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Äspö Hard Rock Laboratory

Instrument plan for the backfill and plug test

Location of instruments for measuring THM processes in the backfill and rock

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July 1998

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Abstract

This report describes the instrumentation for measuring mainly the hydraulic processes in the Backfill and Plug Test. Water pressure in the rock will be measured in 79 points, pore water pressure in the backfill will be measured in 34 points, and water pressure in the drainage layers of filter mats will be measured in all 12 layers. The water saturation process in the backfill will be checked in 59 measuring points. 27 of those are psychrometers and include temperature sensors. Four pressure cylinders will be installed in order to measure the mechanical properties of the backfill.

The positions of the measuring points in the backfill are related to the backfill section, the number of the compacted layer, the tunnel axis, and the rock surface. The positions of the measuring points in the rock are related to the bore hole number and the measuring section in the bore hole.

Sammanfattning

Denna rapport beskriver instrumenteringen för att mäta i huvudsak de hydrauliska processerna i Backfill and Plug Test och positionerna hos instrumenten. Vattentryck i berget mäts i 79 punkter, porvattentryck i återfyllningen mäts i 34 punkter och vattentryck i permeabla skikt av filtermattor mäts i 12 sektioner. Vatteninnehållet i återfyllningen mäts eller indikeras i 59 punkter. Temperaturgivare ingår i instrumenten för mätning av vatteninnehållet med psykrometer. Tryckcylindar installeras på 4 platser för att mäta de mekaniska egenskaperna hos återfyllningen.

Positionen hos mätpunkterna anges för återfyllningen i relation till återfyllningssektion, packningslager, tunnelcentrum och bergyta. För mätpunkterna i berget anges borrhål och mätsektion i borrhålet.

Contents

1 Introduction

The Äspö Hard Rock Laboratory is an important part of SKB's work on design of the deep repository and is constructed with the aim of providing possibilities for research, development and demonstration in a realistic and undisturbed under ground environment at the depth which is considered for the deep repository. The Backfill and Plug Test is one project that will be performed in Äspö HRL with the purposes to

- develop and test different materials and compaction techniques for backfilling of tunnels excavated by blasting
- test the function of the backfill and its interaction with the surrounding rock in full scale in a tunnel excavated by blasting
- develop technique for building tunnel plugs and test the function

An important part of the work is to measure the thermal, hydraulic, and mechanical processes in the backfill and near field rock during the test. Such measurements will be made in 222 points; 79 in the rock, 131 in the backfill, and 12 in permeable mats.

This report describes the exact positions of the measuring points and the permeable mats. The numbering of the measuring points are also given. However, the transducers and measuring systems are not described (see e.g. /1-1/).

2 Backfill and Plug Test

The Backfill and Plug Test is described in the test plan /2-1/. The test is located to the old ZEDEX drift. The test will be made in the old part of the drift that was excavated by normal blasting. The prolongation, that has been excavated with very careful blasting, will not be used for the test. Fig 2-1 shows an overview of the test. The test region can be divided into the following three test parts:

1. The *inner part* filled with backfill containing 30 % bentonite.

2. The *outer part* filled with backfill without bentonite.

3. The *plug*.

The inner test part will be filled with a mixture of 30 % bentonite and crushed granite rock. The outer test part of the tunnel will be filled with crushed rock without addition of bentonite, except for the upper 10-20 cm, where a slot will be left and filled with blocks of highly compacted bentonite/crushed rock mixture and bentonite pellets. The backfill will be compacted with inclined compaction, a technique developed in preparatory field tests. Both the inner and outer part will be divided into five sections parted by drainage layers of permeable mats. Outside the backfill an approximately 3 meter thick plug will be placed with the required function of both being a mechanical support and a hydraulic seal.

The backfill and rock will be instrumented with piezometers, total pressure cells, thermocouples, moisture gauges, and gauges for measuring the local hydraulic conductivity. The axial conductivity of the backfill and the near field rock will after water saturation be tested by applying a water pressure gradient along the tunnel between the mats and measuring the water flow. The flow close to the floor and roof respectively as well as in the central part of the backfill will be measured separately. The hydraulic function of the plug will be tested in a similar way. The mechanical interaction between a simulated swelling buffer material and the backfill and between the roof and the backfill will be tested with pressure cylinders fixed to the floor and the roof of the tunnel.

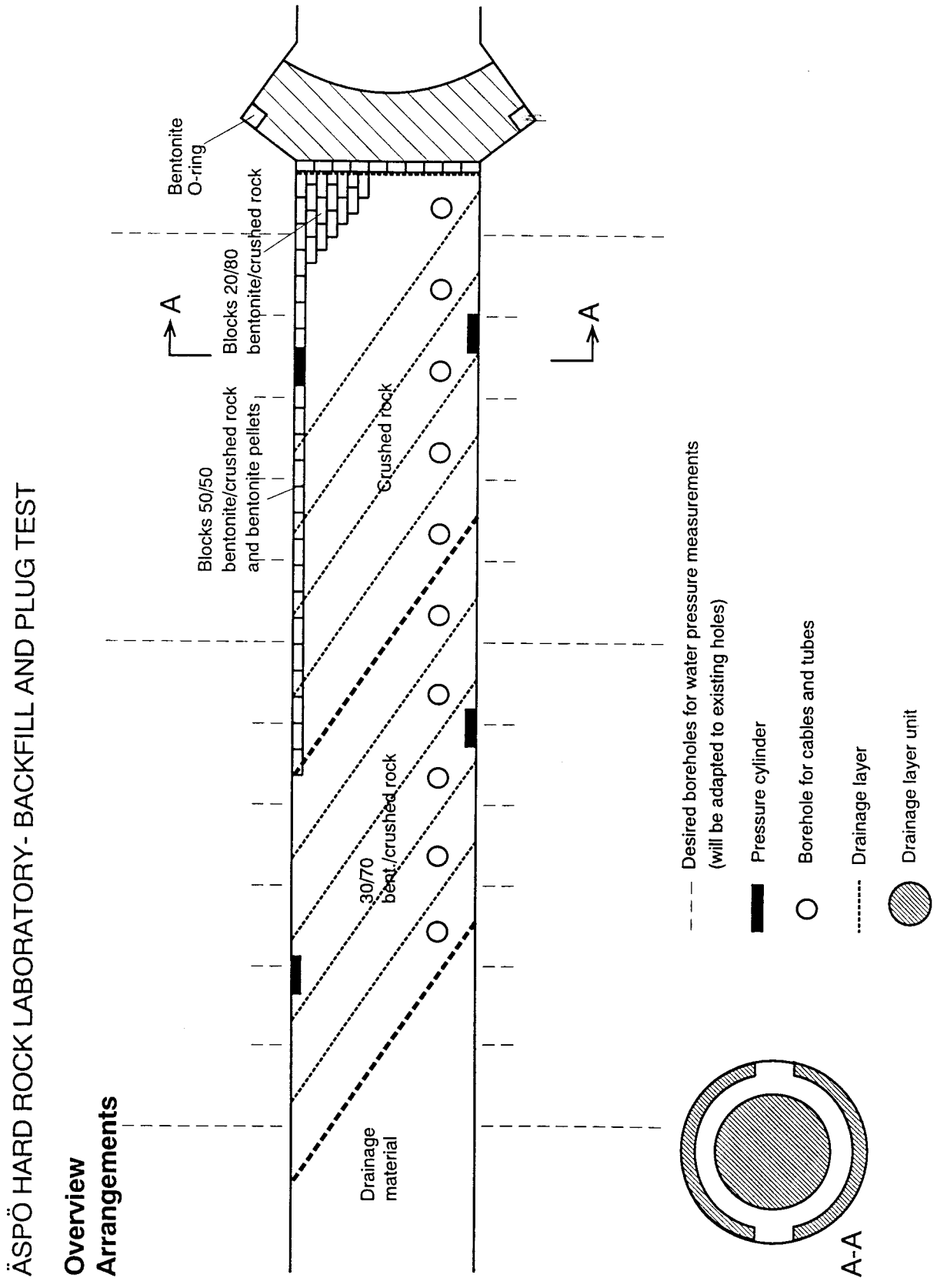

Figure 2-1 An overview of the Backfill and Plug Test

3 Location of permeable mats and backfill sections

The backfilled part is divided into backfill sections separated by drainage layers of permeable mats. The backfill sections are named 0, A1-A5 and B1-B6 and the mats are named D1-D12 according to Fig 3-1.

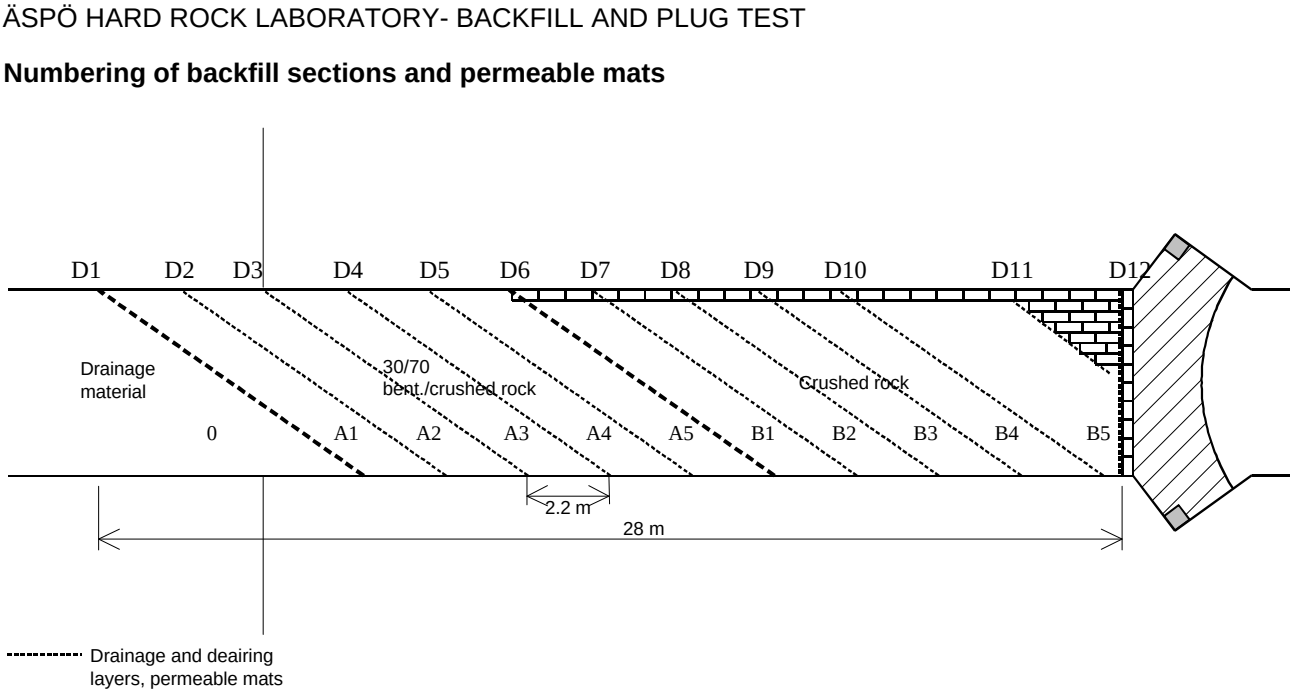

Figure 3-1 Numbering of backfill sections and drainage layers (permeable mats).

The permeable mats will be placed according to Fig 3-2. If the tunnel is supposed to be cylindrical the sections will be elliptical with the large axis 8.7 m and the small axis 5.0 m. The tunnel axis is made the centre of a coordinate system with *x* and *y* coordinates. The drainage layer is divided into 3 parts with one upper, one central and one lower filter.

- The upper filter starts at y=3.3 m and fills the tunnel above that level. At the contact with the rock 0.2 m of filter mat will be folded and attached to the rock surface in order to have a good hydraulic interaction with the rock.

- The central filter will be placed at $-2.5<y<3.0$ and $-2.2<x<2.2$ as shown in Fig 3-2. The central filter must have at least 0.3 m distance to the walls otherwise it will be cut to fulfil that demand.

- The lower filter will be placed between y=-2.8 and the floor with 0.2 m folded and attached to the floor. Since the floor is horizontal the ellipse is cut and at about y = -3.85.

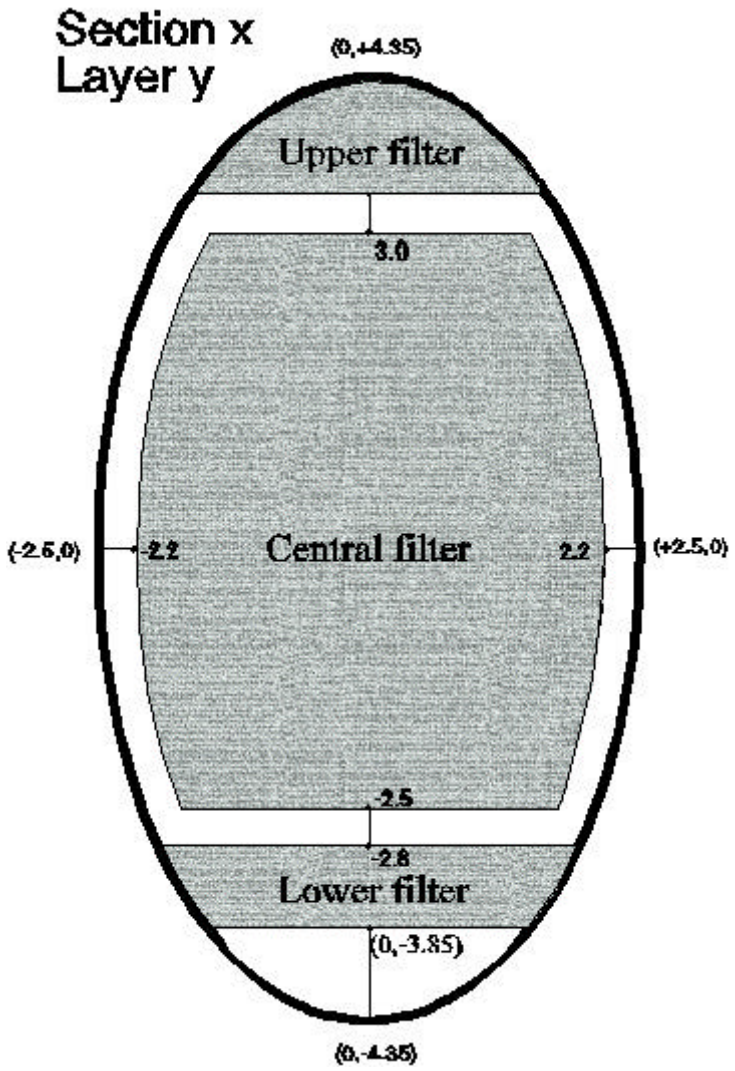

Figure 3-2 Location of the filters in a drainage layer.

Drainage layer D11 does not reach the floor. The central filter will be cut 0.3 m from filter D12. Drainage layer D12 will be made as the circular projection of the other drainage layers.

4 Location of instruments in the backfill

4.1 Brief description of the instruments

The different instruments that will be used in the experiment are briefly described in this section. A more detailed description is given in other reports (see e.g. /1-1/).

Measurement of total pressure in the backfill

Total pressure is the sum of the swelling pressure (or effective stress) and the pore water pressure. It will be measured with the following two instrument types:

- Glötzl total pressure cells of the hydraulic type. Two models will be used: E 10/20 KF 50 VA24 model A (Glötzl A) and model F (Glötzl B). The measuring range is 0-5 MPa. Type A is used for measurement in the soil while type B will be fixed to the rock surface with concrete.9 cells of type A and 4 cells of type B will be installed.

- Roctest total pressure cell with vibrating wire transducer model TPC-0 (0-4 MPa). 8 cells of this type will be installed in the backfill.

Measurement of pore water pressure in the backfill

The pore water pressure in the backfill will be measured with the following two instrument types:

- Glötzl pore pressure cells of the hydraulic type. 18 pore pressure cells of model P4 S 50L VA and the measuring range 0-5 MPa will be used.

- Filter tips connected to Druck pore water pressure cells model PTX 1400 with tecalan tubes. The pore water pressure cells will be located outside the test area. 16 devices with the measuring range 0-4 MPa will be used.

Measurement of the water saturation process in the backfill

The water saturation process will be followed by the following three different techniques:

- Wescor psychrometers model PST-55. These devices measure the relative humidity in the pore system, which can be converted into water ratio or total suction (negative water pressure). The measuring range is 95.5-99.6 RH corresponding to the pore water pressure -0.5 to -6 MPa or the water ratio 11-25% of backfill with the composition 30/70 bentonite/ballast mixture. 27 psychrometers will be installed.

- Resistivity probes developed and built by Clay Technology and the University of Lund will be tested in the bentonite free backfill. The measuring principle is to apply an electrical current between two outer electrodes with the relative distance 30 cm and measure the drop in potential between two inner electrodes with the relative distance 10 cm. The devices have been calibrated for different densities and water ratios of the backfill intended to be used. The measuring range is between the water ratios 5 and 12%. 10 devices will be installed.

- Filter tips connected to thin tecalan tubes. These filters, that mainly will be installed in the bentonite free backfill is a simple device for indicating when water saturation has occurred in the measuring point.

Measurement of the compressibility of the backfill

Pressure cylinders with the diameter 42 cm will be installed in the roof and the floor in order to make compression tests after completed flow testing. The pressure in the cylinders will be increased stepwise and the displacement of the piston measured as a function of time. The displacement of the piston is measured with a potentiometer model Duncan 6304. Four pressure cylinders with the pressure range 0-10 MPa and the maximum deformation 180 mm will be emplaced.

Measurement of temperature

Since no heat will be generated in the experiment, temperature will only be measured in two points for the purpose of general information. Thermocouples of type K from Heraeus Electro-Nite AB will be used. Temperature will also be measured by the psychrometers and by the devices for measuring hydraulic conductivity installed by ENRESA.

Other measurements

Local hydraulic conductivity will be measured in section A4 with devices developed and installed by ENRESA in 13 points. These devices are not further dealt with in this report.

4.2 Strategy for describing the position of each device

Each instrument will be named with a short unique name consisting of 1-2 letters describing the type of measurement and 1-3 figures numbering the device. In addition to the name a short description of the position is added.

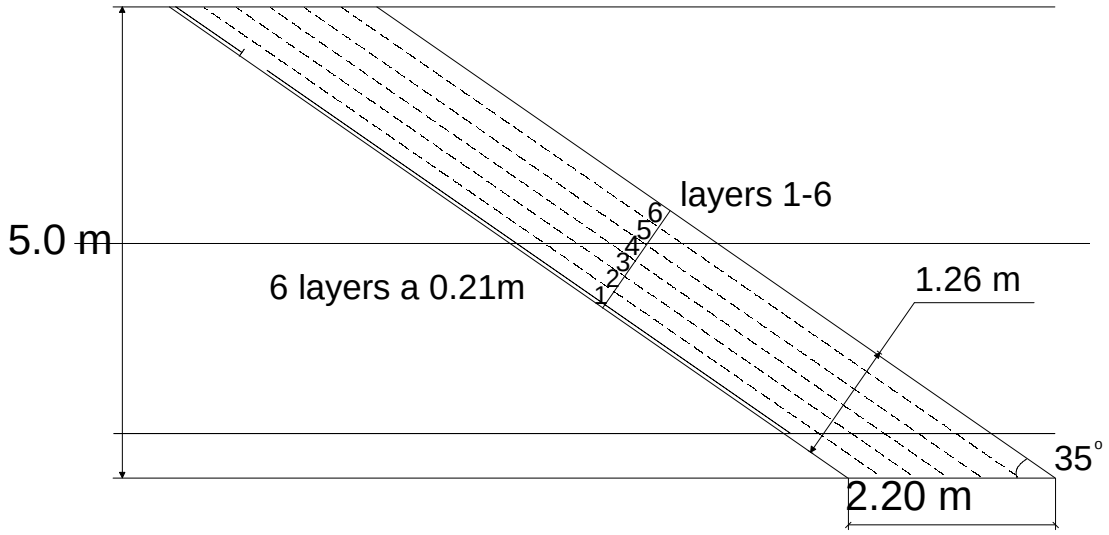

Figure 4-1 Subdivision of a backfill section into backfill layers.

The sections, separated by drainage layers, were shown in Fig 3-1. Sections A1-A5 and B1-B4 are divided into 6 layers with the thickness 0.21 m according to Fig 4-1. Each layer corresponds to one compaction sequence, which means that the backfill will be placed with a thickness before compaction that yields a thickness after compaction of 0.21 m. The layers are numbered 1-6.

The instruments will be placed in the layers after compaction and related to those layers. Each measuring points are also defined by the coordinates in the layer in a coordinate system equal to the one shown in Fig 3-2. The *x*-coordinate is the horizontal distance from the centre of the tunnel and the *y*-coordinate is the distance perpendicular to the *x*-axis. Some of the instruments are more important to place at a specified distance from the rock surface. For those cases the coordinate will begin with the letter R and then be given the coordinate with the intersection with the rock surface as centre. An instrument in the backfill will thus be named in the following way:

1. Type of measurement (1 letter)

2. Serial number (1-2 figures)

3. Section (1 letter, 1 figure)

4. Layer (1 figure)

5. *x*-coordinate

6. *y*-coordinate

Items 1 and 2 identifies the device and items 3-6 describes the location. A pore water pressure transducer (number 8) located in section A2, layer 3, 0.5 m left of the centre line and 0.3 m below the roof in the y-direction will be named:

W8 (A2/3/-0.5/R-0.3)

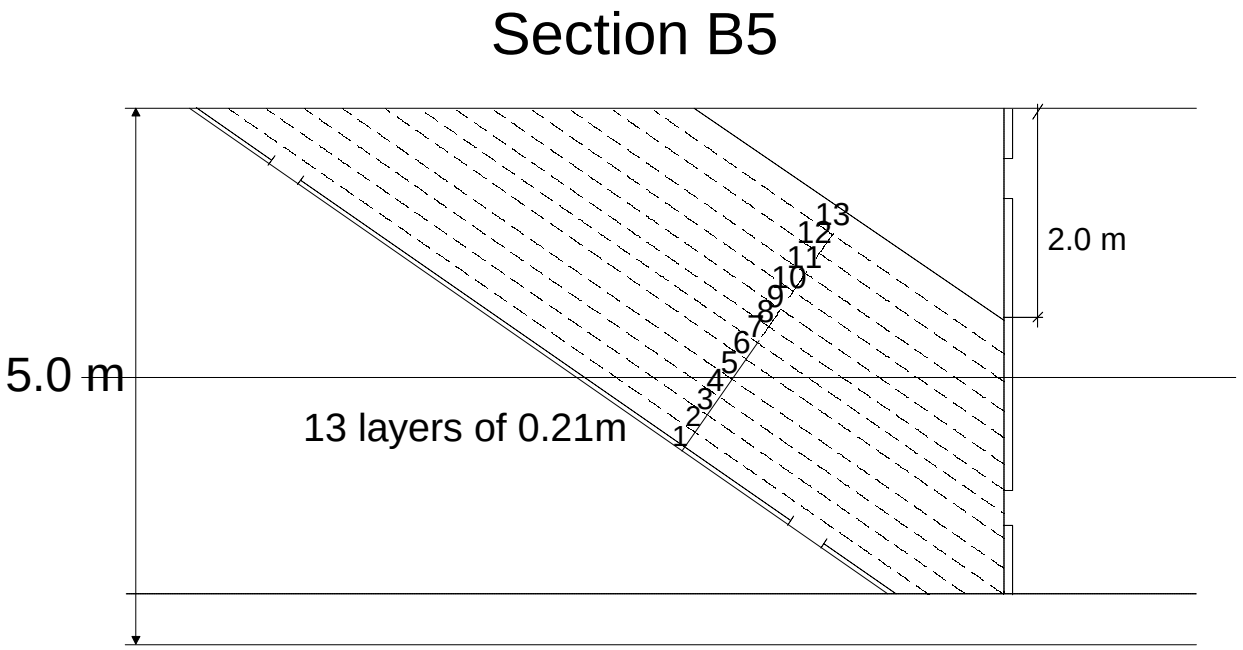

Figure 4-2 Subdivision of backfill section B5.

Section B5 contains more than 5 layers. The numbering is shown in Fig 4-2. Section B6 consists of layers of highly compacted blocks of backfill with the thickness 5 cm and the layer number refers to the block layer number (Fig 4-3).

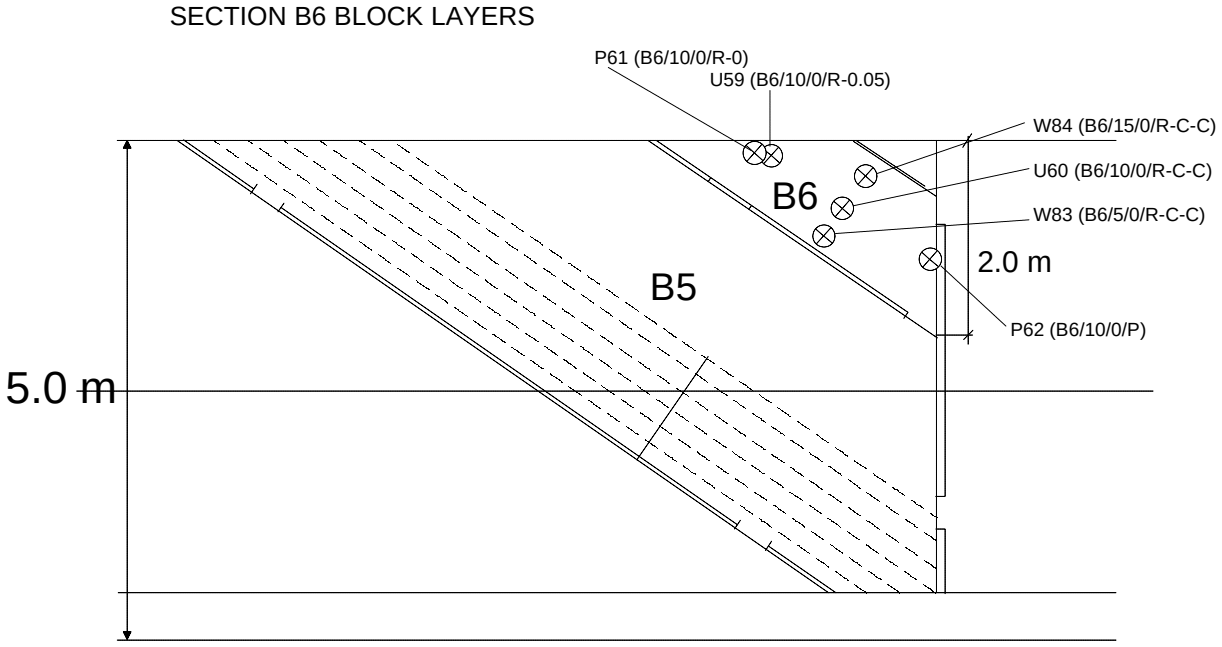

Figure 4-3 Subdivision of backfill section B6.

4.3 Position of each instrument in the backfill

All instruments are placed in layers 1-4 in order to leave the two upper layers unaffected by transducers and cables. Another reason is that the entrance plate where the tubes are attached to the through connections are placed in layers 1-4, which means that the two final layers can be compacted without considering the problems of compacting around the through connections.

The positions of the instruments (except for ENRESA:s hydraulic conductivity devices) are described in Tables 4-1 to 4-4.

Each layer that is instrumented in the backfill are shown in Appendix 1 with the position and numbering of the instrument. The entire section B6 is included in one figure.

Table 4-1 Numbering and position of instruments for measuring total pressure (P)

Type and number	Section	Layer	X	Y	Fabricate	Remarks
P1	A2	2	0	R+0.2	Glötzl A	Horizontal
P2	A1	5	0	R-1.1	Glötzl A	Horizontal
P3	A2	3	0	0,6	Rocktest	Parallel
P4	A2	3	0	R+0.65	Rocktest	Horizontal
P5	A2	1	0	R-0.2	Rocktest	Horizontal
P6	A2	4	0	R+1.1	Glötzl A	Horizontal
P7	A4	3	0	R-0	Glötzl B	At rock
P8	A4	3	0	R+0	Glötzl B	At rock
P9	A5	3	0	R-0.2	GlötzlA	At rock
P51	B1	3	0	R-0.3	Rocktest	Under blocks
P52	B2	3	0	R-0	Glötzl A	Under blocks
P53	B2	3	0	R+0	Glötzl B	At rock
P54	B3	2	0	R+0.2	Rocktest	Horizontal
P55	B3	3	0	0,3	Glötzl A	Parallel
P56	B3	3	0	R+0.65	Glötzl A	Horizontal
P57	B3	4	0	R+1.1	Rocktest	Horizontal
P58	B4	3	0	R-0	Glötzl A	Under blocks
P59	B5	2	0	R-1.1	Rocktest	Horizontal
P60	B5	4	0	R-0.2	Glötzl A	Horizontal
P61	B6	10	0	R-0	Rocktest	Between blocks
P62	B6	10	0	P	Glötzl B	At wall

Table 4-2 Numbering and position of instruments for measuring pore water pressure (U)

Type and number	Section	Layer	X	Y	Fabricate	Remarks
U1	A1	3	0	0,3	Glötzl	
U2	A1	3	0	3,1	Glötzl	
U3	A1	3	0	-2,6	Glötzl	
U4	A1	3	2	0	CT Tube + Druck	Twin tubes
U5	A1	3	-2	0	CT Tube + Druck	Twin tubes
U6	A2	1	0	0,3	Glötzl	
U7	A2	1-2	0	R+0.05	Glötzl	
U8	A2	2	-0,2	R+0.2	Glötzl	
U9	A1	5	-0,2	R-1.1	Glötzl	
U10	A2	3	0	0,3	Glötzl	
U11	A2	3	-0,2	R+0.65	Glötzl	
U12	A2	3	1,3	0	CT Tube + Druck	
U13	A2	3	-1,3	0	CT Tube + Druck	
U14	A2	4	0	0,3	Glötzl	
U15	A2	1	-0,2	R-0.2	Glötzl	
U16	A4	3	0	0,3	Glötzl	
U17	A4	3	0	R-0	Glötzl	
U18	A4	3	0	R+0	Glötzl	
U19	A4	3	R-0	0	Glötzl	
U20	A4	3	R+0	0	Glötzl	
U21	A5	3	0	0,3	Glötzl	
U22	A5	3	1,3	0	CT Tube + Druck	Twin tubes
U23	A5	3	-1,3	0	CT Tube + Druck	Twin Tubes
U24	A5	3	-0,2	R-0.2	Glötzl	
U51	B1	3	-0,2	R-0.3	CT Tube + Druck	Under the Blocks
U52	B1	3	-0,2	-2	CT Tube + Druck	Twin Tubes
U53	B3	1-2	0	R+0.05	CT Tube + Druck	
U54	B3	2	-0,2	R+0.2	CT Tube + Druck	
U55	B3	3	-0,2	R+0.65	CT Tube + Druck	
U56	B4	3	0	R-0	CT Tube + Druck	
U57	B5	2	-0,2	R-1.1	CT Tube + Druck	
U58	B5	4	-0,2	R-0.2	CT Tube + Druck	
U59	B6	10	0	R-0.05	CT Tube + Druck	
U60	B6	10	0	R-C-C	CT Tube + Druck	Twin Tubes

Table 4-3 Numbering and position of instruments for measuring water content (W)

Type and number	Section	Layer	X (m)	Y (m)	Fabricate	Remarks
W1	A1	1	0	0	Wescor Psychrometer	
W2	A1	3	0	0	Wescor Psychrometer	
W3	A1	5	0	0	Wescor Psychrometer	
W4	A2	1	0	0	Wescor Psychrometer	
W5	A2	3	0	0	Wescor Psychrometer	
W6	A2	4	0	0	Wescor Psychrometer	
W7	A3	1	0	0	Wescor Psychrometer	
W8	A3	3	0	0	Wescor Psychrometer	
W9	A3	3	0	2,5	CT Tube	
W10	A3	3	0	R-0.5	Wescor Psychrometer	
W11	A3	3	0	-2	CT Tube	
W12	A3	3	0	R+0.5	Wescor Psychrometer	
W13	A3	3	1,2	0	CT Tube	
W14	A3	3	R-0.3	0	Wescor Psychrometer	
W15	A3	3	-1,2	0	CT Tube	
W16	A3	3	R+0.3	0	Wescor Psychrometer	
W17	A3	4	0	0	Wescor Psychrometer	
W18	A4	1	0	0	Wescor Psychrometer	
W19	A4	3	0	0	Wescor Psychrometer	
W20	A4	4	0	0	Wescor Psychrometer	
W21	A5	1	0	0	Wescor Psychrometer	
W22	A5	3	0	0	Wescor Psychrometer	
W23	A5	3	0	2.5	Wescor Psychrometer	
W24	A5	3	0	-2	Wescor Psychrometer	
W25	A5	4	0	0	Wescor Psychrometer	
W51	B1	1	0	0	Wescor Psychrometer	
W52	B1	3	0	0	CT Res. Probe	
W53	B1	3	0	R-0.4	Ct Tube	
W54	B1	3	0	-2	Ct Tube	
W55	B1	3	-1,3	0	Ct Tube	
W56	B1	3	1,3	0	Ct Tube	
W57	B1	4	0	0	CT Res. Probe	
W58	B2	1	0	0	CT Res. Probe	
W59	B2	3	0	0	CT Res. Probe	
W60	B2	3	0	2,5	Ct Tube	
W61	B2	3	0	R-0.3	Ct Tube	Under the Blocks
W62	B2	3	0	-2	Ct Tube	
W63	B2	3	0	R+0.3	Ct Tube	
W64	B2	3	-1,3	0	Ct Tube	
W65	B2	3	1,3	0	Ct Tube	
W66	B2	4	0	0	Ct Tube	
W67	B3	1	0	0	Wescor Psychrometer	
W68	B3	3	0	0	CT Res. Probe	
W69	B3	3	0	R-0.3	CT Tube	Under the Blocks
W70	B3	3	1,3	0	CT Tube	
W71	B3	3	-1,3	0	CT Tube	
W72	B3	4	0	0	CT Res. Probe	

W73	B4	1	0	0	CT Res. Probe	
W74	B4	3	0	0	CT Res. Probe	
W75	B4	3	1,3	0	CT Tube	
W76	B4	3	-1,3	0	CT Tube	
W77	B5	2	0	0	Wescor Psychrometer	
W78	B5	5	0	0	CT Res. Probe	
W79	B5	8	0	2	CT Res. Probe	
W80	B5	8	2	2	Ct Tube	
W81	B5	8	-2	2	Ct Tube	
W82	B5	11	0	2	Ct Tube	
W83	B6	5	0	R-C-C	Wescor Psychrometer	
W84	B6	15	0	R-C-C	Wescor Psychrometer	

Table 4-4 Numbering and position of pressure cylinders (C)

Type and number	Section	Layer	X	Y	Fabricate	Remarks
C1	A2	1-2	0	R+0	CT Pressure Cylinder	
C2	A2	2	0	R-0	CT Pressure Cylinder	
C51	B3	1-2	0	R+0	CT Pressure Cylinder	
C52	B5	4-5	0	R-0	CT Pressure Cylinder	

5 Location of instruments in the rock

5.1 Brief description of the instruments and the packers

Only the water pressure will be measured in the rock. The measurements will be made in core drilled bore holes in the rock sealed with bentonite packers with the following instrument:

- Tecalan tubes connected to Druck pore water pressure cells model PTX 1400 with tecalan tubes. The pore water pressure cells will be located outside the test area. Water measurements will be made in 79 bore hole sections (measuring range 0-4 MPa).

Measurements will be made in 1-3 sections in the bore holes. Most of the holes are only 1 m long with 1 packer installed in the outer 0.5 m. Two tubes will lead into each measuring section for deairing purpose. The measuring sections will be sealed with packers with bentonite rings surrounded by rubber sealings. A description of the packers for short holes is shown in /1-1/.

5.2 Position of each measuring section

The measuring sections are identified with two letters and 2-3 figures. The letters are U (for pore water pressure) and R (for rock). The numbers are given in the following way:

Short holes in roof: 1-12

Long holes in the roof: 101-107

Short holes in the right wall (seen from the entrance of the drift): 21-32

Long holes in the right wall: 121-129

Short holes in floor: 41-52

Long holes in the floor: 141-147

Short holes in left wall: 61-72

Long holes in the roof: 161-167

Long hole in the end of the drift: 121

Table 5-1 shows the location of the measuring section for each instrument and the corresponding bore hole number. The backfill section in which the bore hole starts is also given.

Figs 5-1 and 5-2 shows the location of the measuring sections in vertical and horizontal cross sections.

Table 5-1 Numbering and positions of instruments for measuring pore water pressure in the rock

Type and number	Location	Measuring sect. (m)	Bore hole number	Section (TC)	Fabricate	Diameter (mm)	Remarks
UR1	Roof	0.5-1.0	KZ0065I01	A1	Druck	56	
UR2	Roof	0.5-1.0	KZ0063I01	A2	Druck	56	
UR3	Roof	0.5-1.0	KZ0061I01	A3	Druck	56	
UR4	Roof	0.5-1.0	KZ0059I01	A4	Druck	56	
UR5	Roof	0.5-1.0	KZ0057I01	A5	Druck	56	
UR6	Roof	0.5-1.0	KZ0054I01	B1	Druck	56	
UR7	Roof	0.5-1.0	KZ0052I01	B2	Druck	56	
UR8	Roof	0.5-1.0	KZ0050I01	B3	Druck	56	
UR9	Roof	0.5-1.0	KZ0048I01	B4	Druck	56	
UR10	Roof	0.5-1.0	KZ0046I01	B5	Druck	56	
UR11	Roof	0.5-1.0	KZ0043I01	B5	Druck	56	
UR12	Roof	0.5-1.0	KZ0041I01	B5	Druck	56	
UR21	Right wall	0.5-1.0	KZ0066B01	O	Druck	56	
UR22	Right wall	0.5-1.0	KZ0064B01	O	Druck	56	
UR23	Right wall	0.5-1.0	KZ0061B01	A1	Druck	56	
UR24	Right wall	0.5-1.0	KZ0059B01	A2	Druck	56	
UR25	Right wall	0.5-1.0	KZ0057B01	A3	Druck	56	
UR26	Right wall	0.5-1.0	KZ0055B01	A4	Druck	56	
UR27	Right wall	0.5-1.0	KZ0053B01	A5	Druck	56	
UR28	Right wall	0.5-1.0	KZ0050B01	B1	Druck	56	
UR29	Right wall	0.5-1.0	KZ0048B01	B2	Druck	56	
UR30	Right wall	0.5-1.0	KZ0046B01	B3	Druck	56	
UR31	Right wall	0.5-1.0	KZ0044B01	B4	Druck	56	
UR32	Right wall	0.5-1.0	KZ0042B01	B5	Druck	56	
UR41	Floor	0.5-1.0	KZ0065G01	O	Druck	56	
UR42	Floor	0.5-1.0	KZ0063G01	O	Druck	56	
UR43	Floor	0.5-1.0	KZ0061G01	O	Druck	56	
UR44	Floor	0.5-1.0	KZ0059G01	A1	Druck	56	
UR45	Floor	0.5-1.0	KZ0057G01	A2	Druck	56	
UR46	Floor	0.5-1.0	KZ0054G01	A3	Druck	56	
UR47	Floor	0.5-1.0	KZ0052G01	A4	Druck	56	
UR48	Floor	0.5-1.0	KZ0050G01	A5	Druck	56	
UR49	Floor	0.5-1.0	KZ0048G01	B1	Druck	56	
UR50	Floor	0.5-1.0	KZ0046G01	B2	Druck	56	
UR51	Floor	0.5-1.0	KZ0043G01	B3	Druck	56	
UR52	Floor	0.5-1.0	KZ0041G01	B4	Druck	56	

UR61	Left wall	0.5-1.0	KZ0066A01	O	Druck	56	
UR62	Left wall	0.5-1.0	KZ0064A01	O	Druck	56	
UR63	Left wall	0.5-1.0	KZ0061A01	A1	Druck	56	
UR64	Left wall	0.5-1.0	KZ0059A01	A2	Druck	56	
UR65	Left wall	0.5-1.0	KZ0057A01	A3	Druck	56	
UR66	Left wall	0.5-1.0	KZ0055A01	A4	Druck	56	
UR67	Left wall	0.5-1.0	KZ0053A01	A5	Druck	56	
UR68	Left wall	0.5-1.0	KZ0050A01	B1	Druck	56	
UR69	Left wall	0.5-1.0	KZ0048A01	B2	Druck	56	
UR70	Left wall	0.5-1.0	KZ0046A01	B3	Druck	56	
UR71	Left wall	0.5-1.0	KZ0044A01	B4	Druck	56	
UR72	Left wall	0.5-1.0	KZ0042A01	B5	Druck	56	
UR101	Roof	1.5-2.0	KZ0065I02	A1	Druck	56	
UR102	Roof	4.0-5.0	KZ0065I02	A1	Druck	56	
UR103	Roof	1.5-2.0	KZ0055I01	A3	Druck	56	
UR104	Roof	4.0-5.0	KZ0055I01	A3	Druck	56	
UR106	Roof	1.5-2.0	KZ0041I02	B5	Druck	56	
UR107	Roof	4.0-5.0	KZ0041I02	B5	Druck	56	
UR122	Right wall	1.5-2.0	KZ0065B02	O	Druck	56	
UR123	Right wall	4.0-5.0	KZ0065B02	O	Druck	56	
UR124	Right wall	4.0-5.0	KXZSD8HR	A2	Druck	86	
UR125	Right wall	8.4-25	KXZSD8HR	A2	Druck	86	
UR126	Right wall	1.5-2.0	KXZRD7HR	A3	Druck	86	
UR127	Right wall	4.0-8.0	KXZRD7HR	A3	Druck	86	
UR128	Right wall	1.5-2.0	kzoo41B02	B5	Druck	56	
UR129	Right wall	4.0-5.0	kzoo41B02	B5	Druck	56	
UR141	Floor	1.5-2.0	KZ0065G02	O	Druck	56	
UR142	Floor	4.0-5.0	KZ0065G02	O	Druck	56	
UR143	Floor	1.5-2.0	KXZB3	A3	Druck	56	
UR144	Floor	4.0-5.0	KXZB3	A3	Druck	56	
UR146	Floor	1.5-2.0	KZ0041G02	B4	Druck	56	
UR147	Floor	4.0-5.0	KZ0041G02	B4	Druck	56	
UR161	Left wall	1.5-2.0	KZ0065A02	O	Druck	56	
UR162	Left wall	4.0-5.0	KZ0065A02	O	Druck	56	
UR163	Left wall	4.0-5.0	KXZSD8HL	A2	Druck	86	
UR164	Left wall	20-25	KXZSD8HL	A2	Druck	86	
UR165	Left wall	1.5-2.0	KXZRD7H	A3	Druck	86	
UR166	Left wall	2.5-3.0	KXZRD7H	A3	Druck	86	
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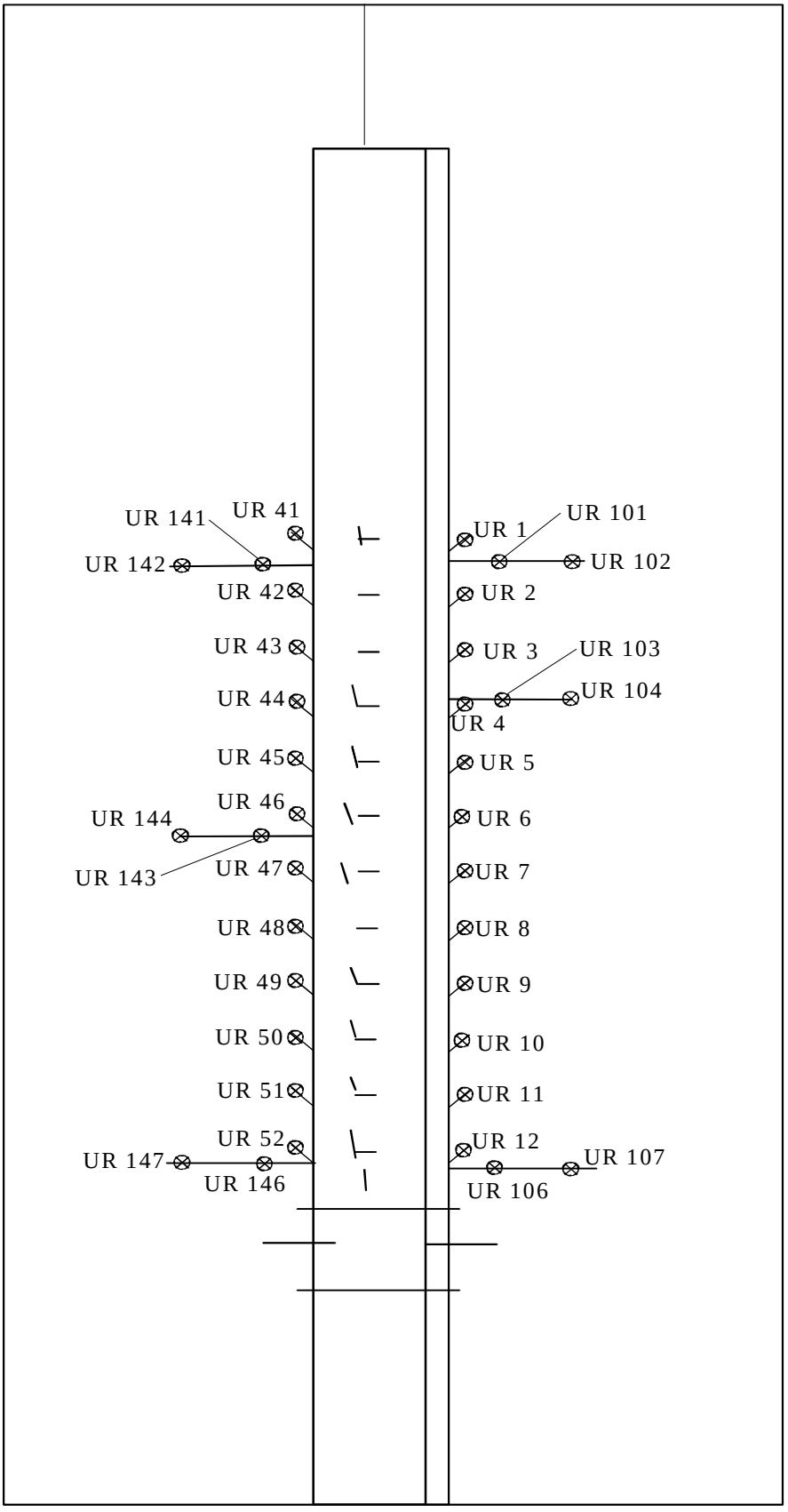


Fig 5-1 Position of measuring points in the boreholes of the rock in the floor (left part) and the roof. Vertical section.

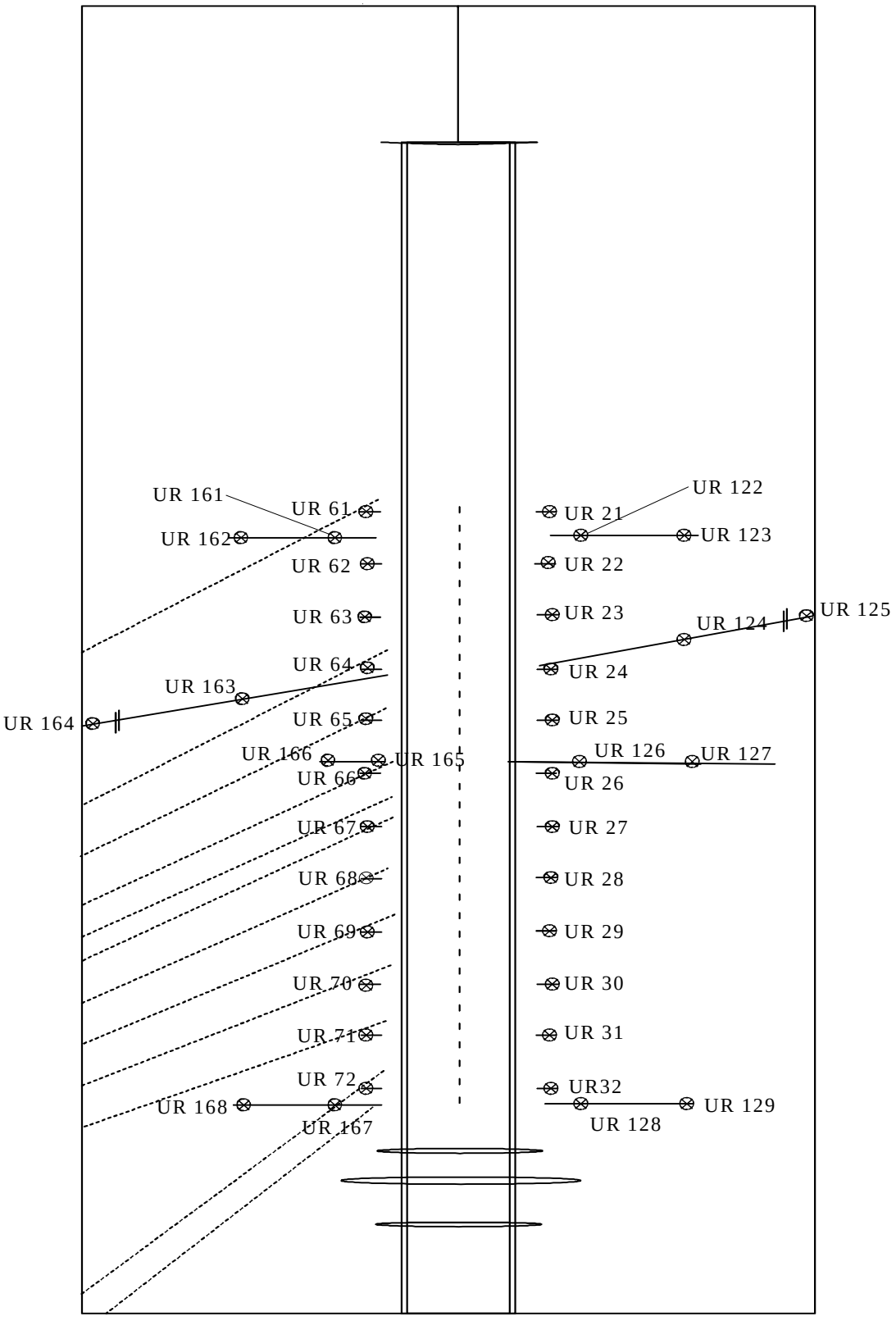


Figure 5-2 Position of measuring points in the boreholes of the rock in the walls. Horizontal section.

References

/1-1/ Börgesson L, Gunnarsson D, Johannesson L-E, Karnland O and Sandén T. Äspö Hard Rock Laboratory. Backfill instrumentation - development and choice of suitable techniques for measuring THM processes in the Backfill and Plug Test. Technical Note TN-98-04f.

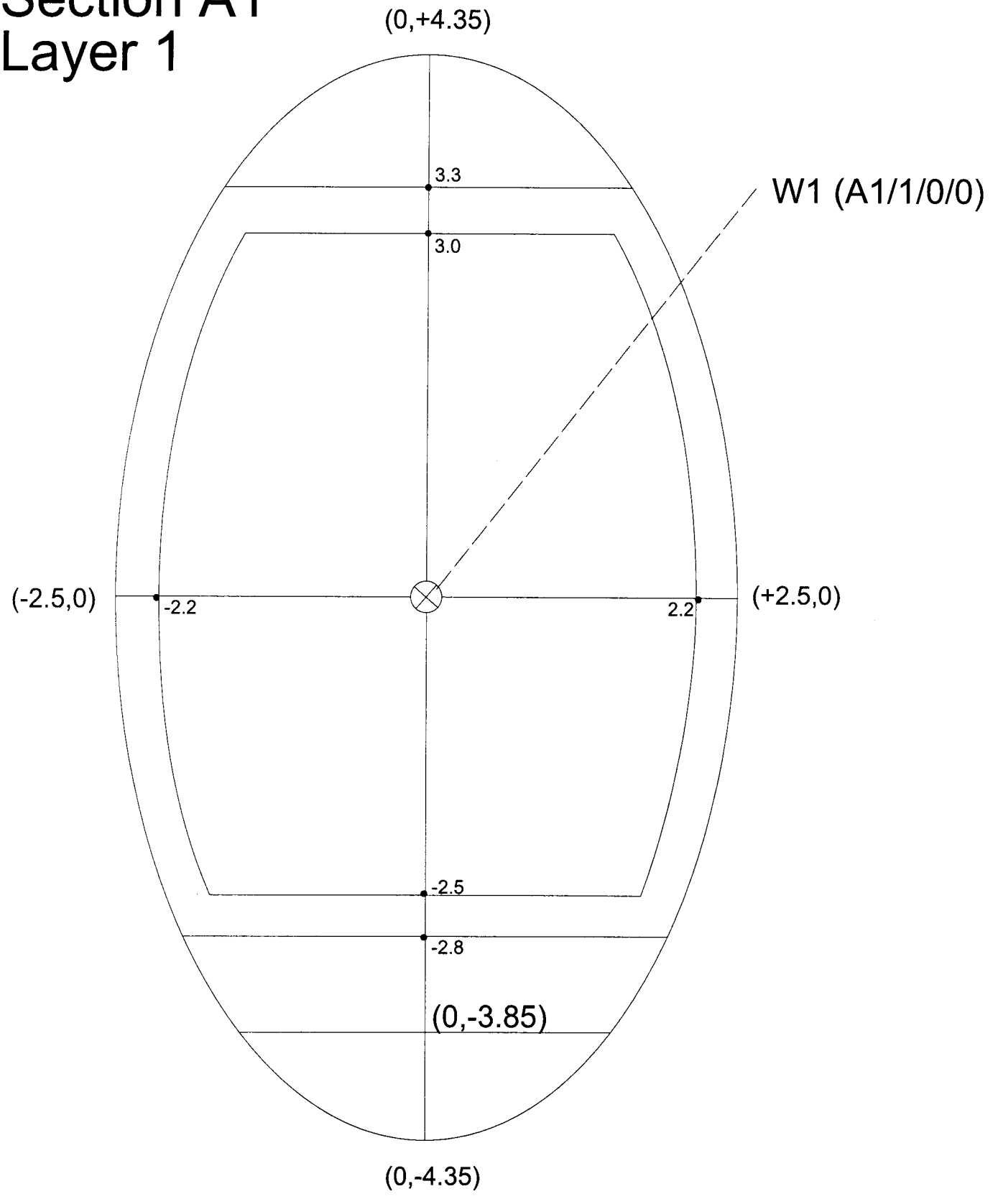
/2-1/ Börgesson L 1997. Äspö Hard Rock Laboratory. Test Plan for Backfill and Plug Test. SKB Progress Report HRL-98-08

Appendix 1

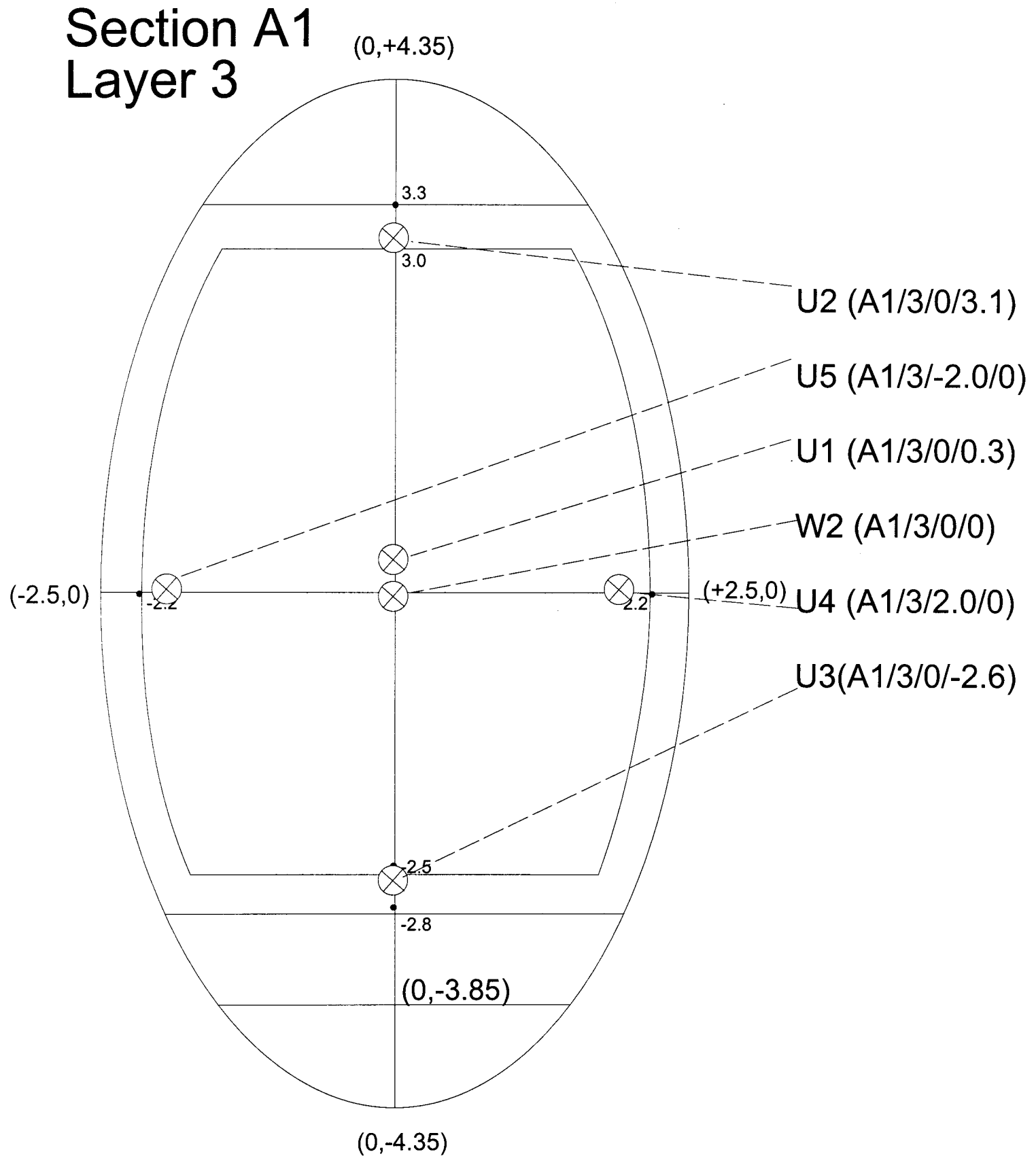
Positions of instruments in the backfill layers

Instrument locations

Section A1
Layer 1



Instrument locations



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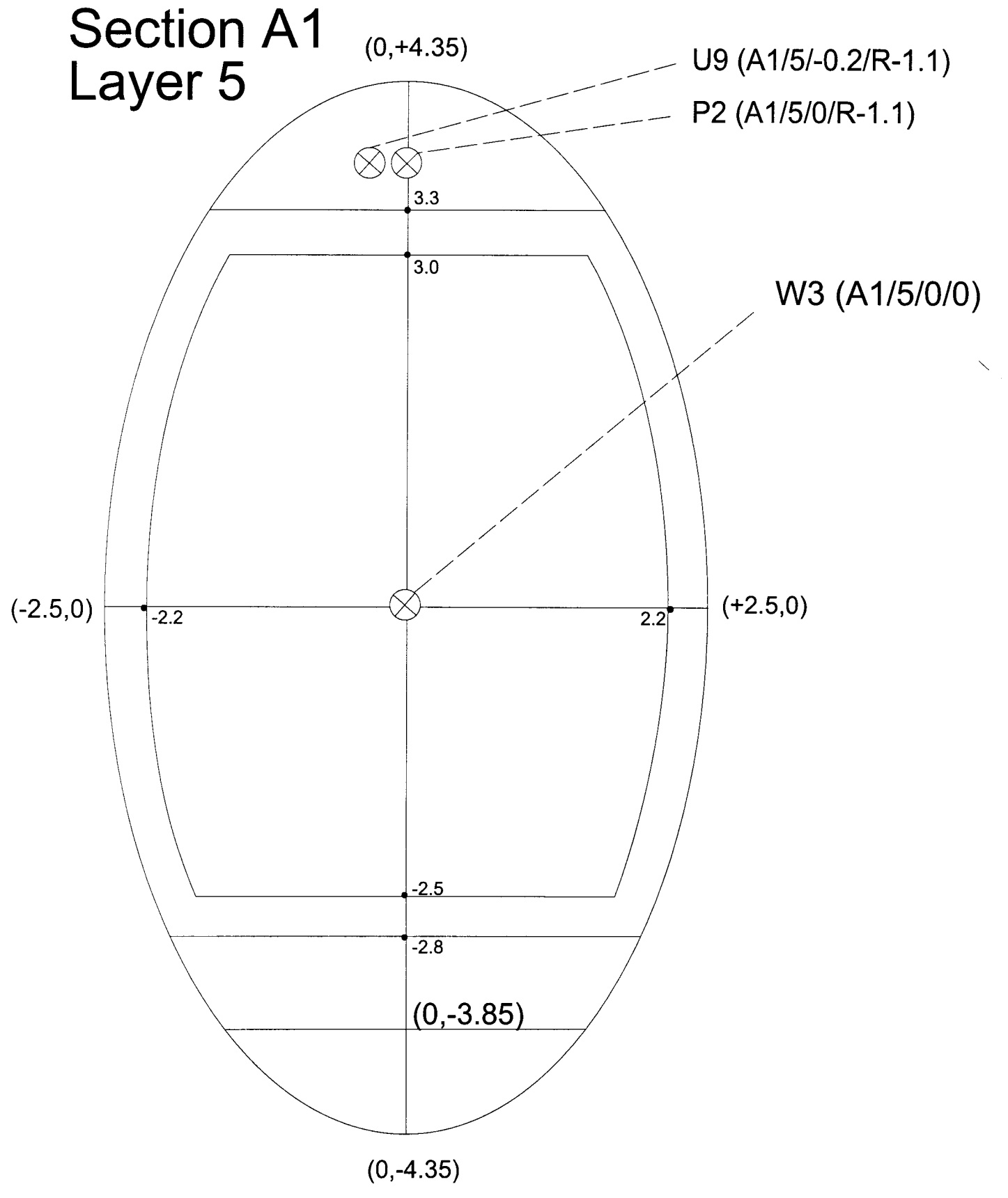

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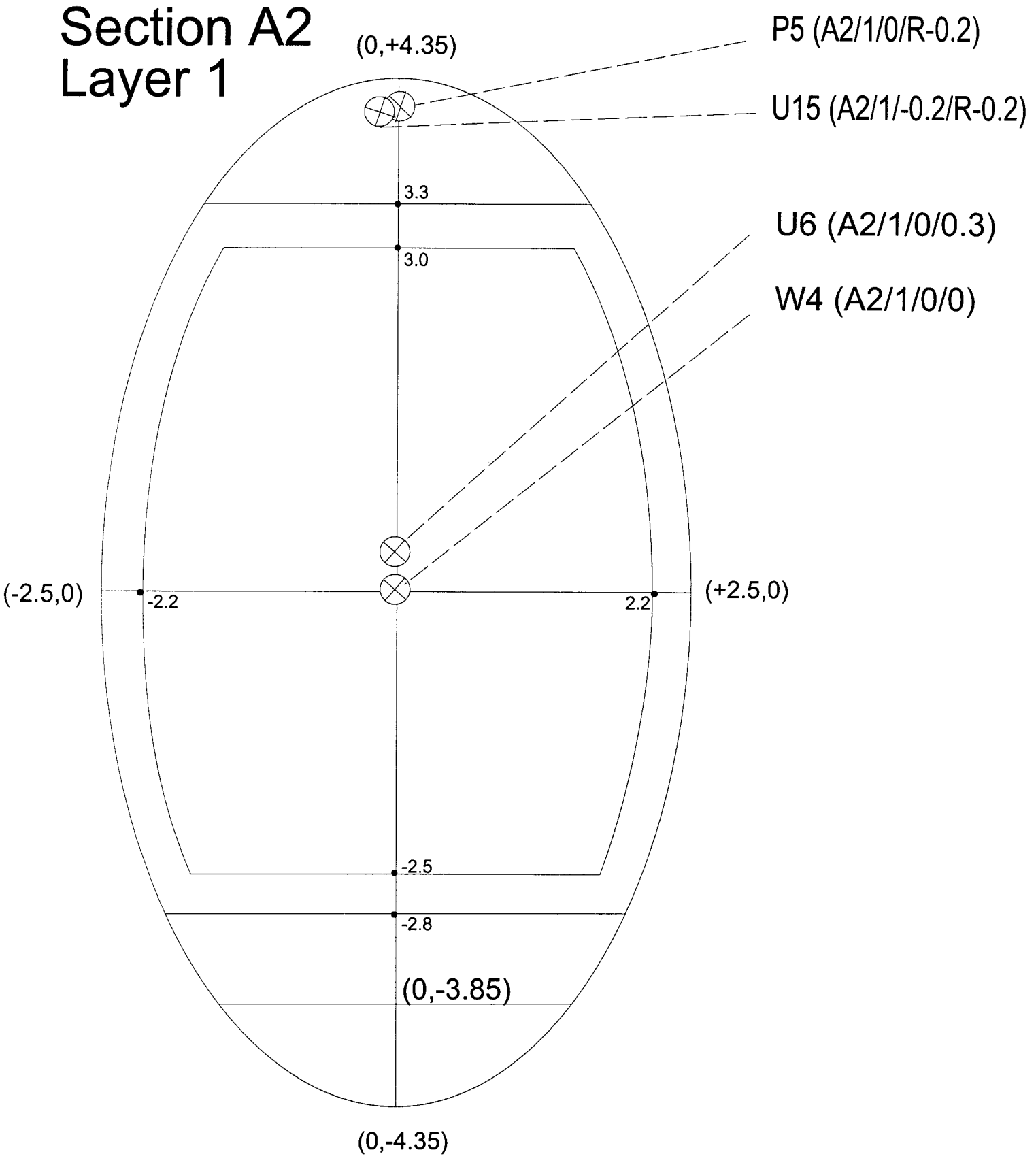

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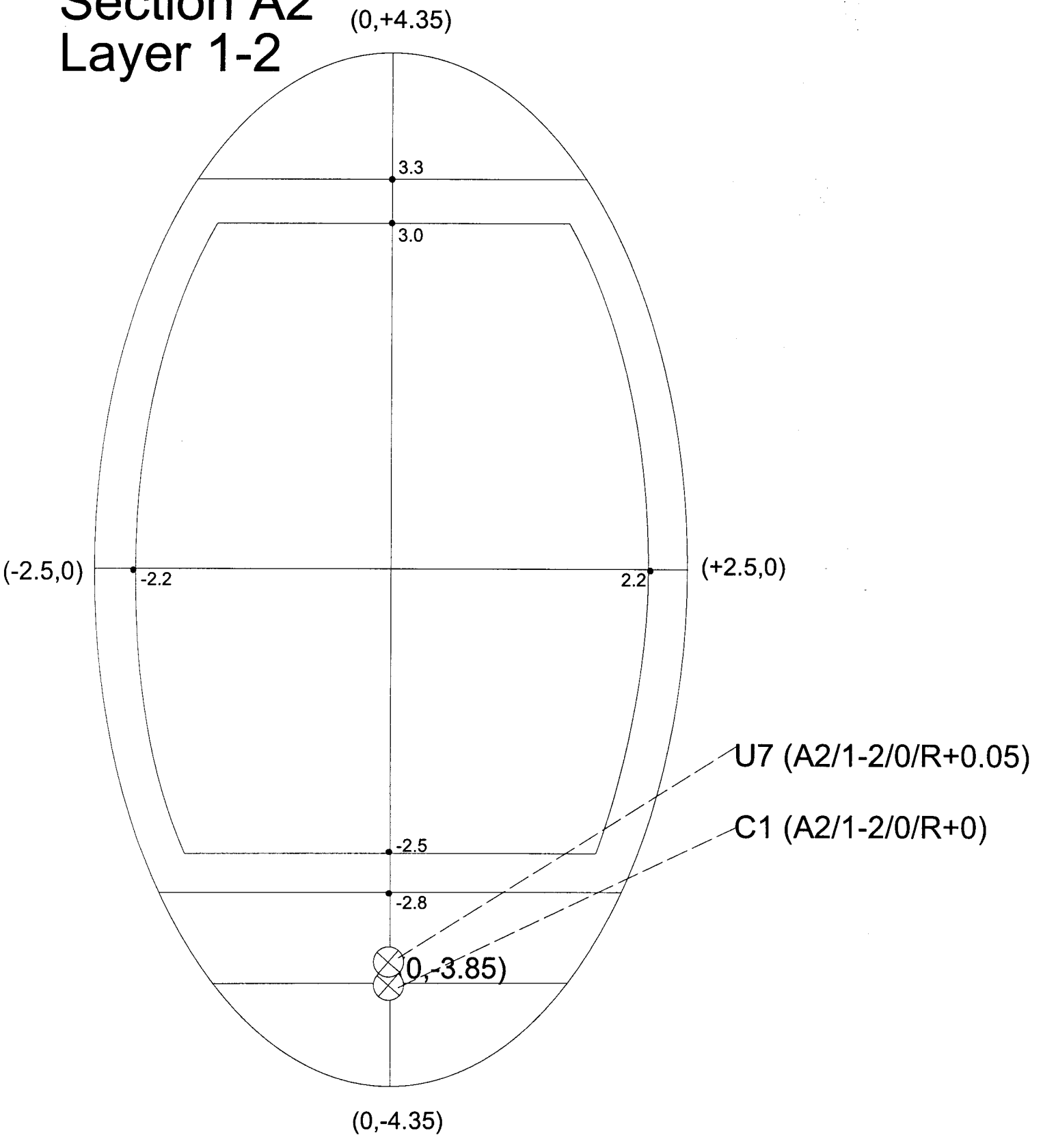

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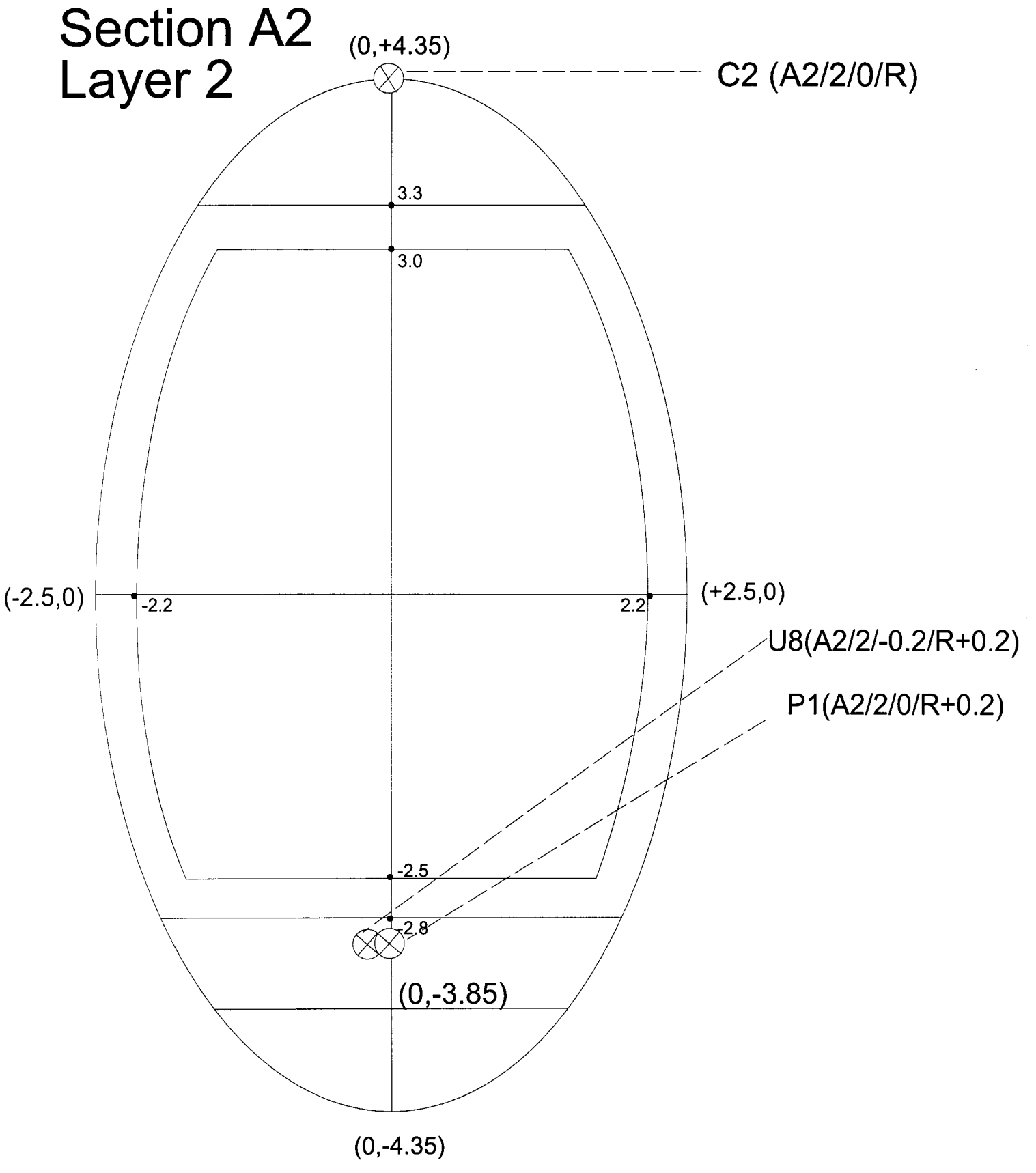

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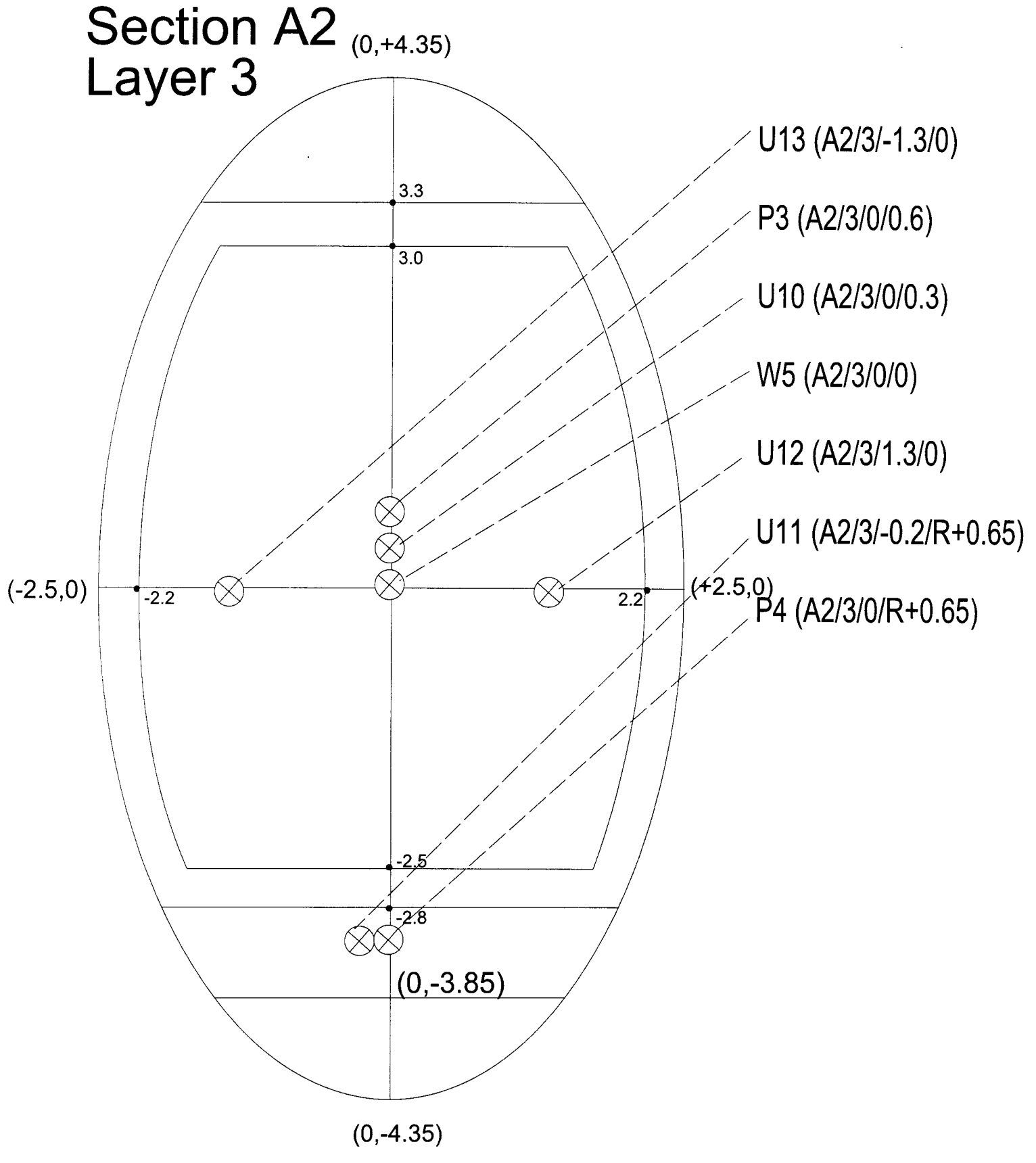

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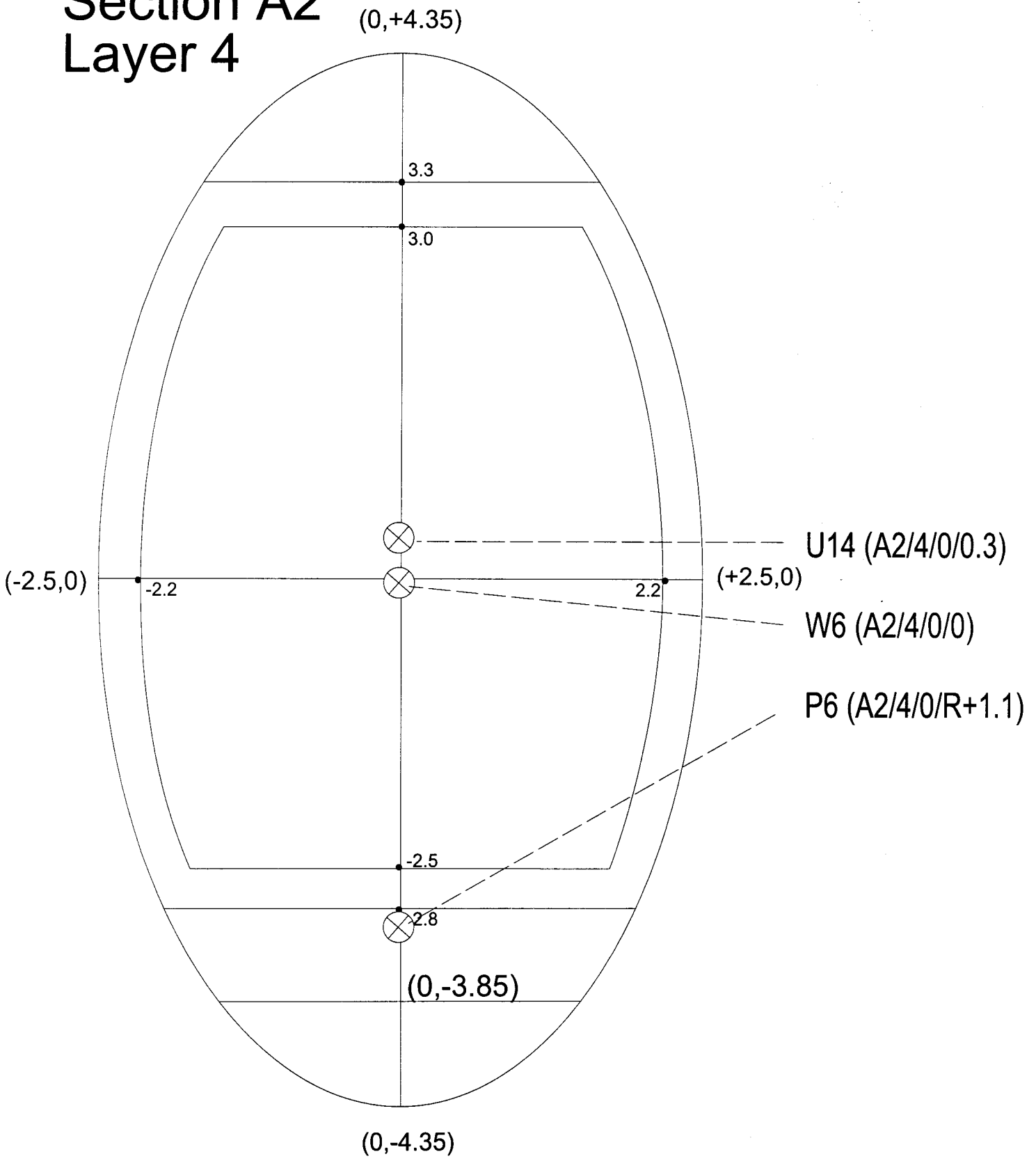

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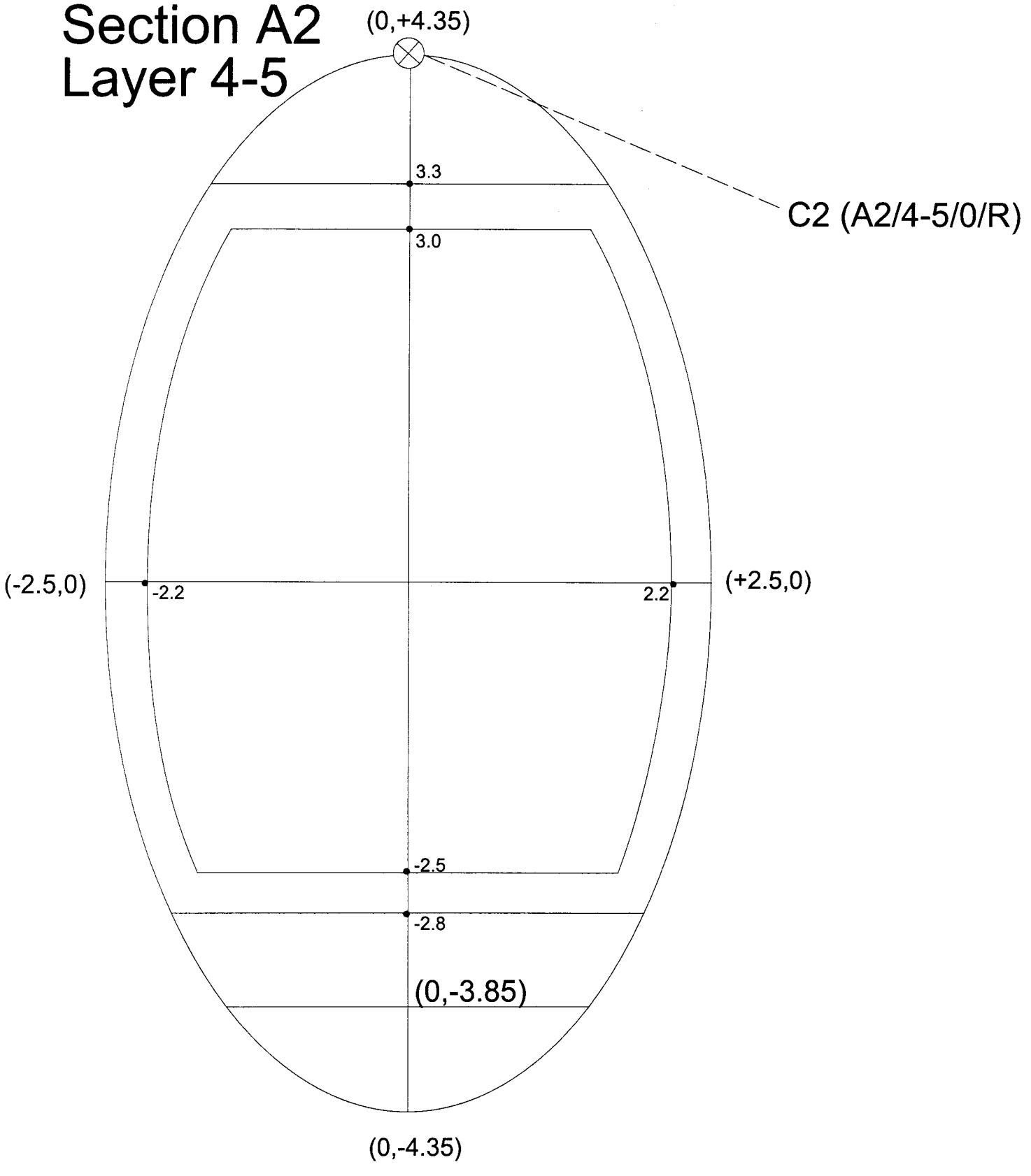

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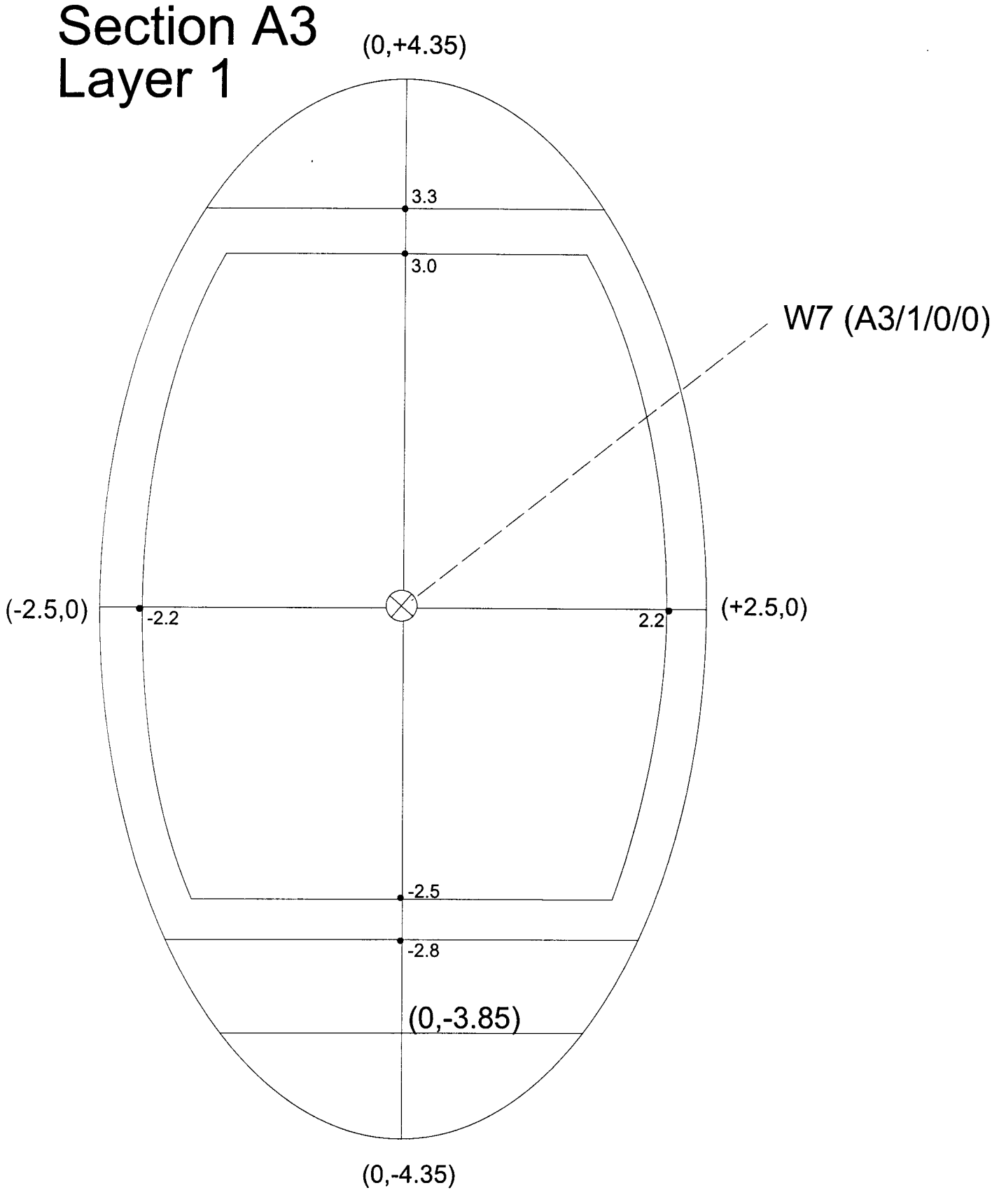

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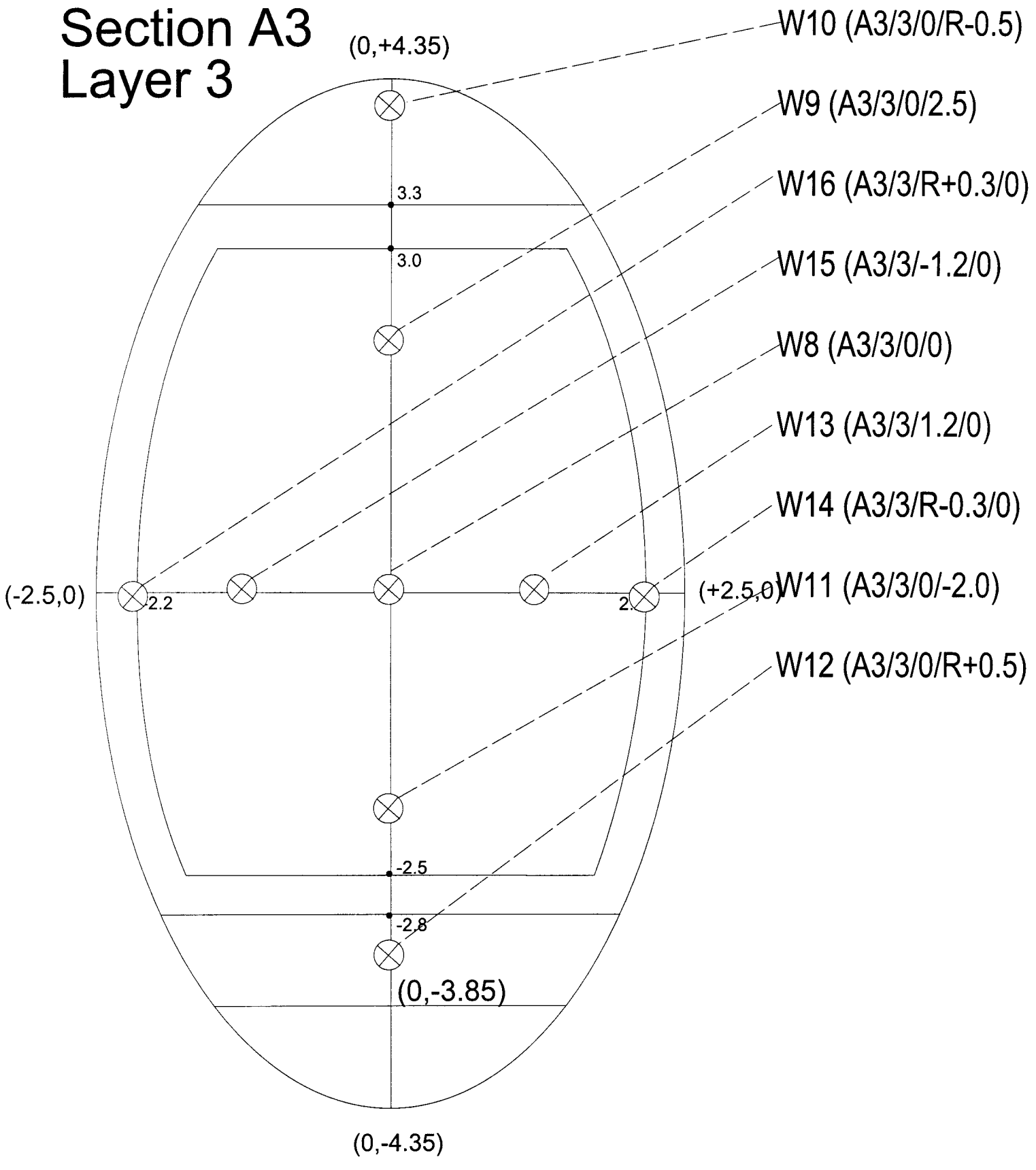

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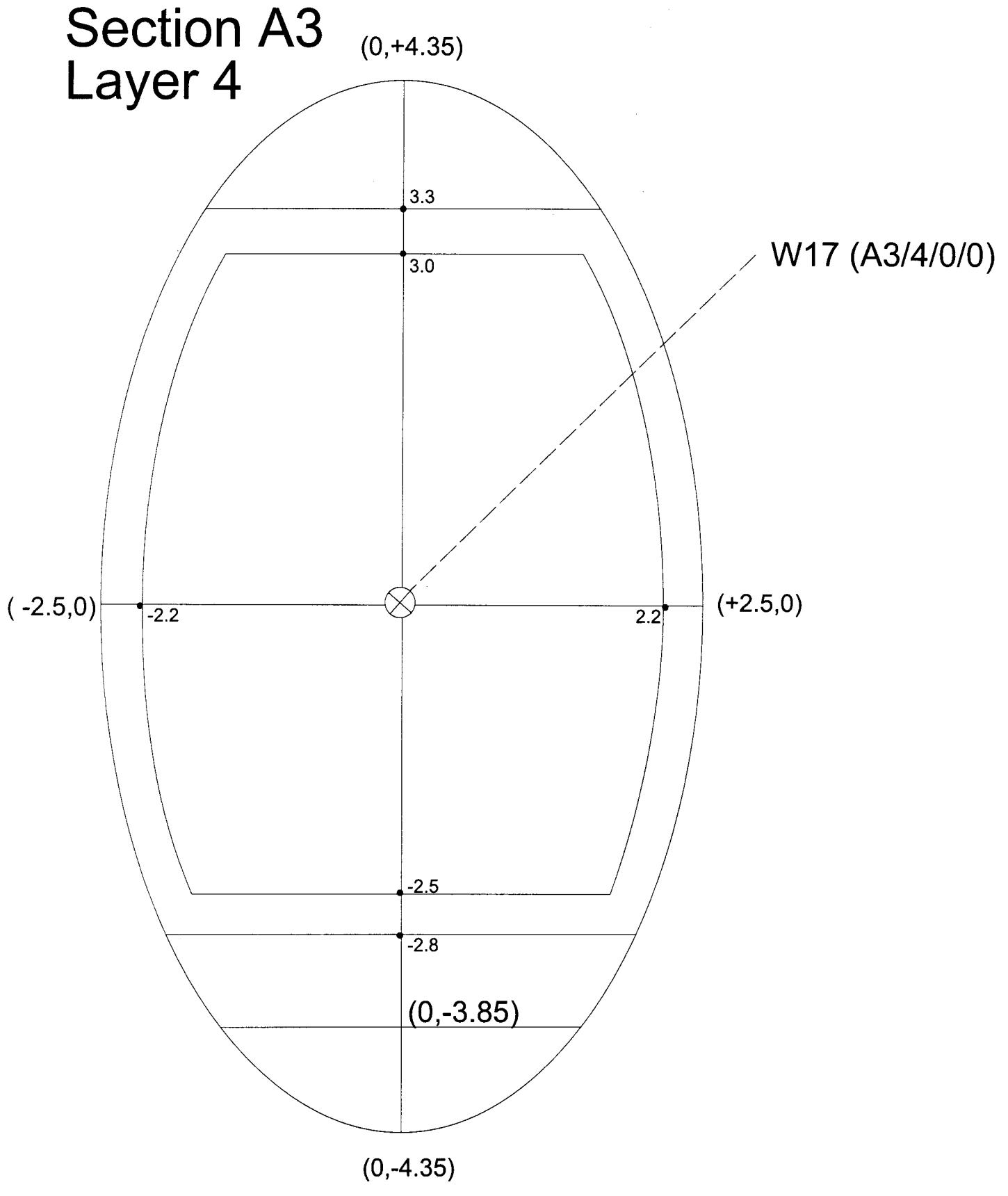

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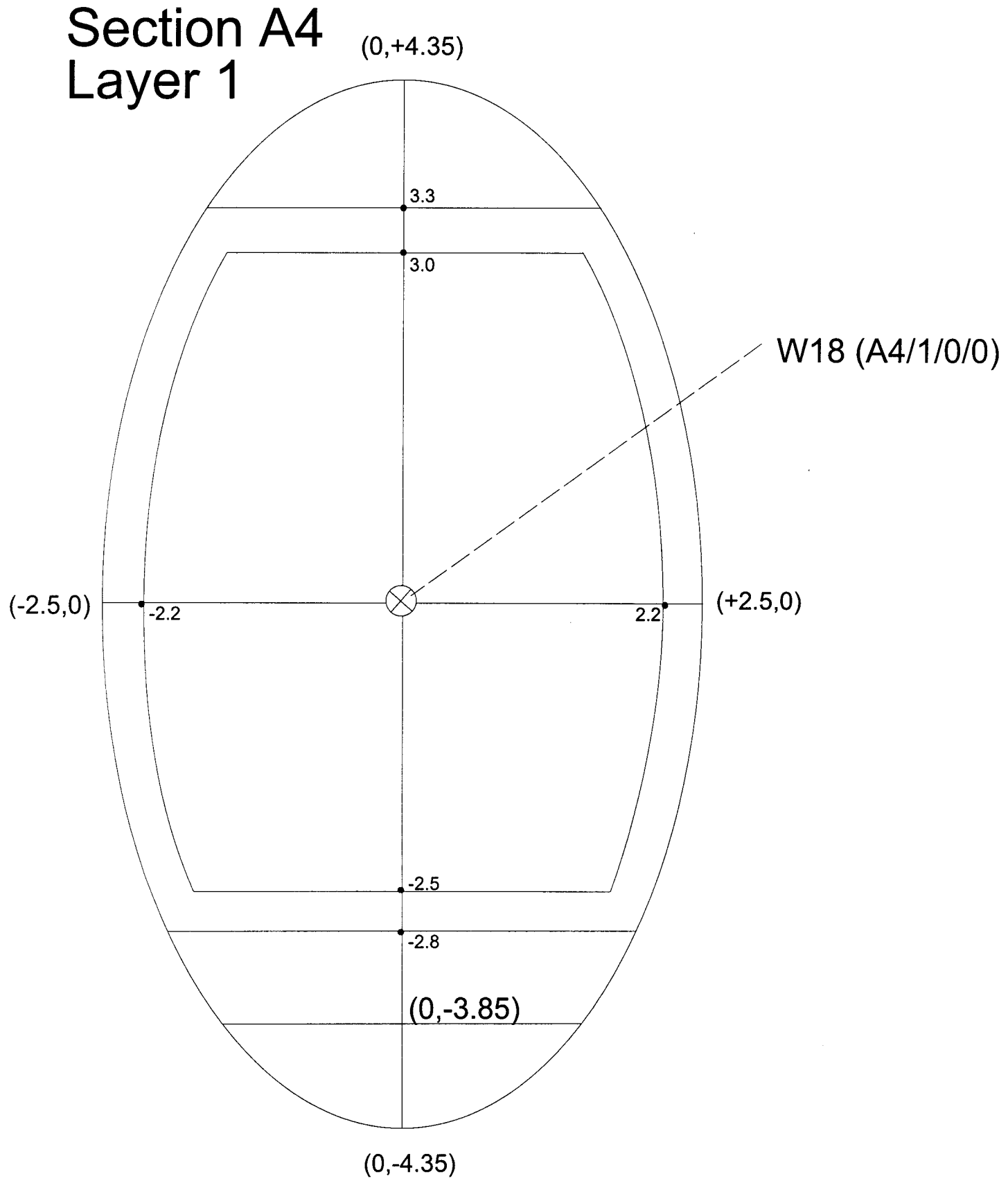

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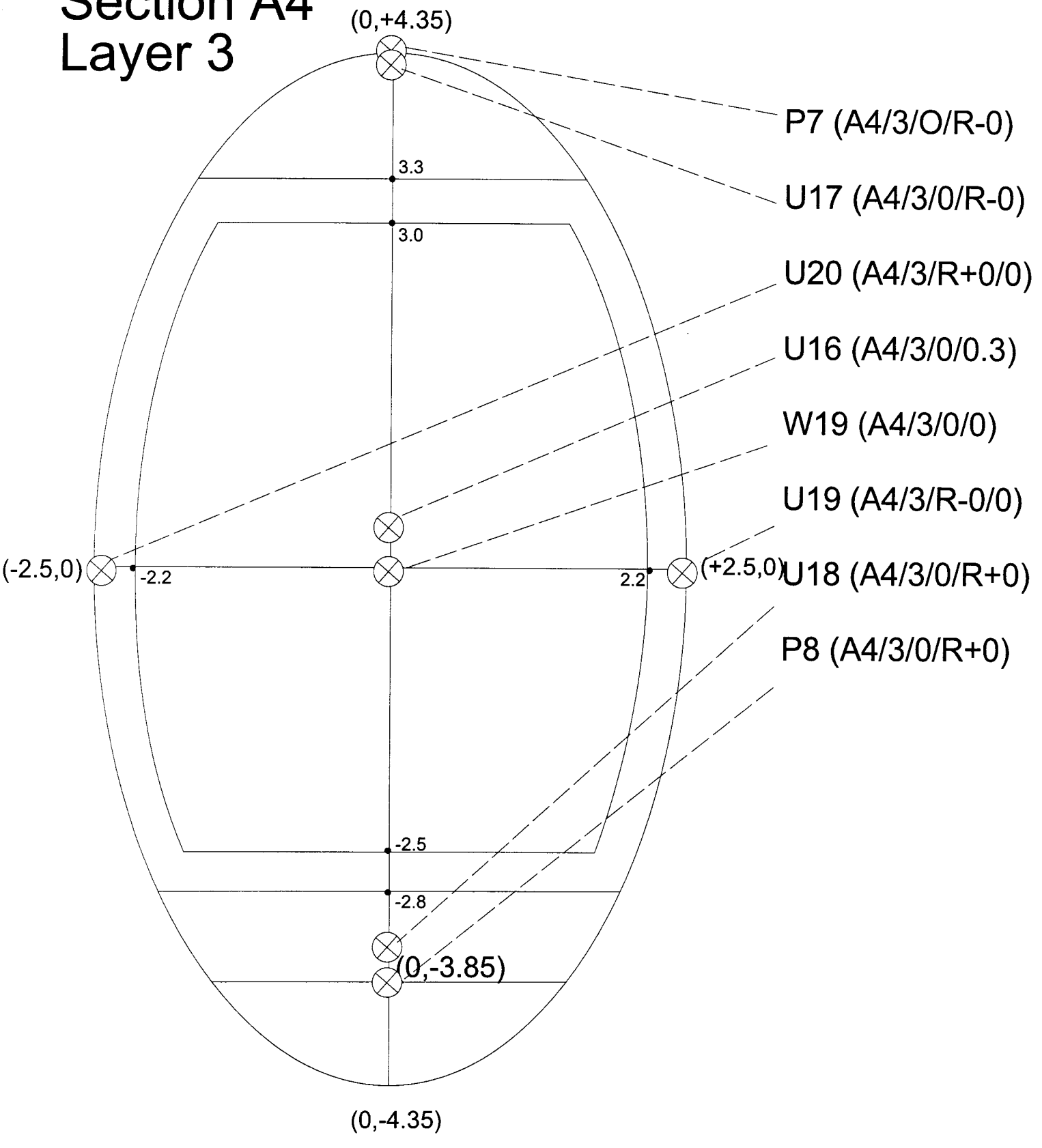

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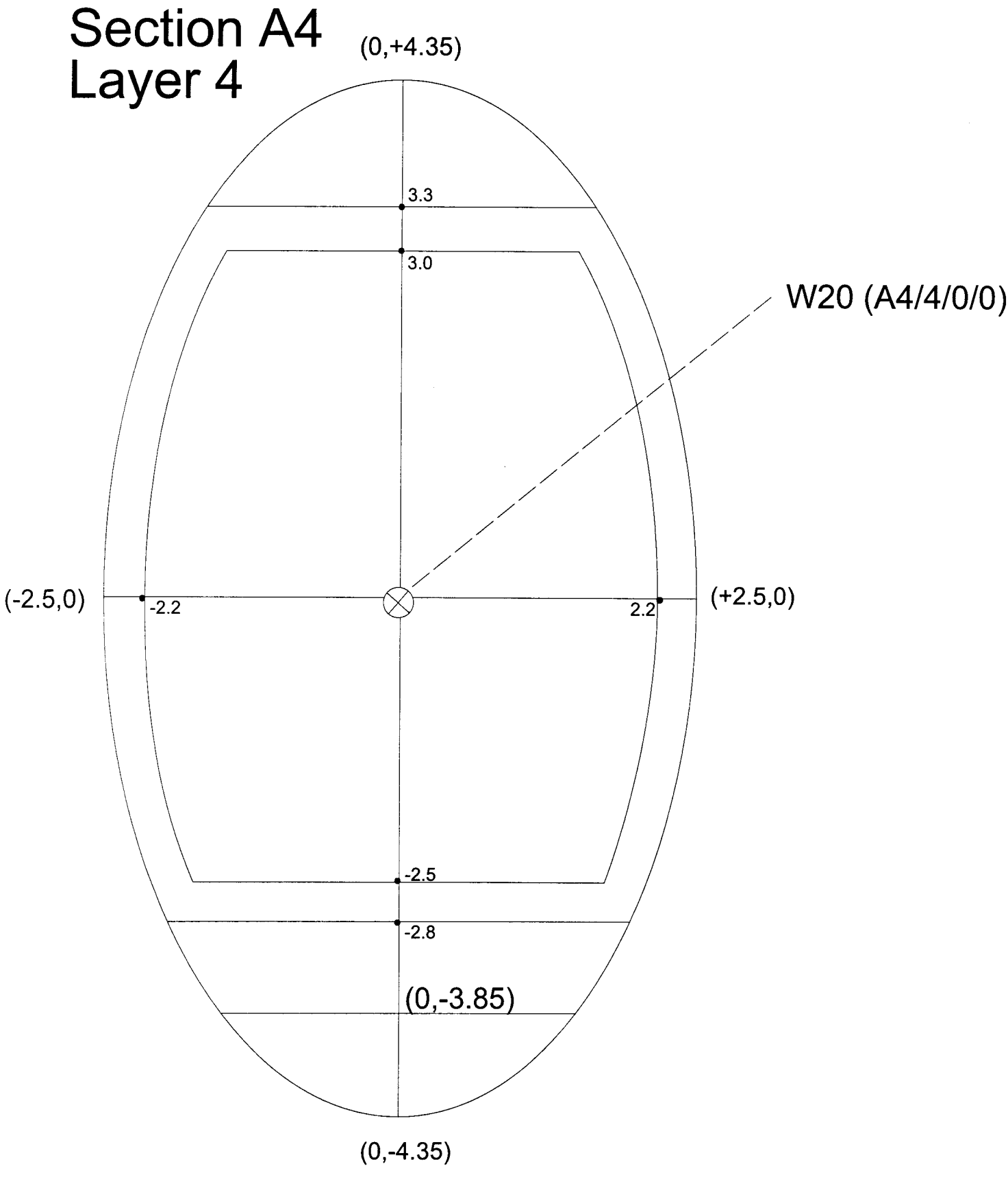

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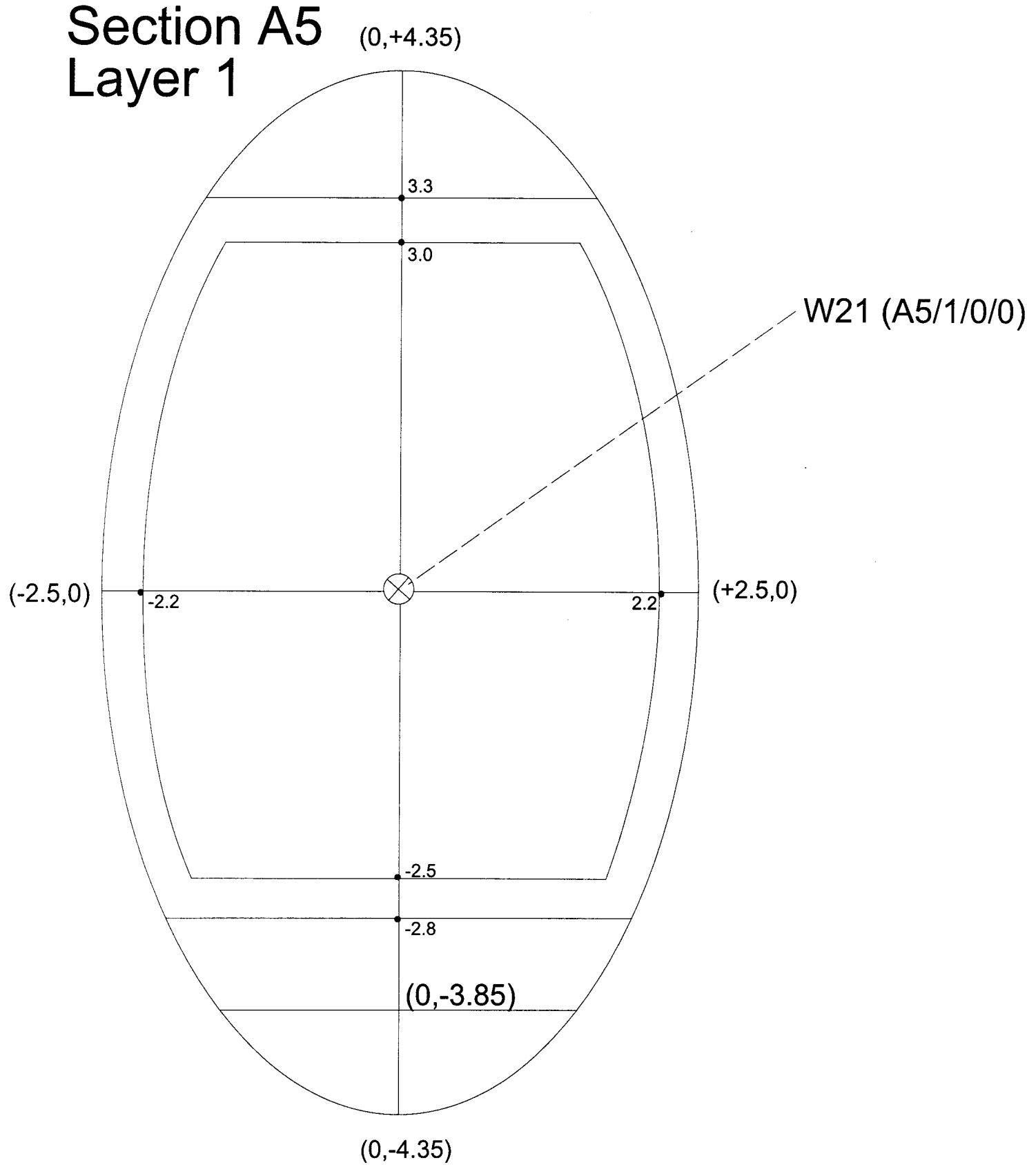

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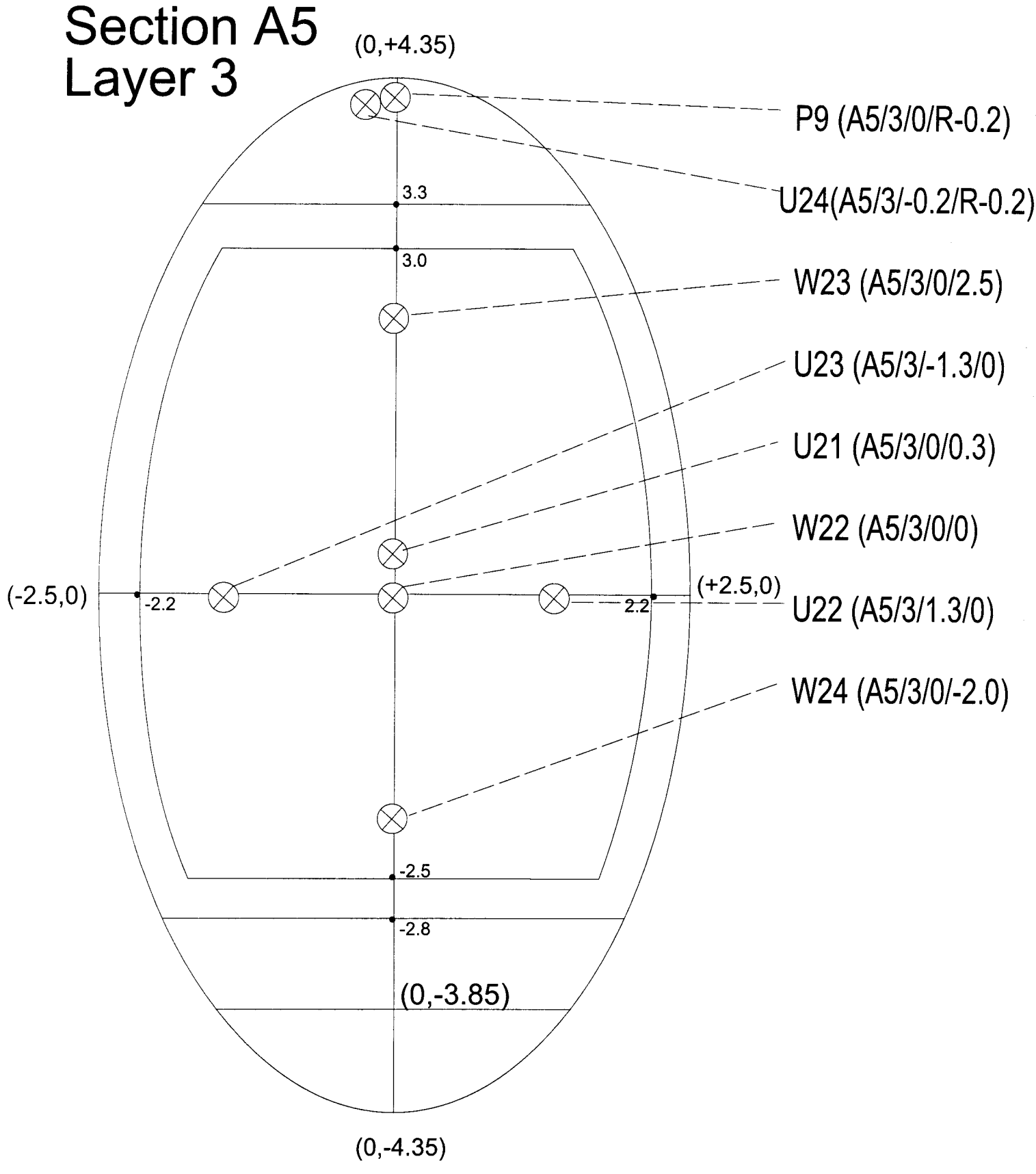

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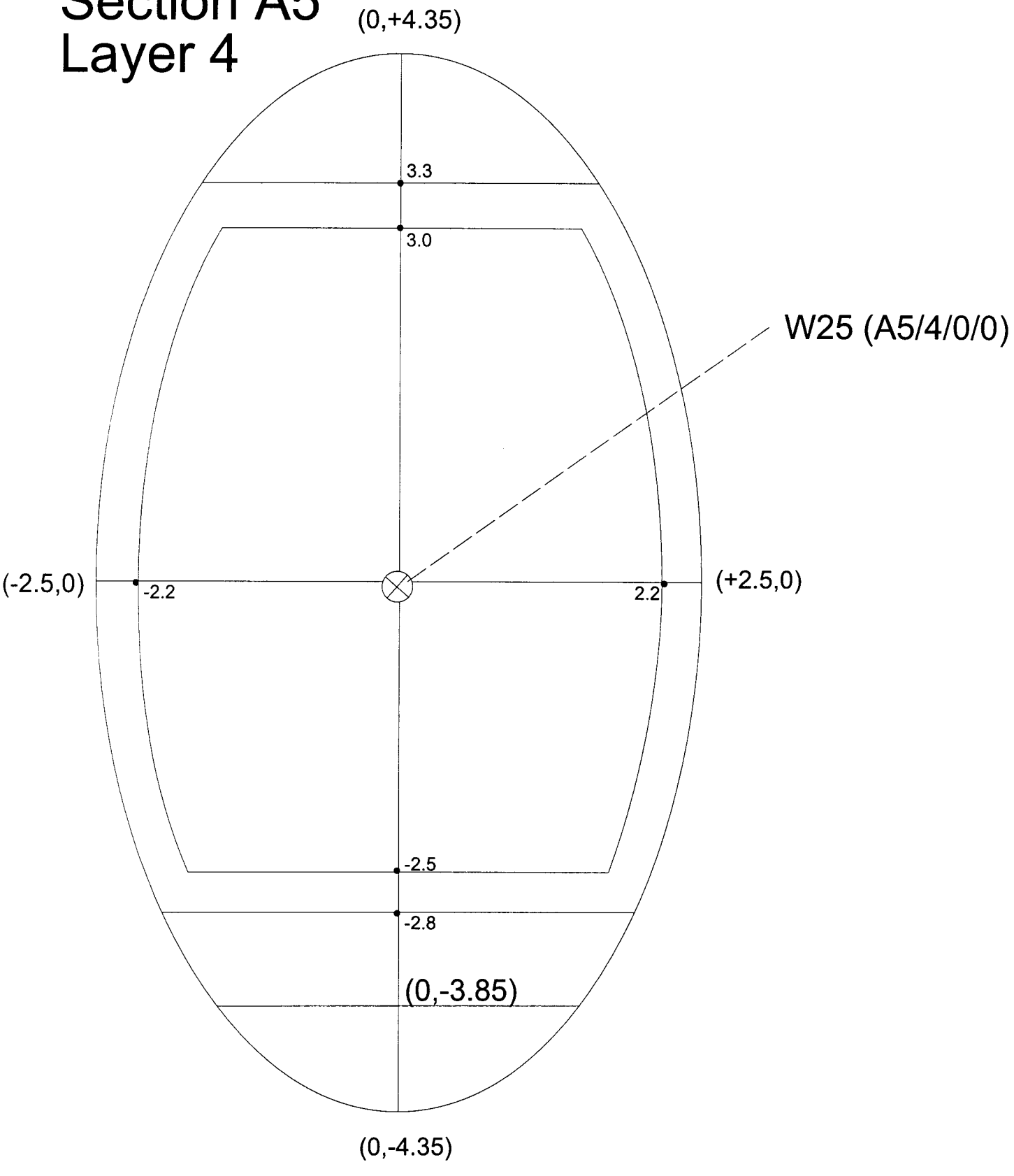

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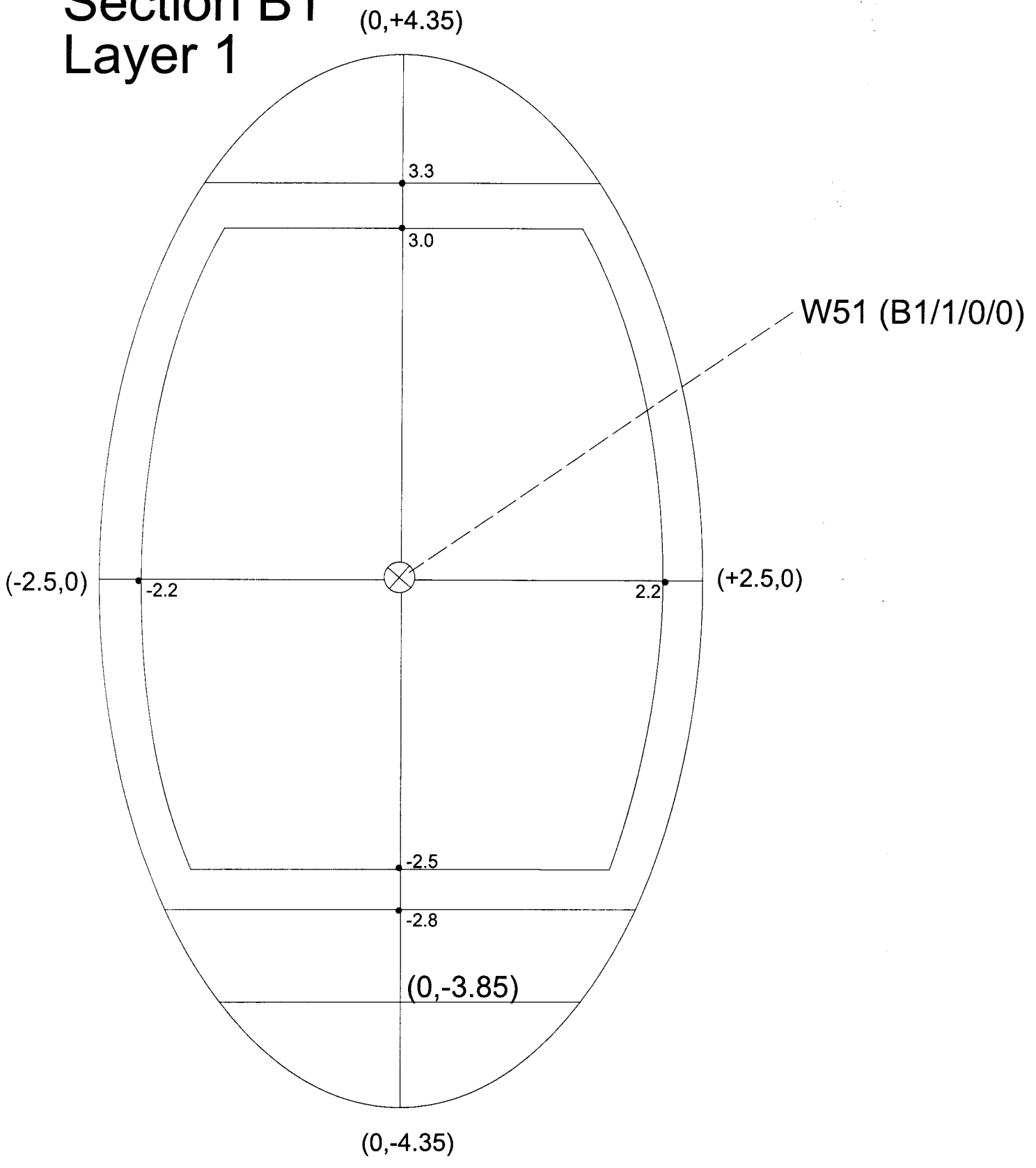

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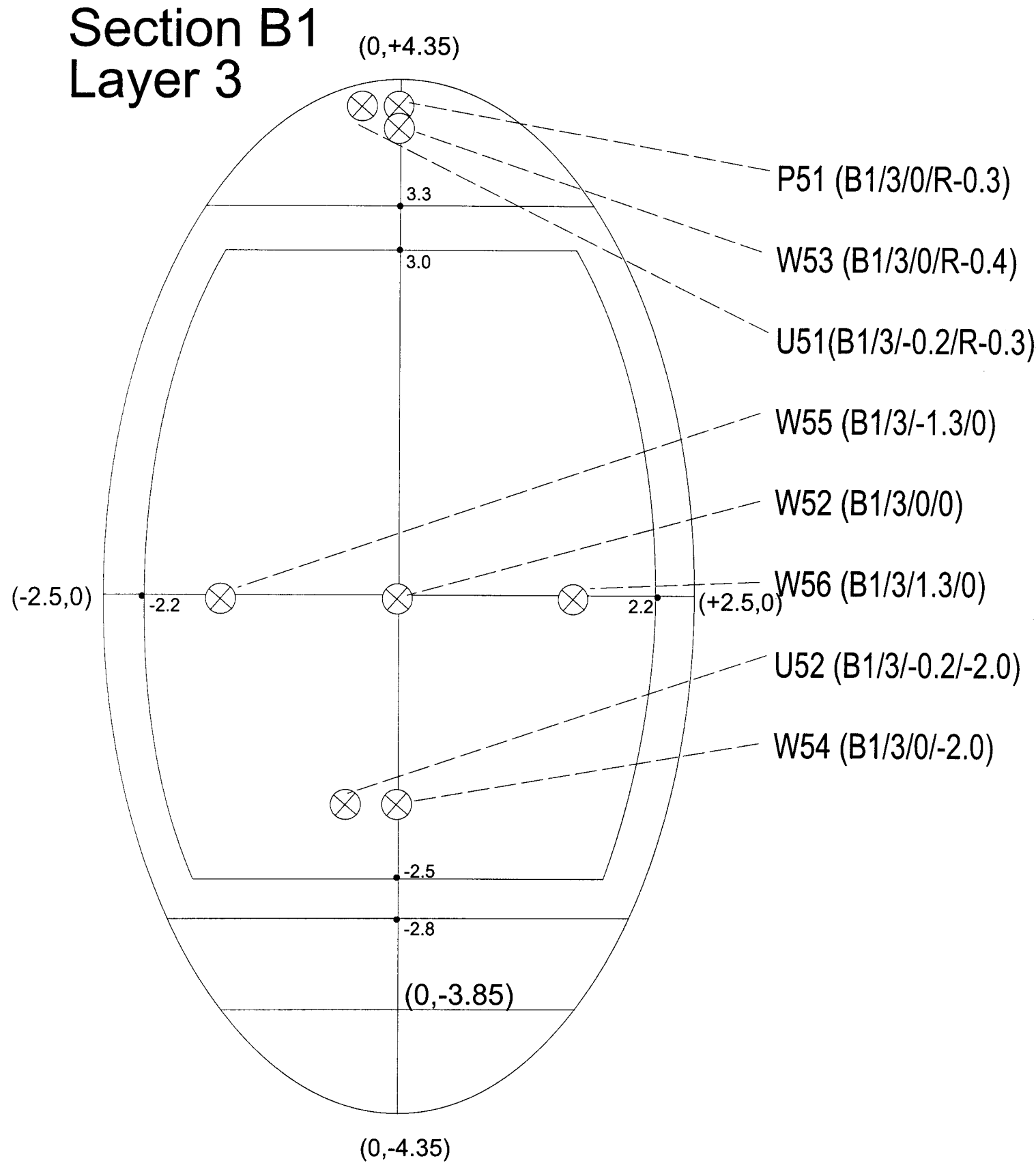

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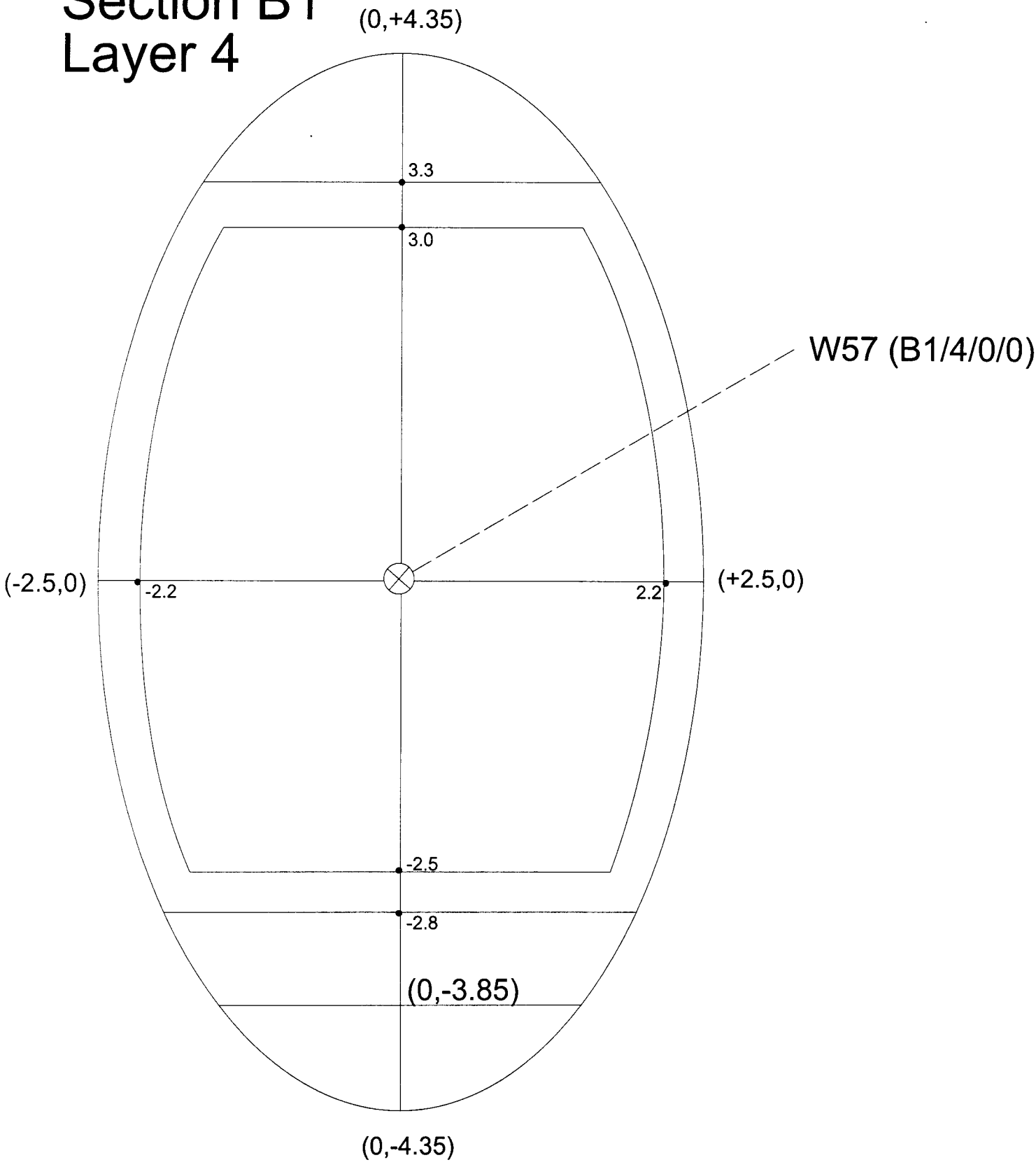

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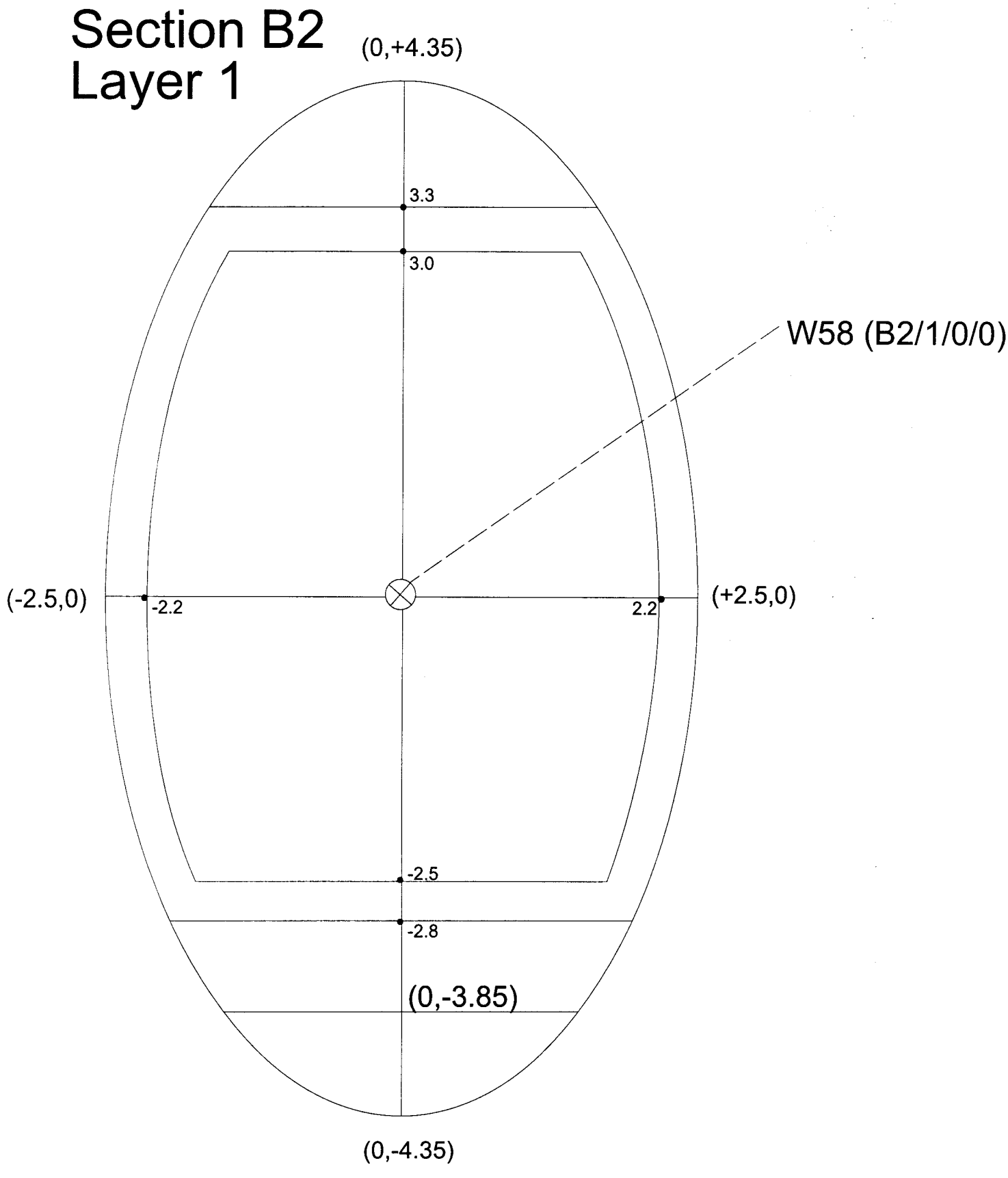

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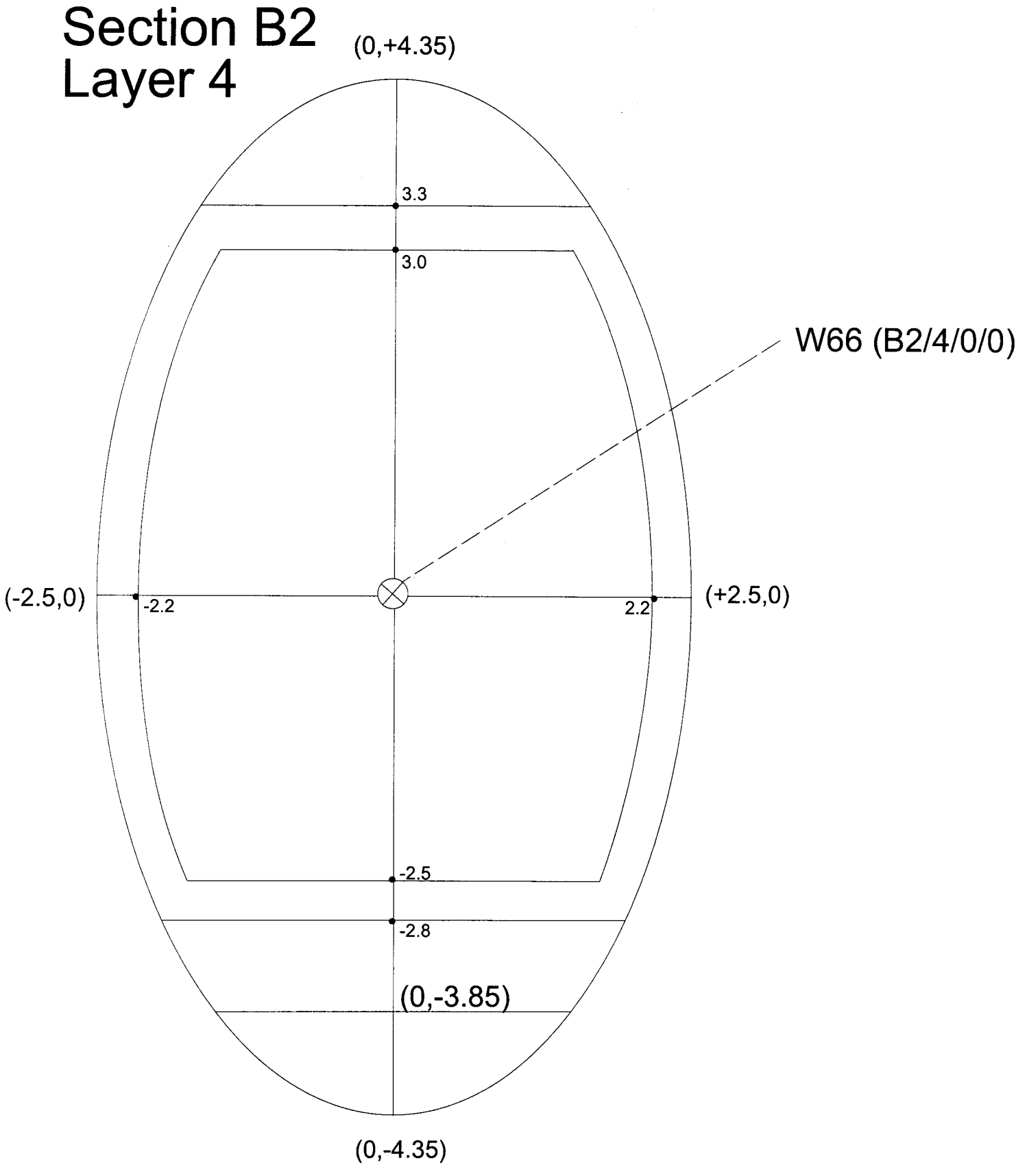

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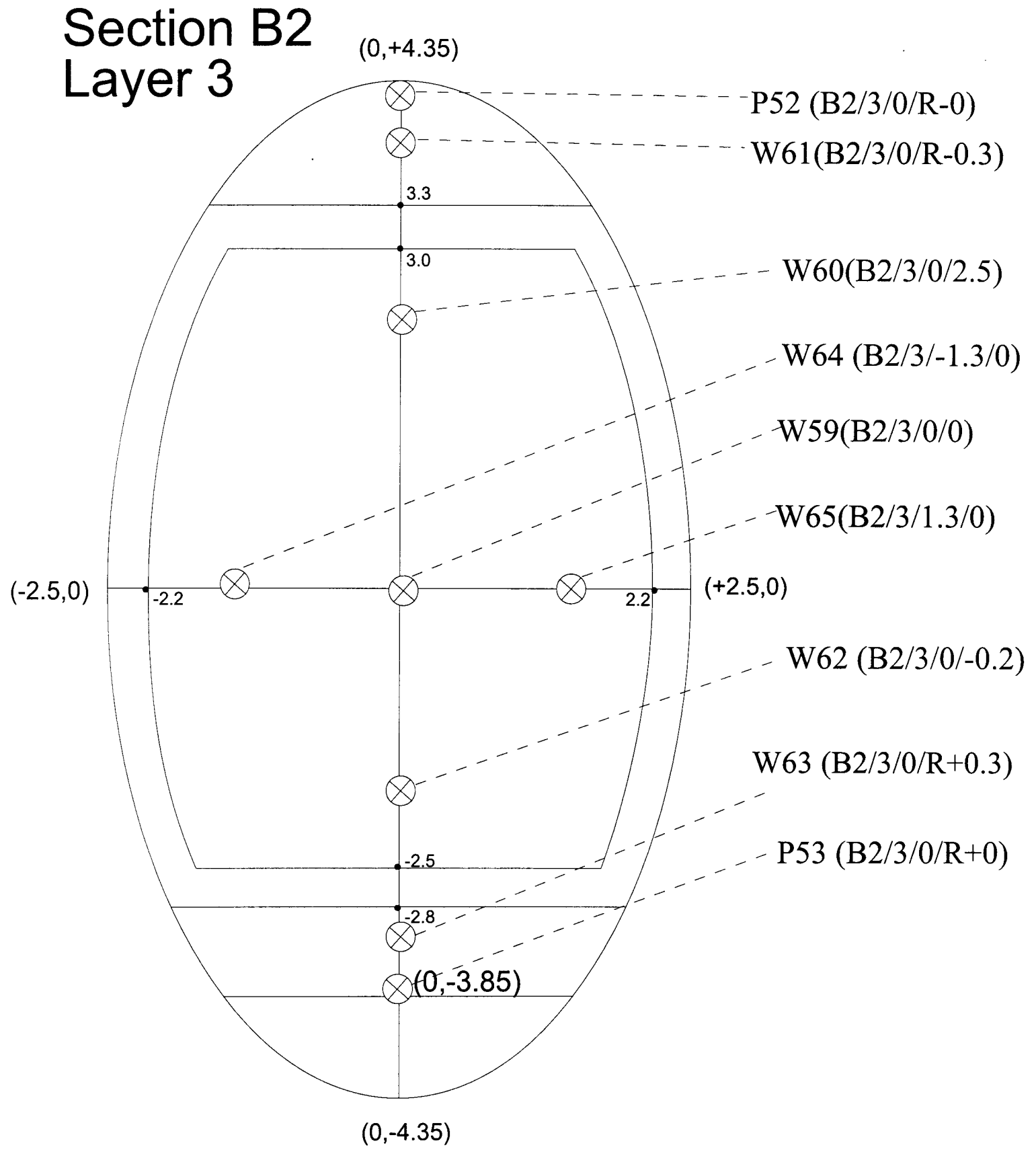

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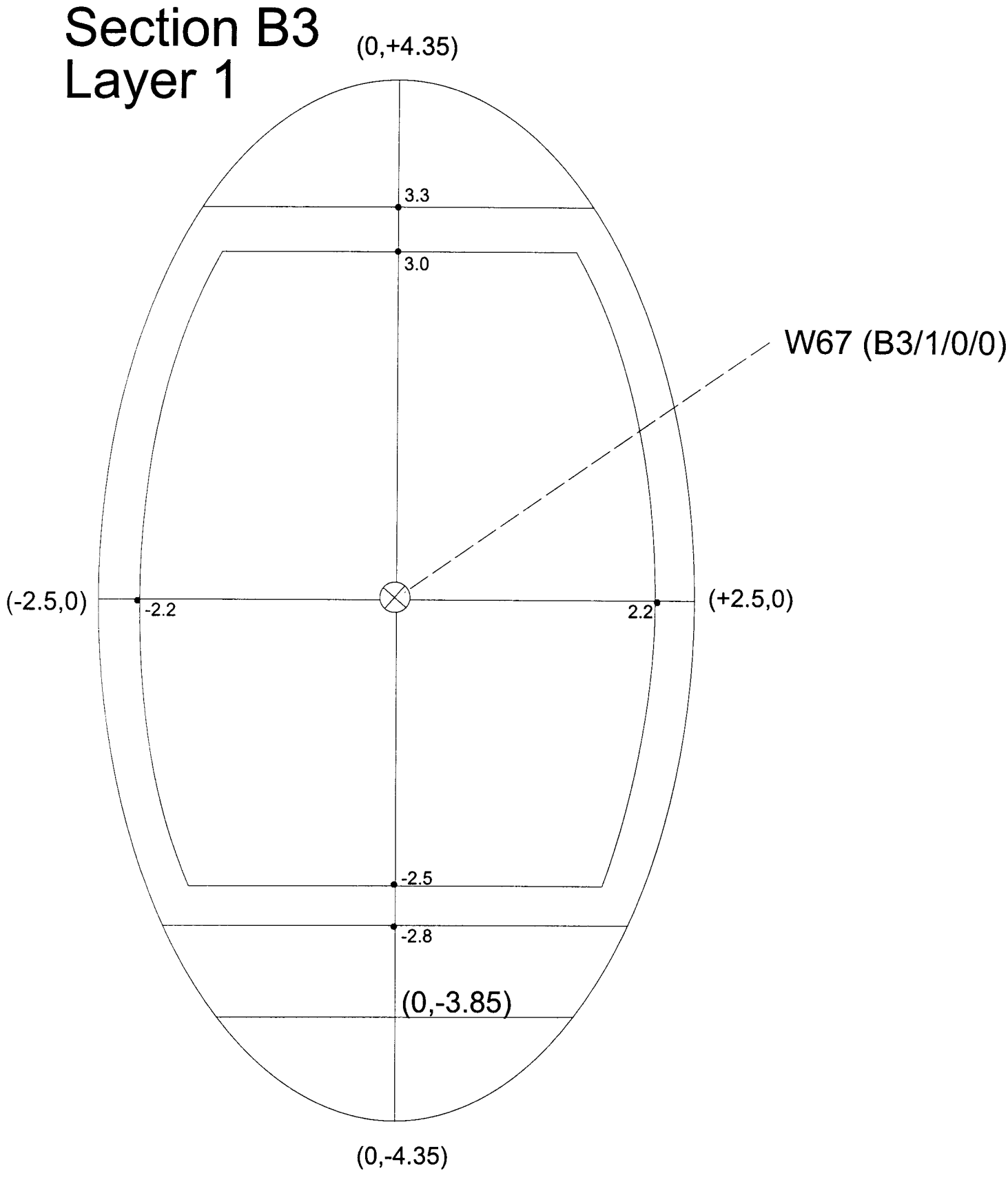

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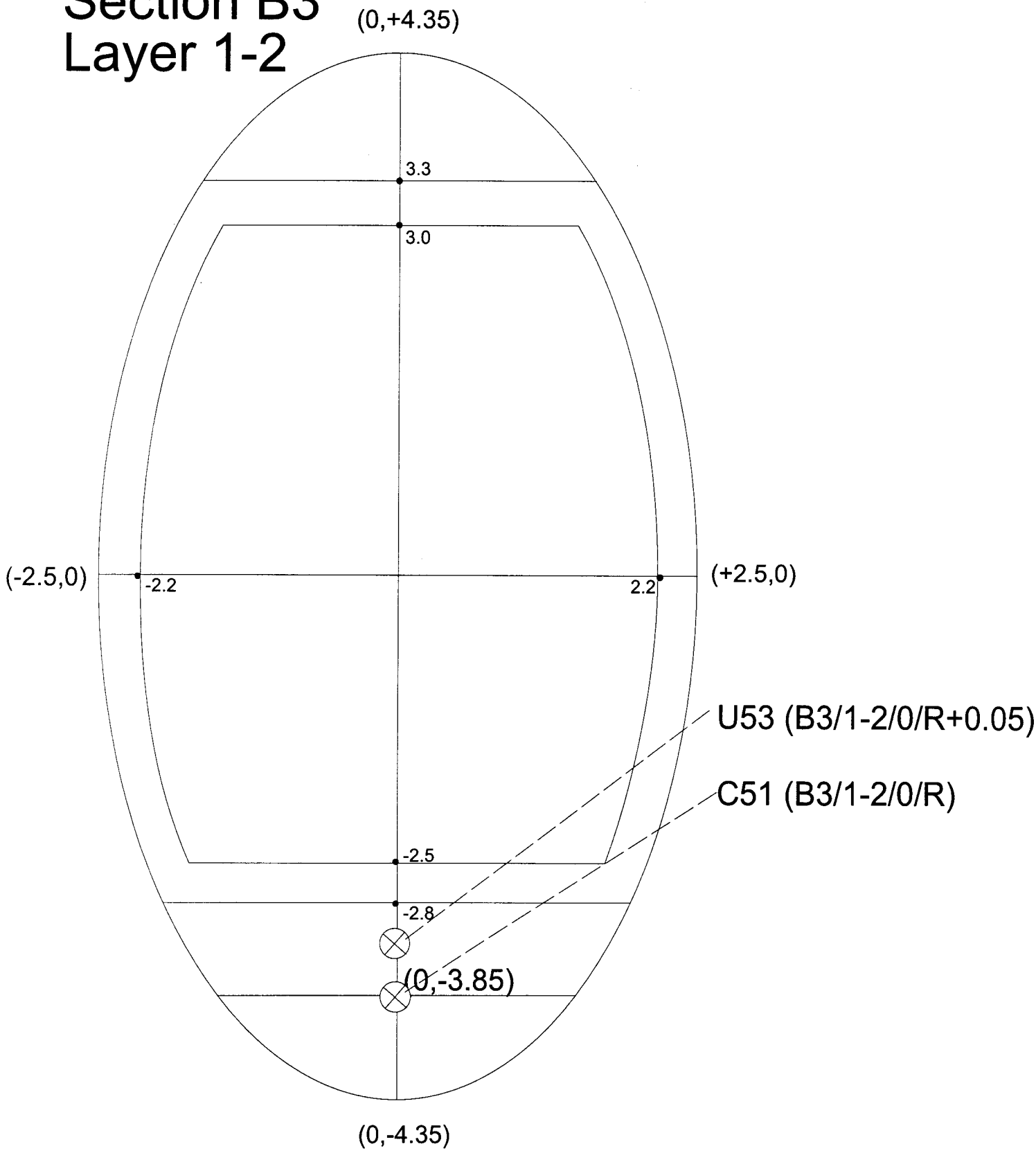

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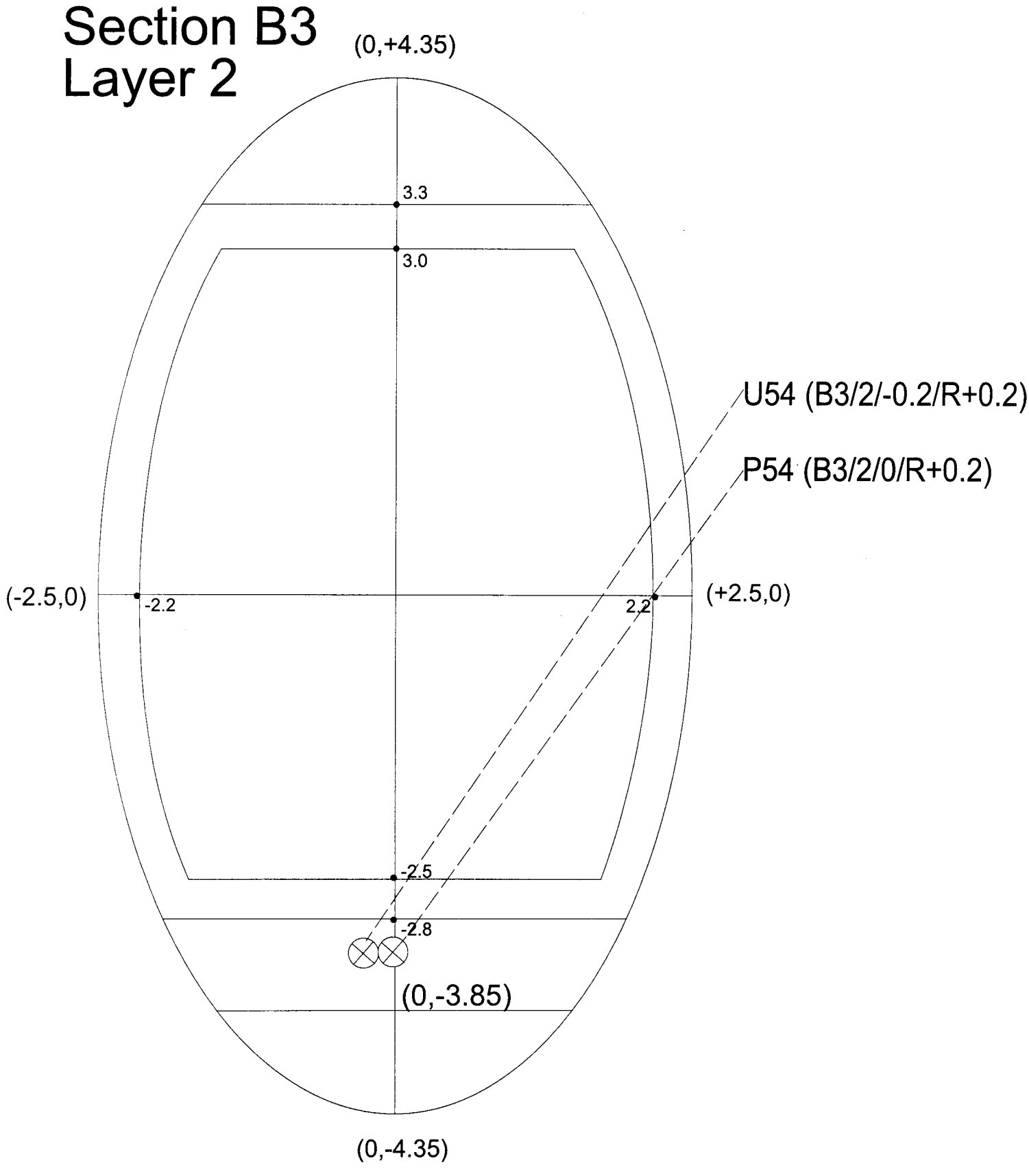

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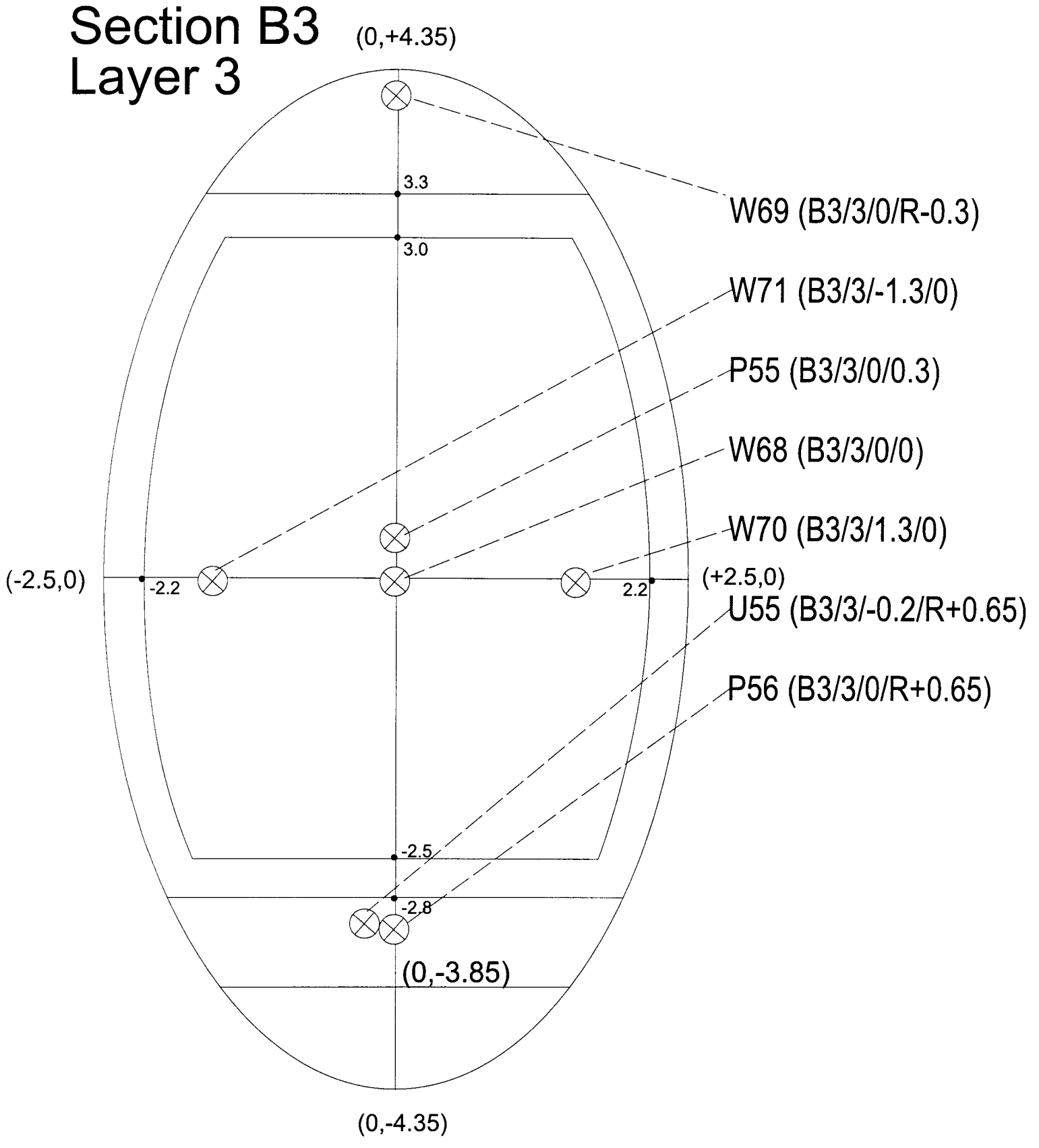

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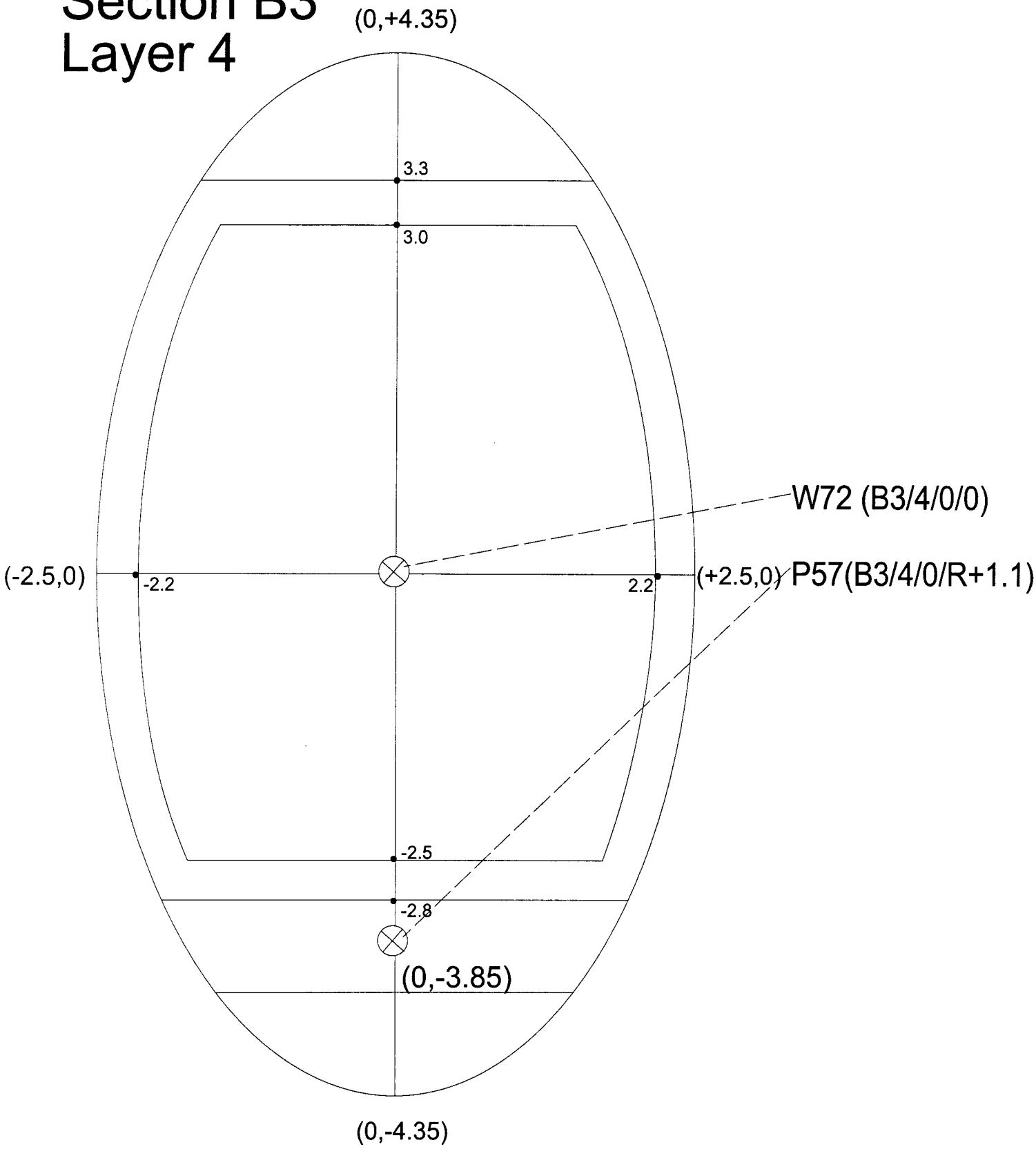

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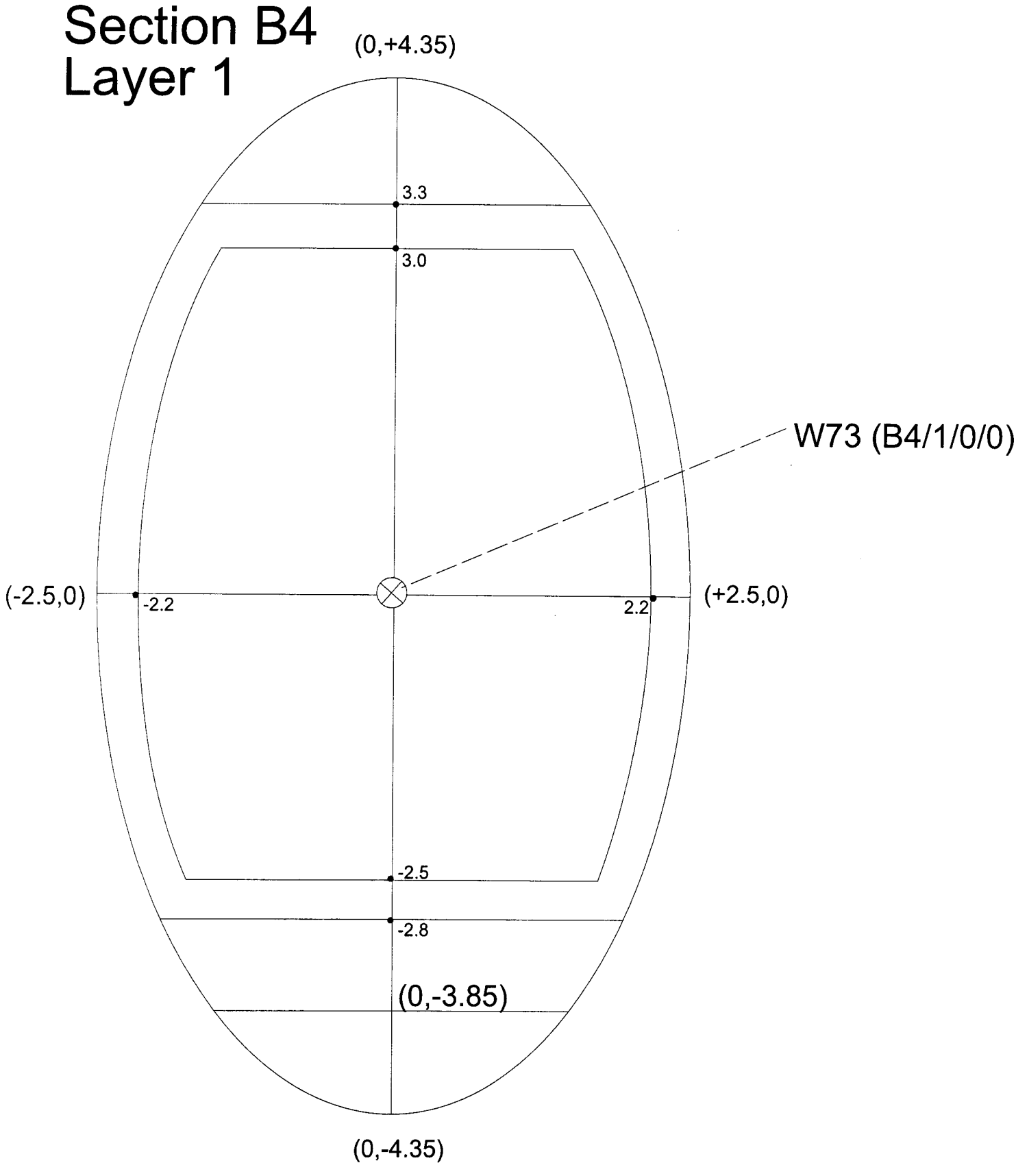
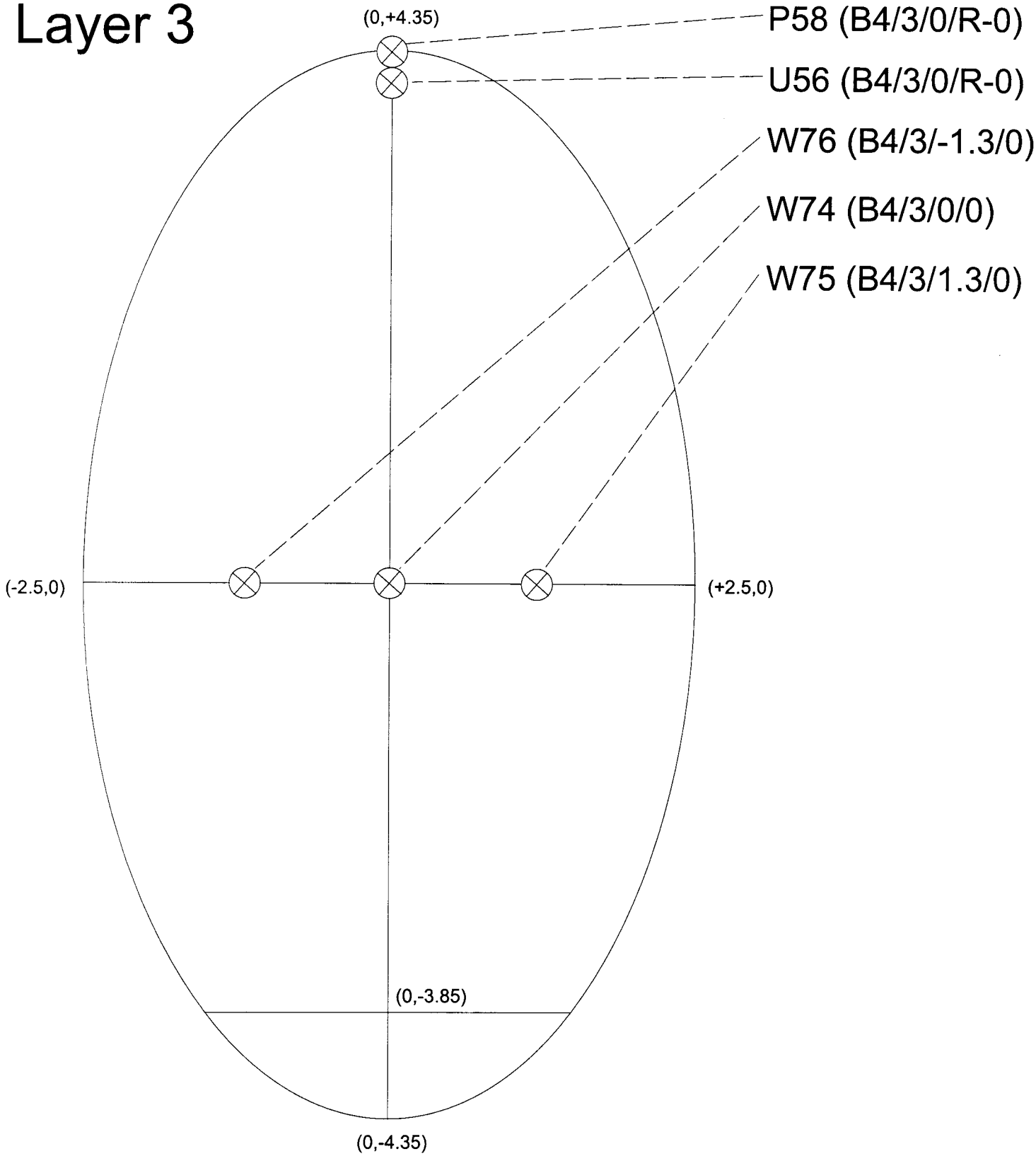


Instrument locations

Section B4
Layer 3



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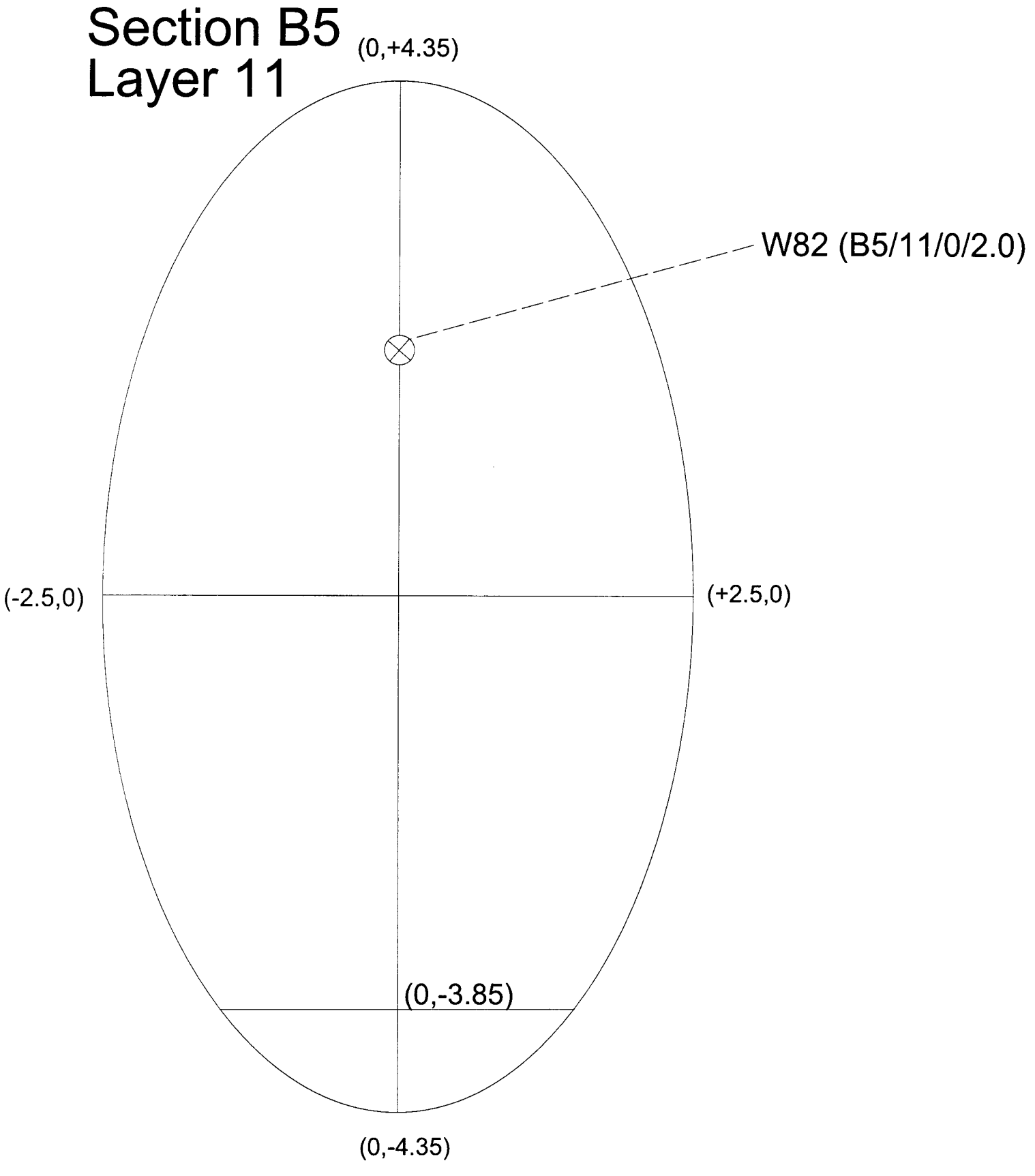

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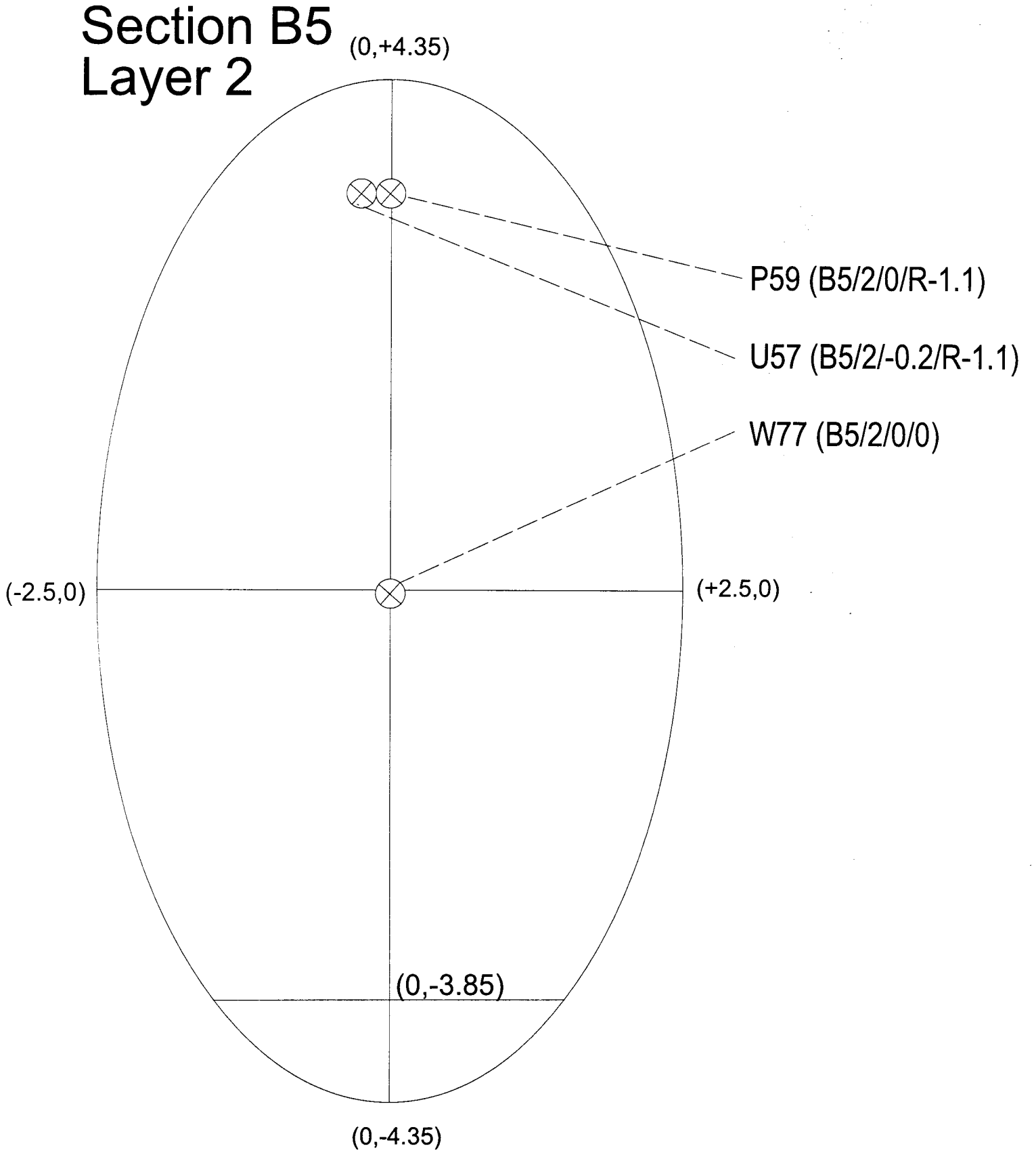

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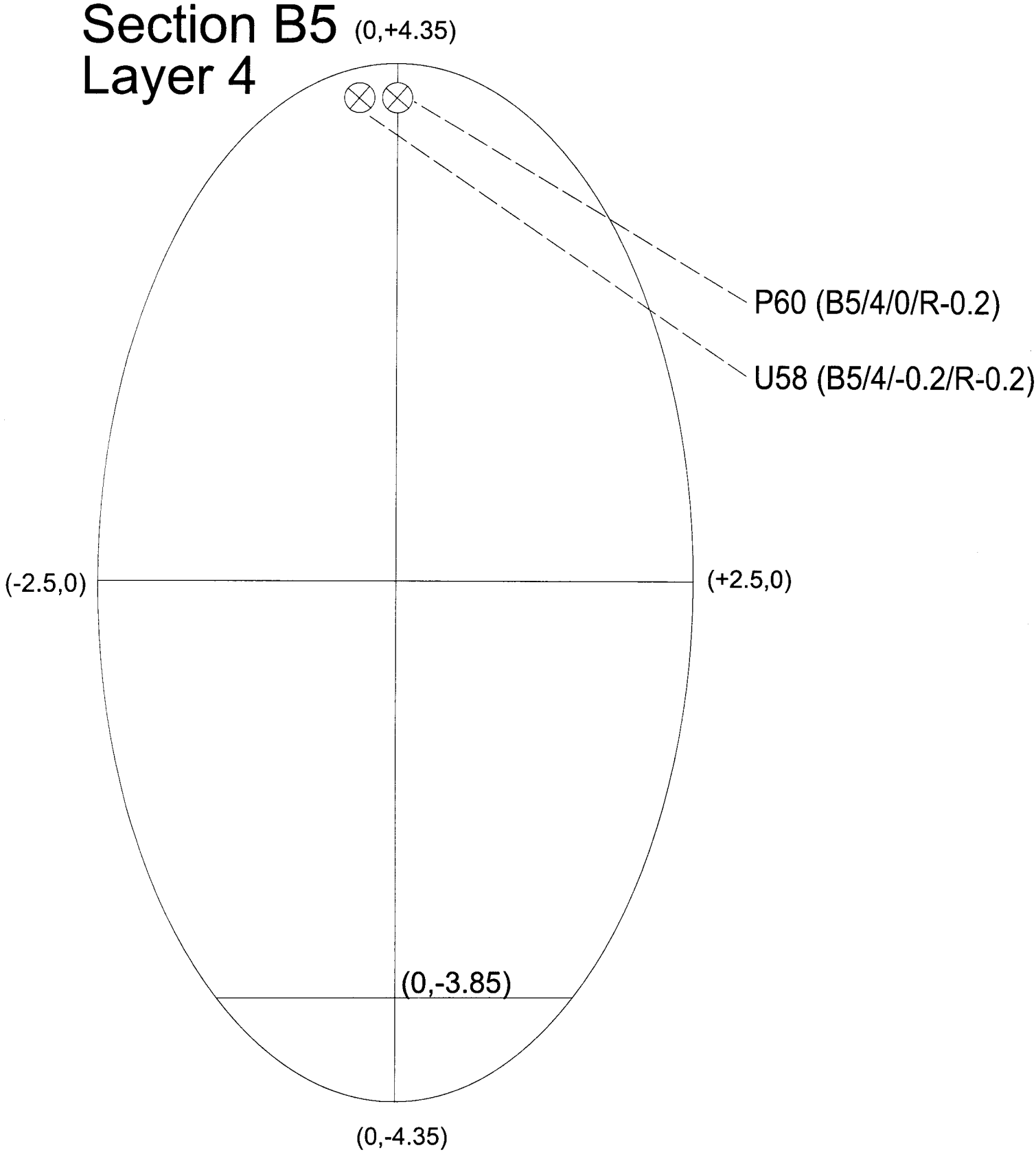

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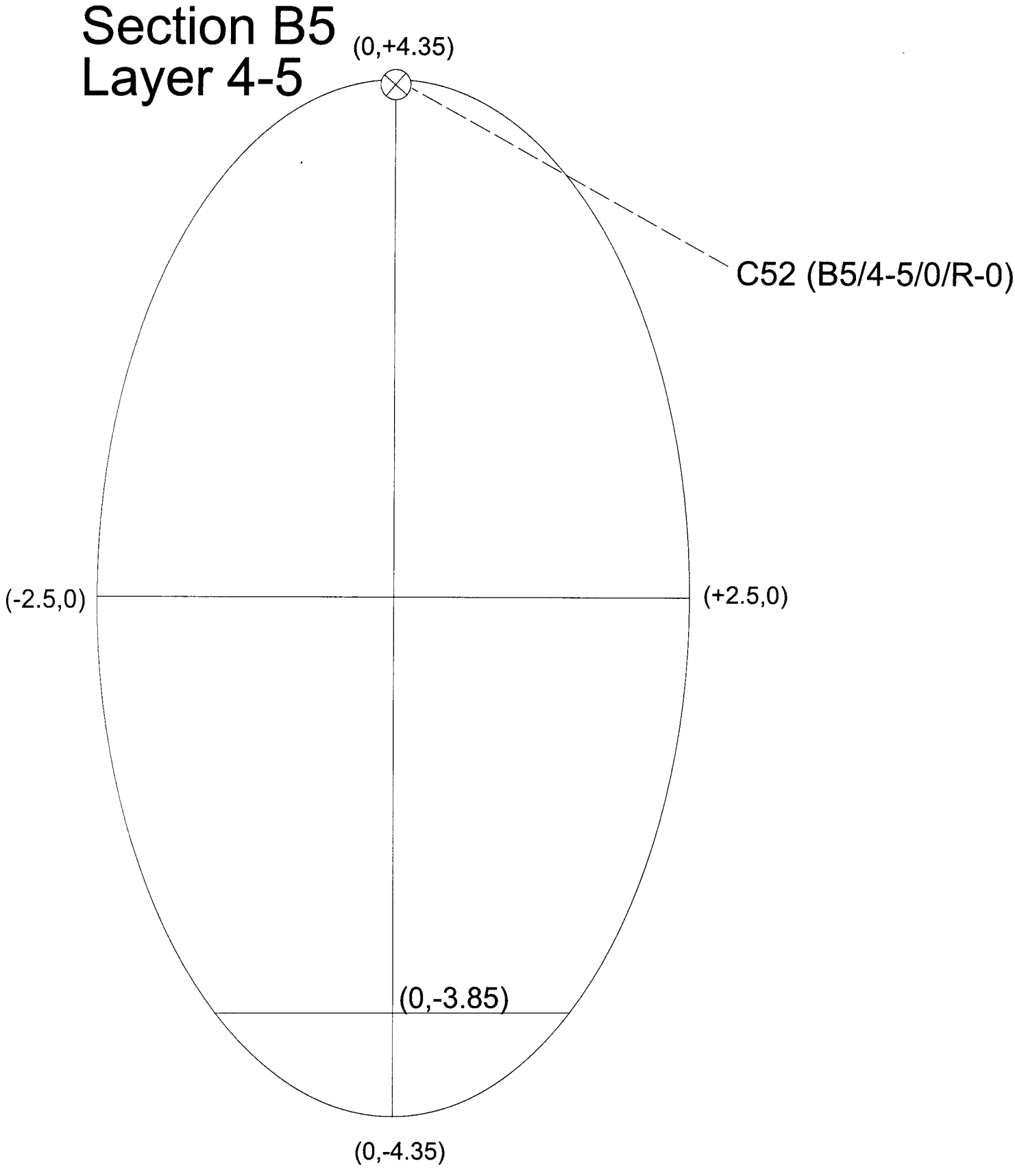

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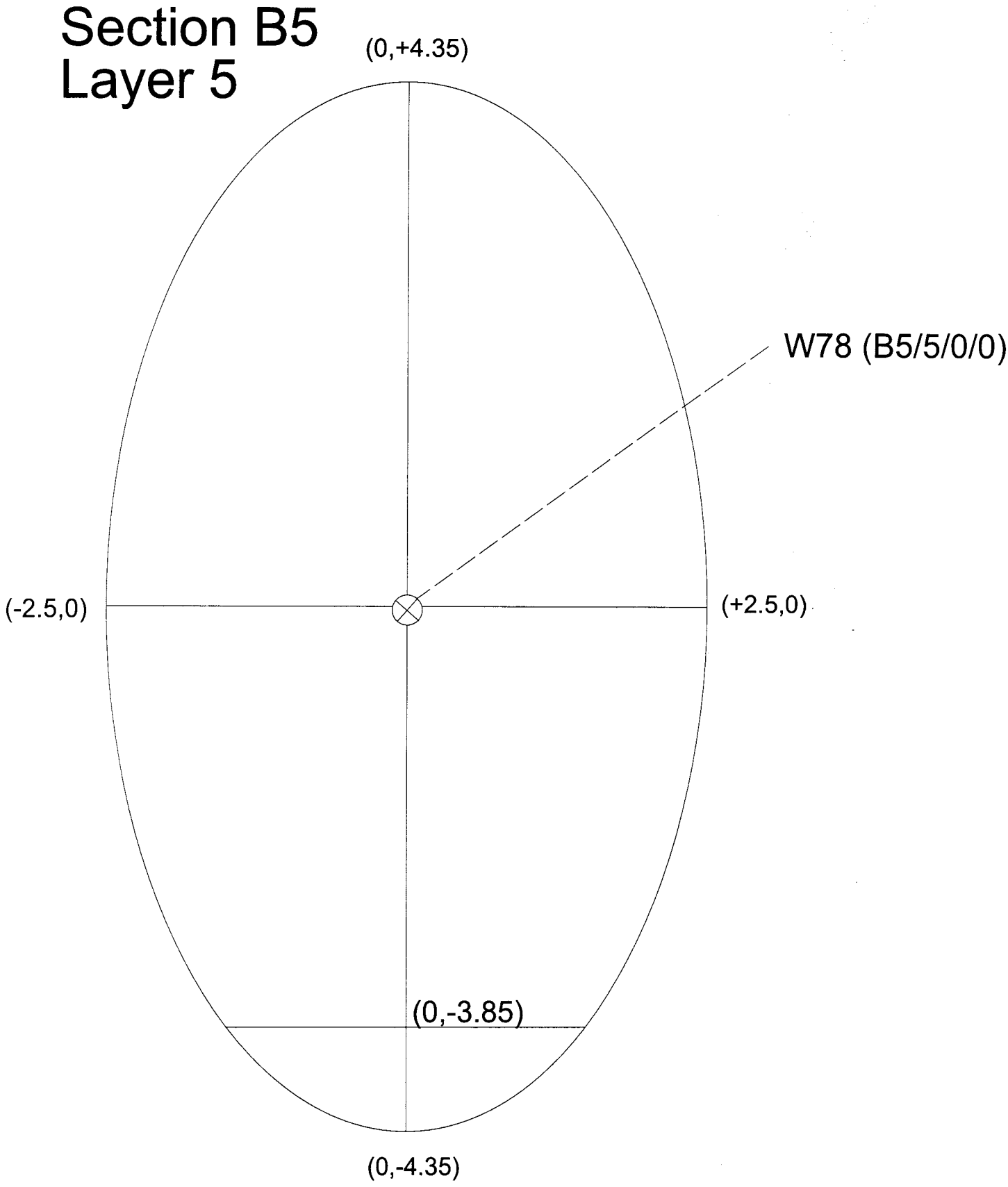

Instrument locations