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Appendix A

TWINS LP calculations

The values of the thermal resistance and capacitance are calculated in this appendix. The TWINS's dimensions and material properties are also given as it is needed for the calculations.

A.1 Dimensions

The dimensional information is given in Table A.1 where OD is outer diameter and ID is inner diameter.

A.2 Material properties

Table lists the material properties needed to calculate the LP resistances and capacitances.

A.3 Thermal resistor values

The resistance values in the radial direction and the thermal capacitance is given in Table A.3. The resistance in the axial direction is given Table A.3. The resistances are calculated using (3.7), (3.10) , (3.15) and (3.18).

In the stator shaft radial and axial heat flow will occur. The radius of the shaft is nearly constant inside the machine ($r = 30$ mm , $l = 154$ mm) and then narrows ($r = 20$ mm). Where it narrows, the rotor is in contact with the high speed bearing which is inside the endplate (stator housing). These two parts can be modelled separately as shaft inside and shaft outside.

Resistors for shaft inside:

Table A.1: TWINS dimensional parameters

Part		Diameter [mm]
Rotor shaft OD	= Rotor lamination ID	30
Rotor lamination OD	= Permanent magnet ID	46
Permanent magnet OD	= Shielding cylinder ID	60
Shielding cylinder OD	= air gap ID	63
air gap OD	= Coil former 1 ID	64
Coil former 1 OD	= Winding, Endwinding ID	66
Winding OD	= Coil former 2 ID	82
Endwinding OD		94
Coil former 2 OD	= Stator lamination ID	84
Stator lamination OD	= Stator housing ID	104
Stator housing OD		130
Axial endwinding length		45
Axial stator housing length		184
Stator housing endcap width		15
Bearing ID		10
Bearing OD		20
Bearing width		10

Table A.2: Material properties

Part	Material	k [W/(m.K)]	ρ [kg/m^3]	c [J/(kg.K)]
Rotor shaft	AISI 304	16.2	8000	500
Laminations	M270-35A	35	7650	430
Permanent magnet	VACODYM 655	10	7630	450
Shielding cylinder	Inconel 718	11.4	8190	435
Coilformer	Tufnol	0.3		
Winding	Copper	400	8933	395
Winding insulation	Epoxylite 006-0838	0.3		
Stator housing	ST 52	60	7854	434

Table A.3: Radial resistances

Part	R_{1r} [K/W]	R_{2r} [K/W]	R_{3r} [K/W]	C [J/k]
Rotor laminations	0.0155	0.0205	-0.0059	169.6
Permanent magnet	0.0321	0.0383	-0.0116	240.11
Shielding cylinder	0.0056	0.0058	-0.0019	61.94
Coil former 1	0.1346	0.1374		
Winding	0.3562	0.4115	-0.1272	118.12
Endwinding	0.7363	0.9313	-0.273	167
Coil former 2	0.1057	0.1074		
Stator laminations	0.0084	0.0096	-0.003	524
Stator housing	0.0017	0.0020	0.0006	2606

Table A.4: Axial resistances

Part	R_{1a},R_{2a} [K/W]	R_{3a} [K/W]
Winding	0.1344	-0.0448
Endwinding	28.42	-9.47

$$\begin{aligned} R_{rRsi} &= \frac{1}{2\pi k_{rs} L_{rs}} \\ &= 0.1637 \text{ [K/W]} \end{aligned} \quad (A.1)$$

$$\begin{aligned} R_{aRsi} &= \frac{L_m}{2\pi k_{rs} r_{rso}^2} \\ &= 3.7114 \text{ [K/W]} \end{aligned} \quad (A.2)$$

Resistors for shaft outside:

$$\begin{aligned} R_{rRso} &= \frac{1}{4\pi k_{rs} L_b} \\ &= 0.9824 \text{ [K/W]} \end{aligned} \quad (A.3)$$

$$\begin{aligned} R_{aRso} &= \frac{L_m}{2\pi k_{rs} r_{rso}^2} \\ &= 3.7114 \text{ [K/W]} \end{aligned} \quad (A.4)$$

The thermal capacitance of the rotor shaft is $C_{Rs} = 565$ [J/K].

Appendix B

Mechanical drawings

The detail mechanical drawings are included in this appendix. The stator housing is shown in Figure B.1 and the stator flange in Figure B.2. The pillar block and top cover are shown in Figures B.3 and B.4, respectively. The coil former is shown in Figure B.5. An assembly drawing of the rotor is shown in Figure B.6. The complete machine assembly can be found in Figure B.7.

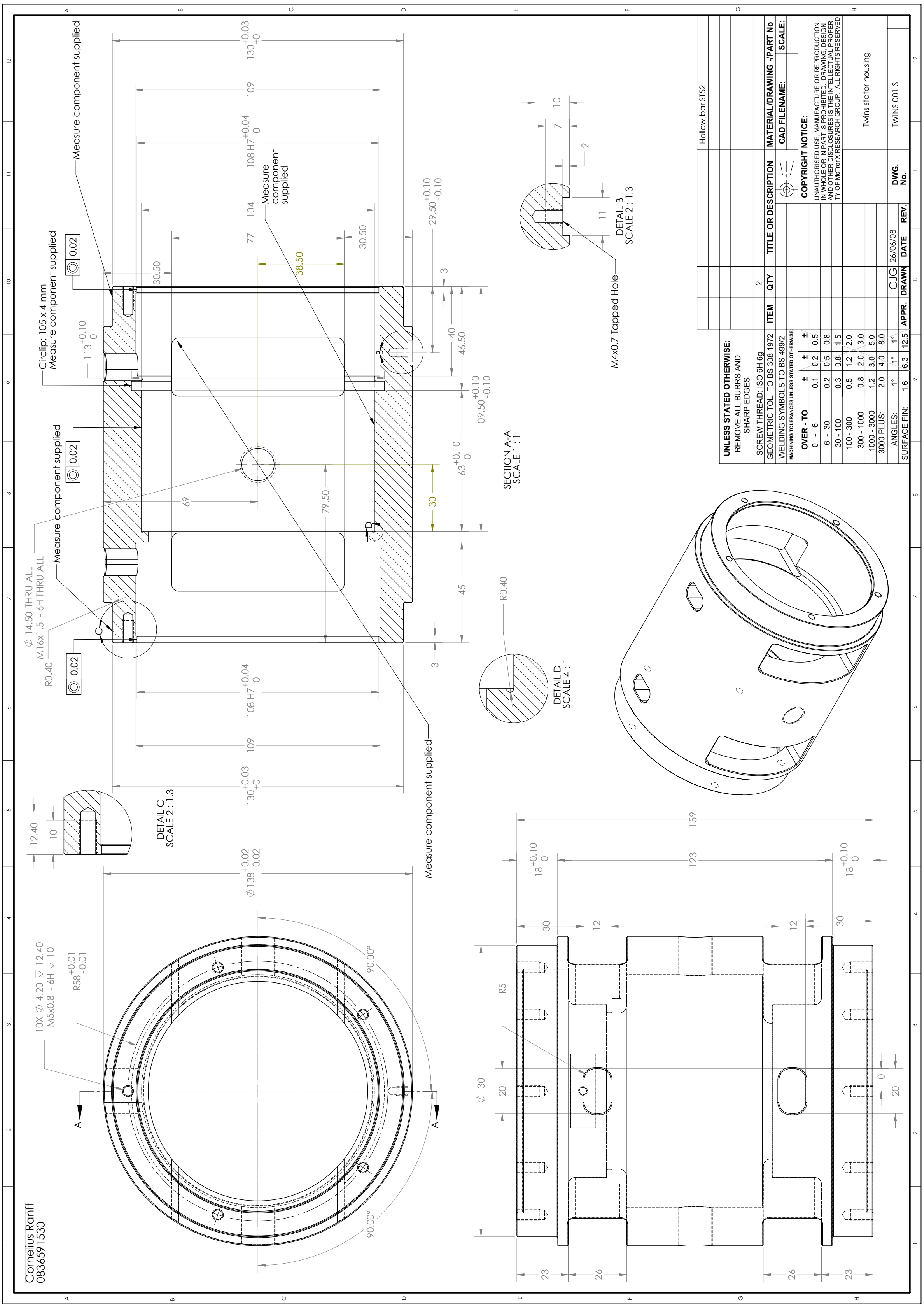

Figure B.1: TWINS stator housing

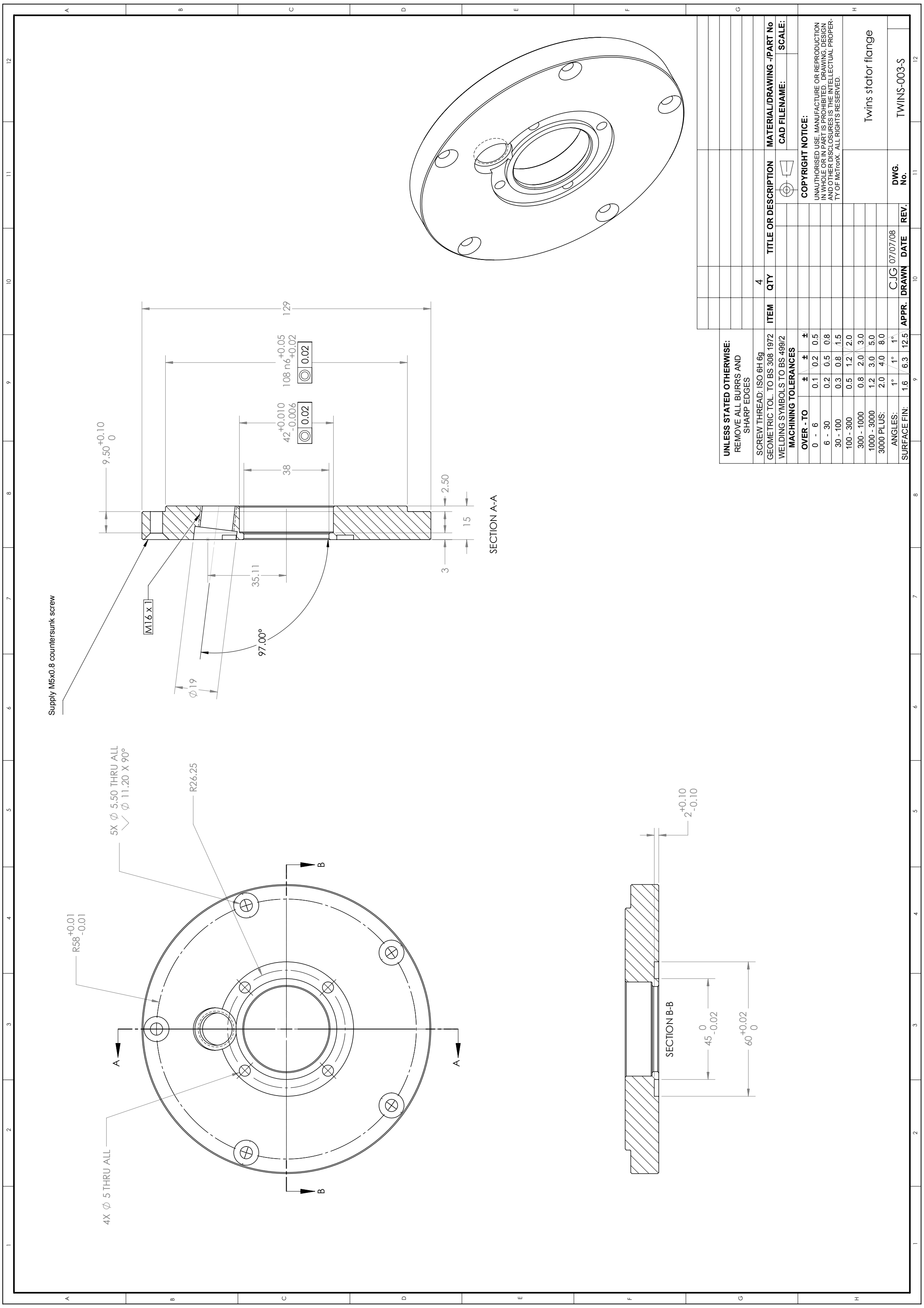

Figure B.2: TWINS stator flange

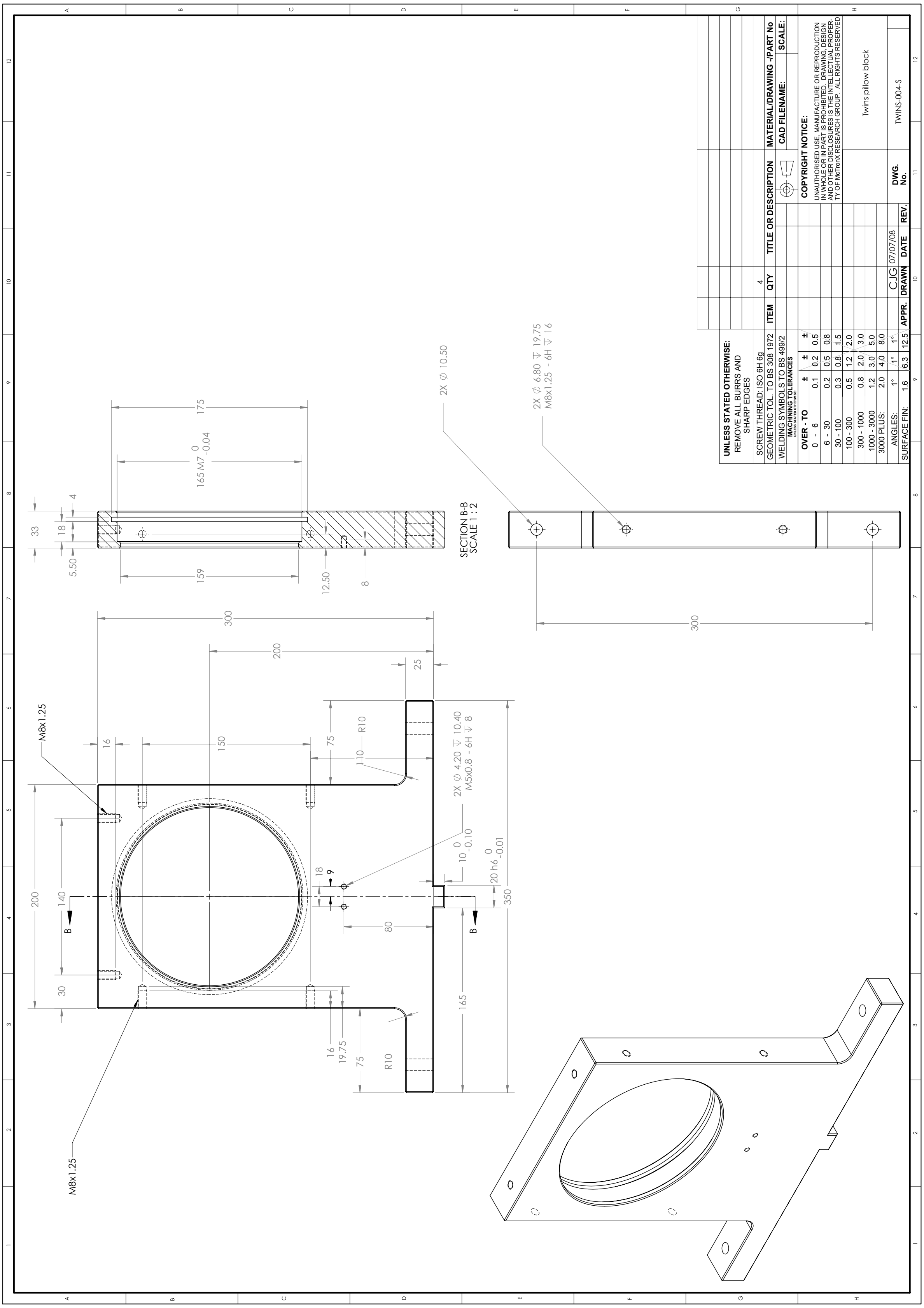

Figure B.3: TWINS pillar block

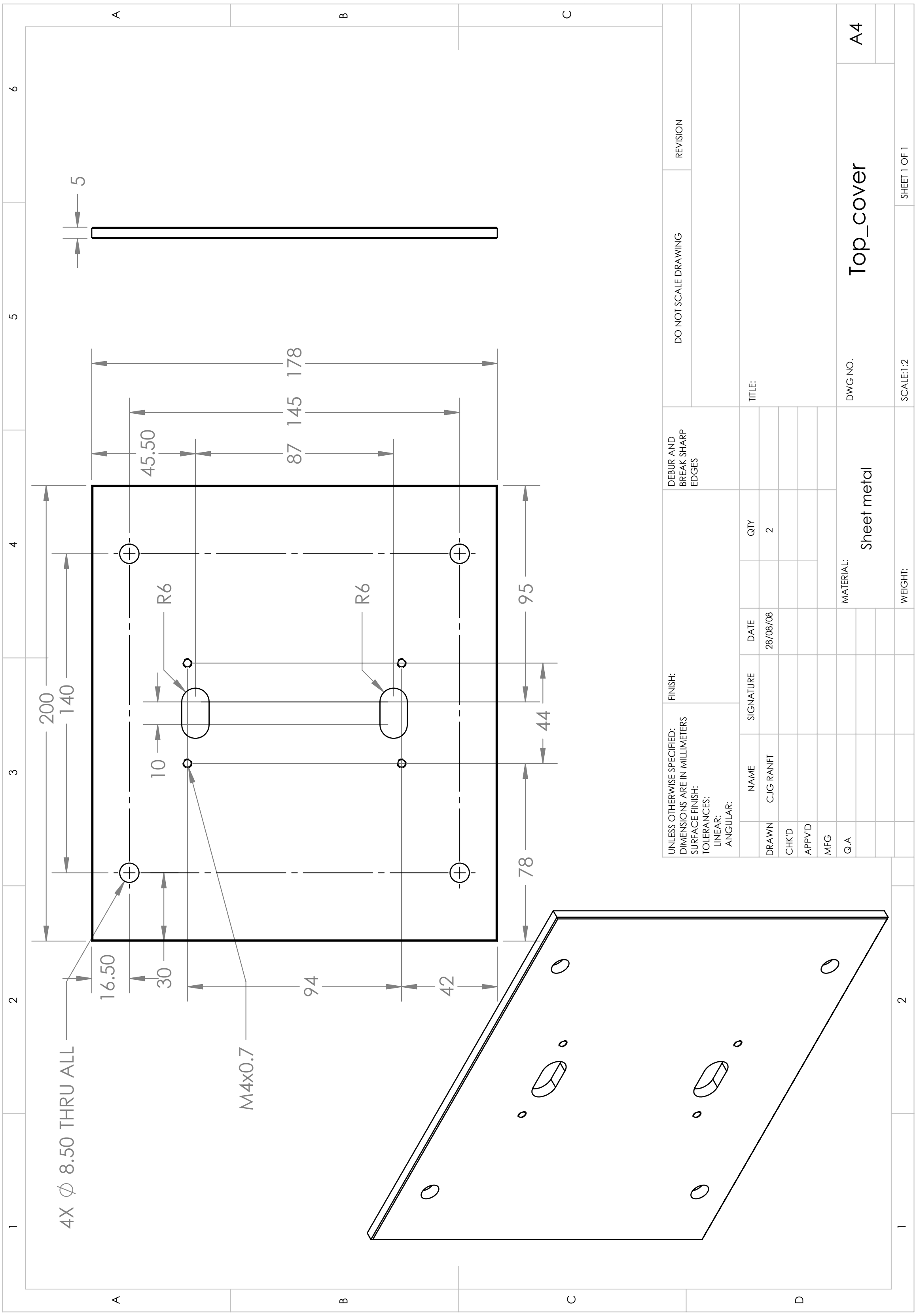

Figure B.4: TWINS top cover

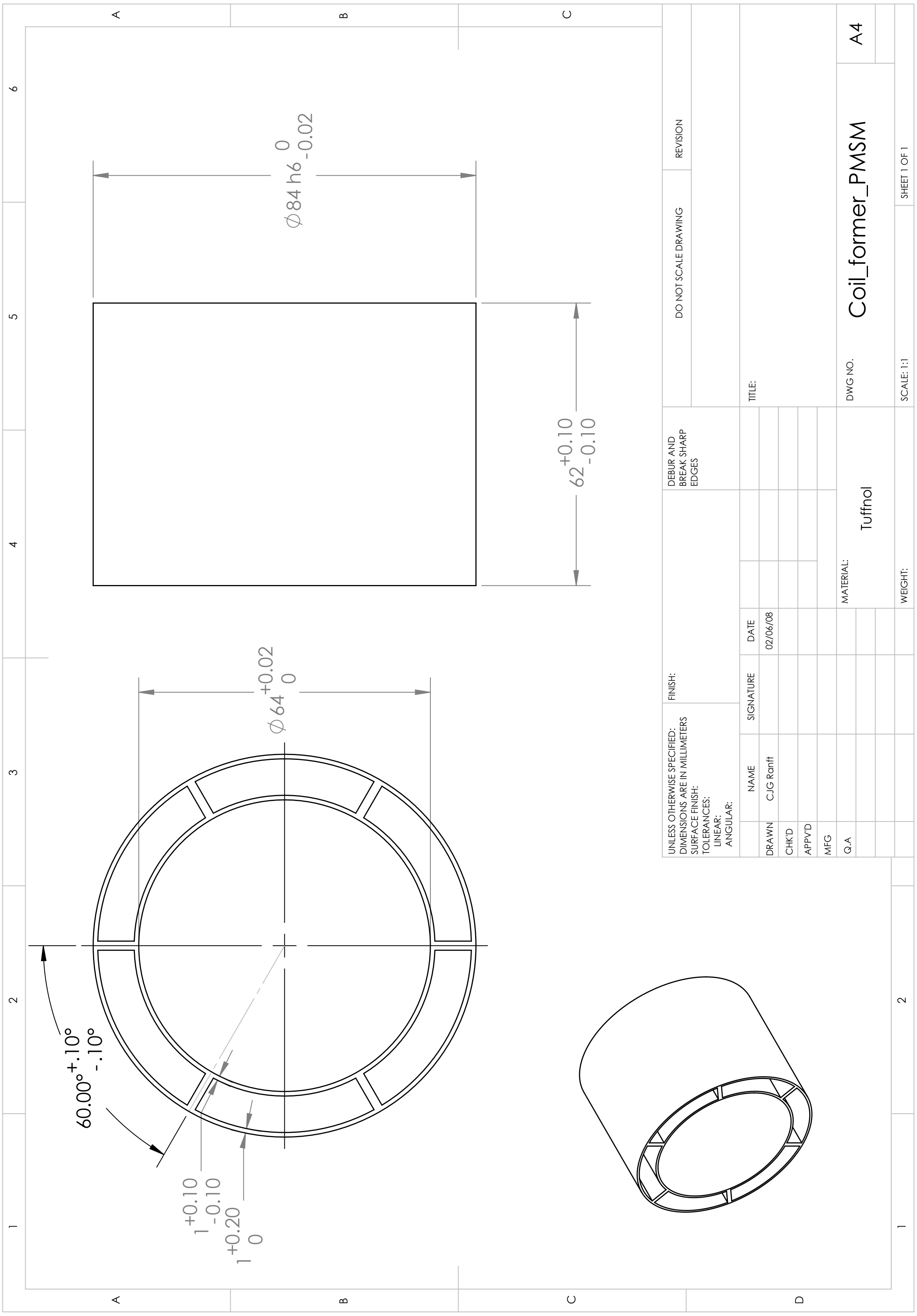

Figure B.5: TWINS coil former

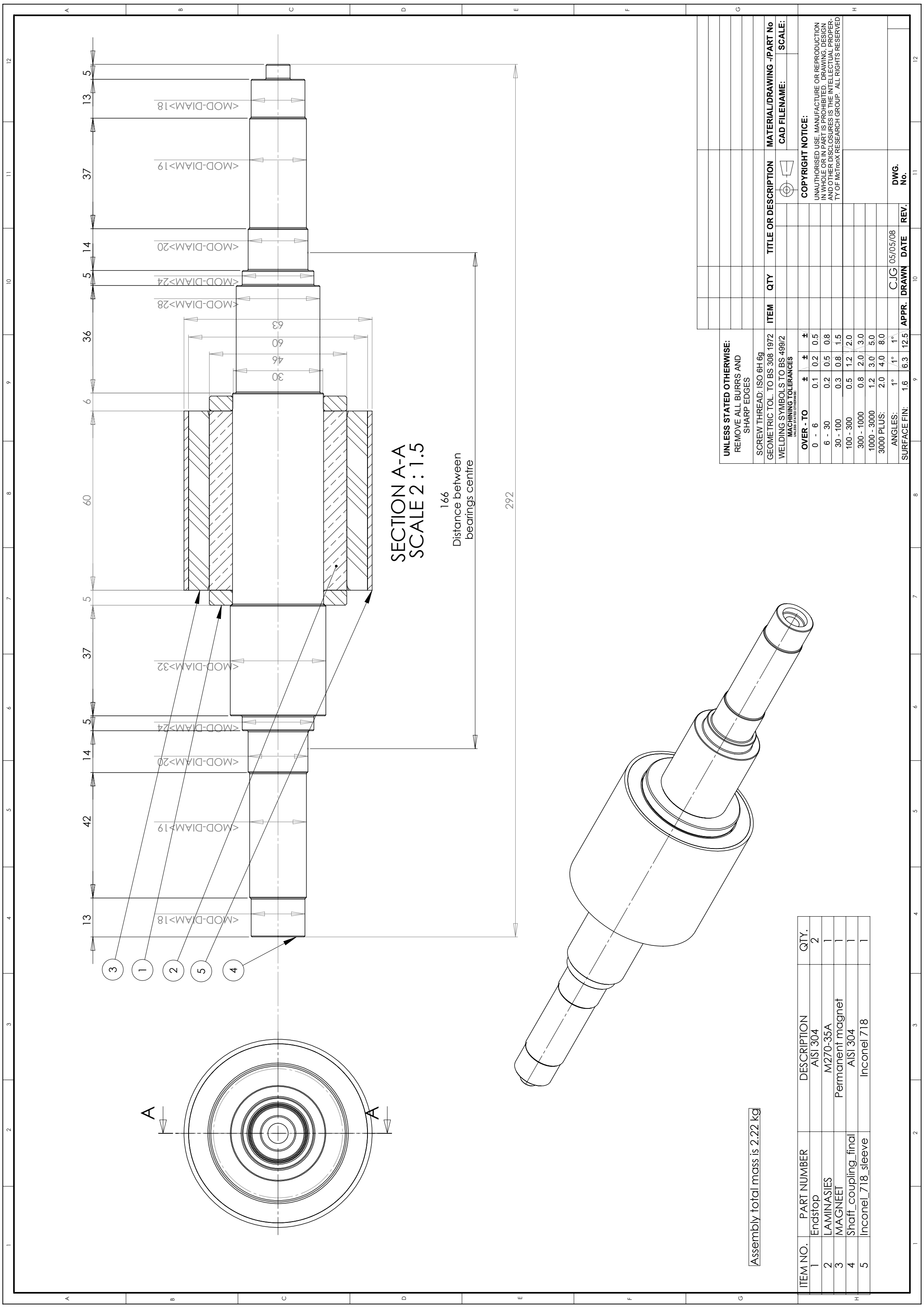

Figure B.6: TWINS rotor assembly

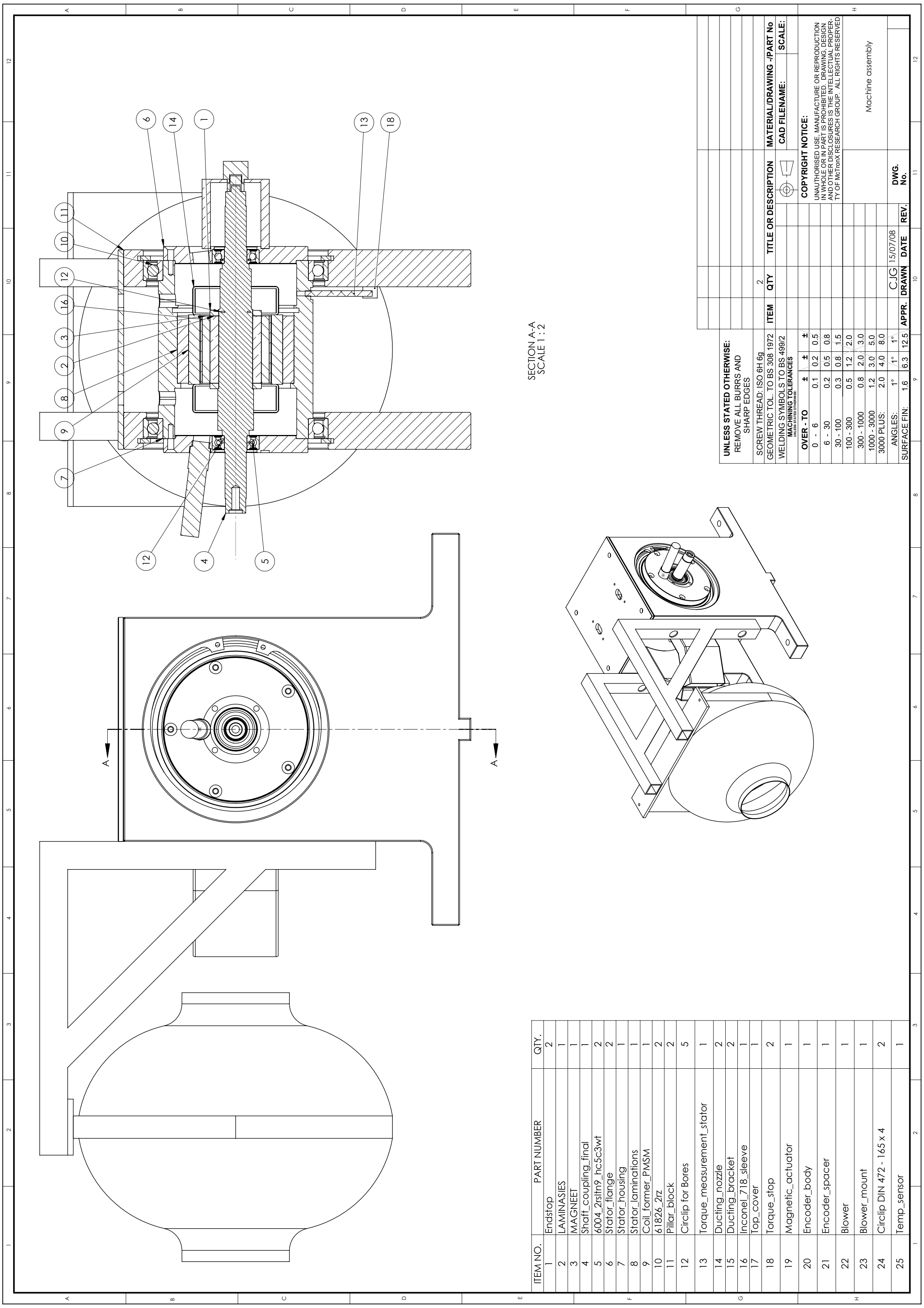

Figure B.7: TWINS machine assembly

Appendix C

System photos

Some photos of the TWINS system are given in this appendix.

Figure C.1: Glue between rotor laminations and PM

Figure C.2: TWINS rotor

Figure C.3: TWINS mounted on the vertical base plate

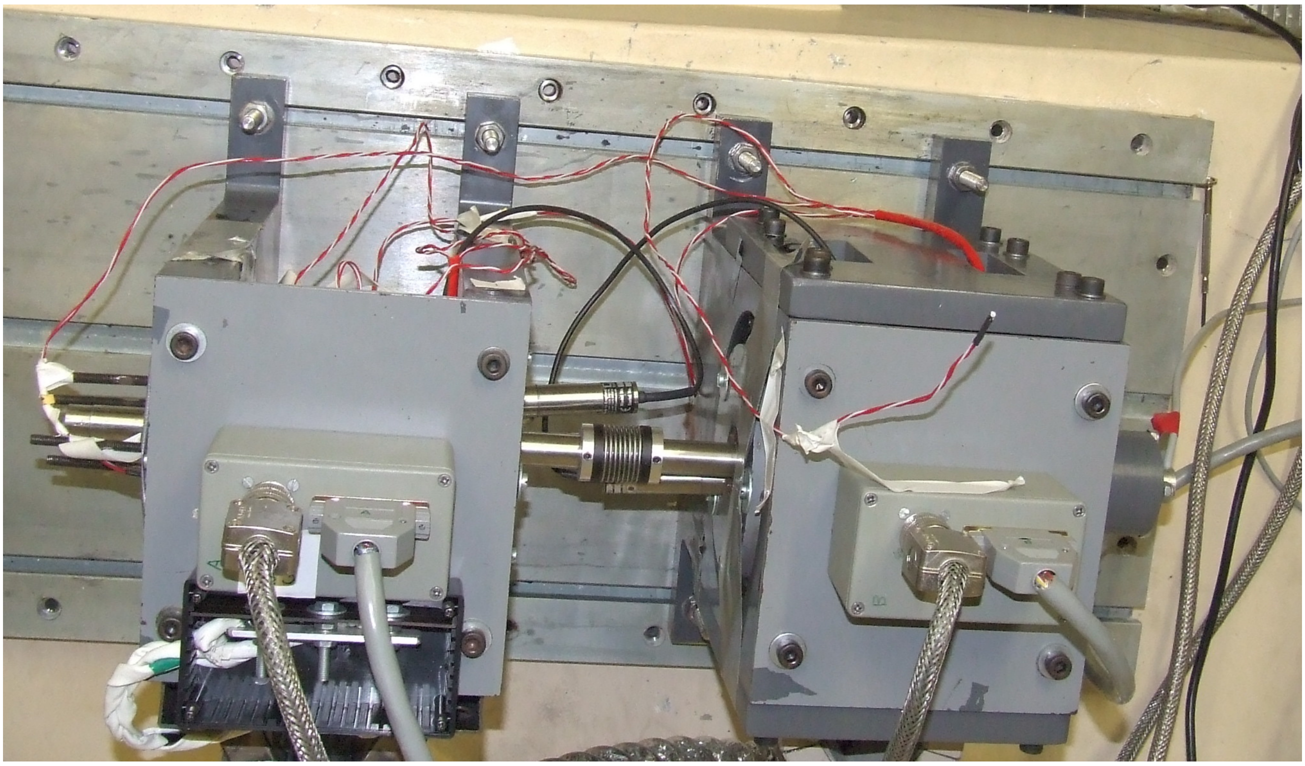

Figure C.4: TWINS top view

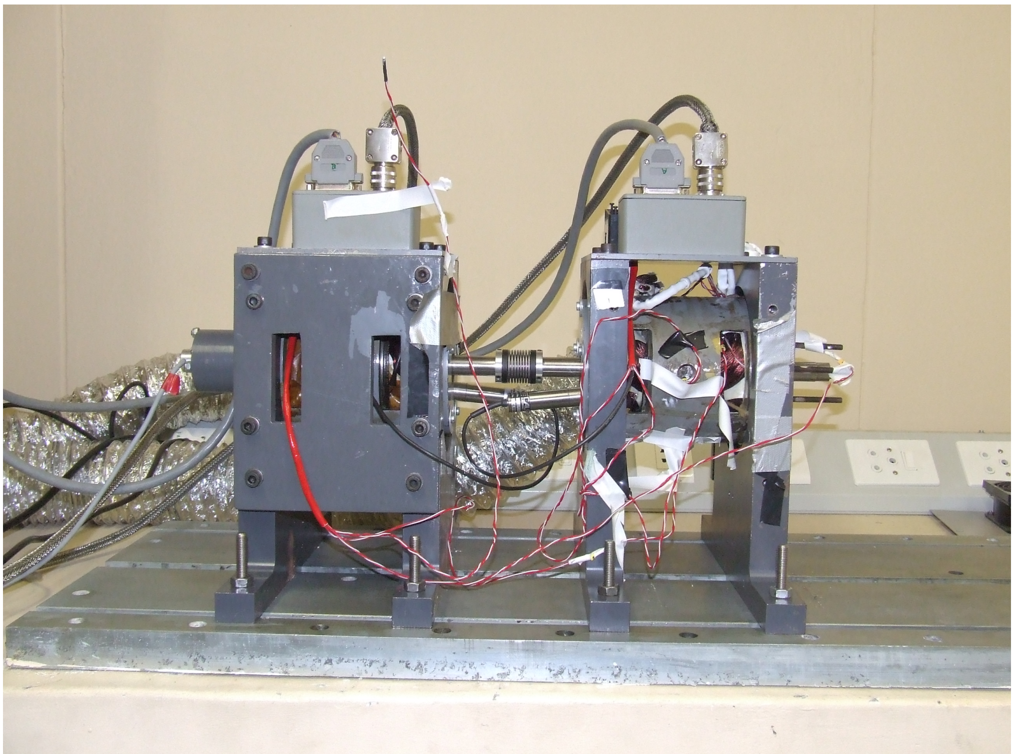

Figure C.5: TWINS side view