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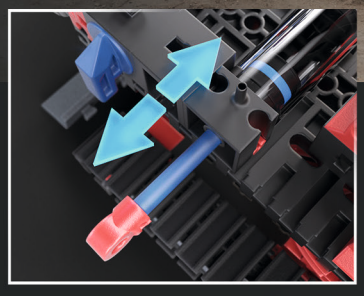

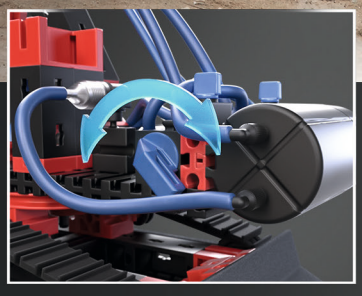

Begleitheft
Activity booklet
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PROFI

Pneumatic Power

MODELS

5

Welcome to the world of fischertechnik's PROFI line

Hello!

Congratulations on your purchase of the "PROFI Pneumatic Power" Construction Set from fischertechnik. This construction set helps you to learn the principles of pneumatics.

Reading through this educational information and trying out the various models will introduce you to the subject of pneumatics step by step. Now we wish you a great deal of fun and success experimenting with your PROFI Pneumatic Power Set.

Your team from

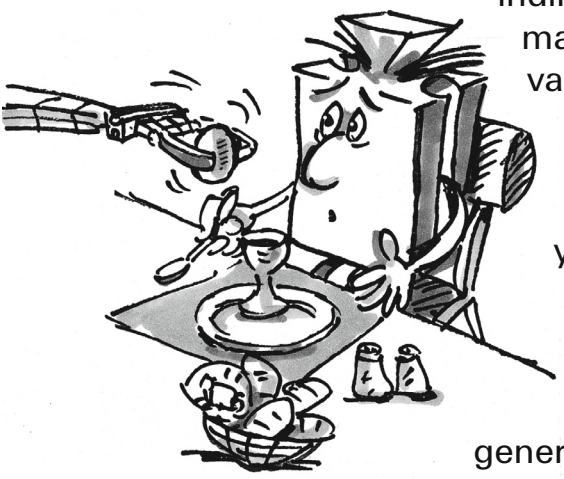
fischertechnik

Some General Information

Before we really get started with the construction set, you still need to know a few things. Even though the components we will work with are very robust, if you do not handle them properly, they can be damaged under certain circumstances.

Pneumatics

Compressed air is so common, it is hard to imagine getting along without it. More than likely you will encounter it daily, directly or indirectly. This can start with your breakfast eggs, which may have been packed with the aid of a pneumatic vacuum gripper. Or at the dentist's when he drills out a cavity with a pneumatically driven drill. You can see pneumatics on construction sites, when a jackhammer is used to break up pavement, in the brake system on your car or in many other situations.



The word pneumatic comes from the Greek word pneuma meaning air. Pneumatics focuses on generating motion and accomplishing mechanical work

with air. Almost anything can be driven with air. It can be used as an alternative for muscular force or any other type of energy such as electricity, water, hydraulic oil or wind power.

Advantages of Pneumatics

The advantages of pneumatics are that ...

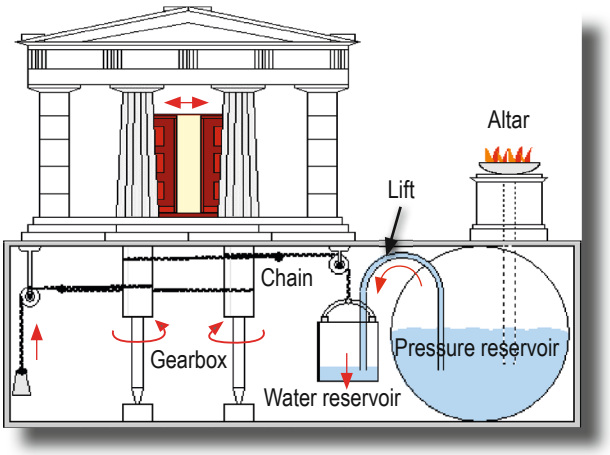
- Compressed air can be stored
- Compressed air can be transported over great distances with pipes and hoses or in appropriate tanks or containers
- Compressed air is clean and does not cause any contamination
- Movements can be performed quickly with compressed air
- Pneumatic cylinders allow many motions to be realized without complicated mechanical systems
- Compressed air is not explosive

Your Pneumatic Power Construction Set explains these advantages and further interesting information.

Moreover we want to show you how pneumatic components work. For this purpose we explain the individual components step by step and show how they work.

Moreover the construction set contains numerous examples of models showing how pneumatics can be used.

A Brief History

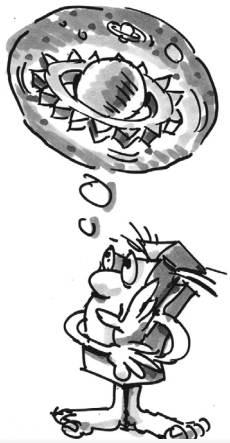


Over 2000 years ago the Greek engineer and inventor Ktesibios built the first machines powered by compressed air, for example, a catapult which used compressed air to hurl shot and spears. Heron of Alexandria built one of the best known compressed air systems, which used the altar fire to generate compressed air to open the huge temple doors, as if by magic.

The heat from the altar fire heated the air in a pressure reservoir half filled with water. When the air was heated, it expanded, increasing the air pressure. The expanding air required more space, thus pressing the water out of the pressure reservoir into a water tank. As the weight increased the water tank moved downward, opening the doors.

Since the beginning of the 20th century pneumatic systems have been used to drive and control machines in industrial applications. In the field of construction and agricultural machines pneumatic systems are used to drive hammers and drills.

In conveying technology, pneumatic systems use vacuum and pressure for applications such as sucking grain into flour mills or conveying flour. Even in the field of music, pneumatics are used for applications such as organs. In a pianola, a player piano, the keys are controlled pneumatically. You can observe pneumatic systems in action in the automotive industry, the textile and foodstuffs industry, electrical engineering, and even in space technology and many other areas encountered every day.



Pneumatic Systems and Components

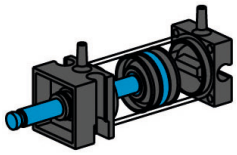
Any pneumatic system consists of five subsystems for

- Generating compressed air
- Storing compressed air
- Conditioning and filtering compressed air
- Distributing compressed air
- Generating and controlling motion

Generating Compressed Air

Compressed air can be generated with a compressor or air pump and stored in compressed air bottles or other pressure containers.

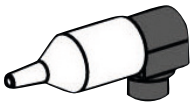
Pump cylinder as compressor



The pump cylinder included in the construction set allows you to generate the compressed air required for the compressed air reservoir. In industrial applications this is called the compressed air source.

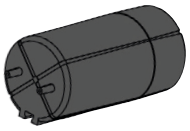
Function of pump cylinder:
The pump cylinder consists of a pneumatic cylinder and an attached non-return shuttle valve. The non-return shuttle valve allows the pneumatic cylinder to be used as a compressed air pump.

Non-return shuttle valve (also called check valve):



The non-return shuttle valve is simply connected to connection A on the pneumatic cylinder. The hose can be connected to the non-return shuttle valve. If the piston rod is pulled out of the cylinder, the non-return shuttle valve allows air to be sucked in from outside the cylinder. Pushing the piston rod back in pumps the air through the second opening in the non-return valve into the hose, while sealing off the first connection. We now have a pump cylinder similar to that used for a bicycle.

Storing Compressed Air

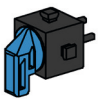


The pump cylinder pumps air into the compressed air reservoir. Similar to blowing up a balloon, the pressure increases on the inside. However the compressed air reservoir is very stable, preventing it from deforming under the pressure of the air. The non-return shuttle valve prevents the compressed air from escaping from the compressed air reservoir and flowing back to the pump cylinder. If a connected valve is now opened, the pressure forces the air to flow into the connected cylinder. This is also similar to an inflated balloon when opened slightly to let the pressure force air out of the balloon.

Conditioning and Filtering Compressed Air

To ensure that the pneumatic components operate correctly in industrial applications, it is important to condition the compressed air properly. For this purpose it is necessary to filter, cool, dehumidify and add oil to the air. However with the models in your Pneumatic Power Construction Set this is not required.

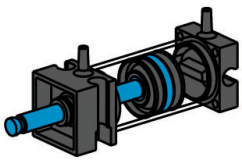
Distributing Compressed Air



The compressed air can be transported to the location required with the blue hoses. You can lay the air lines from the compressed air reservoir to the valves and cylinders.

Generating and Controlling Motion

Pneumatic cylinder:



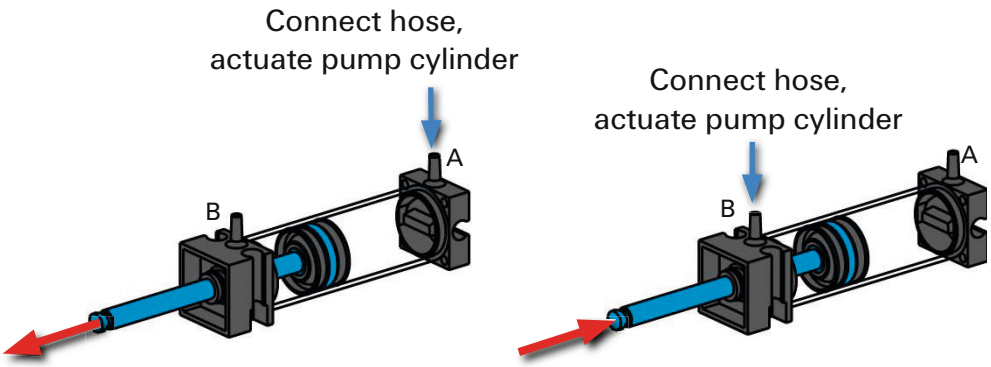
We use pneumatic cylinders to generate motion with air. As a matter of principle we differentiate between "single acting" and "double acting" cylinders. Your Pneumatic Power Construction Set contains three different sizes of pneumatic cylinders with the same "double acting" function.

The blue piston rod is movable and seals the cylinder. If you blow air into the cylinder through one of the two hose connections, the piston rod moves. If air is blown into it from the opposite side, the piston moves back in the other direction. The piston therefore has an active function in both directions of motion.

The connection which causes the piston rod to extend is designated connection A, and the connection for retracting the piston rod is called connection B. Since the piston rod in the cylinder can be extended as well as retracted by the air, we call the cylinder a "double acting" cylinder. You can perform an experiment to examine this in practical application.

Experiment:

Fasten a piece of the blue hose to connection A on a cylinder and connect it to the hose connection on the pump cylinder. When you actuate the pump cylinder, generating compressed air, the piston rod extends. Since the cylinder is double acting, the piston moves back when you connect the hose to connection B and blow in compressed air with the pump cylinder.

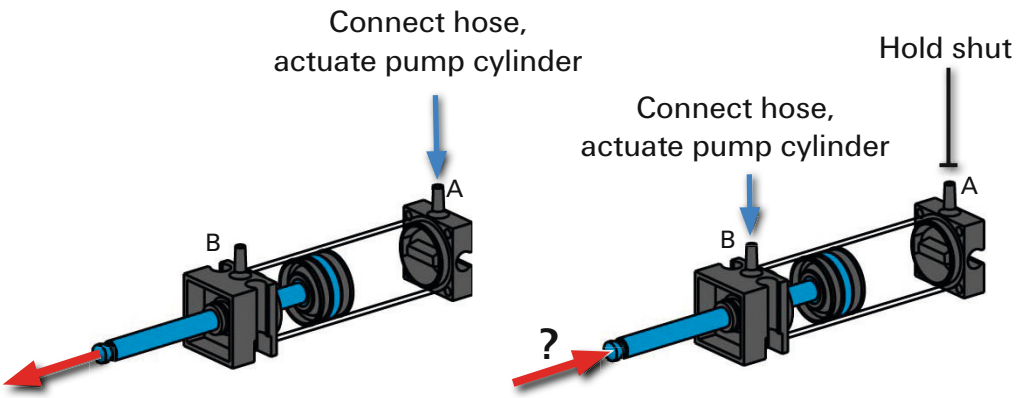


As already mentioned, however, there are also "single acting" cylinders. With such cylinders the piston rod moves in one direction only. A spring is frequently used to move it back in the other direction.

You can perform another experiment to show that air can be compressed.

Experiment:

Now extend the piston in the cylinder again by connecting your blue hose leading to the pump cylinder to connection A and blowing in compressed air. After the piston has extended, change to hose connection B and plug hose connection A by holding it closed with your finger.



Observation:

The piston can only be pressed in a short distance. Do you know why?

Pressure gage

Explanation:

Since you held air connection A closed with your finger, it was not possible for the air to escape. However air can be pressed together. For this reason it was possible to push the piston rod back slightly. The more the air is pressed together, the greater the air pressure in the cylinder. The pressure can be measured with a pressure gage. The unit for pressure is "bars" or "Pascals". The pressure can also be calculated. The equation for calculating the pressure is:

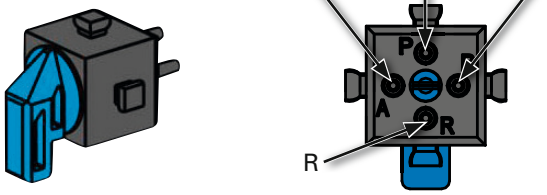
Pressure = force/area or abbreviated $p = F/A$

This equation shows that the pressure depends on the amount of force exerted on the round surface in the cylinder. As you recognized in your experiment, it is rather cumbersome to reconnect the hoses repeatedly. This work can also be accomplished by valves, as explained in detail in the next chapter.

Valves:

In pneumatics, the purpose of the valve is to control the flow of air to the pneumatic cylinder so that the cylinder is extended or retracted. A valve can be actuated mechanically, electrically, pneumatically or manually.

Your Pneumatic PROFI Pneumatic Power Construction Set contains manual valves.
Each of these valves has four connections:



The middle connection P is for the compressed air coming from the compressed air reservoir. The left or right fitting (A or B) guides the compressed air to connection A or connection B on the cylinder. The connection marked R on the bottom of the valve serves to release the air or "relieve" the air pressure. This allows the air returning from the cylinder to escape. Perform the following experiment to see how the valve works.

Experiment:

Connect the compressed air reservoir to one of your valves. You can use the function model as described in the assembly instructions. For this purpose take a piece of the blue hose and fasten it to the hose connection on the compressed air reservoir and to connection P on the valve. Leave the other connections free. Set the blue switch on the manual valve to the center position and switch on the compressed air from the compressed air reservoir. First it is necessary to fill the compressed air reservoir with the pump cylinder.

Observation:

Nothing happens at all.

Explanation:

When the switch on the manual valve is set to the center position, the connections are closed and the air cannot flow in any direction.

Experiment:

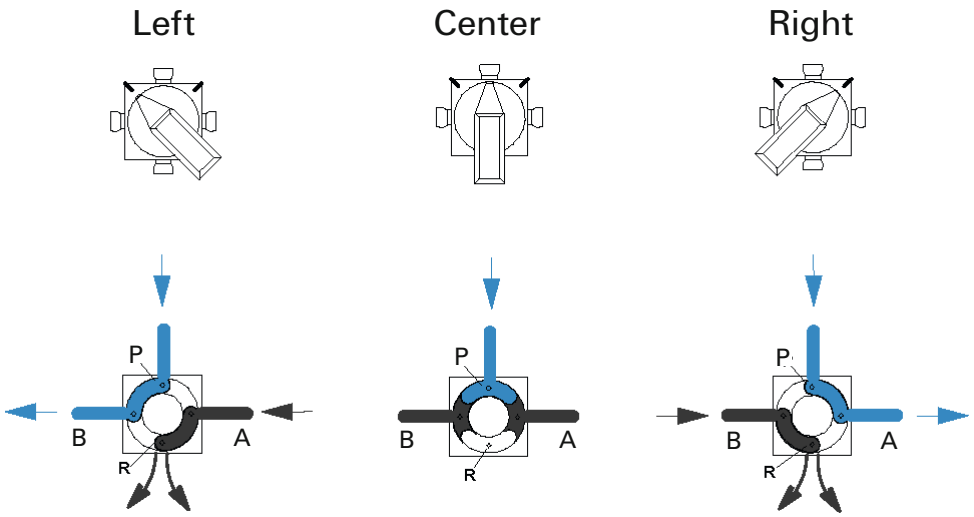
Then turn the switch on the valve to the right (clockwise) and switch on the compressed air to the compressed air reservoir again. While doing this tap against the free fittings A and B repeatedly with your finger. Do the same after turning the valve switch to the left (counterclockwise). Don't forget to continue to fill the compressed air reservoir with compressed air by actuating the pump cylinder.

Observation:

The air always flows through connection A when you turn the blue switch on the valve to the right (clockwise) and through connection B when you turn it to the left (counterclockwise).

Explanation:

This illustration helps you to understand how the air flows through the valve when you turn the switch in the various directions. Here the blue dash indicates compressed air flowing through the valve. The dark lines show how the air flows as it returns from the cylinder.



The valve has **four** connections and **three** switch positions (center - left - right). For this reason the valve is called a 4/3-way valve in pneumatic jargon.

Exhaust throttle:

Have you ever stood on a garden hose in the yard? Or got a kink in your hose? If so, then you probably noticed that less water came out of the hose all of a sudden. But why is that? The kink in the hose means water has less space to flow. It is throttled, and moves more slowly. The same thing happens in pneumatics when the air in the transport medium, in our case the blue hose, is restricted and has less space to move through.

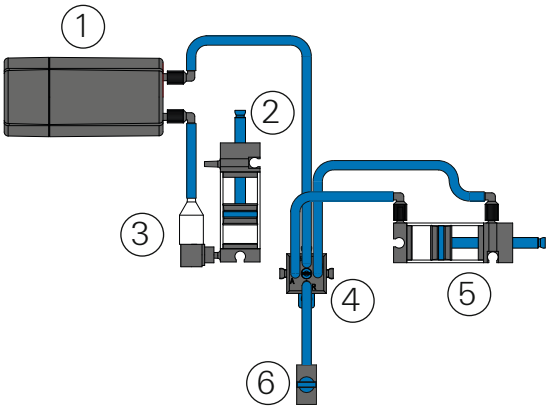
You might be asking yourself why we would want to do something like that?

Throttling the air allows us to carry out the different movements more slowly and in a more controlled manner.

Industrial pneumatic systems are generally operated with a pressure between 6 and 8 bar. This allows pneumatic cylinders to be extended very fast and with a large amount of power if needed. Often, a powerful movement is needed, but it needs to be slow and controlled. A movement that is too fast could endanger machine components, workpieces being handled, or even people.

The compressed air is throttled to move the cylinder more slowly. We allow less air to flow through a hose or line in a certain amount of time, by simply restricting the diameter of the line.

Functional Pneumatic Models



Compressed air reservoir (1) with pump cylinder (2), non-return valve (3), shuttle valve (4), pneumatic cylinder (5) and exhaust throttle (6)

Experiment:

Build the functional model and complete the following experiments: Do not throttle the exhaust by only screwing the blue hose into the housing far enough so that it is not compressed. Observe how quickly the cylinder extends or retracts.Now, throttle the exhaust bit by bit by screwing the blue screw in step by step. Continue to observe the cylinder. What do you notice?

As you can see, the exhaust throttle helps you adjust the extension or retraction speed of the cylinder.

Experiment:

Pump the pump cylinder up and down 10 times. How many times does the pneumatic cylinder extend and retract?

Experiment:

Pump the pump cylinder up and down 20 times. How many times does the pneumatic cylinder extend and retract?

Explanation:

Building up more pressure increases the number of times the pneumatic cylinder extends and retracts.

Pneumatic Play Models

In addition to the function model, the PROFI Pneumatic Power Construction Set includes four additional models with fascinating and amusing functions.

These realistic models are listed below:

- Excavator
- Track mounted recovery vehicle
- Workshop crane
- Punch press

Here you can also install the pump cylinder, non-return shuttle valve and compressed air reservoir in your model and connect it to your pneumatic valves and cylinders. The manual valves then allow you to manually control the arm on your excavator.

In reality, functions like these are accomplished with the aid of hydraulics, instead of pneumatics. Hydraulic applications use oil instead of air to move the cylinders. In contrast to air, oil cannot be compressed, allowing it to transfer significantly higher forces. However, for your play models in the PROFI Pneumatic Power Construction Set the forces achievable with pneumatic actuation are fully sufficient. Moreover it is particularly clean, quick, reliable and above all, fascinating. With the exhaust throttle you can adjust the speed as you like the movement best. We hope you have a great deal of fun building and playing with the models.

If something doesn't work right

If one of your models does not work right, please check the following table. It provides a list of possible errors and the associated causes. Moreover the table is intended to provide you with tips on how to eliminate the faults in each individual case.

Fault	Possible cause	Solution
No motion	• Both valves in position A or B (too much air flowing out through valves).	• Move both valves back to the middle position (off position) after each motion.
The pump cylinder operates normally, but the pneumatic cylinder to be activated moves very slowly or not at all.	• Compressed air reservoir leaky Test: Move valve to center position. Apply pressure to connections on compressed air reservoir and hold under water. If large quantities of bubbles rise, the compressed air reservoir is leaky.	• Replace compressed air reservoir. (Please contact fischertechnik Service: info@fischertechnik.de)
	• Manual valve leaky Test: Move valve to center position. Apply pressure to all three connections one after the other and hold under water. If large quantities of bubbles rise, the valve is leaky.	• Replace manual valve. (Please contact fischertechnik Service: info@fischertechnik.de)
	• Pneumatic cylinder leaky Test: Apply pressure to both connections one after the other and hold under water. If large quantities of bubbles rise, the cylinder is leaky.	• Replace pneumatic cylinder. (Please contact fischertechnik Service: info@fischertechnik.de)
	• Exhaust throttle completely closed	• Open exhaust throttle

Fault	Possible cause	Solution
Pump cylinder, compressed air reservoir and all cylinders are okay, but one cylinder still does not extend.	• Hose clogged at one point. • Hose kinked. Test: Connect each hose to the compressor by itself and check whether compressed air is blown through. You can feel the air.	• If necessary replace clogged hose. (Please contact fischertechnik Service: info@fischertechnik.de) • Ensure that the hose is not kinked.

More About Pneumatics

The fascinating subject of pneumatics is not concluded with the PROFI Pneumatic Power Construction Set by any means.

The PROFI Strong Pneumatics Construction Set teaches further principles of pneumatics. The six models in this construction set go on to illustrate the function of the 9 V compressor contained in the set. In addition to vehicles such as front loaders, Double rotary windrowers and tree trunk grips, other educational models provide further background knowledge on the subject of pneumatics in combination with the instructional activity booklet.