How can we transport and harness water?

This resource was created on behalf of the Norfolk Record Office, using material held in the archive. References for each of the documents included in the pack can be found on the thumbnails. The majority of material is found within the archives of the Norfolk Record Office (prefixed NRO). However, some additional material has been supplied by Picture Norfolk.

Documents can be consulted free of charge at the Norfolk Record Office at:
The Archive Centre,
Martineau Lane,
Norwich, NR1 2DQ

For enquires please contact the Record Office on:
(01603) 222599
or norfrec@norfolk.gov.uk

How can we transport and harness water?

Introduction:

The following activities are based around documents relating to the Boulton and Paul Water Elevator (NRO, MC 2046/1) and various Norfolk watermill images and information. Boulton and Paul were a Norwich manufacturing and engineering firm which spanned over 150 years in the city. The 'Boulton Water Elevator' was created using Caruelle Belts to drain wells and shafts up to 300 feet. At one point or another there have been 147 watermills in Norfolk and there is still a working watermill which produces flour in Letheringsett.

This pack links in with physics sections of the science curriculum and looks at forces and energy. There is also scope for crossing over with design and technology areas and information technology for research.

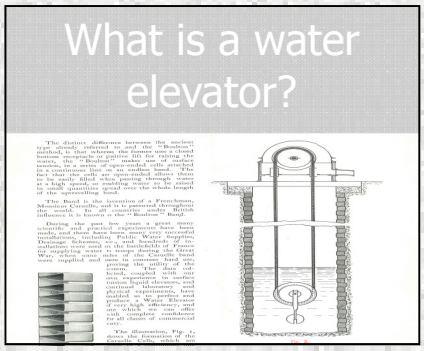
The resource was designed for the KS2 Years 5 and 6 programme Forces. It can be particularly helpful in order to look at the effects of water resistance and frication, and in studying mechanisms including levers, pulleys and gears.

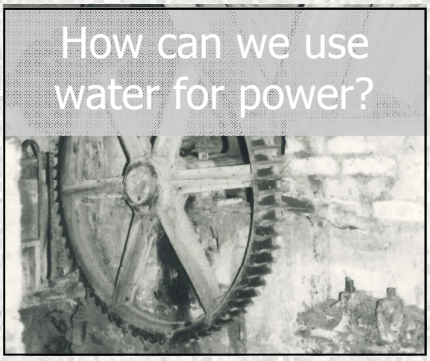
The pack contains four sections:

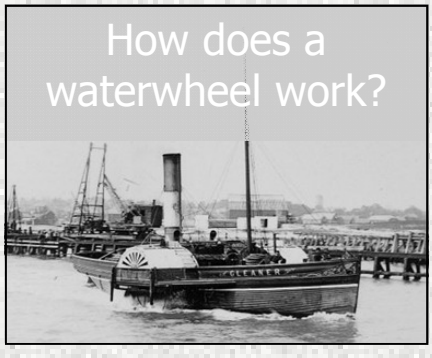
- What is a water elevator?
- How can we use water for power?
- How does a waterwheel work?
- How does a pulley system work?

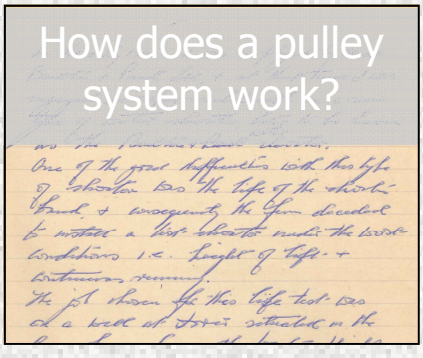
Each section is designed to form one lesson. Pupils can work through the sections online under the guidance of the teacher. Videos of the experiments are included.

Click on a thumbnail to view









What is a water elevator?

Introduction:

Water elevators have been used for thousands of years in various designs, to raise water from wells. Some of the earliest forms of water lifts include Archimedean Screws and Persian lifts. The Archimedean Screw is a spiralling water lifting machine; inside the wooden barrel there is a another element that resembles a corkscrew. This is rested in the bottom pool and then the operator rotates the drum and the screw carries the water upwards to the higher pool.

The Persian lift is basically a waterwheel with pots attached to it. As the wheel rotates it submerges the pots and water flows inside before it is raised out of the other side. Neither of these methods is suited to deep wells.

In the 1920s Boulton and Paul manufactured the Bouton Water Elevator for use in deeper, narrow wells with increased efficiency.

Click on an activity to start

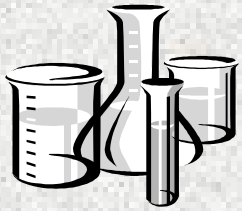
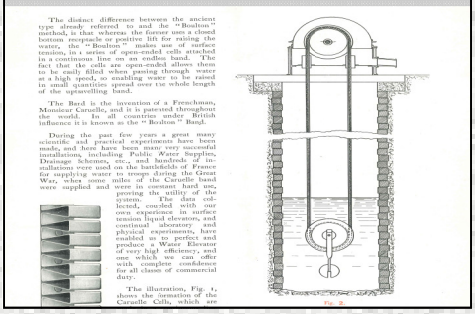
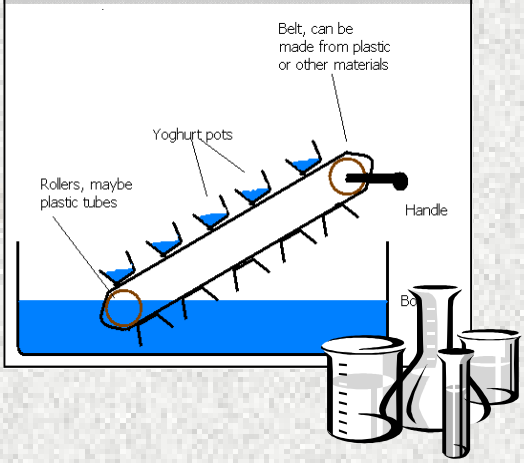


Diagram of
Archimedean Screw and Persian Lift

Starter
How can we lift water from wells?



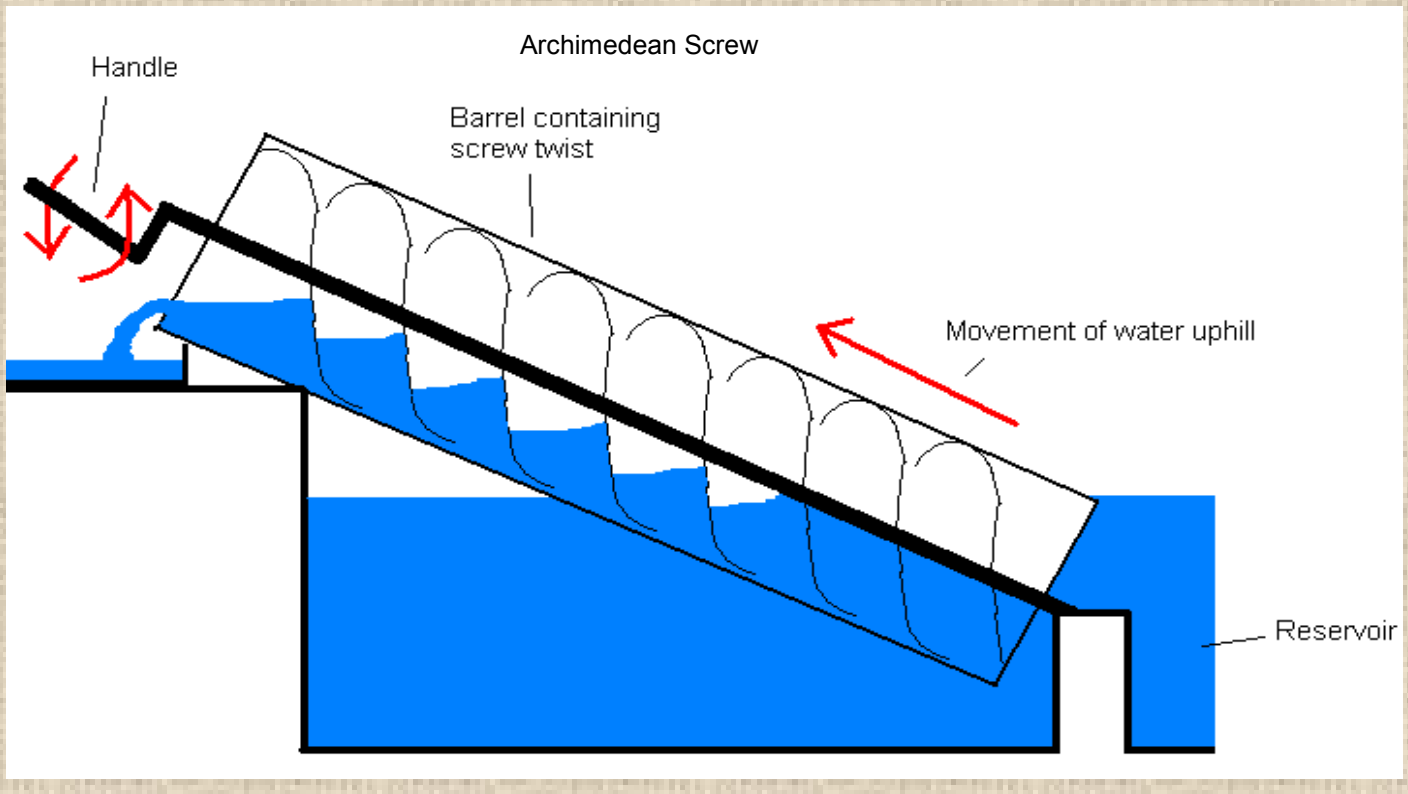
Main
Create a water elevator

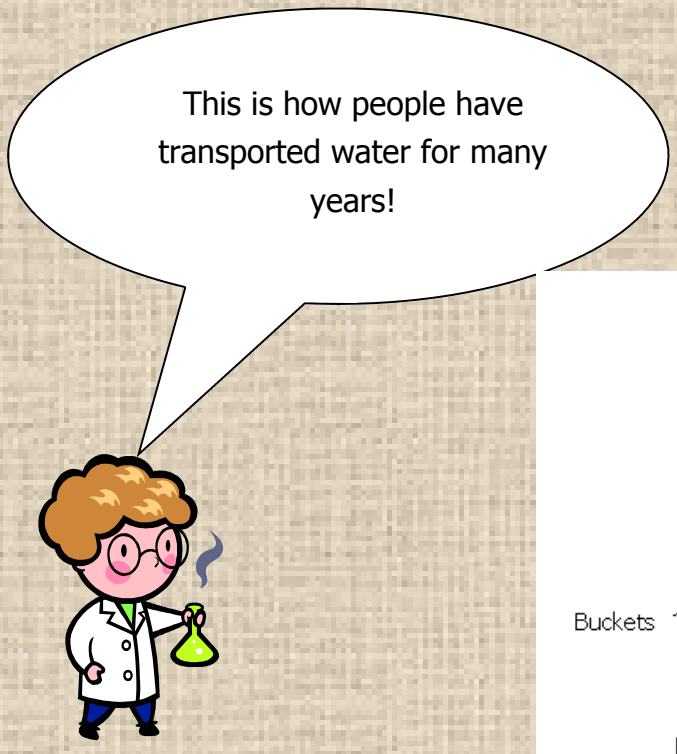


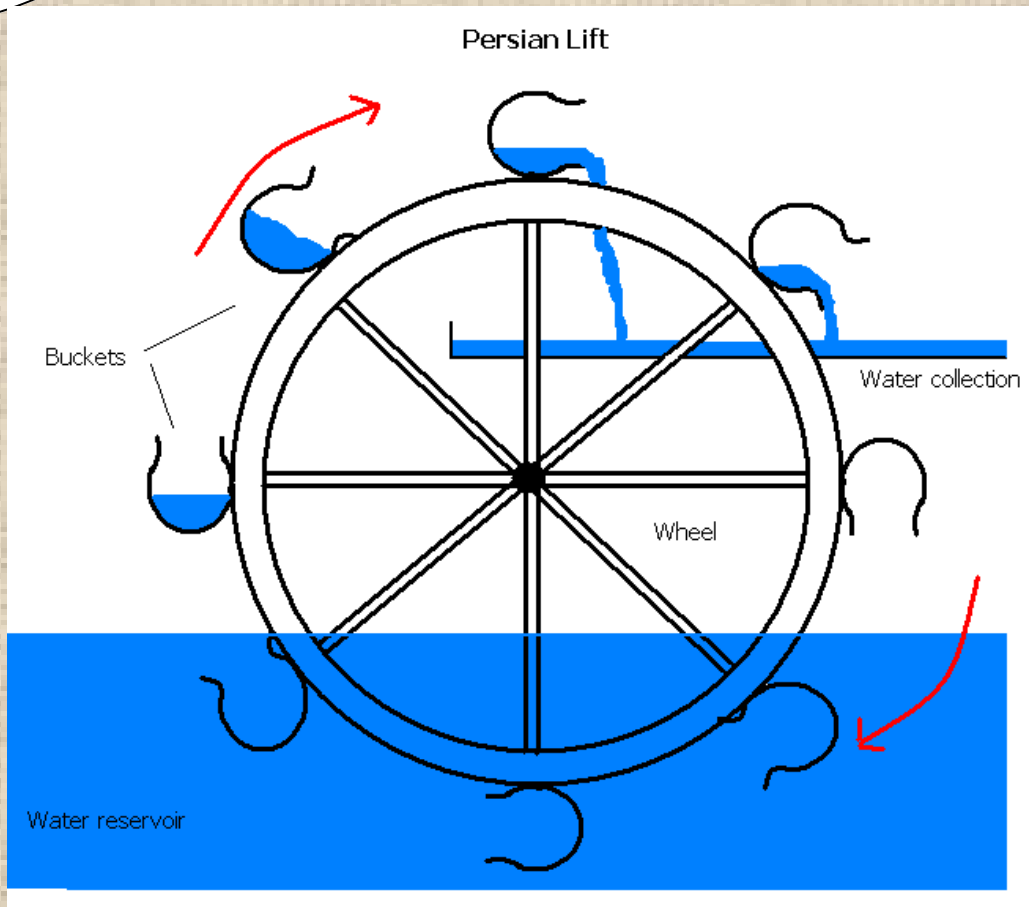
Plenary
What do we need to consider when locating a water elevator?

Go to Home

Archimedean Screw and Persian Lift







Starter activity

How can we lift water from wells?

In pairs look at the internet and other materials to research ways of lifting water from wells and shafts.

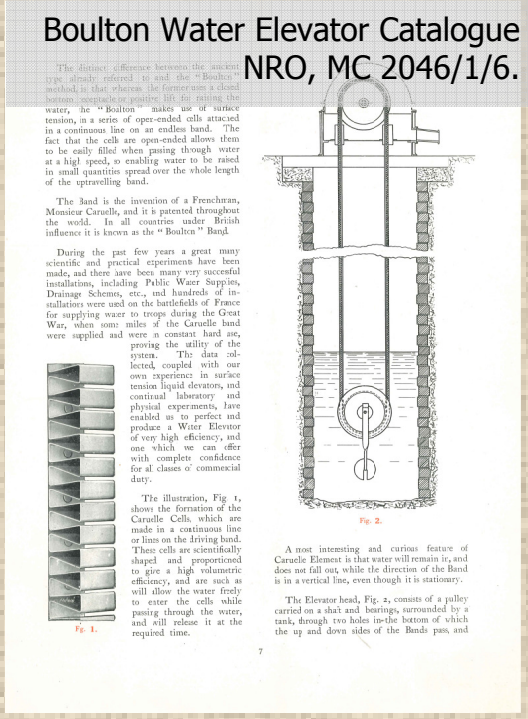
- Out of all the methods you have found which do you think is the best?
- In your pair decide on two reasons for your choice and share with the class.
- Did you notice any other interesting facts when you researched the different methods?
- As a class, brain storm some other ideas for lifting water and any points which the group think are important to consider when using a water elevator.

Look at the Boulton Water Elevator catalogue (NRO, MC 2046/1/6) to see the solution a local firm came up with.

Documents you will need

Click on an image to see full size version

Boulton Water Elevator Catalogue
NRO, MC 2046/1/6.



The distinct difference between the ancient type already referred to and the "Boulton" method, is that whereas the former uses a closed bottom receptacle requiring lift for raising the water, the "Boulton" makes use of surface tension, in a series of open-ended cells attached in a continuous line on an endless band. The fact that the cells are open-ended allows them to be easily filled when passing through water at a high speed, so enabling water to be raised in small quantities spread over the whole length of the upravelling band.

The Band is the invension of a Frenchman, Monsieur Caruelle, and it is patented throughout the world. In all countries under British influence it is known as the "Boulton" Band.

During the past few years a great many scientific and practical experiments have been made, and there have been many very succesful installations, including Public Water Supplies, Drainage Schemes, etc., and hundreds of installations were used on the battlefields of France for supplying water to troops during the Great War, when some miles of the Caruelle band were supplied and were in constant hard use, proving the utility of the system. The data collected, coupled with our own experience in surface tension liquid elevators, and continual laboratory and physical experiments, have enabled us to perfect and produce a Water Elevator of very high efficiency, and one which we can offer with complete confidence for all classes of commercial duty.

The illustration, Fig 1, shows the formation of the Caruelle Cells which are made in a continuous line or links on the driving band. These cells are scientifically shaped and proportioned to give a high volumetric efficiency, and are such as will allow the water freely to enter the cells while passing through the water, and will release it at the required time.

Fig. 1.

Fig. 2.

A most interesting and curious feature of Caruelle Element is that water will remain in, and does not fall out, while the direction of the Band is in a vertical line, even though it is stationary.

The Elevator head, Fig. 2, consists of a pulley carried on a shaft and bearings, surrounded by a tank, through two holes in the bottom of which the up and down sides of the Bands pass, and

7

Main activity

Create a water elevator

Have a go at designing your own water elevator. You can also try to create a Caruelle Belt.
This activity involves transporting water so would ideally be performed outside.

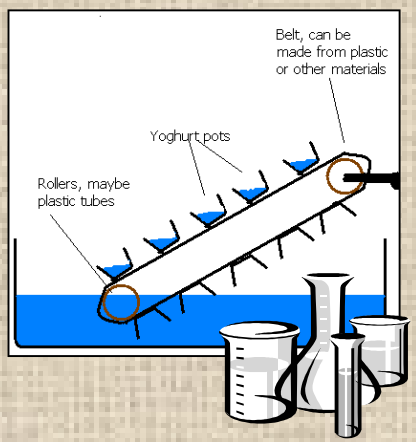
What you need:

- Scrap materials for creating elevators
- Water
- Tubs or trays for holding the water
- Measuring jug

Procedure:

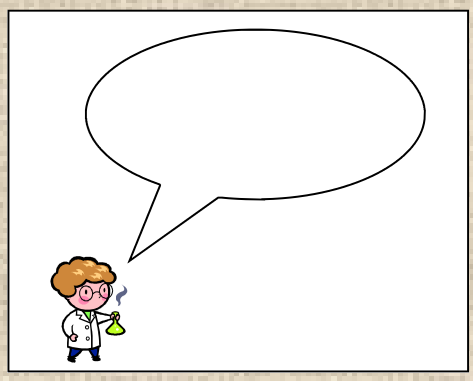
1. In groups or pairs have a go at designing your own water elevator. You can use variations of any of the methods you have researched or the Boulton/Caruelle Belt method. Think about the available materials you have and what you will be draining the water from so you can design accordingly. The designs do not have to be complicated. Have a look at some examples on the next page.
2. Test your designs and see how much water your elevator can transport in a given amount of time. Once you have measured the water can you come up with some improvements or alterations that will make the elevator transport more water? Try out the improvements and test your design.
3. Were there any issues with your design? Did anything stop it from working properly? Why do you think that is? What would you do differently in the future?

Click on the links below to find out more



Diagram

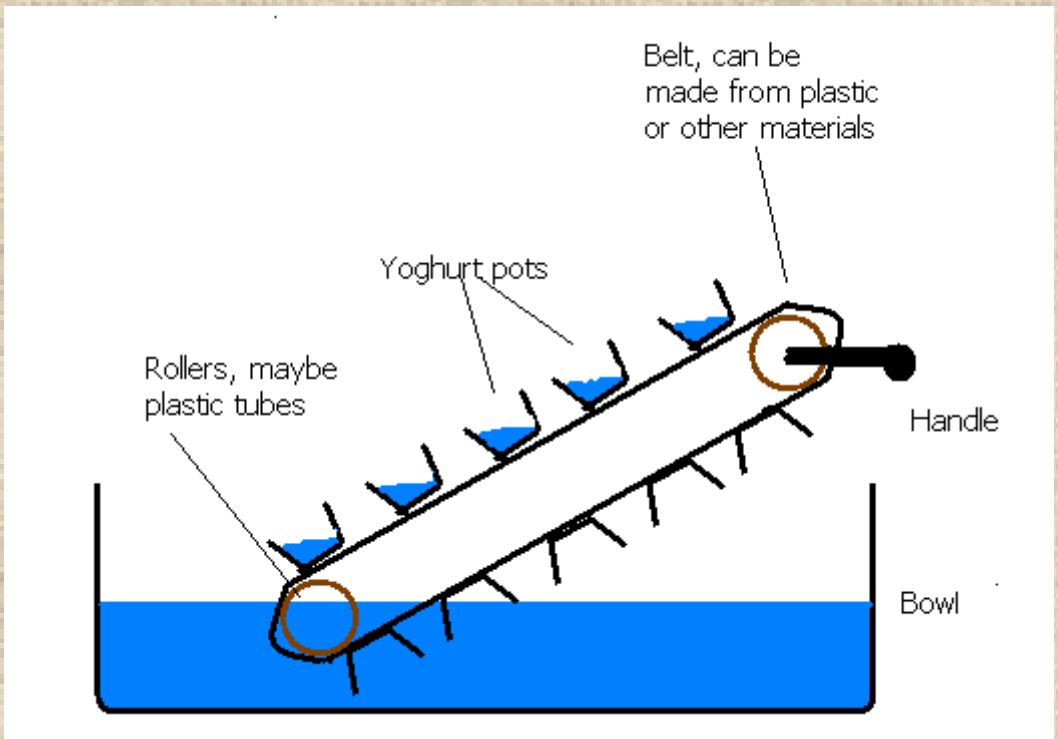
Video



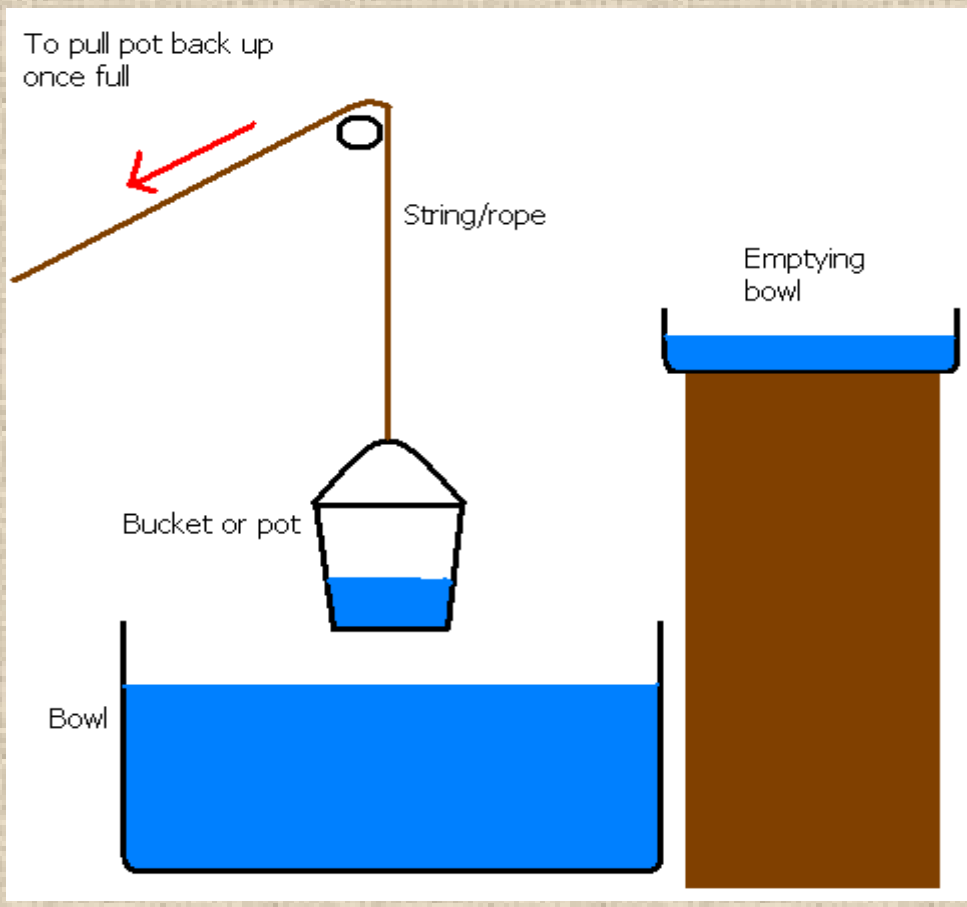
Explanation

Main activity

Create a water elevator



These are some examples of how you may want to make your water elevator



Explanation

The Caruelle Belt works owing to surface tension.

Water is made up of water molecules which contain one oxygen atom and two hydrogen atoms. Each water molecule is slightly charged like a magnet. The oxygen atom has a slight negativity and the hydrogens are slightly positive. This means when you have several together they are attracted to one another. All molecules in water act as magnets attracting each other although these forces are very small so we can still separate volumes of water.

At the surface, the outer layer of molecules has fewer neighbouring molecules than those in the bulk of the water; this means the attractive forces are stronger and the outer molecules create a type of film as they hold together a little better than the molecules in the main body of the water. This is what causes surface tension.

In practice, this means that water molecules at the surface hold together and create a kind of outer layer. Water Boatmen insects use surface tension to their advantage. As they are so light and can distribute their weight evenly, they do not 'overload' the surface tension and so break through the outer layer. In other words, they are able to walk on water.

Another way of visualising surface tension is to look at a drop of water on the end of a tap or a pipette. If you squeeze the pipette gently some water will come out and form a spherical drop. Instead of immediately falling the drop will stay on the end of the pipette, getter larger as the surface tension on the outside of the drop holds it all together. Once the drop is big enough it becomes too heavy for the surface tension to hold and falls. All drops are spherical because of surface tension, this is to minimise the number of molecules on the outer layer.

The Caruelle Belt allows for the surface tension to hold the water inside. As the belt travels up along the straight side, surface tension holds the water inside each compartment. When the belt bends at the top of the system the surface tension is overcome and the water flows out into the container.

Plenary activity

What do we need to consider when locating a water elevator?

During the initial research, did anyone find particular areas of the world where water elevators are used, or perhaps specific situations, such as on a farm. Take some time to investigate where water elevators are used.

As a class or in small groups discuss what you found out from the investigation.
From this, discuss what are important factors when designing a water elevator, for example

- What needs to be considered when looking at possible materials?
- Where would the device be used?
- Would you need to take into account where on the site it should be built and whether there are any ecological issues to think about?
- Does the situation make a difference to what sort of elevator can be used?

What is a water elevator?

Glossary

Caruelle Belt: (Also known as Boulton Band) A special band which has open cells for transporting water using surface tension. It allows the cells to be filled even at high speed and the weight is spread across the whole band.

Watermill: A building that uses water power to drive a wheel. This wheel then powers the machinery inside the mill for various purposes including grinding flour etc.

Archimedean Screw: A device used in ancient times for transporting water uphill. The barrel of the device houses a screw twist which when rotated can carry the water upwards in the screw thread.

Persian Lift: Another ancient water lift device. It basically comprises a water wheel with a series of pots attached to it. The pots gather the water as they are submerged and are emptied as they reach the top.

Surface tension: An intermolecular force which enables the outer layer of water molecules to act as a film across the top of the water.

Intermolecular Force: This is a force which acts between separate molecules. The forces are not strong enough to be called bonds so the molecules can be easily separated. The slight attraction between two molecules of water is an intermolecular force.

How can we use water for power?

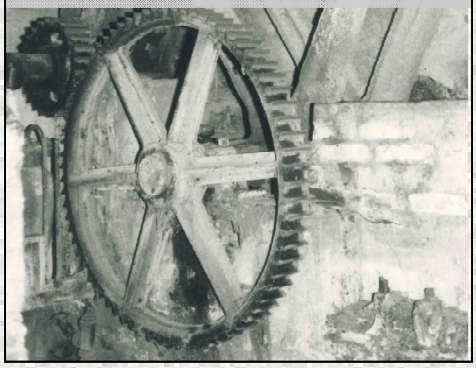
Introduction:

Waterwheels can be used to lift heavy loads and grind corn/grain as well as having other uses. In Norfolk there have been around 150 watermills in existence at some point. The watermill at Letheringsett is still working today and produces flour. The wheels are turned by the water supply and these then turn gears throughout the mill. The gears in turn power the grinding stones. The grain is ground between the grinding stones. The typical waterwheel turns 10 revolutions per minute; the gears increase this speed to 120 revolutions per minute.

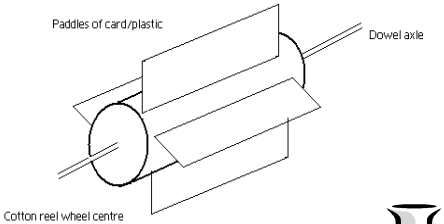
The power for the waterwheel is gained from the kinetic (movement) energy of the water. It falls on to the wheel due to gravity and this energy moves the wheel round.

Click on an activity to start

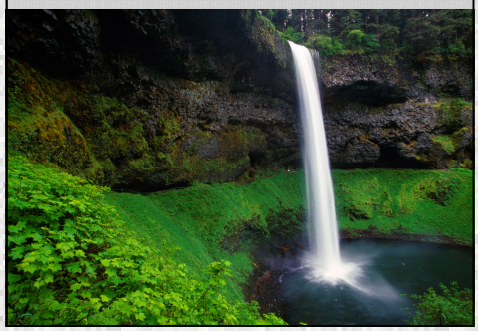
Starter
What is a waterwheel?



Main
Using water for rotation



Plenary
What forces does a waterwheel use?



Go to Home

Starter activity

What is a waterwheel?

Have a look at the picture of Stoke Holy Cross Watermill (Picture Norfolk: NP00012875).

- Can you guess what the building might be?
- Can you spot the waterwheel in the picture?
- Think about what the mill may produce.

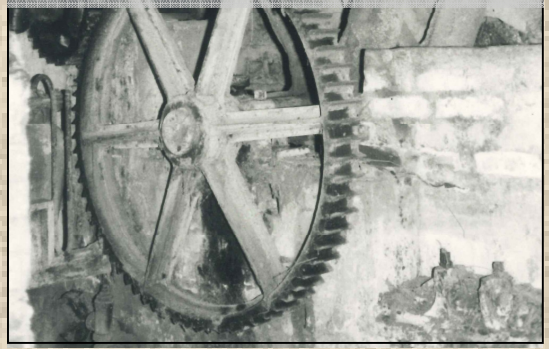
Look at the images of the waterwheel and the grinding stones.

- Can you understand from these images how parts of the mill work?

Documents you will need

Click on an image to see full size version

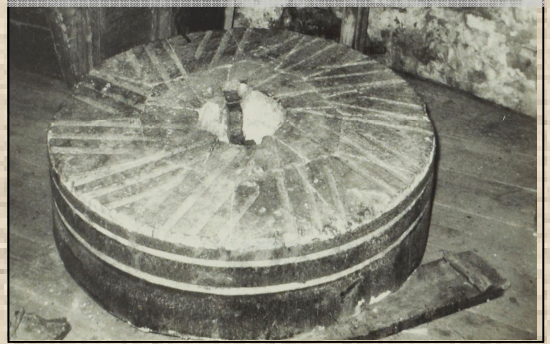
Photograph of waterwheels
NRO, C/WT UNCAT



Stoke Holy Cross Watermill
Picture Norfolk, NP00012875

Image courtesy of Norfolk County Council Library And Information Service - Enjoy Thousands Of Images Of Norfolk's Unique History At www.picture.norfolk.gov.uk

Photograph of grinding stones
NRO, C/WT UNCAT



Main activity

Using water for rotation

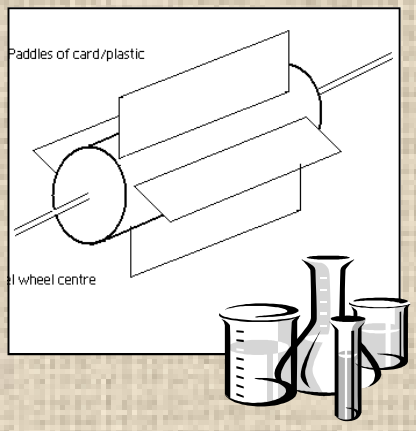
What you need:

- Empty 2-litre bottle (the top third/half needs to be cut away)
- Small wooden dowels (cocktail sticks or straws could be used instead)
- Cotton reel (cork could be used as an alternative)
- Rectangles of cardboard or plastic
- Scissors
- Jug of water
- Modelling clay
- Pressure sensitive tape

Procedure:

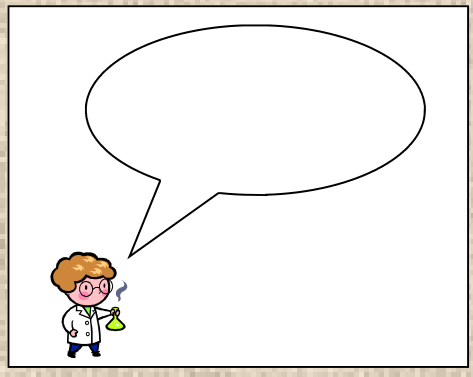
1. Take the bottom section of the bottle and cut two v-shapes out of the rim, opposite to one another.
2. Tape the rectangles of cardboard or plastic to the cotton reel so that they stick out like spokes. It may be necessary to fold a small piece of one edge of the 'paddle' to give a greater area to stick down to the reel.
3. Using a dowel that spans the width of the bottle, thread it through the centre of the cotton reel. Use modelling clay and wedge in the holes to ensure the dowel is secure in the reel and does not move.
4. Sit the dowel in the two v-shapes cut into the bottle, making sure that the dowel is allowed to rotate freely.
5. Holding the jug of water over the wheel, pour the water over it and watch the wheel spin round.

Click on the links below to find out more



Diagram

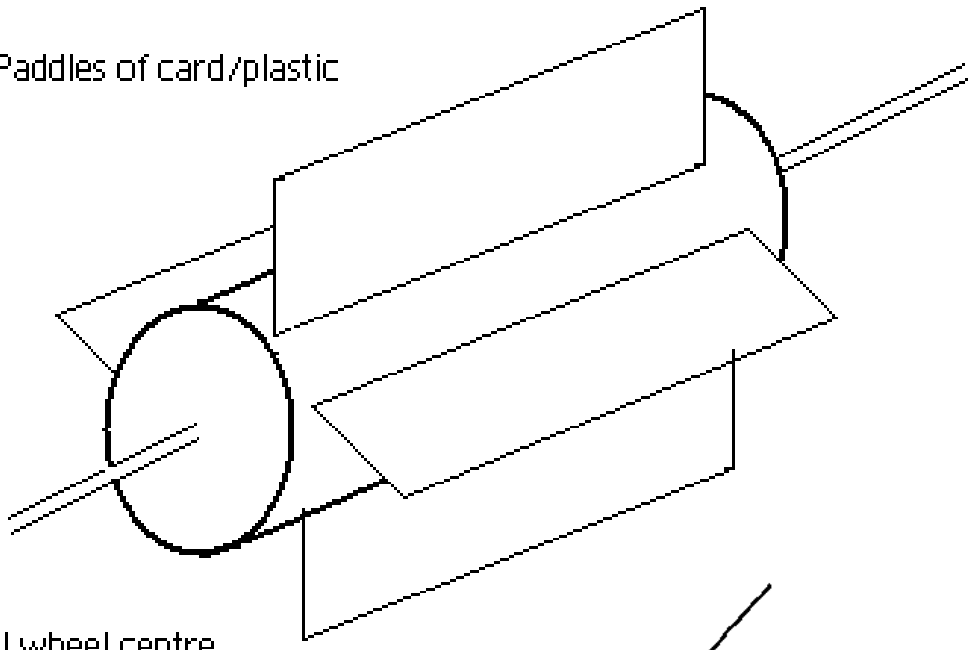
Video

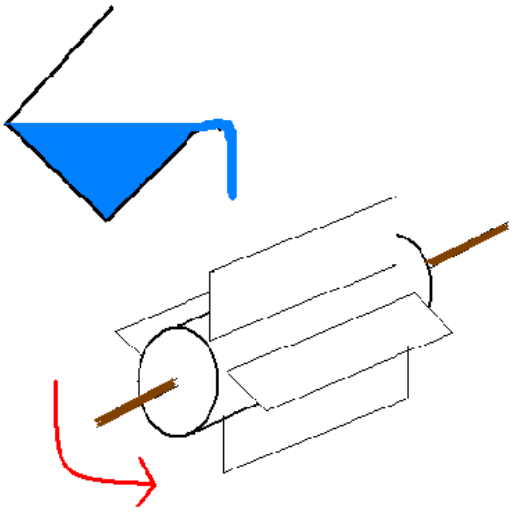


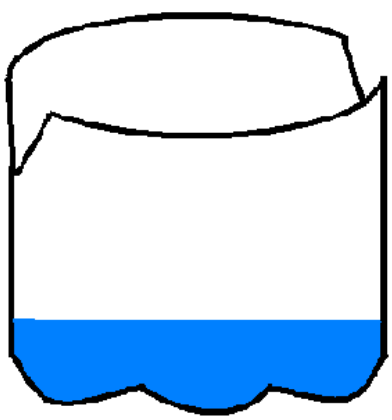
Explanation

Main activity

Using water for rotation







Your waterwheel should look something like this!

Explanation

The waterwheel is powered by forces and the transfer of energy. The water in the jug has stored potential energy. When the water falls the potential energy becomes kinetic energy as the water is moving. This is then transferred to the wheel. The kinetic (or movement) energy is what makes the wheel turn. For a movement to occur you need kinetic energy.

Imagine sitting on a swing. When you are at either end of the swinging arc you pause for a second before changing direction. When you are changing direction you have potential energy, you are not using energy to move but you have it ready to move again. It is stored and waiting to become kinetic energy. Once you start moving again, this has become kinetic energy.

To get energy out you must put energy in. In this case we are getting the energy from the water. An alternative way of turning the wheel could be with a handle, but you would need to use kinetic energy (put energy in) by turning the wheel with your hand.

But what causes the water to fall down on to the wheel? Gravity acts on all things on Earth, pulling things down closer to the planet. It is what keeps us on the ground. The gravity on the Moon is not so strong, and this is why astronauts can jump so far when on the surface of the Moon.

Gravity acts on the water so when you tip the jug it does not go up or stay still but falls down on to the wheel and transfers this movement energy to the wheel. As discussed in the previous activity, surface tension acts as a film on the top of water however gravity overcomes this and allows it to fall down.

Plenary activity

Which forces does a waterwheel use?

Discuss the forces involved and the energy being transferred in this process.
Why does the water fall on to the wheel? Think about gravity.
What happens if the water is poured from a greater height?

- Try it out on your wheel and see if it changes the speed.

Try experimenting with different types of wheel. The Norfolk Mills website has information on all types of mill in Norfolk and the three main types of wheel: overshot, undershot and breastshot wheel. (http://www.norfolkmills.co.uk/)

Have a look at the different sorts of paddles there are. Do you think a different sort of paddle will improve your wheel?

How can we use water for power?

Energy: available power. Energy is used to power an action. We eat food because we need it to give us the basic energy we need for our bodies to work.

Gravity: a force that pulls things downwards.

Kinetic energy: Energy which is being used for movement, e.g. a moving car has kinetic energy.

Potential energy: Energy which can be accessed but is not yet being used e.g. batteries store potential energy when not in use. Food is also a store of potential energy as we will be able to access it once it is eaten.

Grinding stones: These are large stones which are circular and used in a mill. The stones have channels carved into them. They are used in pairs and are twisted against each other. Flour or other materials are put between them. The action of the two wheels turning against each other breaks the material down into smaller particles.

Revolution: A complete turn of a wheel.

How does a waterwheel work?

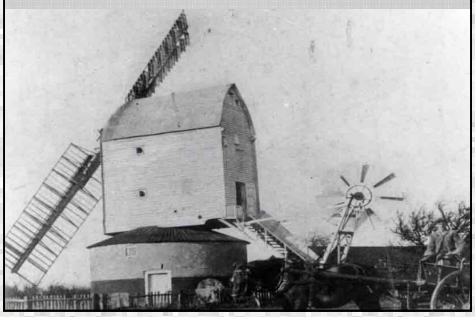
Introduction:

Waterwheels are used to power grinding stones in mills. The wheel rotates and turns a series of gears which pass the movement through the mill to the grinding stones. In the previous activity the class created a waterwheel and in this activity they will attempt to make the wheel power a lifting mechanism.

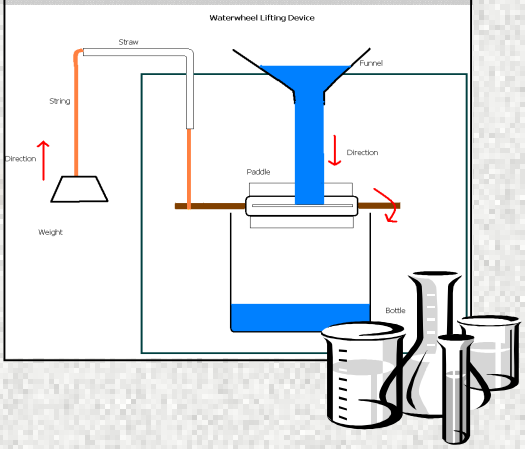
Waterwheels use the kinetic (movement) energy of the water to power the wheel which in turn powers the gears in the mill. The wheel is a continuous inclined plane which means the load on it rolls as opposed to being dragged; this decreases the friction which would be wasted energy, therefore making the wheel more efficient.

Click on an activity to start

Starter
What can we use to create energy?



Main
Create a waterwheel



Plenary
Why do we need to use hydroenergy?

Go to Home

Starter activity

What can we use to create energy?

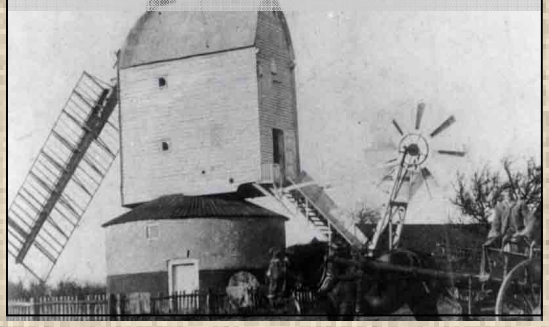
In pairs write a list of as many different types of energy as you can, for example solar and fuel. When you have decided on your list give an example of where each type is used. Share the lists with the class and see how many the class can identify.

Look at the picture of the waterwheel and the windmill. Which categories do these fit into?

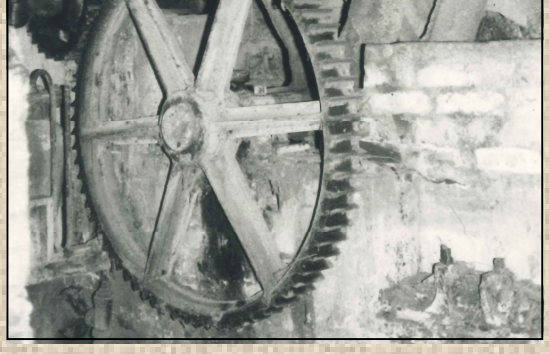
Documents you will need

Click on an image to see full size version

Photograph of Garboldisham Windmill
NRO, C/WT/1/6/1/2, PH 29



Photograph of waterwheels
NRO, C/WT UNCAT



Main activity

Create a waterwheel

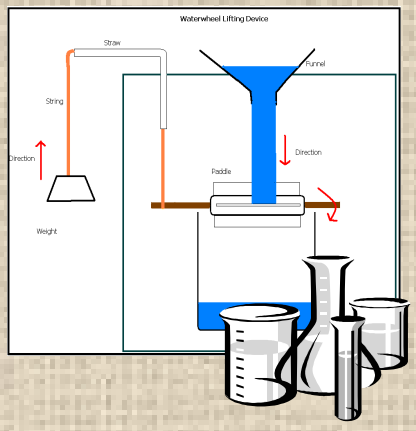
What you need:

- String
- Cardboard box without the lid
- Bendy straws
- Small weight
- Waterwheel from last activity
- Funnel (use the top half of a plastic bottle and turn it upside down)
- A reusable adhesive putty, such as Blu-Tack

Procedure:

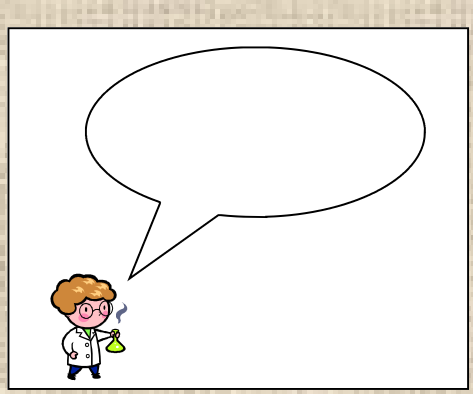
1. It may be necessary to adjust the waterwheel by cutting two small lengths of straw and fixing these with the putty into the v-shapes of the bottle section of the waterwheel. This will ensure that the wheel will stay in the correct place. The straws must not touch the reel and the dowel must be long enough to stick out of either end.
2. Turn the cardboard box on to its end with the top facing outwards.
3. Cut a hole in the top left corner of the box and insert a bendy straw into it. Make sure you keep the bend on the outside of the box and that it extends over the side.
4. Thread the string through the straw into the box and tie to one end of the dowel on the waterwheel. Place the waterwheel inside the box.
5. Cut a hole in the top of the box above the wheel and insert a funnel.
6. Attach a small weight to the free end of the string, on the outside of the box
7. Pour water through the funnel on to the wheel and see whether the wheel can lift it.

Click on the links below to find out more



Diagram

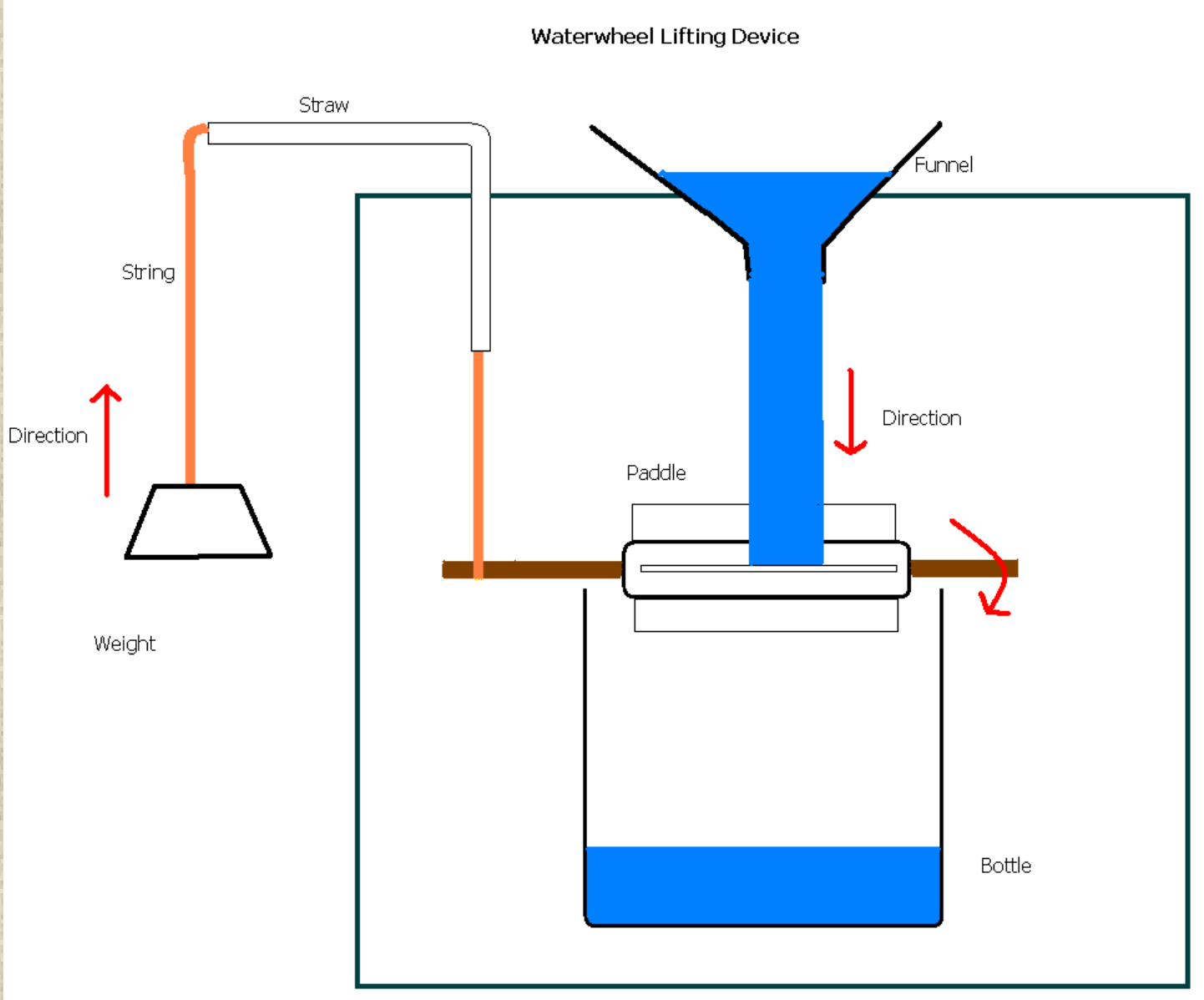
Video



Explanation

Main activity

Create a waterwheel



This is what your waterwheel should look like

Explanation

The waterwheel is working under the same principles as in the last activity. Gravity is pulling the water down on to the wheel. The kinetic energy is then passed to the wheel. The wheel turns and therefore turns the dowel too. This winds the string around the end of the dowel (wheel axle) and starts to lift the weight.

These kinds of devices were used for lifting in ancient times as they didn't have machines powered by electricity.

Plenary activity

Why do we need to use Hydroenergy?

- How effective do you think the waterwheel is?
- What other uses could it have?

Look at the picture of the Great Yarmouth paddleboat (Picture Norfolk, NP00014394)

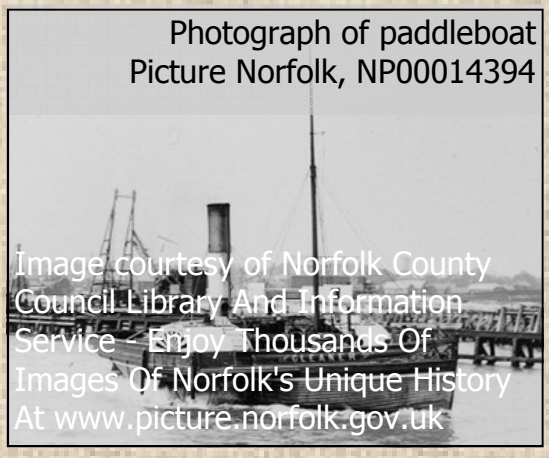
- Why might hydroenergy be better than petrol and fuel?
- Discuss renewable energy sources and see if you can classify your list from the beginning of the activity into renewable and non-renewable.

- Can you convert your wheel into wind power?

Try using a hair drier to power the device.

Documents you will need

Photograph of paddleboat
Picture Norfolk, NP00014394



How does a waterwheel work?

Friction: A force that slows down moving objects. When you rub your hands together they become hot due to the friction between them. Things that slide easily over one another have less friction. Ice is very slippery as there is less friction.

Hydroenergy: This is power created by water and tides. The kinetic energy of water can be collected, stored and used as other forms of power.

How does a pulley system work?

Introduction:

With the Boulton Water Elevator and waterwheels, a lot of effort is needed for the end task, whether it is powering the belt to lift the water or turning the grinding stones. Engineering can make these tasks easier by reducing the amount of effort you need to put in at the start whilst still getting out enough power. A typical waterwheel in a mill turns at 10 revolutions per minute but the runner stone (top one of the pair of grinding stones) used for grinding flour turns at 120 revolutions per minute. This is done with gears, by changing the size and number of teeth on a gear you can step up or down the number of turns. If the first gear has 50 teeth and the next gear has 25 then the speed is doubled. This way you can increase the speed of the runner stone without having to try to make the wheel work faster than practicable.

Pulleys are used for the belt system of the Boulton Water Elevator. You can also see a pulley system in the picture of men drilling for water (Picture Norfolk, NP00015820). Pulleys are wheels with raised edges so that a rope, chain or belt can fit inside. Pulleys are used to change the direction of a force, e.g. on a crane. In the picture of the men drilling they are trying to lift something. It would be incredibly hard to pull straight up so by using the pulley they can pull the rope towards them with more ease but with the same outcome. Pulleys can also be used in series to spread the amount of effort needed. If you run the rope over two pulleys the effort needed is spread across them so you do not need to pull as hard as you would have done if there were only one. Increase the pulleys to four and the weight is spread further and the effort reduced even more.

Click on an activity to start

Photograph of drilling for water
Picture Norfolk, NP00015820

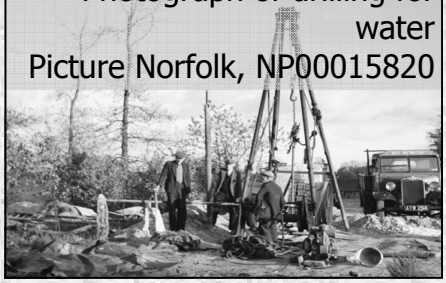
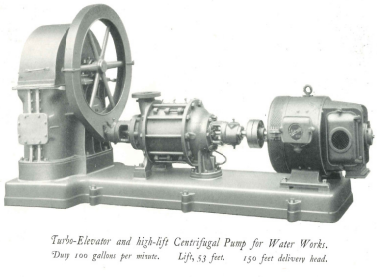


Image courtesy of North Walsham Historical Society and Norfolk County Council Library and Information Service - Enjoy thousands of images of Norfolk's unique history at www.picture.norfolk.gov.uk

Starter

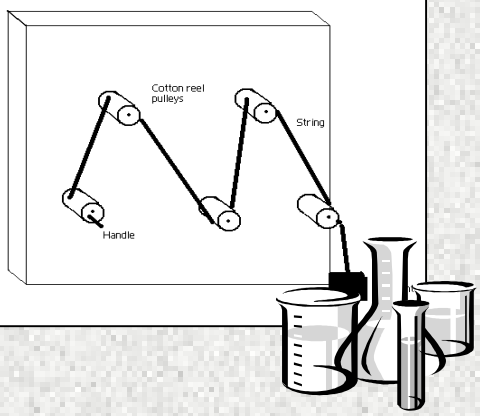
How can we change the speed of a wheel?



Turbo-Elevator and high-lift Centrifugal Pump for Water Works. Duty 100 gallons per minute. Lift, 53 feet. 150 feet delivery head.

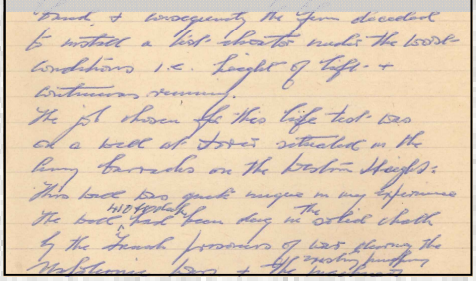
Main

Create a pulley system



Plenary

Which are 'good' and 'bad' forces on the pulley?



Go to Home

Starter activity

How can we change the speed of a wheel?

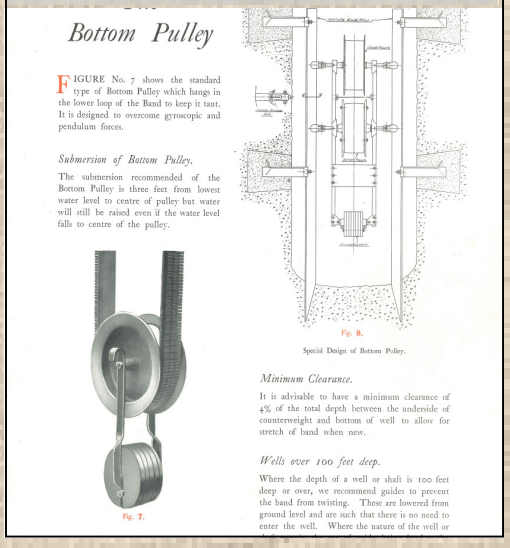
In pairs experiment with cog sets. Consider how to make the speed of the end wheel faster or slower than the start wheel by using a series of cogs/gears.

Look at the pictures of gears and the illustration of the pulley in the Boulton and Paul catalogue.

Documents you will need

Click on an image to see full size version

Pictures of gears and cogs in Boulton and Paul Catalogue NRO, MC 2046/1



Bottom Pulley

FIGURE No. 7 shows the standard type of Bottom Pulley which hangs in the lower loop of the Band to keep it taut. It is designed to overcome gyroscopic and pendulum forces.

Submersion of Bottom Pulley.

The submersion recommended of the Bottom Pulley is three feet from lowest water level to centre of pulley but water will still be raised even if the water level falls to centre of the pulley.

Fig. 7.

Fig. 8.

Special Design of Bottom Pulley.

Minimum Clearance.

It is advisable to have a minimum clearance of 4% of the total depth between the underside of counterweight and bottom of well to allow for stretch of band when new.

Wells over 100 feet deep.

Where the depth of a well or shaft is 100 feet deep or over, we recommend guides to prevent the band from twisting. These are lowered from ground level and are such that there is no need to enter the well. Where the nature of the well or

Main activity

Create a pulley system

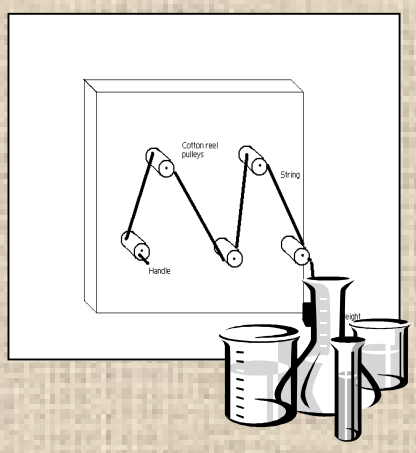
What you need:

- Box lid
- Wooden dowels (approx 7cm length)
- Cotton reels
- String
- Weight
- Pin
- Pressure sensitive tape
- Straw
- A reusable adhesive putty, such as Blu-Tack

Procedure

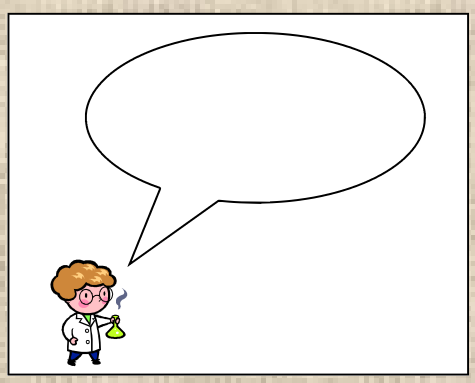
1. Fix the dowels on to the board at various points. The best orientation would be in two horizontal rows where the dowels are offset into a zigzag pattern.
2. Slide reels on to the dowels that you would like to use as pulleys.
3. On the left-hand reel, blue tack the straw on to the front to use as a handle.
4. Tape the string to the middle of the left-hand cotton reel.
5. Wind the string around the pulleys and until you get to the right-hand reel and tie the end to the weight.
6. Using the handle start to wind up the string and see whether the weight lifts.

Click on the links below to find out more



Diagram

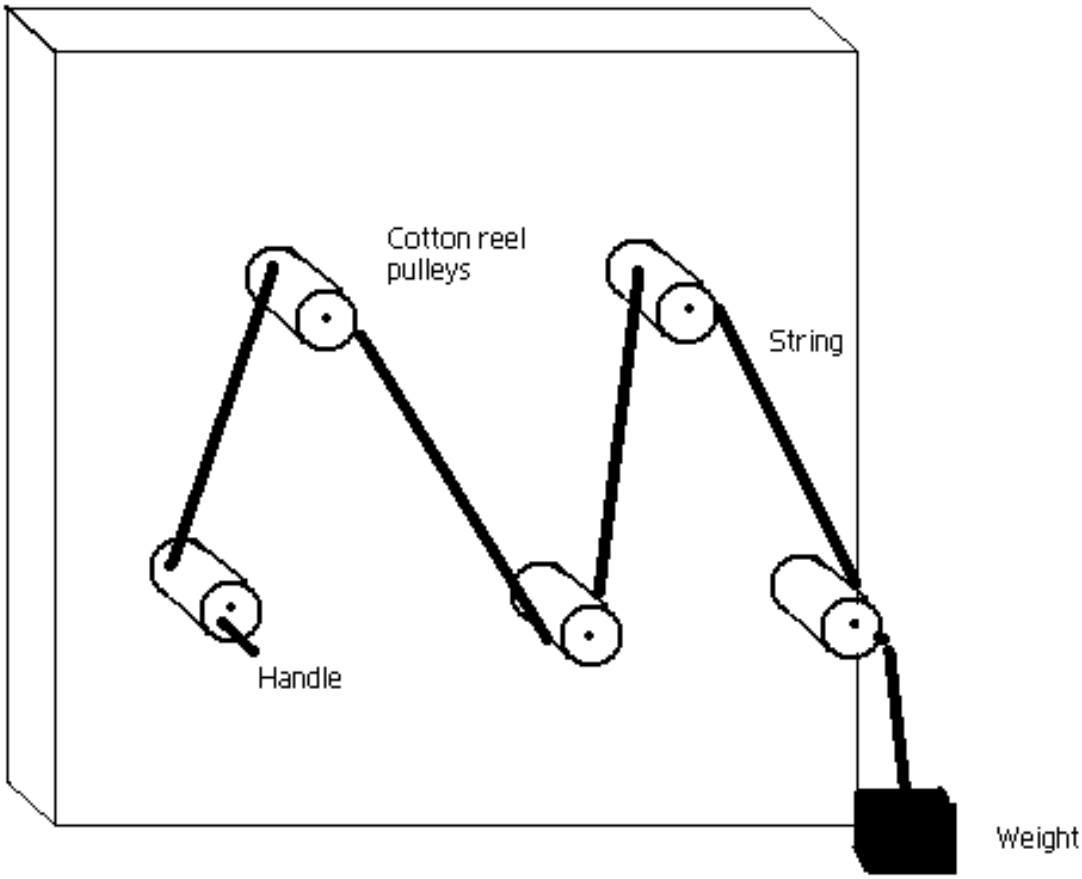
Video



Explanation

Main activity

Create a pulley system



Your pulley should look something like this!

Explanation

Pulley systems have been used throughout history to make lifting objects easier and to transmit power. Pulleys work by decreasing the amount of effort that has to go into the system to lift the object. The more pulleys there are the less the effort that is needed to get the same result.

Differing sizes of pulleys also give you a mechanical advantage. Imagine you are turning a pulley or cog which leads to a cog or pulley half its size. One revolution of the first cog would result in two revolutions of the second. You have therefore increased the speed.

Plenary activity

Which are 'good' and 'bad' forces on the pulley?

Look at page 13 of the Boulton and Paul catalogue. This page shows the bottom pulley of the belt.

- Why does it need the bottom wheel attached?
- What would the pendulum forces do?
- Look up this term and discuss why you would need to make sure this does not happen to the bottom pulley. How might the pulley help stop this?

Note that the orientation of the Caruelle Belt is important so the surface tension of the water is not broken. When the band bends at the top and bottom the surface tension is overcome and the water spills out (or is allowed in). It would also be detrimental to the equipment if the Belt were to swing and hit the sides of the shaft.

Think about the safety aspects of these machines. The Boulton and Paul catalogue mentions how it is a benefit of the elevator that people do not need to go down the well to install it.

Read William Baldeston's account of going down into the test well (NRO, MC 2046/1/1) and his daughter's letter about the time the cage he was in nearly fell (NRO, MC 2046/1/2).

- What safety precautions would you need to take when working with the water elevator and when near watermills?

Documents you will need

Click on an image to see full size version

Boulton and Paul Catalogue
Page 13
NRO, MC 2046/1

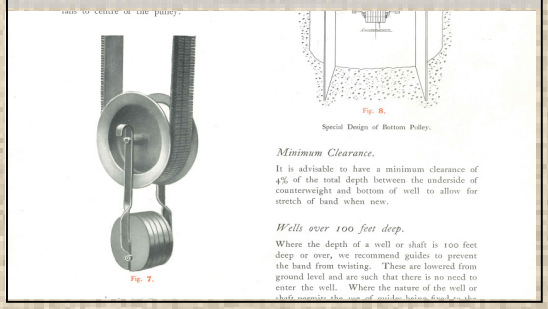


Fig. 8.

Special Design of Bottom Pulley.

Minimum Clearance.

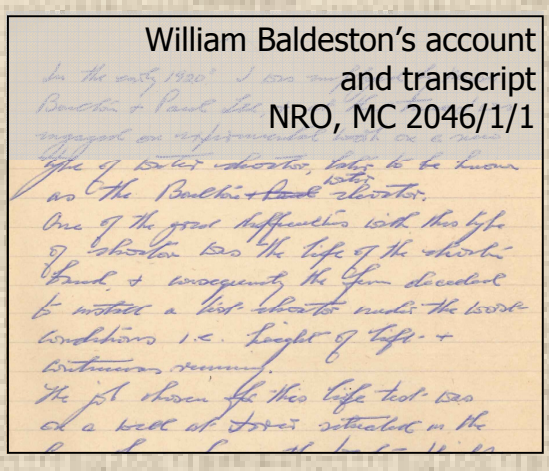
It is advisable to have a minimum clearance of 4% of the total depth between the underside of counterweight and bottom of well to allow for stretch of band when new.

Wells over 100 feet deep.

Where the depth of a well or shaft is 100 feet deep or over, we recommend guides to prevent the band from twisting. These are lowered from ground level and are such that there is no need to enter the well. Where the nature of the well or

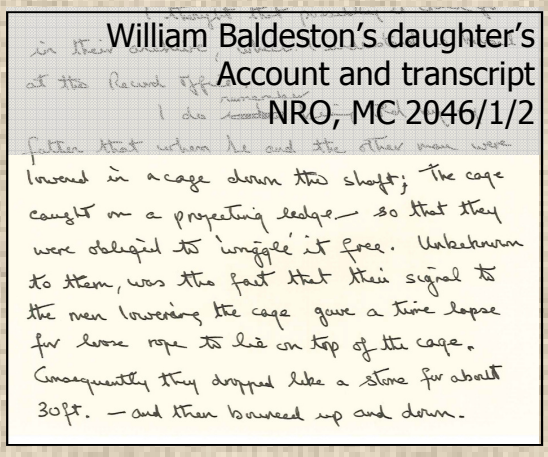
Fig. 7.

William Baldeston's account and transcript
NRO, MC 2046/1/1



In the early 1920's I was ... Boulton & Paul Ltd ... engaged on experimental work on a ... type of bucket elevator, today to be known as the Boulton & Paul elevator. One of the great difficulties with this type of elevator was the life of the chain & consequently the firm decided to install a test elevator under the worst conditions i.e. height of lift & continuous running. The pit chosen for this test was ... a well of 30 feet situated in the

William Baldeston's daughter's Account and transcript
NRO, MC 2046/1/2



... at the Record Office ... I do ... father that when he and the other man were lowered in a cage down the shaft; the cage caught on a projecting ledge — so that they were obliged to 'wiggle' it free. Unbeknown to them, was the fact that their signal to the men lowering the cage gave a time lapse for loose rope to lie on top of the cage. Consequently they dropped like a stone for about 30ft. — and then bounced up and down.

How does a pulley system work?

Glossary

Pulley: A wheel on an axle that supports movement or is used to lift. Can be used in a sequence to increase mechanical advantage.

Pendulum force: A pendulum is a weight suspended from a fixed point which can hang freely. If the weight is pushed off centre it will accelerate back in an arc towards the bottom, directly beneath the fixed point (pivot). It will then carry on past the pivot, and travel in an arc the other way. It will carry on like this moving backwards and forwards. If there is no loss of energy then this movement can carry on happening.

The distinct difference between the ancient type already referred to and the "Boulton" method, is that whereas the former uses a closed bottom receptacle or positive lift for raising the water, the "Boulton" makes use of surface tension, in a series of open-ended cells attached in a continuous line on an endless band. The fact that the cells are open-ended allows them to be easily filled when passing through water at a high speed, so enabling water to be raised in small quantities spread over the whole length of the uptravelling band.

The Band is the invention of a Frenchman, Monsieur Caruelle, and it is patented throughout the world. In all countries under British influence it is known as the "Boulton" Band.

During the past few years a great many scientific and practical experiments have been made, and there have been many very successful installations, including Public Water Supplies, Drainage Schemes, etc., and hundreds of installations were used on the battlefields of France for supplying water to troops during the Great War, when some miles of the Caruelle band were supplied and were in constant hard use, proving the utility of the system. The data collected, coupled with our own experience in surface tension liquid elevators, and continual laboratory and physical experiments, have enabled us to perfect and produce a Water Elevator of very high efficiency, and one which we can offer with complete confidence for all classes of commercial duty.

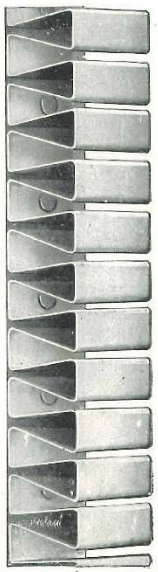


Fig. 1.

The illustration, Fig. 1, shows the formation of the Caruelle Cells, which are made in a continuous line or lines on the driving band. These cells are scientifically shaped and proportioned to give a high volumetric efficiency, and are such as will allow the water freely to enter the cells while passing through the water, and will release it at the required time.

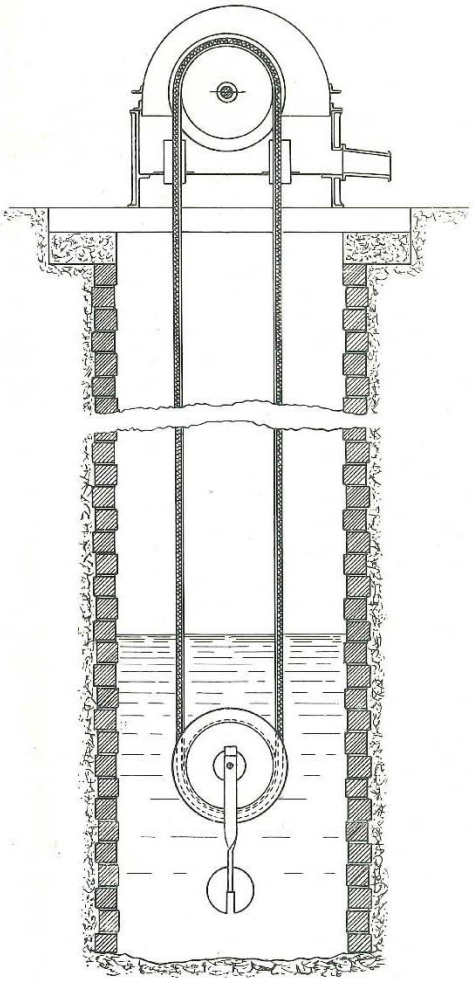


Fig. 2.

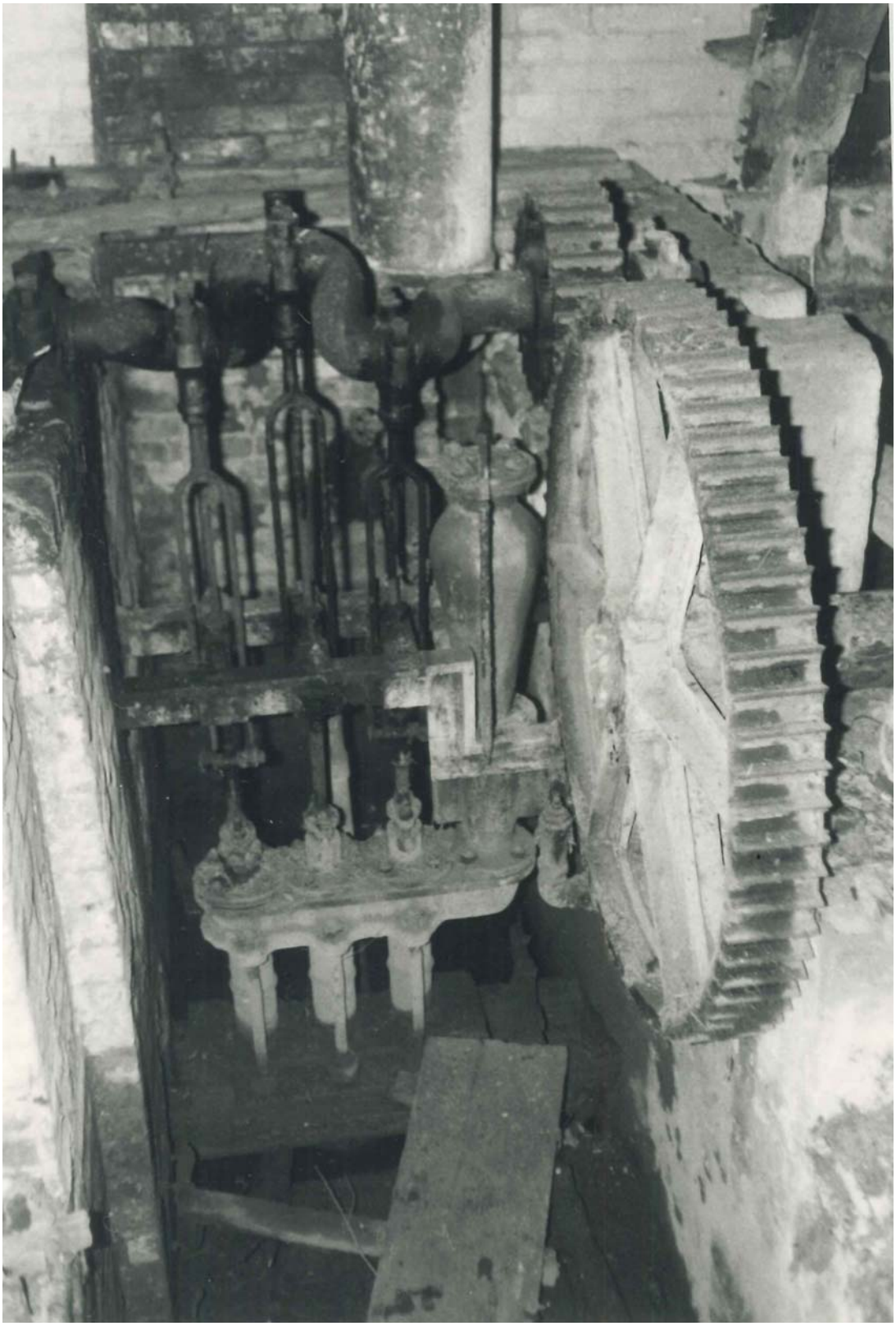
A most interesting and curious feature of Caruelle Element is that water will remain in, and does not fall out, while the direction of the Band is in a vertical line, even though it is stationary.

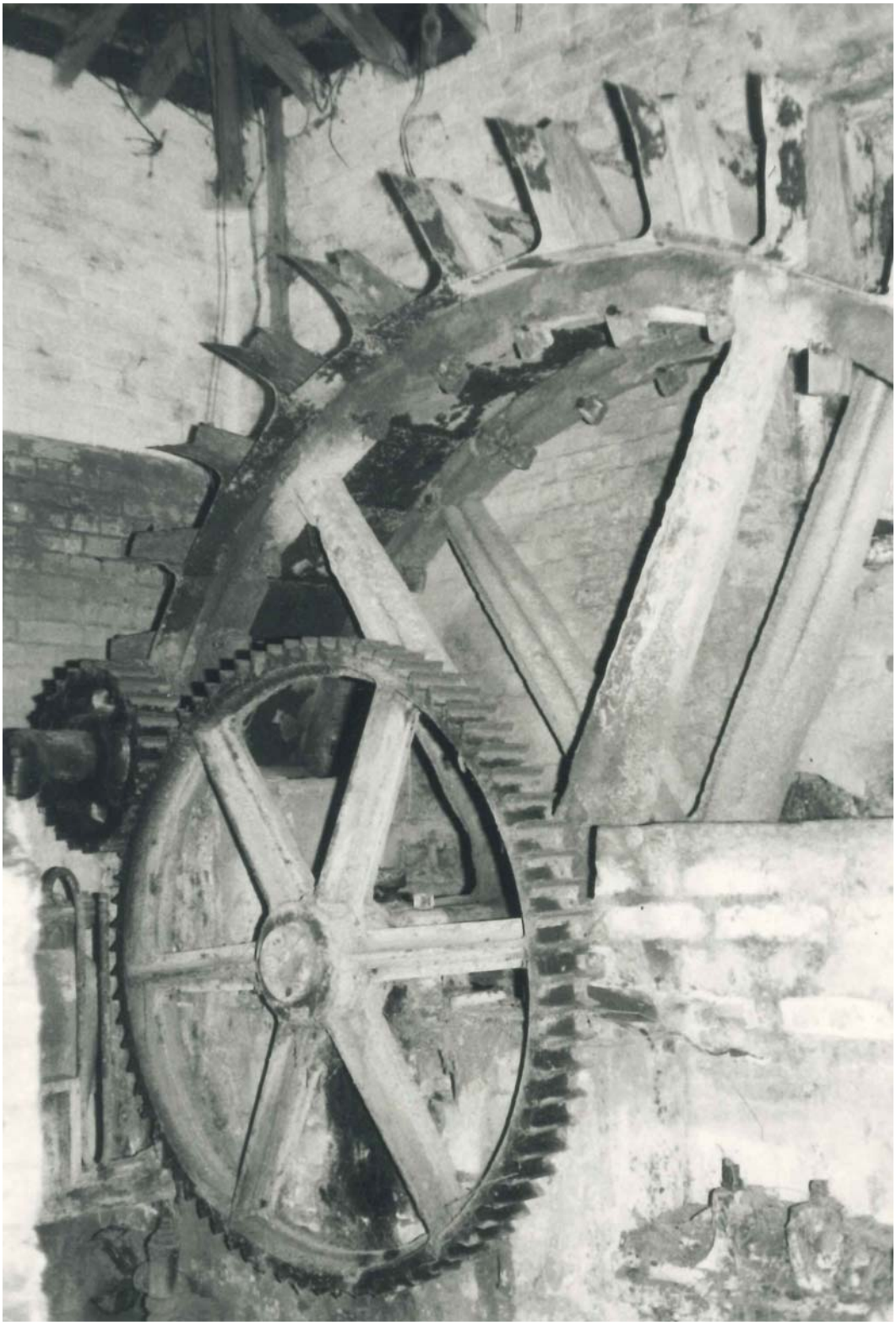
The Elevator head, Fig. 2, consists of a pulley carried on a shaft and bearings, surrounded by a tank, through two holes in the bottom of which the up and down sides of the Bands pass, and

Back to *What is a Water Elevator?*

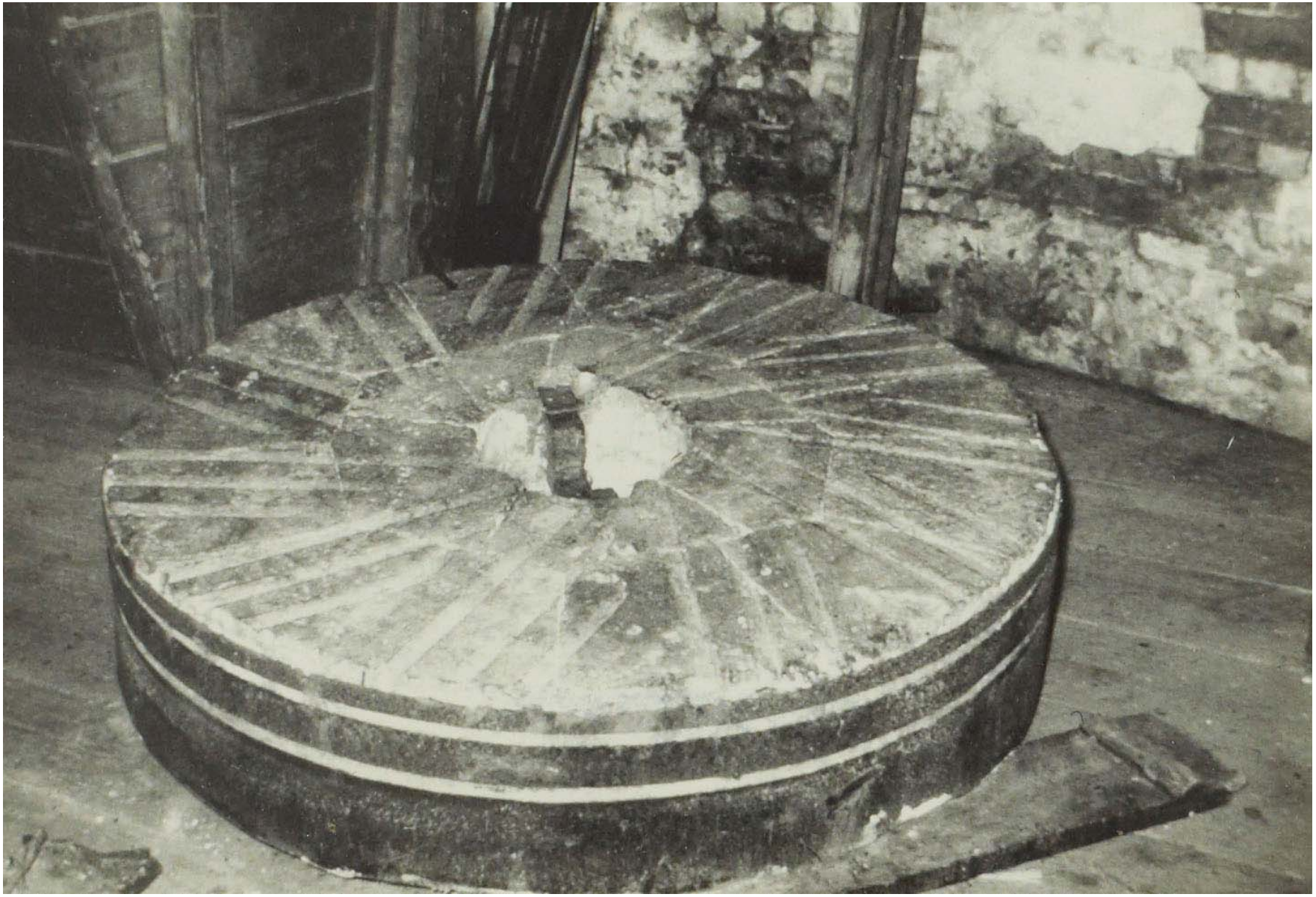
Image courtesy of NORFOLK COUNTY COUNCIL LIBRARY AND INFORMATION SERVICE - ENJOY THOUSANDS OF IMAGES OF NORFOLK'S UNIQUE HISTORY AT www.picture.norfolk.gov.uk

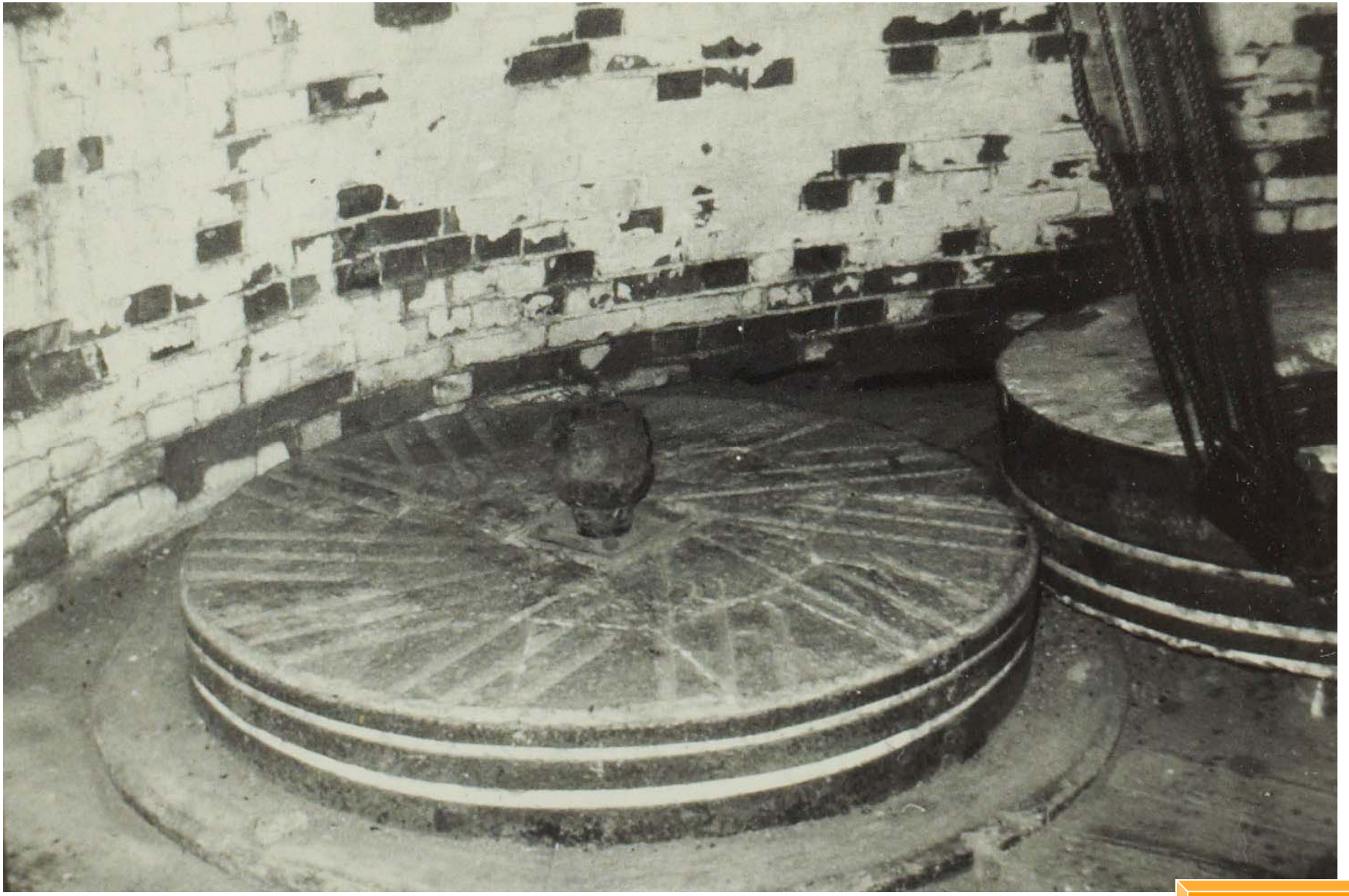
Back to *How can we use water for power?*





Back to *How can we use water for power?*





Back to *How can we use water for power?*

Back to *How does a waterwheel work?*

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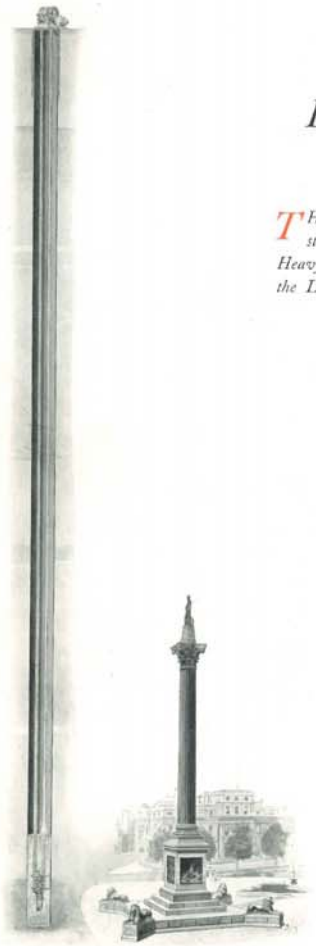
Back to *How does a waterwheel work?*

Image courtesy of North Walsham Historical Society NORFOLK COUNTY COUNCIL LIBRARY AND INFORMATION SERVICE - ENJOY THOUSANDS OF IMAGES OF NORFOLK'S UNIQUE HISTORY AT www.picture.norfolk.gov.uk

Back to *How does a pulley system work?*



A Lift of 410 Feet

THIS Illustration represents an actual installation consisting of an Electrically Driven Heavy Duty "Boulton" Water Elevator and shows the Lift by comparison with Nelson's Monument.

Capacity		3400 gallons per hour
Lift	... ...	410 feet
Overall Efficiency	...	59%

The Plant is operated by a float switch and is entirely automatic.

Average running 18 hours per day

The Bottom Pulley

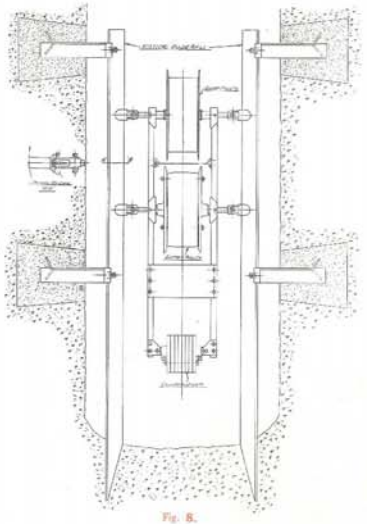
FIGURE No. 7 shows the standard type of Bottom Pulley which hangs in the lower loop of the Band to keep it taut. It is designed to overcome gyroscopic and pendulum forces.

Submersion of Bottom Pulley.

The submersion recommended of the Bottom Pulley is three feet from lowest water level to centre of pulley but water will still be raised even if the water level falls to centre of the pulley.

Fig. 7.

Standard Type of Bottom Pulley.



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Special Design of Bottom Pulley.

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Wells over 100 feet deep.

Where the depth of a well or shaft is 100 feet deep or over, we recommend guides to prevent the band from twisting. These are lowered from ground level and are such that there is no need to enter the well. Where the nature of the well or shaft permits the use of guides being fixed to the sides, figure No. 8 shows the method adopted.

Back to *How does a pulley system work?*

In the early 1920's I was employed by Messrs Boulton & Paul Ltd, & at that time I was engaged on experimental work on a new type of water elevator, later to be known as the Boulton & Paul water elevator.

One of the great difficulties with this type of elevator was the life of the chain band, & consequently the firm decided to install a test elevator under the load conditions i.e. height of lift & continuous running.

The site chosen for this life test was at a well at Dover situated in the Army barracks on the Western Heights. This hole was quite unique in my experience the bottom 410 feet being in the solid chalk by the French prisoners of war during the Napoleonic wars, & the machinery must have been one of the oldest in the country. The pump with a stroke of about 4 feet, had a beam working over

1

3 tons + 10 cwt drawn by an ordinary single cylinder steam engine, with the usual Buffers on the track plate.
The best arrangement here was ideal for our purpose, because when the well was dug a second shaft was sunk about 30 feet away with a gallery joining the two shafts at the bottom, thus ensuring a natural draught + clean air.
This shaft was empty + was ideal for our purpose, if it was plumb, so that the skip could hang clear with no fear of hitting the sides of well.
Plumbing this shaft was quite an adventure. A cage was constructed of 2" & 1½" boards + iron rods as per sketch + was suspended over the shaft, by an arrangement of pulleys controlled by a Hand winch in the engine room, which required a team of 4 men to work it.

An ^crude^ arrangement of bell wire was used to operate a set of signals to the winch men
i.e. 1 Stop ~~Bask~~ away 2 Lower away 3 pull up.
An old engineer named [illegible] who had worked on the pumps here for many years was my assistant.
[illegible] be put in the cage on our plumbing expedition + all went well until we were 200 feet

In the early 1920s I was employed by Messers Boulton and Paul Ltd and at that time I was engaged on experimental work on a new type of water elevator, later to be known as The Boulton water elevator.
One of the great difficulties with this type of elevator was the life of the elevator band and consequently the firm decided to install a test elevator under the worst conditions i.e. height of lift and continuous running.
The job chosen for this life test was on a well at Dover situated in the Army barracks on the Western Heights.
This well was quite unique in my experience.
The well [410 ft deep] had been dug in the solid chalk by the French prisoners of war during the Napoleonic Wars and the [existing pumping] machinery must have been of the oldest in the country. The pump with a strike of about 4 feet, had a beam weighing over

3 tons and was drawn by an ancient single cylinder steam engine, with the word Betton on the bedplate.
The well arrangement here was ideal for our purpose, because where the well was dug a second shaft was sunk about 30 feet away with a gulley joining the two shafts at the bottom, thus ensuring a natural drahght and clear air.
This shaft was empty and was ideal for our purpose, as it was plumb, so that the shorter band would hang clear with no fear of hitting the sides of well.
Plumbing this shaft was quite an adventure

a cage was constructed of 1 ¾ boards and iron rods as per sketch and was suspended over the shaft, by an arrangement of pedles controlled by a hand winch in the engine room. Which required a team of 4 men to work it.

An crude arrangement of bell wire was used to operate a set of signals to the winch men.
i.e. 1 [stationary], 2 lower away, 3 pull up
An old engineer named West who had worked on the pump here for many years was my assistant.
Down we went in the cage on our plumbing expedition and all went well until we were 200 feet.

Back to *How does a pulley system work?*

Clearing out old papers I came across this report that my father William Balderston wrote about some work that he did at Dover Castle in the 1920's when he worked for Boulton & Paul.

I thought that possibly it could go in their archive, which I understand is housed at the Record Office.

I do remember being told by my father that when he and the other man were lowered in a cage down the shaft; the cage caught on a projecting ledge — so that they were obliged to 'wiggle' it free. Unbeknown to them, was the fact that their signal to the men lowering the cage gave a time lapse for loose rope to lie on top of the cage. Consequently they dropped like a stone for about 30ft. — and then bounced up and down.

He told me they were rather sick!
Possibly this letter could go with his account.
He always seemed to like courting danger,
although he seemed such a quiet man.
Having gone all through the first war, at the
age of 45. he rejoined the 1939 army
— as a bomb disposal officer.!!

Yours sincerely

Janet Howard
nee Balderston

Clearing out old papers I came across
this report that my father William Balderston
wrote about some work that he did at Dover Castle
in the 1920s. When he worked for Boulton and Paul.
I thought that possibly it could go
in their archive, which I understand is house
at the Record Office.
I do remember being told by my
father that when he and the other men were
lowered in a case down the shaft; the cage
caught on a projecting ledge - so that they
were obliged to ‘wriggle’ it free. Unbeknown
to them, was the fact that their signal to
the men lowering the cage gave a time lapse
for loose rope to lie on top of the cage.
Consequently they dropped like a stone for about
30ft. – and then bounced up and down.
He told me they were rather sick!
Possibly this letter could go with his account.
He always seemed to like courting danger,
although he seemed such a quiet man.
Having gone all through the first war, at the
age of 45 he rejoined the 1939 army
- as a bomb disposal officer!!

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