Design of Vertical Stabilizing Shells and Tutorial on Electromagnetic Pumps

I. N. Sviatoslavsky and E. A. Mogahed

Fusion Technology Institute, UW-Madison, Wisconsin

ARIES Project Meeting

University of Wisconsin, Madison, WI

June 19-21, 2000

Description of Vertical Plasma Stabilizing Shells

University of Wisconsin

- ***There are conducting shells located on the inboard and outboard side of the plasma chamber that stabilize the vertical location of the plasma.***
- ***These shells must be electrically conducting in the toroidal direction, but since they are imbedded in the removable segments, they have to make good electrical contact between them. Parameters of the shells are given below:***

	Inboard	***Outboard***
Material	***WRe***	***WRe***
Thickness (cm)	***4.0***	***4.0***
Radial location (cm)	***3.45***	***5.0 - 6.0***
Vertical location (± m)	***1.8 - 2.9***	***1.8 - 2.9***
Cooling	***Radiative***	***Radiative***
Estimated temp. (C)	***1260***	***1260***
Number of shells	***32***	***32***
Mass of each shell (kg)	0.58×10^6	1.32×10^6

Support of the Shells on the Segments

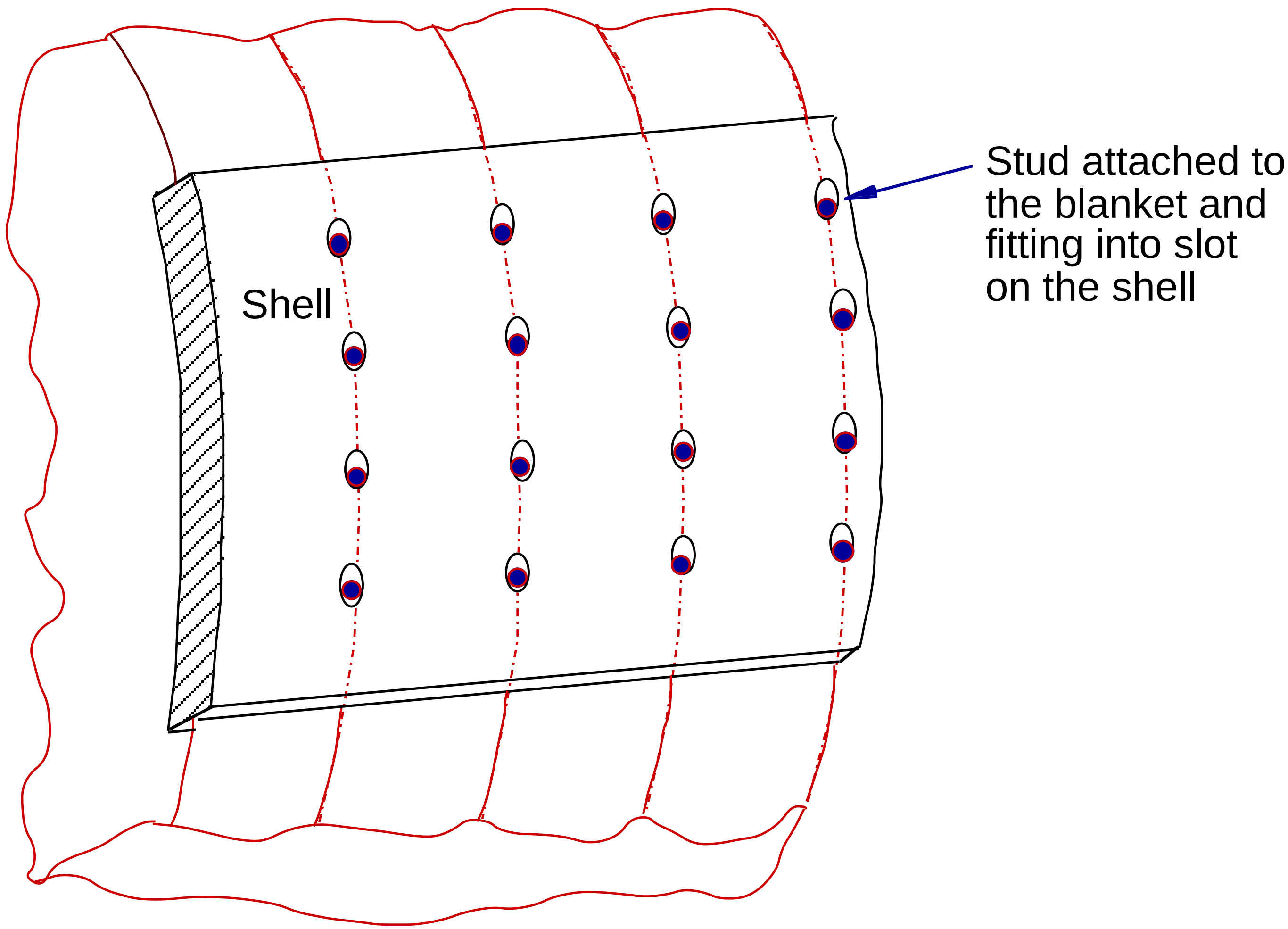
Each segment of the chamber will have an inboard and an outboard shell supported on it. Further, there are upper and lower shells.

<u>Inboard Shells</u>: There are indentations in the inboard high-temperature (HT) shield and the individual shells are imbedded in it at the interface between the inboard FW/blanket and the inboard HT shield. SiC studs built into the junctions between modules fit into slots in the shells to support them.

<u>Outboard Shells</u>: In the same way as in the inboard side, there are indentations in the blanket II aseembly at the interface between FW/blanket I and blanket II, where the shells are imbedded. They also are supported on studs that fit into the shells.

Support of Shells on Components of the Blanket and Shield

University of
Wisconsin-Madison



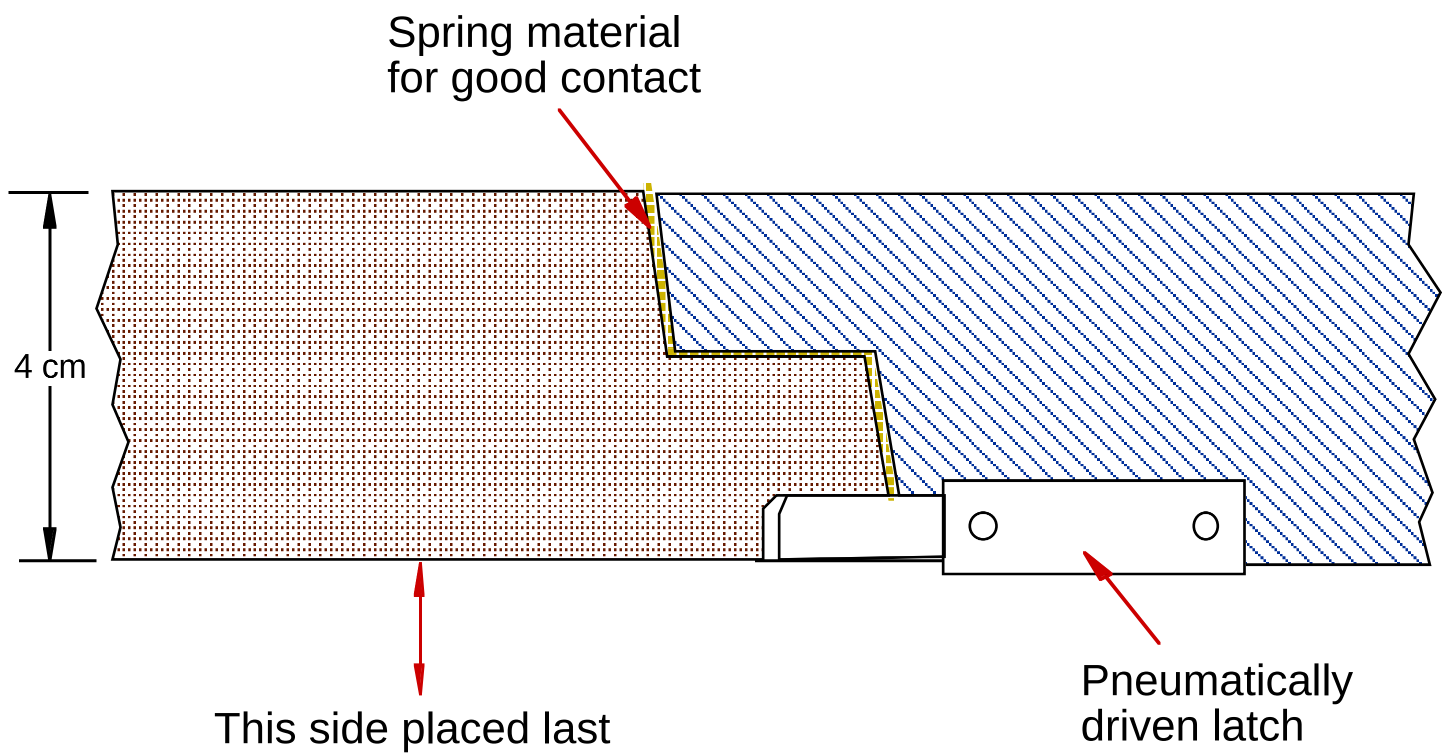
Electrical Contact Between Stabilizing Shells

University of Wisconsin

- *The stabilizing shells will be an integral part of the chamber segments and will be removed with the segments when they are maintained.*
- *Stepped surfaces at the interface between the shells are provided with spring material (W wool) to facilitate electrical conduction between them.*
- *Each segment will be provided with pneumatically activated latches at the interfaces between the stabilizing shells. High pressure He gas is used to drive the pneumatic pistons for engagement and disengagement. These latches compress the spring material at the interfaces, prevent relative vertical motion of the plates, and provide good electrical contact.*
- *The He gas is exhausted after the latches are engaged to prevent leakage into the chamber.*
- *Failure to disengage a latch during maintenance can be overcome by removing neighboring segments first, then sliding the failed segment circumferentially.*

Electrical Junction between Stabilizing Shells

University of
Wisconsin-Madison



Forces on the Vertical Stabilizing Shells

University of Wisconsin

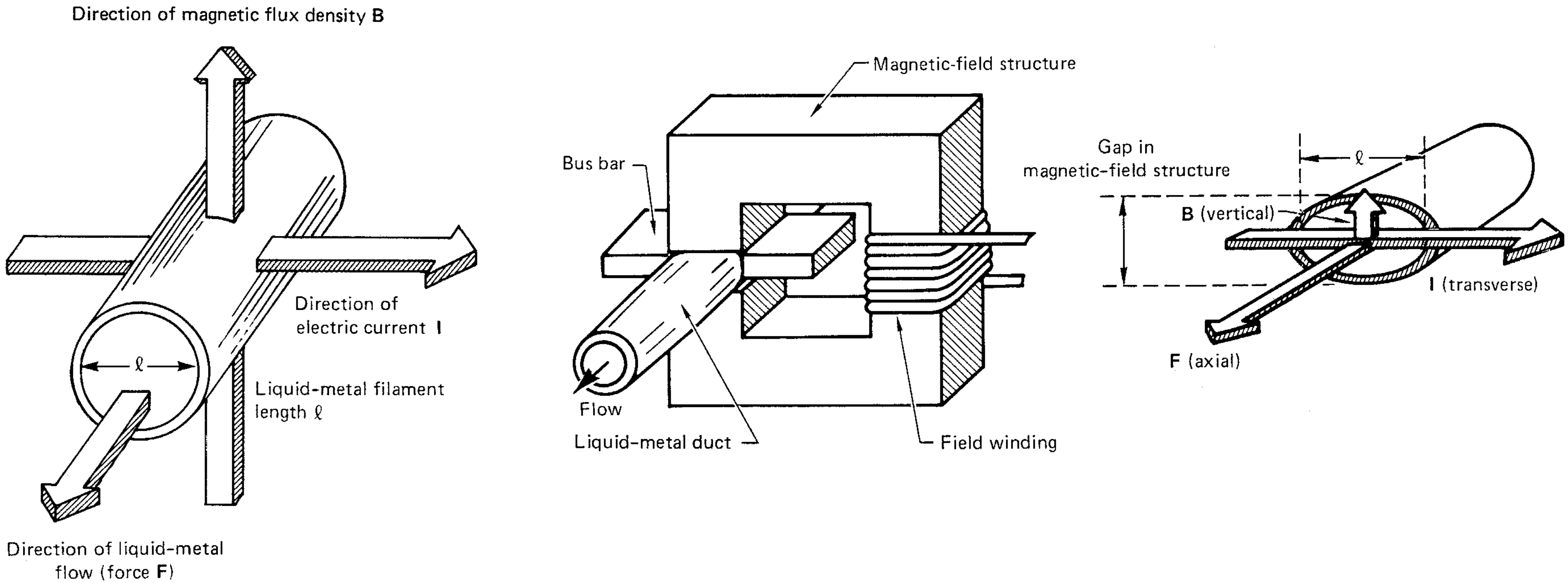
- *Electric currents induced in the shells by plasma displacement will interact with the magnetic field to create both radial and vertical forces.*
- *The shells are captured between chamber components (blanket and shield) and are recessed within them, essentially immobilizing them. These forces on the shells will have to be determined to access their impact on the blanket/shield components.*
- *The latches between shells will restrain relative vertical motion between them and will keep the interfaces compressed for good electrical contact.*

Electromagnetic Pumps for Boosting Pressure for Divertor Cooling

University of Wisconsin

Conduction Pumps:

The Most Basic EM Pump in the Direct Current Conduction Pump

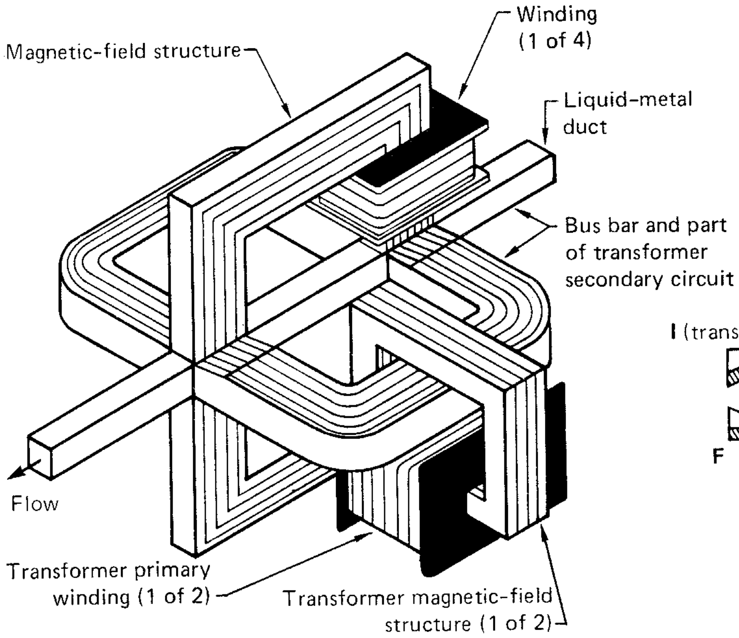


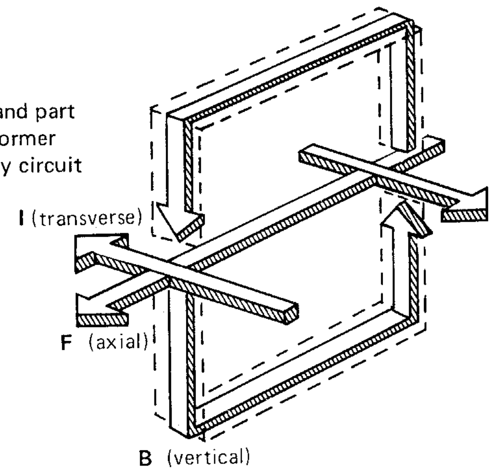
High pressure, low flow, low efficiency, steady-state flow

EM Pumps (cont.)

University of Wisconsin

The Alternating - Current Conduction Pump



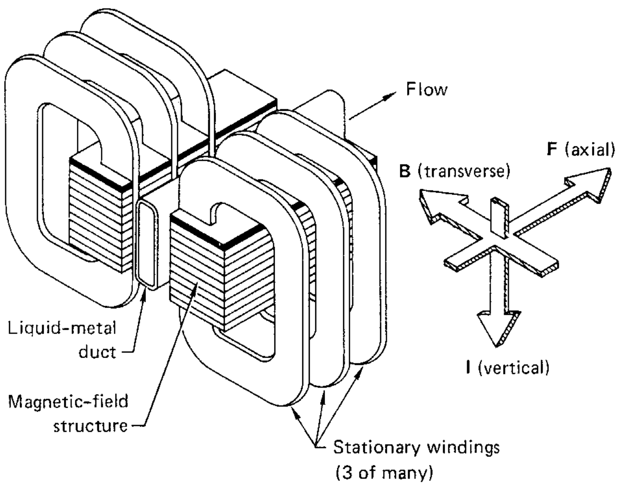


High pressure, low flow, low efficiency. ***Pulsating flow***

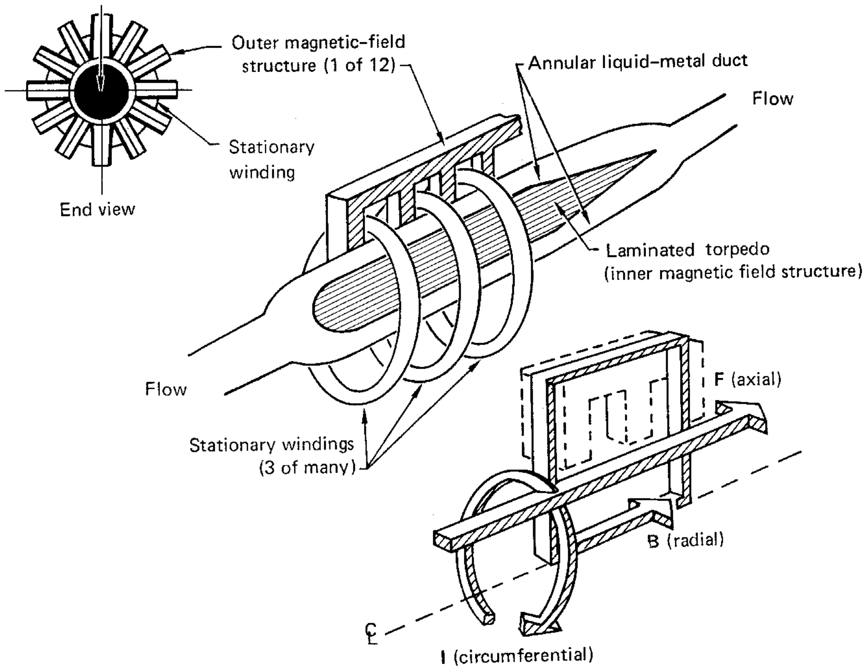
EM Pumps (cont.) -- Induction Pumps

University of Wisconsin

Induction EM pumps require a pulsating magnetic field generated by either rotating magnets or stationary AC windings which cause a



Flat Linear Induction Pump (FLIP)



Annular Linear Induction Pump (ALIP)

Pumping Power Using EM Pumps

University of Wisconsin

Lower divertor and IB blanket region:

Flow = 6,500 kg/s, Boosted pressure = 1 MPa or 10 kg/cm^2

Flow/segment = 203 kg/s or 203 kg/s.pump, $\dot{V}$***= 2.03 x 10^4 cm^3/s.pump***

Pump power P = $\dot{V}$˜***p = .02 MW/pump***

Upper divertor and OB blanket region, P = .022 MW/pump

<u>Conduction Pumps</u>: ***Efficiency ¯ 10%, but with existing B field ¯ 25%***

Pumping power = $\frac{0.02}{0.25}$ ***= 0.08 MW/pump***

Total EM electric power requirement is 5.38 MW

<u>Induction Pumps</u>: ***Assuming ALIP, efficiency ¯ 46%, but with existing B field ¯ 60%***

Pumping power $\frac{0.02}{0.6}$ ***= 0.033 MW/pump.***

Total EM electric power requirement is 2.23 MW

Conclusion for EM Pumps

University of Wisconsin

- ***Conduction pumps are inefficient and troublesome, although they would be the easiest to use. Efficiency is low and power requirement is very high.***
- ***Induction pumps are more efficient. Largest ALIP pump designed has a capacity of 0.9 m^3/s at Δp of 1.26 MPa, designed for LMFBR using Na at 540°C. It was never built and tested, but it had a predicted efficiency of 46%.***