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Äspö Hard Rock Laboratory

Canister Retrieval Test

Report on instrument positions and preparation of bentonite blocks for instruments and cables

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May 2000

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Abstract

This report describes the instrumentation in the bentonite for the deposition hole in the Canister Retrieval Test with identification numbering, exact location in each bentonite block and required preparations of each block for installation of instruments and cables. In the deposition hole temperature will be measured in 32 points, total pressure in 27 points, pore water pressure in 14 points and water content in 55 points. Additional temperature measurements can be done in some of the pressure gauges and in all water content gauges.

The positions of the measuring points in the bentonite are related to a coordinate system in the deposition hole. Three coordinates are related to every measuring point.

Sammanfattning

Denna rapport beskriver instrumenteringen av bentoniten i deponeringshålet i Canister Retrieval Test med identitetsnummer, exakt position i varje bentonitblock och erforderlig bearbetning av varje block för att kunna installera instrument och kablar. I deponeringshålet kommer temperaturen att mätas i 32 punkter, total trycket i 27 punkter, porvattentrycket i 14 punkter och vatten innehållet i 55 punkter. Ytterligare temperaturmätningar kan göras i flera av tryckgivarna och i alla givare som mäter vatteninnehållet.

Positionerna hos givarna i bentoniten är relaterade till ett koordinatsystem i deponeringshålet. Till varje mätpunkt finns kopplat tre koordinater.

Contents

Appendicies

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 Canister Retrieval Test is one project that will be performed at Äspö HRL with the purpose to

- demonstrate that a future retrieve of the nuclear waste is possible
- test and develop techniques for retrieving a copper canister

An important part of the work is to measure the thermal, hydraulic and mechanical processes in the bentonite during saturation. In the test hole measurements will be done in 128 points in the bentonite. Additional measurements will be done on the inside of the canister, on the canister surface and in the surrounding rock.

This report deals with the measurements in the bentonite. The instruments exact positions and the technique for placing them in the bentonite blocks will be described. The transducers and the measuring system are not described (see /1-1/).

2 Canister Retrieval Test

The Canister Retrieval Test is described in the test plan /2-1/. The test is located in the inner part of the D-tunnel. The test consists a full scale deposition hole, copper canister equipped with electrical heaters and bentonite blocks (cylindrical and ring shaped). A plug of concrete will be made on top of the bentonite.

The bentonite will be instrumented with pressure cells (total and water pressure), thermocouples and moisture gauges. Thermocouples will also be installed in the rock. In order to measure the axial swelling pressure from the bentonite, three strain gauges will be mounted in the rods holding the concrete plug. Temperature and strain will also be measured on the surface of the canister.

The saturation of the bentonite will be done artificially by vertical filter stripes. About 16 pieces with a width of 0.1 meters and a length of 5.5meters will be applied on the surrounding rock.

Slots will be made in the rock in order to lead out cables and tubes /2-2/.

3 Location of instruments in the bentonite

3.1 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 /1-1/.

Measurements of temperature

Thermocouples from BICC will be used to measure the temperature. Measurements will be done in 32 points in the test hole. In addition, temperature gauges are built in into the capacative relative humidity sensors (29 pcs) as well as in the pressure gauges of vibrating wire type (13 pcs). Temperature is also measured with the psychrometers. In addition temperature will be measured on the surface of the canister with optical fiber cables /1-1/.

Measurement of total pressure

Total pressure is the sum of the swelling pressure and the pore water pressure. It will be measured with the following instrument types:

- Geocon total pressure cells with vibrating wire transducer. 14 cells of this type will be installed in each of the test holes.
- Kulite total pressure cells with piezo resistive transducer. 14 cells of this type will be installed in each of the test holes.

Total pressure will be measured in totally 27 points in the test hole.

Measurement of pore water pressure

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

- Geocon pore pressure cells with vibrating wire transducer. 7 cells of this type will be installed in each of the test holes.

- Kulite pore pressure cells with piezo resistive transducer. 7 cells of this type will be installed in each of the test holes.

Pore pressure will be measured in totally 14 points in the test hole.

Measuring of the water saturation process

The water saturation process will be measured with the following techniques:

- Vaisala relative humidity sensor of capacitive type. 29 cells of this type will be installed in the test hole.

- Wescor psychrometers model PST-55. The 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 –6MPa or the water ratio 25-65% in the bentonite. 26 cells of this type will be installed in each of the test holes.

The water content will be measured in totally 55 points in the test hole.

3.2 Strategy for describing the position of each device

The deposition hole is termed DD0092G01 where "92" concerns the distance to the middle line in the A-tunnel. Measurements will be done in four vertical sections A, B, C and D according to Figure 3-1 and 3-2. Direction A and B are placed in the tunnels axial direction with A headed almost against north.

The bentonite blocks are called cylinders and rings. The cylinders are numbered C1-C4 and the rings R1-R10 respectively (Figure 3-1).

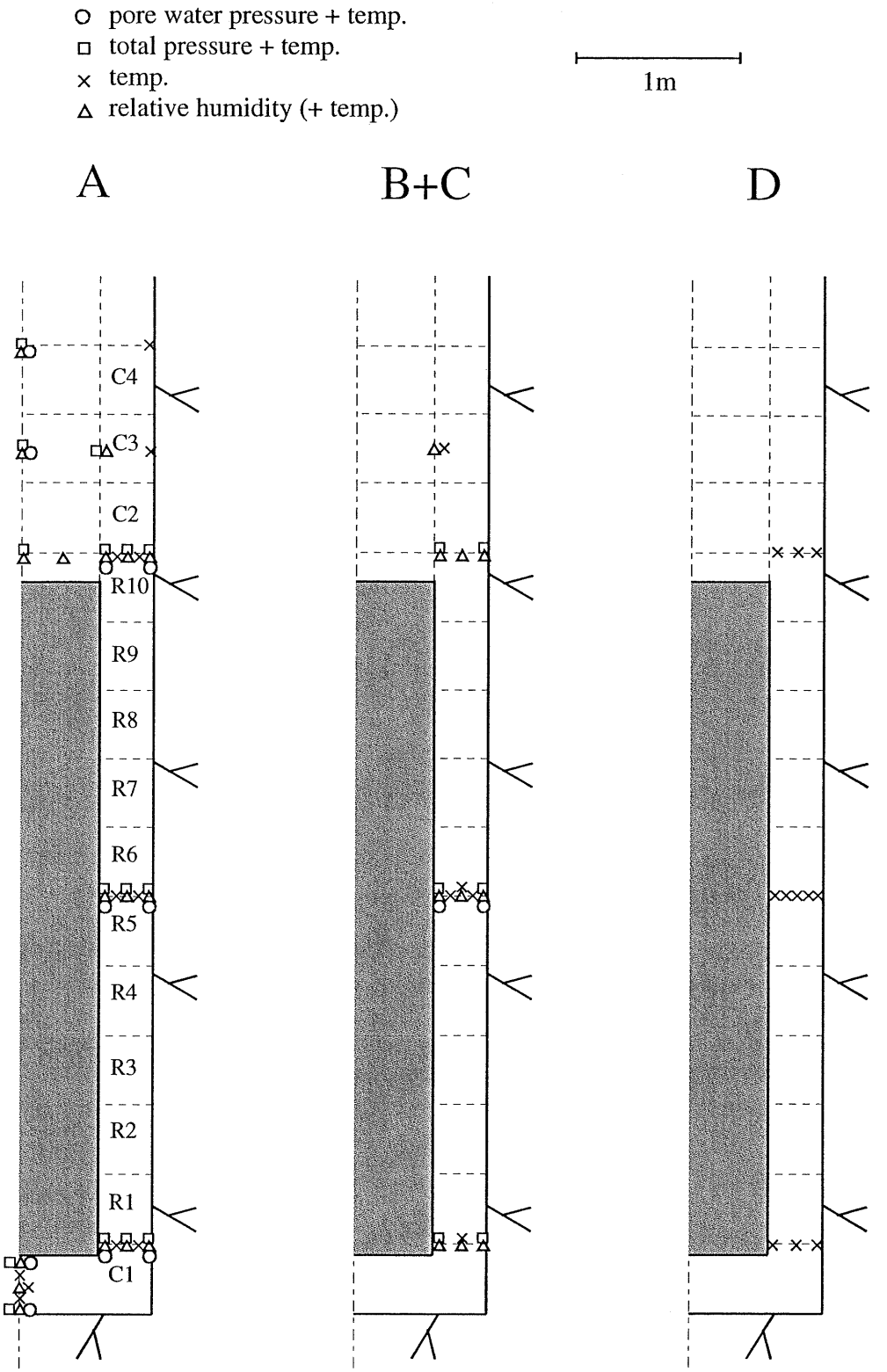


Figure 3-1 Schematic view over the instruments in four vertical sections and the block designation.

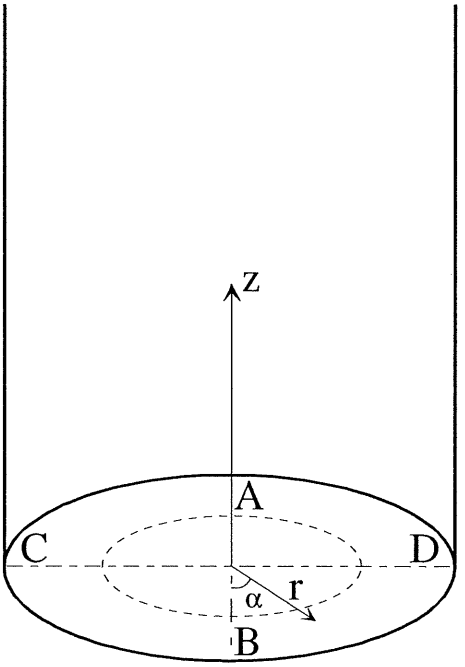


Figure 3-2 Figure describing the coordinate system used when determining the instrument positions.

Every instrument will be named with a short unique name consisting of 1-2 letters describing the type of measurement and 3 figures numbering the device. Every instrument position is described with three coordinates according to Figure 3-2. The r-coordinate is the horizontal distance from the center of the hole and the z-coordinate is the height from the bottom of the hole (the block height is set to 500mm). The α–coordinate is the angle from the vertical direction B (almost South according to Figure 4-1).

3.3 Position of each instrument in the bentonite, DD0092G01

The instruments are located in two main levels in the blocks, 50 mm and 160 mm, from the upper surface. The thermocouples are mostly placed in the 50mm level and the other gauges in the 160 mm level.

The position of the instruments are described in Tables 3-1 to 3-4.

Each instrumented bentonite block is shown in Appendix 1 with the position and numbering of the instruments.

Table 3-1 Numbering and position of instruments for measuring temperature (T)

		Instrument position in block				Cable pos.		
Type and number	Block	Direction	α	r	z	α	Fabricate	Remark
T101	Cyl. 1	Center	90	50	50	242	BICC	
T102	Cyl. 1	Center	90	50	250	238	BICC	
T103	Cyl. 1	Center	90	50	450	230	BICC	
T104	Cyl. 1	A	180	635	450	206	BICC	
T105	Cyl. 1	A	180	735	450	202	BICC	
T106	Cyl. 1	B	365	685	450	38	BICC	
T107	Cyl. 1	C	275	685	450	274	BICC	
T108	Cyl. 1	D	90	585	450	96	BICC	
T109	Cyl. 1	D	90	685	450	94	BICC	
T110	Cyl. 1	D	90	785	450	92	BICC	
T111	Ring 5	A	180	635	2950	224	BICC	
T112	Ring 5	A	180	735	2950	218	BICC	
T113	Ring 5	B	360	610	2950	318	BICC	
T114	Ring 5	B	360	685	2950	322	BICC	
T115	Ring 5	B	360	735	2950	324	BICC	
T116	Ring 5	C	270	610	2950	258	BICC	
T117	Ring 5	C	270	685	2950	260	BICC	
T118	Ring 5	C	270	735	2950	262	BICC	
T119	Ring 5	D	90	585	2950	44	BICC	
T120	Ring 5	D	90	635	2950	46	BICC	
T121	Ring 5	D	90	685	2950	48	BICC	
T122	Ring 5	D	90	735	2950	50	BICC	
T123	Ring 5	D	90	785	2950	52	BICC	
T124	Ring 10	A	180	635	5450	200	BICC	
T125	Ring 10	A	180	735	5450	194	BICC	
T126	Ring 10	D	90	585	5450	54	BICC	
T127	Ring 10	D	90	685	5450	56	BICC	
T128	Ring 10	D	90	785	5450	58	BICC	
T129	Cyl. 3	A	180	785	6250	166	BICC	
T130	Cyl. 3	B	365	585	6250	358	BICC	
T131	Cyl. 3	C	275	585	6250	280	BICC	
T132	Cyl. 4	A	180	785	6950	66	BICC	

Table 3-2 Numbering and position of instruments for measuring total pressure (P)

		Instrument position in block				Cable pos.		
Type and number	Block	Direction	α	r	Z	α	Fabricate	Remark
P101	Cyl. 1	Center	180	50	0	244	Kulite	In concrete
P102	Cyl. 1	Center	180	50	450	232	Kulite	
P103	Cyl. 1	A	185	585	340	208	Geocon	
P104	Cyl. 1	A	185	685	340	204	Geocon	
P105	Cyl. 1	A	185	785	340	186	Geocon	
P106	Cyl. 1	B	365	585	340	40	Geocon	
P107	Cyl. 1	B	365	785	340	2	Geocon	
P108	Cyl. 1	C	275	585	340	278	Kulite	
P109	Cyl. 1	C	275	785	340	270	Kulite	
P110	Ring 5	A	185	585	2840	228	Geocon	
P111	Ring 5	A	185	685	2840	222	Geocon	
P112	Ring 5	A	185	785	2840	188	Geocon	
P113	Ring 5	B	365	535	2840	36	Kulite	In the slot
P114	Ring 5	B	365	825	2840	16	Kulite	In the slot
P115	Ring 5	C	275	585	2840	296	Kulite	In the slot
P116	Ring 5	C	275	785	2840	290	Kulite	In the slot
P117	Ring 10	Center	180	50	5340	24	Kulite	
P118	Ring 10	A	180	585	5340	216	Geocon	
P119	Ring 10	A	180	685	5340	198	Geocon	
P120	Ring 10	A	180	785	5340	192	Geocon	
P121	Ring 10	B	365	585	5340	20	Kulite	
P122	Ring 10	B	365	785	5340	18	Kulite	
P123	Ring 10	C	275	585	5340	286	Kulite	
P124	Ring 10	C	275	785	5340	284	Kulite	
P125	Cyl. 3	Center	180	50	6250	158	Geocon	
P126	Cyl. 3	A	180	585	6250	162	Geocon	
P127	Cyl. 4	Center	180	50	6840	64	Kulite	

Table 3-3 Numbering and position of instruments for measuring pore water pressure (U)

		Instrument position in block				Cable pos.		
Type and number	Block	Direction	α	r	Z	α	Fabricate	Remark
U101	Cyl. 1	Center	270	50	50	246	Kulite	
U102	Cyl. 1	Center	270	50	450	236	Geocon	Horizontal
U103	Cyl. 1	A	175	585	340	126	Geocon	
U104	Cyl. 1	A	175	785	340	178	Kulite	
U105	Ring 5	A	175	585	2840	138	Geocon	
U106	Ring 5	A	175	785	2840	180	Kulite	
U107	Ring 5	B	355	535	2840	314	Kulite	In the slot
U108	Ring 5	B	355	825	2840	348	Kulite	In the slot
U109	Ring 5	C	265	585	2840	256	Geocon	In the slot
U110	Ring 5	C	265	825	2840	264	Geocon	In the slot
U111	Ring 10	A	175	585	5340	146	Kulite	
U112	Ring 10	A	175	785	5340	152	Geocon	
U113	Cyl. 3	Center	270	50	6250	156	Geocon	
U114	Cyl. 4	Center	270	50	6950	62	Kulite	

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

		Instrument position in block				Cable pos.		
Type and number	Block	Direction	α	r	Z	α	Fabricate	Remark
W101	Cyl. 1	Center	360	50	50	248	Vaisala	
W102	Cyl. 1	Center	360	400	160	240	Vaisala	
W103	Cyl. 1	Center	360	50	450	234	Vaisala	Horizontal
W104	Cyl. 1	A	180	585	340	128	Vaisala	
W105	Cyl. 1	A	180	685	340	132	Vaisala	
W106	Cyl. 1	A	180	785	340	184	Vaisala	
W107	Cyl. 1	A	170	585	340	124	Wescor	
W108	Cyl. 1	A	170	685	340	130	Wescor	
W109	Cyl. 1	A	170	785	340	134	Wescor	
W110	Cyl. 1	B	360	585	340	304	Vaisala	
W111	Cyl. 1	B	360	685	340	308	Vaisala	
W112	Cyl. 1	B	360	785	340	360	Vaisala	
W113	Cyl. 1	B	355	585	340	302	Wescor	
W114	Cyl. 1	B	355	685	340	306	Wescor	
W115	Cyl. 1	B	355	785	340	310	Wescor	
W116	Cyl. 1	C	270	585	340	250	Wescor	
W117	Cyl. 1	C	270	685	340	252	Wescor	
W118	Cyl. 1	C	270	785	340	254	Vaisala	
W119	Ring 5	A	180	585	2840	226	Vaisala	
W120	Ring 5	A	180	685	2840	220	Vaisala	
W121	Ring 5	A	180	785	2840	182	Vaisala	
W122	Ring 5	A	170	585	2840	136	Wescor	
W123	Ring 5	A	170	685	2840	140	Wescor	
W124	Ring 5	A	170	785	2840	142	Wescor	
W125	Ring 5	B	360	535	2840	316	Vaisala	In the slot
W126	Ring 5	B	360	685	2840	34	Vaisala	
W127	Ring 5	B	360	785	2840	350	Vaisala	
W128	Ring 5	B	350	535	2840	312	Wescor	In the slot
W129	Ring 5	B	350	685	2840	320	Wescor	
W130	Ring 5	B	350	785	2840	346	Wescor	
W131	Ring 5	C	270	585	2840	294	Wescor	In the slot
W132	Ring 5	C	275	685	2840	292	Wescor	
W133	Ring 5	C	270	785	2840	288	Wescor	
W134	Ring 10	Center	360	50	5340	22	Vaisala	
W135	Ring 10	A	180	262	5340	26	Vaisala	
W136	Ring 10	A	180	585	5340	214	Vaisala	
W137	Ring 10	A	180	685	5340	196	Vaisala	
W138	Ring 10	A	180	785	5340	190	Vaisala	
W139	Ring 10	A	170	585	5340	144	Wescor	
W140	Ring 10	A	170	685	5340	148	Wescor	
W141	Ring 10	A	170	785	5340	150	Wescor	
W142	Ring 10	B	360	585	5340	328	Vaisala	
W143	Ring 10	B	360	685	5340	332	Vaisala	
W144	Ring 10	B	360	785	5340	336	Vaisala	
W145	Ring 10	B	355	585	5340	326	Wescor	
W146	Ring 10	B	355	685	5340	330	Wescor	
W147	Ring 10	B	355	785	5340	334	Wescor	
W148	Ring 10	C	270	585	5340	266	Wescor	
W149	Ring 10	C	270	685	5340	268	Wescor	
W150	Ring 10	C	270	785	5340	272	Vaisala	
W151	Cyl. 3	Center	360	50	6250	154	Vaisala	
W152	Cyl. 3	A	180	585	6250	160	Vaisala	
W153	Cyl. 3	B	360	585	6250	356	Vaisala	
W154	Cyl. 3	C	270	585	6250	276	Wescor	
W155	Cyl. 4	Center	360	50	6840	60	Vaisala	

4 Position of each cable and tube on the block periphery

All cables and tubes, coming out from the instruments in the bentonite blocks, from the thermocouples in the rock, from the filter mats, the two 12 mm signal cables from the canister and the four fiber optic cables also from the canister will be lead up, in the slot between the rock and the blocks, along the bentonite block periphery surface. In order to pass the cement plug, slots are made in the rock (Figure 4-1). The other cables from the canister (2 x 38 mm power cable and 2 x 38 mm signal cable) will be led directly into slots on a level with the canisters upper surface. The other cables and tubes will enter the slots about 700 mm under the cement plug.

Since a lot of cables and tubes will be led in the slot between rock and bentonite in the deposition hole (about 180 units) it's important to distribute them on the block periphery in prescribed order. Every cable or tube has an α–coordinate (Table 3-1 to 3-4), which is the angle from direction B (Figure 3-2). In this position on the bentonite block periphery, the cable or the tube will be led. The tubes and cables will be kept in place by expandable straps.

The bentonite block periphery is divided in sections, where the cables and tubes within every sector are predestinated for a special slot (Table 4.1 and 4.2). The slots are described in detail in /2-2/.

4.1 Cables and tubes from instruments in the bentonite

All instrument cables are led in titanium tubes (Ø 8 mm or Ø 6 mm) except for the thermocouples (Ø 4.5 mm) which are made of cupro nickel. Tracks will be made on the block surface from the instrument position in the bentonite block to the decided position on the bentonite block periphery. They will be bend and led axial along the bentonite block.

4.2 Tubes from the filter mats

The tubes leading water to the filter mats have an outer diameter of 6mm and are made of acid proof steel. Four tubes come from the bottom of the hole and are led along the bentonite block periphery to the slots in the rock. Four tubes start about 500 mm under the cement plug and enter the slots directly.

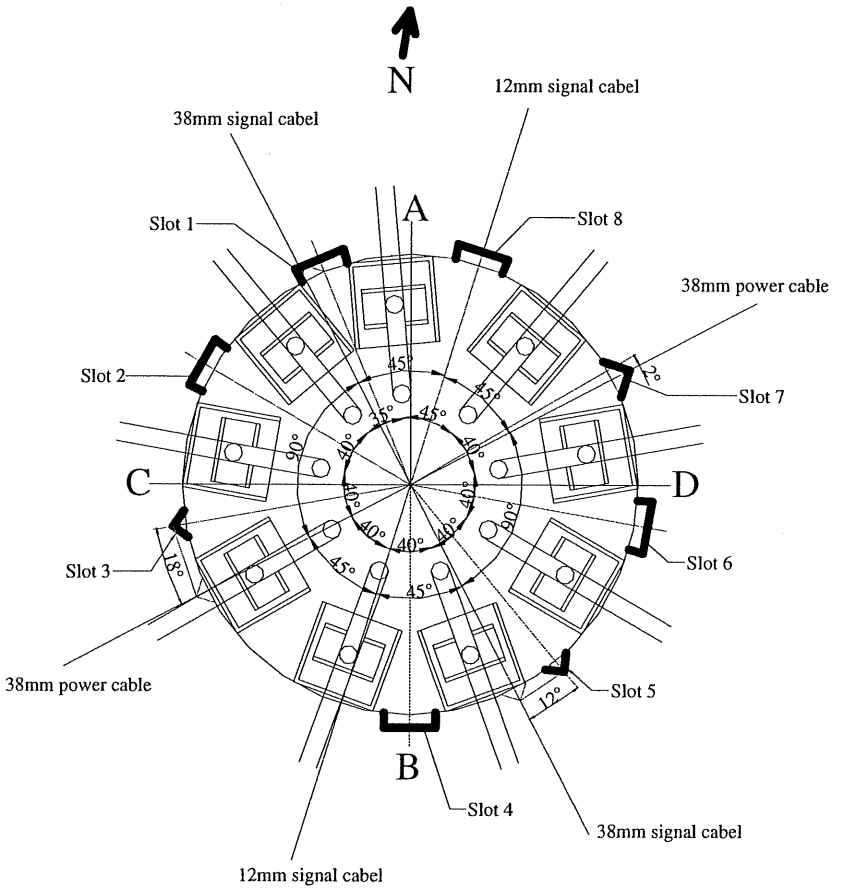


Figure 4-1 Schematic view over deposition hole DD0092G01, showing the position of the slots relative the rods and the cables from the canister.

Table 4-1 Table showing how the cables and tubes are distributed in the slots in deposition hole DD0092G01.

Slot 1 Instrument No.	Cable position α
W121	182
W06	184
P105	186
P112	188
W138	190
P120	192
T125	194
W137	196
P119	198
T124	200
T105	202
P104	204
T104	206
Optic Fiber	207
P103	208
38mm Signal	210
	212
W136	214
P118	216
T112	218
W120	220
P111	222
T111	224
W119	226
P110	228

Slot 2 Instrument No.	Cable position α
T103	230
P102	232
W103	234
U102	236
T102	238
W102	240
T101	242
P101	244
U101	246
W101	248
W116	250
W117	252
W118	254
U109	256
T116	258
T117	260
T118	262
U110	264
W148	266
W149	268
P109	270
W150	272
T107	274
W154	276
P108	278
OpticFiber	280
T131	280
38mm El.Out	282
P124	284
P123	286
W133	288
P116	290
W132	292
W131	294
P115	296

Slot 3 Instrument No.	Cable position α
38mm El.In	300

Slot 4 Instrument No.	Cable position α
W113	302
W110	304
W114	306
W111	308
W115	310
W128	312
U107	314
W125	316
T113	318
2 x Optic Fiber	320
W129	322
T114	324
T115	326
W145	328
W142	330
W146	332
W143	334
W147	336
W144	338
	340
	342
12mm Signal	344
W130	346
U108	348
W127	350
	352
	354
W153	356
T130	358
W112	360
P107	2
	4
TR105-TR108	6
	8
TR117-TR120	10
	12
TR129-TR132	14
P114	16
P122	18
P121	20
W134	22
P117	24
W135	26
	28
38mm Sig.In	30
	32
W126	34
P113	36
T106	38
P106	40

Slot 5 Instrument No.	Cable position α
38mm Sig.Out	42

Slot 6 Instrument No.	Cable position α
T119	44
T120	46
T121	48
T122	50
T123	52
T126	54
T127	56
T128	58
W155	60
U114	62
P127	64
T132	66
	68
	70
	72
TR101-TR104	74
	76
TR109-TR112	78
	80
TR121-TR124	82
	84
TR133-TR136	86
	88
	90
T110	92
T109	94
T108	96
	98
	100
	102
	104
	106
	108
	110
	112
	114
	116

Slot 7 Instrument No.	Cable position α
	118
38mm El.	120
	122

Slot 8 Instrument No.	Cable position α
W107	124
U103	126
W104	128
W108	130
W105	132
W109	134
W122	136
U105	138
W123	140
W124	142
W139	144
U111	146
W140	148
W141	150
U112	152
W151	154
U113	156
P125	158
W152	160
P126	162
12mm Signal	164
T129	166
TR113-TR116	168
	170
TR125-TR128	172
	174
TR137-TR140	176
U104	178
U106	180

4.3 Thermocouples from the rock

40 thermocouples will be placed in the rock and on the rock surface. Holes will be bored in three directions in three levels and one additional hole will be bored in the bottom of the deposition hole i.e. totally 10 holes. The installation of the thermocouples is described in Quality Plan /4-1/. They are of the same type as those in the bentonite i.e. the material is cupro nickel and the outer diameter is 4.5 mm. They are led from the rock, over the gap between rock and bentonite and up along the bentonite block periphery. The position of the thermocouples in the rock and on the bentonite block periphery is shown in Table 4-2.

Table 4-2 Numbering and position of thermocouples in the rock, DD0092G01 (T)

				Cable pos.		
Type and number	Level	Direction	Distance from rock surface	α	Fabricate	Remark
TR101	0	Center	0.000	70°-90°	BICC	
TR102	0	Center	0.375	70°-90°	BICC	
TR103	0	Center	0.750	70°-90°	BICC	
TR104	0	Center	1.500	70°-90°	BICC	
TR105	0.61	10°	0.000	4°-14°	BICC	
TR106	0.61	10°	0.375	4°-14°	BICC	
TR107	0.61	10°	0.750	4°-14°	BICC	
TR108	0.61	10°	1.500	4°-14°	BICC	
TR109	0.61	80°	0.000	70°-90°	BICC	
TR110	0.61	80°	0.375	70°-90°	BICC	
TR111	0.61	80°	0.750	70°-90°	BICC	
TR112	0.61	80°	1.500	70°-90°	BICC	
TR113	0.61	170°	0.000	168°-176°	BICC	
TR114	0.61	170°	0.375	168°-176°	BICC	
TR115	0.61	170°	0.750	168°-176°	BICC	
TR116	0.61	170°	1.500	168°-176°	BICC	
TR117	3.01	10°	0.000	4°-14°	BICC	
TR118	3.01	10°	0.375	4°-14°	BICC	
TR119	3.01	10°	0.750	4°-14°	BICC	
TR120	3.01	10°	1.500	4°-14°	BICC	
TR121	3.01	80°	0.000	70°-90°	BICC	
TR122	3.01	80°	0.375	70°-90°	BICC	
TR123	3.01	80°	0.750	70°-90°	BICC	
TR124	3.01	80°	1.500	70°-90°	BICC	
TR125	3.01	170°	0.000	168°-176°	BICC	
TR126	3.01	170°	0.375	168°-176°	BICC	
TR127	3.01	170°	0.750	168°-176°	BICC	
TR128	3.01	170°	1.500	168°-176°	BICC	
TR129	5.41	10°	0.000	4°-14°	BICC	
TR130	5.41	10°	0.375	4°-14°	BICC	
TR131	5.41	10°	0.750	4°-14°	BICC	
TR132	5.41	10°	1.500	4°-14°	BICC	
TR133	5.41	80°	0.000	70°-90°	BICC	
TR134	5.41	80°	0.375	70°-90°	BICC	
TR135	5.41	80°	0.750	70°-90°	BICC	
TR136	5.41	80°	1.500	70°-90°	BICC	
TR137	5.41	170°	0.000	168°-176°	BICC	
TR138	5.41	170°	0.375	168°-176°	BICC	
TR139	5.41	170°	0.750	168°-176°	BICC	
TR140	5.41	170°	1.500	168°-176°	BICC	

4.4 Cables from the canister

From the canister comes the following cables:

- 2 x 38 mm power cables for the electrical heaters
- 2 x 38 mm signal cable from strain gauges inside the canister
- 2 x 12mm signal cable from strain gauges on the canister surface
- 4 x 2 mm fiber optic cables (two loops) from the temperature measurements on the canister surface

The direction of the cables are shown in Figure 4-4 and in Table 4-2.

From the canister the cables are led through the bentonite where slots have been sawed in advance (block no. R10), see Figure 4-4. The four 38 mm cables are then led directly into slots in the rock, but the two 12 mm signal cables and the four fiber optic cables are led up along the bentonite block periphery surface and are entering slots in the rock about 700 mm under the cement plug.

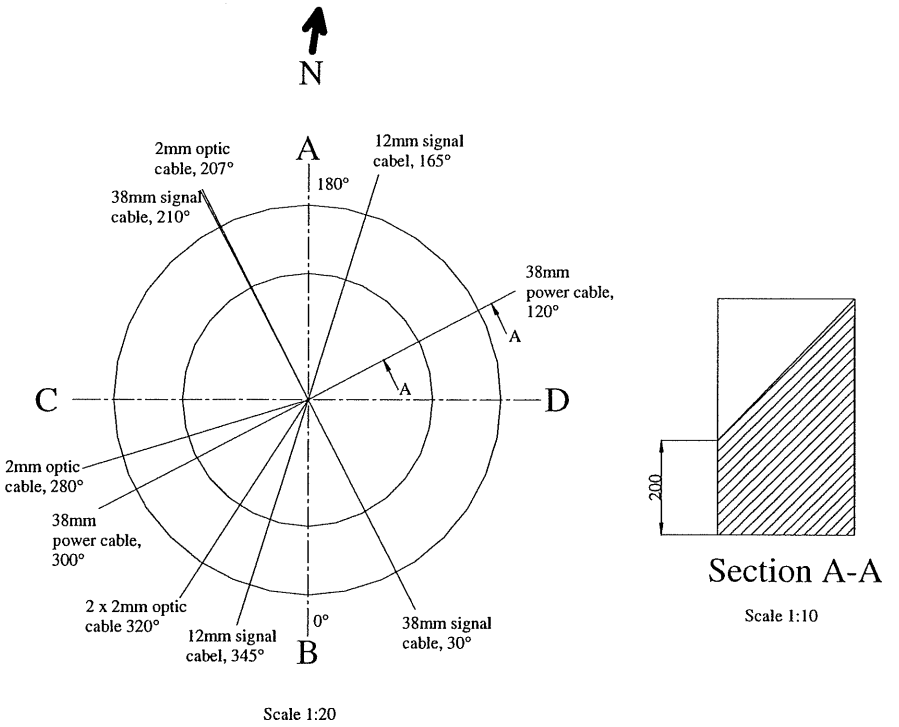


Figure 4-2 Figure showing the directions of cables from the canister relative the instrument directions A, B, C and D in block R10. In this block will slots be sawed in order to let the cables pass through the bentonite and out to the rock.

5 Preparation of the bentonite blocks

5.1 Preparation for instruments

Every instrumented block (see Appendix 1) will be prepared in advance, i.e. most of the bentonite work will be done on the ground in a laboratory. The preparation is somewhat different depending on instrument type.

Thermocouples

They have an outer diameter of 4.5 mm. A hand-hold boring-machine with a 5.0 mm drill will be used at installation.

Total pressure

- **Geokon.**. Shaped as a cylindrical tube with an outer diameter of 25 mm and a length of 117 mm. The holes for these gauges will be bored with a drilling machine of Hilti-type fastened with a vacuum plate.

- **Kulite.** Shaped as an ice hockey puck with a diameter of 55 mm and a thickness of 23 mm. The instruments are countersunk in the bentonite block surface by use of a hand hold cutter.

Pore pressure

- **Geokon.**. Shaped as a cylindrical tube with an outer diameter of 25 mm and a length of 127 mm. The holes for these gauges will be bored with a drilling machine of Hilti-type fastened with a vacuum plate.

- **Kulite.** Shaped as a cylindrical tube with an outer diameter of 19 mm and a length of 55 mm.. The holes for these gauges will be bored with a drilling machine of Hilti-type fastened with a vacuum plate

Water content

- **Vaisala.**. Shaped as a cylindrical tube with an outer diameter of 22 mm and a length of 63 mm. The holes for these gauges will be bored with a drilling machine of Hilti-type fastened with a vacuum plate.

- **Wescor.** Shaped as a cylindrical tube with an outer diameter of 22 mm and a length of 35 mm.. The holes for these gauges will be bored with a drilling machine of Hilti-type fastened with a vacuum plate

5.2 Tracks for cables and tubes on the bentonite blocks surface

Tracks will be made on the blocks surface from each instrument position, leading out the tubes to the block periphery. The tracks will be made by a hand–hold cutter.

5.3 Preparation for cables through block R10

The cables from the canister must be led through the bentonite (block R10). This will be done by sawing slots in the bentonite block in advance (see Figure 4-2). The slots will have different width depending on the cable type. They will be sawed with a special alligator-saw.

The slots will result in a weakening of the bentonite block since about 30% of the cross-section will be cut off. In order to minimize the strain, a special case will be manufactured which will be placed in the center of the block during all handling.

References

/1-1/ **Collin M and Börgesson L.** Canister Retrieval Test. Instrumentering av buffert för registrering av THM-processer

/2-1/ Test Plan for Canister Retrieval Test.

/2-2/ **Sandén T and Börgesson L.** Placering och utformning av slitsar för kablar från kapsel och instrument i Återtagsförsöket. Technical Document TD 00-08

/4-1/ **Dahlström L-O.** Installation av temperaturgivare runt deponeringshålen i Återtagsförsöket

APPENDIX

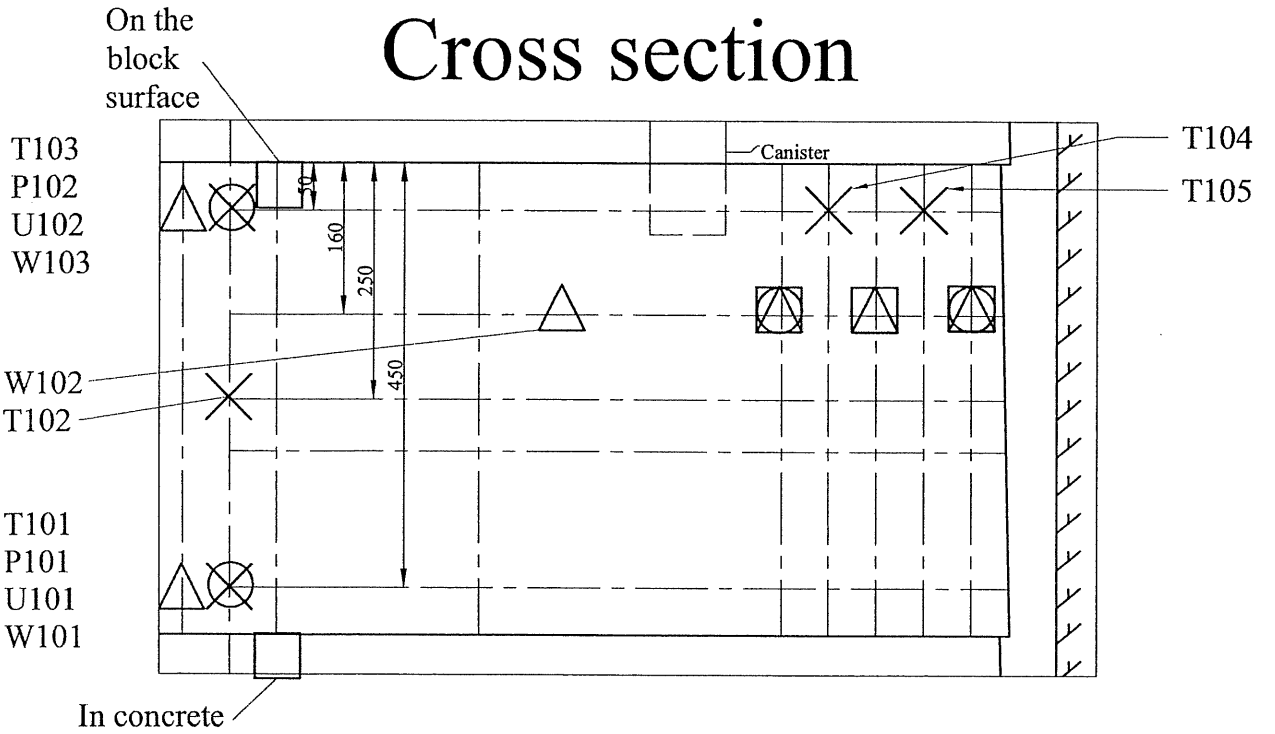
Instrument locations

DD0092G01

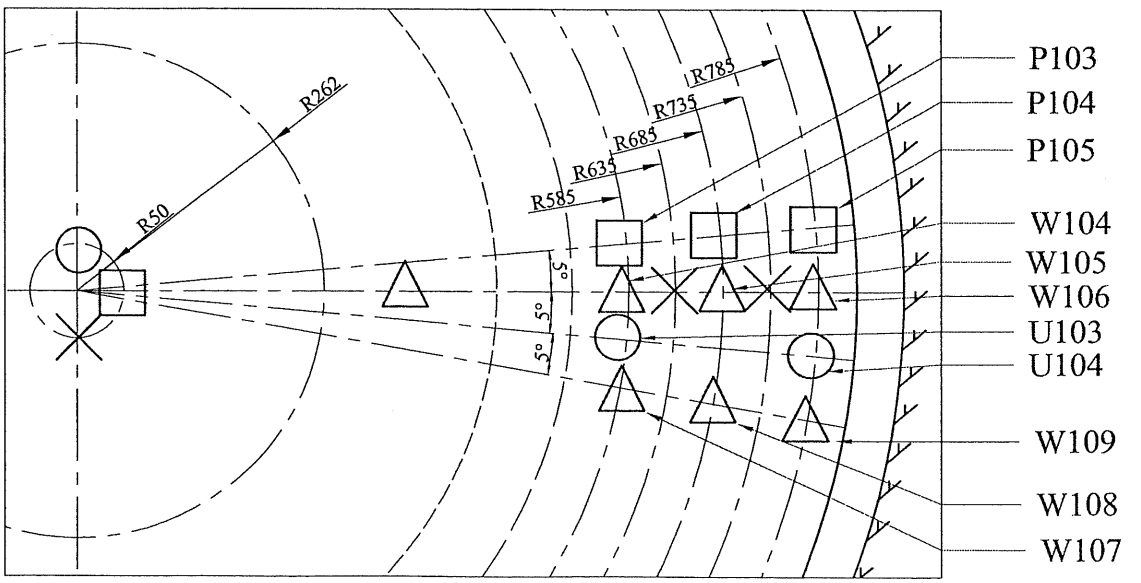
Cylinder 1

Instrument direction A (180°) and Center

Cross section



Top view



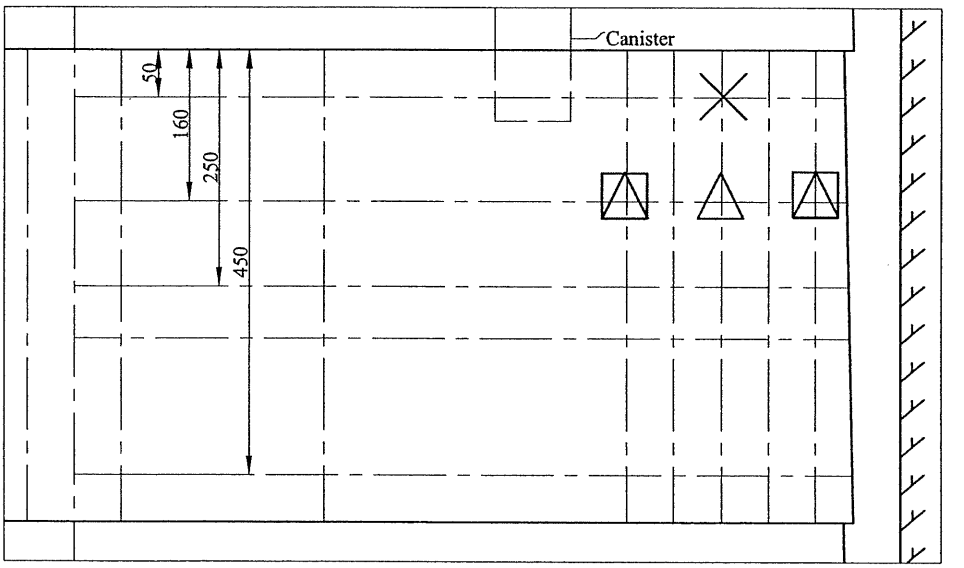
Instrument locations

DD0072G01

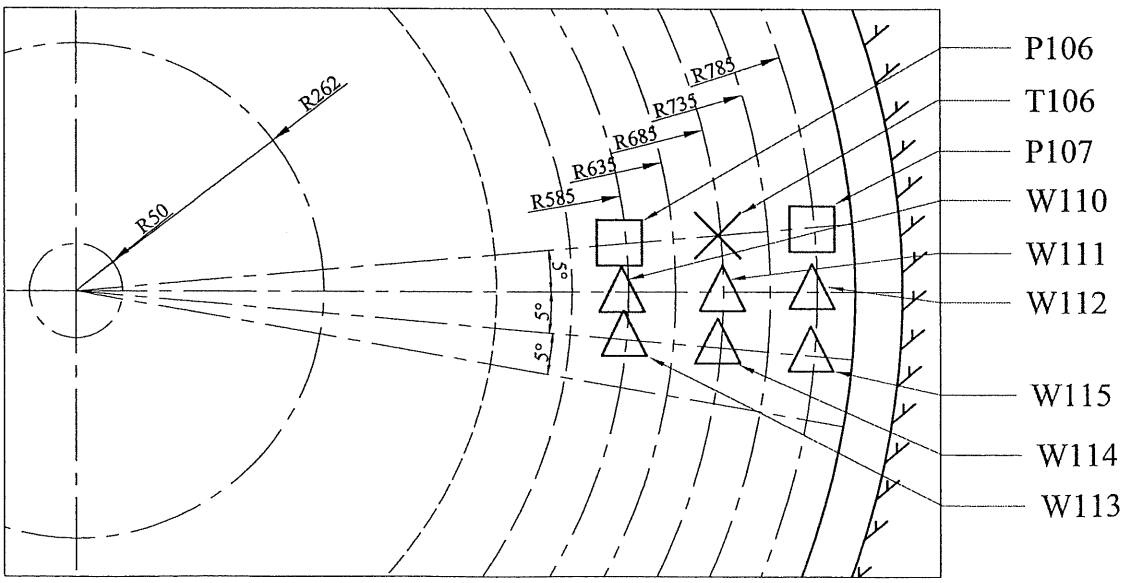
Cylinder 1

Instrument direction B (0°)

Cross section



Top view



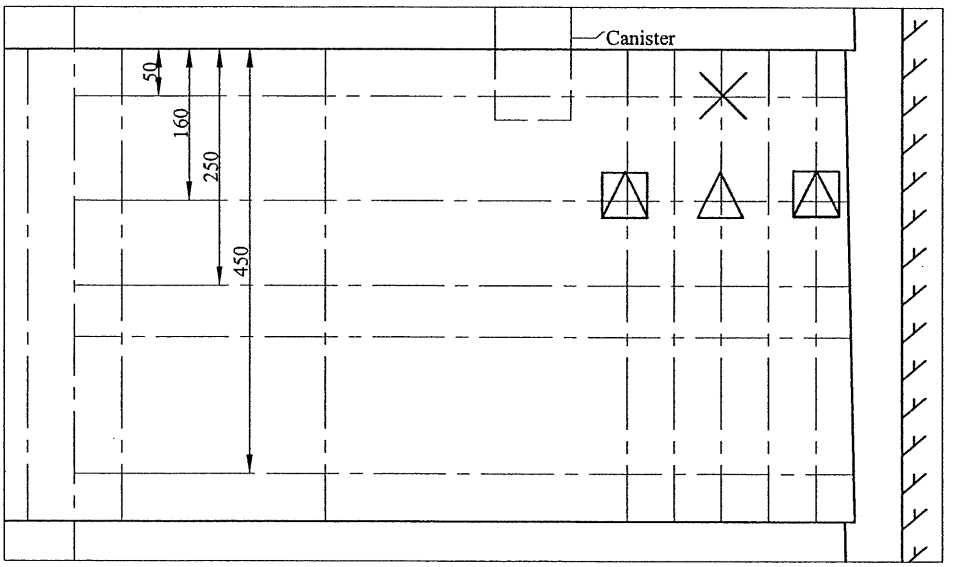
Instrument locations

DD0092G01

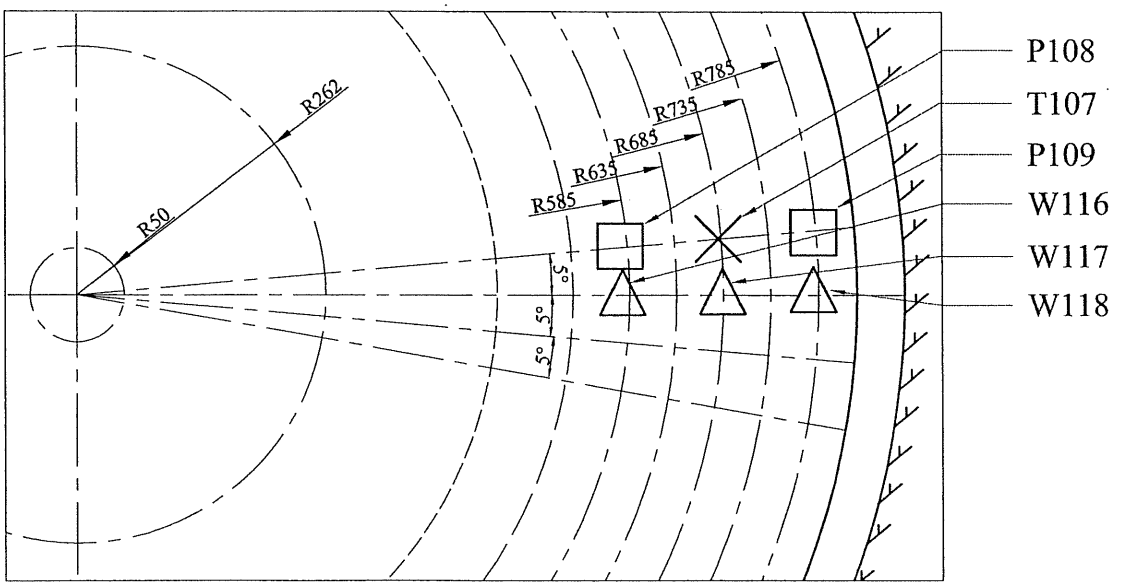
Cylinder 1

Instrument direction C (270°)

Cross section



Top view



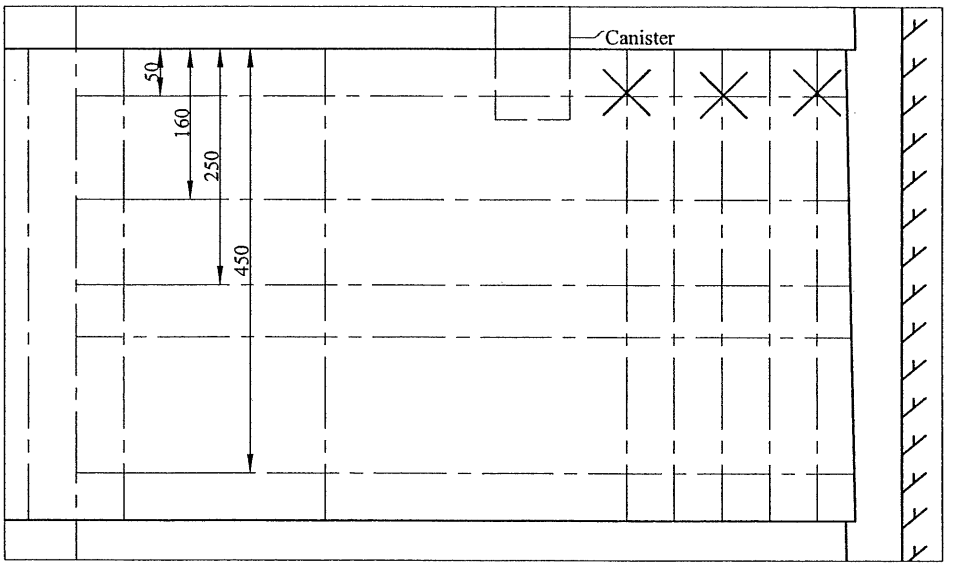
Instrument locations

DD0092G01

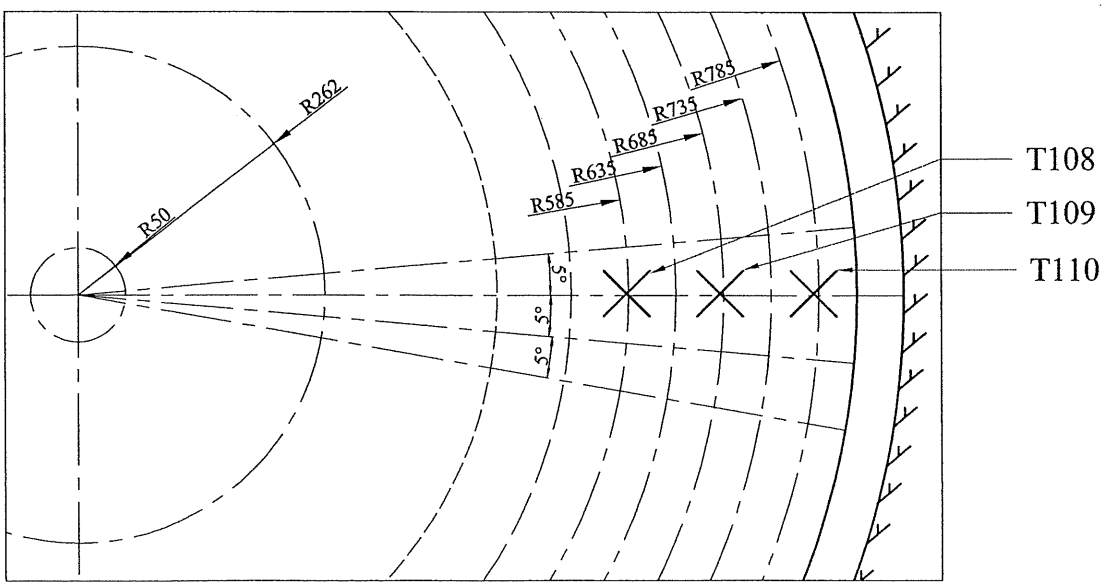
Cylinder 1

Instrument direction D (90°)

Cross section



Top view



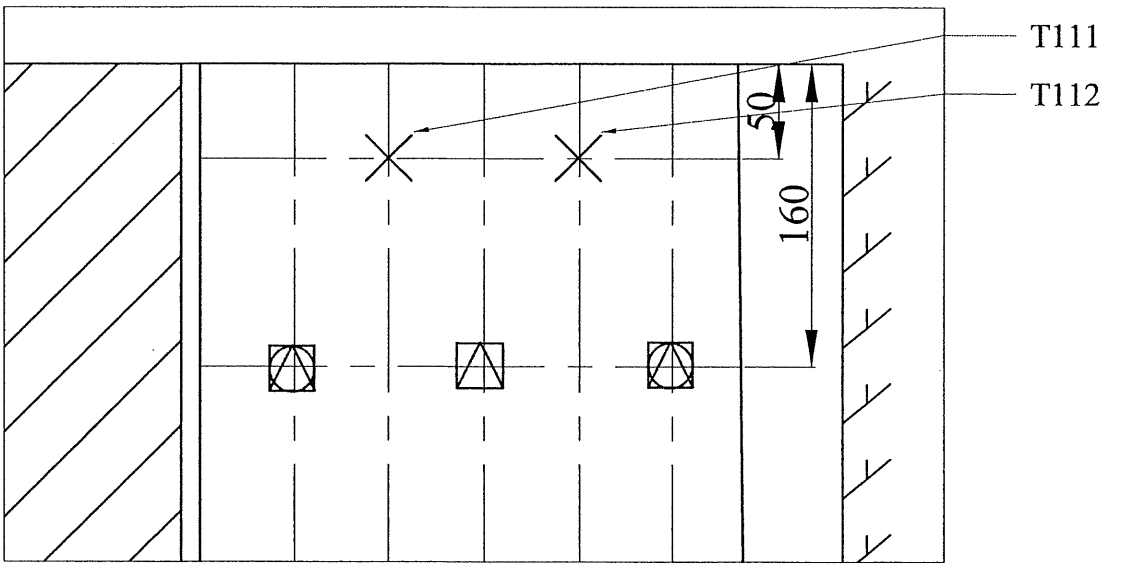
Instrument locations

DD0092G01

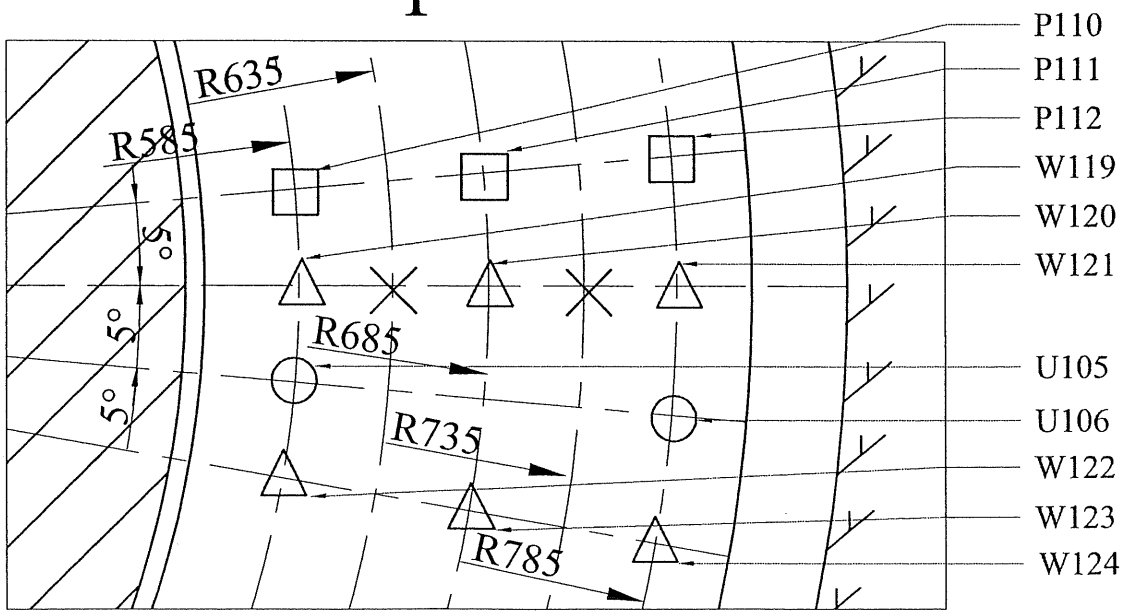
Ring 5

Instrument direction A (180°)

Cross section



Top view



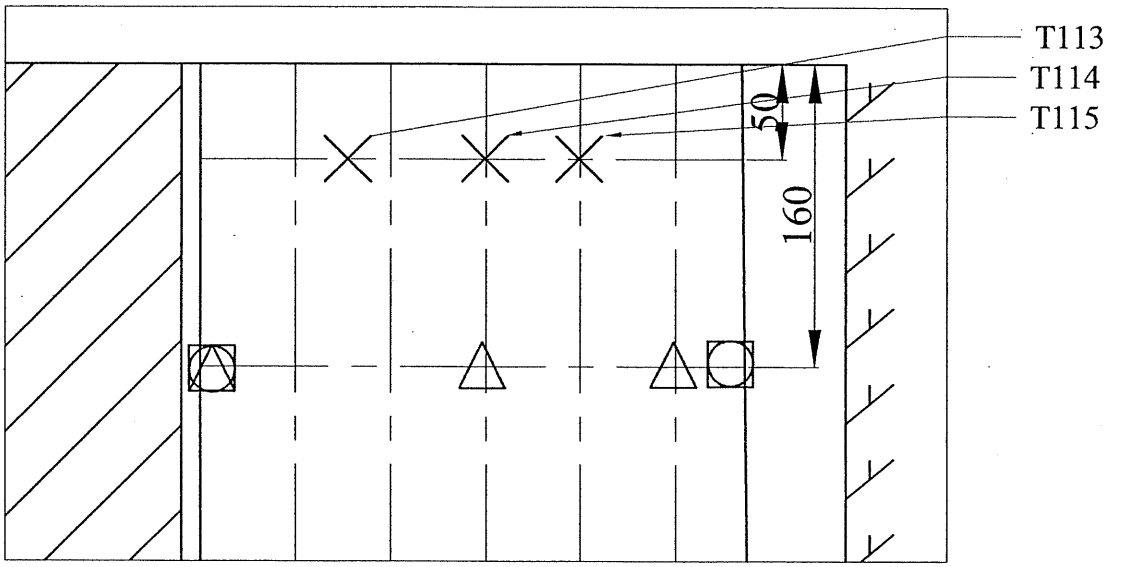
Instrument locations

DD0092G01

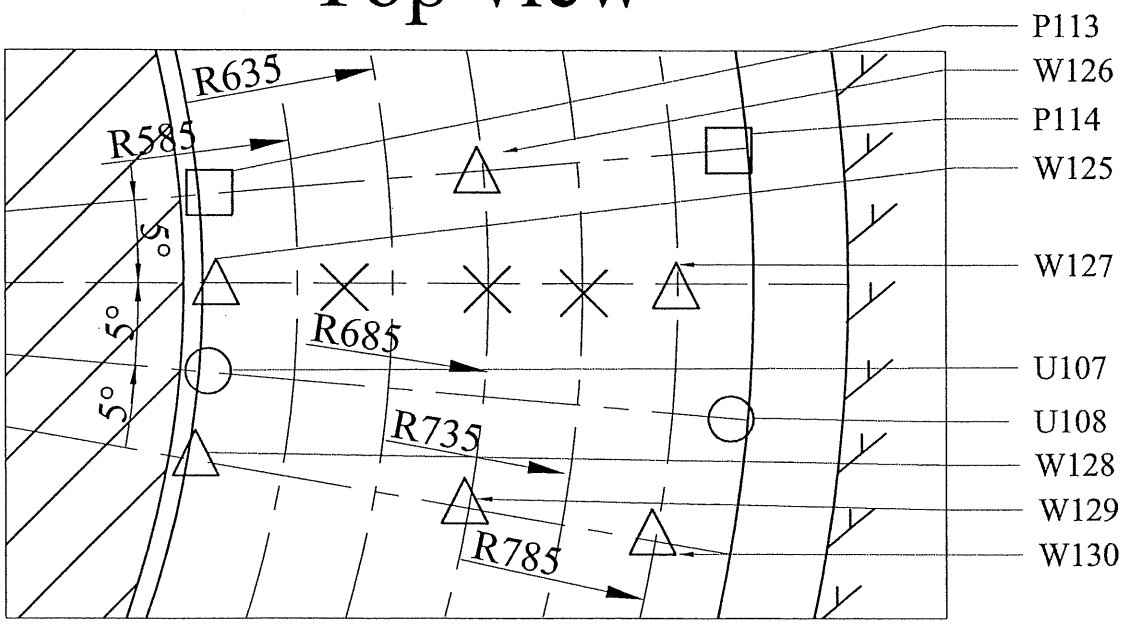
Ring 5

Instrument direction B (180°)

Cross section



Top view



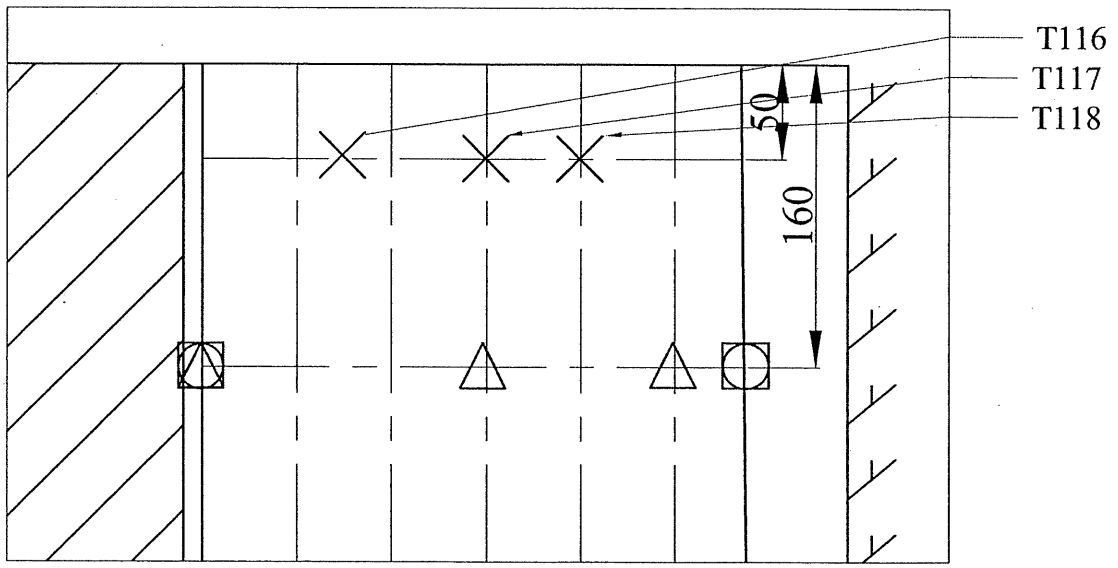
Instrument locations

DD0092G01

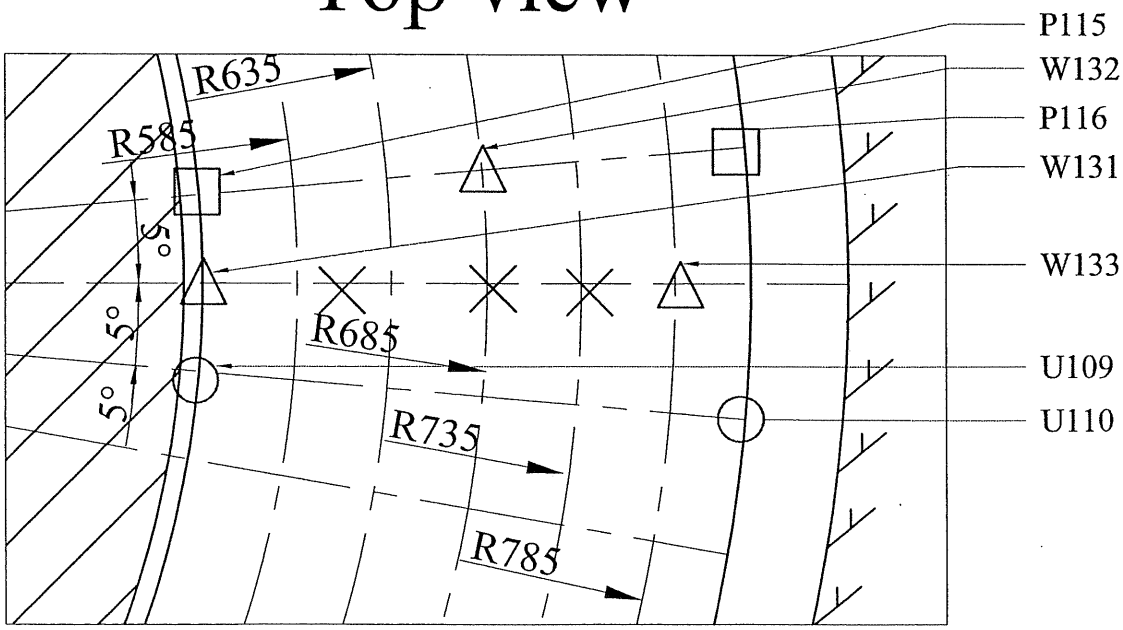
Ring 5

Instrument direction C (270°)

Cross section



Top view



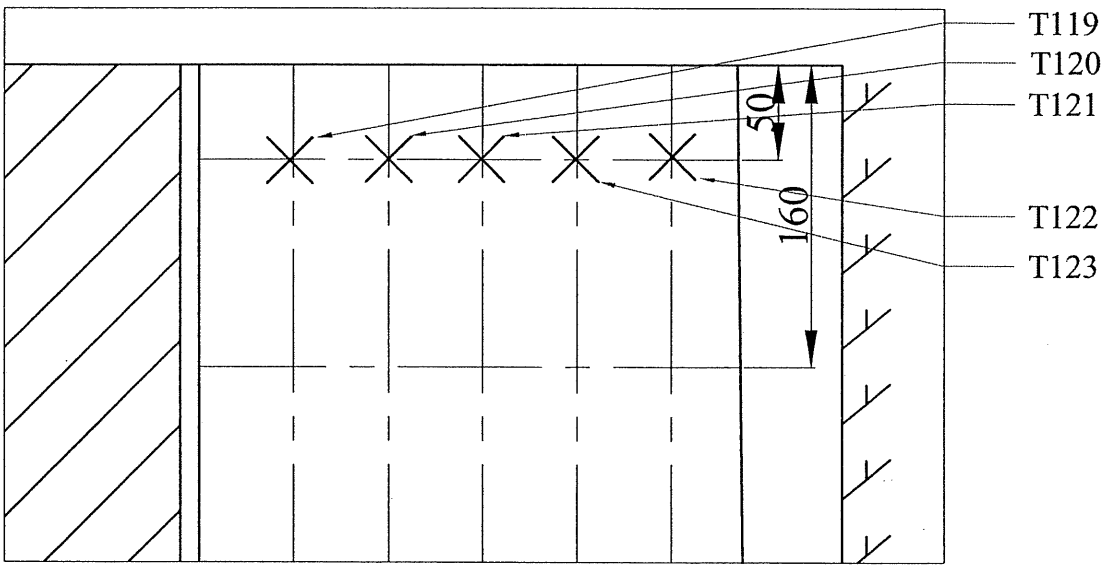
Instrument locations

DD0092G01

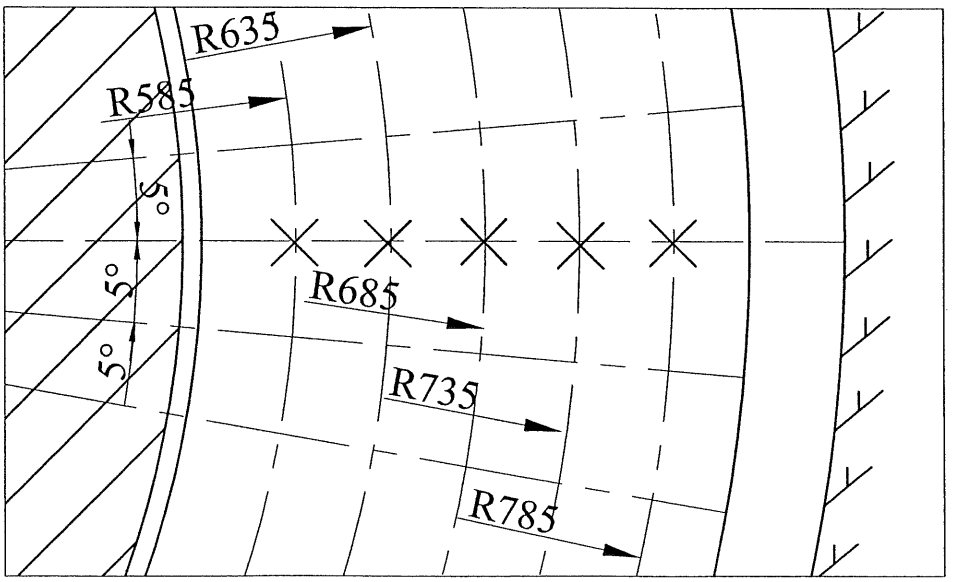
Ring 5

Instrument direction D (90°)

Cross section



Top view



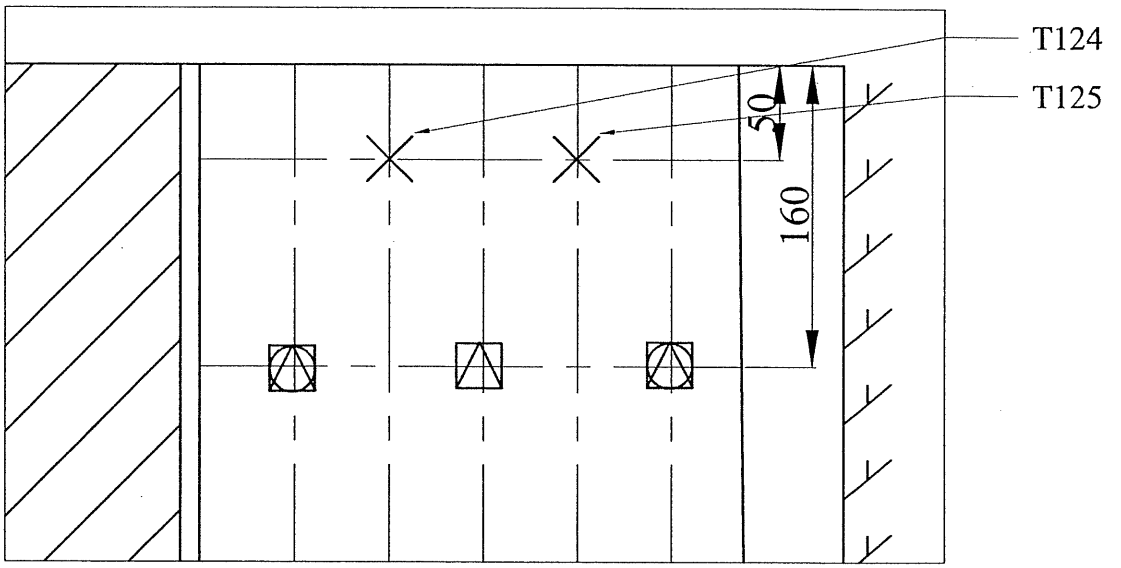
Instrument locations

DD0092G01

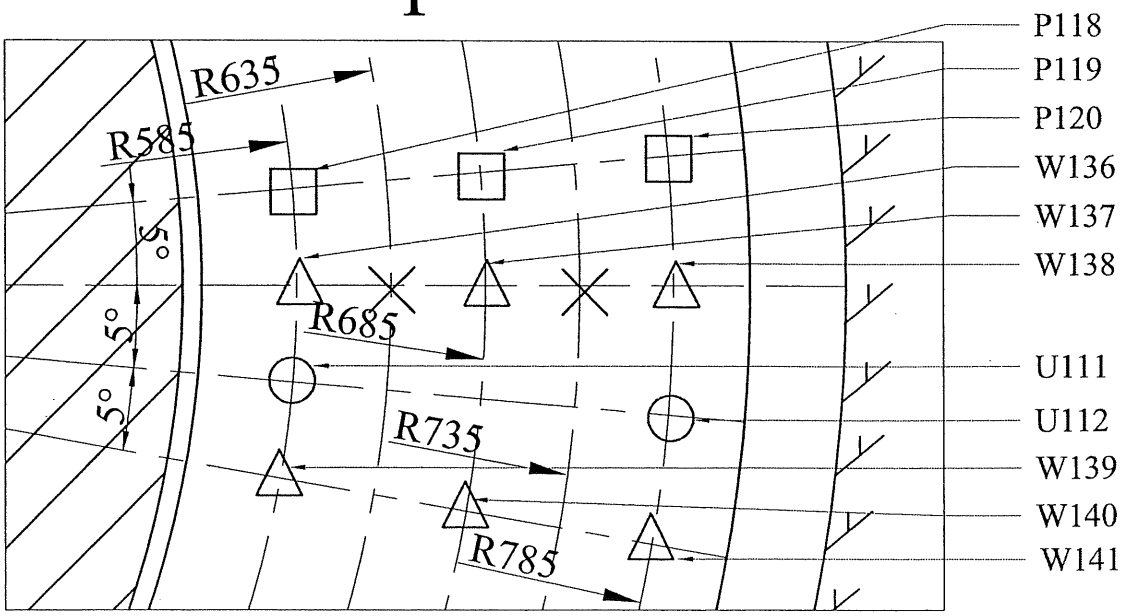
Ring 10

Instrument direction A (180°)

Cross section



Top view



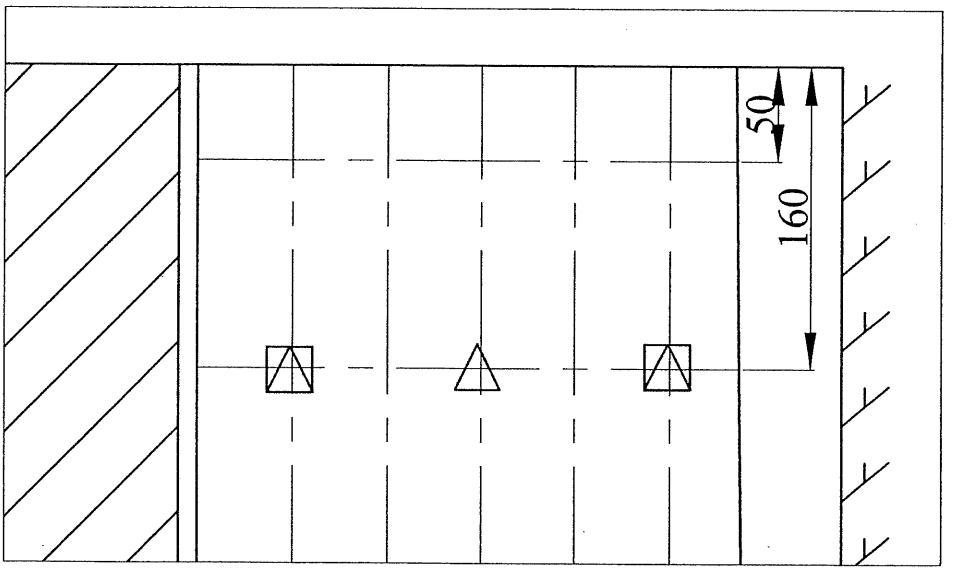
Instrument locations

DD0072G01

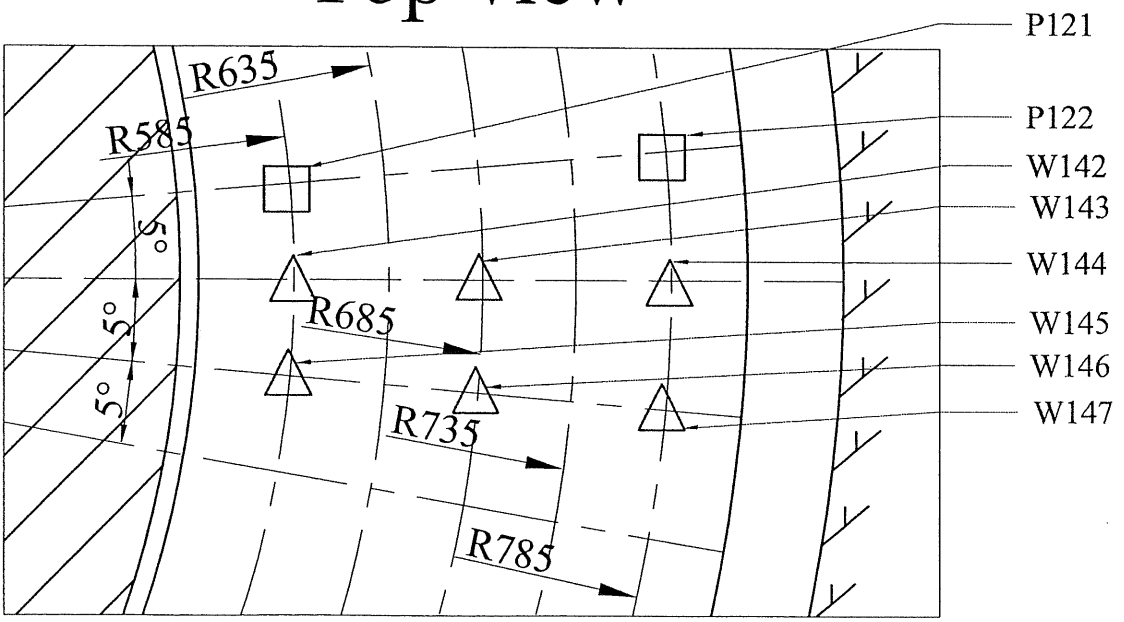
Ring 10

Instrument direction B (0°)

Cross section



Top view



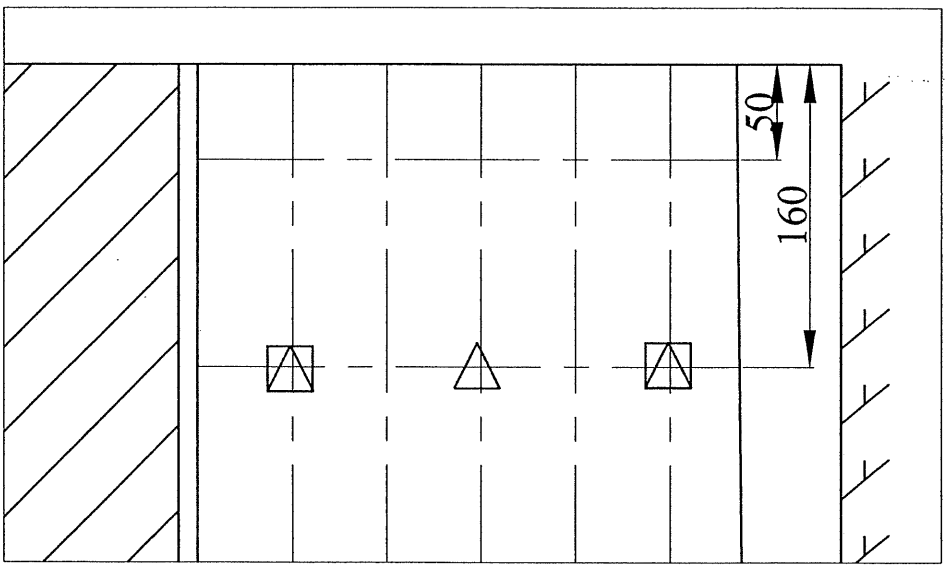
Instrument locations

DD0092G01

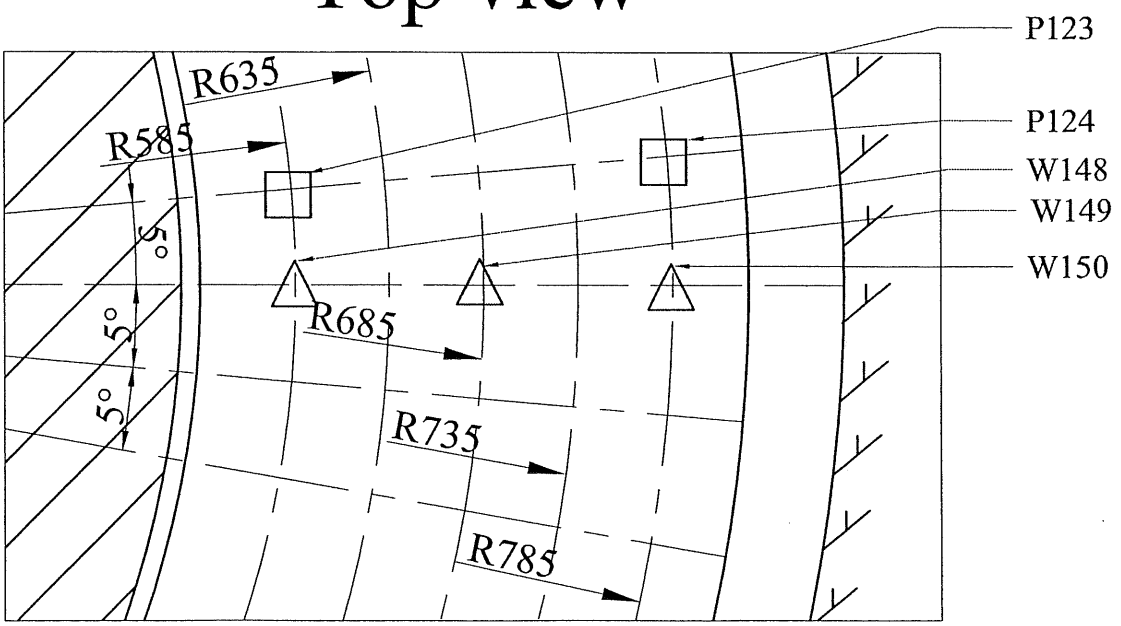
Ring 10

Instrument direction C (270°)

Cross section



Top view



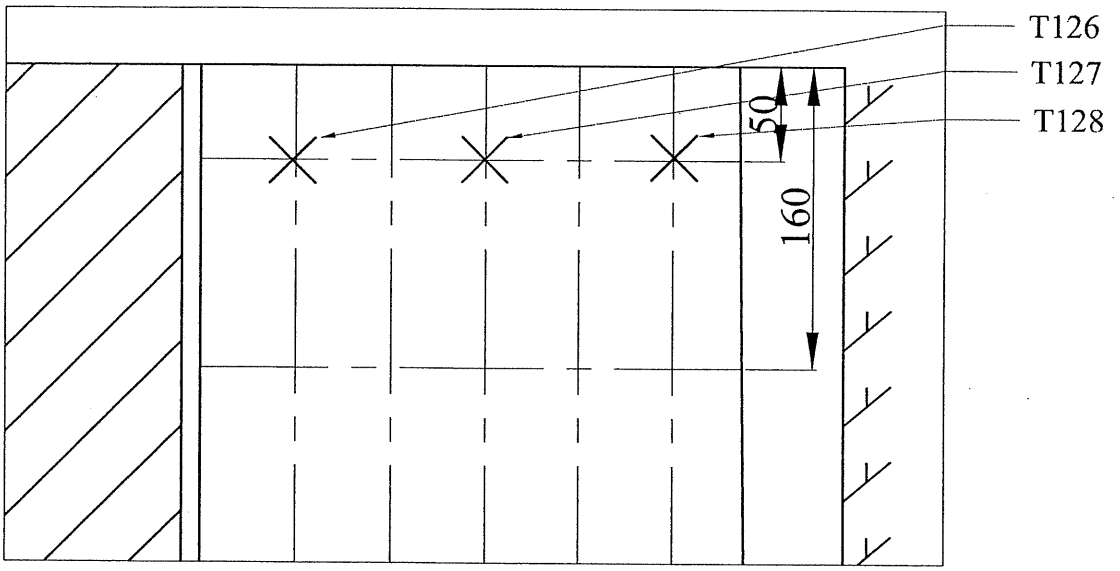
Instrument locations

DD0092G01

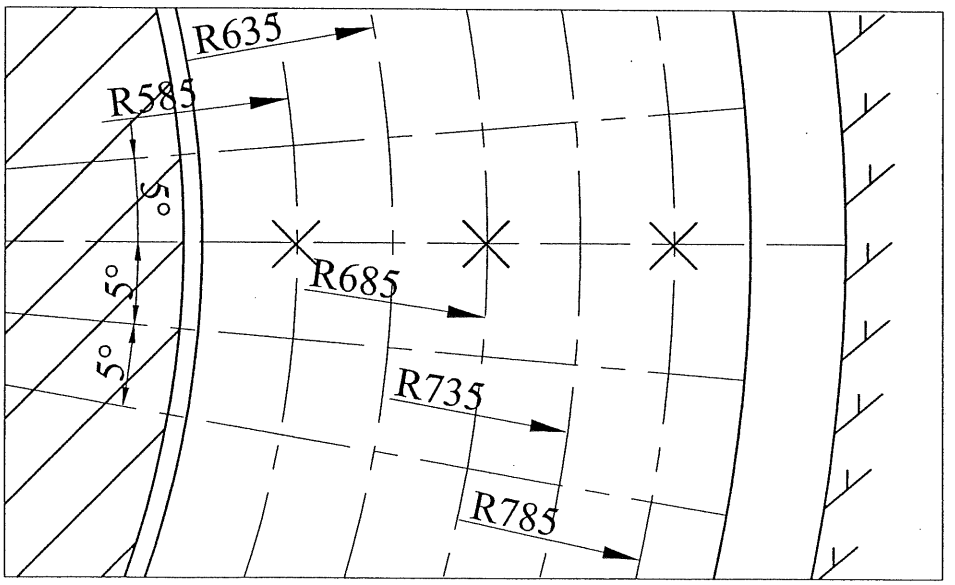
Ring 10

Instrument direction D (90°)

Cross section



Top view



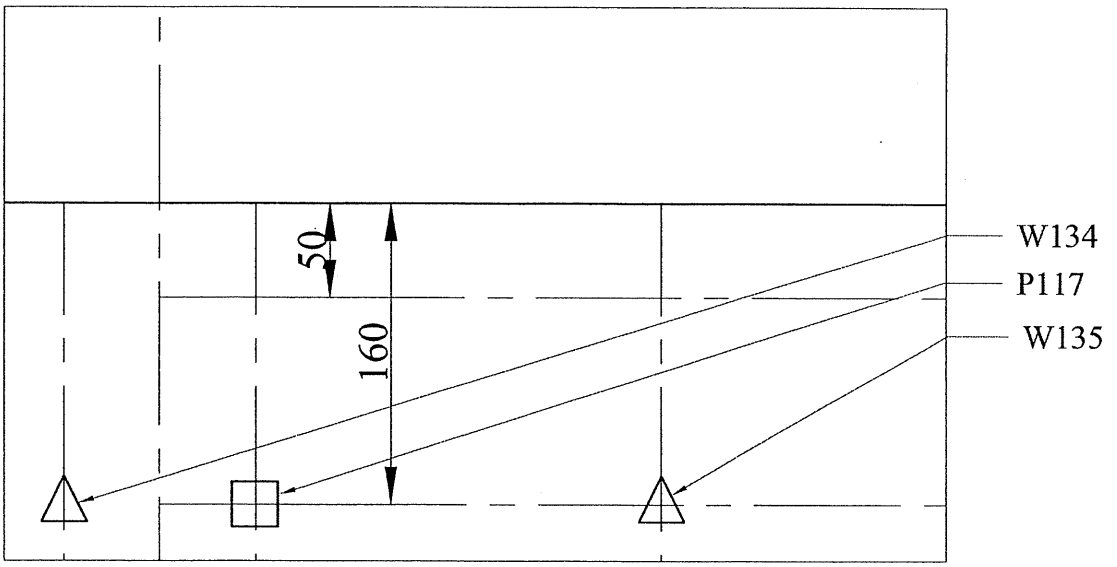
Instrument locations

DD0092G01

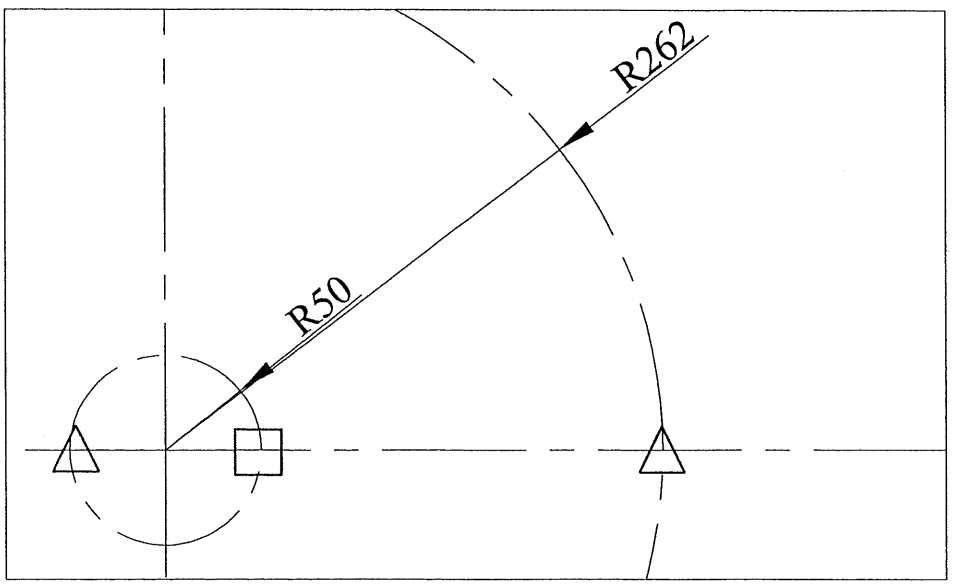
Ring 10

Instrument direction A (180°) and Center

Cross section



Top view



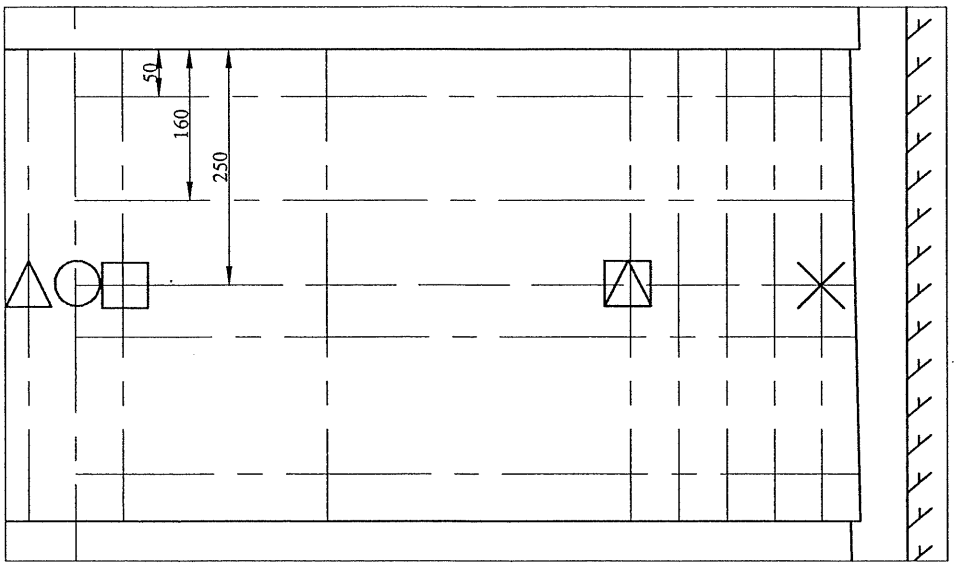
Instrument locations

DD0092G01

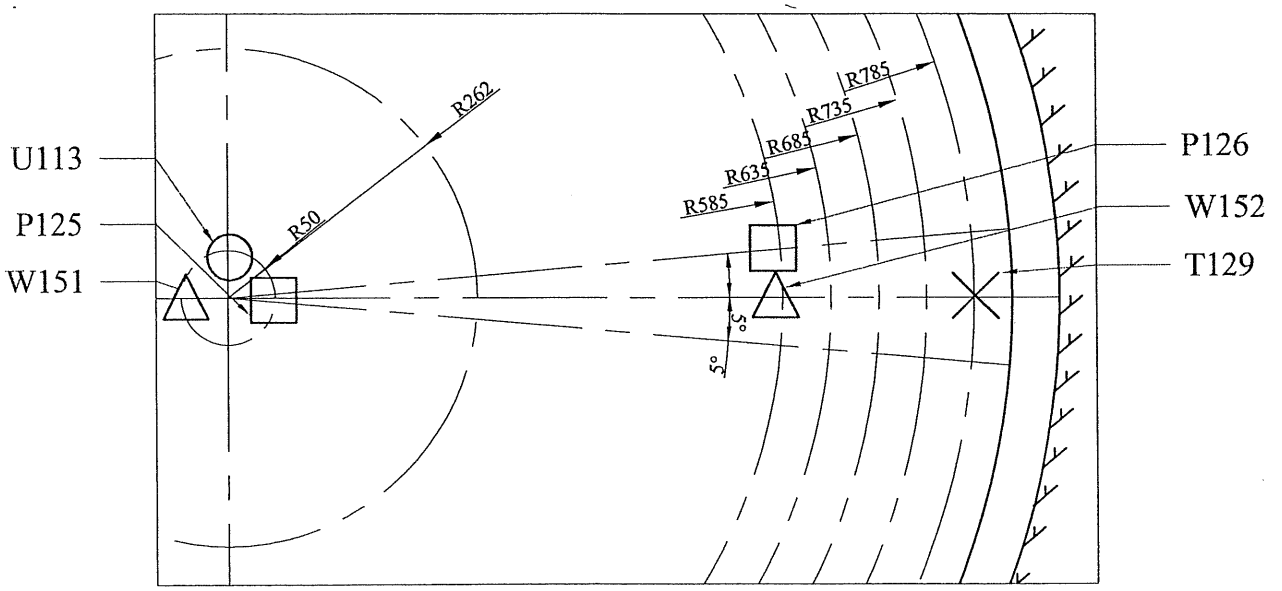
Cylinder 3

Instrument direction A (180°) and Center

Cross section



Top view



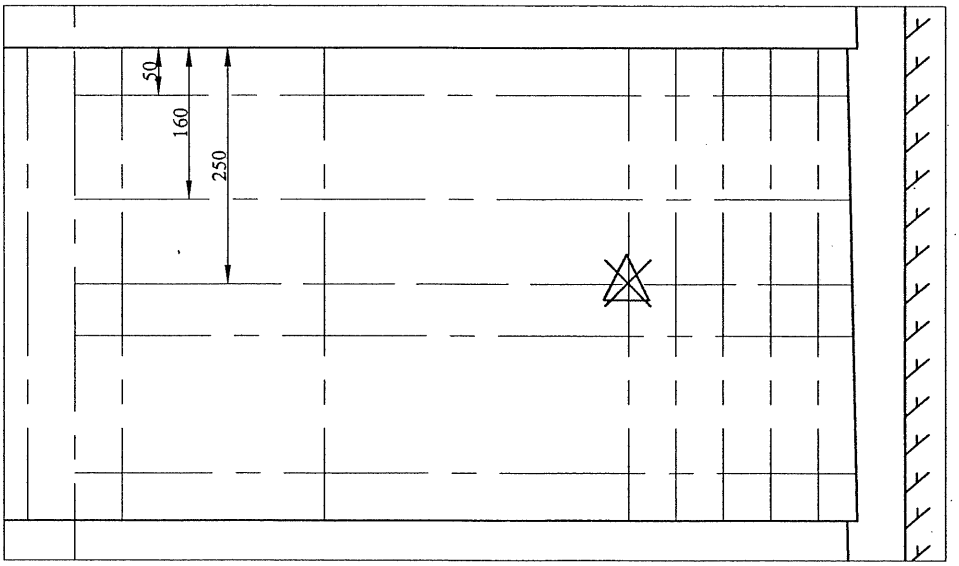
Instrument locations

DD0092G01

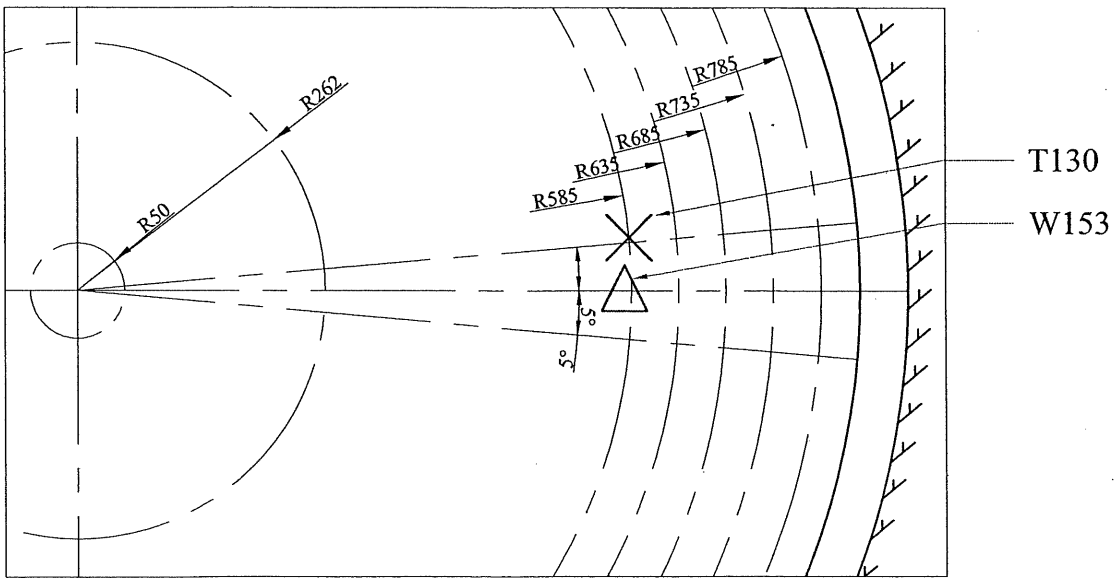
Cylinder 3

Instrument direction B (0°)

Cross section



Top view



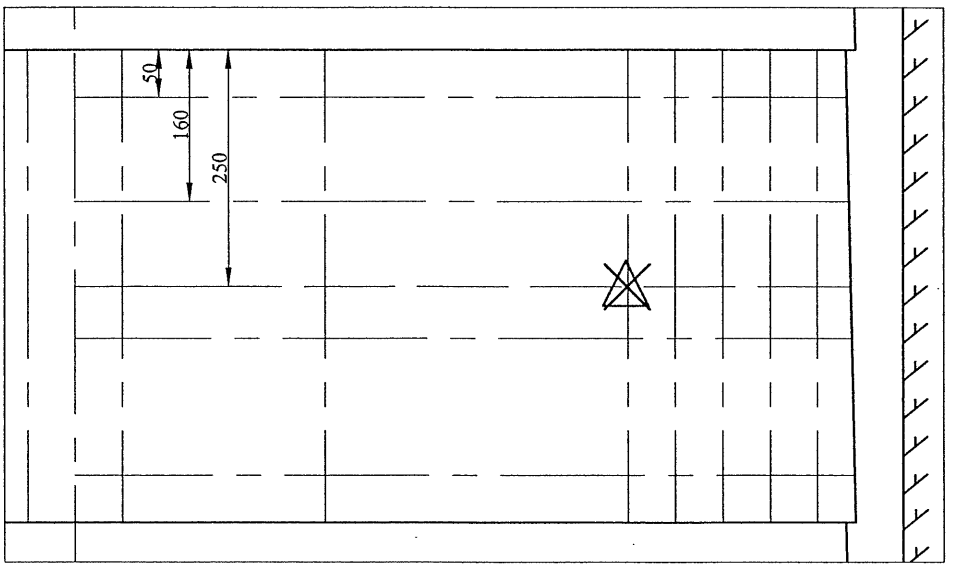
Instrument locations

DD0092G01

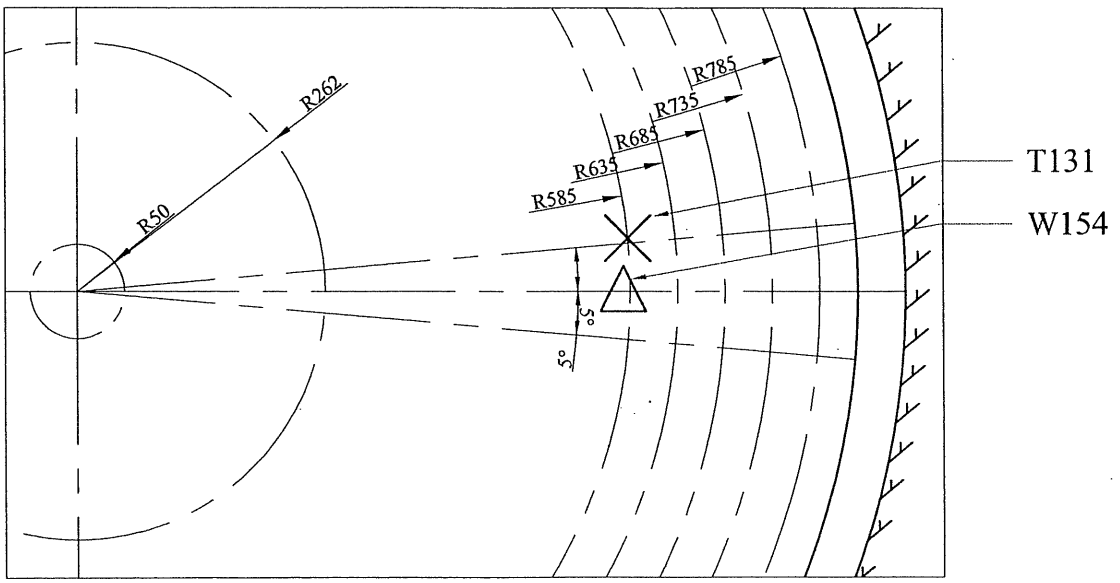
Cylinder 3

Instrument direction C (270°)

Cross section



Top view



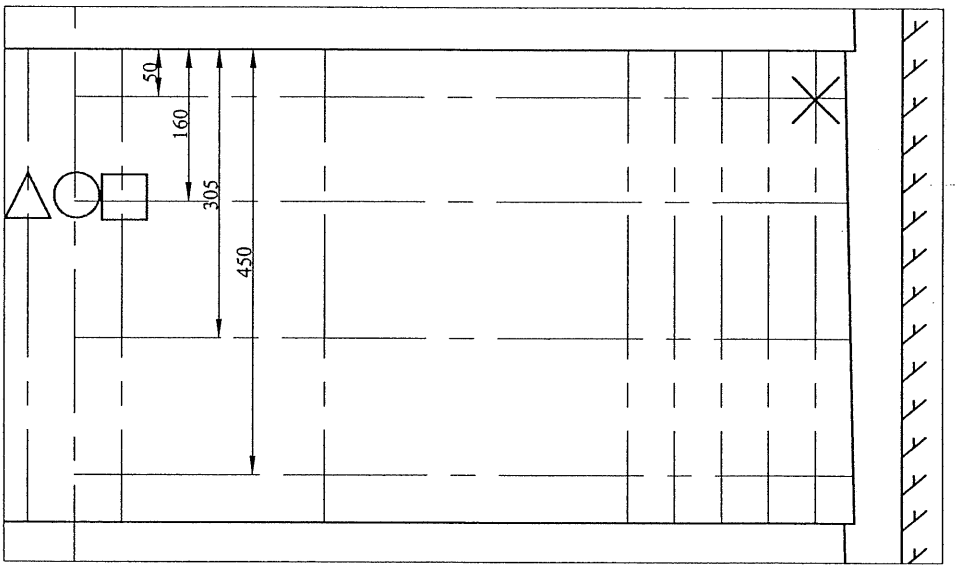
Instrument locations

DD0092G01

Cylinder 4

Instrument direction A (180°) and Center

Cross section



Top view