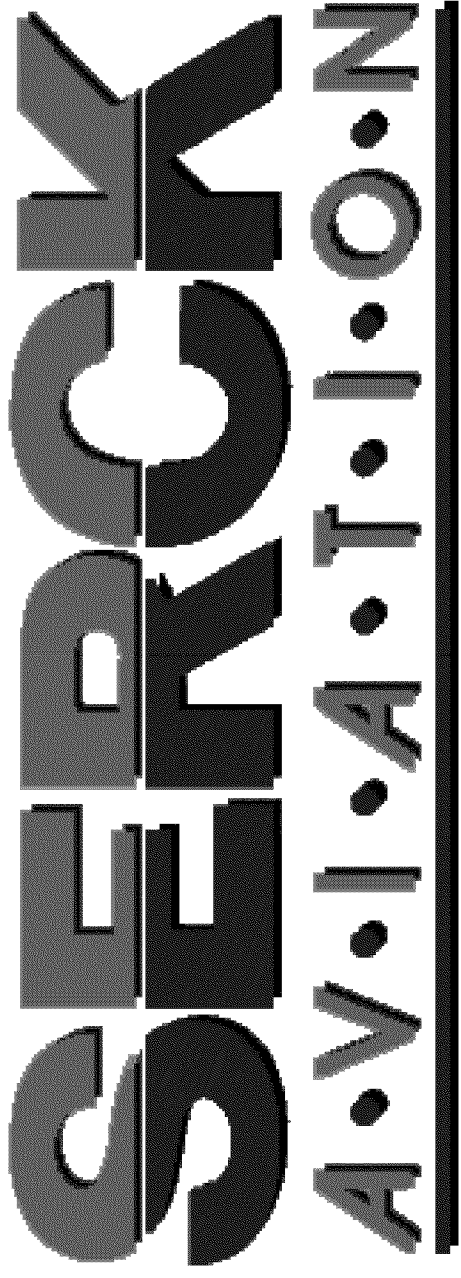




Design of Compact Heat Exchangers for Aero-Gas Turbines

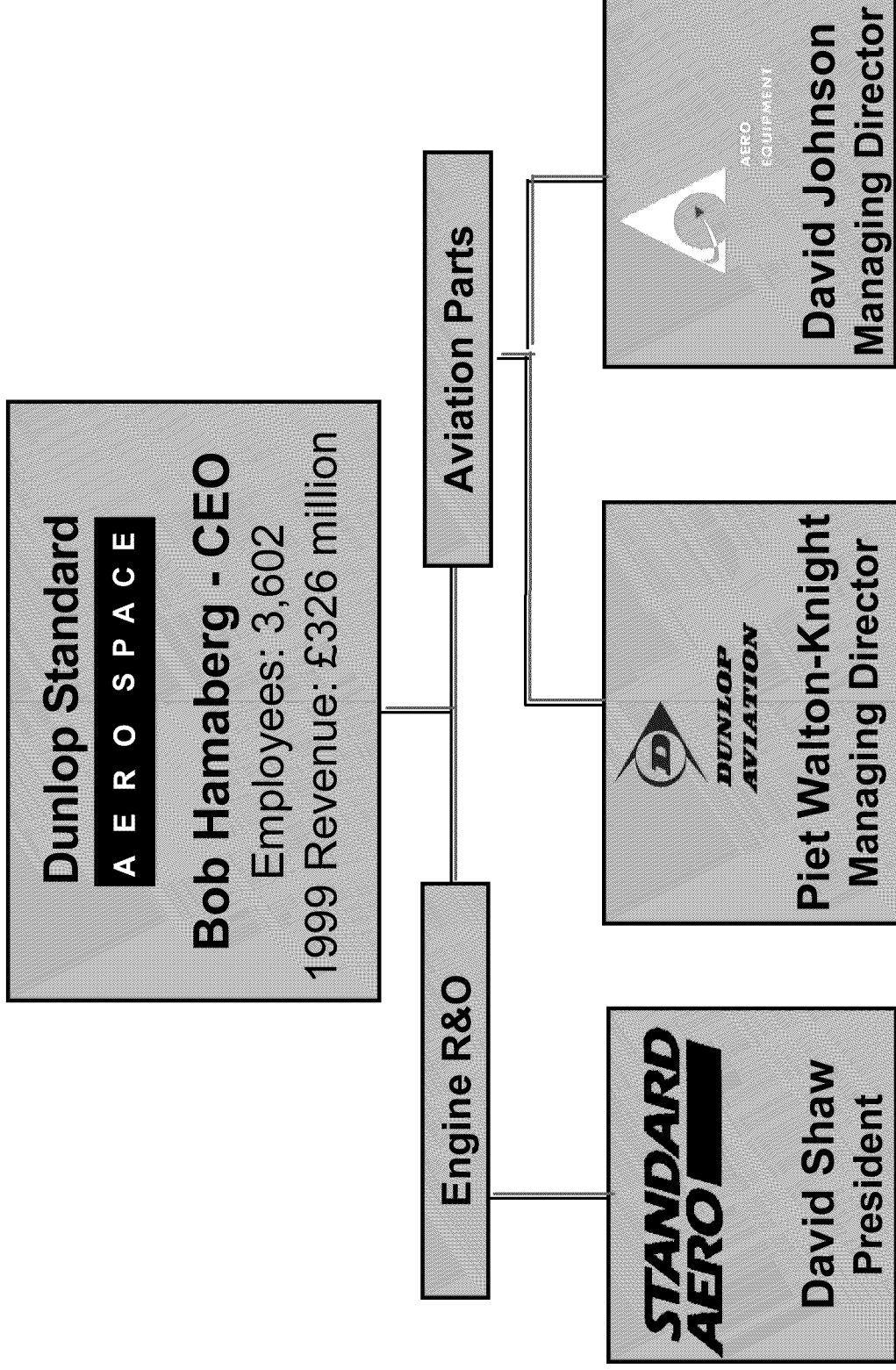
Presented by:-

Stan Payne	Engineering Manager
Steve Hughes	Team Leader: Development
Alex Allen	New Technology Engineer

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The Company

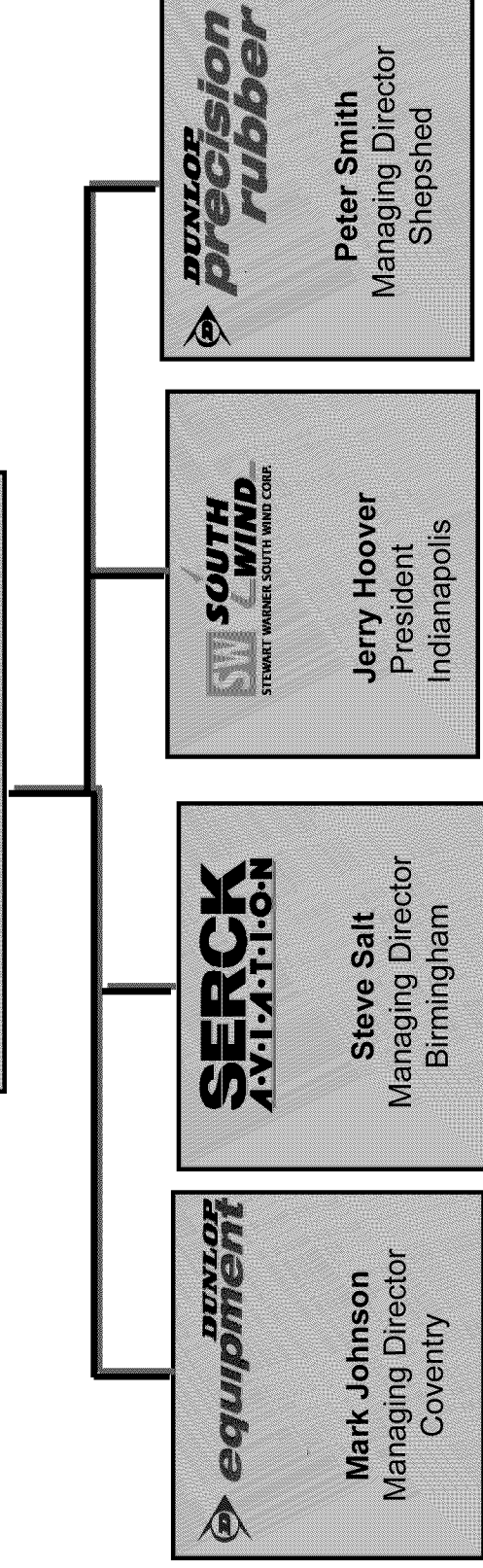
SERCK
A.V.I.A.T.I.O.N



The Company

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Aero Equipment Division
David Johnson
Managing Director
Employees: 660
2000 Revenue £60M



The Company

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Headline Figures

- 2000 Sales £15m
- Employees 130
- Sole Market in Aerospace (91% export)
 - 85% Civil
 - 15% Military
- OEM - 59% of sales
- Spares - 27% of sales
- R&O - 14% of sales



Product Applications include

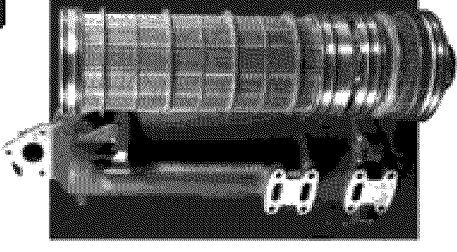
- Pratt and Whitney
 - JT8, JT9, PW2000, PW4000, PW6000, F100
- Rolls Royce
 - Tay, Adour, RB211 524 & 535, Pegasus, Trent, RTM322
- General Electric
 - F404, CF34
- SNECMA
 - CFM56 All Marks
- Boeing 777
- BAe Harrier, Hawk



The Products

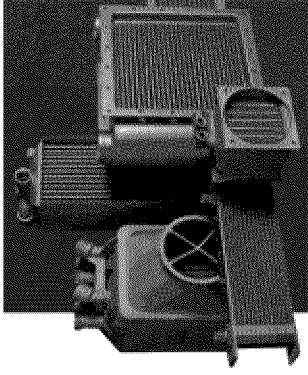
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- Compact aluminium tubular construction offers the advantage of low weight
- Modular design for repair and overhaul provides low cost of ownership
- Well proven design and robust construction meets High Mean Time Between Failure requirements



Shell & Tube

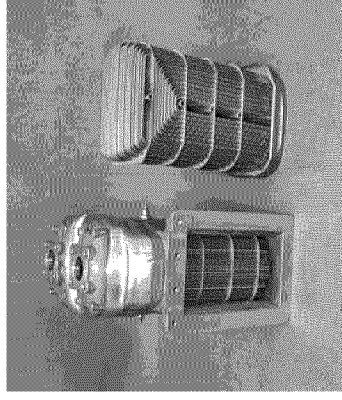
Plate & Fin



- Compact aluminium construction offers the advantage of low weight and cost.
- Brazing technology used provides high joint integrity

- Operating at approximately 1200°F to provide positive cooling to bearing chambers.
- Compact inconel tubular construction offers exceptionally long service life

High Temperature



Existing Products

<u>Type</u>	<u>Applications</u>		<u>Heat transfer area/volume</u>
	Fuel/Oil	Air/Oil Air/Air	(Compactness)
• Tubular	✓	✓	650 m ² /m ³
• Plate - Fin	✓*	✓	800 - 1500 m ² /m ³

* Low Pressure & Temperature applications

Metal Foam Heat Exchanger

Construction

- Use of Metal foam, (nickel or aluminium) to increase heat transfer.
- Several designs under consideration.
- Rapid development of product expected.

Benefits

- ⇒ Cost Reduction
- ⇒ Weight Reduction
- ⇒ Performance Improvement

Metal Foam

Design Option - 1

- ⇒ The heat exchanger built up of alternate plates. Plate Fin/Foam Heat Exchanger
- ⇒ Note: the foam can be brazed to the plates.

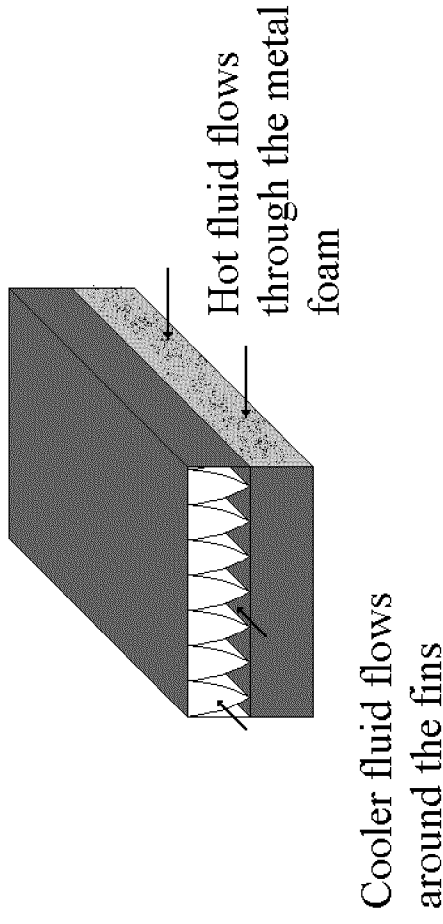


Fig.1

Metal Foam

Design Option - 2

- ⇒ Contact between tubes and foam is fixed by brazing.
- ⇒ Extended secondary surface for heat transfer.
- ⇒ Increased turbulence of the shell-side fluid.
- ⇒ The materials of construction have the same thermal expansion.

Tube - Foam Heat Exchanger

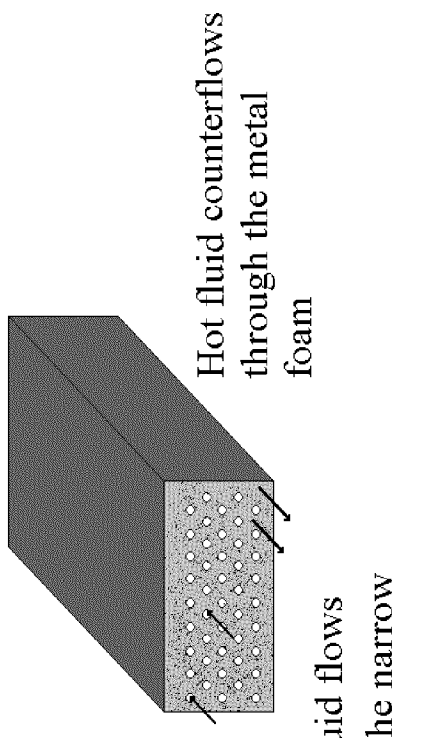


Fig.2

Metal Foam

Design Option - 3

Rotating Air/Oil Heat Exchanger
& Separator:

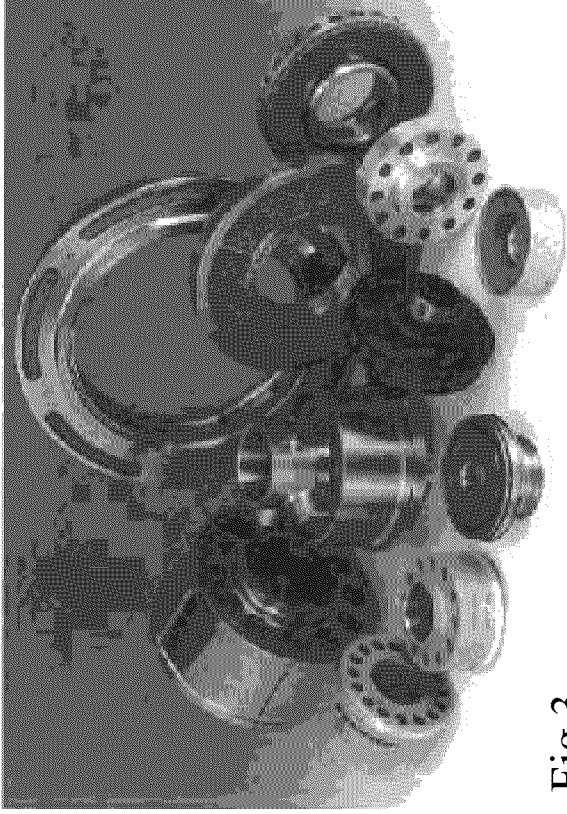


Fig.3

- ⇒ The Retimet® uses centrifugal action to force the denser oil to separate from the less dense air.
- ⇒ Rotational energy required is available within the gearing system.
- ⇒ Heat exchange possibilities present in such a configuration.

Metal Foam

Key points for consideration

Using metal foam:

- ⇒ Is the pressure drop acceptable ?
- ⇒ Fouling is likely to occur with a small-celled metal foam.
Therefore, can we make larger cells without losing performance, or should it have a filter added?
- ⇒ Will Foam break/fragment under operation?

Metal Foam



Compactness of the Metal Foam HE

Estimated @ $\approx 2500 \text{ m}^2/\text{m}^3$

Compare with current tubular of $650 \text{ m}^2/\text{m}^3$

Design considerations

- Heat Transfer Performance & pressure loss
- Economic manufacturing cost
- Size, installation and removal for overhaul
- Dynamic loading induced from engine including vibration, blade out, manoeuvre
- Static loading from internal fluid pressures
- Thermal structural loading
- Material properties
- Fluid Properties
- Contamination / Fouling
- Repair and overhaul
- Life

Structural loading

- ⇒ Design is evaluated by Finite Element Analysis (FEA) to determine resonant frequencies and displacement of the assembly and component parts over the engine frequency range (typically from 5 to 3000 Hz with 20G load applied above 100Hz).
- ⇒ Static FEA for pressure loads
- ⇒ Dynamic FEA for blade out (120G) and manoeuvre loads

⇒ Thermal loading: particularly in the case of high temperature heat exchangers, a transient thermal FEA is completed using a validated model. This evaluates the induced metal temperatures and strain range throughout an entire flight cycle. A fatigue life analysis can be completed using the strain range, material properties and the number of defined engine cycles

⇒ Computation Fluid Dynamics (CFD) is used to identify flow patterns (hot spots, reduced flow zones) within the unit which enables us to refine our heat transfer models. It also provides a good indicator of whether flow induced vibration will be a problem, and if so, how effective different design solutions will be.

Testing

Component Certification for flight worthiness testing will include:

- Vibration
- Pressure - including Proof/Burst/cycling
- May include PTF - pressure/temperature/flow cycling
(although this may be avoided with the use of validated FEA)
- Impact
- Fire
- Icing
- Bird Strike/FOD.

Pass by analysis for sand, dust & fungus.