

1)

The main function of the spindle is to drive to the transmission via rotational torque and not tensile forces. When studying the component it can be seen that there is a machined keyway on the shaft which will need to resist constant friction and exposure to heat generated by the motor. Some of the other nail mechanical properties required are as follows:

- High shear strength - when exposed to large loads of the engine running at varying rotations it must be able to withstand shear stress to effectively transmit the torque without failure.

- Low density - Due to the development in automotive vehicles all parts need to be as light as possible to improve performance and efficiency.

- High strength modulus - due to the fact the shaft needs to transmit torque it must not be highly elastic and quite rigid to transmit it without deforming.

- Corrosion resistance - Due to the varying conditions it is exposed to it must be corrosion resistant and be able to handle road salt and water ingress without fatigue. Fatigue strength - If this component were to fatigue whilst the motor was turning it would result in catastrophic failure and possible injury.

If I were to chose a material for this

application it would be a heat treated aluminium alloy. This is due to the fact that it is a medium to high strength material which ~~has~~ you have the ability to control its fatigue strength and ability to resist wear through heat treatment. It is also low density and has corrosion resistant properties which covers all mechanical requirements.

This material would have good machineability and could be produced within the following steps:

- 1) Alloying the aluminium with other metals to increase desired properties.
- 2) Machining the shape required which would require a 6 axis CNC machine produce the desired shape in one operation.

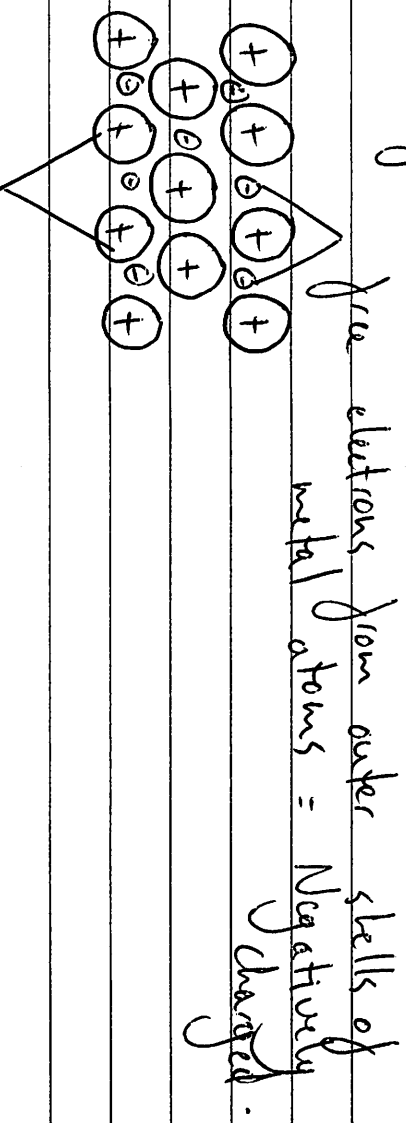
These processes would ensure ~~the~~ low tolerances and accuracy could be achieved.

2)

Description of Metallic Bonds:

- a) Metals form giant structures. Electrons in outer shells of metal atoms are free to move. A metallic bond is the force of attraction between free moving (delocalised) electrons and positive metal ions. Metallic bonds are very strong and this allows metals to maintain a regular structure. This strong bonds means that metals have high melting and boiling points.

Diagram of Metallic Bonds:



Metals ions = positively charged.

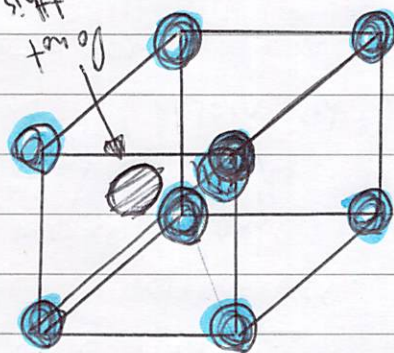
Valency of 1 Vs 2:

Extra electrons means it is more reactive to not maintain shape and easily deformed.

b)

Body

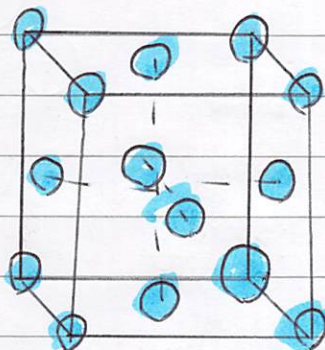
centred cubic:



BCC unit cell structure consists of atoms arranged in a cube where each corner of the cube shares an atom and with 1 atom positioned at the centre.

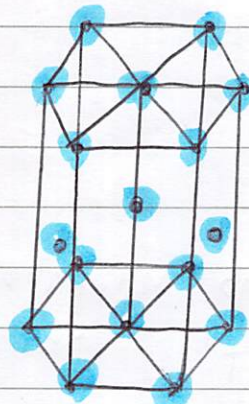
Face

centred cubic:



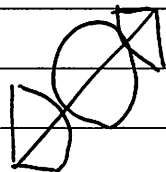
FCC unit cell structure consists of atoms arranged in a cube where each corner of the cube has a fraction of an atom with 6 additional atoms positioned at the centre of each cube.

Hexagonal close packed:



HCP is one of the most common ways in which metals arrange themselves. HCP crystal structure is based on the Bravais lattice of the same name, 1 atom per lattice point at each corner of the hexagonal prism, and 3 inside the prism. It is one of the most stable and has the highest pack density.

c) Length of side of cell (r)



$\therefore$
 $4r$

$$s^2 + s^2 = (4r)^2$$

$$\text{so } 2s^2 = 16r^2$$

$$\therefore s^2 = 8r^2 \quad \therefore s = \sqrt{8} \times r$$

$$\text{length} = \sqrt{8} \times r$$

$$\therefore \text{Volume} = s^3 = \sqrt{8}^3 \times r^3$$

There are $8 \times \frac{1}{8}$ atoms + $6 \times \frac{1}{2}$ atoms = 4 atoms

$$\text{Volume of 4 atoms} = 4 \times \frac{4\pi}{3} r^3 = \frac{16\pi}{3} r^3$$

$$\text{Packing ratio} = \frac{\text{Volume of atoms}}{\text{Volume of cell}}$$

$$\text{Packing ratio} = \left(\frac{16\pi}{3} \right) r^3 \div \frac{\sqrt{8}^3 \times r^3}{3}$$

$$= \frac{16\pi}{\sqrt{8}^3}$$

$$= 0.74$$

d)

@ 400°C :

At this temperature the composition would be at liquid state.

@ 250°C :

At this temperature the composition would be at liquid state.

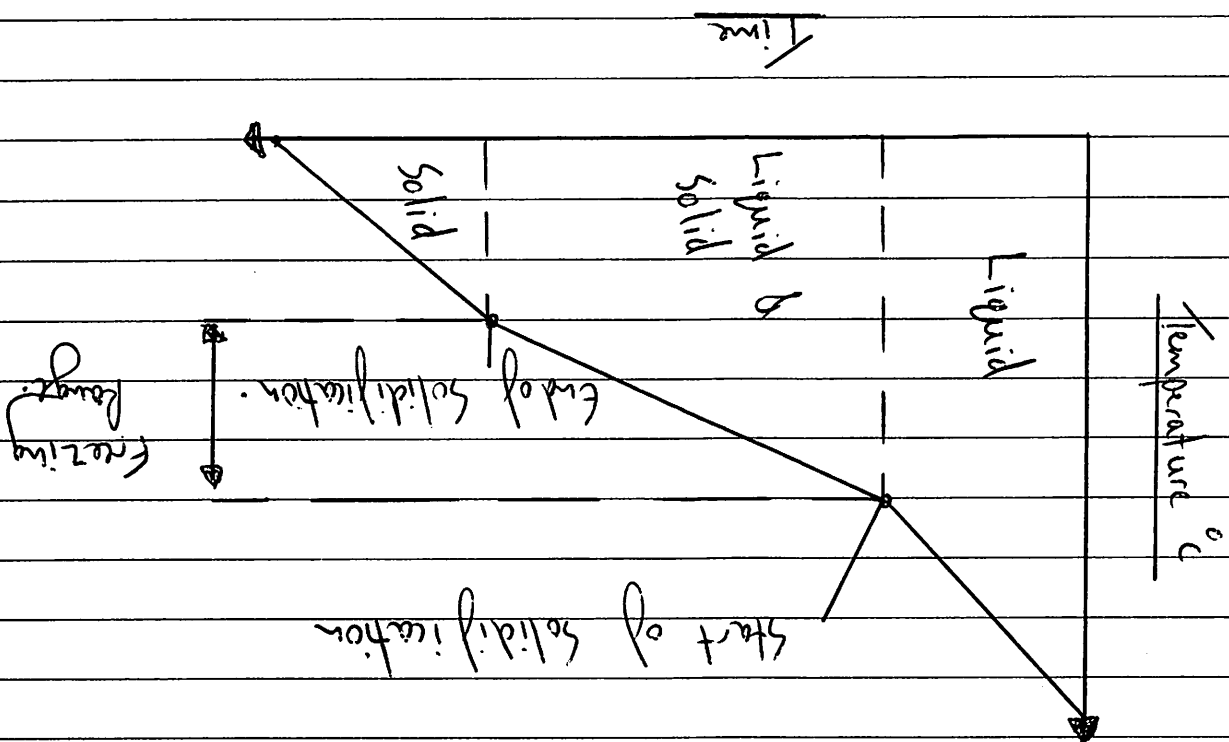
@ 180°C

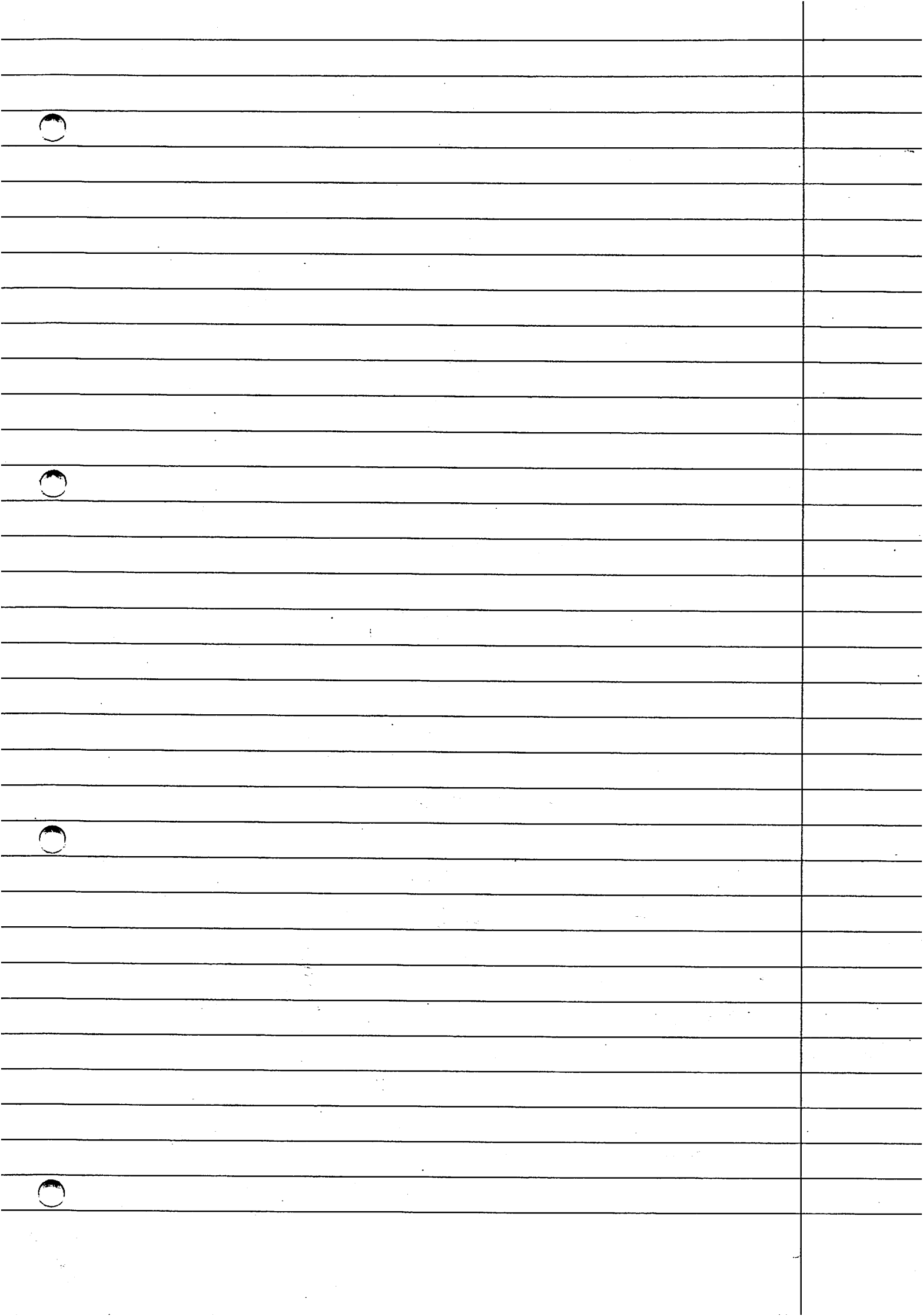
At this temperature the lead ~~has~~ has also solidified making a solid alloy of tin and lead.

@ 50°C

At this temperature the composition is in a solidified state, creating an alloy of tin and lead.

31.9% Tin for the alloy at the lowest melting point.





3)

a)

When looking at the material classes the 3 main classes I would consider are Metals, Technical ceramics and Polymers (when combined with other materials). These choices are based on the fact of their high Young's modulus (stiffness) which will allow them to be rigid and maintain form. They are also quite dense which will help with keeping the vehicle grounded and positively influence aerodynamics.

b)

The classes I would reject for practical reasons are as follows:

- Polymers (on their own)
- Natural materials.
- Foams
- Elastomers

This is due to the fact that they have a low Young's modulus and density when compared to the chosen materials. This is due to the fact that the materials selected will be able to perform the task much more efficiently and withstand the forces applied. If the undesired materials were chosen it could result in catastrophic failure and you would require a lot more of them to achieve the same results.

d) Welding changes the mechanical properties of the material and ~~affords~~ reduces the natural material properties whilst brazing is low heat and can be used without having any effect on the material properties being joined together. When looking at this practically it would decrease the ductility and increase fatigue strength.

Pros	Cons
- low cost	- susceptible to corrosion
- easy to manufacture	- heavier than other materials
- readily available	
- material	
- good strength	

Steel Pros & Cons:

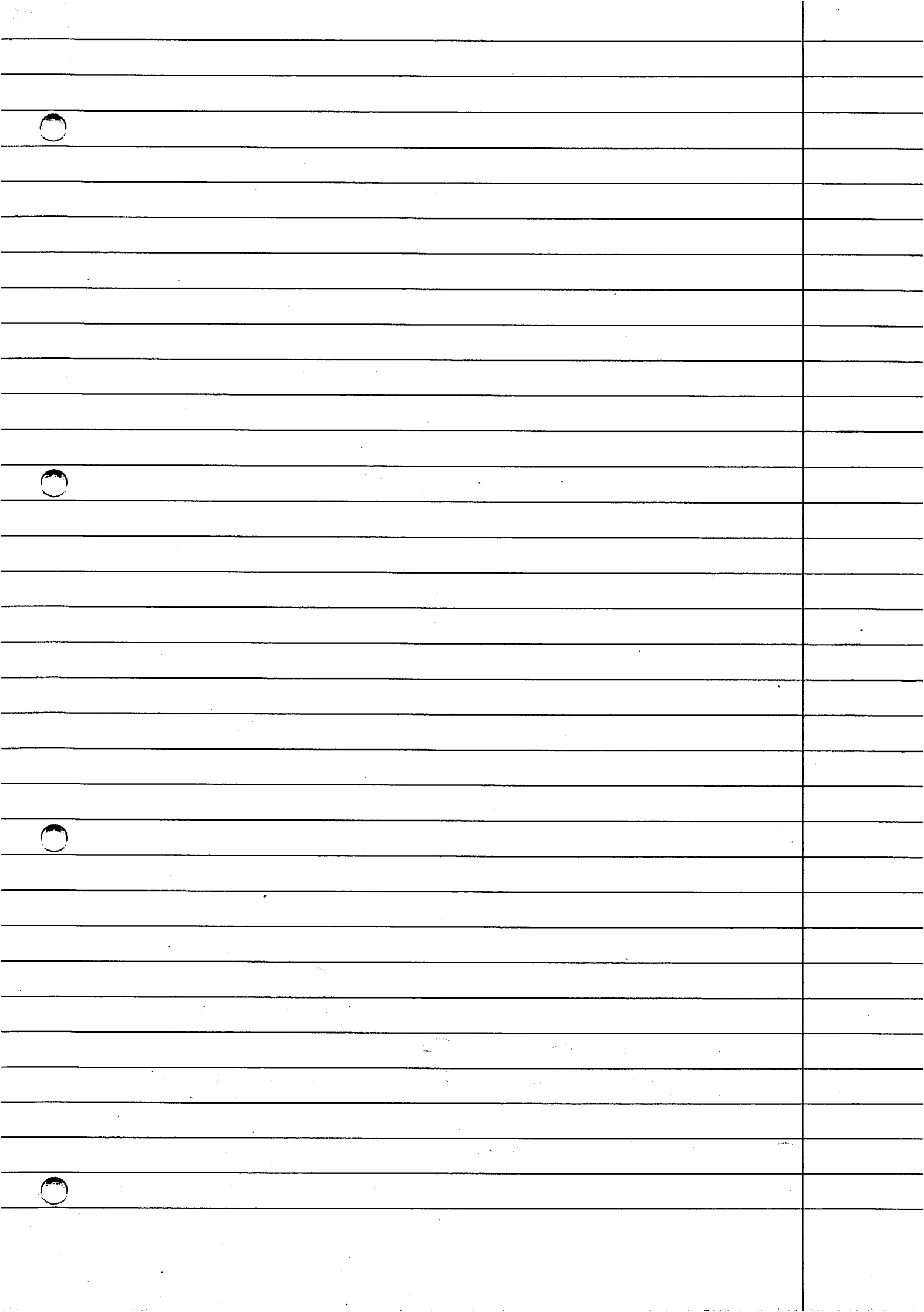
Pros	Cons
- low density	- expansive
- High Young's Modulus	- takes a lot of time to manufacture
- Extremely strong	- Non recyclable.
- Shaped exactly as required	

Carbon fibres Pros & Cons:

William Davies

c) 2 other methods of joining
would be ~~stitching~~

- Bonding - using strong adhesives with heat + pressure
- riveting.



4) a) When looking at the practical application there are many different requirements for the air cylinder. These include:

Low Density:

The tank must have low density in order for it to be portable and light weight to be carried on someones back.

High Yield Strength:

Due to the fact that they are highly pressurised it must be able to withstand large pressure differences.

Corrosion Resistant:

Due to its constant exposure to salt water it must be corrosion resistant to give it a long lifecycle.

Elasticity:

It must need to be able to expand and contract due to the varying pressures and withstand against creep.

b) Review:

6062 T6 Aluminium:

This material has a high yield strength and relatively low density when compared to other materials. When looking at the practical applications it may be suitable for use when looking at the aircraft fuselage skins ability to expand and contract at varying temperatures.

Steel Alloy 1020 - Hot rolled:

This material has a low yield strength and high density. This would mean it would be too heavy and hard to form into the desired shape. There is also an increased risk of failure when pressurised.

304 stainless steel (UNS S30400):

Although this is one of the highest yield strength it has a high density. This would be a good option for corrosion resistance and cleanliness due to its hygiene grading but would be too dense to carry around.

Choice A Pre-pregated carbon fibre composite:

This material has a very high yield strength and low density. Due to it being a carbon composite it would take a longer time