Pneumatic tools on Mars?

Sending equipment to Mars is going to be expensive and could take several months if not 2 years to get replacement parts. It would be beneficial to the mission if astronauts could use existing materials and 3D printers to replace parts instead of waiting for them to come from Earth. Using the thin carbon dioxide atmosphere of Mars as a resource, NASA could use compressed air for storing energy and demonstrate that 3D printed parts can make the use of compressed air tools a better choice than battery powered tools because of longevity and repairability. This would save launch cost of replacement batteries and lost time waiting for the replacements.

Work in Progress

Objective:

- **Design, build and test** an air powered motor that will demonstrate good power and replaceability if damaged or worn out

Demonstrate

- Make a rotating motor and tool that can drive a ½" bolt--4" long class 2A thread, using compressed air from a 12oz paintball tank at 80psi
- Or make a reciprocating tool that can cut through a 2" x 2"x 1/8" thick aluminum angle using a metal cutting blade and compressed air from 12 oz paintball tank at 80psi
- Motor body parts shall be 3D printed—choose your plastics
- You may use off-the-shelf nuts and bolts.
- You may use off the shelf gaskets and o-rings but its even better if you can print your gaskets and o-rings.
- You can use an off the shelf socket to attach to the bolt
- You can use an off the shelf metal cutting saw blade

If students can demonstrate pneumatic motors and applications with plastic 3D printed parts, NASA could do it with similar parts and capability with 3D printed aluminum parts on Mars.

This will test your CAD skills and your ability to use your 3D printing knowledge. Explore the print orientation and the print infill.

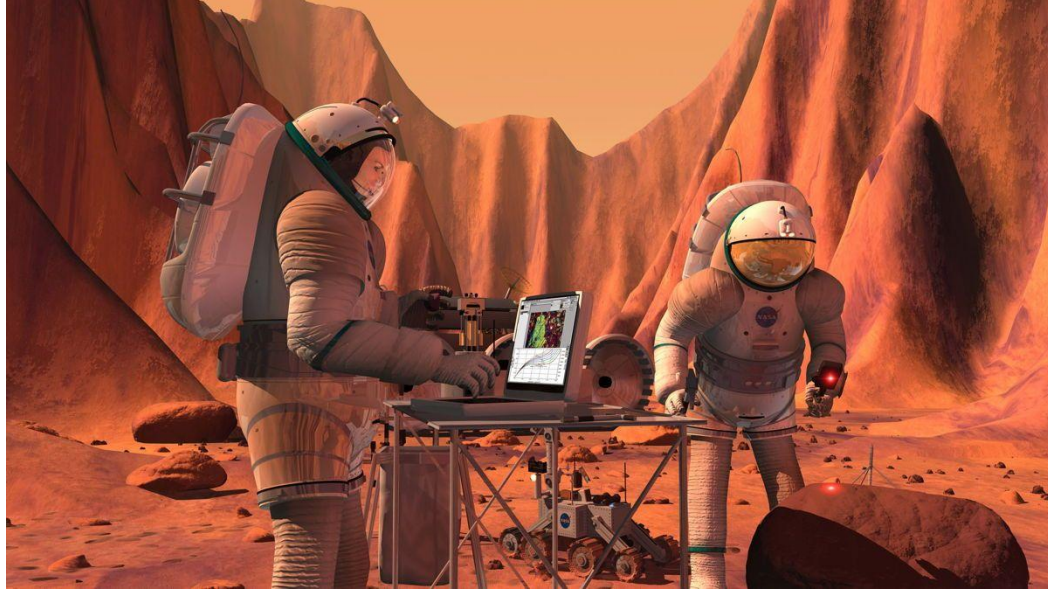
Glenn Johnson is working with the HUNCH Team to make improvements on this project and will be mostly done by August 1st 2026. Changes will be made during the school year as students ask questions and need clarifications.

The problem:

Every tool, piece of equipment or material that is sent to Mars is an investment in the base/city that is being built. If the tool has a limited life time without repair and has a planned disposal time, that tool is less of an investment and more like a planned piece of trash.

- Most of the time solar panels send the electricity to be stored in batteries. This is a good storage system but as we all know from owning cell phones, the batteries eventually have a decreasing storage capacity due to the internal chemistry of the batteries. This can also be affected by the temperature changes and the number of cycles of charging and discharging.
- The weak point in the solar panels and batteries is the chemical battery. Batteries can not be built or repaired on Mars without a lot of other supplies being available. This means new batteries would have to be shipped to Mars when old ones fail. That could be a lot of mass.
- When on Mars, it would be valuable to use the local materials when possible—like the carbon dioxide atmosphere. **It's about 1/100th of our atmosphere but it is there.** So, another method might be to use some solar panels to power a motor that compresses the carbon dioxide air into a tank, then later use the compressed air for tools or maybe mobility. The advantage is that a storage tank will handle many cycles of use without loss of capacity over many years. This may be less efficient than storing electricity in a chemical battery but we would be gaining longevity of use. For example, I've had the same air compressor and tank for over 29 years but I've gone through many cellphones and batteries.
- Because pneumatic tools are mechanical, the parts can be made on Mars using 3D printers. Remaking batteries on Mars would be much more difficult and require mining and chemical processes that would be expensive to get to Mars.
- Since the atmosphere is very low humidity, the tank will not be collecting condensation and corroding (like here in Houston)—longer lasting tank.
- The weak point in the solar panels and the compressed air tank is the compressor and motor—how long do those last. Can we 3D print parts to replace the motors worn out pieces. (yes for many of the parts)

Here are some options.



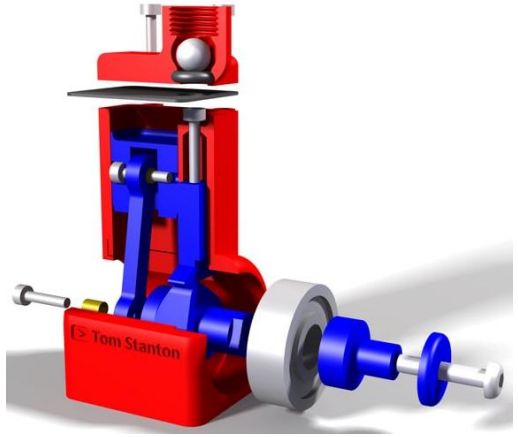
Making air turbine

- https://www.youtube.com/watch?v=zXEnXEfVBA8
- https://www.youtube.com/watch?v=Yg5swK_AnbU
- https://www.youtube.com/watch?v=RMUHxo2TOUk

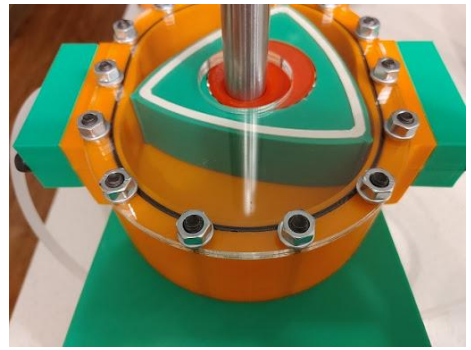
Air turbine

Air powered Wankel engine

- https://www.youtube.com/watch?v=b399G61Z3fo&t=515s



Piston driven



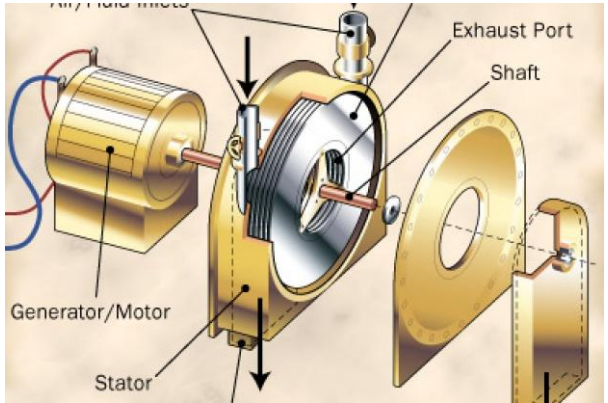
Wankel engine

Air powered piston engines

- https://www.youtube.com/watch?v=b399G61Z3fo&t=515s
- https://www.youtube.com/watch?v=cYF_D-4PhUU

Tesla turbine

- https://www.youtube.com/watch?v=Tynjk555cxk
- https://www.youtube.com/watch?v=DLKE_DbUdRg



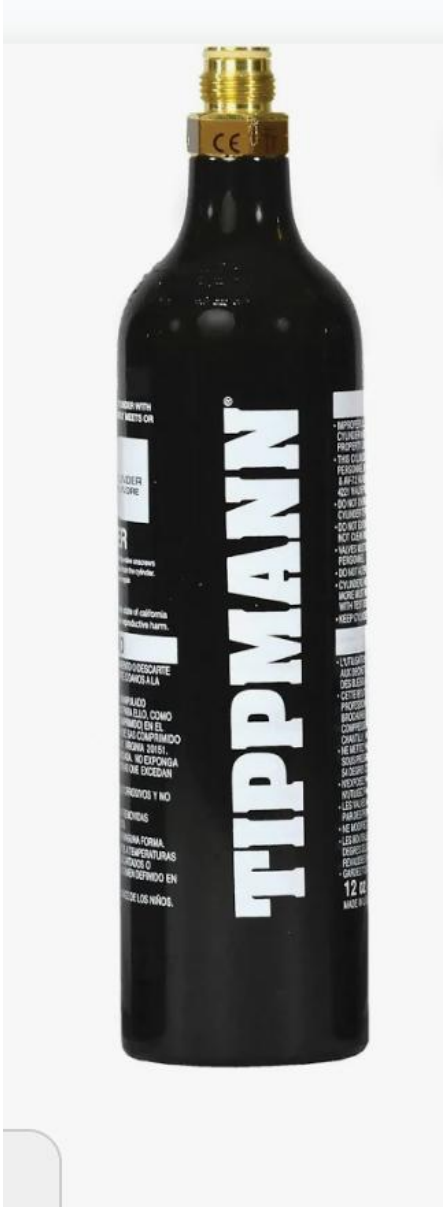
Tesla Turbine

Other possibilities are welcome

Air tank

I don’t have any reason to use this company’s air tank except that it is cheap and certified. If you find another tank that is the same size and rated for this use, that will work fine. The point is that everyone is using the same size and capacity and it is safe for this kind of use. You don’t have to purchase a new tank. It could be cheaper to buy a used one. I see that the Warrior brand has a gage on it but it makes it a little more expensive. I suggest filling it with air from a compressor. I don’t see a need to fill with CO_2 for our activity. A regular shop compressor will fill it to about 100psi and that will be plenty for the 3D printed equipment you are building.

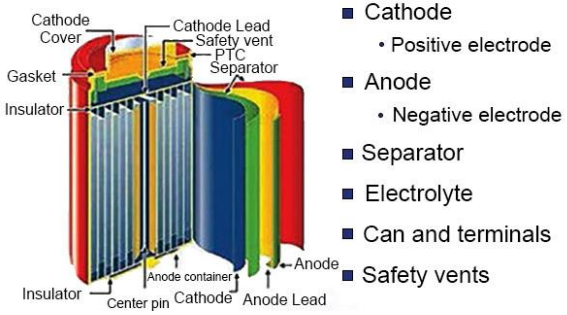
By driving the bolt or cutting the pipe with the allotted amount of air, you are demonstrating the efficiency of your tool. The more efficient it is at using air, the more work can be done with the stored air.



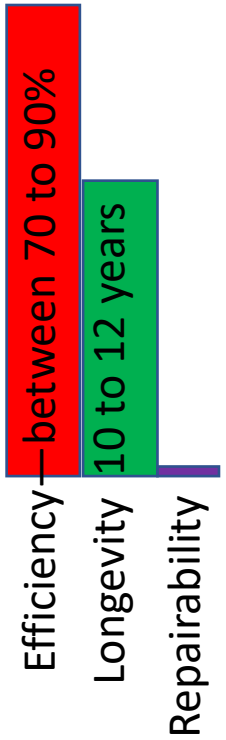
- Tipman 12 oz paintball CO_2 tank
  - https://shop.gisportz.com/products/40012?variant=16462580711470&country=US&currency=USD&utm_medium=product_sync&utm_source=google&utm_content=sag_organic&utm_campaign=sag_organic&srsltid=AfmBOooSUoMf0xq3qn-hPOpeyDkgSQw3CDxEGyL4ZBvZKBj0-Rpjo1-xZtU&com_cvv=8fb3d522dc163aeadb66e08cd7450cbbdddc64c6cf2e8891f6d48747c6d56d2c

Reasons for the discussion
Batteries vs Compressed Air

Lithium Cell Structure

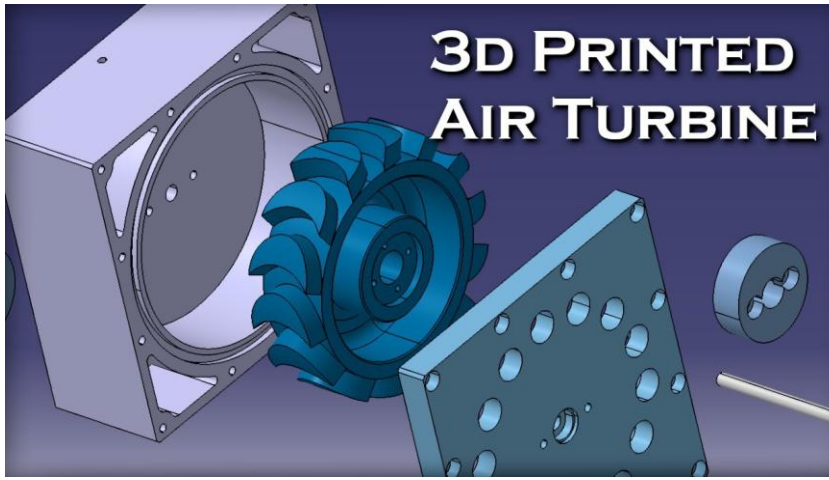


- Cathode
  - Positive electrode
- Anode
  - Negative electrode
- Separator
- Electrolyte
- Can and terminals
- Safety vents



Lithium Batteries

Compressed air tank and compressor?



Pneumatic Tools

- If there is an electric tool, there is probably the same tool that is pneumatic.
- No sparks, smaller, safe in flammable areas, similar power/torque (sometimes more sometimes less)
- Air tools vs electric tools—this company makes both and helps you understand when and where you might want one over the other.
- https://ronixtools.com/en/blog/air-tools-vs-power-tools/#What_Are_Air_Tools

Size comparisons—drill vs drill

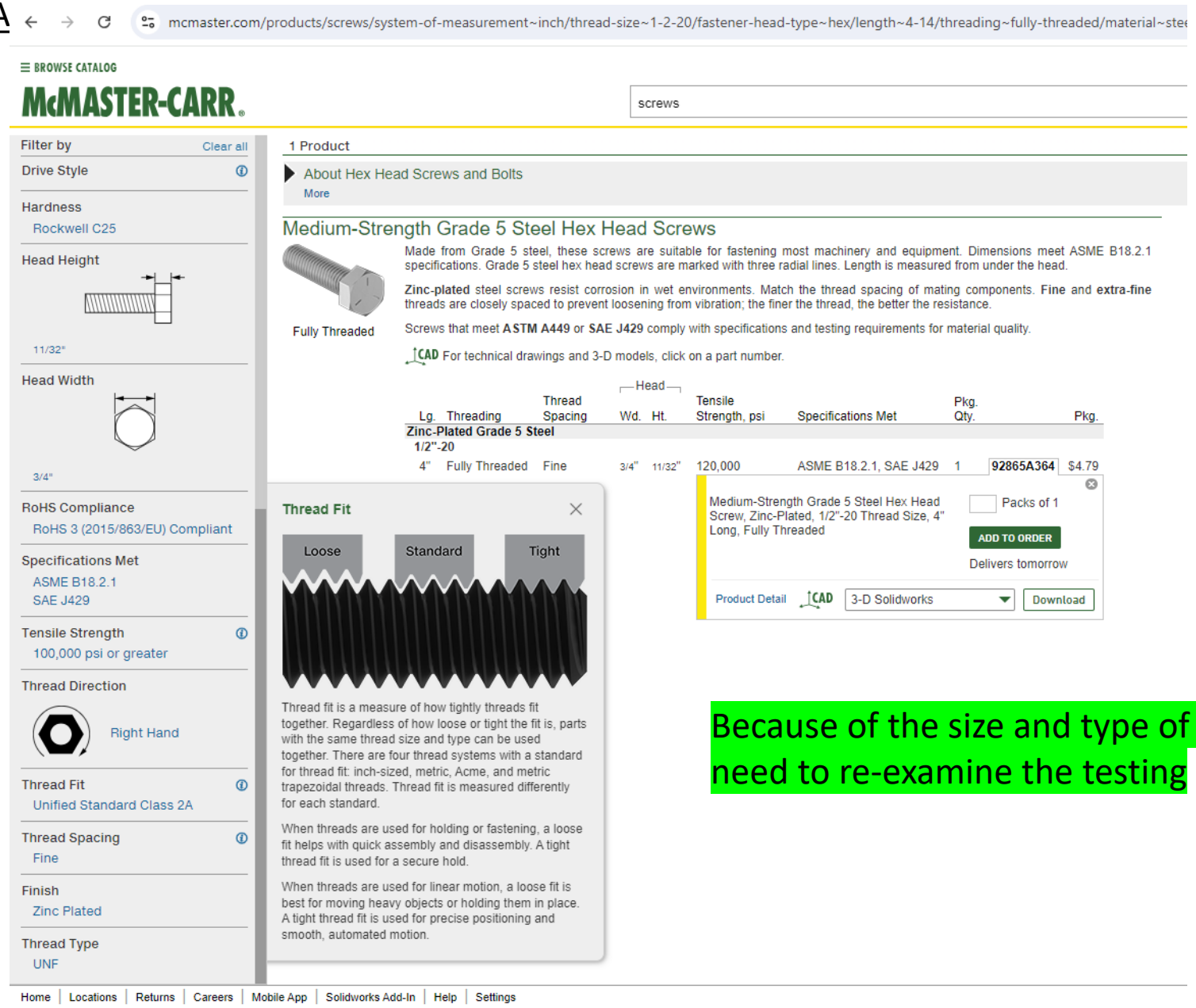
Testing hardware for bolt driver

4”long ½” Bolt 20 threads per inch, class 2A
https://www.mcmaster.com/products/screws/system-of-measurement~inch/thread-size~1-2-20/fastener-head-type~hex/length~4-14/threading~fully-threaded/material~steel-1/fastener-strength-grade-class~sae-grade-5/

Hex nut—20 threads per inch, class 2B
https://www.mcmaster.com/products/nuts/system-of-measurement~inch/thread-size~1-2-20/nut-type~hex/hex-nuts-2~/thread-fit~unified-standard-class-2b/

- Set your hex nut onto a board or 3D printed stand so it doesn’t move.
- Use your motor and 2L bottle of 80 psi air to drive the bolt into the nut.
- Count the number or rotations you are able to drive the bolt.

A class 2A thread on the bolt and a class 2B nut is desired so that there is some resistance to driving the bolt into the nut. The nut was chosen to avoid galling between two similar steels.



Because of the size and type of tank, I need to re-examine the testing

Testing hardware for reciprocating cutter

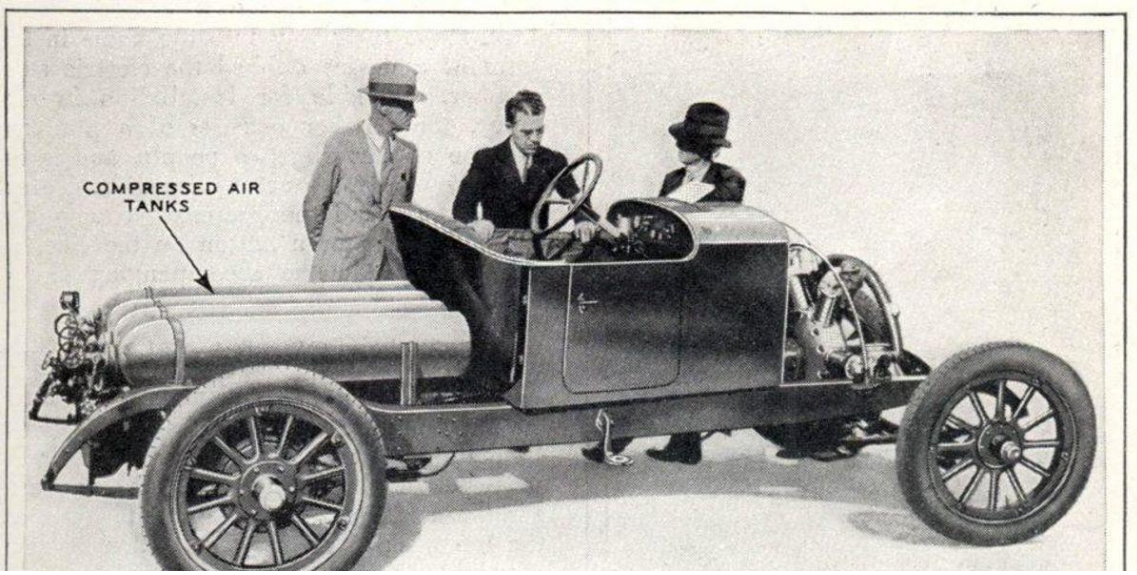
- 2” x 2” x 1/8” aluminum angle
- https://www.homedepot.com/p/Everbilt-2-in-x-8-ft-1-8-in-Thick-Aluminum-Angle-6423/332735297
- If you already have some aluminum angle, you don’t need to buy this
- I’m not advocating Home Depot, you can get it from whatever hardware or metal supplier is available. If you tell them it is for a high school project for NASA, you might be able to get it donated.

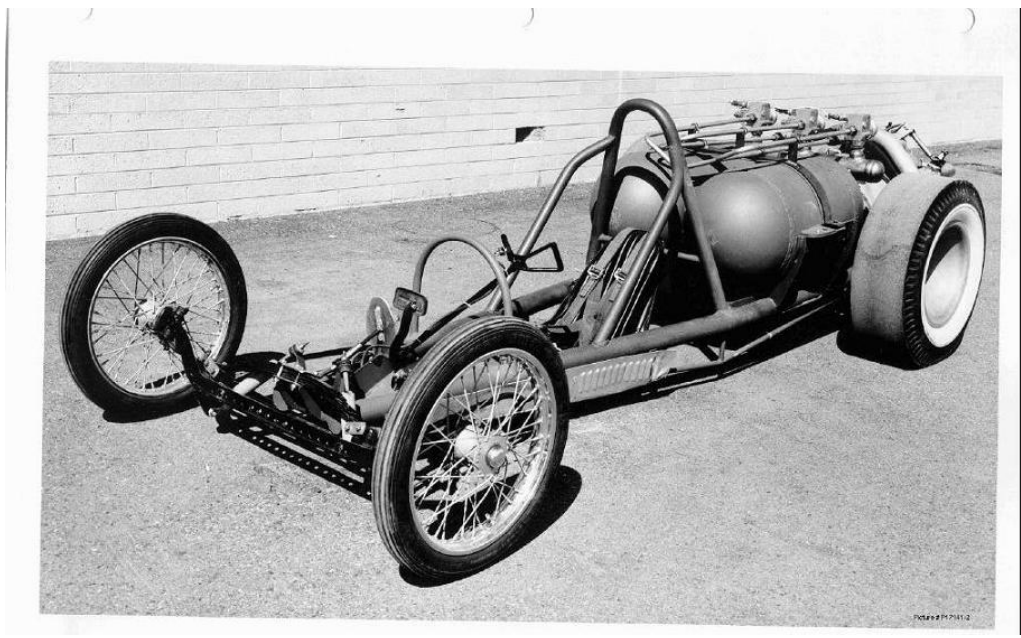
Air powered but not compressed air—just too cool

Compressed air trains used in mining operations to minimize chances of fires and explosions

Air Powered Trains

Pneumatic trains and even cars have been around for a very long time. When mining coal or other areas where natural gas may be a problem, air powered trains were necessary to prevent sparking a fire or explosion. Some would run at pressures of 1000 psi. There are some companies currently reexamining compressed air and approaching efficiencies similar to electric cars. Depending on how the electricity is generated to run the compressors, the cars could be zero emission vehicles.





Compressed Air Powered Cars

https://www.youtube.com/watch?v=fFoYPj3Ntzc

Pneumatic Dental Tools

Many dental tools are pneumatic because they are small and have high speeds.