a boiler
a piston
a design
a centre
a movement
a minute
a year

coal
steam

invent
pump
enter
force
condense
decrease
complete

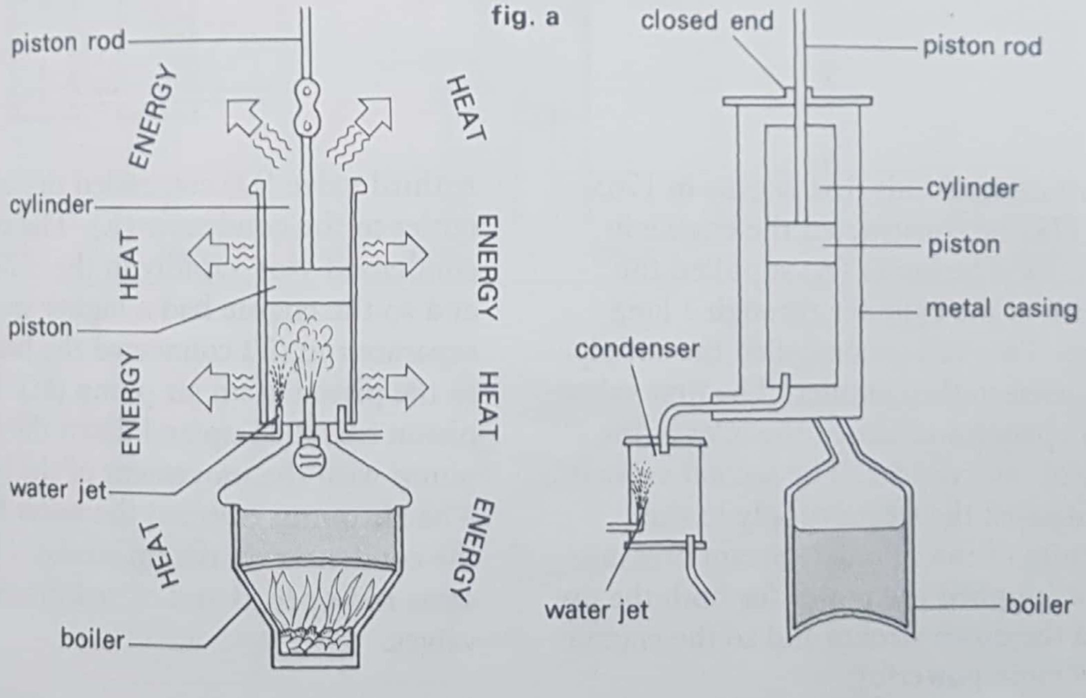
similar
complex
early
late(r)
powerful
slow

up
down

(the) top of . . . .
nowadays

SECTION B: WATT'S ENGINES

fig. a

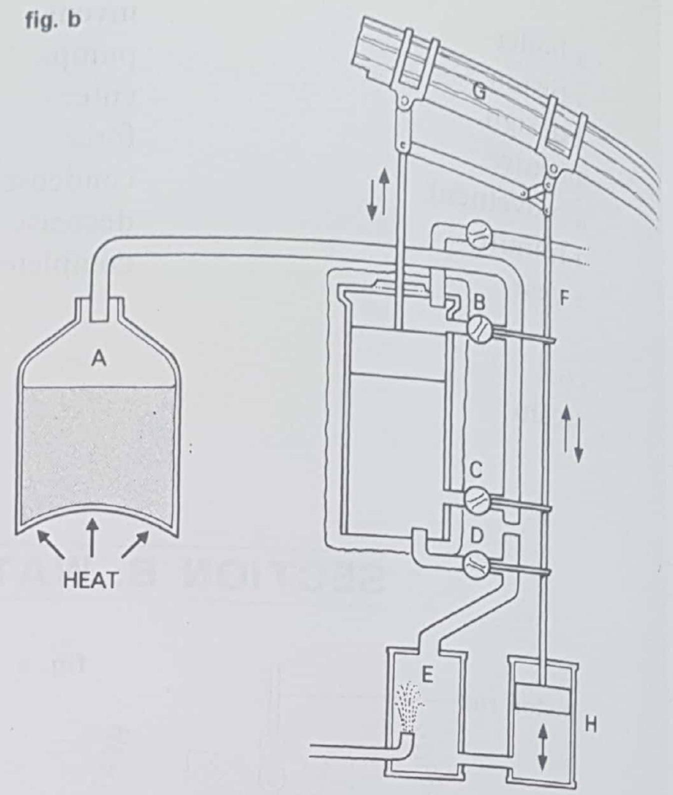


NEWCOMEN (1712) WATT (1765)

In Newcomen's engine, the steam heated the cylinder and then the condensing water cooled it. Therefore heat energy escaped and the engine was not very efficient. In his engine, Watt fitted a steam jacket around the cylinder and so the cylinder remained hot. He also fitted a separate condenser to avoid spraying water into the cylinder.

In Newcomen's engine, a water jet condensed the steam inside the cylinder and so the temperature inside the cylinder went up and down over a wide range. Therefore a large amount of steam was used for raising the cylinder temperature at each up stroke. Watt fitted a separate condenser to his engines. Thus it was possible to condense the steam outside the cylinder and so the cylinder remained at a steady temperature.

fig. b



Watt designed his first engine in 1765. In 1787 he constructed the engine in fig. (b). The boiler (A) supplied the steam to the cylinder through a long pipe. Two valves controlled the supply of steam to the cylinder. The first valve (B) opened and closed the inlet at the top of the cylinder. The second valve (C) controlled the steam supply to the bottom of the cylinder. Steam pressure now supplied the power for both the up and the down strokes and so the engine was more powerful.

A third valve (D) controlled the steam outlet to the condenser (E). The steam condensed very rapidly in the condenser and so the engine had a higher speed. A separate rod (F) connected the beam (G) to the piston of an air pump (H). This piston travelled up and down the air pump with the movement of the beam. The air pump emptied the water from the condenser on the up stroke. The same rod opened and closed the three valves.

This engine had an efficiency of about 4%. It was about four times as efficient as Newcomen's engine and so it used only 25% as much fuel.

Exercise 5 Answer these questions.

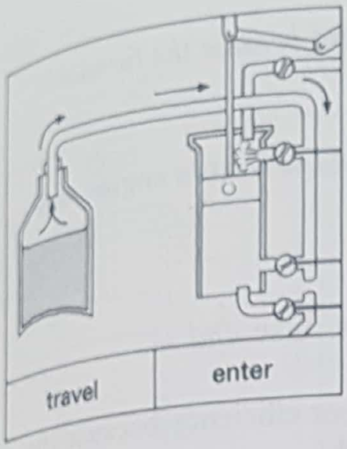
Newcomen's Engine

1. How did heat energy escape from the engine and decrease its efficiency?

Watt's Engines

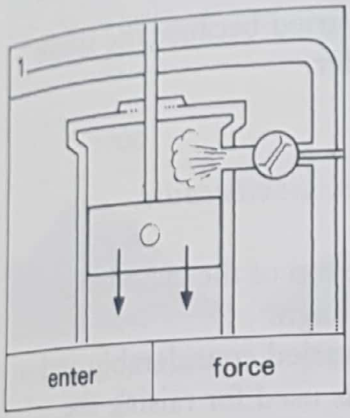
2. How did Watt improve the design of steam engines? (*Two answers.*)
3. How did Watt control the steam supply to the cylinder?
4. How did he make his engines more powerful?
5. How did the beam control the air pump?
6. How did the beam open and close the three valves?

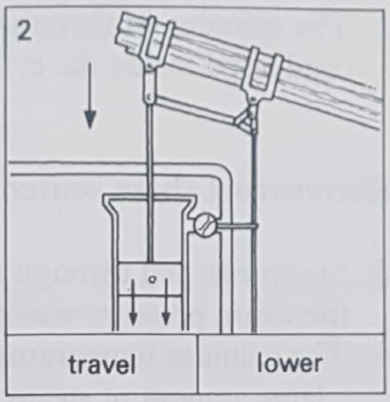
Exercise 6 Look at this example.

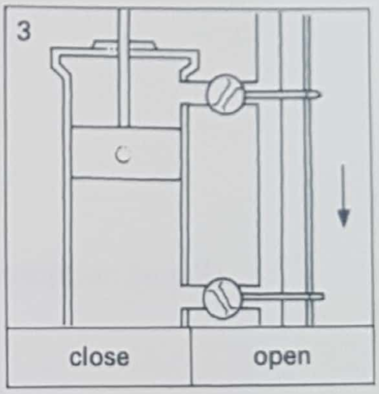


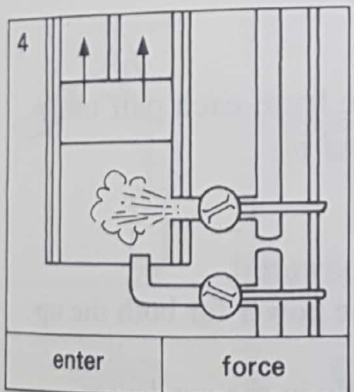
The steam *travelled* through a pipe and *entered* the cylinder.

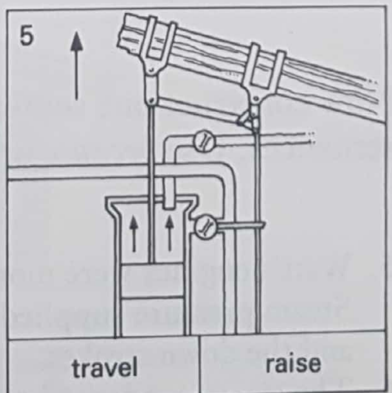
Now make a sentence about each picture in the same way.

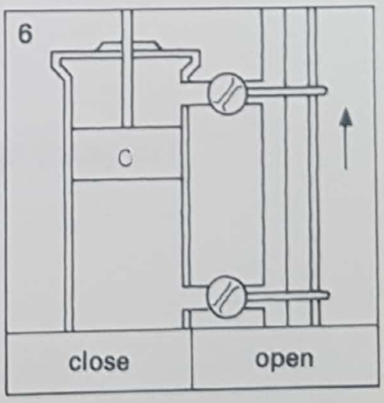


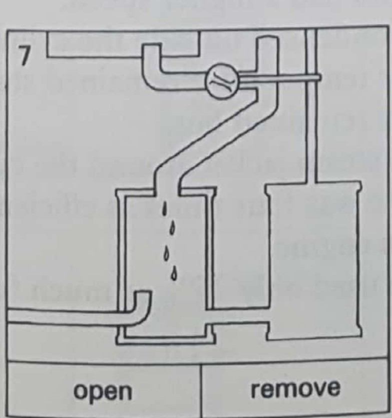


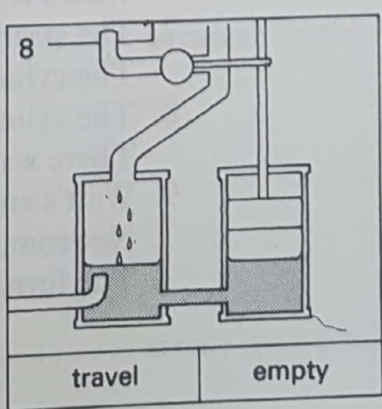












Exercise 7 Read the examples below.

Watt's engine was more efficient *because the furnace required less fuel.*

The furnace required less fuel and so Watt's engine was more efficient.

Reconstruct these sentences. Use *and so.*

1. Newcomen's engine had poor efficiency because the cylinder temperature varied.
2. The cylinder temperature varied because the steam condensed inside the cylinder.

Reconstruct these sentences. Use *because.*

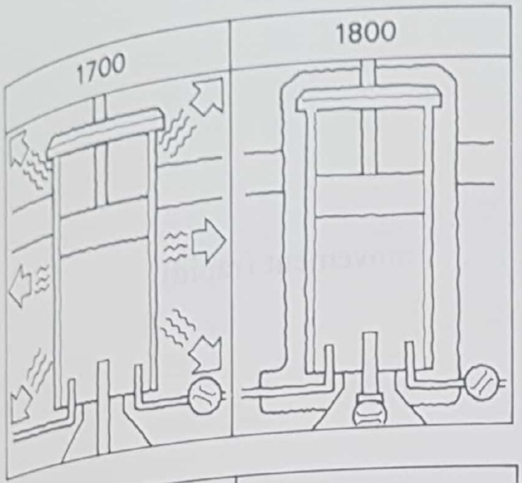
3. Steam escaped through the top of the cylinder and so the steam pressure was not high.
4. The cylinder temperature varied considerably and so a large amount of steam was used for raising the cylinder temperature.

Now construct one sentence from each pair of sentences. Use *because* or *and so.*

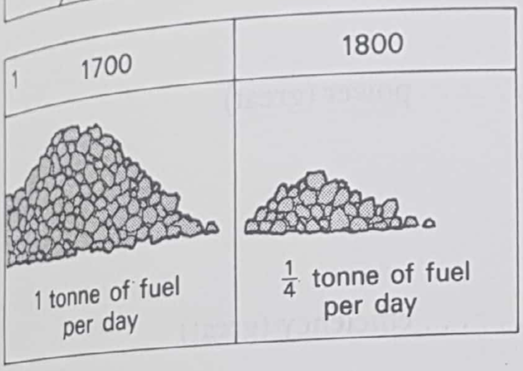
5. Watt's engines were more powerful.
   Steam pressure supplied the power for both the up and the down strokes.
6. The steam condensed rapidly in the condenser.
   Watt's engines had a higher speed.
7. The steam condensed outside the cylinder.
   The cylinder temperature remained stable.
8. The cylinder remained hot.
   There was a steam jacket around the cylinder.
9. Watt's engine was four times as efficient as Newcomen's engine.
   The furnace used only 25% as much fuel.

Exercise 8 How did steam engines change between 1700 and 1800? How did they improve?

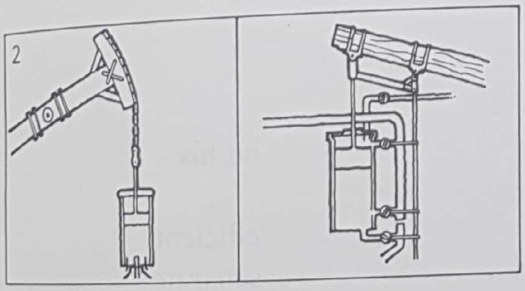
Look at the example.



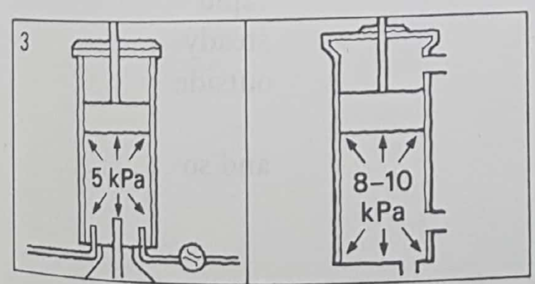
.... loss (small)
The <u>heat</u> loss was <u>smaller</u>. The <u>loss</u> of heat was <u>smaller</u>.



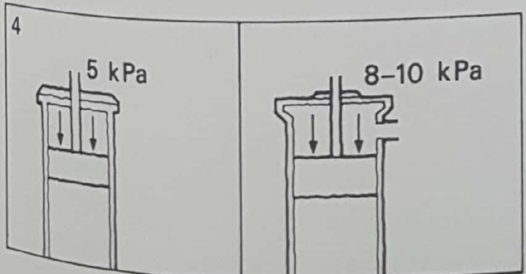
. . . . consumption (small)



. . . . design (complex)

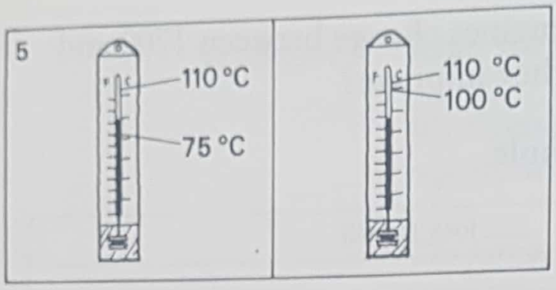


. . . . pressure (high)



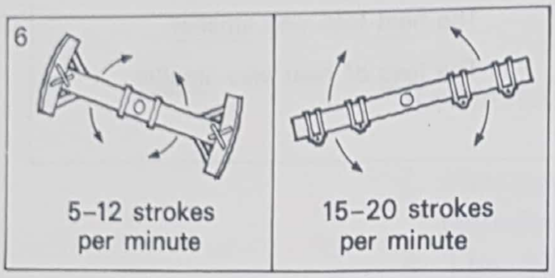
. . . . stroke (powerful)

5



.... temperature (stable)

6



.... movement (rapid)

7

750 W – 3 kW	6 kW – 8 kW

.... power (great)

8

1%	4%

.... efficiency (great)

a supply
a day
a date
an invention

a pump
a condenser
an inlet
an outlet
a loss

energy
efficiency
consumption

improve
vary
design
construct
supply
control
empty

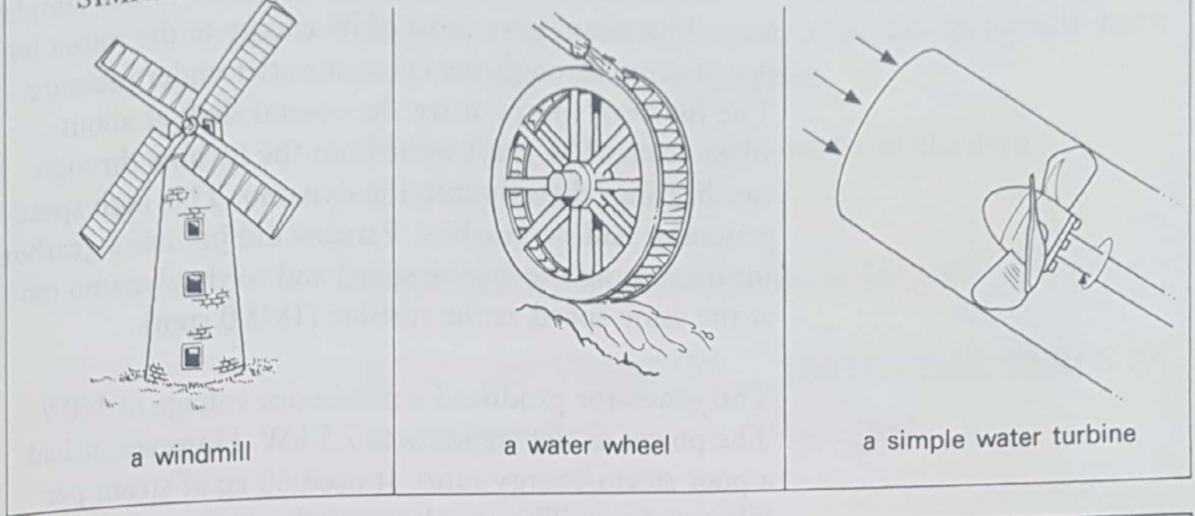
he/his

efficient
separate
rapid
steady
outside

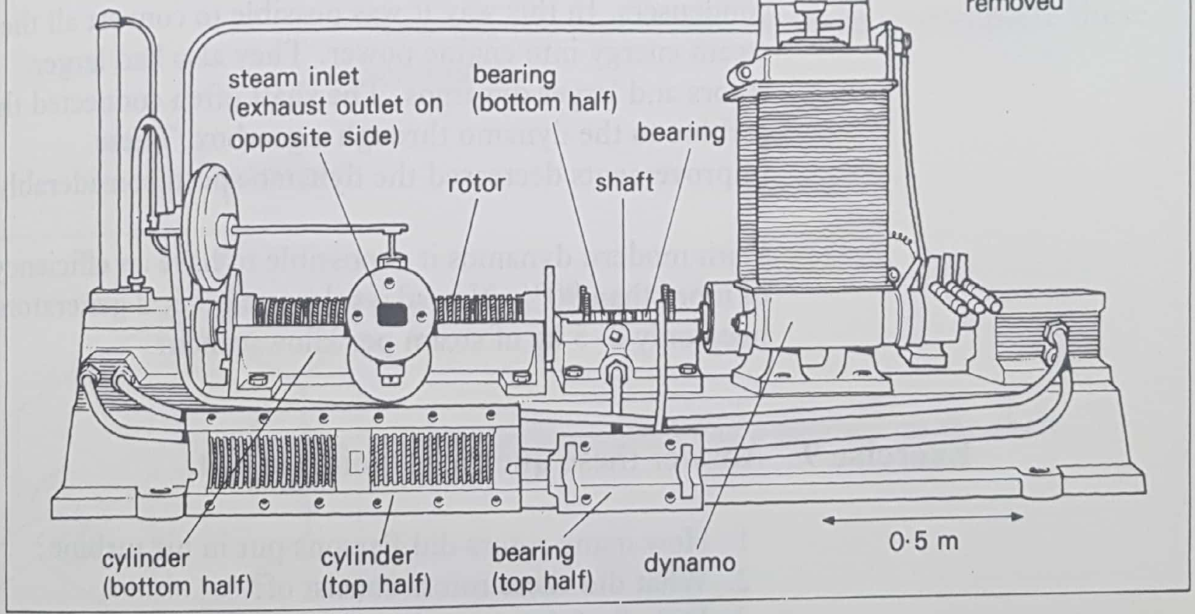
and so ....

SECTION C: PARSONS' TURBINE

SIMPLE TURBINES



PARSONS' STEAM TURBINE AND DYNAMO 1884
Science Museum, London



In Parsons' turbine, the boiler supplied the steam at a pressure of 550 kPa. The steam entered the engine casing at high speed. It then expanded rapidly in opposite directions along two cylinders. Parsons put seven rotors in each cylinder. These rotors consisted of thick metal rings around a central shaft. He cut slots at an angle of 45° in the rings. The slots sloped in opposite directions in the two cylinders.

The steam forced its way along the cylinders from the central steam inlet and travelled through the slots.

It pushed against the slot walls and turned all the rotors in the same direction.

Steam pressure became mechanical power in this simple way. The steam gave most of its energy to the rotors but it still came through the exhaust outlet under pressure. The fourteen rotors drove the central shaft at about 18 000 rpm. The shaft went from the turbine through two bearings directly into the dynamo. This high speed generator had no gearbox. Parsons did not use a gearbox for decreasing the engine speed and so the dynamo ran at the same speed as the turbine (18 000 rpm).

The generator produced a maximum voltage of 100 V. The power of the engine was 7.5 kW. However, it had a poor steam/energy ratio. It used 60 kg of steam per kilowatt hour. This was because the engine speed was too high and because the exhaust steam escaped directly into the atmosphere under pressure. Later turbines had steam condensers. In this way it was possible to convert all the steam energy into engine power. They also had larger rotors and larger dynamos. The shaft often connected the turbine to the dynamo through a gearbox. These improvements decreased the dynamo speed considerably.

With modern dynamos it is possible to have an efficiency of more than 90%. Nowadays, large electrical generators need only 2–5 kg of steam per kilowatt hour.

Exercise 9 Answer these questions from the text.

1. How many rotors did Parsons put in his turbine?
2. What did these rotors consist of?
3. Did all of the rotor slots slope at the same angle?
4. Did all of the rotors slope in the same direction?
5. What was the engine speed of Parsons' generator?
6. How did the steam turn the rotors?
7. Did the steam give all of its energy to the rotors?
8. How did the turbine drive the dynamo?
9. What voltage did Parsons' generator produce?
10. Why did the generator have a poor steam/energy ratio? (*Two answers*)
11. How did later designers improve the efficiency of steam generators? (*Two answers*)
12. What is the maximum efficiency of modern generators?

Exercise 10 Read the first three paragraphs of the text again.

'In Parsons' turbine . . . . (18 000 rpm).'
The paragraphs contain ten *regular verbs* and nine *irregular verbs*. Irregular verbs do not generally have '*-ed*' endings in the past tense.

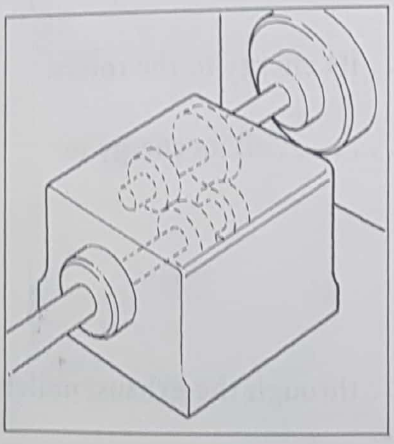
Make a list of the nineteen verbs in the two columns below.

One of each type has been done for you.

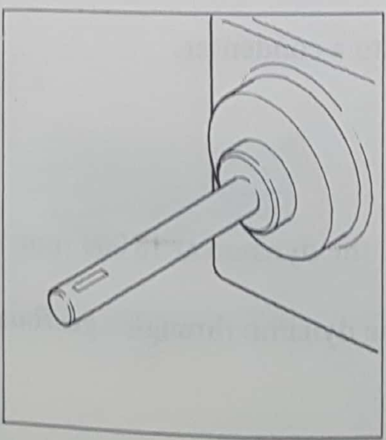
REGULAR VERBS (10)	IRREGULAR VERBS (9)
supply (supplied)	have (had)
. . . .	. . . .
. . . .	. . . .
. . . .	. . . .

Now use the nine irregular verbs to complete these sentences.

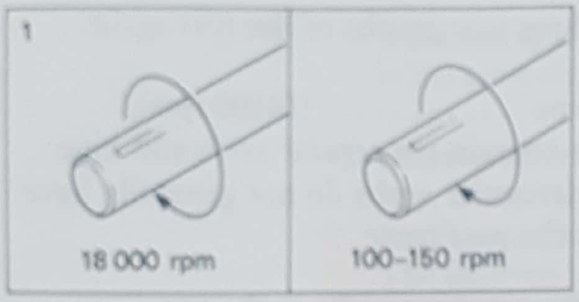
Example:



Later turbines often *had* a gearbox on the shaft.

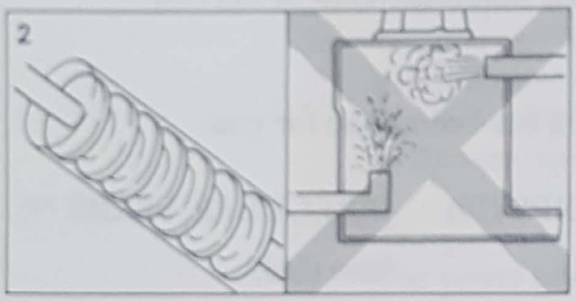


Parsons' turbine *did not have* a gearbox.



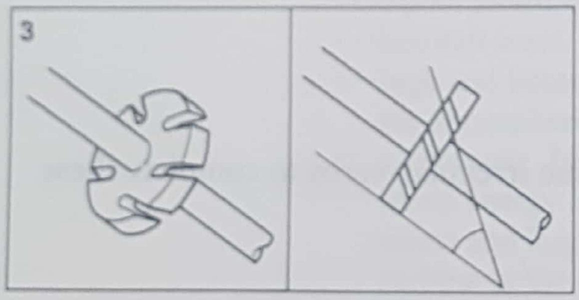
Parsons' turbine . . . . at very high speed.

Piston steam engines . . . . at high spe



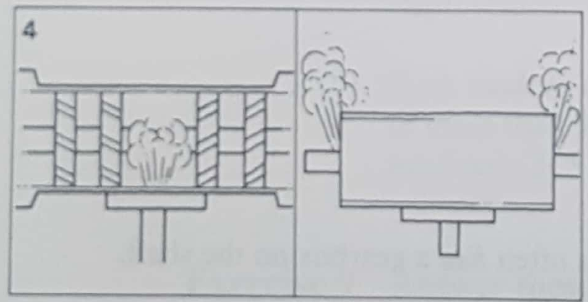
Parsons . . . . seven rotors in each cylinder.

He . . . . a condenser in his turbine.



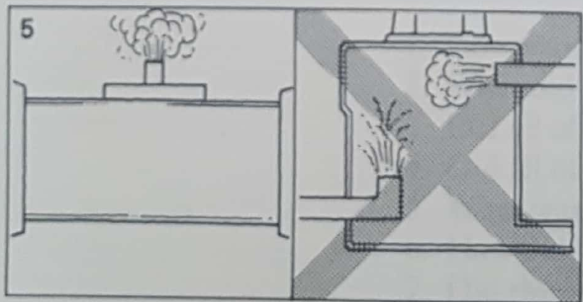
He . . . . slots in the outside of the rotors.

He . . . . the slots parallel to the shaft.



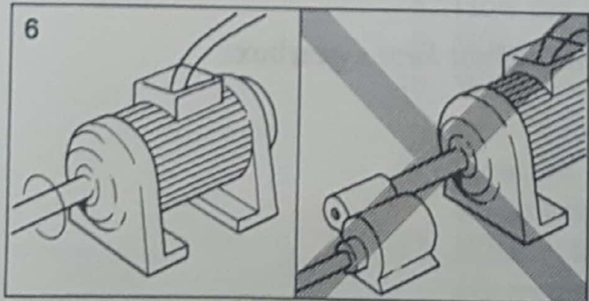
The steam . . . . its energy to the rotors.

However, it . . . . all its energy to the rotors.



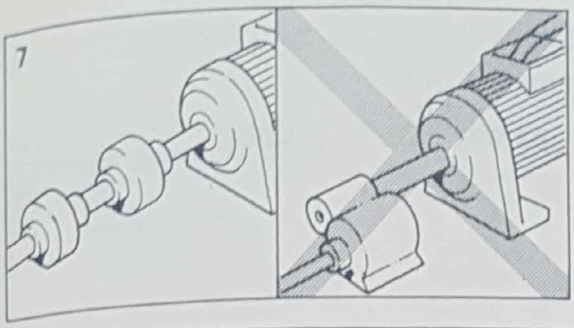
The steam . . . . through the exhaust outlet under pressure.

It . . . . into a condenser.



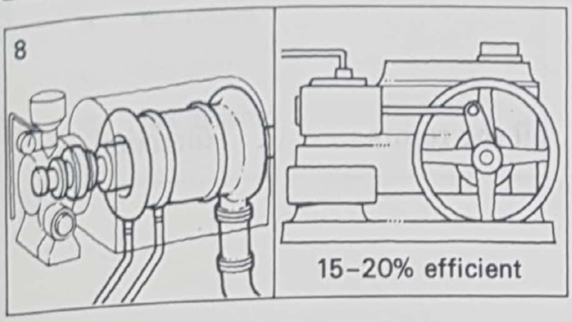
The shaft . . . . the dynamo at 18 000 rpm.

It . . . . the dynamo through a gearbox.



The shaft . . . . from the turbine to the dynamo through two bearings.

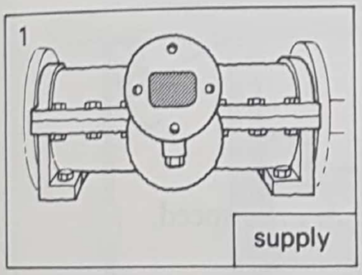
It . . . . through a gearbox.



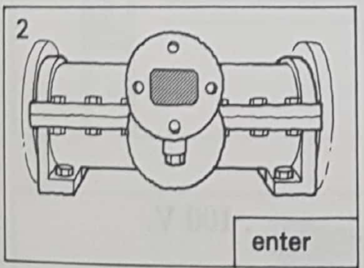
Later turbines . . . . much more efficient.

Piston steam engines . . . . more than 15–20% efficient.

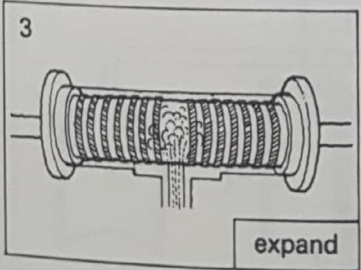
Exercise 11 Complete these sentences and describe how Parsons' turbine worked.



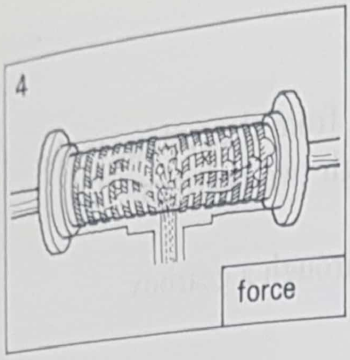
The boiler . . . . steam . . . . 550 kPa.



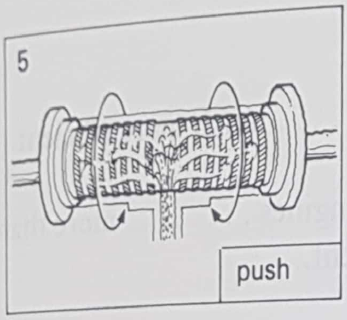
The steam . . . . the engine casing . . . . speed.



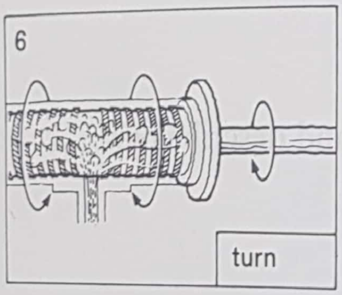
The steam . . . . rapidly . . . . directions . . . . the two cylinders.



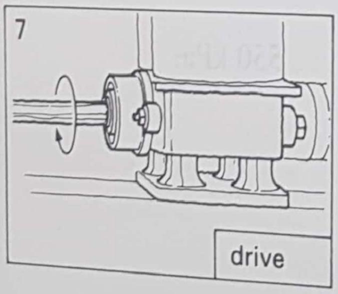
The steam . . . . its way . . . . slots.



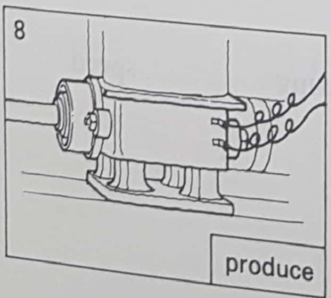
The steam . . . . all the rotors . . . . direction.



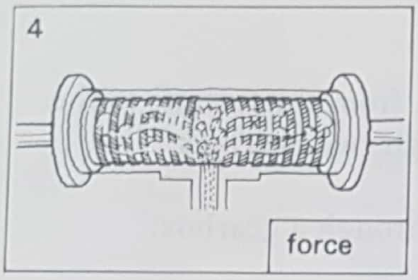
The rotors . . . . the shaft . . . . rpm.



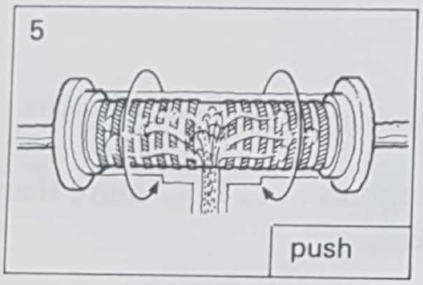
The shaft . . . . the dynamo . . . . speed.



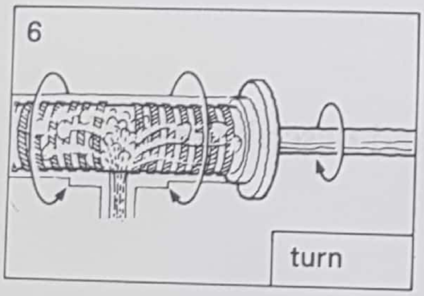
The dynamo . . . . a voltage . . . . 100 V.



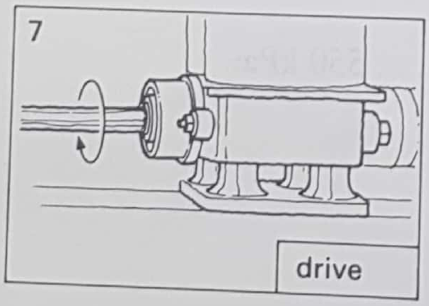
The steam . . . . its way . . . . slots.



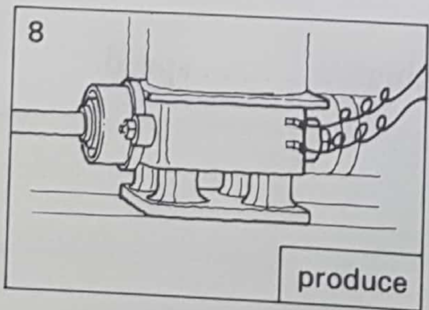
The steam . . . . all the rotors . . . . direction.



The rotors . . . . the shaft . . . . rpm.



The shaft . . . . the dynamo . . . . speed.



The dynamo . . . . a voltage . . . . 100 V.

Exercise 12 Look at the table below. Then look at the questions and the answers beside it.

Parsons' generator (1884)	
MAIN PARTS	
a.	a boiler
b.	the rotors
c.	the shaft
d.	the dynamo

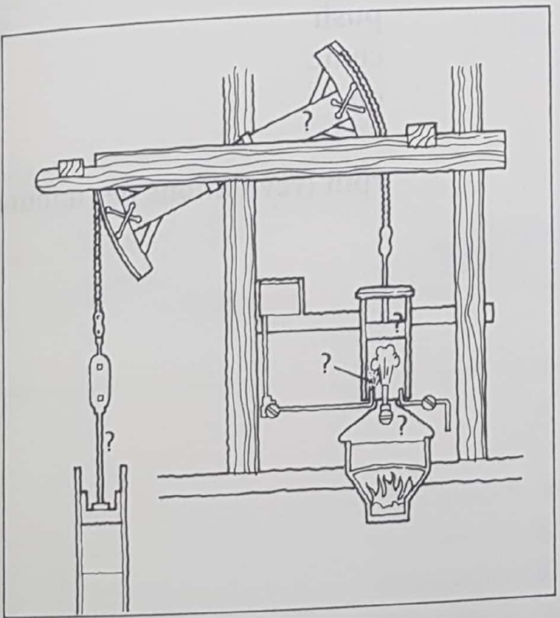
What did the boiler do?
It supplied the steam.

What did the rotors do?
They turned the shaft.

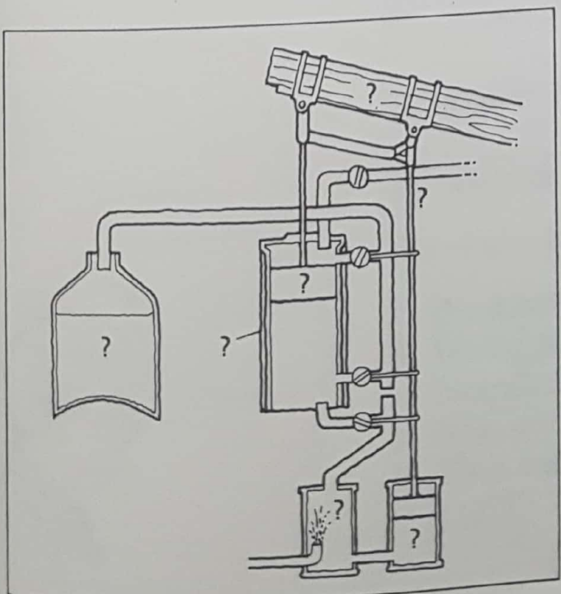
What did the shaft do?
It drove the dynamo.

What did the dynamo do?
It produced the electricity.

Now complete these two tables. Then make questions and answers from them in the same way.



Newcomen's engine (1712)	
MAIN PARTS	
a.	
b.	
c.	
d.	
e.	



Watt's engine (1787)	
MAIN PARTS	
a.	
b.	
c.	
d.	
e.	
f.	
g.	

LANGUAGE NOTE 3

Newcomen's engine

Watt's engine

BUT

Parsons' generator

LANGUAGE NOTE 4

a generator
a turbine
a dynamo
a rotor
a ring
a bearing

a direction
an improvement
a voltage

exhaust

directly
still

along

need
run
drive
cut
put
slope
push
come
go

rpm (revolutions per minute)