Accelerator Division
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Technical Note

No. 254

Present Order of Magnets in the AGS Ring, with B.dl Offsets

R.E. Thern

June 5, 1986

TECHNICAL NOTE

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1. INTRODUCTION

When the AGS magnets were originally put in the ring, results from the magnetic measurements were used to determine the "stacking order" in the ring and the radial offsets for each magnet. Now that we are doing a radial survey (ref 1) and may do a radial realignment, it is important that this data be taken into account again. Over the years, magnet replacements have shuffled the magnets from their original order and brought in the magnets that used to be the spares. Thus the old publications of this data (ref 2-3) have to be brought up to date.

The present order of the magnets in the ring -- which "magnet name" is in which "ring location" -- was checked by walking around the ring and reading the numbers stamped in the backleg of each magnet.

The description of the magnetic measurement data and the rationale for how it is used is given below. The data are listed in Table 1, ordered by magnet name, and in Table 2, ordered by location in the ring. Table 3 summarizes the changes that have been made to the original magnet order.

2. B.DL AT 5000 GAUSS

At a set current, the integrated B.dl along the equilibrium orbit should be the same for all members of each class (A, B, or C) of magnet. The line determined from the socket holes on the top of the magnet does not satisfy this requirement, due to variations in the gap, the steel, the length of the magnet, and the placement of the socket holes relative to the gap. Since the magnets are gradient magnets, the B.dl at a given current can be changed by moving the magnet sideways. The data in reference 2 are the radial offsets of the magnet sockets from the design positions in the ring such that the B.dl values along the equilibrium orbit are uniform, within each class, at a fixed current corresponding to about 5000 gauss. The sign convention used is that positive offsets mean that the socket is to be moved away from the center of the ring. These offsets also effect a slight rotation so the orbit is parallel to the front face of the magnet.

The definition of the offsets is as shown in Figure 1. Note that half the magnets in each superperiod have their gaps facing outward, and half inward, so the offsets for the surveyors to use - "upstream and downstream", "in and out" - will depend on position in the ring.

Note that magnet B1, which was originally a spare but now is in use, seems to have no magnetic measurement data. (In compendia of mechanical data, it is refered to as B-1A, but I have not found anyone who remembers why.) Magnet B1 was used as the reference magnet for the rest of the B series; the reference magnets for the A and C series were themselves measured by using another magnet for the reference.

3. REMANENT FIELD

Since the variations in remanent field are larger (percentagewise) than the variations at higher fields, the original stacking order of the magnets in the ring was designed to reduce the low order harmonics introduced by the remanent field at injection. With the present low field dipole correction system (and higher energy injection) this is no longer as important; the remanent field data is nevertheless included here for the sake of completeness.

The remanent field numbers are the offsets, in mils from the 5000 gauss centerline defined above, which give a uniform B.dl for the remanent field. The sign of the effect is, as best I can determine, such that a positive number means that the remanent field is higher than the standard. The remanent field gradient is about 1.5 gauss/inch (2.1 g/in) for classes A and B (class C), with a central field of about 16 gauss.

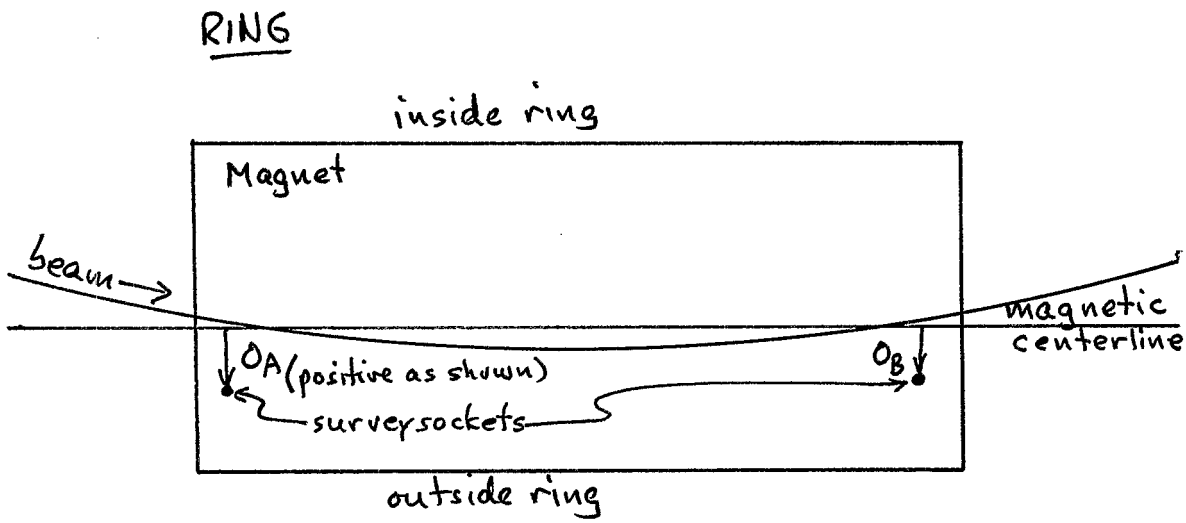
The remanent field for the class A magnets (but not classes B and C) were found in reference 3; the class B and C numbers were found compiled on sheets in the data books. They are, apparently, not exactly the same as were used in figuring the stacking order in reference 3 because several magnets are interchanged in rank from that implied by the reference 3 order. The differences are only a few mils, however, much less than the variation in multiple measurements.

REFERENCES

1. R. E. Thern, "The 1985 Horizontal Survey. Part II. Magnets", AGS Accelerator Division Technical Note No. 253, May 30, 1986.

2. J. P. Palmer and R. H. Phillips, "Summary of Magnetic Measurements of Classes A, B, and C Magnets Reduced to Equivalent Radial Offset Corrections on the AGS Ring", Accelerator Development Department Internal Report JPP/RHP-2, July 17, 1959. This report covers the magnets that were originally placed in the ring. Over the years the magnets have been shuffled and the spares brought in; the offsets for the spares were found in the data books with the help of J. Weisenbloom.

3. E. D. Courant, "Stacking Order for Class A and Class B Magnets in the AGS", Accelerator Development Department Internal Report EDC-29, March 6, 1959, and "Stacking Order of Class C Magnets in the AGS", Report EDC-30, May 25, 1959.



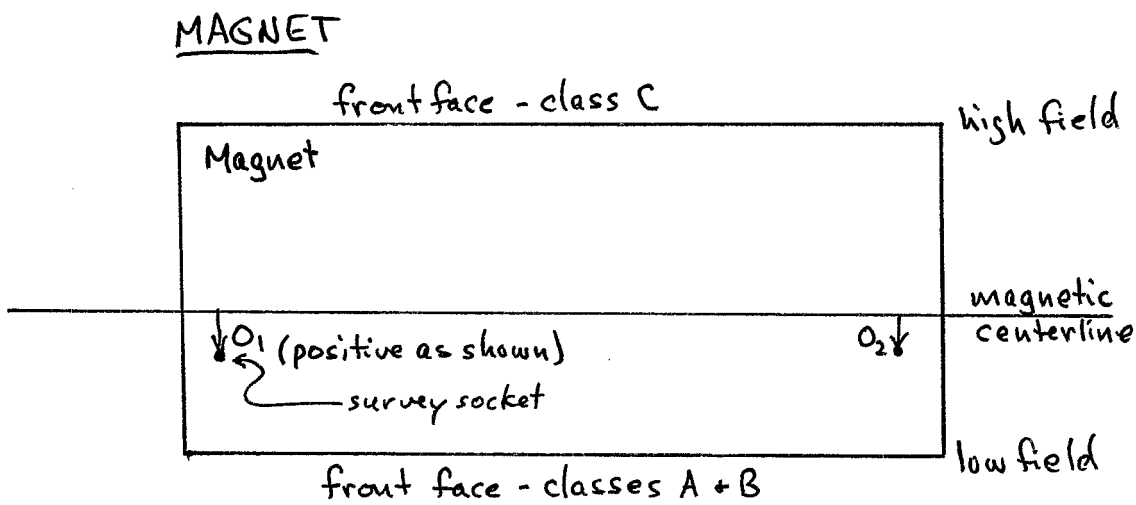


Figure 1. Definitions of the offsets, in the magnet coordinate system, and in the ring coordinate system. The convention is that the two are the same for magnets with their wide gap (low-field side) facing outward, i.e., the defocussing magnets (class C in the first half of each superperiod, classes A and B in the second). For the other magnets, the offsets are interchanged and the signs reversed.

Table 1a. Magnet list ordered by magnet name for class A magnets. The offsets, in mils, are from the socket holes to a magnetic centerline which has the same B.dl for all members of a class (at a set current corresponding to about 5000 gauss). Xrem is the offset, in mils from the above centerline, needed to make the remanent field the same as in the reference magnet. The asterisk (*) denotes that the magnet is in a location different from its original location. NA = data not available. "Spare" denotes magnets not in the ring, and "242" denotes the magnet under the Siemens power room.

Mag. name	Ring loc.	Mag. offset off1	off2	Xrem
A01	B-05	-7	23	166
A02	K-16	3	37	28
A03	I-15	5	8	86
A04	H-06 *	-8	19	13
A05	D-06	0	22	-6
A06	J-15	-3	31	96
A07	J-16	22	22	30
A08	L-06	1	14	-34
A09	C-16	3	28	28
A10	B-16	-13	32	22
A11	K-06	-16	22	-19
A12	J-06	6	9	-15
A13	B-06	-5	30	-20
A14	G-06	-11	21	14
A15	F-06 *	6	34	-118
A16	G-16	1	34	65
A17	spare*	-8	15	11
A18	A-06	-23	23	-58
A19	A-16	11	17	15
A20	I-05	0	9	137
A21	F-16	-11	28	46
A22	H-16	8	12	38
A23	G-15 *	0	20	-120
A24	I-06	10	39	-5
A25	F-15	-9	24	70
A26	L-15	0	10	102
A27	C-06	-12	12	-16
A28	L-16	-15	8	20
A29	D-15	-1	40	88
A30	E-15	2	13	80
A31	J-05	-14	32	146
A32	K-05	-4	12	155
A33	G-05	-9	26	111
A34	I-16	8	3	33
A35	E-06	3	23	11
A36	C-15	-6	16	96
A37	H-15	-8	33	75
A38	D-16	1	21	32
A39	B-15	14	24	99
A40	L-05	0	14	187
A41	K-15	-13	32	97
A42	A-05	-10	27	197
A43	H-05	-8	17	132
A44	F-05	-12	23	131
A45	A-15	4	12	111
A46	E-05	-9	26	132
A47	C-05	-1	15	155
A48	D-05	-19	23	140
A49	"242"*	-9	34	65
A50	E-16	-10	22	34

Table 1b. Magnet list ordered by magnet name for class B magnets.

Mag. name	Ring loc.	Mag. offset off1	off2	Xrem
B01	B-01 *	NA	NA	NA
B02	J-09	-3	4	151
B03	G-12 *	4	16	64
B04	K-12	18	18	11
B05	K-20	8	8	2
B06	L-01	-22	20	185
B07	L-11	-10	21	105
B08	G-20	-4	5	61
B09	K-09	-1	9	180
B10	F-20	0	15	61
B11	E-01	-2	0	123
B12	B-11 *	-11	19	71
B13	G-10	7	-3	-26
B14	H-01	8	15	118
B15	J-20	2	-4	23
B16	F-01 *	9	2	214
B17	B-09	-4	4	176
B18	B-19	-4	5	102
B19	I-19 *	-3	-10	80
B20	I-20	-3	-1	41
B21	H-11	-8	0	73
B22	J-12	-12	-2	32
B23	L-12	-7	3	-6
B24	A-02	5	-19	-163
B25	J-11	10	-6	86
B26	C-10	-1	10	-64
B27	D-20	-12	5	41
B28	L-02	3	3	-129
B29	I-01	3	0	125
B30	K-02 *	2	1	160
B31	E-11 *	4	13	51
B32	K-19	6	16	103
B33	C-12	-13	16	20
B34	E-20	-7	26	47
B35	I-02	-15	16	-47
B36	A-09	4	3	206
B37	J-02	1	0	-64
B38	D-02	-8	9	-59
B39	F-10	-2	17	-26
B40	J-19	-12	12	93
B41	G-01	3	8	113
B42	G-11 *	-12	7	104
B43	E-10	1	6	-41
B44	J-10	-4	12	-74
B45	H-02	14	21	-31
B46	L-20	10	4	-15
B47	A-11	6	6	107
B48	E-02	-13	6	-47
B49	D-01	-8	9	140
B50	L-09	2	10	207
B51	D-10	0	11	-48
B52	B-20	6	2	6
B53	I-11 *	10	2	76
B54	C-01	-16	11	152
B55	D-12	3	5	34
B56	G-09	-14	10	114
B57	C-19	-16	4	92
B58	C-09	-13	12	148
B59	D-09	4	14	136
B60	G-19 *	-2	8	62
B61	C-02	-5	6	-77
B62	H-10	-8	10	-45
B63	D-19	2	8	81
B64	B-12	-13	11	1
B65	H-19 *	-6	4	82
B66	A-10	-6	15	-130
B67	H-20 *	-6	16	43
B68	A-20 *	-6	12	72
B69	I-10	-21	17	-48
B70	B-10	-18	18	-85
B71	K-01 *	10	5	-78
B72	G-02	-6	3	-23
B73	H-12	-10	3	50
B74	spare*	-6	5	-13
B75	H-09	-10	1	122
B76	D-11	-12	20	84
B77	A-01 *	-4	0	182
B78	C-20	-13	6	30
B79	A-19	7	6	105
B80	L-19	-2	11	106
B81	I-12 *	-4	5	46
B82	E-12	1	8	45
B83	F-19	-2	18	66
B84	F-09	-10	12	113
B85	spare*	-3	15	114
B86	E-19	5	4	75
B87	I-09	-3	8	139
B88	K-11	0	-11	101
B89	F-12 *	-2	12	79
B90	L-10	-6	11	-131
B91	F-11 *	-18	4	-206
B92	J-01	-13	9	141
B93	E-09	-1	11	120
B94	C-11	-2	7	99
B95	B-02	-11	21	-110
B96	K-10	-8	2	-107
B97	A-12	2	4	-18
B98	F-02	-14	11	-28

Table 1c. Magnet list ordered by magnet name for class C magnets.

Mag. name	Ring loc.	Mag. offset off1	Mag. offset off2	Xrem
C01	A-07	-10	-30	53
C02	L-03	1	-3	54
C03	B-04	-4	-12	-13
C04	F-17	-21	-21	59
C05	J-13	5	-17	93
C06	J-08	-15	-7	-2
C07	I-03	-14	-18	36
C08	F-18	-27	1	-23
C09	G-08	-21	-11	15
C10	K-04	-29	1	-6
C11	F-14	-8	-6	-28
C12	D-18	-7	-5	-38
C13	I-18	-1	-17	-40
C14	A-18	-3	-11	-87
C15	L-14	-21	-7	-86
C16	E-17	-23	3	73
C17	D-04	-8	14	6
C18	H-14	-25	-3	-30
C19	A-14	-6	-14	-128
C20	E-18	-25	-11	-33
C21	spare*	-11	-9	19
C22	L-08	-16	-8	-22
C23	F-07 *	-3	-7	-150
C24	J-03	-17	-21	41
C25	G-04	-23	-23	17
C26	spare	-9	3	-147
C27	D-14	-4	-28	-42
C28	I-04	-14	-24	10
C29	A-04	-4	-6	-21
C30	K-14	-5	-19	-62
C31	J-04	-15	1	4
C32	G-18	-14	-24	-25
C33	H-04	-11	-1	7
C34	B-17	-23	-9	110
C35	G-13	-11	-3	58
C36	D-03	-8	-2	40
C37	A-13	-18	-20	143
C38	H-17	-19	-9	79
C39	G-07	-16	0	25
C40	K-07	-3	-19	50
C41	F-04	-30	4	13
C42	A-03	-17	-5	56
C43	G-14	-8	2	-21
C44	I-14	-12	-12	-38
C45	C-03	-18	-6	47
C46	C-07	-12	-10	44
C47	I-08	-24	-6	5
C48	B-13	-12	-8	111
C49	C-17	-8	-6	94
C50	K-18	-15	-13	-66
C51	L-18	-6	-8	-91
C52	F-03	-2	-4	24
C53	J-14	3	-13	-46
C54	K-03	-5	-23	47
C55	D-08	-15	7	6
C56	H-18	-13	-27	-32
C57	B-18	-5	-5	-64
C58	C-14	-15	-3	-60
C59	D-13	-28	-12	90
C60	B-07	-11	-17	48
C61	H-03	-22	-14	27
C62	J-17	-17	-25	95
C63	G-17	-23	-13	63
C64	D-17	-10	-8	85
C65	K-13	-23	5	105
C66	I-13	-21	-29	83
C67	C-18	-22	-16	-48
C68	D-07	-19	-27	36
C69	C-13	-28	0	104
C70	J-07	-10	-4	46
C71	I-07	-35	-11	38
C72	L-13	-12	-36	120
C73	E-13	-28	-20	82
C74	F-13	-19	-15	67
C75	H-13	-29	-13	69
C76	H-07	-23	-23	28
C77	L-17	-17	-7	138
C78	K-17	-10	-24	109
C79	L-07	-27	-1	57
C80	A-17	-6	-22	131
C81	E-04	-26	-2	9
C82	J-18	-12	-14	-56
C83	L-04	-6	-4	-12
C84	C-04	-1	-15	-5
C85	B-08	-2	-6	-6
C86	C-08	-10	-10	3
C87	G-03	10	-12	18
C88	B-14	-24	2	-78
C89	F-08	6	-8	15
C90	I-17	-15	11	90
C91	A-08	0	4	-18
C92	K-08	-27	-5	-9
C93	E-03	1	-11	32
C94	H-08	-29	21	10
C95	E-08	1	-5	9
C96	B-03	-38	0	52
C97	E-07	6	-4	28
C98	E-14	-7	25	-33

Table 2. Magnet names and offsets, ordered by location in ring. The asterisk (*) denotes that a location has a magnet different from the original stacking order. NA = data not available.

Ring loc.	Mag name		Ring offset offA	offB
A-01	B77	*	0	4
A-02	B24		19	-5
A-03	C42		-17	-5
A-04	C29		-4	-6
A-05	A42		-27	10
A-06	A18		-23	23
A-07	C01		-10	-30
A-08	C91		0	4
A-09	B36		-3	-4
A-10	B66		-15	6
A-11	B47		6	6
A-12	B97		2	4
A-13	C37		20	18
A-14	C19		14	6
A-15	A45		4	12
A-16	A19		11	17
A-17	C80		22	6
A-18	C14		11	3
A-19	B79		7	6
A-20	B68	*	-6	12
B-01	B01	*	NA	NA
B-02	B95		-21	11
B-03	C96		-38	0
B-04	C03		-4	-12
B-05	A01		-23	7
B-06	A13		-30	5
B-07	C60		-11	-17
B-08	C85		-2	-6
B-09	B17		-4	4
B-10	B70		-18	18
B-11	B12	*	-11	19
B-12	B64		-13	11
B-13	C48		8	12
B-14	C88		-2	24
B-15	A39		14	24
B-16	A10		-13	32
B-17	C34		9	23
B-18	C57		5	5
B-19	B18		-4	5
B-20	B52		6	2

Ring loc.	Mag name	Ring offset offA	offB
C-01	B54	-11	16
C-02	B61	-6	5
C-03	C45	-18	-6
C-04	C84	-1	-15
C-05	A47	-15	1
C-06	A27	-12	12
C-07	C46	-12	-10
C-08	C86	-10	-10
C-09	B58	-12	13
C-10	B26	-10	1
C-11	B94	-2	7
C-12	B33	-13	16
C-13	C69	0	28
C-14	C58	3	15
C-15	A36	-6	16
C-16	A09	3	28
C-17	C49	6	8
C-18	C67	16	22
C-19	B57	-16	4
C-20	B78	-13	6
D-01	B49	-9	8
D-02	B38	-9	8
D-03	C36	-8	-2
D-04	C17	-8	14
D-05	A48	-23	19
D-06	A05	-22	0
D-07	C68	-19	-27
D-08	C55	-15	7
D-09	B59	-14	-4
D-10	B51	-11	0
D-11	B76	-12	20
D-12	B55	3	5
D-13	C59	12	28
D-14	C27	28	4
D-15	A29	-1	40
D-16	A38	1	21
D-17	C64	8	10
D-18	C12	5	7
D-19	B63	2	8
D-20	B27	-12	5

Table 2 (continued).

Ring loc.	Mag name		Ring offset offA	offB
E-01	B11		0	2
E-02	B48		-6	13
E-03	C93		1	-11
E-04	C81		-26	-2
E-05	A46		-26	9
E-06	A35		-23	-3
E-07	C97		6	-4
E-08	C95		1	-5
E-09	B93		-11	1
E-10	B43		-6	-1
E-11	B31	*	4	13
E-12	B82		1	8
E-13	C73		20	28
E-14	C98		-25	7
E-15	A30		2	13
E-16	A50		-10	22
E-17	C16		-3	23
E-18	C20		11	25
E-19	B86		5	4
E-20	B34		-7	26
F-01	B16	*	-2	-9
F-02	B98		-11	14
F-03	C52		-2	-4
F-04	C41		-30	4
F-05	A44		-23	12
F-06	A15	*	-34	-6
F-07	C23	*	-3	-7
F-08	C89		6	-8
F-09	B84		-12	10
F-10	B39		-17	2
F-11	B91	*	-18	4
F-12	B89	*	-2	12
F-13	C74		15	19
F-14	C11		6	8
F-15	A25		-9	24
F-16	A21		-11	28
F-17	C04		21	21
F-18	C08		-1	27
F-19	B83		-2	18
F-20	B10		0	15

Ring loc.	Mag name		Ring offset offA	offB
G-01	B41		-8	-3
G-02	B72		-3	6
G-03	C87		10	-12
G-04	C25		-23	-23
G-05	A33		-26	9
G-06	A14		-21	11
G-07	C39		-16	0
G-08	C09		-21	-11
G-09	B56		-10	14
G-10	B13		3	-7
G-11	B42	*	-12	7
G-12	B03	*	4	16
G-13	C35		3	11
G-14	C43		-2	8
G-15	A23	*	0	20
G-16	A16		1	34
G-17	C63		13	23
G-18	C32		24	14
G-19	B60	*	-2	8
G-20	B08		-4	5
H-01	B14		-15	-8
H-02	B45		-21	-14
H-03	C61		-22	-14
H-04	C33		-11	-1
H-05	A43		-17	8
H-06	A04	*	-19	8
H-07	C76		-23	-23
H-08	C94		-29	21
H-09	B75		-1	10
H-10	B62		-10	8
H-11	B21		-8	0
H-12	B73		-10	3
H-13	C75		13	29
H-14	C18		3	25
H-15	A37		-8	33
H-16	A22		8	12
H-17	C38		9	19
H-18	C56		27	13
H-19	B65	*	-6	4
H-20	B67	*	-6	16

Table 2 (continued).

Ring loc.	Mag name		Ring offset offA	offB
I-01	B29		0	-3
I-02	B35		-16	15
I-03	C07		-14	-18
I-04	C28		-14	-24
I-05	A20		-9	0
I-06	A24		-39	-10
I-07	C71		-35	-11
I-08	C47		-24	-6
I-09	B87		-8	3
I-10	B69		-17	21
I-11	B53	*	10	2
I-12	B81	*	-4	5
I-13	C66		29	21
I-14	C44		12	12
I-15	A03		5	8
I-16	A34		8	3
I-17	C90		-11	15
I-18	C13		17	1
I-19	B19	*	-3	-10
I-20	B20		-3	-1
J-01	B92		-9	13
J-02	B37		0	-1
J-03	C24		-17	-21
J-04	C31		-15	1
J-05	A31		-32	14
J-06	A12		-9	-6
J-07	C70		-10	-4
J-08	C06		-15	-7
J-09	B02		-4	3
J-10	B44		-12	4
J-11	B25		10	-6
J-12	B22		-12	-2
J-13	C05		17	-5
J-14	C53		13	-3
J-15	A06		-3	31
J-16	A07		22	22
J-17	C62		25	17
J-18	C82		14	12
J-19	B40		-12	12
J-20	B15		2	-4

Ring loc.	Mag name		Ring offset offA	offB
K-01	B71	*	-5	-10
K-02	B30	*	-1	-2
K-03	C54		-5	-23
K-04	C10		-29	1
K-05	A32		-12	4
K-06	A11		-22	16
K-07	C40		-3	-19
K-08	C92		-27	-5
K-09	B09		-9	1
K-10	B96		-2	8
K-11	B88		0	-11
K-12	B04		18	18
K-13	C65		-5	23
K-14	C30		19	5
K-15	A41		-13	32
K-16	A02		3	37
K-17	C78		24	10
K-18	C50		13	15
K-19	B32		6	16
K-20	B05		8	8
L-01	B06		-20	22
L-02	B28		-3	-3
L-03	C02		1	-3
L-04	C83		-6	-4
L-05	A40		-14	0
L-06	A08		-14	-1
L-07	C79		-27	-1
L-08	C22		-16	-8
L-09	B50		-10	-2
L-10	B90		-11	6
L-11	B07		-10	21
L-12	B23		-7	3
L-13	C72		36	12
L-14	C15		7	21
L-15	A26		0	10
L-16	A28		-15	8
L-17	C77		7	17
L-18	C51		8	6
L-19	B80		-2	11
L-20	B46		10	4
spare	A17	*		
"242"	A49	*		
spare	B74	*		
spare	B85	*		
spare	C21	*		
spare	C26			

Table 3. Summary of magnet changes.

Ring loc.	Original magnet	Present magnet
A-01	B16	B77
A-20	B74	B68
B-01	B77	B01
B-11	B42	B12
E-11	B89	B31
F-01	B85	B16
F-06	A04	A15
F-07	C21	C23
F-11	B68	B91
F-12	B31	B89
G-11	B03	B42
G-12	B60	B03
G-15	A49	A23
G-19	B12	B60
H-06	A17	A04
H-19	B53	B65
H-20	B81	B67
I-11	B19	B53
I-12	B67	B81
I-19	B65	B19
K-01	B30	B71
K-02	B71	B30
spares:	A15	A17
	A23	A49
	B01	B74
	B91	B85
	C23	C21
	C26	C26