Structural Composite Elements with Special Behavior

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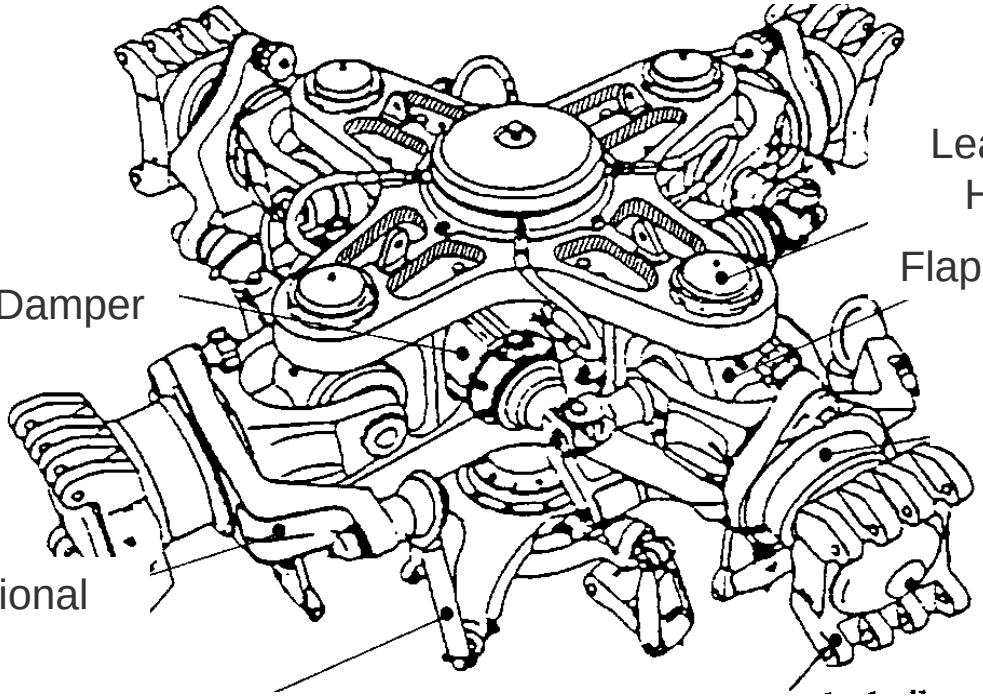
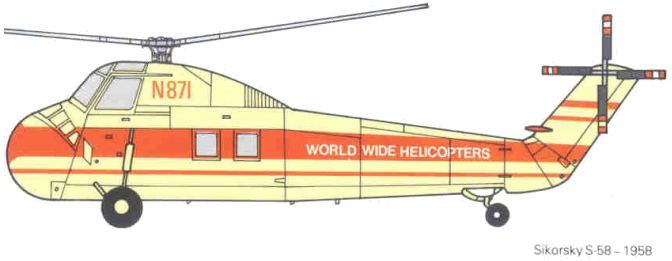
Sikorsky S 58

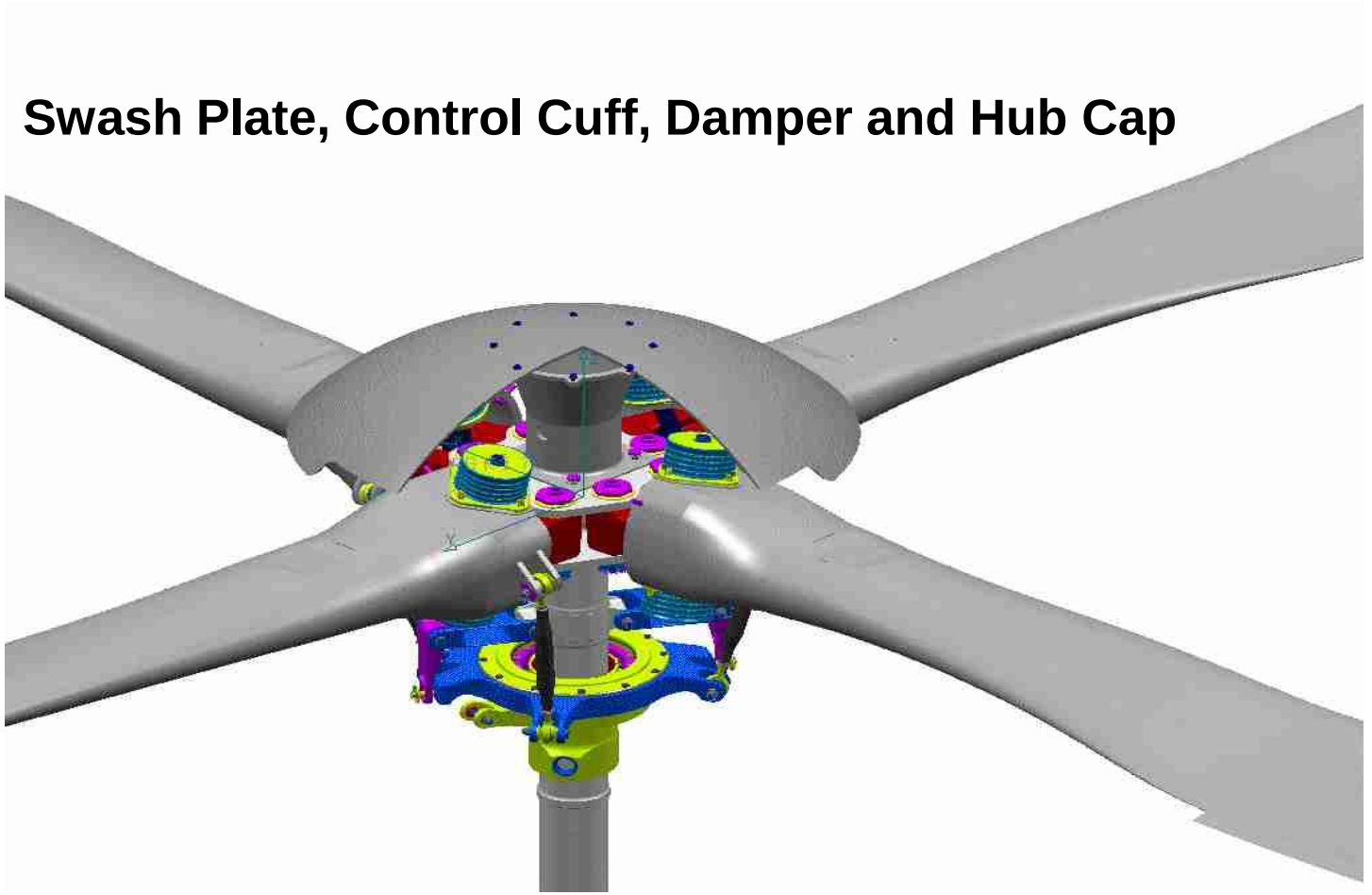


Sikorsky S-58



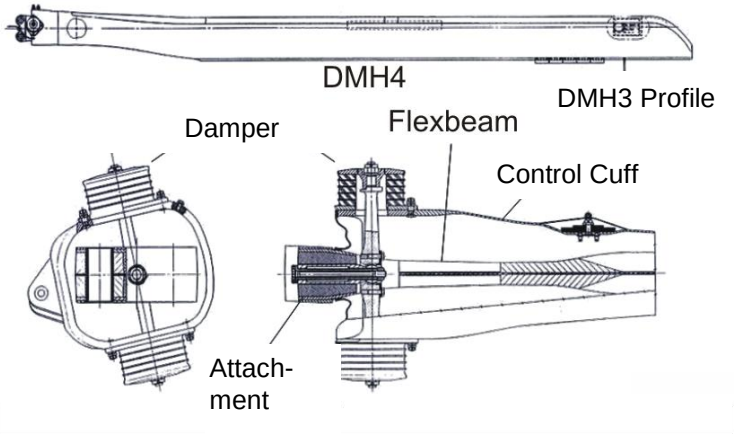
Design Features of the EC 135 Rotor

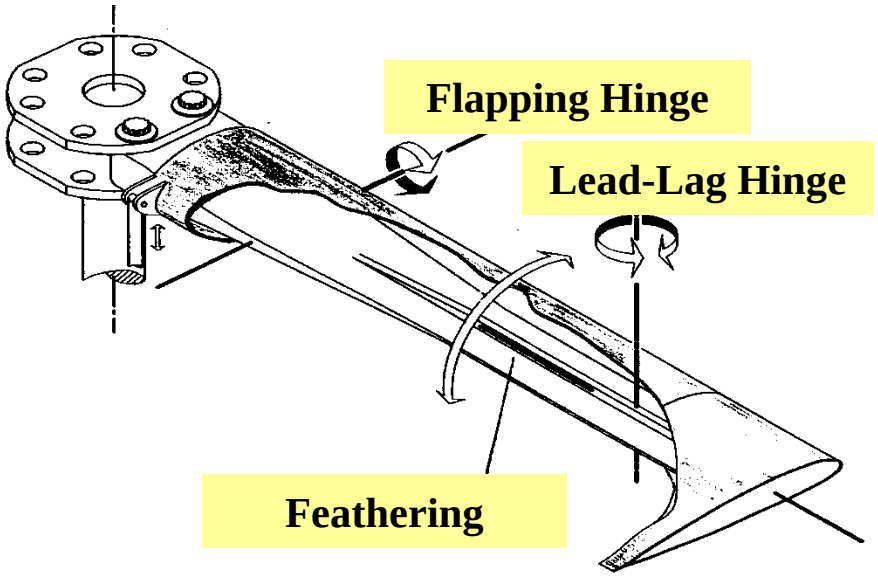
Swash Plate, Control Cuff, Damper and Hub Cap



Principle of the Bearingless Main Rotor

The main rotorblade of the helicopter EC 135 with several integrated functions

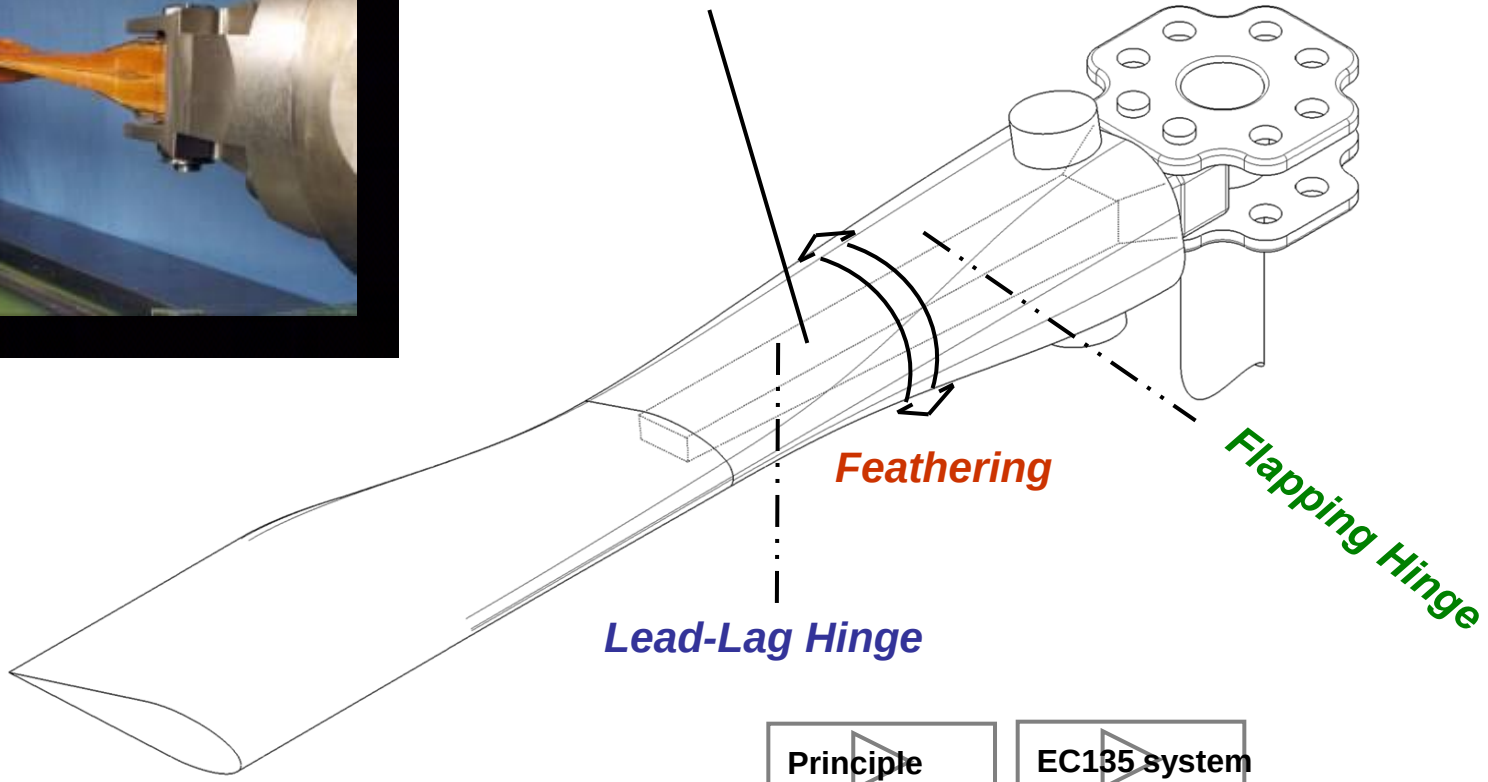




Principles of Bearingless Main Rotor

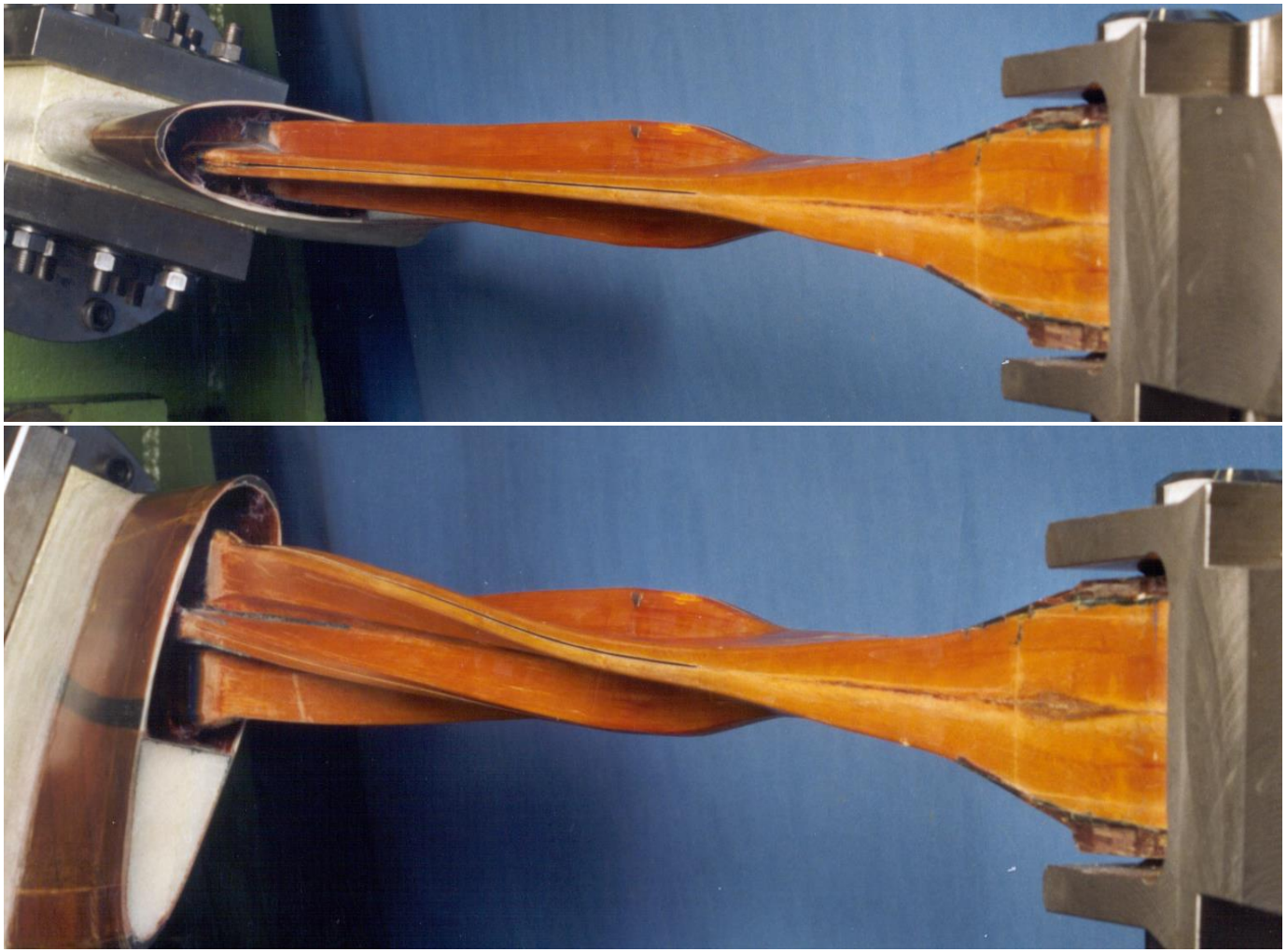
Flexible/Elastic Blade Neck in

Flapping, Lead-Lag and Torsion



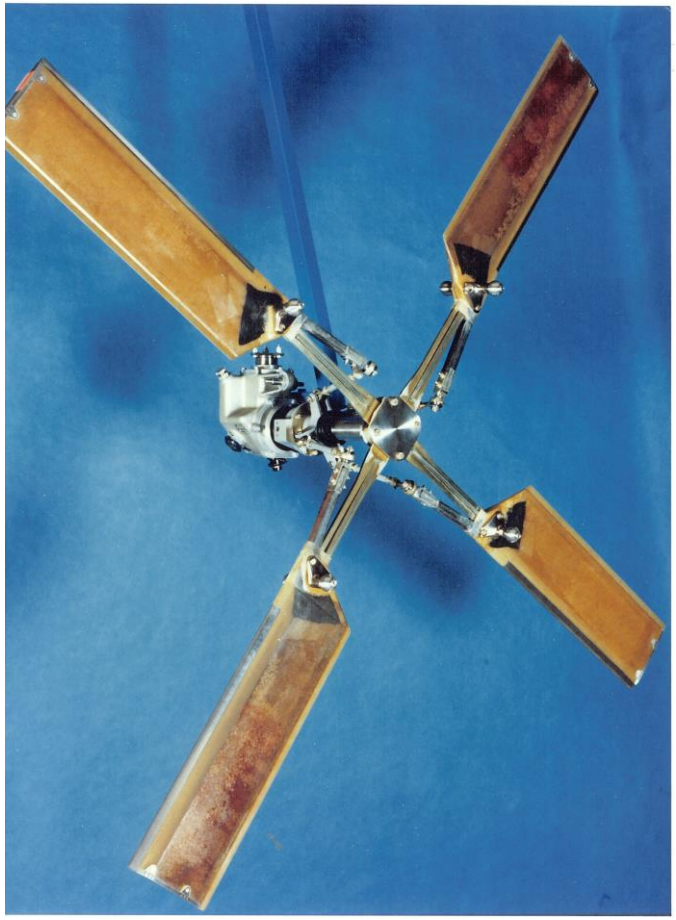
Multirole Helicopter EC 135 with the Attachment Element and Flexbeam Torsional Cross Section

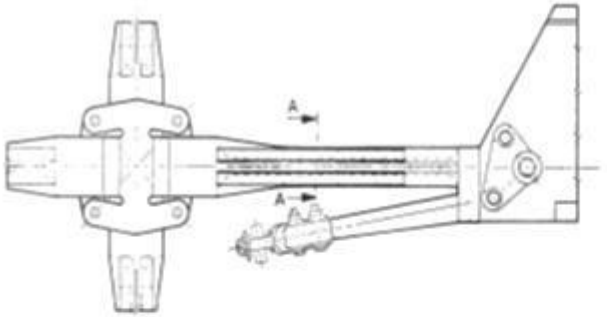
Flexbeam Torsion Test

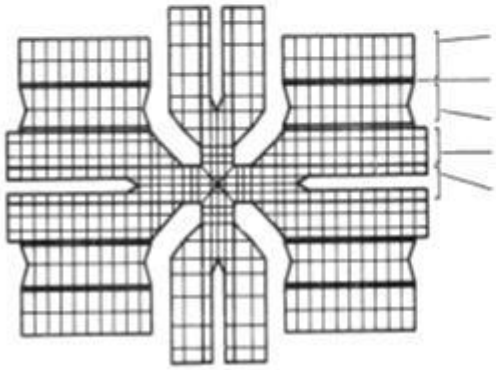


- **Flexbeam unloaded**
- **Flexbeam loaded by centrifugal force and twisted by 100°**

Bearingless and Hingeless Tailrotor for the BK 117 (Soft in Lead-Lag Direction)



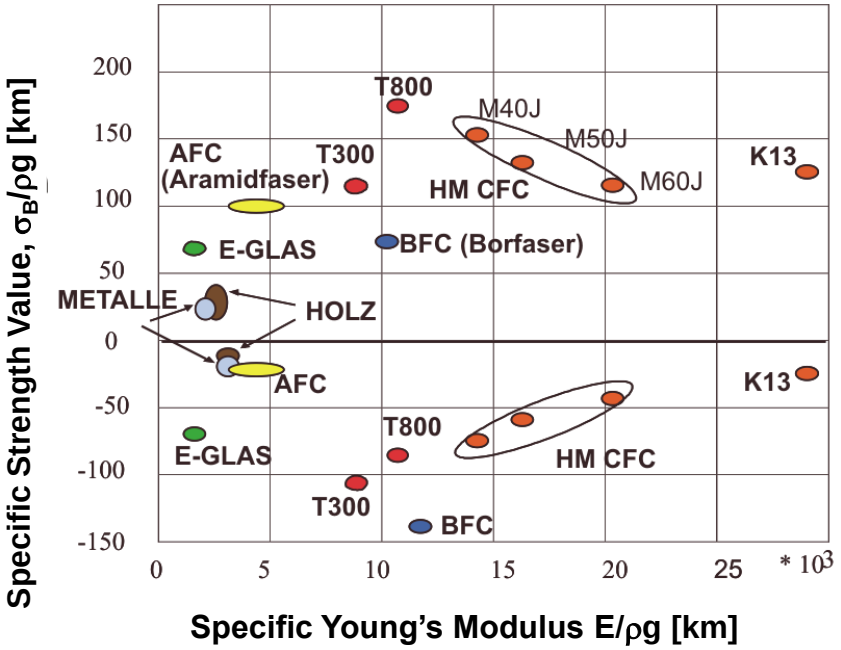




Damper-Plate
Adhesive
Damping Material
Glasfiber-Unidirectional
Glasfiber-Shear-Layer

Material Properties of Unidirectional Fiber-Composites (60%) and Metals

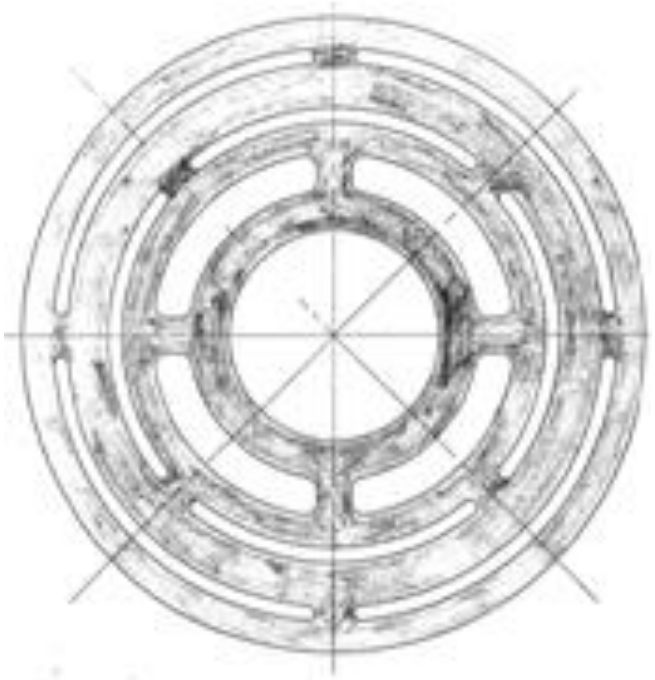
Comparison between Fiber-Composites and Metals



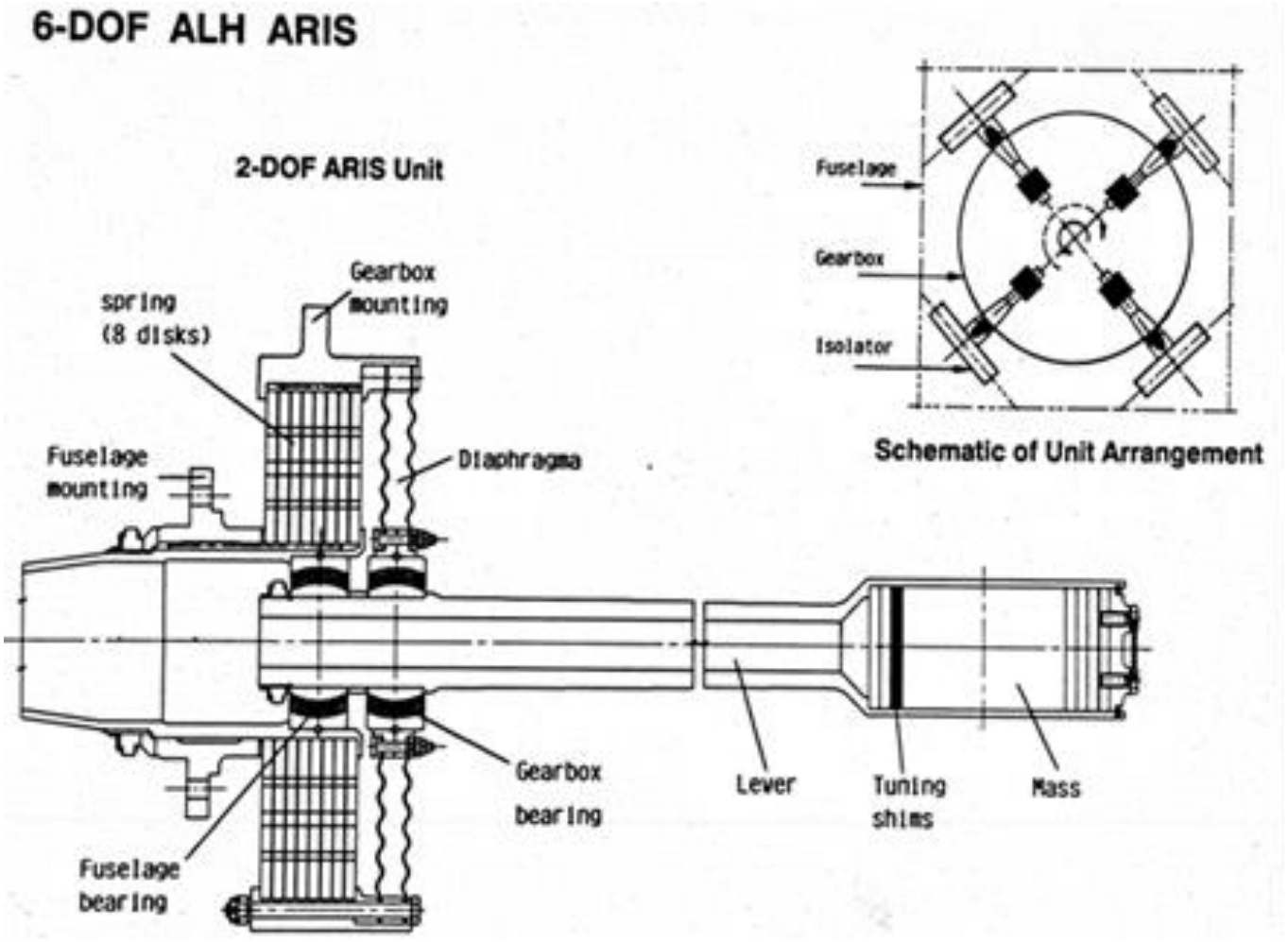
Material	S2-Glas	T300	M55J	K13	Alumium	Titan	Stahl
	Data of unidirectional composites				Material data		
$E_{\parallel}$ N/mm²	54 000	133 000	300 000	500 000	72 200	105 200	208 000
$E_{\perp}$ N/mm²	14 000	10 800	6 400	5 700			
$G_{\#}$ N/mm²	5 400	5 700	3 900	4 500	27 200	38 700	80 000
$\sigma_{\parallel Zug}$ N/mm²	1 690	1 610	1 860.00	2 100	400	1 000	800
$\sigma_{\parallel Druck}$ N/mm²	1 220	1 810	835.00	410			
$\alpha_{T\parallel}$ 10^{-6} 1/K	6,5	0,4	-0,7	-1,4	24	8,35	11,1
$\alpha_{T\perp}$ 10^{-6} 1/K	35,8	42	35,2	32,2			
$\lambda_{T\parallel}$ W/Kcm (293K)	0,01	0,05	0,544	8	2,1	0,15	0,12
$\lambda_{T\parallel}$ W/Kcm (4K)	0.002	0,000					

The Indian Multipurpose Helicopter Dhruv with the Composite Spring Element

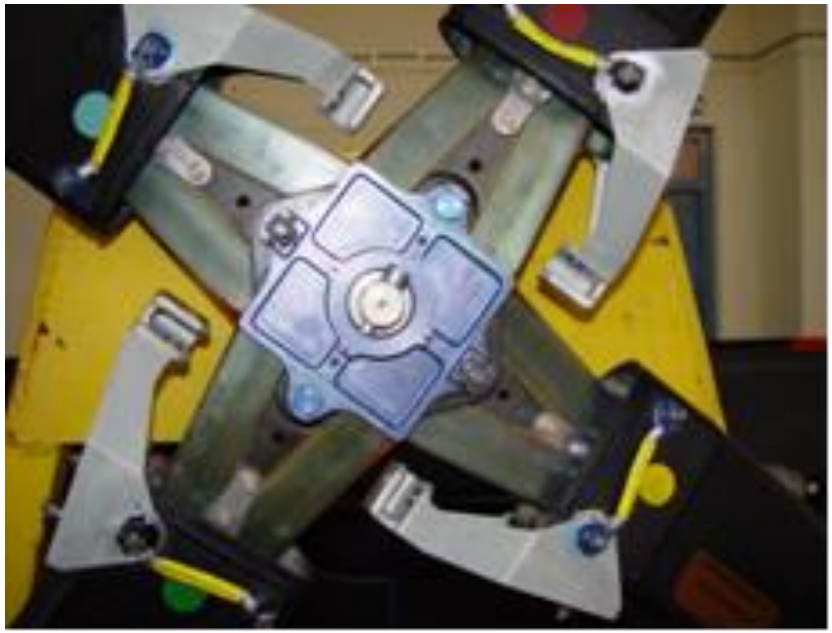
The “Out of Plane” behavior of the “Spring Element” is driven by the low shear modulus. The arms of the Spring Element are loaded in torsion and thus the Spring is soft in “Out of Plane” direction.

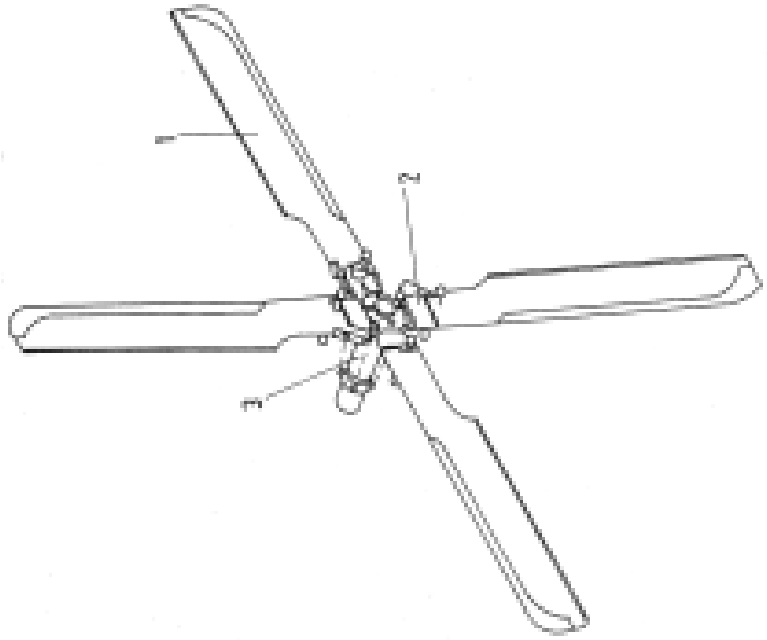


The resonator of the “Anti Resonance Isolation System” of the Indian Multipurpose Helicopter

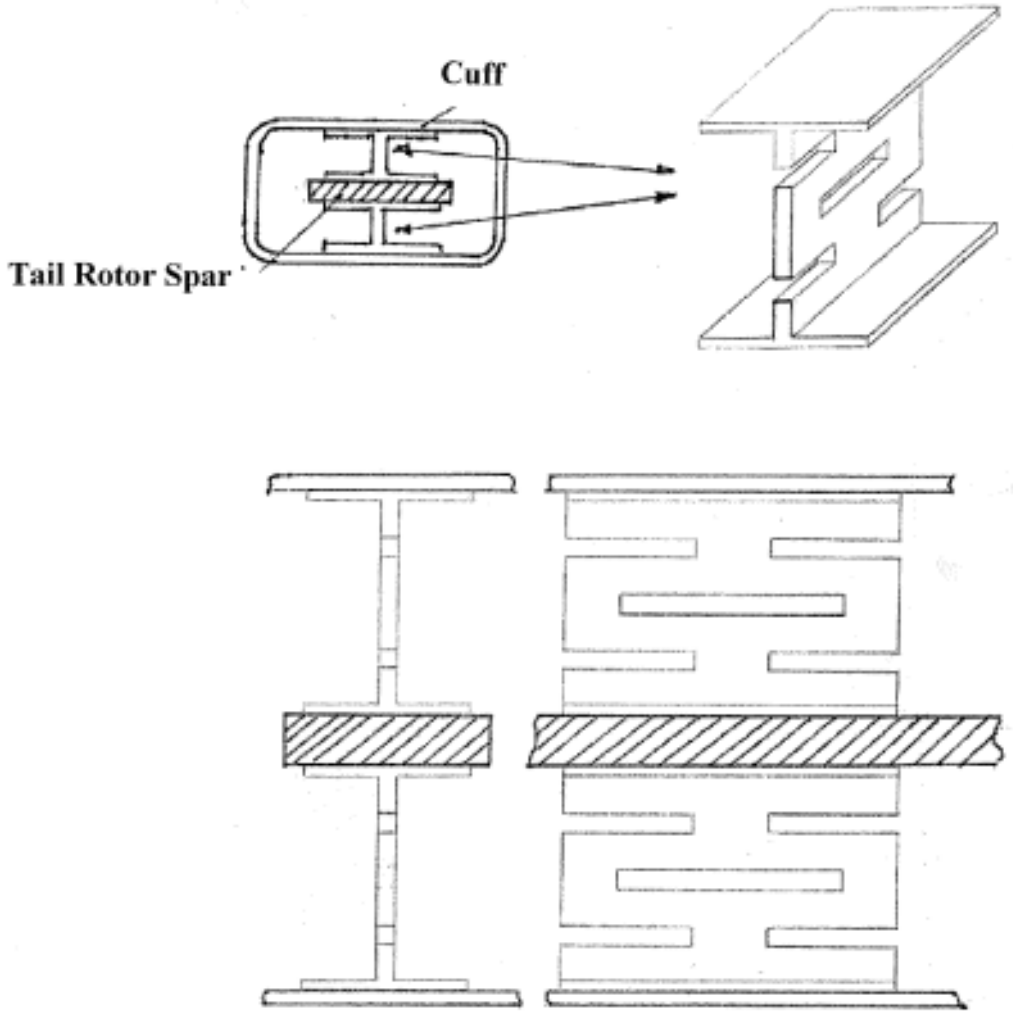


The Tail Rotor of the Indian Multipurpose ALH Helicopter System

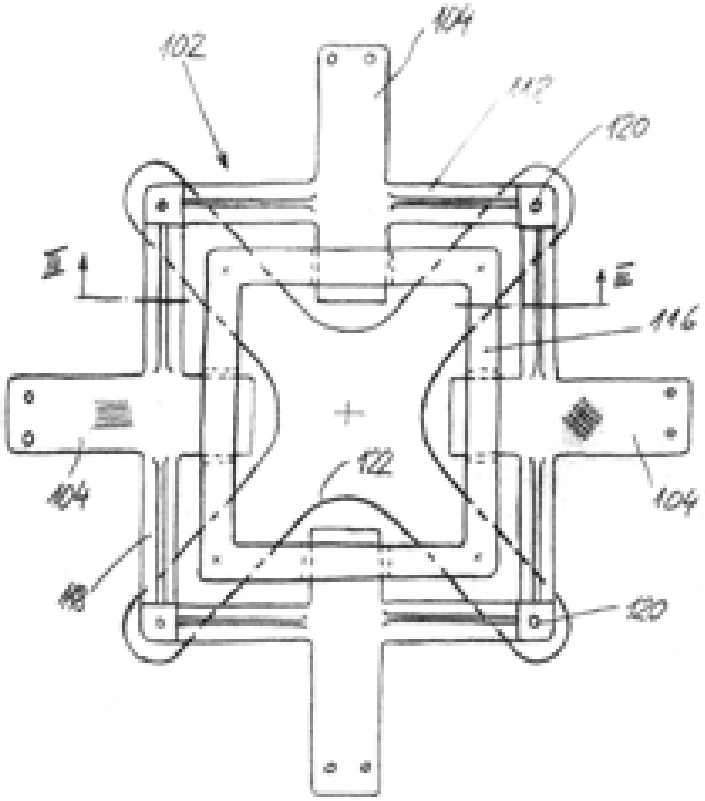


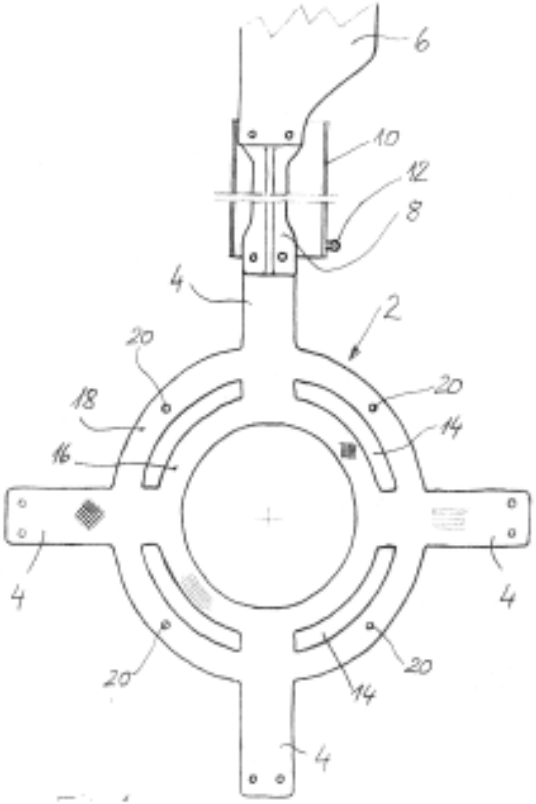


The Flexible Composite Support of the Tail Rotor of the Indian ALH Helicopter System [4]

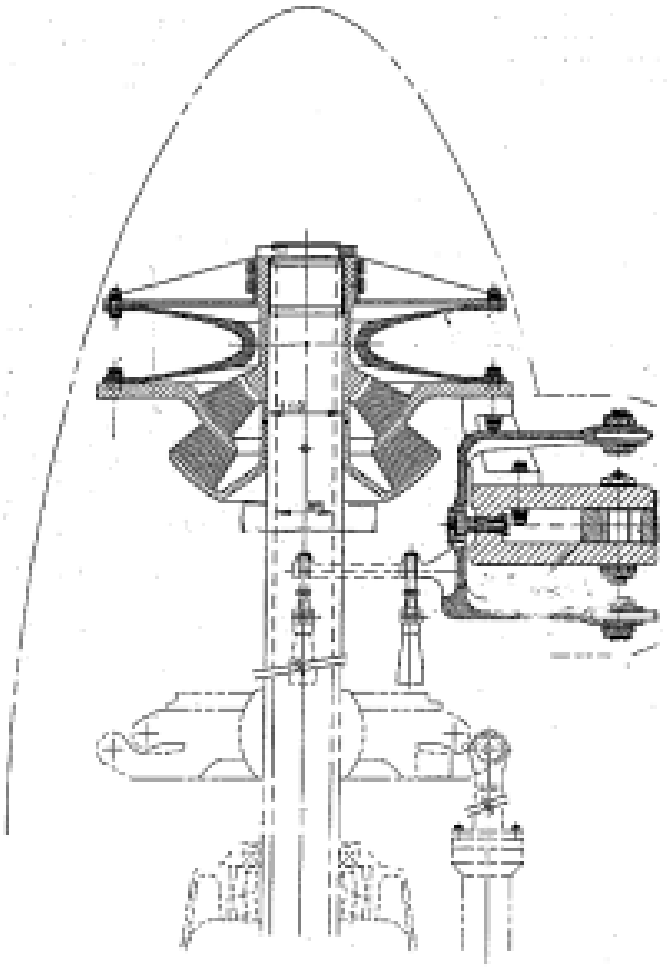


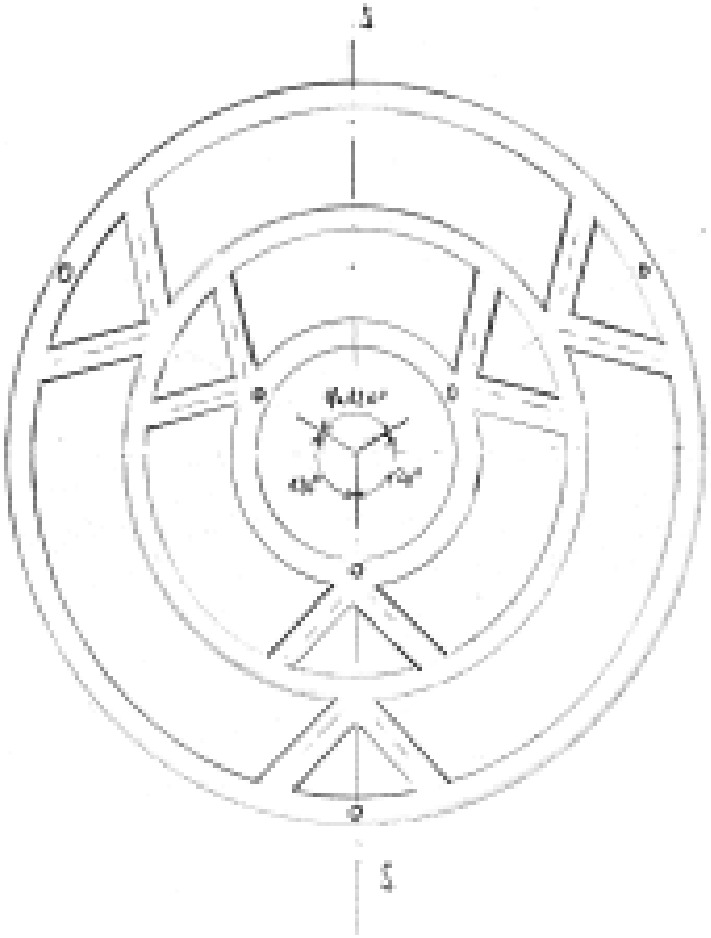
The Flexible Composite Main Rotors “Flex Beam” and “Flex Plate” System [5]



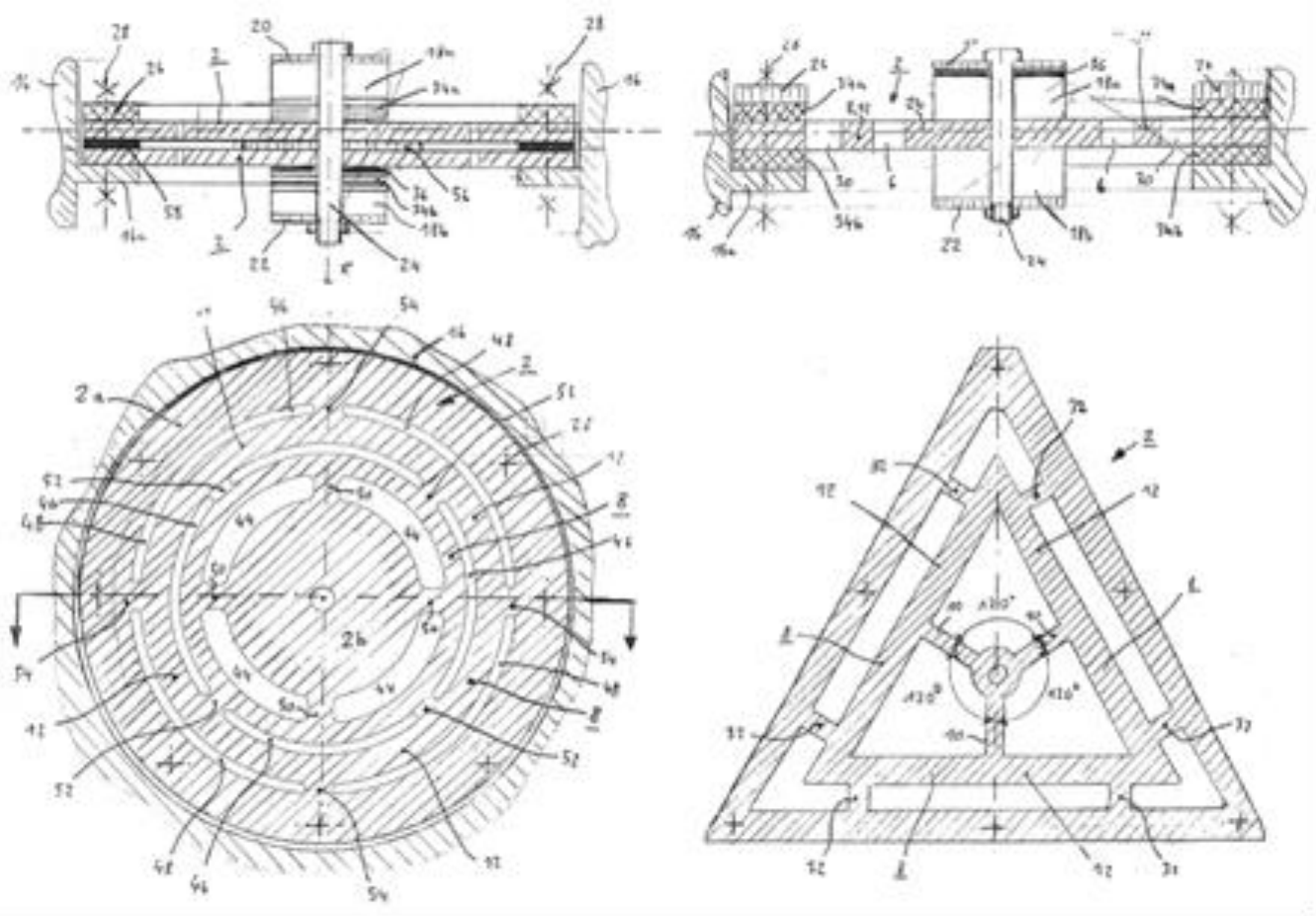


The “Gimbal Rotor” with a Flexible Composite Quasiisotrope Membrane [7]

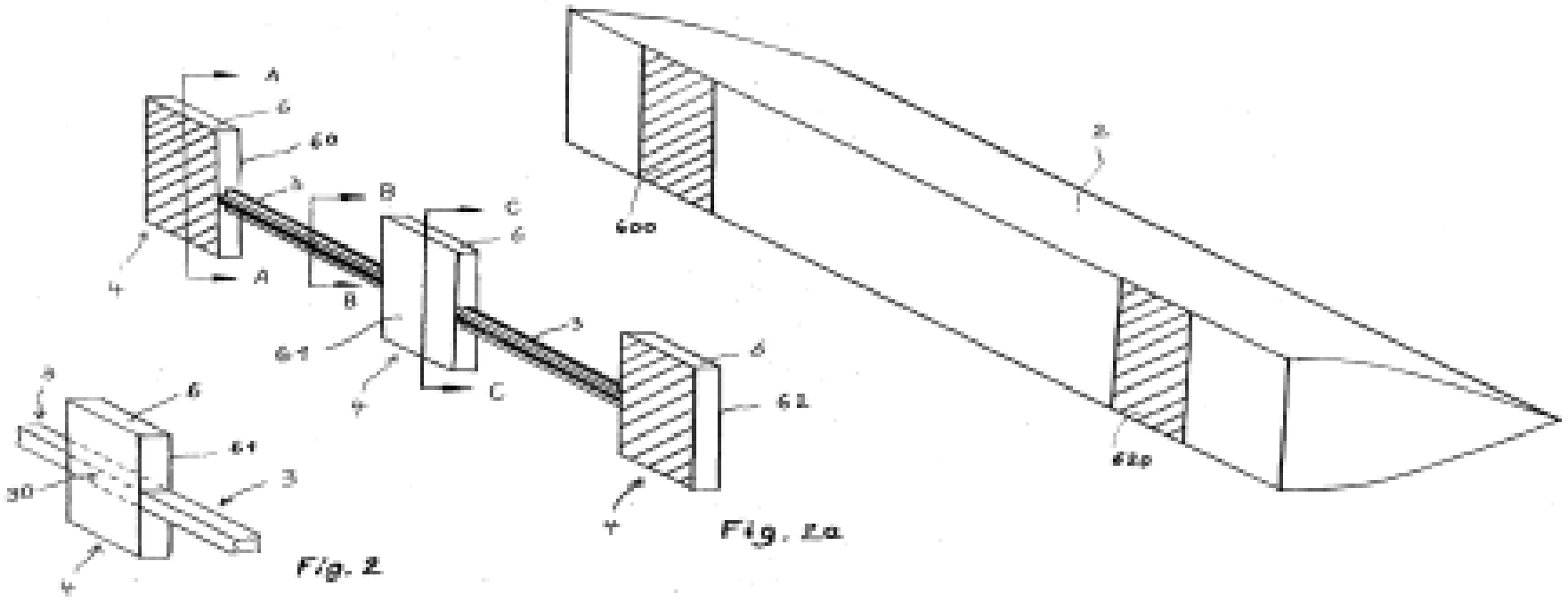




Flexible Composite Membrane Springs of Vibration Absorbers [9]



Flexible Composite Blade Attachment System [10]



Flexible Composite Bearingless Seat Hinge System [6]

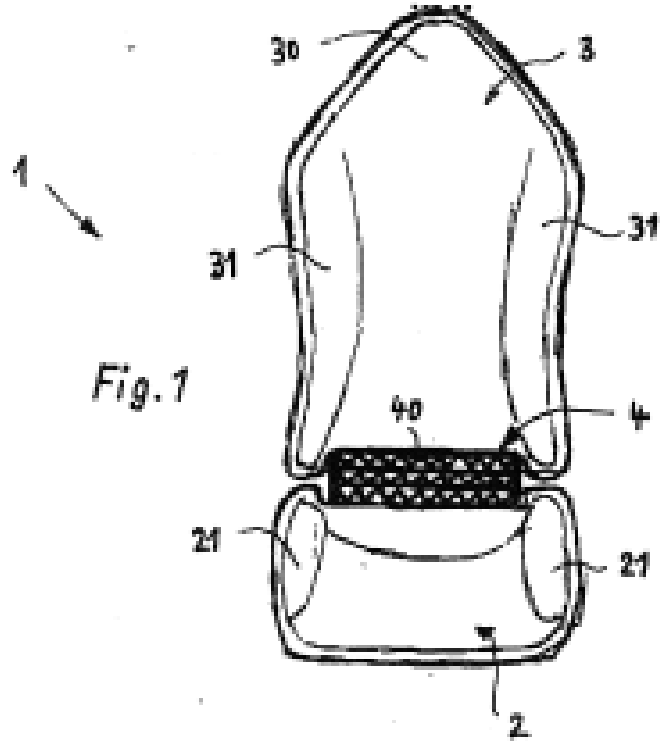


Fig. 1

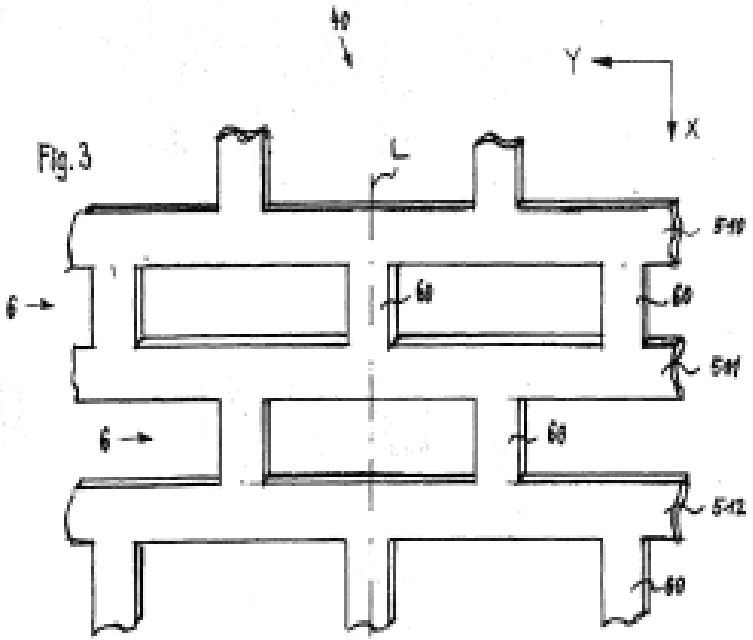


Fig. 3

Conclusion / Summary

- The spectrum of material properties of composites is very high.
- The low modulus of shear allows the design of special advantageous designs.
- Very simple helicopter rotor designs are possible.
- The „Gimbal Rotor“ needs a composite flexible quasiisotrope membrane, which is shown in the patent [7].
- Flexible Composite Membrane Springs can be used for non- and adaptive ”Vibration Absorbers” [9].
- Flexible Composite Blade Attachment Systems [10] can be used for simple bearingless attachments of flaps.
- “Flexible Composite Bearingless Seat Hinge Systems” [6] can be used for simple automotive seats.

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