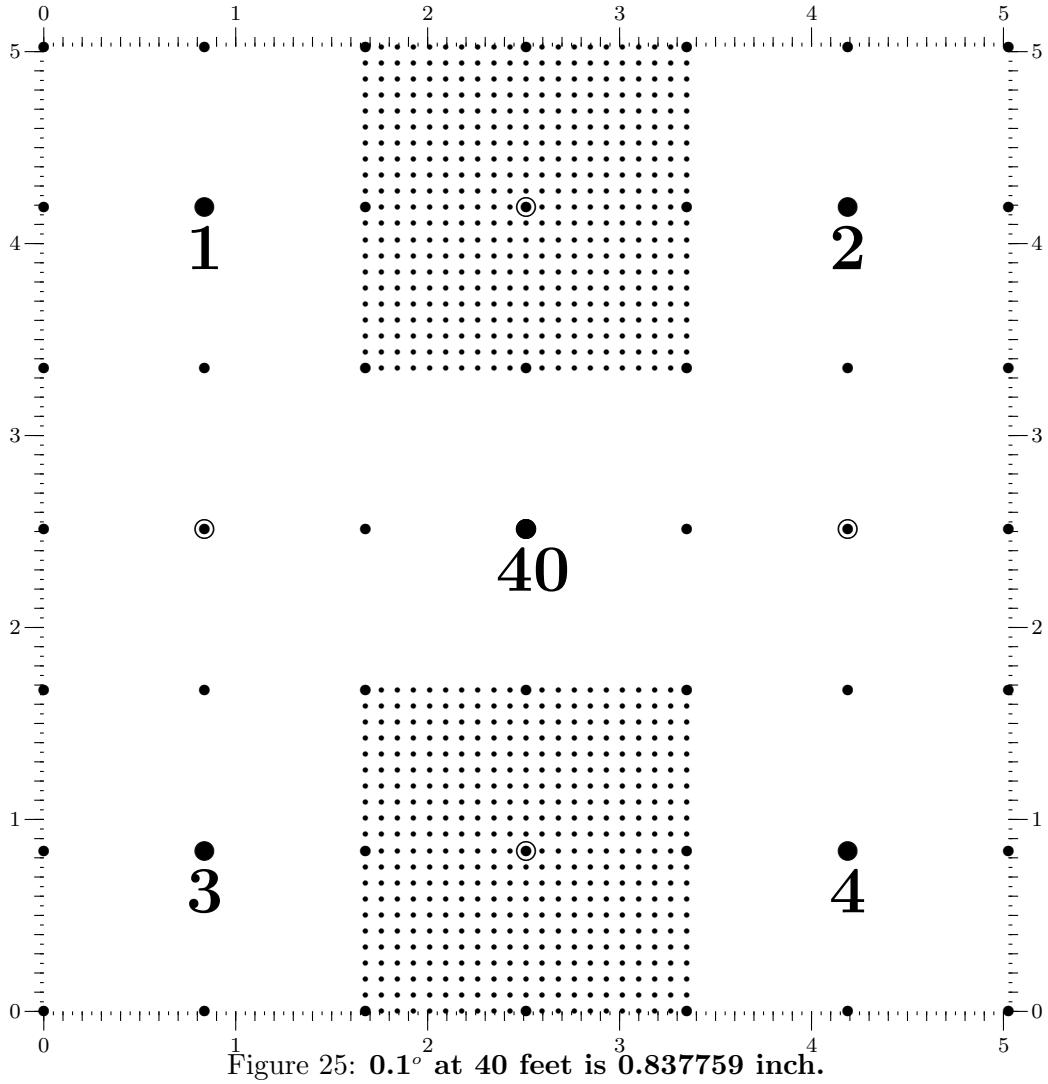

Figure 25: **0.1^o at 40 feet is 0.837759 inch.**

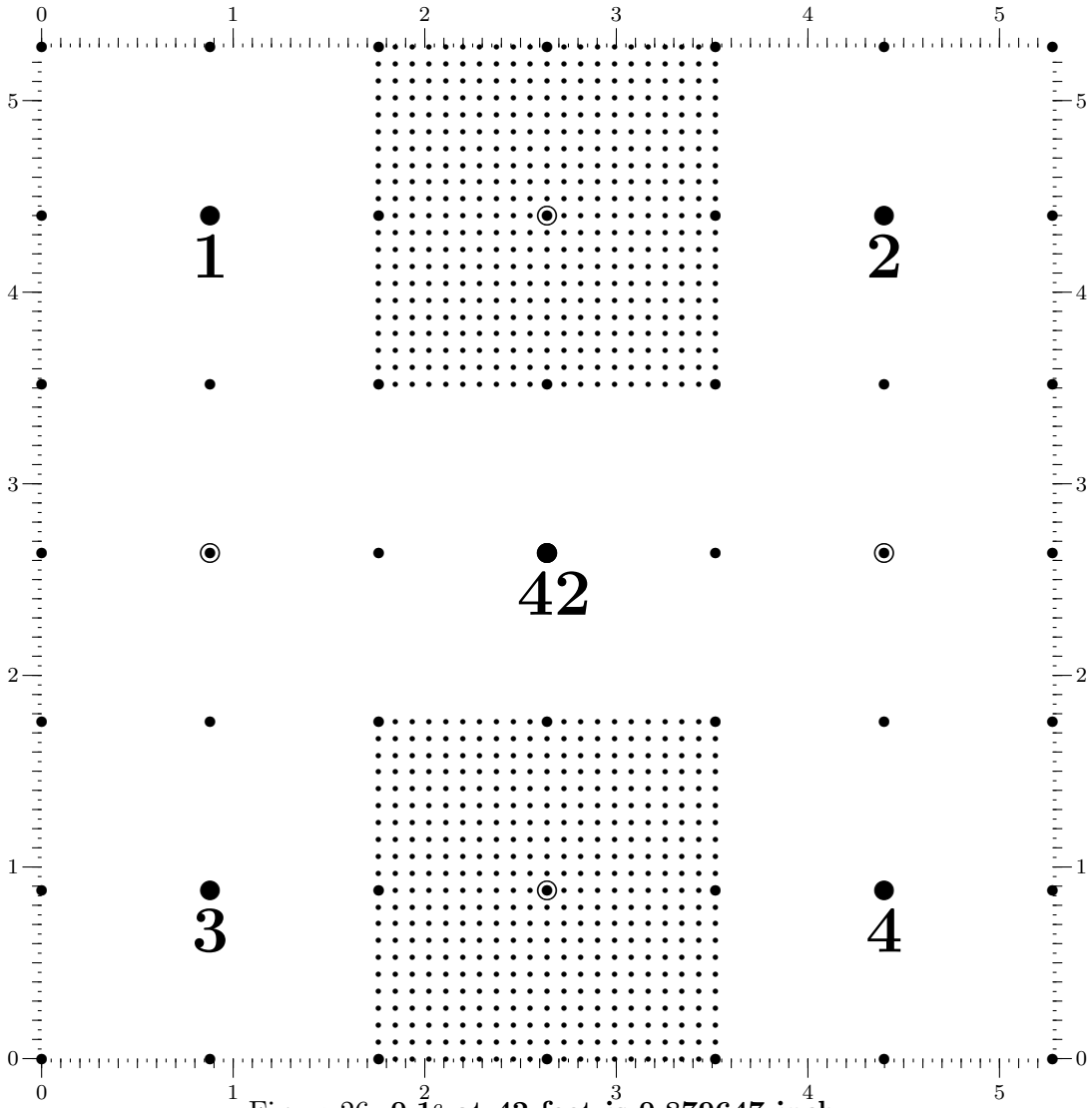

Figure 26: **0.1° at 42 feet is 0.879647 inch.**

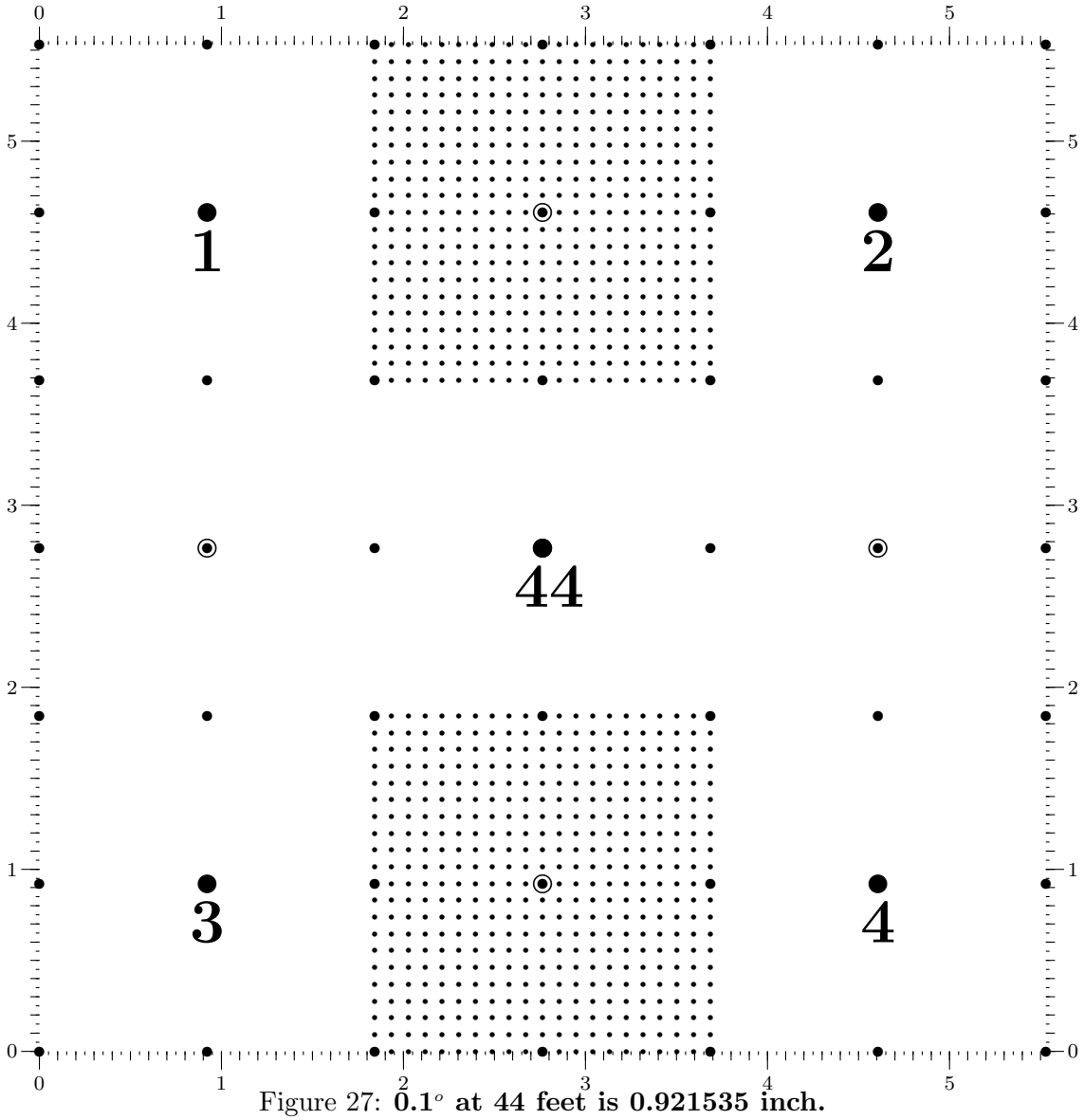

Figure 27: **0.1^o at 44 feet is 0.921535 inch.**

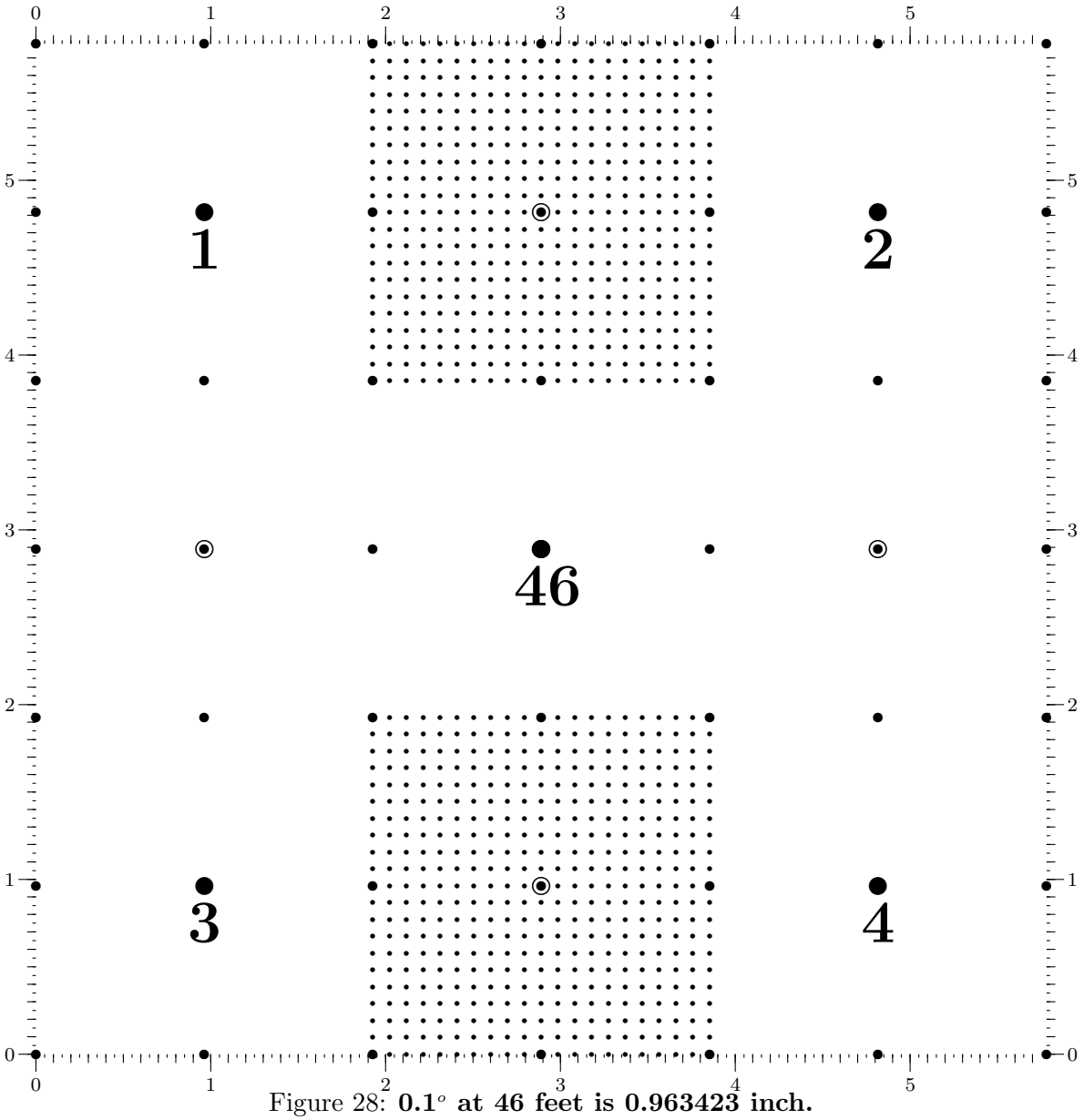

Figure 28: **0.1^o at 46 feet is 0.963423 inch.**

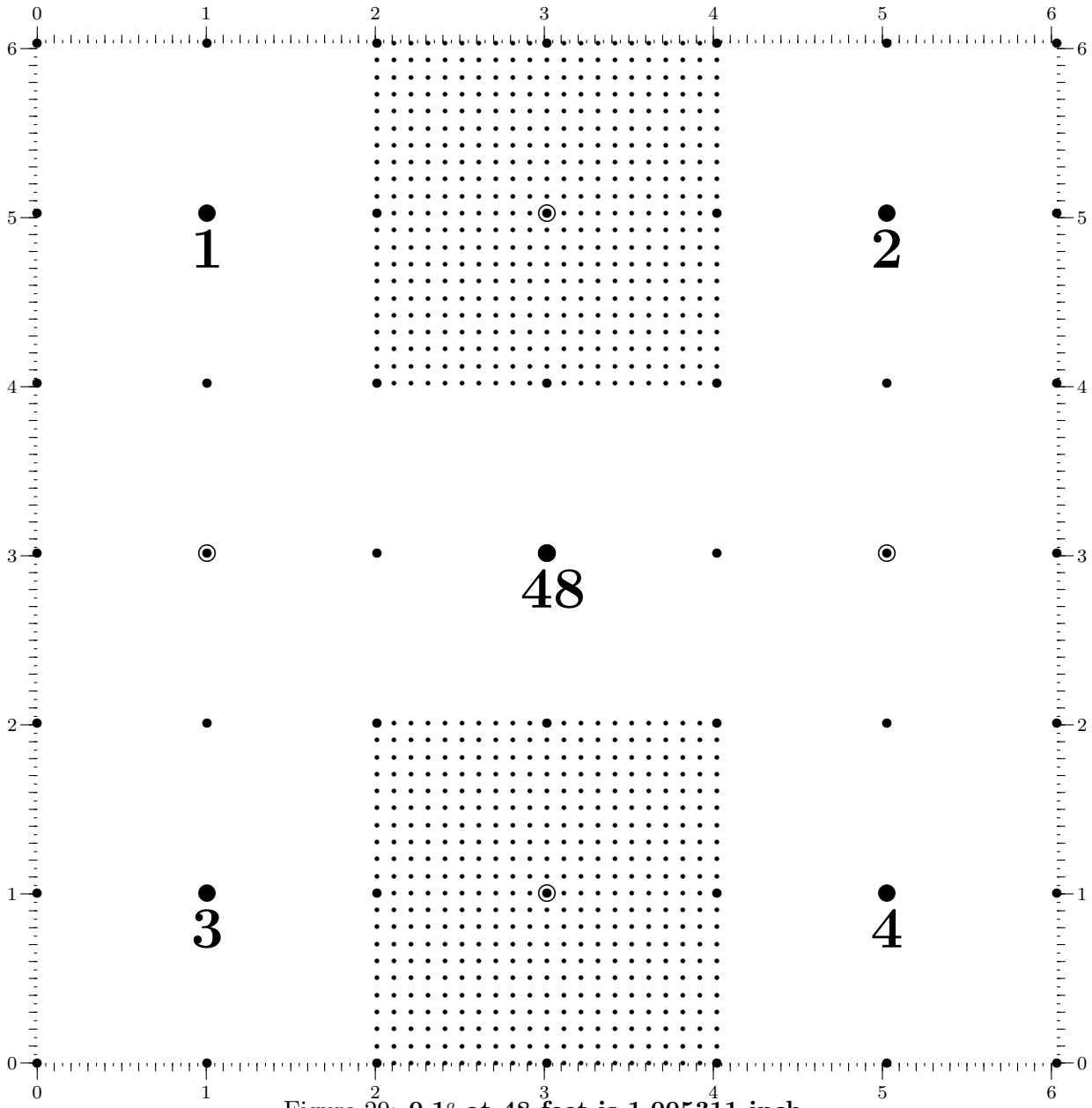

Figure 29: **0.1^o at 48 feet is 1.005311 inch.**

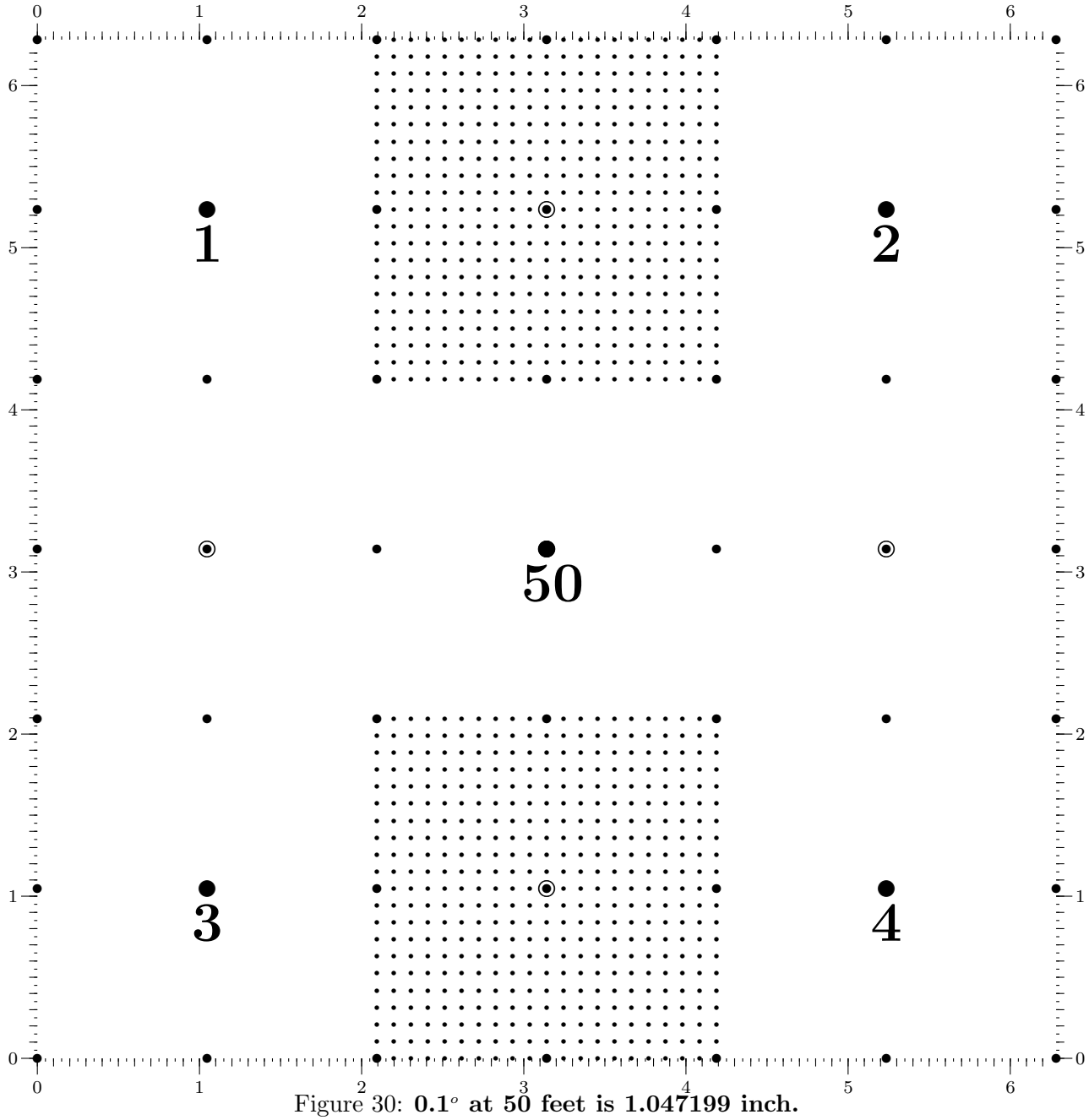

Figure 30: **0.1^o at 50 feet is 1.047199 inch.**

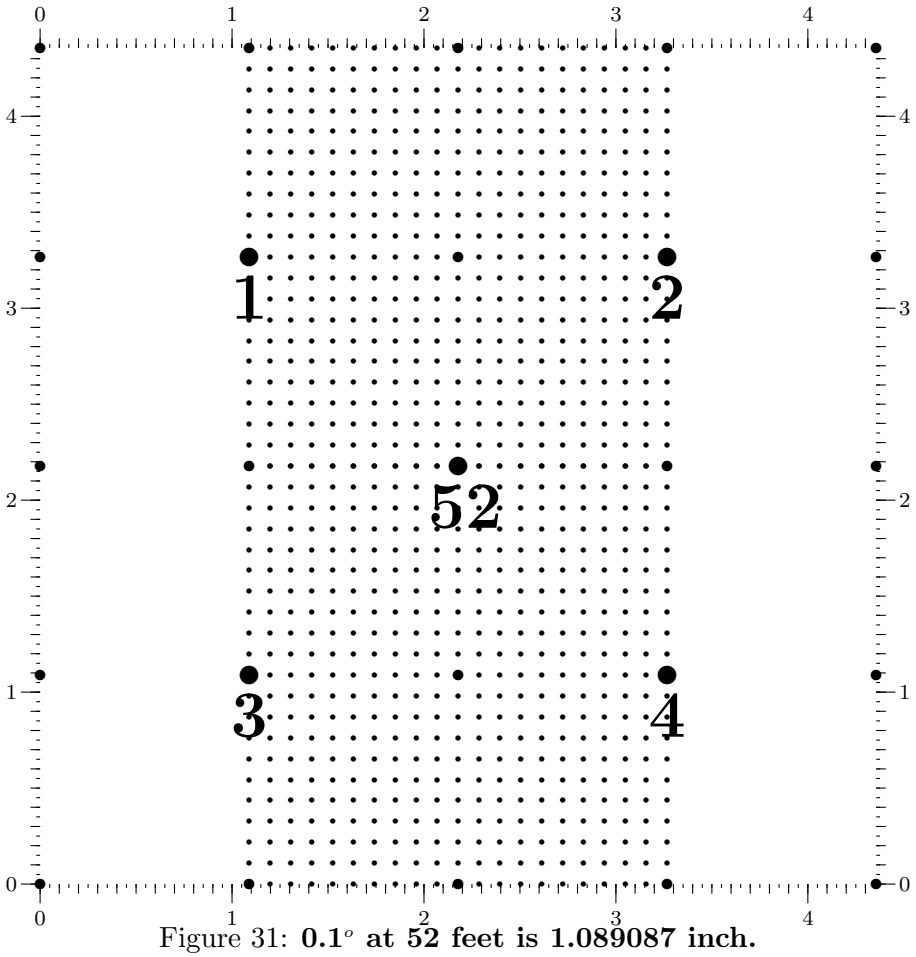

Figure 31: **0.1° at 52 feet is 1.089087 inch.**

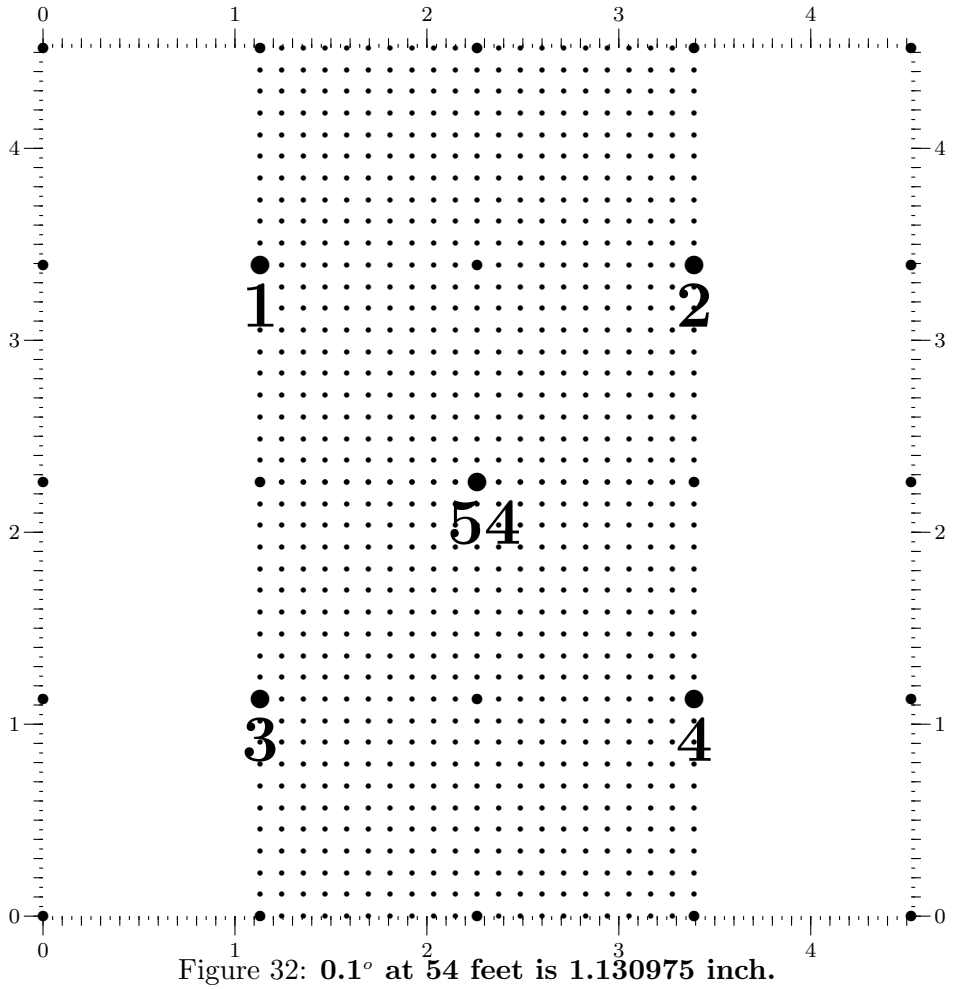

Figure 32: **0.1° at 54 feet is 1.130975 inch.**

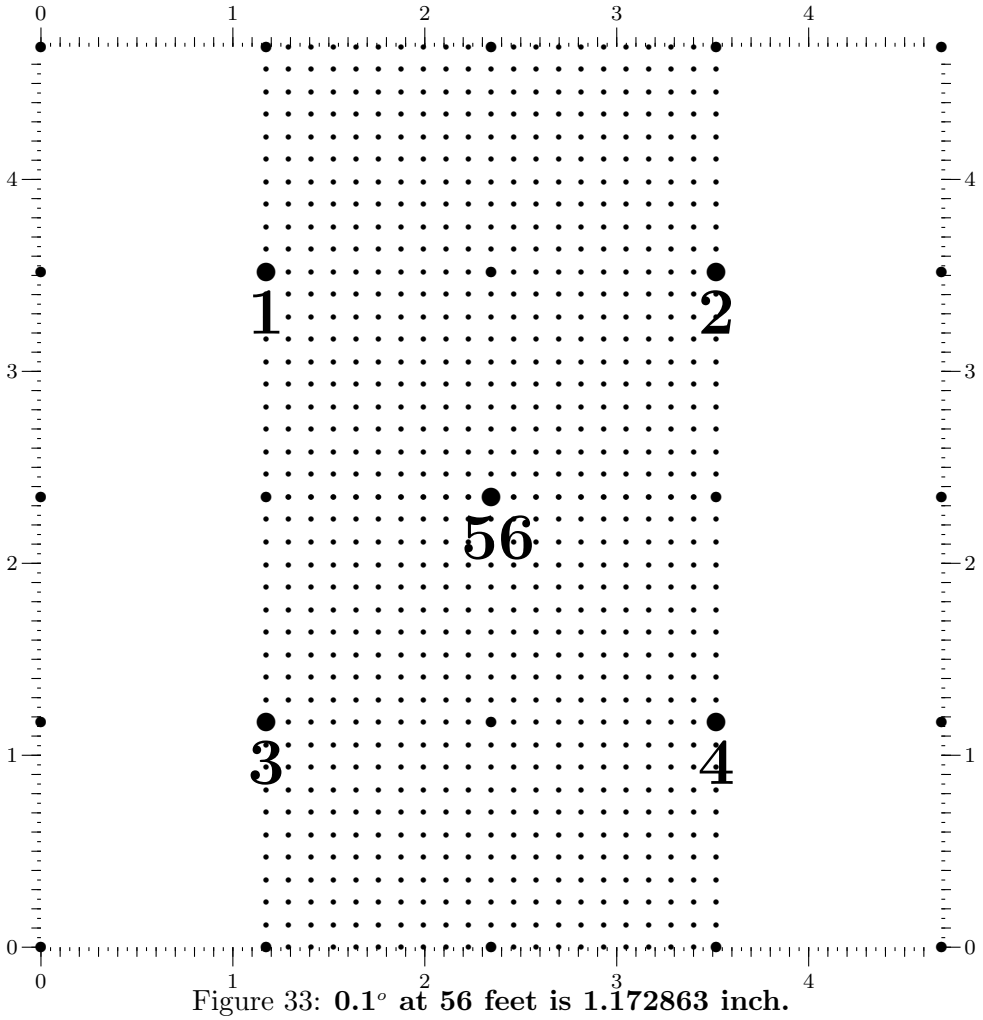

Figure 33: **0.1° at 56 feet is 1.172863 inch.**

1.3 Metric Calibration Grids

Distance	Page
1.0	Figure 34, page 45
1.5	Figure 35, page 46
2.0	Figure 36, page 47
2.5	Figure 37, page 48
3.0	Figure 38, page 49
3.5	Figure 39, page 50
4.0	Figure 40, page 51
4.5	Figure 41, page 52
5.0	Figure 42, page 53
5.5	Figure 43, page 54
6.0	Figure 44, page 55
6.5	Figure 45, page 56
7.0	Figure 46, page 57
7.5	Figure 47, page 58
8.0	Figure 48, page 59
8.5	Figure 49, page 60
9.0	Figure 50, page 61
9.5	Figure 51, page 62
10.0	Figure 52, page 63
11.0	Figure 53, page 64
12.0	Figure 54, page 65
13.0	Figure 55, page 66
14.0	Figure 56, page 67
15.0	Figure 57, page 68
16.0	Figure 58, page 69
17.0	Figure 59, page 70
18.0	Figure 60, page 71
19.0	Figure 61, page 72
20.0	Figure 62, page 73

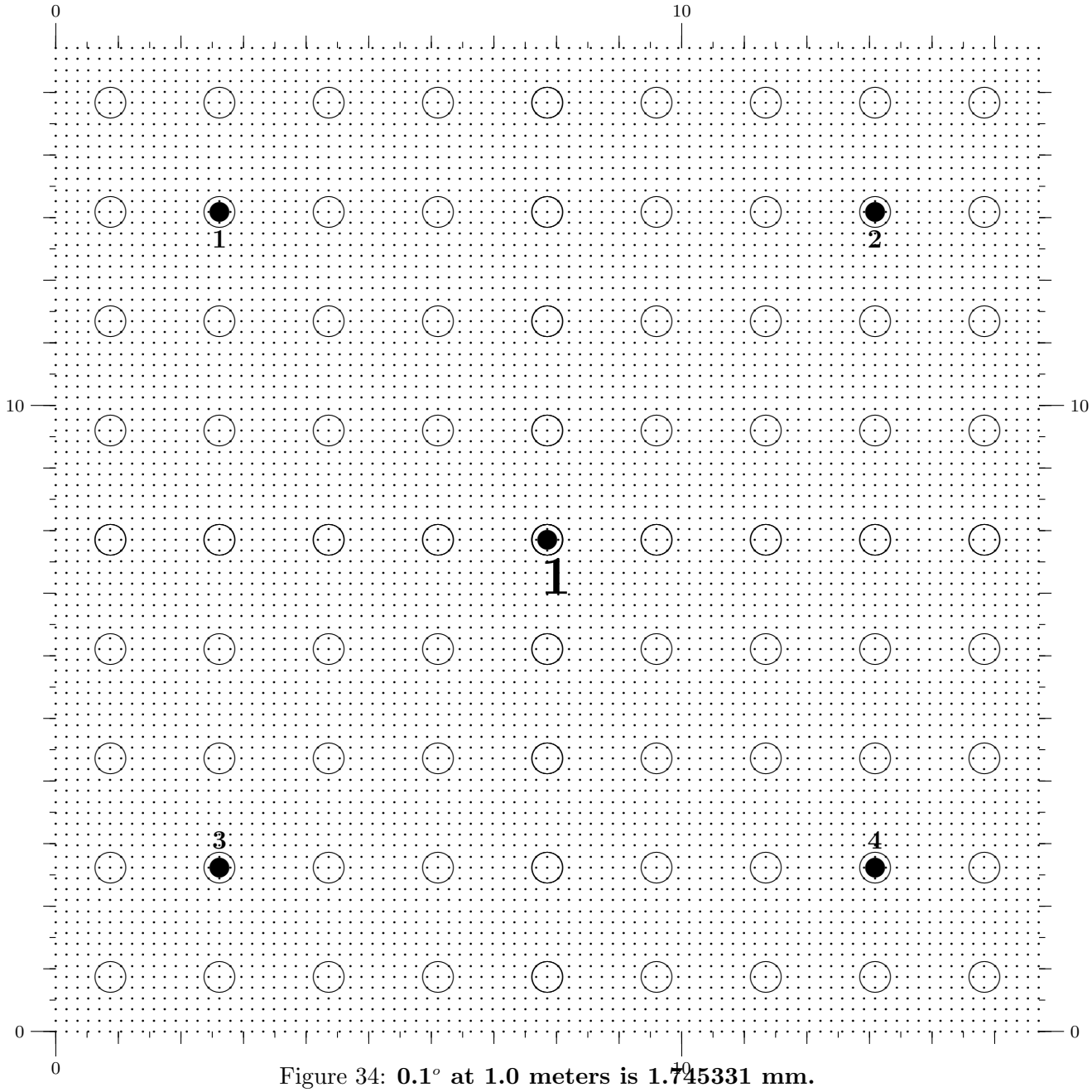

Figure 34: **0.1° at 1.0 meters is 1.745331 mm.**

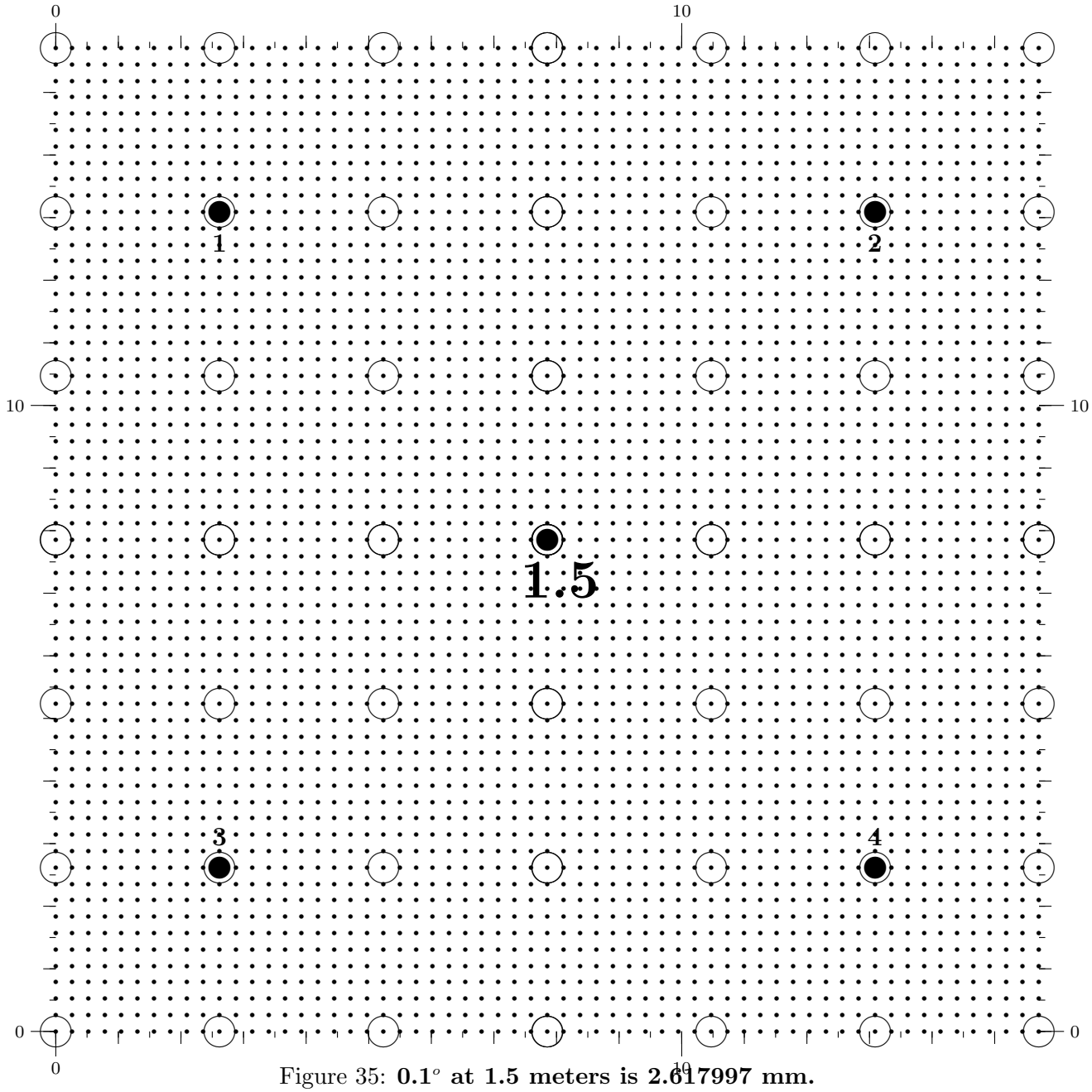

Figure 35: **0.1° at 1.5 meters is 2.617997 mm.**

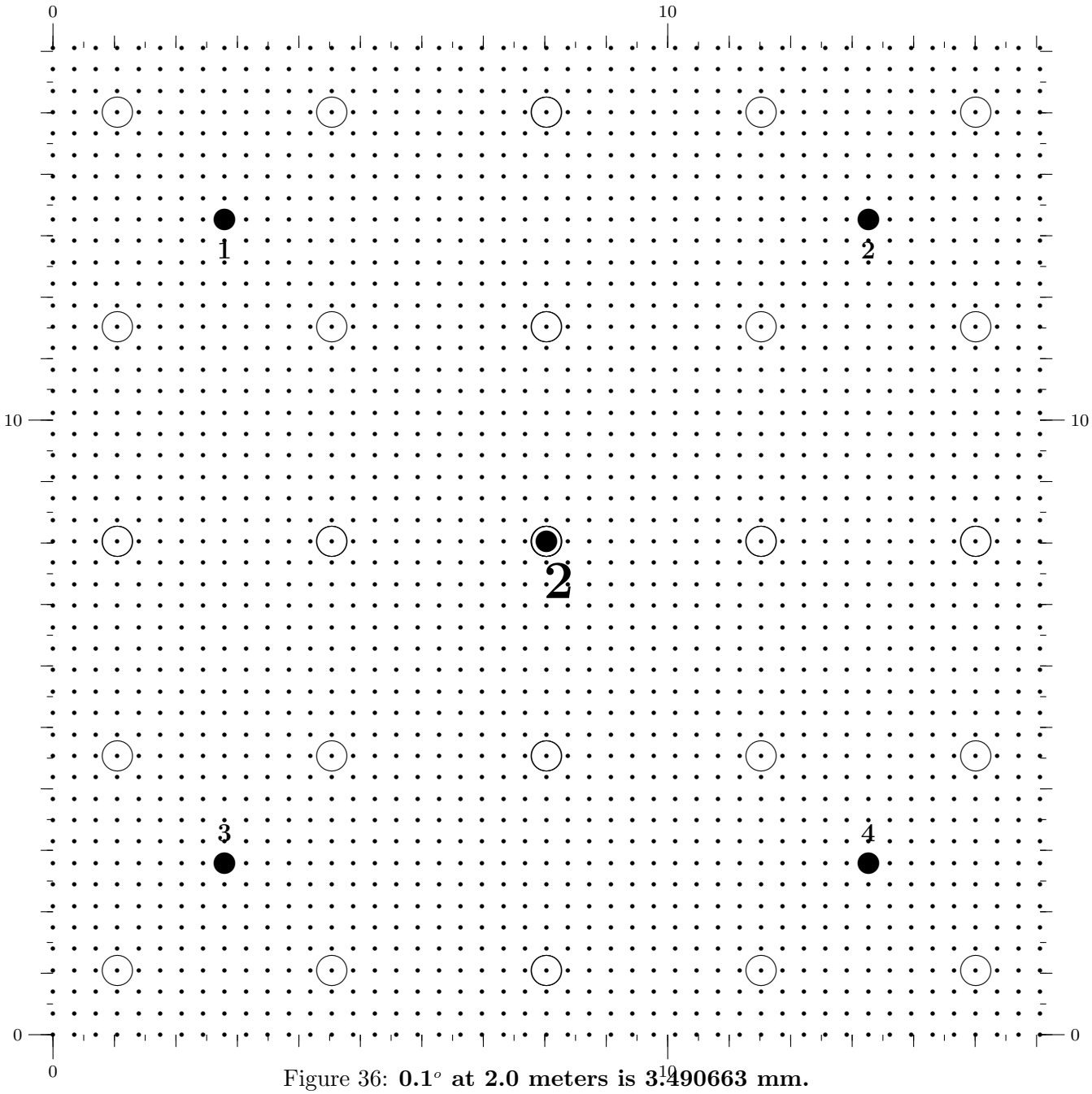

Figure 36: **0.1° at 2.0 meters is 3.490663 mm.**

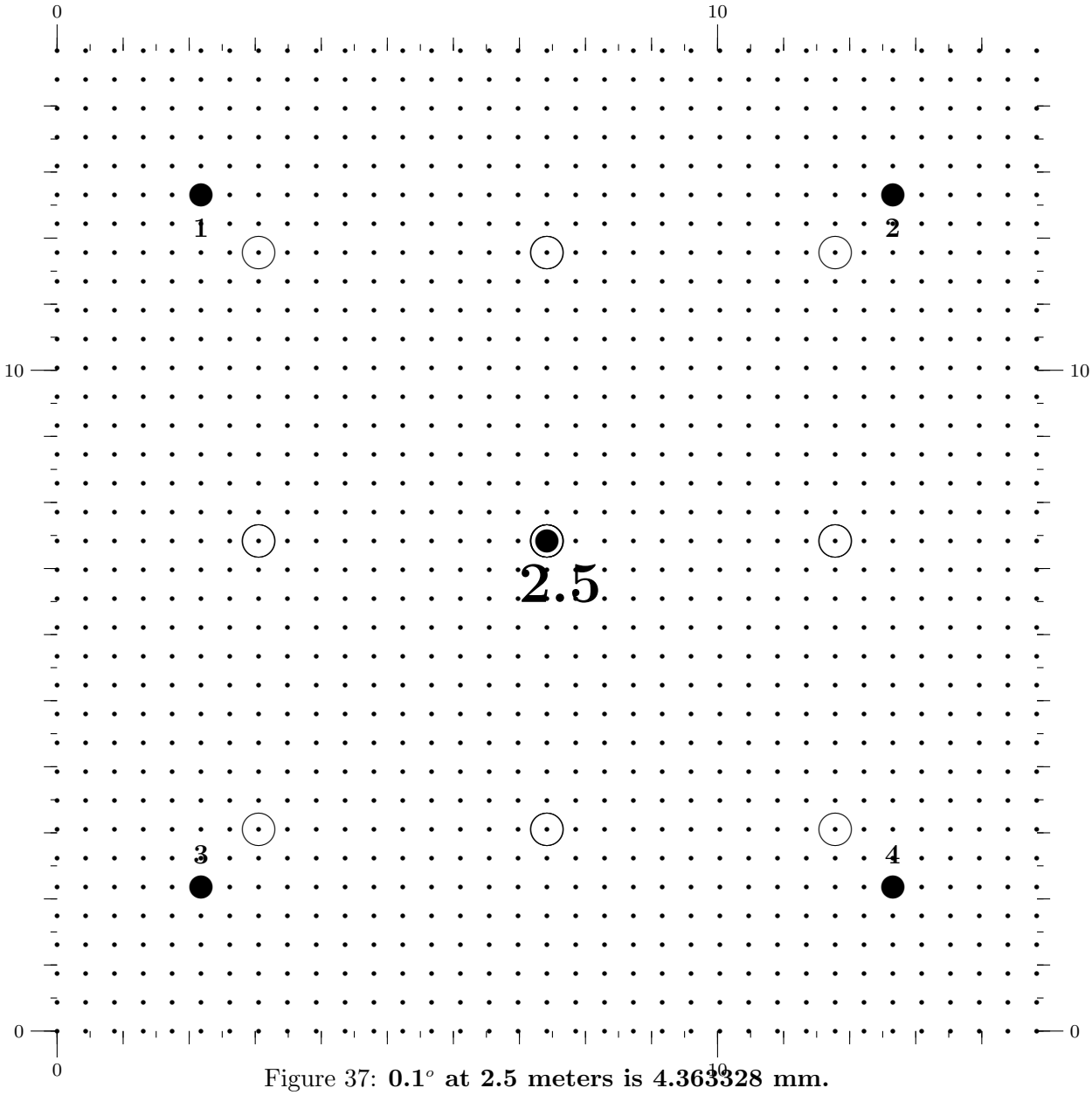

Figure 37: **0.1^o at 2.5 meters is 4.363328 mm.**

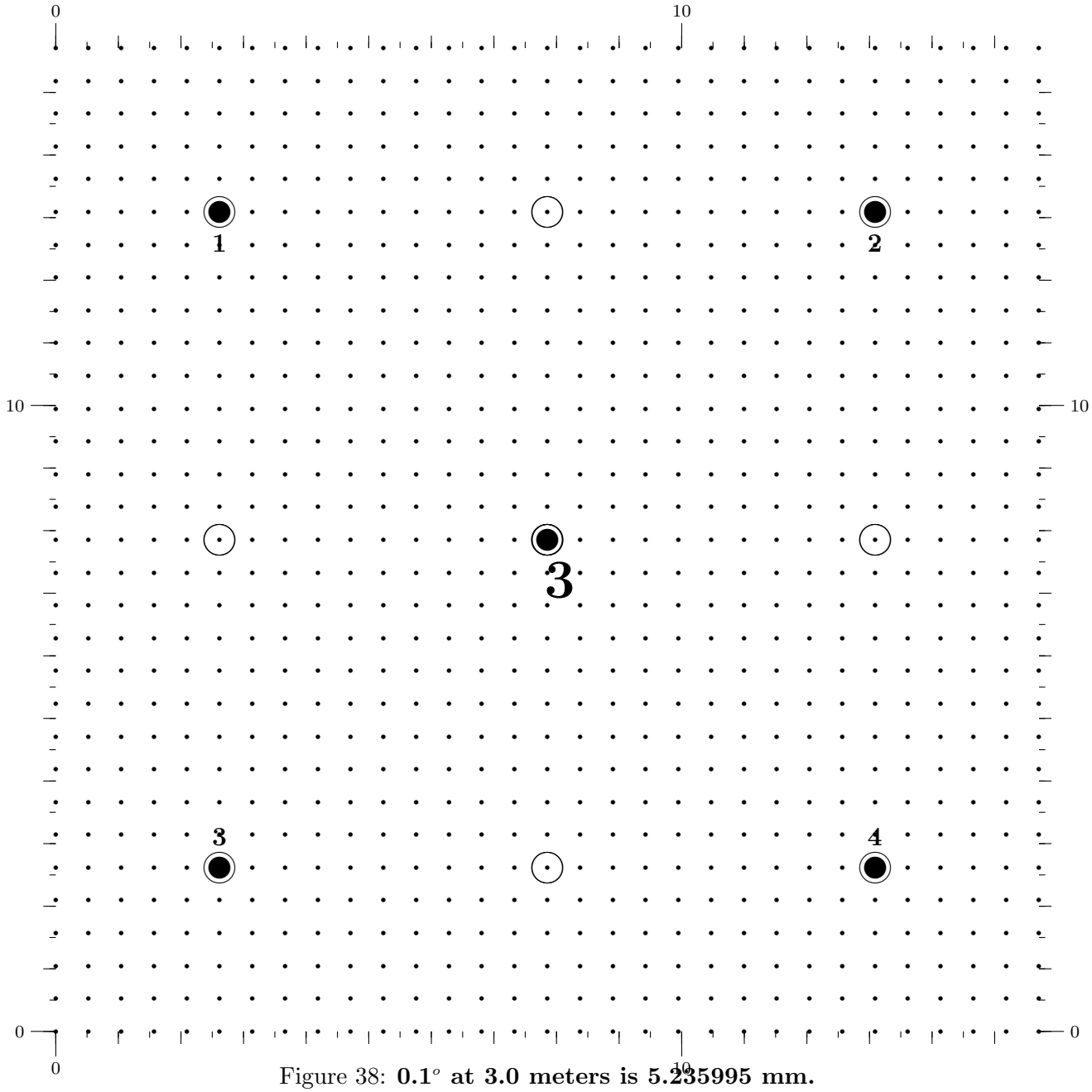

Figure 38: **0.1° at 3.0 meters is 5.235995 mm.**

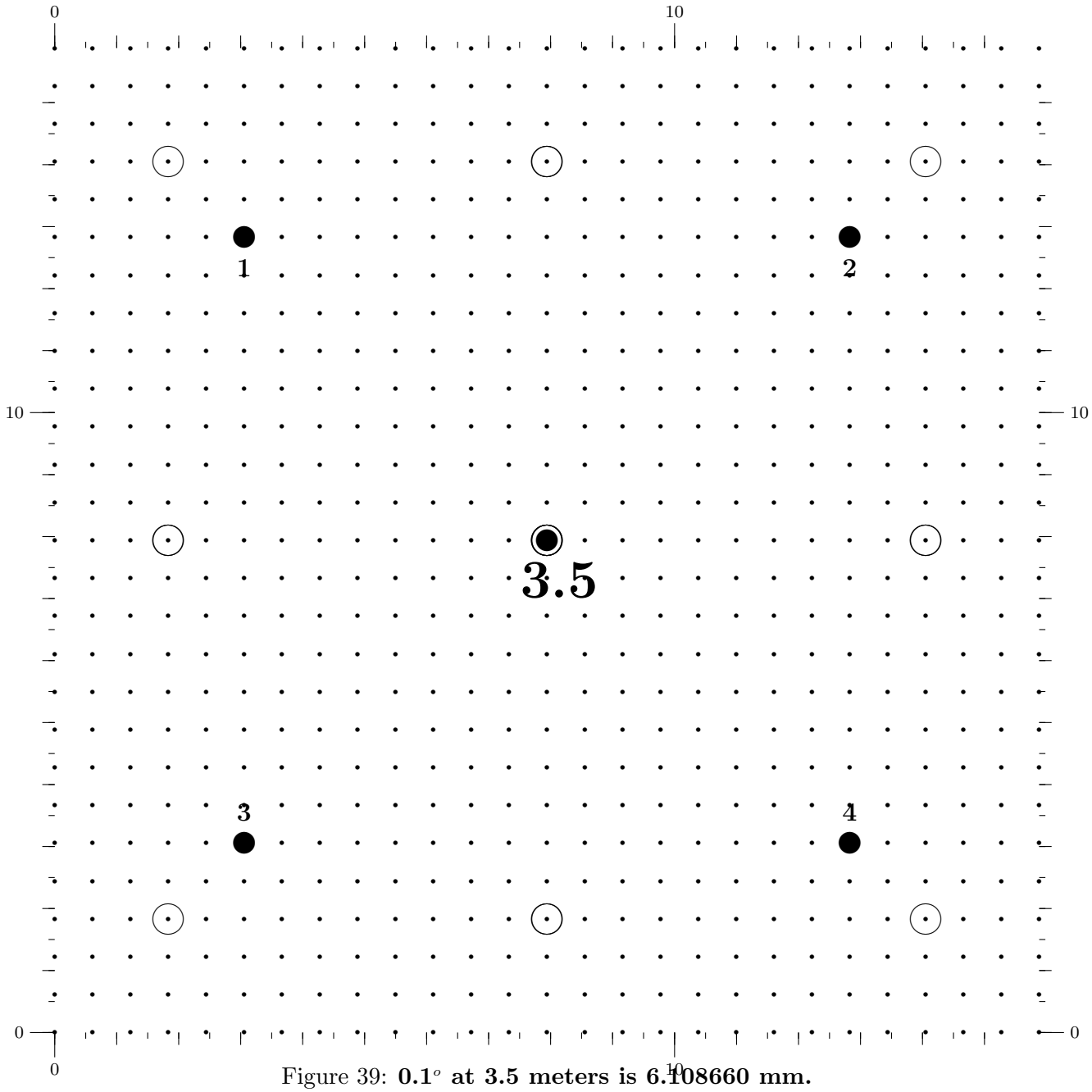

Figure 39: **0.1° at 3.5 meters is 6.108660 mm.**

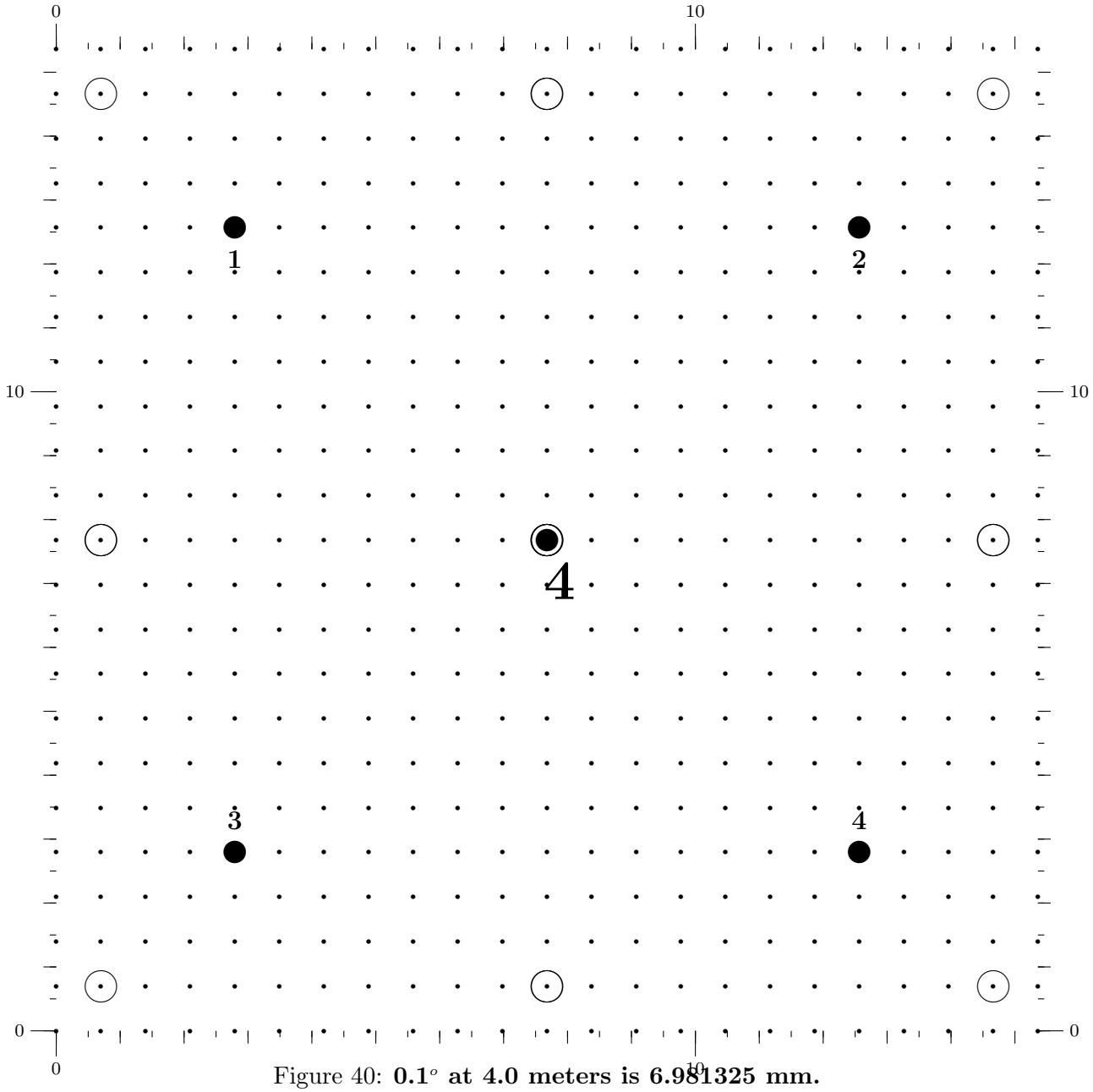

Figure 40: **0.1° at 4.0 meters is 6.981325 mm.**

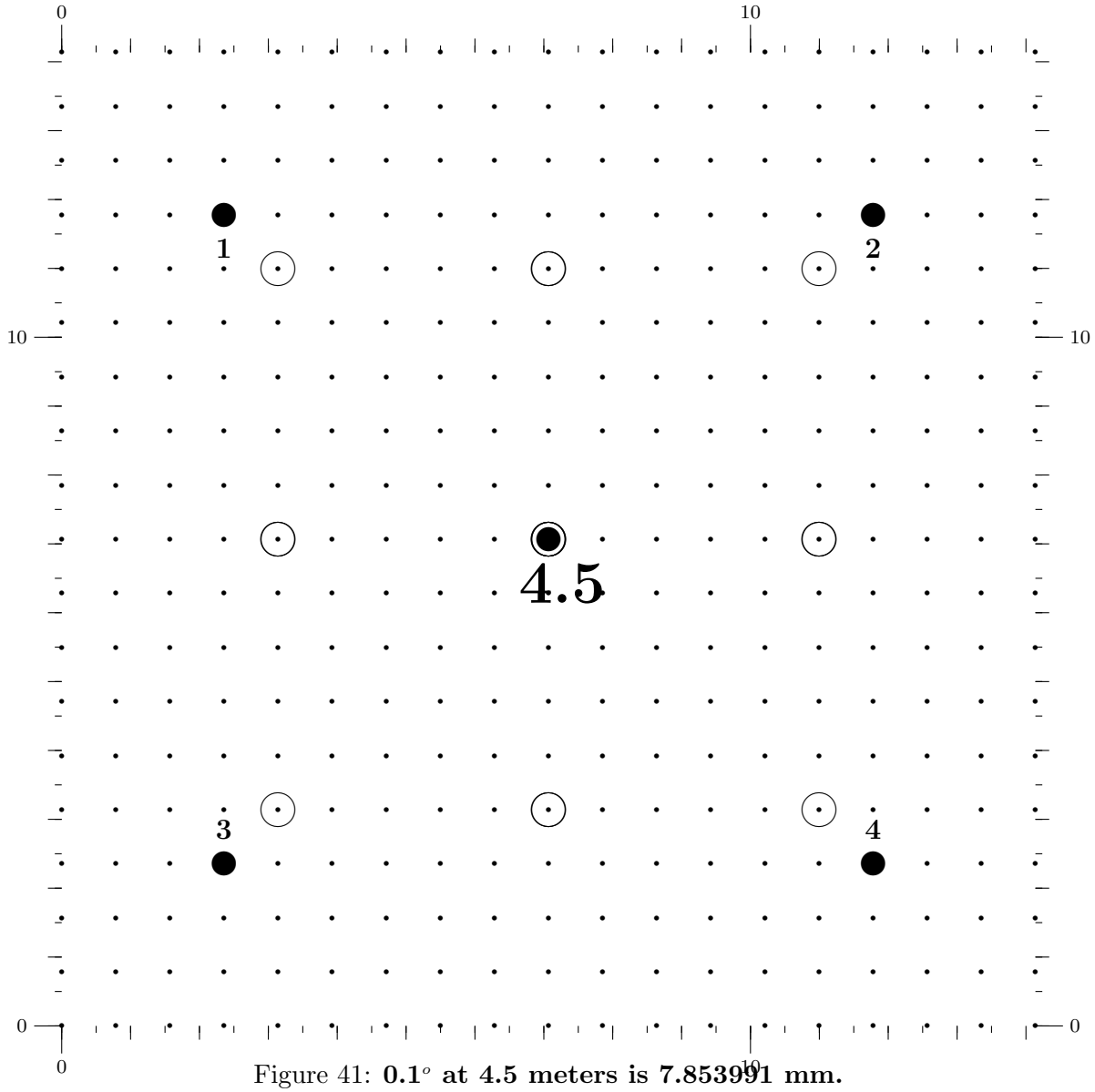

Figure 41: **0.1° at 4.5 meters is 7.853991 mm.**

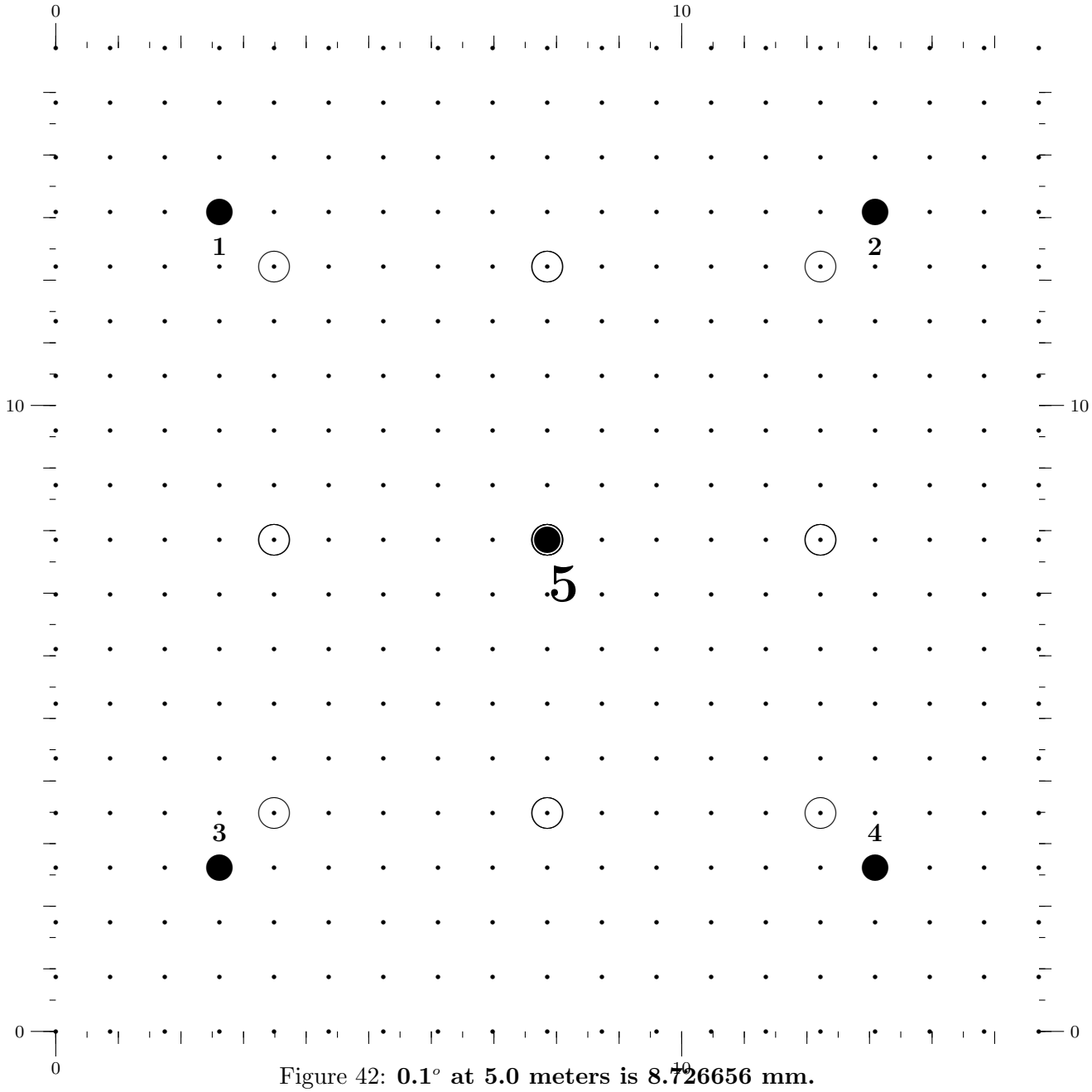

Figure 42: **0.1° at 5.0 meters is 8.726656 mm.**

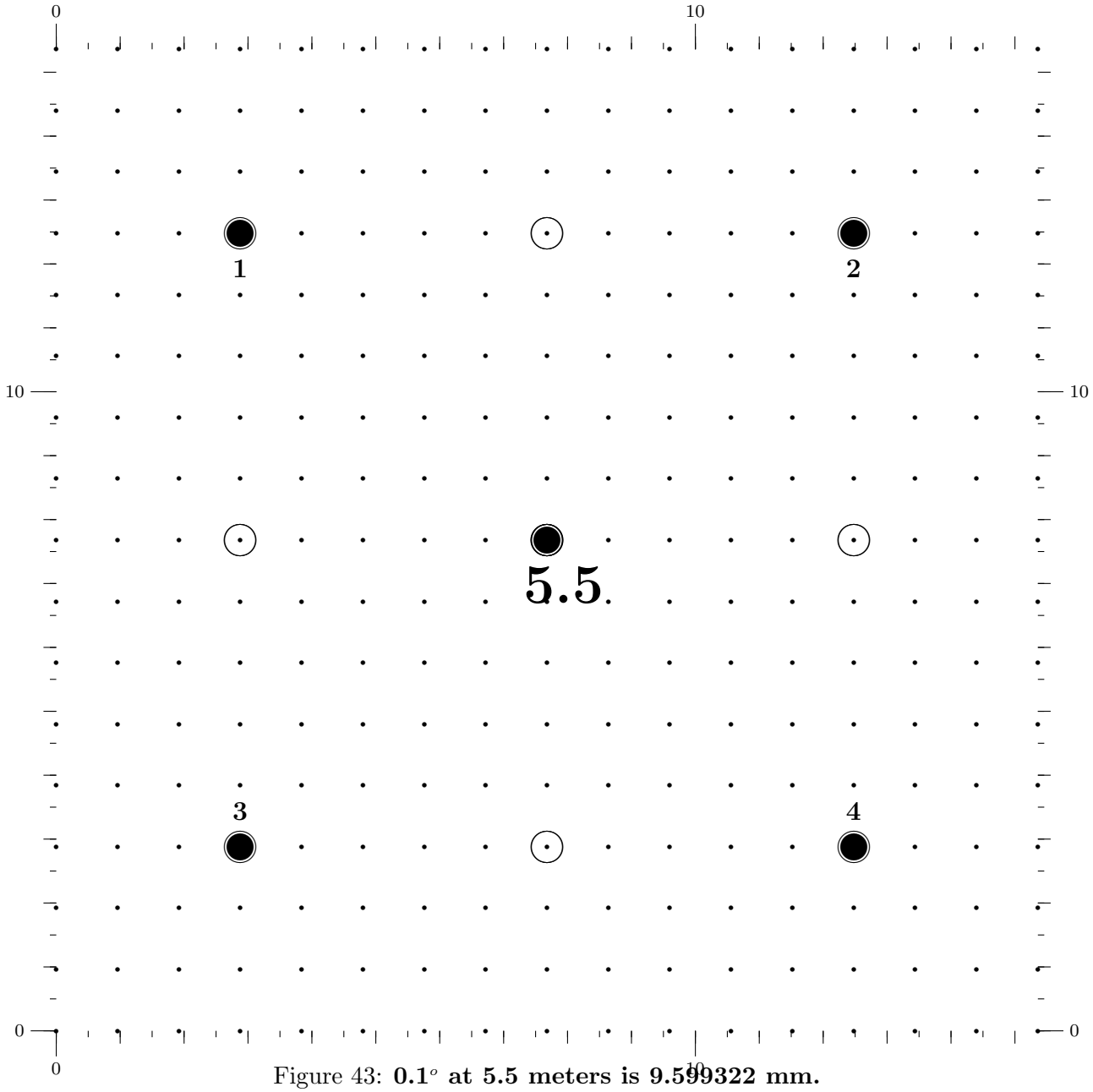

Figure 43: **0.1° at 5.5 meters is 9.599322 mm.**

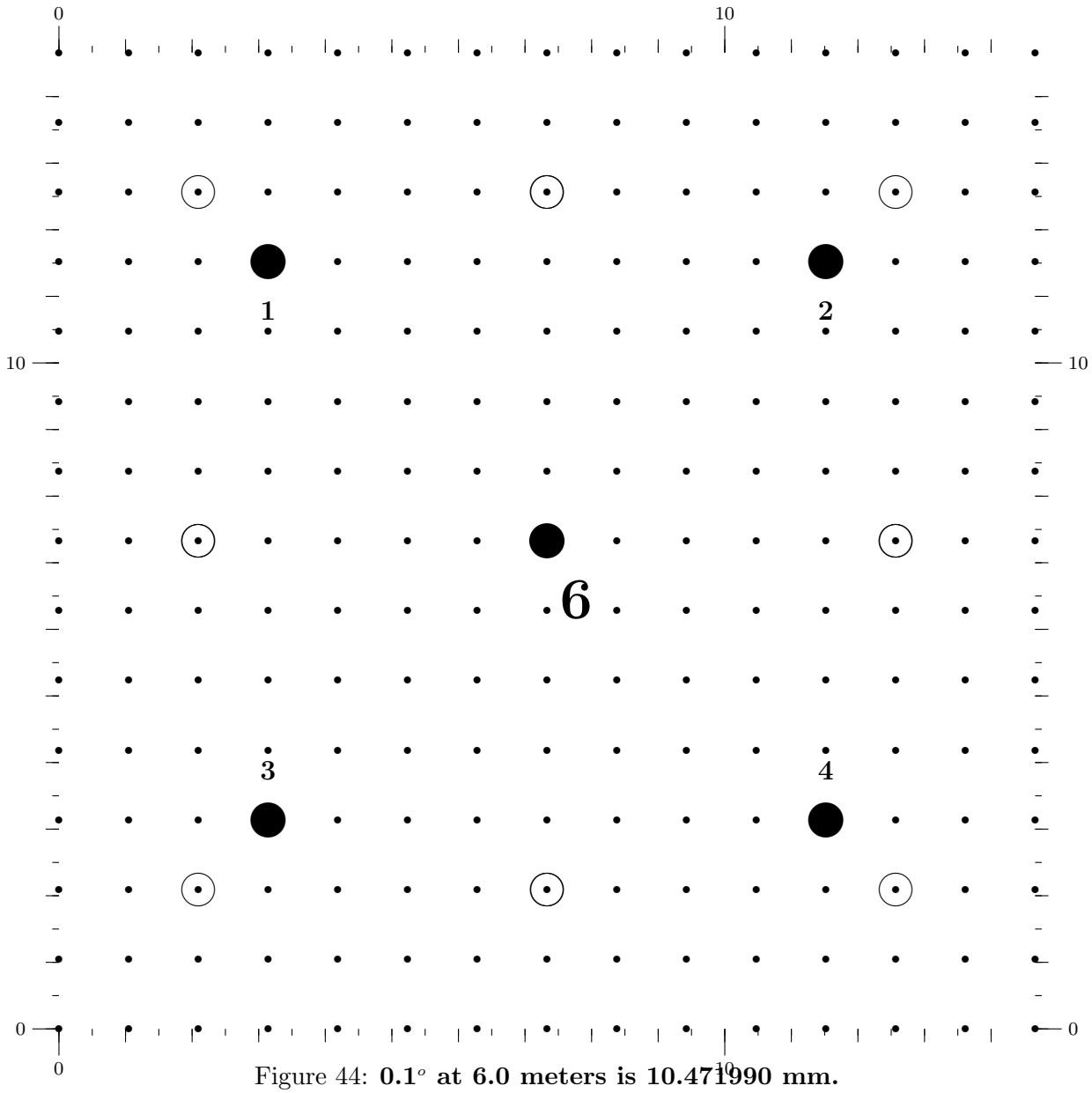

Figure 44: **0.1° at 6.0 meters is 10.471990 mm.**

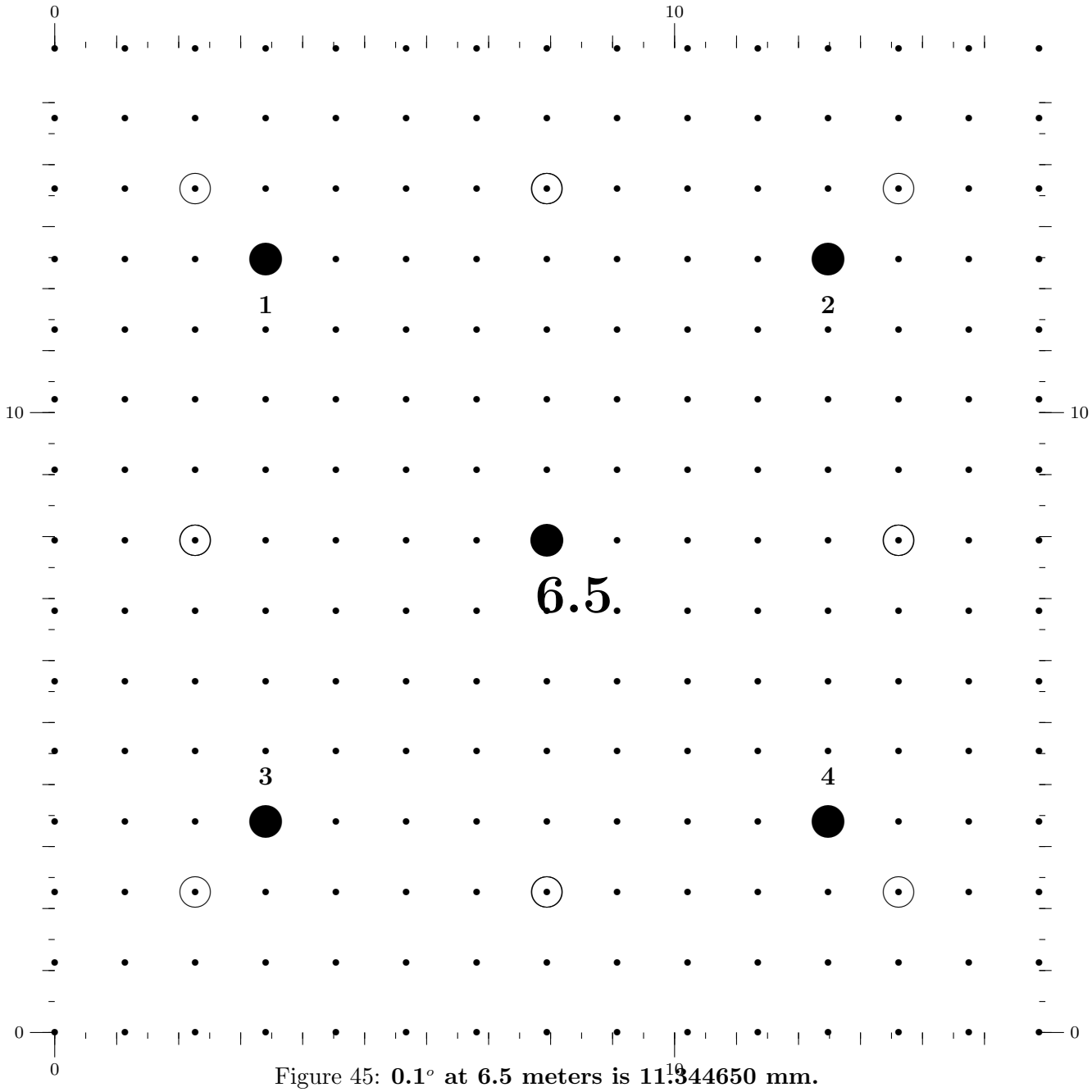

Figure 45: **0.1° at 6.5 meters is 11.344650 mm.**

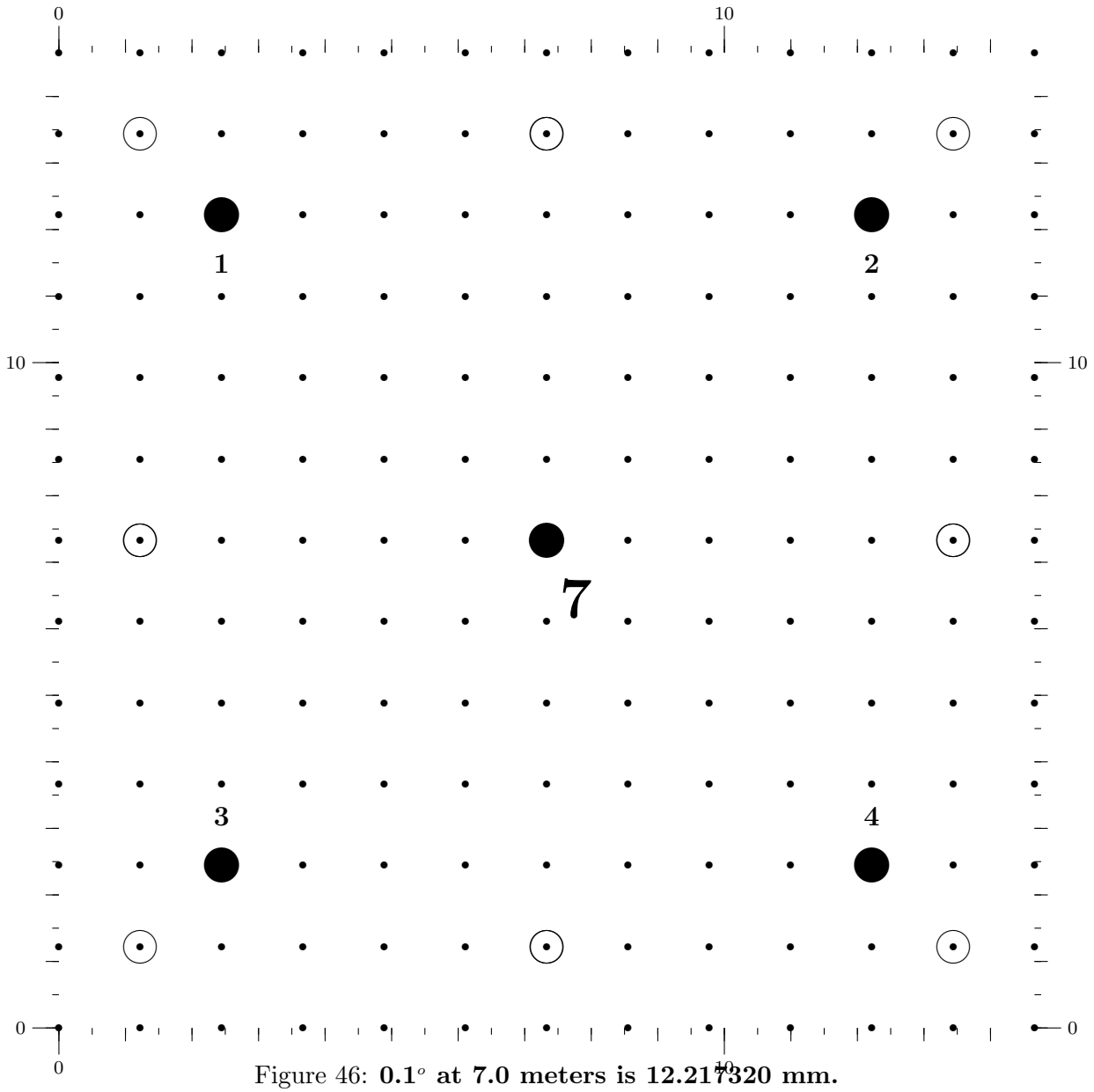

Figure 46: **0.1^o at 7.0 meters is 12.217320 mm.**

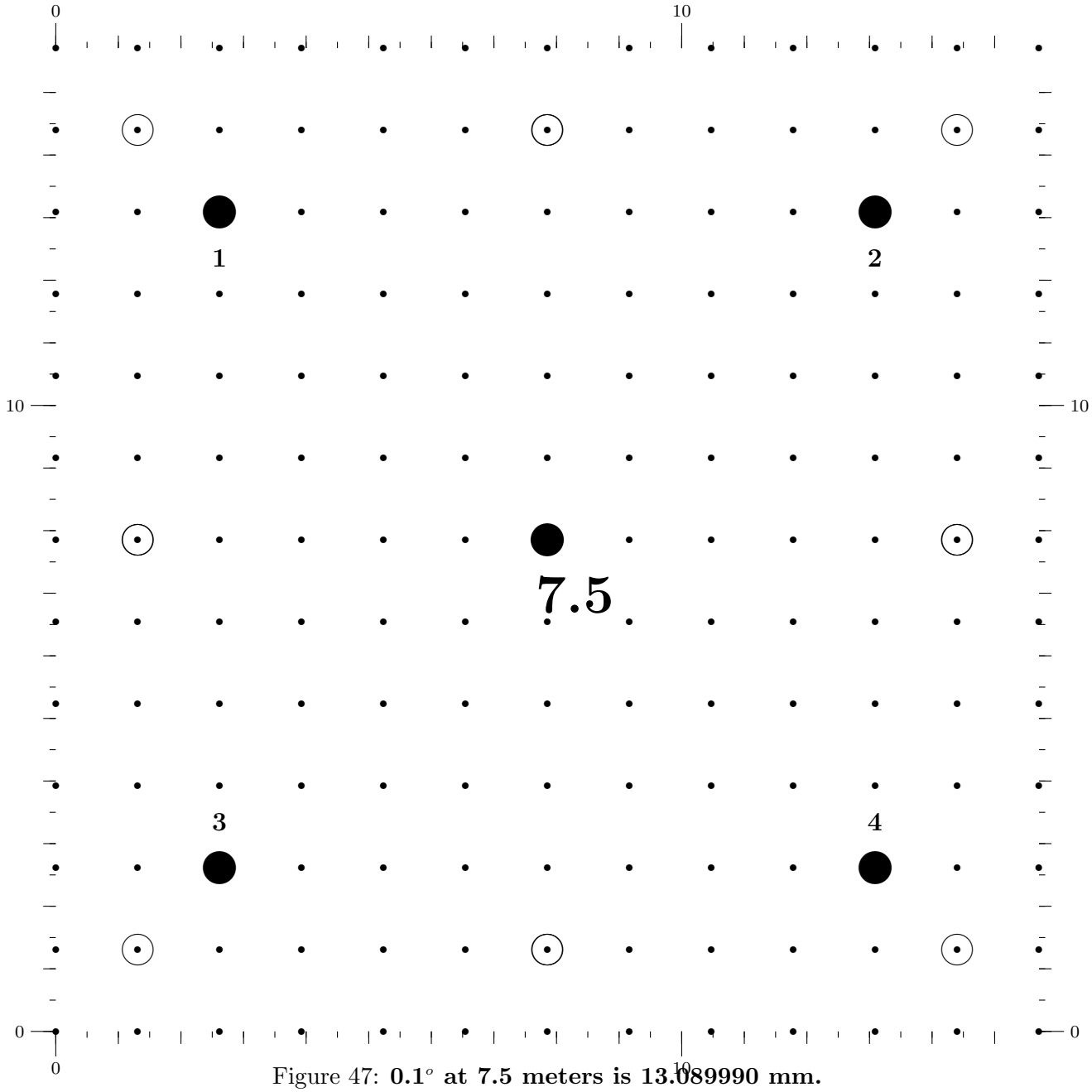

Figure 47: **0.1^o at 7.5 meters is 13.089990 mm.**

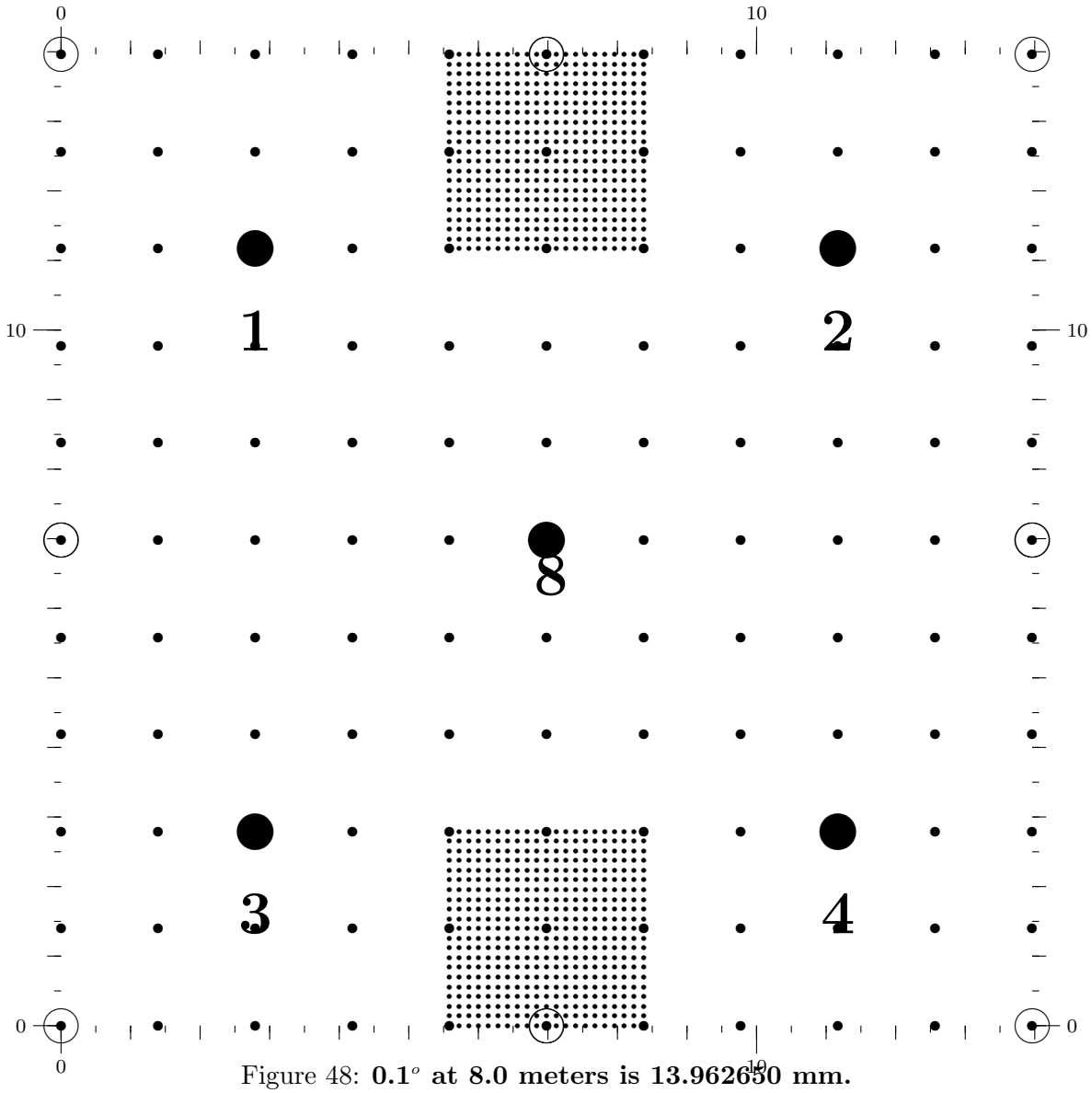

Figure 48: **0.1° at 8.0 meters is 13.962650 mm.**

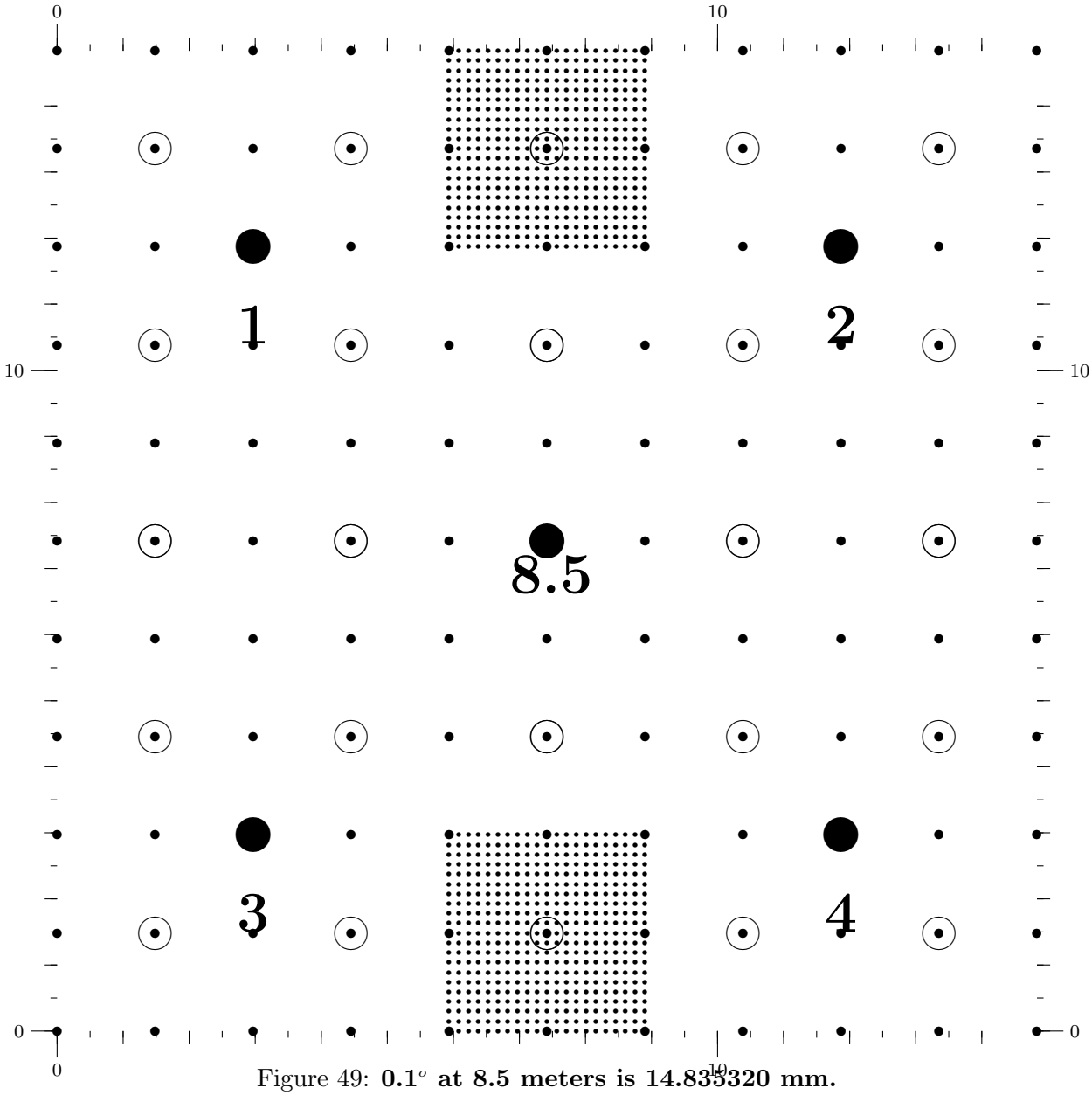

Figure 49: **0.1^o at 8.5 meters is 14.835320 mm.**

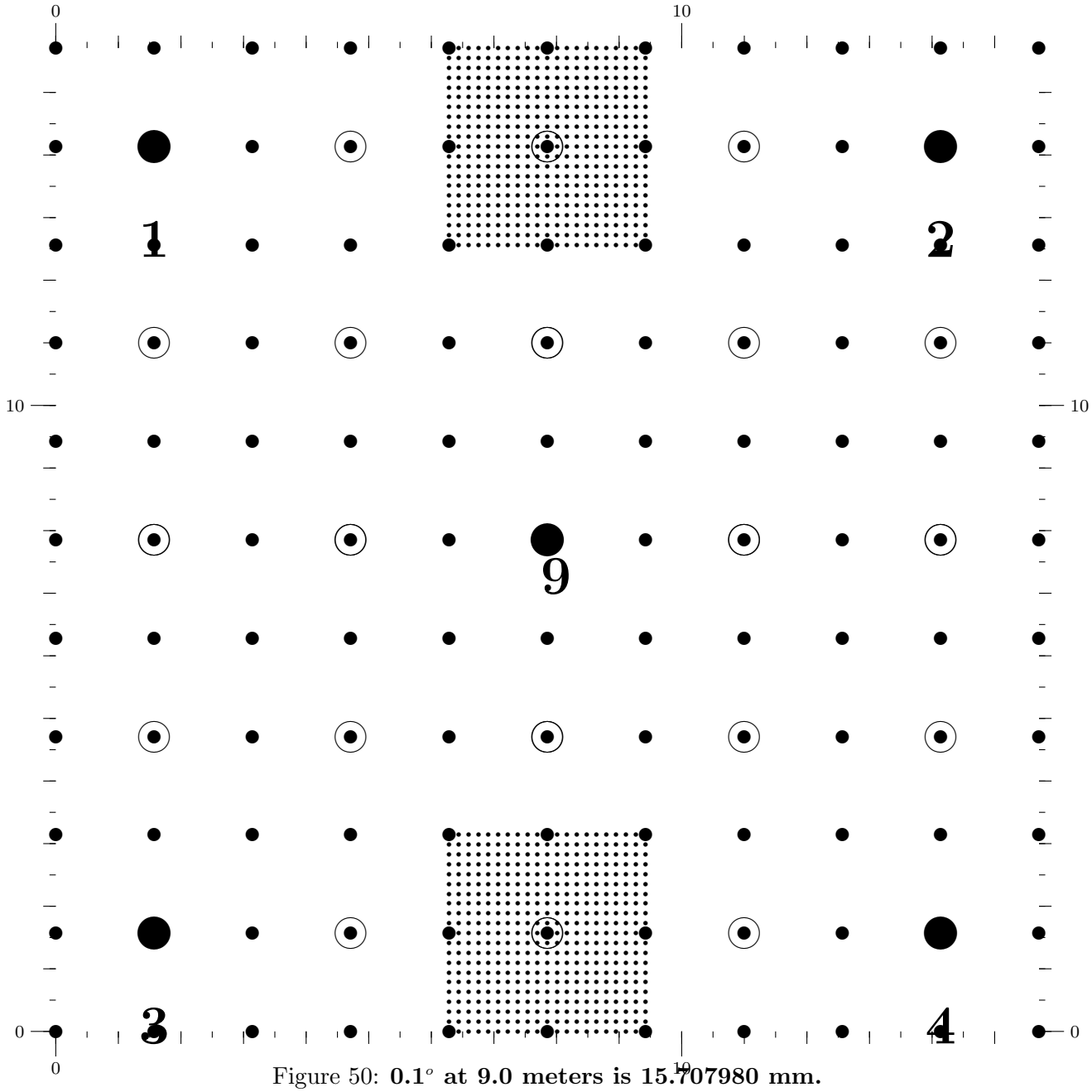

Figure 50: **0.1^o at 9.0 meters is 15.707980 mm.**

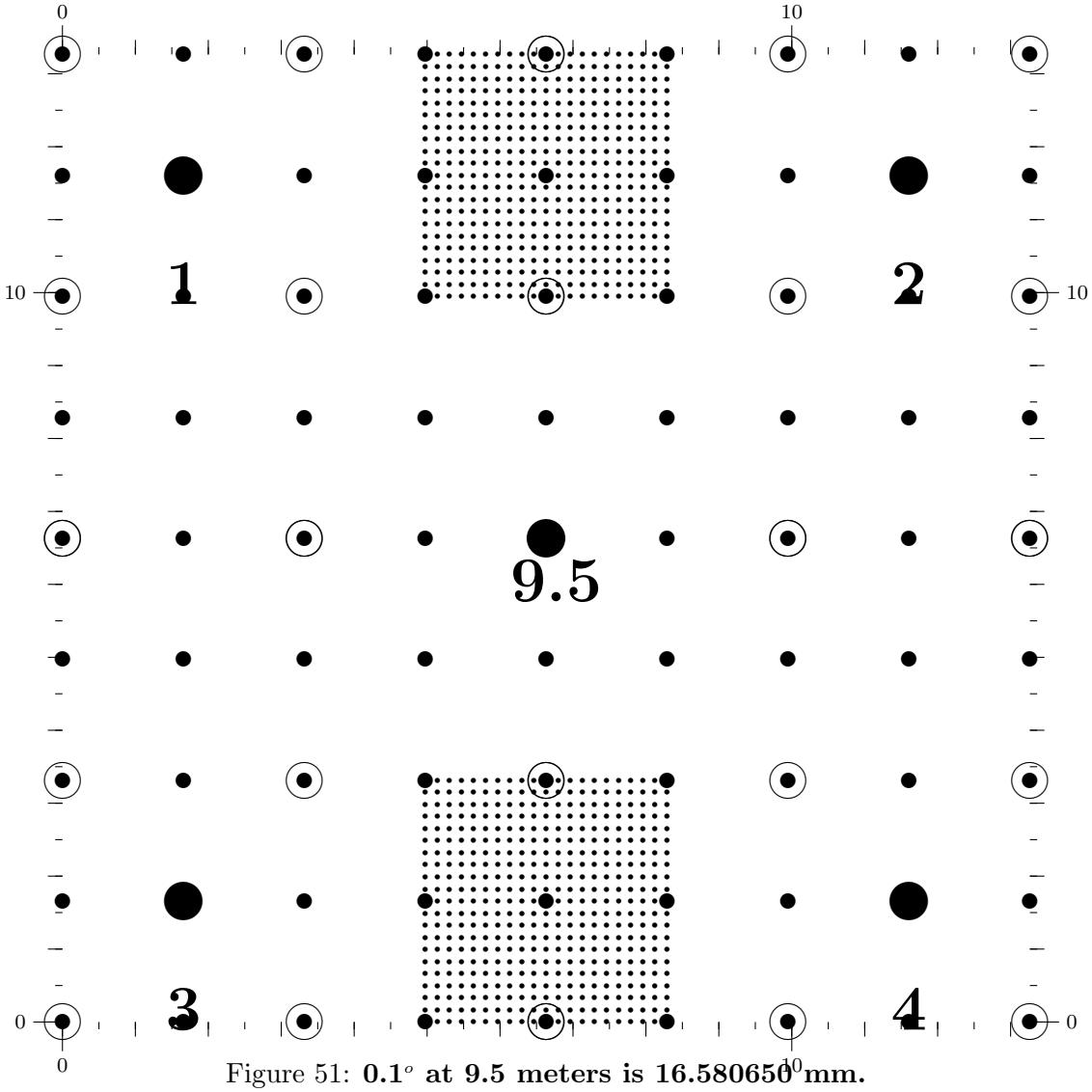

Figure 51: **0.1^o at 9.5 meters is 16.580650mm.**

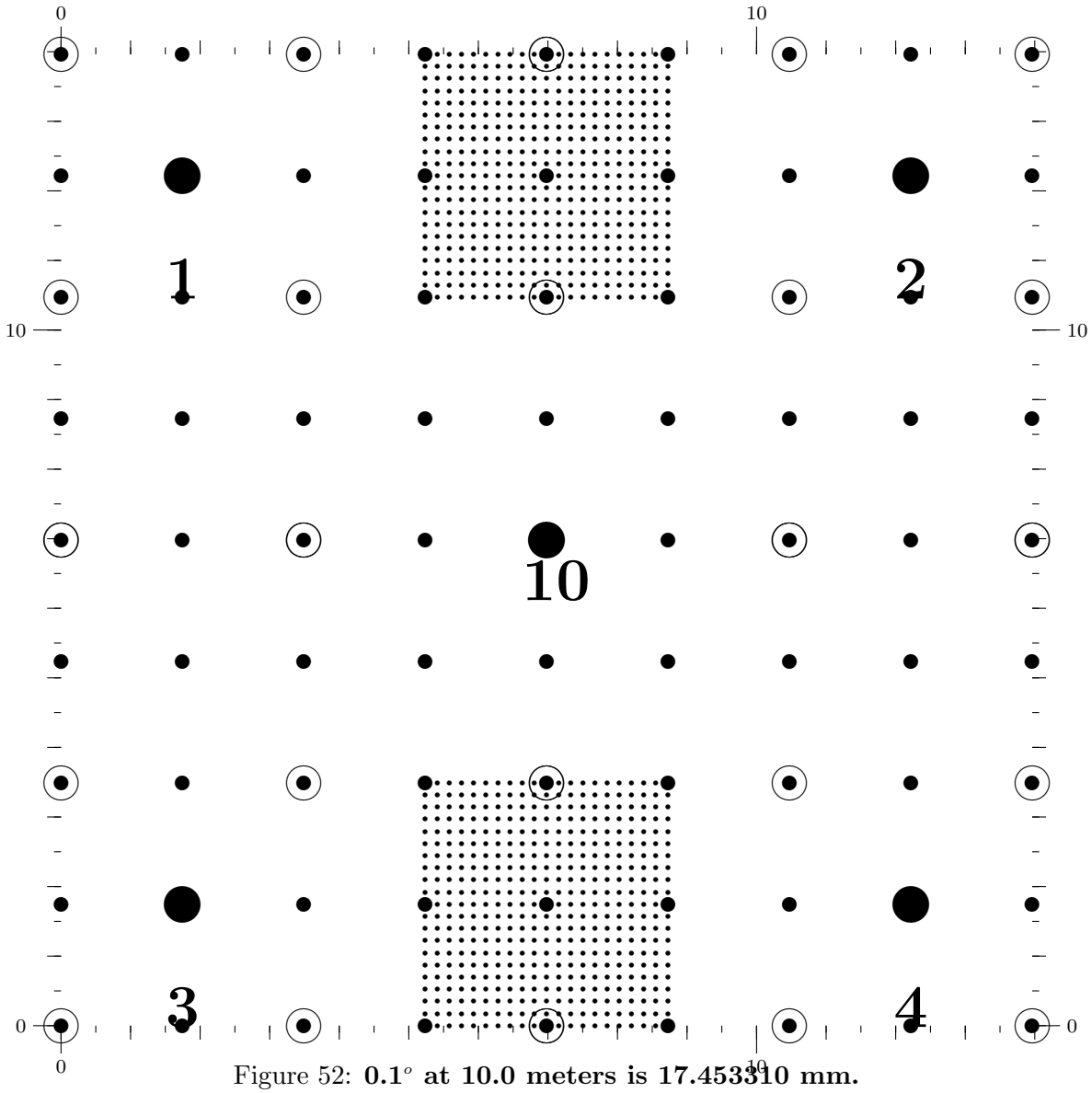

Figure 52: **0.1^o at 10.0 meters is 17.453310 mm.**

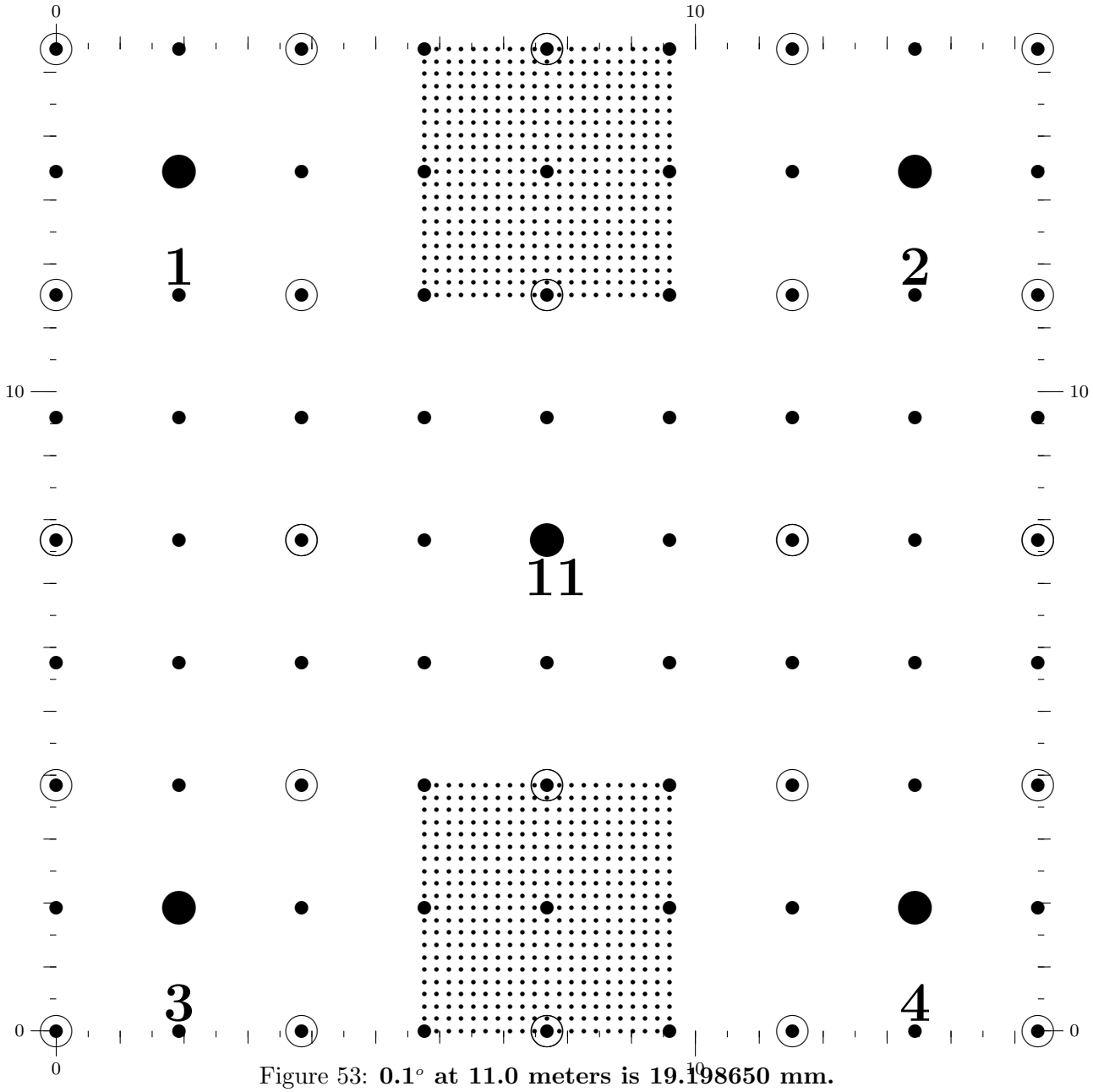

Figure 53: **0.1^o at 11.0 meters is 19.198650 mm.**

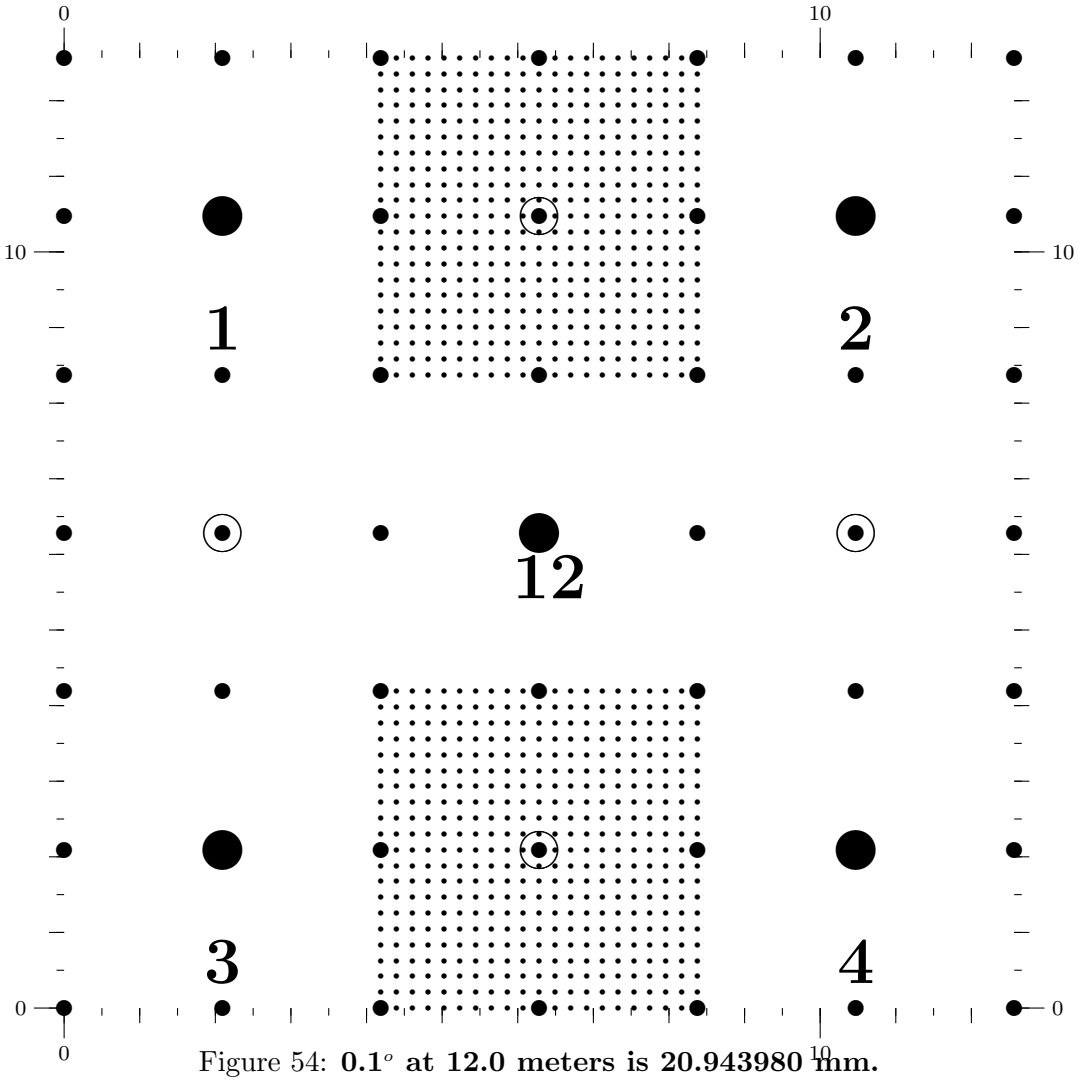

Figure 54: **0.1^o at 12.0 meters is 20.943980 mm.**

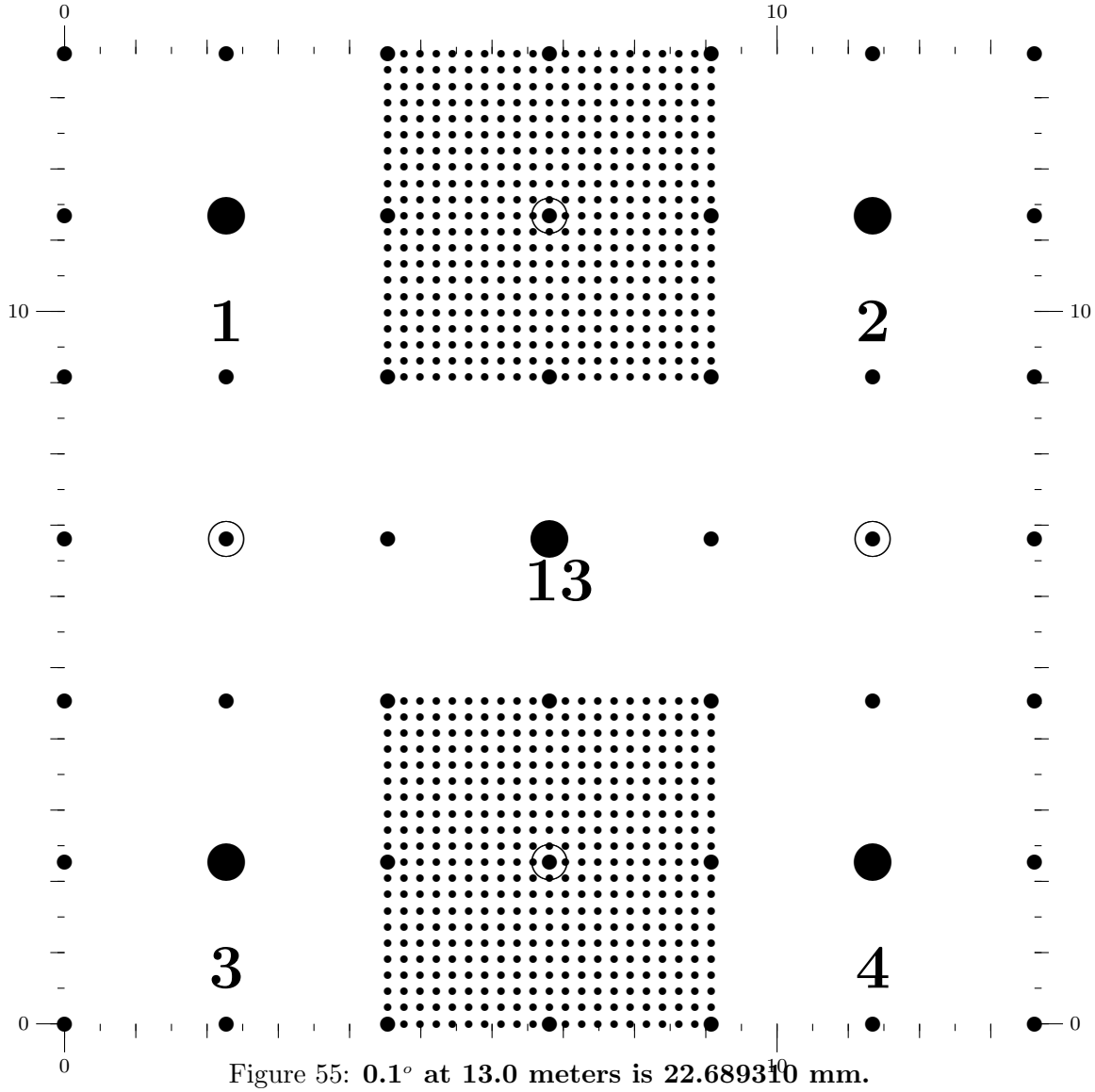

Figure 55: **0.1^o at 13.0 meters is 22.689310 mm.**

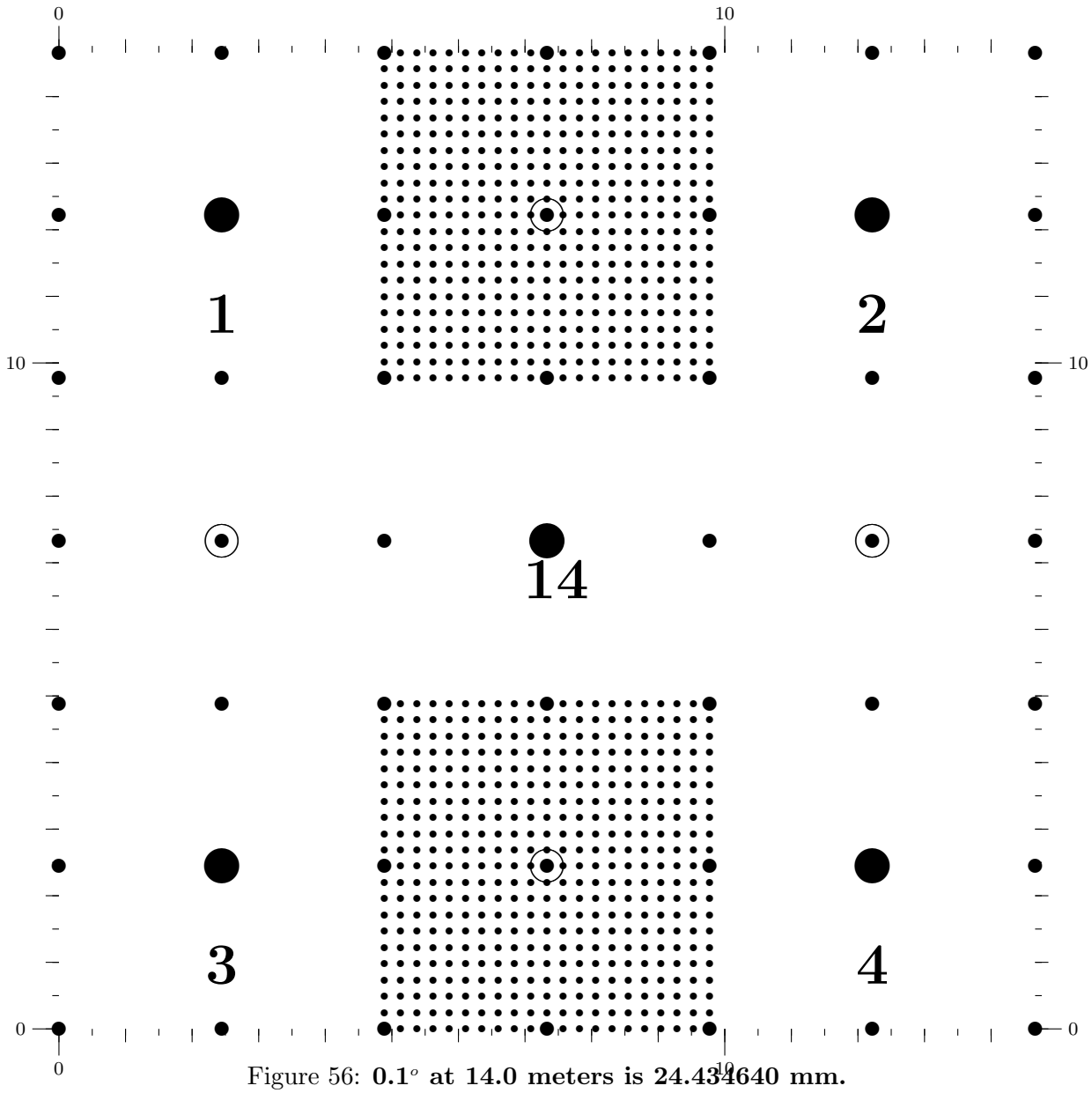

Figure 56: **0.1^o at 14.0 meters is 24.434640 mm.**

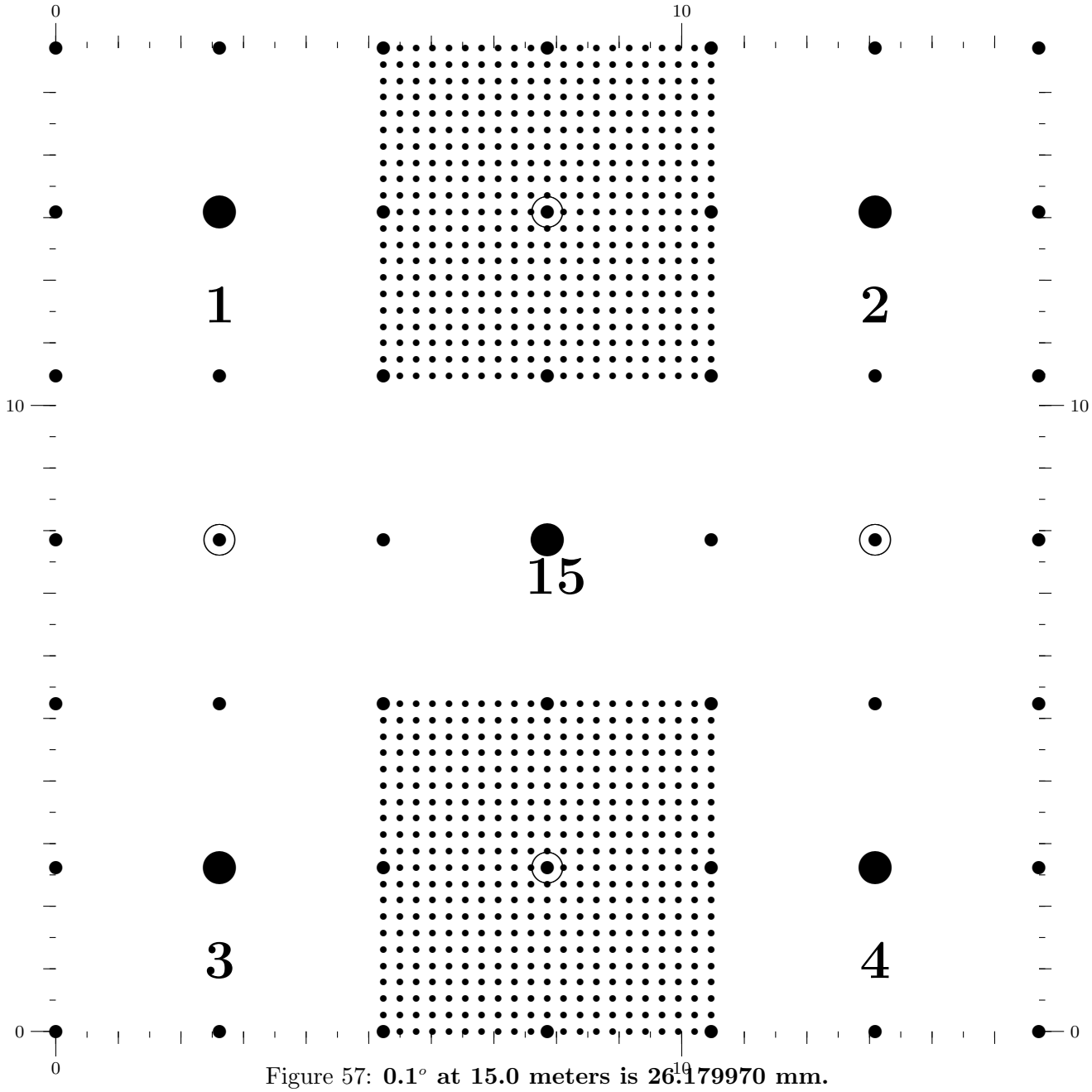

Figure 57: **0.1° at 15.0 meters is 26.179970 mm.**

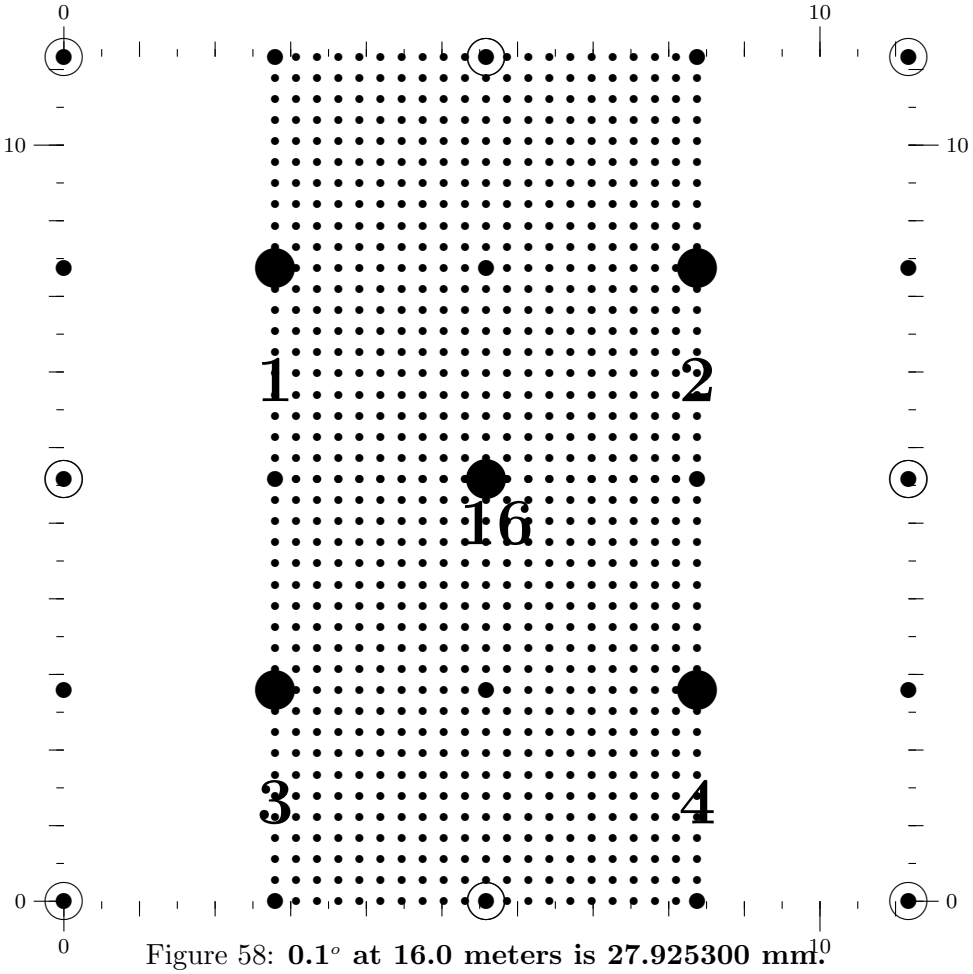

Figure 58: **0.1° at 16.0 meters is 27.925300 mm.**

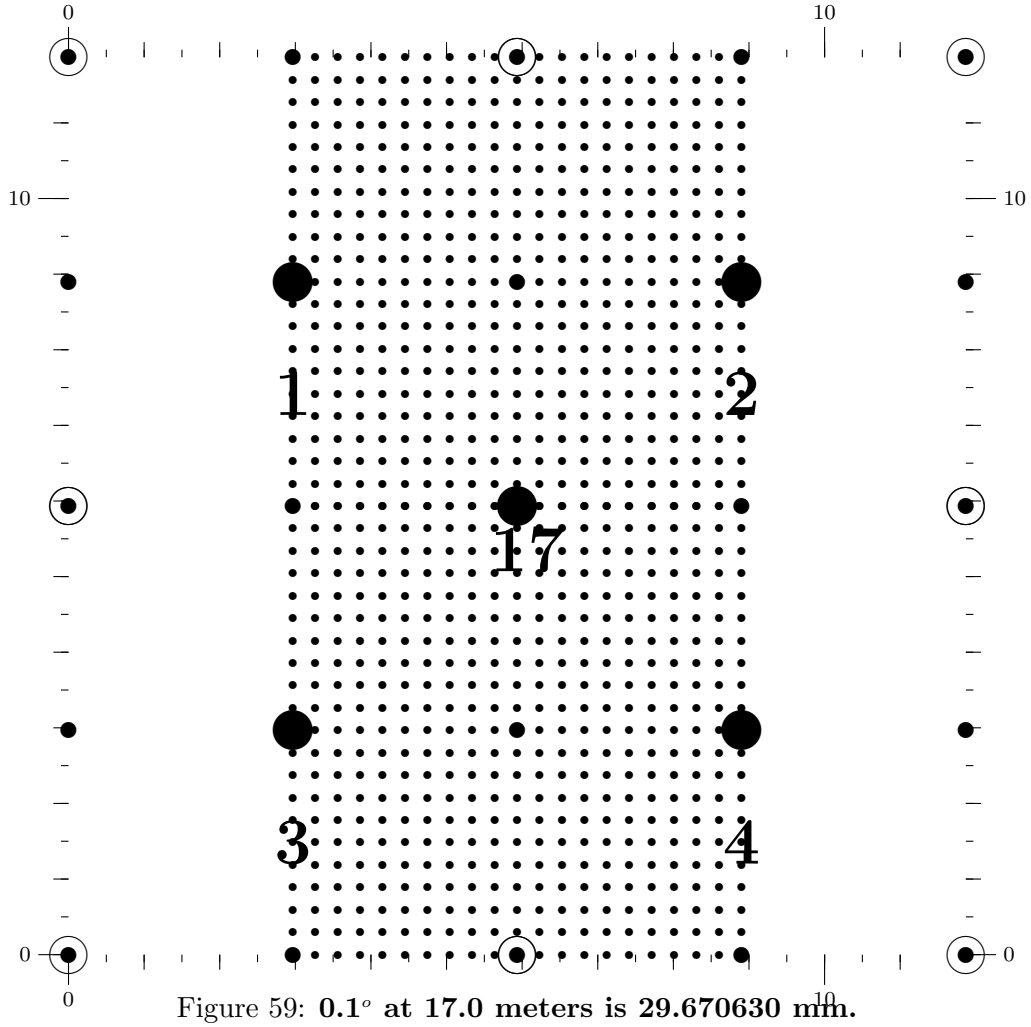

Figure 59: **0.1^o at 17.0 meters is 29.670630 mm.**

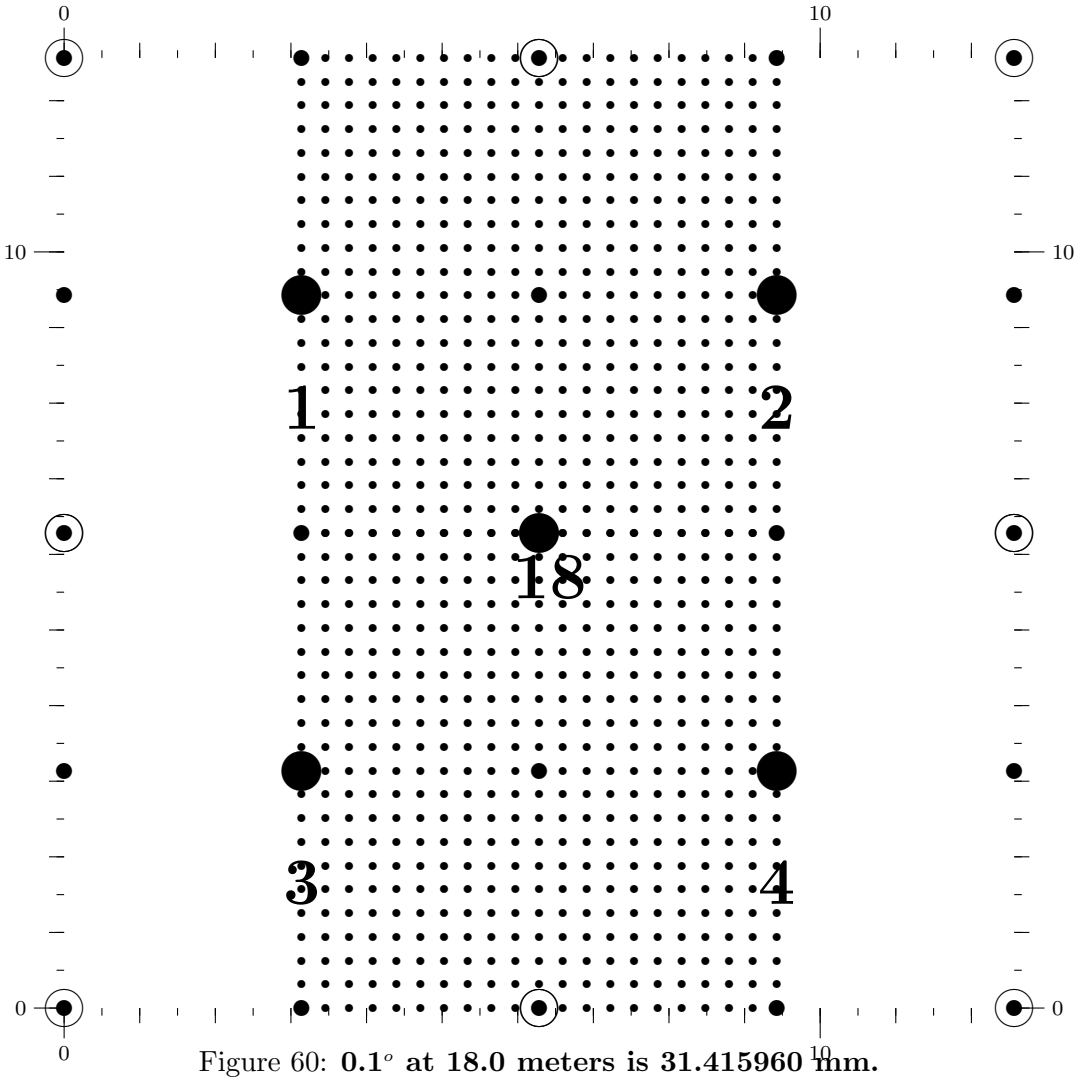

Figure 60: **0.1^{o} at 18.0 meters is 31.415960 mm.**

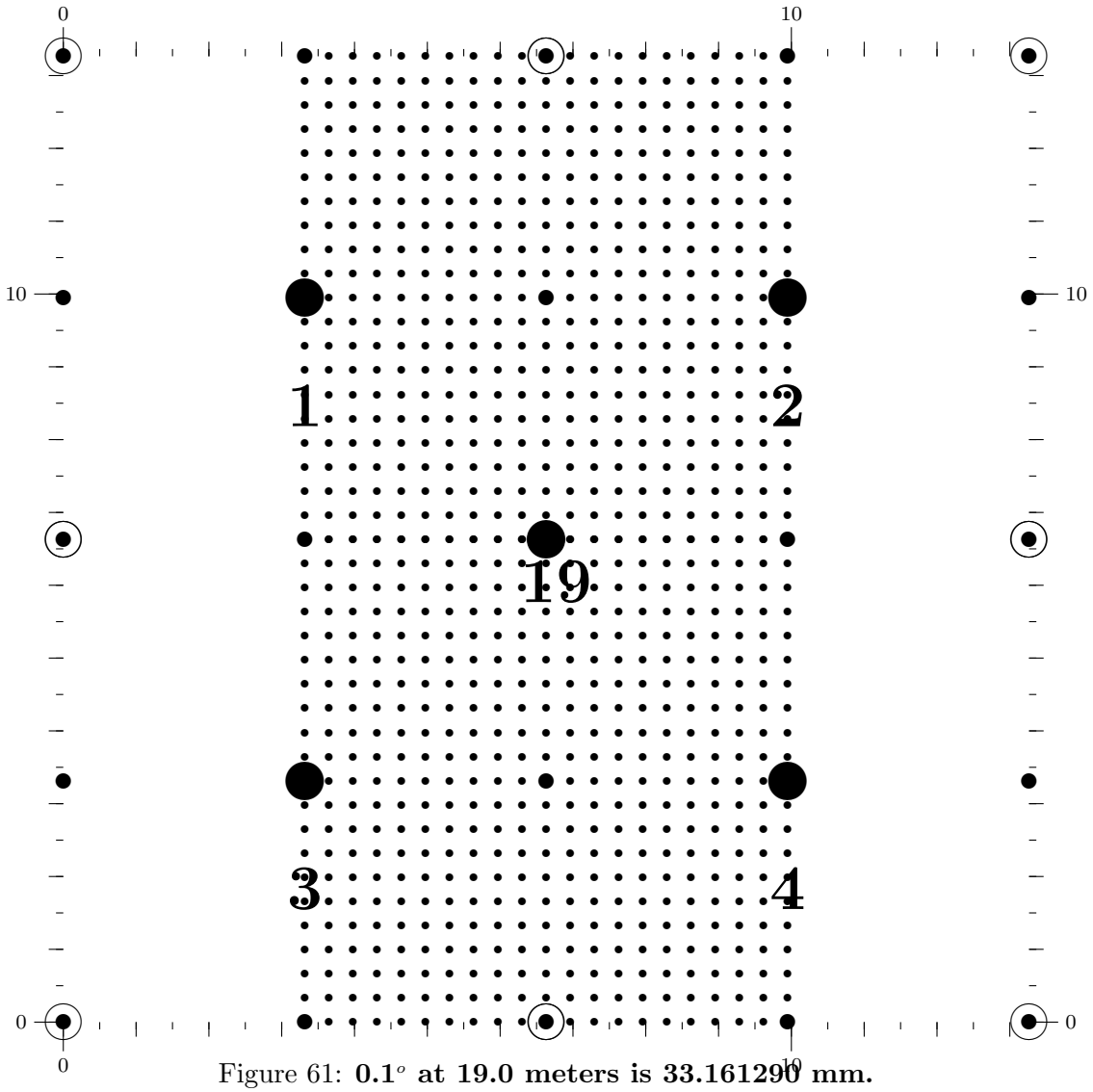

Figure 61: **0.1^o at 19.0 meters is 33.161290 mm.**

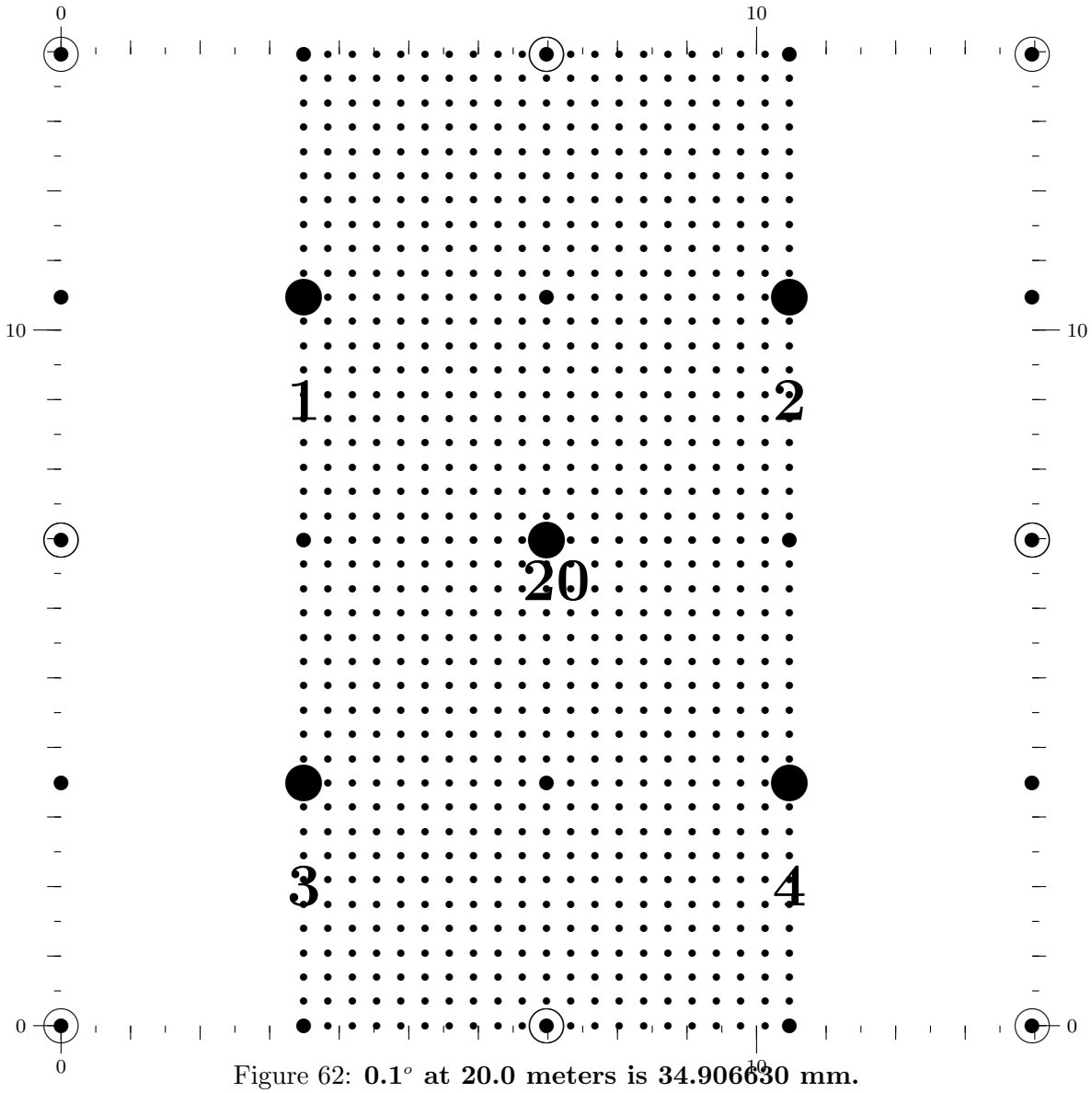

Figure 62: **0.1^o at 20.0 meters is 34.906630 mm.**

1.4 `TgtGen.bas` Routines

A short program written in GW-BASIC was developed to generate the LaTeXplot files used in making the actual targets. Here they are. *These have been temproarly delted.*