Helmholtz Coil Systems





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HC1®, HC2® & HC16 Helmholtz Coil Systems

These Helmholtz Coils are used in the calibration of magnetic field sensors, or for conducting any test or experiment requiring a known magnetic environment.

The coils are available with nominal diameters of 350mm (HC16), 500mm (HC1®) or 1m (HC2®). They can be supplied on their own, or together with our Power Amplifier (PA1) and Control Unit (CU1).

The CU2 Module allows for closed-loop compensation to take place for improved field stability.

A compatible National Instruments acquisition card enabling software control is also available.

A range of Ferronato® Helmholtz Coils with 1.3 and 2m diameters are also available. These are compatible with the control system described in this brochure.

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Features

- PA1 Power Amplifier provides power and offers DC offset compensation
- CU1 interfaces the PA1 to a National Instruments™ acquisition card
- CU2 provides closed-loop control for cancellation of DC and AC field variations
- Mounting table available
- HC2® coils provided in flat-pack assembly to facilitate freight and installation

Typical Applications

- Calibration of three-axis magnetic field sensors
- Creation of a known magnetic environment

Product Identification

Product name	Code	Item
HC1®	-3	Three-axis Helmholtz Coil 500mm nominal diameter: 3 pairs of coils
HC2®	n/a	Three-axis Helmholtz Coil 1m nominal diameter: 3 pairs of coils
HC16	n/a	Three-axis Helmholtz Coil 350mm nominal diameter: 3 pairs of coils on plastic coil formers
PA1	-3	Power Amplifier for HC1®-3, HC2® or HC16
CU1	n/a	Control Unit for PA1
CU2	n/a	Closed-Loop Module supplied with CU2 Reference Magnetometer

HC1® Helmholtz Coils

A 500mm nominal diameter 3-axis Helmholtz coil compatible with CU1 and PA1.

Each pair of coils generates a homogeneous magnetic field in one specific axis: X, Y or Z. The coils can be calibrated to add or subtract from distortions in the Earth's magnetic field.



Specifications

Performance	
Number of axes	3
Parallelism	<1°
Orthogonality error	<0.1° (electronic adjustment possible to <0.05° with PA1)
Maximum field (DC, X-axis) - continuous	706µT
Coil homogeneous area (<0.1% error)	8cm diameter sphere
Coil homogeneous area (<1% error)	15cm diameter sphere

Environmental	
Operating temperature range	+15°C to +30°C
Storage temperature	+10°C to +40°C

Mechanical	X	Y	Z
Coil Effective Diameter	507mm ±1mm	560mm ±1mm	618mm ±1mm
Dimensions	674mm H x 584mm W x 642mm D		
Coil maximum aperture	280 x 220mm		
Weight	43kg		
Coil construction material	Plastic coil former		
Optional accessories	Bartington sensor mounting adaptors		

Electrical	X	Y	Z
Field/Current Ratio	35.3µT/A ±4%	32.2µT/A ±4%	29.1µT/A ±4%
DC resistance per axis (with harness)	<0.2Ω	<0.2Ω	<0.2Ω
Number of turns (per coil)	10	10	10
Inductance per axis	TBC	TBC	TBC
Inductance per coil	112µH ±5%	127µH ±5%	143µH ±5%
Coil Maximum current - continuous	20A		
Harness Connectors	Neutrik Speakon 8-Way NL-8-FC		

HC2® Helmholtz Coils

A 1000mm nominal diameter, square profile, 3-axis Helmholtz coil compatible with CU1 and PA1.



Each pair of coils generates a homogeneous magnetic field in one specific axis: X, Y or Z. The coils can be calibrated to add or subtract from distortions in the Earth's magnetic field.

The HC2® coils are provided in flat-pack form for assembly at the customer's convenience.

Specifications

Performance	
Number of axes	3
Parallelism	<±1°
Orthogonality error	<0.1° (electronic adjustment possible to <0.05° with PA1)
Maximum field (DC, Y-axis) - continuous	446μT
Coil homogeneous area (<0.1% error)	13.6cm cube
Coil homogeneous area (<1% error)	24cm cube

Environmental	
Operating temperature range	+15°C to +30°C
Storage temperature	+10°C to +40°C

Mechanical	X	Y	Z
Coil Effective Diameter (Square – edge to edge)	1120mm ±1mm	1030mm ±1mm	1210mm ±1mm
Dimensions	1226mm H x 1136mm W x 1226mm D		
Coil maximum aperture	620 x 550mm		
Weight	130kg		

Electrical	X	Y	Z
Field/Current Ratio	20.5µT/A ±4%	22.3µT/A ±4%	19µT/A ±4%
DC resistance per axis (with harness)	0.4Ω ±4%	0.36Ω ±4%	0.44Ω ±4%
Number of turns (per coil)	14	14	14
Inductance per axis	TBC	TBC	TBC
Inductance per coil	812µH ±5%	730µH ±5%	892µH ±5%
Coil Maximum current - continuous	20A		
Coil Connectors	Neutrik Speakon 4-Way NL-4-MP		
Harness Connectors	Neutrik Speakon 8-Way NL-8-FC Neutrik Speakon 4-Way NL-4-FC (6 off)		

HC16 Helmholtz Coils

A 270-370mm nominal diameter 3-axis Helmholtz coil compatible with CU1 and PA1.

Each pair of coils generates a homogeneous magnetic field in one specific axis: X, Y or Z. The coils can be calibrated to add or subtract from distortions in the Earth's magnetic field.



Specifications

Performance	
Number of axes	3
Parallelism	<±1°
Orthogonality error	<0.1° (electronic adjustment possible to <0.05° with PA1)
Maximum field (DC, Z-axis) - continuous	2.8mT
Coil homogeneous area (<0.1% error)	40mm diameter sphere
Coil homogeneous area (<1% error)	65mm diameter sphere
Coil homogeneous area (<5% error)	100mm diameter sphere

Environmental	
Operating temperature range	+15°C to +50°C
Storage temperature	0°C to +50°C

Mechanical	X	Y	Z
Coil Effective Diameter	368.5mm ±0.5mm	320.5mm ±0.5mm	273.5mm ±0.5mm
Dimensions	403mm H x 380mm W x 342mm D		
Coil maximum aperture	140 x 134mm		
Weight	10kg		
Coil construction material	Plastic coil former		

Electrical	X	Y	Z
Field/Current Ratio	106µT/A ±4%	122µT/A ±4%	144µT/A ±4%
DC resistance per axis (with harness)	0.158Ω ±4%	0.138Ω ±4%	0.114Ω ±4%
Number of turns (per coil)	22	22	22
Inductance per axis	900µH ±5%	760µH ±5%	615µH ±5%
Coil Maximum current - continuous	20A		
Coil Connectors	4mm sockets		
Harness Connector	Neutrik Speakon 8-Way NL-8-FC & 4mm Plugs		

PA1 Power Amplifier

This unit supplies the necessary current to the Helmholtz coil assemblies in order to generate the required magnetic field. It also applies a DC offset current to the coils, typically used to cancel the ambient magnetic field.



Additional electronic adjustment of the scaling and orthogonality enables the generation of high precision magnetic field with excellent orthogonality accuracy.

The PA1 runs from a standard mains AC supply. The amplifier is fan-cooled with a self-resetting thermal shut-down mechanism to prevent damage through overheating.

Specifications

Environmental	
Operating temperature range	+15°C to +30°C
Storage temperature	+10°C to +40°C
Operating humidity	Up to 90% RH non-condensing
Usable locations	Indoor use only
Maximum operating altitude	2000m
Pollution degree	Pollution Degree 2

Mechanical	
Enclosure dimensions	6U 19in rack mount box Height: 27cm Width: 51cm Depth: 60cm
Enclosure gross weight	50kg

Electrical	
Input connector	Hirose RM15TRD-10S
Coils output connector	Neutrik NLT8MPXX Speakon 8 poles
Current monitor output connector	Hirose RM15TRD-10P
Power requirement	100V–240V AC, 50/60Hz permanent installation
Maximum power consumed	1.5kW
Mains supply voltage fluctuation	±10% max
Overvoltage category	OVC II
Control input (maximum voltage)	±10V
Current monitor output (maximum voltage)	±15V
Coil drive output (minimum voltage)	±25V (no load)
Maximum total output current to Helmholtz coils	29A (maximum 20A per axis)
Output impedence per individual axis	1.35Ω

CU1 Control Unit

This unit is an interface between the PA1 and a National Instruments™ based control system. The signal required to generate the field is routed through the CU1.

The CU1 also provides power to two sensors, with signals from these and the current monitor, filtered and sent to the National Instruments™ system.



Specifications

Functionality		
Magnetometer / auxiliary sensing	Description	Two separate inputs compatible with most Bartington magnetometers with up to 3 axes, differential or single-ended output, dual or single rail
	Analogue input	Up to ±10V differential or single-ended
	Input filter	Type Butterworth 2-pole 12dB per octave low pass Frequencies (software selectable): 10kHz, 1kHz, 100Hz & 10Hz
	Supply outputs: Magnetometer Auxiliary	 0 to ±20V programmable (100mA max) ±15V (50mA max) per channel
	Connector	Hirose RM15TRD-10P (front panel)
	Mating connector	Hirose RM15TRD-10S (supplied on request)
	Maximum cable length	10m[1]
Current sense	Description	Up to three axes connected to current sense output on Helmholtz drive amplifier
	Analogue input	Up to ±10V differential
	Input filter	Type Butterworth 2-pole 12dB per octave low pass Frequencies (software selectable): 10kHz, 1kHz, 100Hz & 10Hz
	Connector	Hirose RM15TRD-10P (front panel)
	Mating connector	Hirose RM15TRD-10S (supplied on request)
	Maximum cable length	3m[1]

Output to PA1 Power Amplifier	Description	Up to three axes connected to Helmholtz drive amplifier
	Analogue output	±10V differential
	Connector	Hirose RM15TRD-10S (front panel)
	Mating connector	Hirose RM15TRD-10P (supplied on request)
	Maximum cable length	3m*
NI DAQ interface	Description	Two separate interfaces for NI DAQ card
	Connector	2 x 68-way Harting 6001 068 5232
	Mating cable	NI cable SHC68-68EPM
	Maximum cable length	3m[1]

* This is to ensure compliance with FCC and CE regulatory approvals.

Environmental	
Operating temperature range	+10ºC to +30ºC
Operating humidity	0 to 90% RH non-condensing
Storage temperature	+10ºC to +40ºC
Usable locations	Indoor use only
Maximum operating altitude	2000m
Pollution degree	Pollution Degree 2

Mechanical	
Dimensions	The CU1 conforms to the standard 19-inch rack mount specification and is 1U high
Weight	2.4kg

Electrical	
Power supply voltage	100–240V AC 50/60Hz
Power supply current	1100mA (115V) / 640mA (230V) type
Mains supply voltage fluctuation	±10% max
Overvoltage Category	OVC II
Power input (rear panel)	3-way IEC 320 with integral filter (mains cable provided)
Working common mode input voltage	±10V
Absolute maximum input voltage	±15V on any input pin
ESD Protection	±15V on any input pin Comprehensive ESD surge protection on input and output channels for ESD protection

CU2 Closed-Loop Module

The CU2 Closed-Loop Module, supplied with a dedicated Reference Magnetometer, provides active compensation for external DC and AC magnetic field variations. This module is only compatible with 3-axis coils.



Specifications

Functionality when used with CU1 and PA1	
DC disturbance field attenuation	-46dB ±1dB
Zero field DC drift over 6 hours	<100nT
System noise	<3nT peak to peak
Bandwidth: HC1, HC2, HC16, & BH1300HF-4-3-A BH1300-C, BHC2000-A	 DC to 12Hz -3dB, one pole LPF DC to 4Hz -3dB, one pole LPF
Reference magnetometer range	±500µT
Reference magnetometer scaling	20mV/µT (±10V full scale)
Maximum field per axis	<±500µT (applied and disturbing field combined)
Warm-up time	30min
Orthogonality error adjustment range	±1˚ nominal
Gain adjustment range	±10% nominal
Offset adjustment range	±800nT nominal

Environmental	
Operating temperature range	+10ºC to +50ºC
Storage temperature	-40ºC to +85ºC
IP Rating	IP20

Mechanical	CU2 Module	CU2 Reference Magnetometer
Dimensions (W x H x L)	106.1 x 57.6 x 143.8mm	25 x 23.4 x 73mm (excluding cable)
Weight	430g	320g (approximate)
Mounting	N/A	4 x M2.5 tapped holes, centres are 67 x 18 mm
Mounting accuracy relative to Helmholtz Coils	N/A	<±10°

Electrical	
Power supply voltage	±15V DC from the CU1 Auxiliary
Power supply current	<50mA in zero field
Working common mode input voltage	±10V
Absolute maximum input voltage	±15V on any input pin

Connections	Reference Magnetometer	Auxiliary Connection	Current Control Input	Current Control Output
Analogue Input/output	Excitation signal outputs and Detection coil inputs	±10V single-ended output (Reference Magnetometer signal)	±10V differential input	±10V differential output
Connector	Hirose RM15TRD-10P		Hirose RM15TRD-10S	
Maximum cable length	10m	1m	1m	1m



Control System Components

In order to control the Helmholtz Coil system from a PC, a suitable National Instruments™ acquisition card can be supplied. This connects to the CU1, and enables a user to control the field generated using the supplied control software.

Signals from the Device Under Test and Auxiliary sensor are also digitised by the acquisition card.

Standalone suitable acquisition cards include the USB-6363.

Compatibility

Combination	HC1® with PA1	HC2® with PA1	HC16 with PA1
Maximum field DC single axis*	>±500µT	>±250µT	>±1mT
Corner frequency	100Hz	20Hz	>100Hz
Maximum field at AC (single axis)*	>±100µT at 3kHz	>±100µT at 300Hz	>±100µT at 5kHz
DC field compensation	>±80µT	>±45µT	>±80µT

* Axis dependent, stated for larger coil. Smaller coils can achieve approximately 20% higher fields.

HC16 additional PA1 compatibility information	
Max DC Field (all axes simultaneously driven)	1mT (target)
Max AC Field (all axes simultaneously driven)	1mT Peak <440 Hz (target)
Maximum frequency	5kHz
Field at maximum frequency (per axis, all axes simultaneously driven – value for largest diameter axis, other axes are higher)	110 µT Peak

Accessories

Sensor for Helmholtz Coil Setup and Recalibration

A sensor is required to complete the setup procedure of the Helmholtz Coil at the customer location. Bartington recommends the use of the Mag-13MS and associated mounting accessories. This equipment will allow for final checks and adjustments after installation of the coils, together with periodical calibration.

Sensor Mounting Accessories

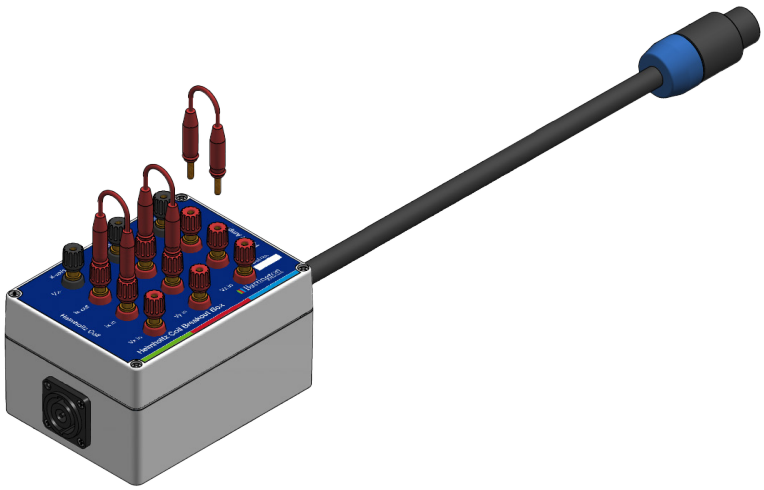
Bartington offers a range of mounting accessories for positioning of Bartington sensors within the centre of the homogeneous volume.

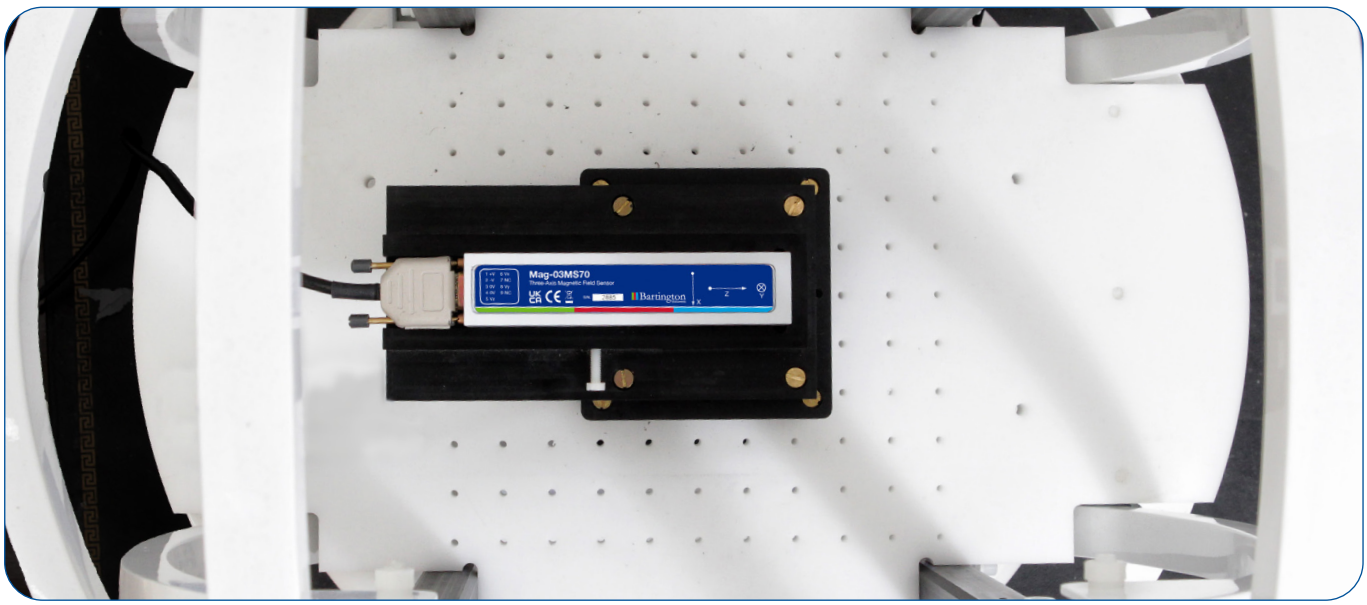
HC1® and HC2® coils are supplied with mounting tables. HC16 coils are supplied with mounting tables or pillars. These make it possible to bring test jigs to the centre of the coil.

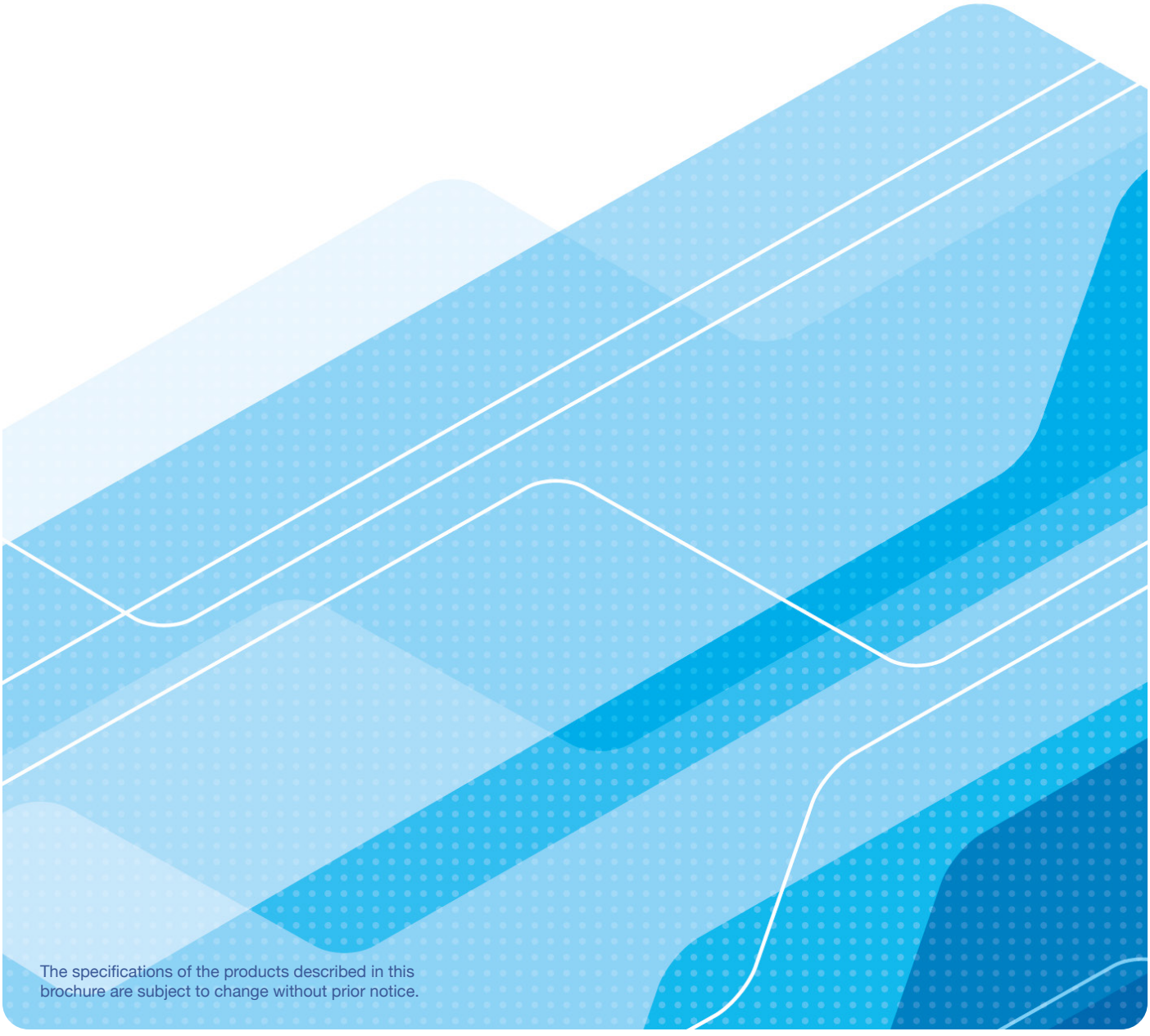
Helmholtz Coil Breakout Box

A Helmholtz Coil Breakout box can be supplied for monitoring the voltage and current between the HC1®, HC2® or HC16 and a PA1 on each axis.

The box enables straightforward testing and real-time monitoring of the system.







The specifications of the products described in this brochure are subject to change without prior notice.

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