EXPERIMENT MANUAL

WIND POWER 2.0

THAMES & KOSMOS

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FEATURES

Explore the future of renewable energy: the endless power of the wind!

This kit allows children to explore one of the most environmentally friendly methods of electricity generation at home. Create your own vehicles and power them with the electricity your generate!

1. COMPONENTS

This kit includes two windmills and a three-stage gear box to suit all wind conditions.

- **a.** Windmill with long blades: Similar to the real windmills used for wind power generation, this design is great for use on beaches or in strong winds.
- **b.** Windmill with short blades: With blades similar in shape to airfoils, this model is functional even in weak wind conditions. It can generate electricity in common backyard wind conditions.
- **c.** Both of the windmills can be used for teaching indoors with electric fans.
- **d.** The three-stage gearbox allows you to adjust the gear ratio depending on the strength of the wind.
- **e.** The tubular tower allows you to easily set up the turbine for experiments.

2. EDUCATION

- **a.** This manual gives step-by-step instructions for assembly of the two windmills and six model vehicles. Following the experiments shown in the manual, children can learn in a hands-on way.
- **b.** When experimenting inside, encourage the child to choose different windmill blades, quantities, and angles, and adjust the levels of the gearbox to suit the different "wind" conditions of the electric fans you are using. Find the best combination to make the LED the brightest!
- **c.** Based on their indoor experiences, teach children to observe the strength of the wind outdoors and accordingly calibrate the windmill to charge the battery in the shortest period of time.
- **d.** During the experiments, help the child understand how the wind generates electricity and how the rechargeable battery stores that electricity. Use the fully charged battery to activate the models.

3. CREATIVITY

Add more unique experiences by encouraging children to make their own models of windmills and electric vehicles using their own ideas and creativity!

4. COMPETITION

Host a scientific challenge! Under the same wind conditions, see whose windmill can charge the battery that makes the electric vehicle run the longest.

RECOMMENDATIONS

This specialized kit makes it possible to investigate how natural resources such as wind can be used to generate electricity through assembling models and transforming them from one form to another. These activities can stimulate children's independent thinking, and lead children to discover how different types of energy are formed and where these energies can be applied in real life.

1. Please read the instructions, follow the safety rules, and keep them for reference. We recommend that you make the models in the given order. You will then be able to better understand the assembly and operation of the parts.
2. This is a kit designed for children over 8 years of age. It helps children discover wind power and electricity during assembly.
3. Discuss the safety warnings and possible risks involved with the children before allowing them to build the models.
4. Do not insert the wire connectors and other components into any electrical sockets, which will cause serious damage. Only rechargeable batteries can be used with this kit.
5. CLEANING:
   - Before cleaning, remove the batteries.
   - Use only a cloth that has been slightly dampened with water.
   - Never use soap or detergent.

SAFETY GUIDELINES

1. Regular batteries must never be recharged.
2. Only an R6-size (AA) rechargeable battery and NiMH type can be charged under the supervision of an adult.
3. Pay attention to the safety warnings and recycling instructions on the rechargeable batteries.
4. Do not force open the battery.
5. Do not throw the battery into the fire.
6. Pay attention to the correct polarity.
7. Pay attention to the charging time.
8. Do not short-circuit rechargeable batteries. They could explode!
9. Do not mix rechargeable and non-rechargeable batteries.
10. The exhausted batteries must be disposed of as hazardous waste.

WARNING

Only for use by children age 8 years and older.

NOTE: An age higher than 8 years may be stated.

Instructions for parents are included and have to be observed.

1. Remove the batteries when not planning to use the device for a long period of time.
2. Misuse of batteries can cause them to leak, which damages and corrodes the area around the battery, creating the danger of fire, explosion, and personal injury.

WARNING TO PARENTS

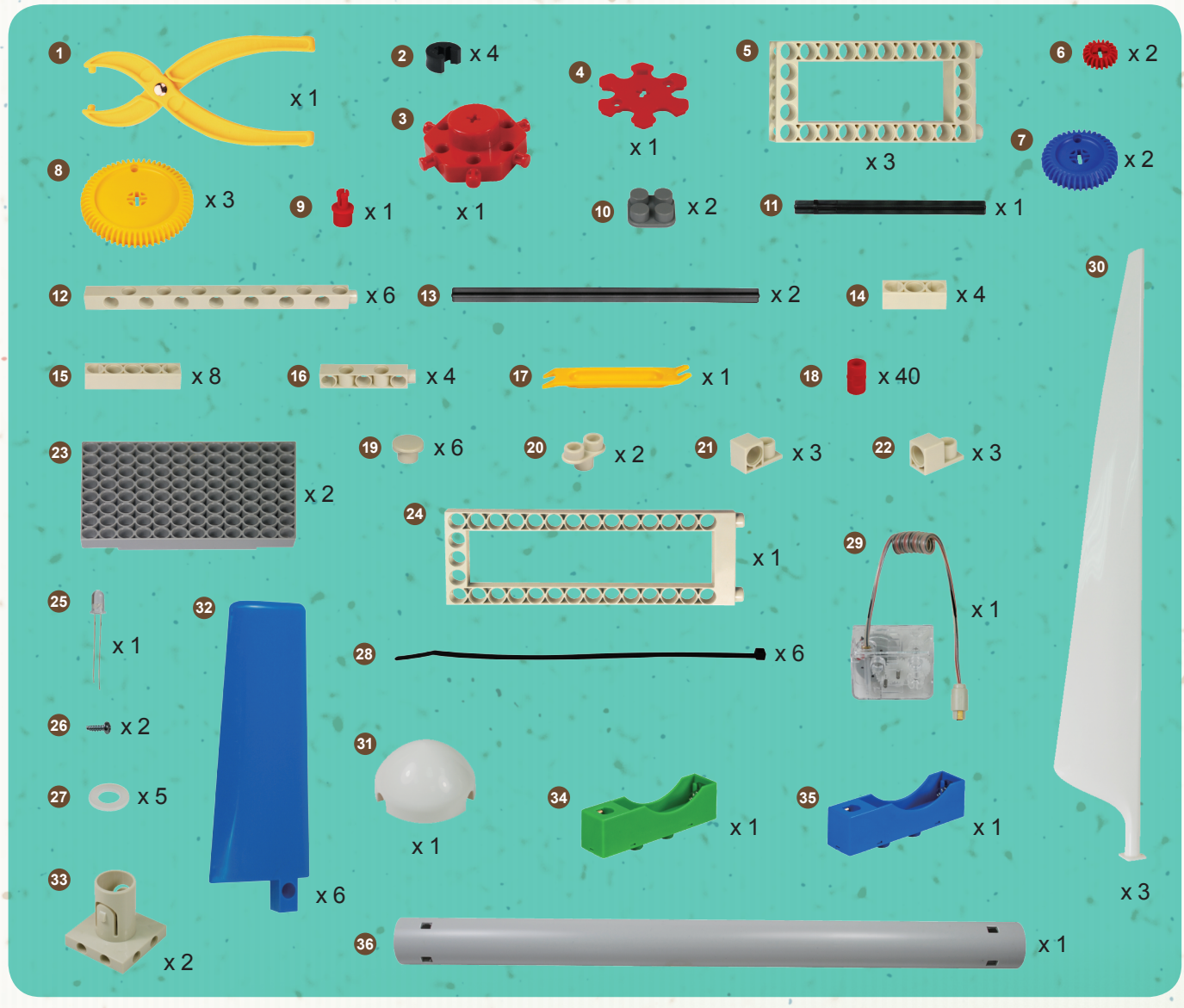
This kit is not suitable for children under 3 years of age. It contains small parts that a child could swallow. This kit must be kept out of the reach of very young children.

WIND POWER 2.0 | Parts List

No	PARTS NAMES	PCS
1	RELEASE PLIERS	1
2	AXLE LOCK	4
3	UNIVERSAL ADAPTOR - BODY	1
4	UNIVERSAL ADAPTOR - COVER	1
5	SHORT FRAME	3
6	SMALL GEAR	2
7	MEDIUM GEAR	2
8	LARGE GEAR	3
9	SHAFT PLUG	1
10	BASE PLATE CONNECTOR	2
11	LONG AXLE	1
12	LONG ROD	6
13	EXTRA LONG AXLE	2

No	PARTS NAMES	PCS
14	3-HOLE ROD	4
15	5-HOLE ROD	8
16	7-HOLE DUAL ROD	4
17	PART SEPARATOR TOOL	1
18	ANCHOR PIN	40
19	BUTTON PIN	6
20	TWO-TO-ONE CONVERTER	2
21	90 DEGREE CONVERTER - L	3
22	90 DEGREE CONVERTER - R	3
23	BASE PLATE	2
24	LONG FRAME	1
25	LED (LIGHT EMITTING DIODE)	1
26	SCREW	2

No	PARTS NAMES	PCS
27	WASHER	5
28	CABLE TIES	6
29	REVERSIBLE GENERATOR/ MOTOR WITH WIRE CONNECTOR	1
30	LONG TURBINE BLADE	3
31	TURBINE HUB	1
32	SHORT TURBINE BLADE	6
33	TUBE ADAPTOR	2
34	BATTERY CHARGER	1
35	BLUE BATTERY HOLDER	1
36	TOWER TUBE (41 CM)	1
TOTAL		133



WIND AND THE HISTORY OF WIND POWER

How is wind formed? What are the properties of wind? How is wind utilized?

Earth's surface is surrounded by an atmosphere. With continuous, but uneven, solar radiation hitting Earth's surface, different regions of Earth heat up to different degrees. This produces varied air pressures, because temperature is an important factor in air pressure. An elevated temperature will cause hot air to ascend and the air pressure to decrease. On the other hand, a low temperature will cause cold air to descend, and air pressure to increase, resulting in a pressure differential. The air circulation caused by Earth's rotation and the uneven distribution of solar radiation results in the formation of wind.

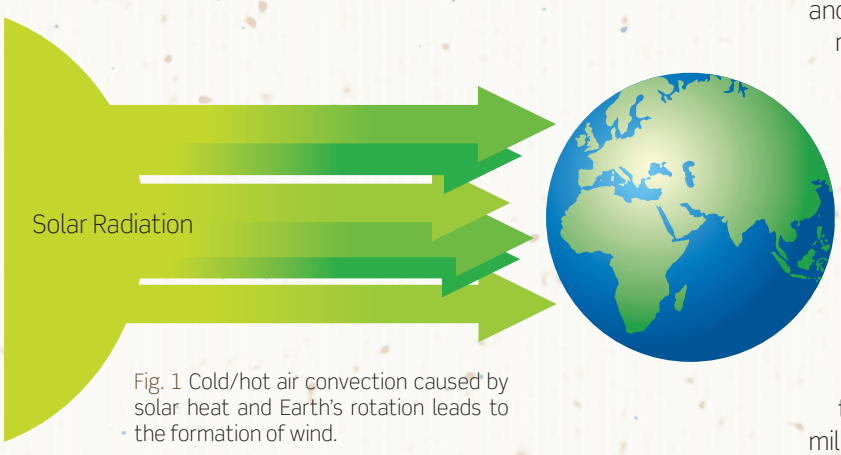


Fig. 1 Cold/hot air convection caused by solar heat and Earth's rotation leads to the formation of wind.

Humans began using wind as a power source in an early stage of civilization. The Chinese and Persians designed windmills for irrigation, pumping water, and grinding grain about 1,000 years ago. Later, European peoples also started using wind power. For examples, the Netherlands improved windmills for many uses, and people in Crete, a Greek Island, pumped water with one hundred canvas windmills. By the Middle Ages, windmills became an important energy source in Europe and extensive research on windmills was conducted. In 1890, meteorologists in Denmark created the first wind turbine and turned a new leaf for the technological development of wind power. With the maturity of wind turbine technology, wind power generation became more and more effective.

Wind power made a huge leap in the 20th century. In the early 1900s, wind power was still solely used for agricultural needs. It was not until the 1970s, when the energy crisis occurred, that wind power generation finally received great attention around the world and wind turbines underwent systematic development. Wind generation related assessments, research, and redevelopment took place around the world at that time. In the 1990s, wind farms started to appear on larger scales, and wind-generated electricity become commercially available. As alternative energy continues to gain emphasis, the development of wind power technology heads into a new era.

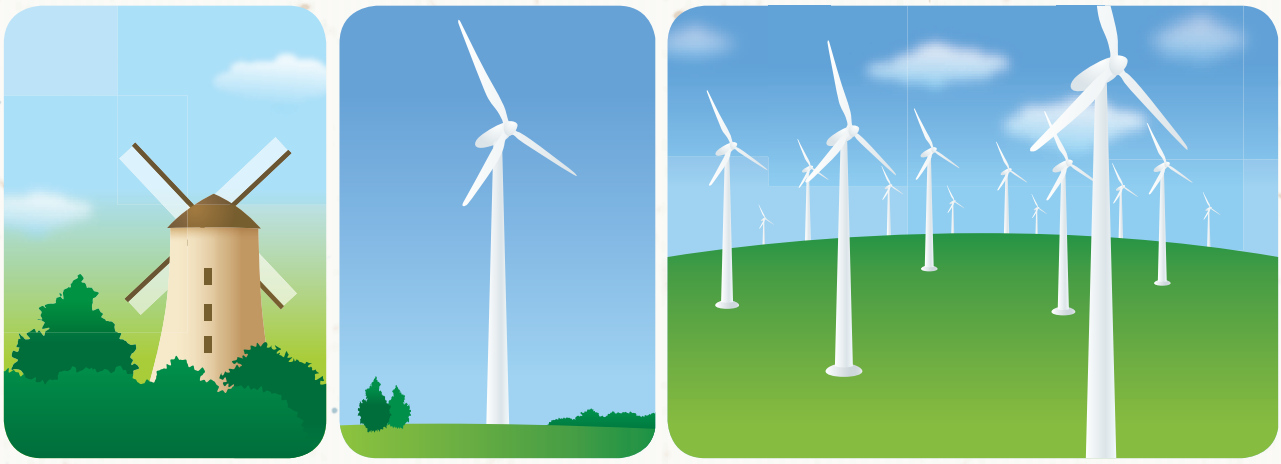


Fig. 2 These illustrations show the earliest conventional windmill, a modern wind turbine, and a wind farm.

WIND STRENGTH SCALE

The strength of the wind can be measured by observing the sea or land conditions, and quantified using a wind strength scale. At present, the most common scale used internationally is the Beaufort Scale, which was created in 1805 by Sir Francis Beaufort, an Irish-born British admiral. The scale was first applied to observations made at sea under varying wind strengths, and later applied to observations on land. Through many revisions over the years, the scale was refined and perfected.

Table 1 Beaufort Scale used for land observations

Beaufort Number	Wind speed knots	Wind speed m/s	Description	Wind Effects on Land
0	<1	< 0.3	Calm	Calm. Smoke rises vertically.
1	1 - 2	0.3 - 1.5	Light air	Wind motion visible in smoke but not in vanes.
2	3 - 6	1.5 - 3.3	Light breeze	Wind felt on exposed skin. Leaves rustle. Vanes move.
3	7 - 10	3.3 - 5.5	Gentle breeze	Leaves and smaller twigs in constant motion. Light flags extended.
4	11 - 15	5.5 - 8.0	Moderate breeze	Dust, leaves, and loose paper lifted. Small tree branches moved.
5	16 - 20	8.0 - 10.8	Fresh breeze	Small trees in leaf begin to sway.
6	21 - 26	10.8 - 13.9	Strong breeze	Large branches in motion. Whistling heard in telephone wires. Umbrella used with difficulties.
7	27 - 33	13.9 - 17.2	High wind, Moderate gale, Near gale	Whole trees in motion. Inconvenience felt when walking against the wind.
8	34 - 40	17.2 - 20.7	Fresh gale	Twigs broken off trees. Progress impeded.
9	41 - 47	20.7 - 24.5	Strong gale	Larger branches broken off trees, and some small trees blown over. Slight structural damage occurs, such as chimney collapse.
10	48 - 55	24.5 - 28.4	Whole gale/storm	Trees are broken off or uprooted. Considerable structural damage occurs.
11	56 - 63	28.4 - 32.6	Violent storm	Seldom experienced. Accompanied by wide-spread damage.
12 - 17	≥ 64	≥ 32.6	Hurricane-force	Maximum and extensive damage occurs. Very rarely encountered.

The formula for actual wind speed and Beaufort Number is $V = 0.836 \cdot (B \hat{} (3/2))$ (B = Beaufort Number; V = Actual wind speed (m/s))

From the Beaufort Number 3 - 7, the wind is categorized as Gentle Breeze, Moderate Breeze, Fresh Breeze, Strong Breeze, and Near Gale (the actual wind speed is around 3 - 17 m/s). These wind levels are applicable to wind generators.

2. WIND TURBINE BLADE DESIGN AND NUMBER

Traditional windmills come with more blades, a variety of shapes in cross-section, and low efficiency in converting wind into energy.

The cross-sections of modern wind turbine blades and airplane wings show convex tops and flat bottoms. When air passes over and under the blade, a faster air flow on the top creates a lower pressure, while the slower air flow on the underside is due to a higher pressure (Bernoulli's principle). Therefore, the side with the higher pressure pushes against the side with the lower pressure to reduce the frontal pressure in the blades. The teardrop-shaped cross section is less likely to produce a vortex (or turbulent, spinning air flow) when air passes around the blades; thus, higher energy conversion and efficiency is achieved. The windmill blades in this kit have a cross-sectional design developed using the principles of fluid mechanics.

Fig. 3 Dutch windmills, and water-pumping windmills found in the Midwestern and Western United States.

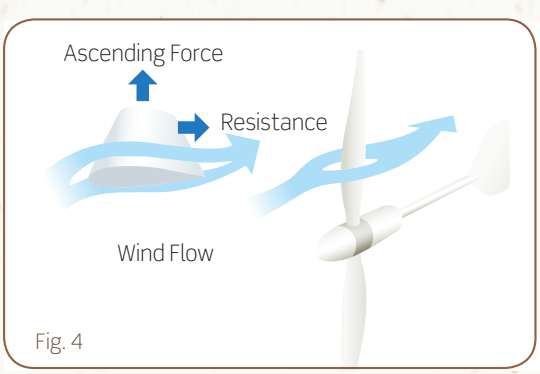


Fig. 4

Fig. 5

Fig. 6

Most commercial, electricity-generating wind turbines in use now use a three-blade design. Experimental findings show that the power generation capacity of turbines with three blades is optimal because, while the efficiency increases a little with more blades, turbines with more than three blades start to have structural problems. Also, enormous rotational torque is produced by ultra long blades. All blades therefore take on an elongated design.

This wind power kit facilitates the completion of numerous alternative energy-related experiments. Although it is true that the model's efficiency cannot match that of a commercial wind turbine, you will gain valuable scientific knowledge through this hands-on experience.

Fig. 7 Modern wind turbines are very large. This diagram shows you the size, as compared to a person standing on it.

3. WIND POWERED ELECTRIC GENERATORS

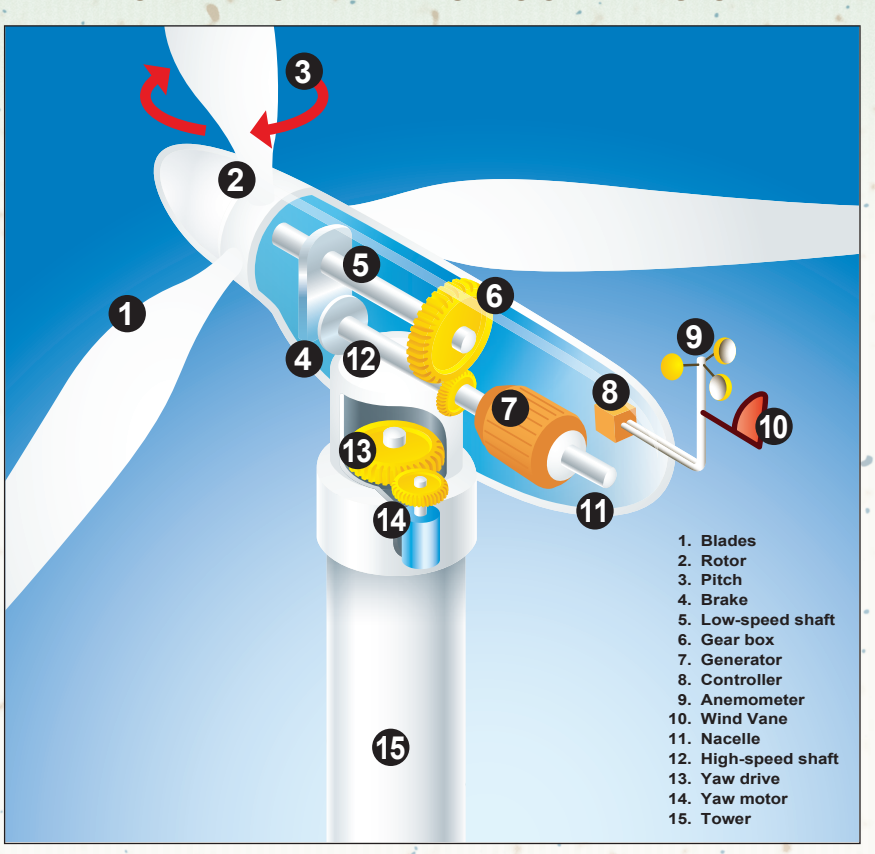


Fig. 8

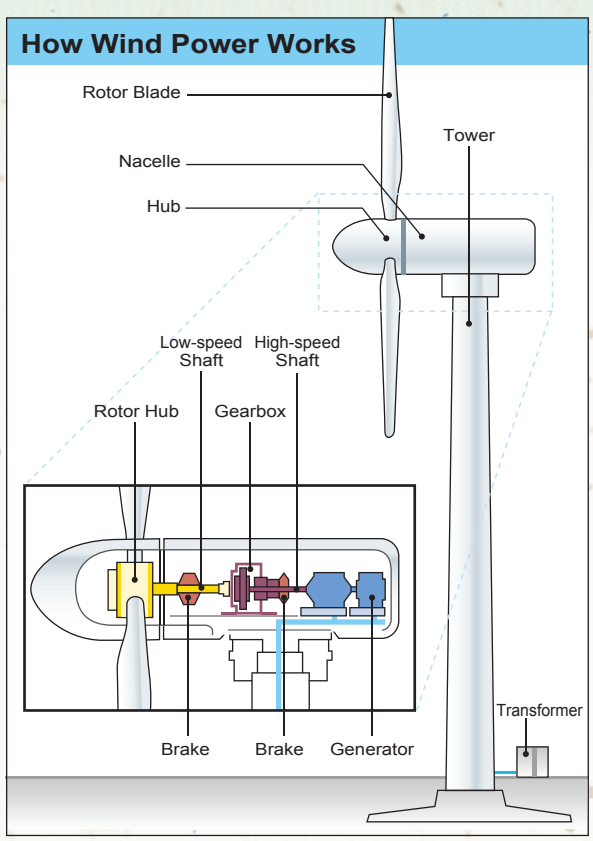


Fig. 9

Wind is a clean and favorable source of sustainable energy with few drawbacks. Because wind is clean and renewable, and wind turbine technology has reached a practical efficiency, people around the world have started to manufacture more and more wind turbines for commercial use, making wind the fastest growing renewable energy source. When wind turns windmill blades, torque is generated to turn the gearbox, power the generator, and then create electricity. The process shows how wind power is converted into mechanical power, and then turned into electrical power through generators. For home use, the electrical power needs a further transformation by transformers, and is finally distributed to consumers via the electrical grid. The real-world wind power generator uses an alternating current (AC) generator. Its electrical power has to be rectified into direct current (DC) when stored in a battery.

4. DIRECT CURRENT GENERATOR

According to Fleming's right hand rule, when the right index finger is pointing towards a magnetic field, the thumb is meanwhile indicating the direction of motion of the conductor, and the middle finger is showing the direction of the electrical current (positive charge of current). This is the principle behind power generator.

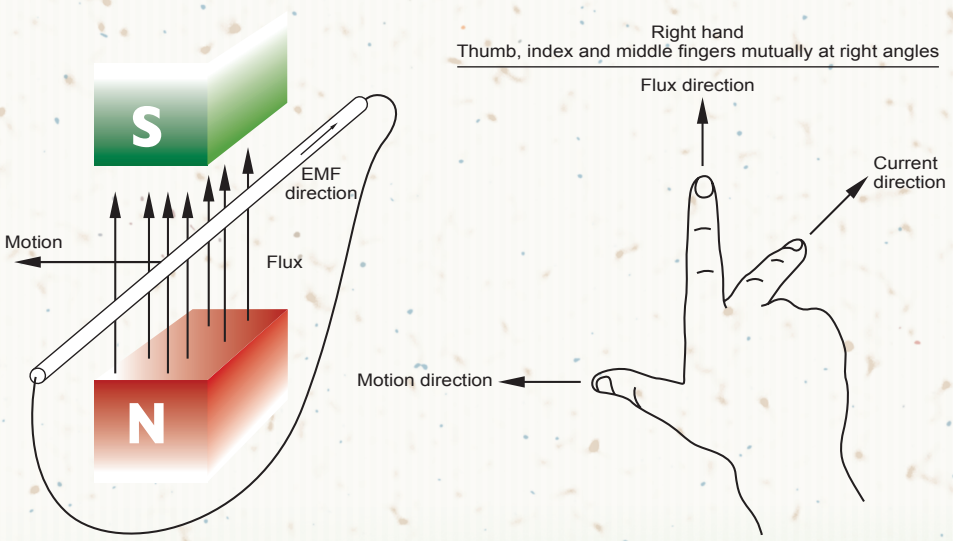


Fig. 10 The biggest difference between a direct current generator and an alternating current generator is the commutator connecting the coil, also known as the "brush" structure.

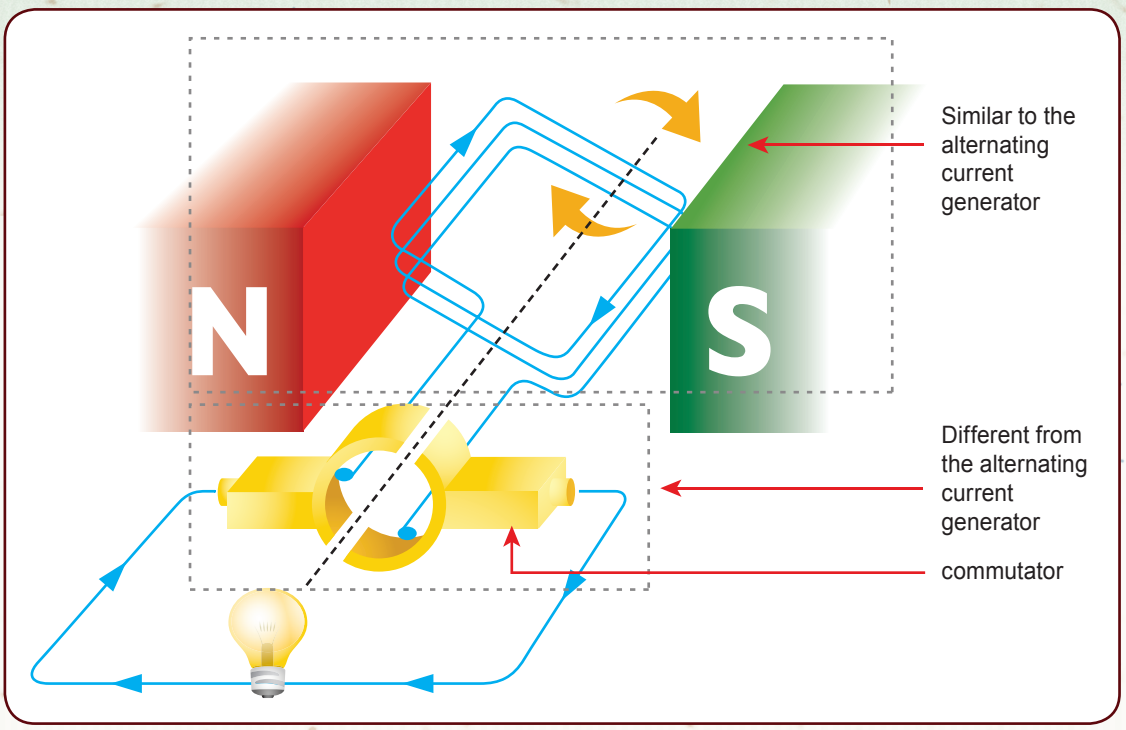


Fig. 11

When the coil passes through the vertical position, the commutator changes the connecting direction of the coil and the external wiring, making the electric current outside of the coil always move in a single direction. When there is a switch between the positive and negative charge in the loop, the terminal block of the contact also switches, and thus the positive and negative voltages discharged from contacts do not switch, as shown in Fig 12. This type of connecting-exchanging process is known as "commutation," therotatablesemicircularconductors as "commutator segments," and the position-fixing contacts as "brushes." The whole setup is called a "commutator."

Current generated by a direct current generator:

During the coil's rotation of one cycle, the current (I) is constantly changing.

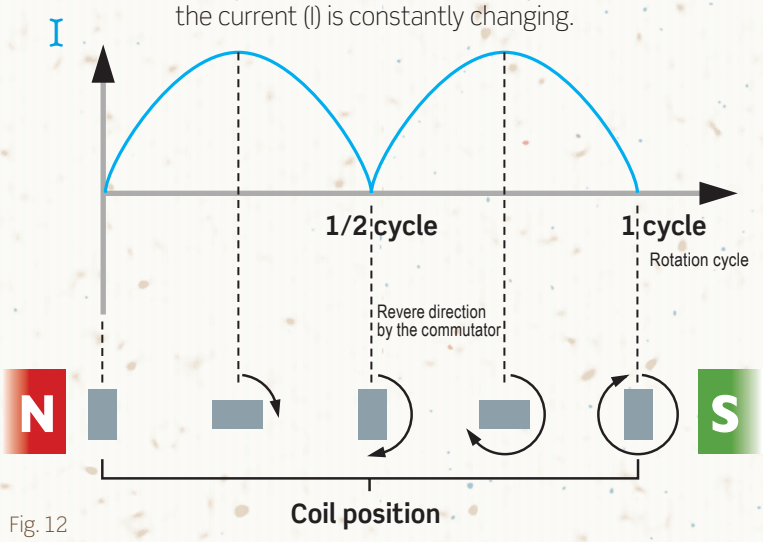


Fig. 12

5. USING A MOTOR AS A GENERATOR

A motor and a generator share the same basic structure. Applying an electric current to a motor will create motion; on the other hand, applying motion to a motor will create an electric current. In this way, you will use the generator in this kit as both a generator to produce electricity with the wind turbine, and as a motor to drive your electric vehicles powered by a battery.

6. REVERSIBLE GENERATOR WITH WIRE CONNECTOR

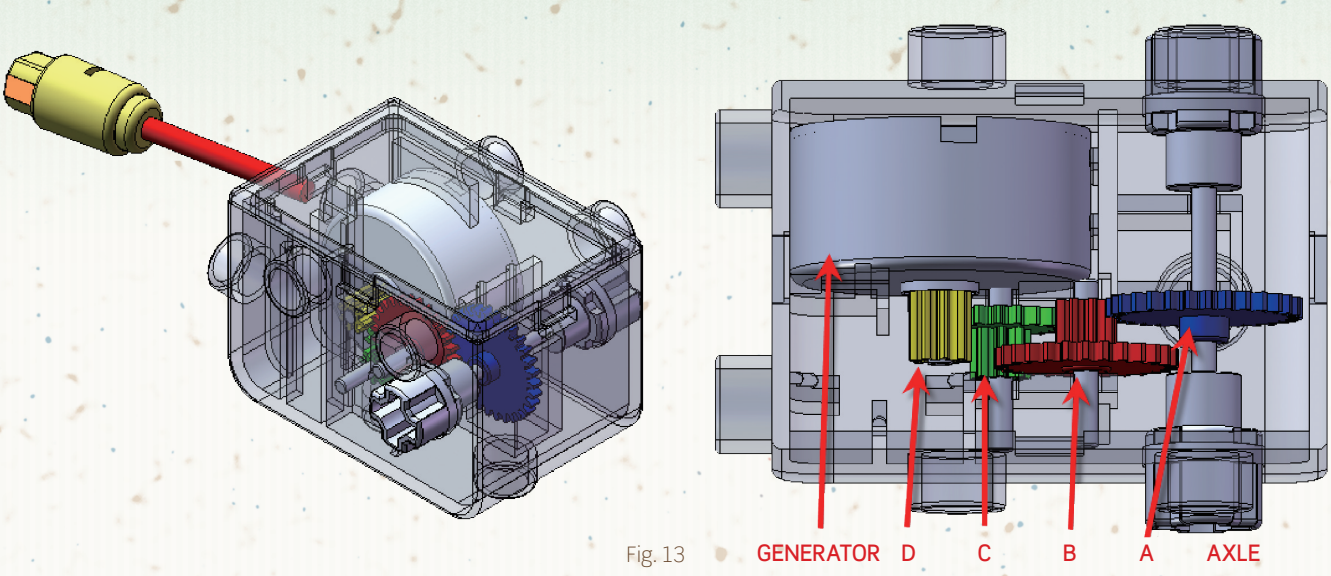


Fig. 13

In this kit, we use a special generator, as shown in Figure 13. On its right side, there is an axle that takes the rotational input from the turbine. The force generated by the turbine is then transmitted via the gears A, B, C, and D to the generator. Through the transmission, this gear ratio is produced:

THE GEARBOX = 30/8 × 28/8 × 20/8 = 32.8125

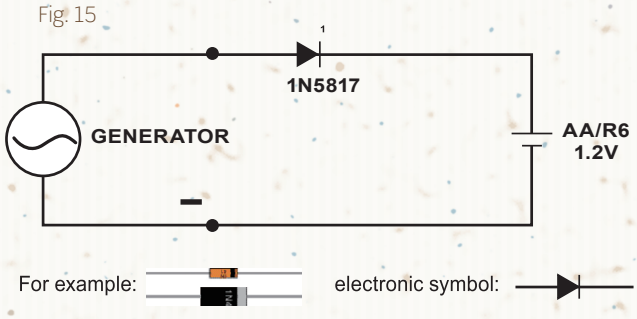
This indicates that when the axle for the turbine input rotates at a speed of 1 rpm, the generator shaft will rotate at the speed of 32.8 rpm. If the rotational speed of the axle for the turbine input reaches 100 rpm, and that of the generator shaft accordingly reaches 3200 rpm, the generator can produce a 3 V direct current (DC). The faster the rotational speed is, the higher the voltage of the current.

7. THE BATTERY CHARGER

Fig. 14

A diode is located in the green battery charger.

Fig. 15



A diode in the battery charger allows electric current to flow in only one direction. The electronic symbol for the diode (the arrow) indicates the permitted direction for the electric current to flow. Generally speaking, only if the electric current is a forward current with the voltage of 0.7 V, will it be able to pass through the circuit. When the electric current flows in the opposite direction (as in the case in which the positive and negative poles of the wire connector are backwards), it will be blocked, which is shown by the electronic symbol.

Using the charger under ideal wind speed conditions, the wind turbine generates a current, and the current from the positive electrode of the wire passes into the positive electrode of the rechargeable battery in the battery charger, and slowly charges the battery. As the wind speed becomes too slow, the voltage from the power generation will reduce as well. However, a reverse current leakage will not take place since the diode in the battery charger functions as a protector. Using the device under steady wind conditions, the wind turbine can fully charge a 1.2 V 1200 mAh rechargeable battery in three to four hours.

TIPS AND TRICKS FOR MODEL BUILDING

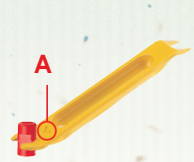


Fig. 16

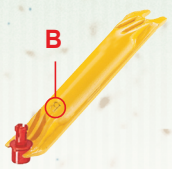


Fig. 17

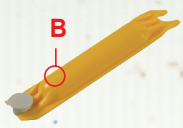


Fig. 18

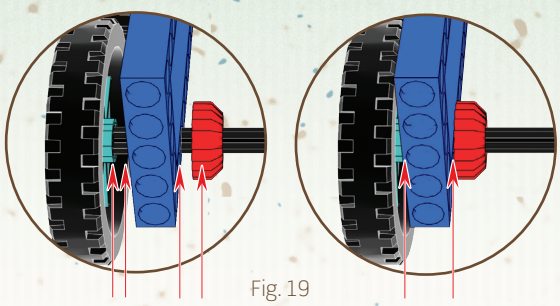


Fig. 19

1. Use the end “A” of the part separator tool to pry off the anchor pin (Fig. 16).
2. Use the end “B “ of the part separator tool to pry off the shaft plug (Fig. 17).
3. Use the end “B” of the part separator tool to pry off the button pin (Fig. 18).
4. When fixing a gear or a tire onto the framework with a drive axle, be sure to keep a gap of about 1 mm between the gear or the tire and the framework to decrease the friction that arises during operation, so that the model will run smoothly (Fig. 19).

How to assemble and disassemble the tower tube and tube adapter

Note: Do not hold the tube support and the tube where you insert each piece as your fingers may get pinched (Fig. 20).

Fig. 20

Push the tube support into tube and turn the tube until you hear a click. They are then fixed together (Fig. 20).

Fig. 21

Put the release pliers into the holes that have safety lock pins coming through and squeeze the pliers to release the tube and the tube support (Fig. 21).

How to remove the battery

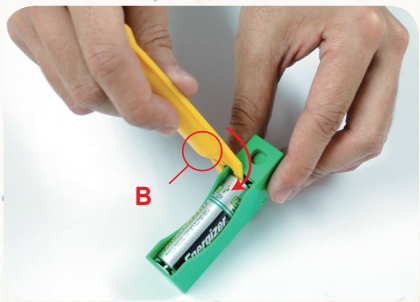


Fig. 22

Using the “B” end of the part separator tool, remove the battery from the battery holder as Fig. 22 shows.

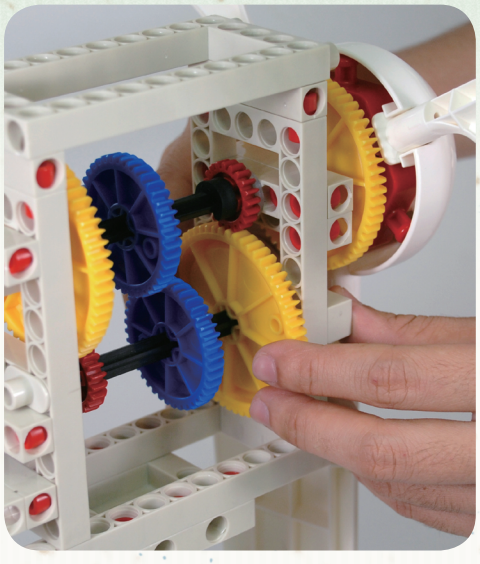


Fig. 23

To adjust the gear ratio to 3:1, hold the gearbox and the yellow gear as shown in Fig. 23 and move the yellow gear backward so that it will mesh with the upper red gear, while the other two gear sets are left unmeshed,

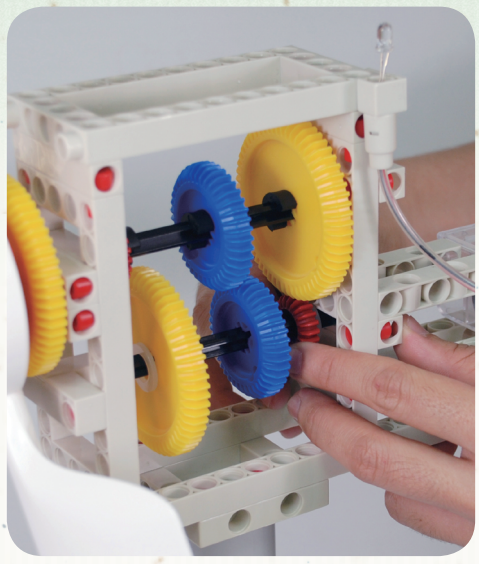


Fig. 24

To adjust the gear ratio at 1:3, hold the gearbox and the red gear as shown in Fig. 24 and move the red gear backward so that it will mesh with the upper yellow gear, while the other two gear sets are left unmeshed.

(Turbine assembly instructions begin on page 20.)

Gearbox

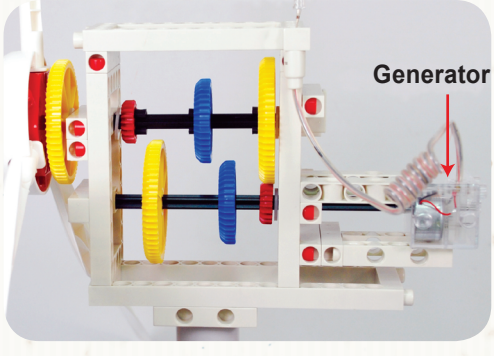


Fig. 25

Gear Ratio 1:3

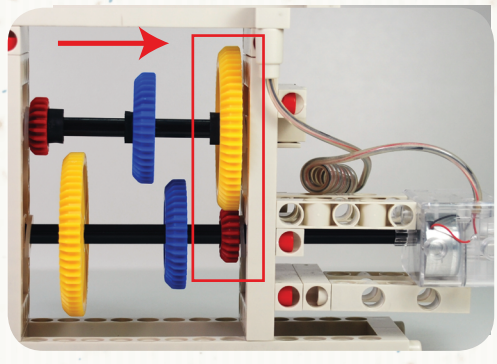


Fig. 26

Fig 26 shows only the upper yellow gear (60T) meshed with the lower red gear (20T) so that the current gear ratio is 1:3.

Gear Ratio 1:1

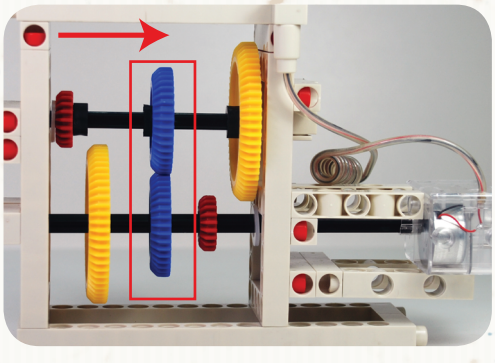


Fig. 27

If you shift the gears so that only the upper and the lower blue gears (40T) are meshed together, the gear ratio of this gearbox will be changed to 1:1. (Fig. 27)

Gear Ratio 3:1

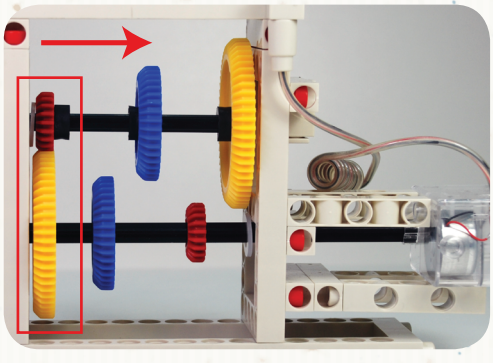


Fig. 28

If you shift the gears so that only the upper red gear (20T) and the lower yellow gear (60T) are meshed together, the gear ratio of this gearbox will be changed to 3:1. (Fig. 28)

SETTING UP A FAN AND THE WINDMILL FOR INDOOR EXPERIMENTS

Refer to these instructions to properly set up a fan in order to conduct experiments with your wind turbines indoors.

18" Industrial Fan

The Windmill with Long Blades

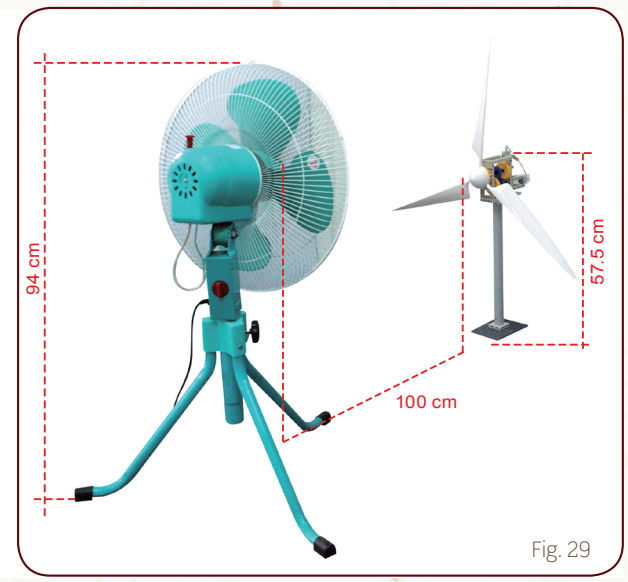


Fig. 29

18" Industrial Fan

The Windmill with Short Blades

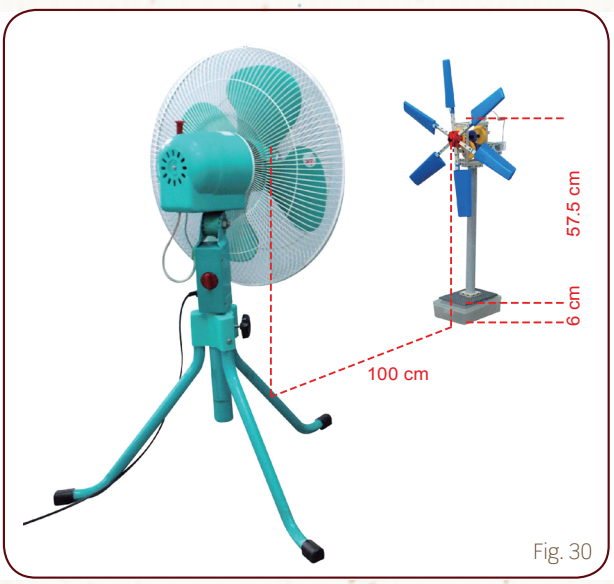


Fig. 30

16" House Fan

The Windmill with Long Blades

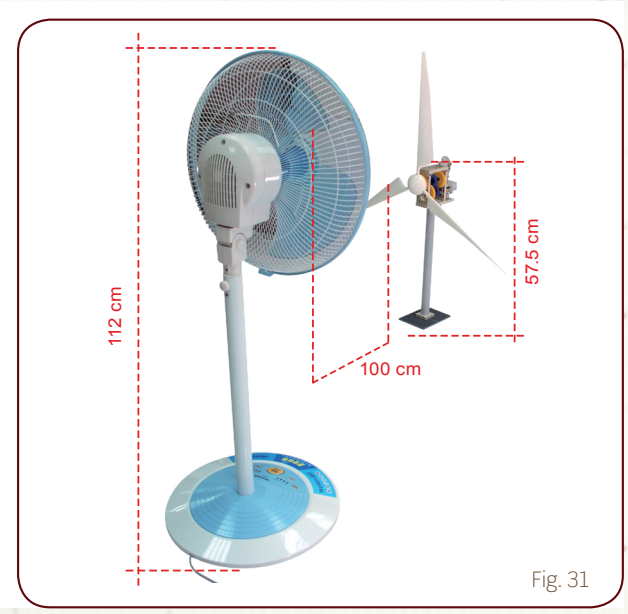


Fig. 31

16" House Fan

The Windmill with Short Blades

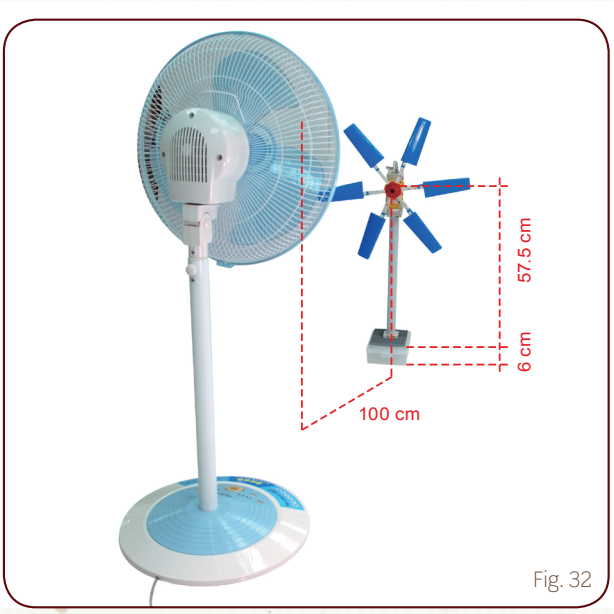


Fig. 32

Outdoors

- Install the windmill on a broomstick or bamboo rod with two cable ties (Fig. 34). Fasten the cable ties to ensure the windmill is secure (Fig. 33).

Fig. 33

Fig. 34

Indoors

- Hold the gearbox with your hand (Fig. 35) while securing the windmill base to the floor with packing tape (Fig. 36).
- Put two iron blocks or stones that weigh 3 lb each on the base to further secure the windmill (Fig. 37).

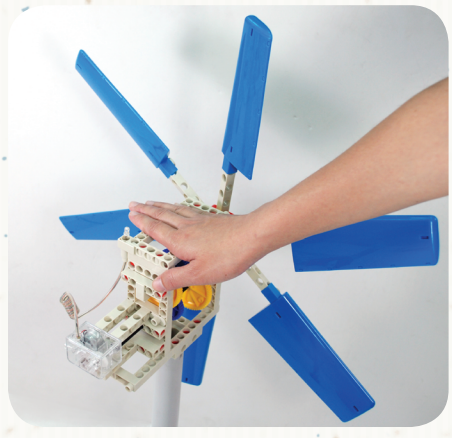


Fig. 35

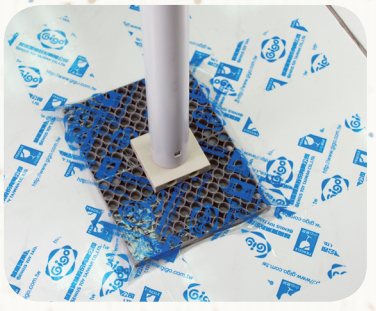


Fig. 36

Fig. 37

- You can demonstrate the windmill's power generation by simply spinning the blades with one hand and holding the windmill with the other hand (Fig. 38 & 39).

Fig. 38

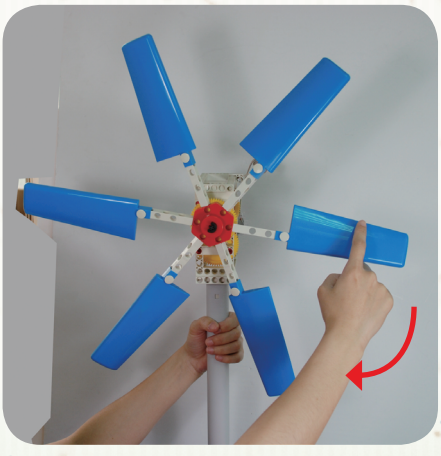


Fig. 39

EXPERIMENT 1: ADJUST THE GEAR RATIO OF GEARBOX

Use a windmill with short blades (Fig. 41) to observe the variation of power generation (the brightness of the LED) under the same wind speed. Fix the angles of the blades and change the gear ratios by shifting the gears on the lower axle of the gearbox.

Fig. 40 shows you the upper yellow gear (60T) meshed with the lower red gear (20T) so that the current gear ratio of this gear box is 1:3.

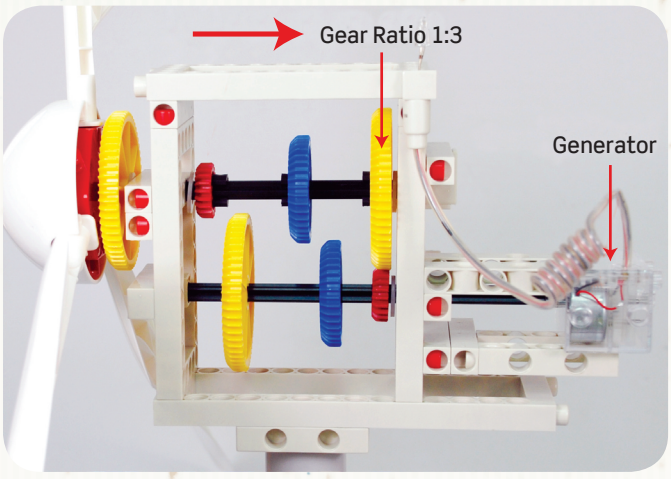


Fig. 40

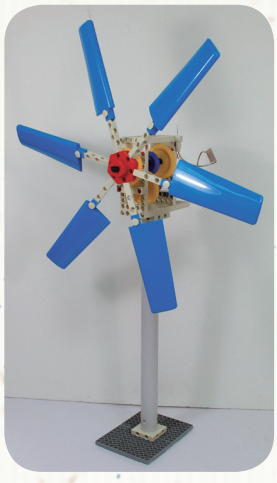


Fig. 41

SET GEAR RATIO 1:1 FOR EXPERIMENTS 2-4

Experiment 2: Use a windmill with short blades (Fig. 41) to observe the variation of power generation under different wind speeds (different settings on a fan). Can you figure out any correlation between wind speed and power generation (the brightness of the LED)?

Experiment 3: Use a windmill with short blades (Fig. 41) to observe the variation of power generation (the brightness of the LED) under the same wind speed. Change the angles of the blades. Can you find the best and most efficient blade angle that makes the LED shine brightest?

Experiment 4: Use a windmill with short blades (Fig. 41) to observe the variation of power generation (the brightness of the LED) under the same wind speed. Change the blade numbers (6 blades, 4 blades, 3 blades, 2 blades). Make sure that you arrange the blades symmetrically with equal intervals. Can you find the best and most efficient blade numbers to make the LED shine brightest?

Experiment 5: Use the windmill with long blades (Fig. 43) and repeat Experiments 1-3. Can you also find the best and most efficient conditions for this new wind turbine?

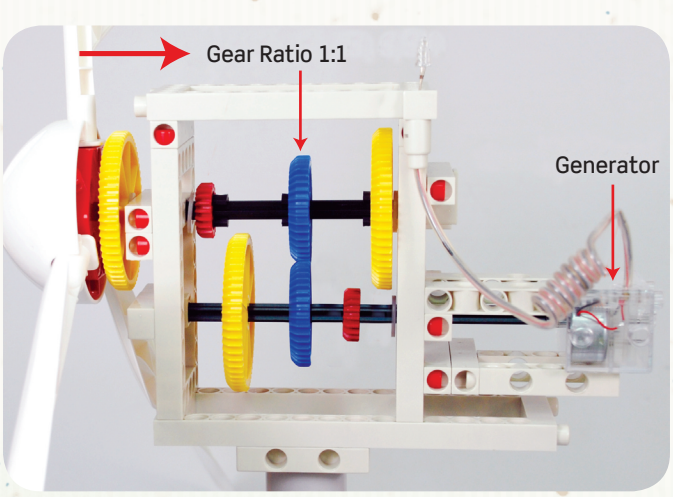
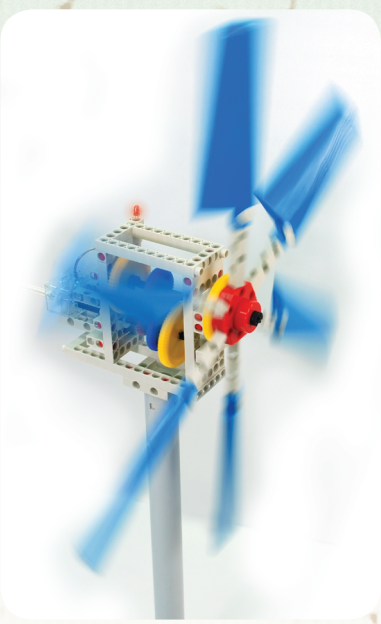


Fig. 42

Fig. 43

A MINI WIND POWER PLANT



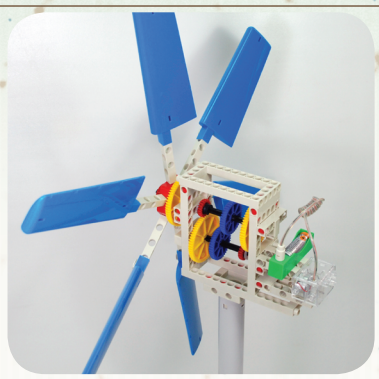
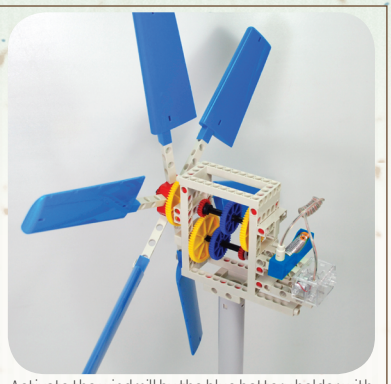


Fig. 44 Charge electricity by the green charger with a rechargeable battery.



Activate the windmill by the blue battery holder with fully charged battery or a disposable AA battery.

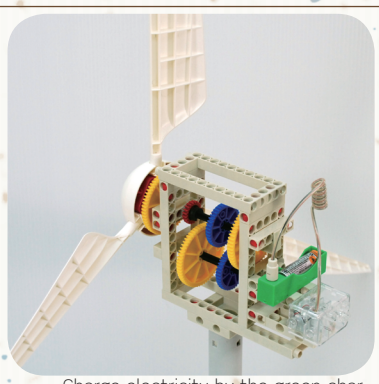
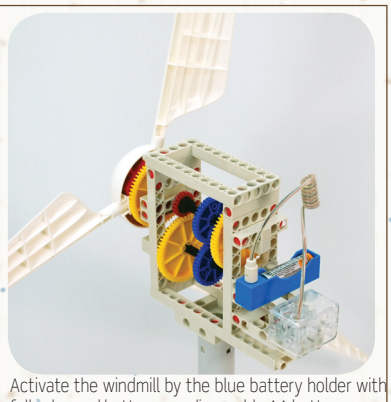


Fig. 45 Charge electricity by the green charger with a rechargeable battery.



Activate the windmill by the blue battery holder with fully charged battery or a disposable AA battery.

After the windmill is assembled, securely fasten its base with heavy objects or bricks.

How to charge a battery using the windmill:

1. Remove the LED and connect the wire connectors to the green battery charger.
   Note: The blue battery holder looks like the green charger and holds a battery, but it is not a charger.
2. Adjust the blades to the optimal angle obtained in the previous experiments.
3. Secure the rechargeable batteries (below R6/AA 1.2 V 1600 mAh). Do not use rechargeable batteries with excessive charging values; otherwise, the results will not be apparent.)

   Note: Never insert regular, non-rechargeable AA batteries in the green charger. There is a risk that the battery could heat up and/or explode.
4. Use natural wind outdoors or an electric fan inside to turn the turbine and allow the batteries to charge.
5. You can also use the blue battery holder with a fully charged battery to turn the windmill into a fan, in case there is no wind.
6. If the rechargeable battery is not fully charged, use a regular battery (disposable AA battery) in the blue battery holder to activate the models your are instructed to build further on in this manual.
7. Interestingly, the fast-rotating windmill slows down when rechargeable batteries are inserted. This is a normal phenomenon because the weak batteries have an ultra high capacitance. The effect is negligible, like water being poured into a large pond. As the voltage slowly increases after some time, the windmill will start to rotate faster.
8. Under normal wind speeds (4 m/s), a 1300 mAh rechargeable battery can be fully charged in 1 to 1.5 hours and a 2400 mAh rechargeable battery in 2 to 2.5 hours.
9. You should expect extended charging times as natural wind speeds always vary. The varied voltages will form voltage pulses that enhance the charging capacity. No risk of overcharging will take place if left unattended over a long period of time, because of the diode. The wind turbine voltage under a wind speed of 4 m/s is about 4.5 V. In the case of excessive winds, the windmill blade will detach and reduce the rotational speed due to the centrifugal force.

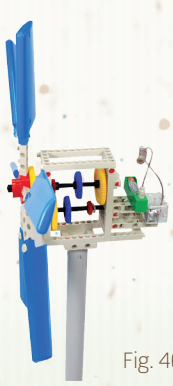


Fig. 46

Reference for parents and Teachers

1. All of the experiments above use empirical scientific analysis. Three variables are included: the fixed conditions of each experiment are called controlled variables. Dependent variables represent the source of different experimental results, and independent variables are those factors assumed to have an effect on the dependent variables.
2. Under different testing conditions, the best experimental results can be attained by repeating experiments with different independent variables. The goal is to find the optimal windmill design and various experiments must be conducted in order to reach this goal. This process is highly beneficial for kids so that they can develop their problem solving skills.
3. When measuring the correlation between wind speeds and power generation (the brightness of the LED), it is difficult to concretely quantify the result and turn it into numerical data with only the brightness of the LED. In order to more accurately record the experimental results, a multimeter is recommended for measuring voltage changes (DC-V).
4. This experiment kit is excellent for experiments and fun learning experiences either outdoors with natural wind or indoors with an electric fan.

ADVANCED REFERENCE

1. Analysis of Fan Blade Angle vs. Power Generation Capacity

Quantitative analysis is used to verify the optimum blade angle with the aid of a measuring instrument, such as a multimeter. In Experiment 3, the LED brightness is determined by the power generation voltage. When it is lower than 1.7 V, the LED light will not turn on. A higher voltage will produce a brighter LED light. The higher the rotational speed of the turbine, the higher the voltage will be. Thus, fixed test conditions such as fixed wind speed are called controlled variables, the blade angle is the independent variable, and the voltage output is the dependent variable.

Fig. 47

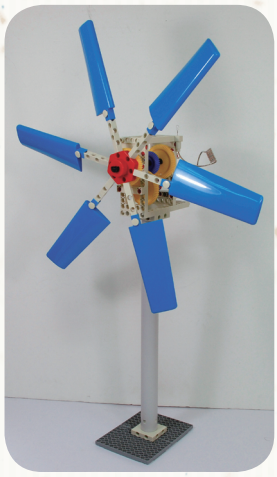


Fig. 48

MEASURING INSTRUMENTS

(Not included in this kit. For reference only!):

Fig. 49

From the left:

- Anemometer
- Digital Multi-Meter (DMM)
- Tachometer
- Angle meter
- Two ammeters

Fig. 50

Adjust the angle using the angle meter. You can also draw the angle on a paper template in advance, and use the template to set the angle.

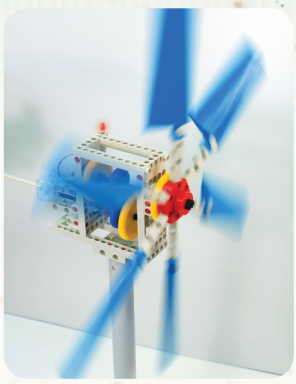


Fig. 51

Since the LED brightness cannot be quantified, use a DMM to test the relationship model between voltage and blade angle, after removing the LED light.

Diagram of Blade Angle vs. Voltage...

...for Turbine with 6 Short Blades

Blade angle (with the the universal connector hub as a basis)	14" House fan	16" Industrial fan
0	0	0
5	0.6	1.2
10	1.01	2.72
15	2.39	3.51
20	2.42	4.05
25	2.16	3.04
30	1.88	2.44

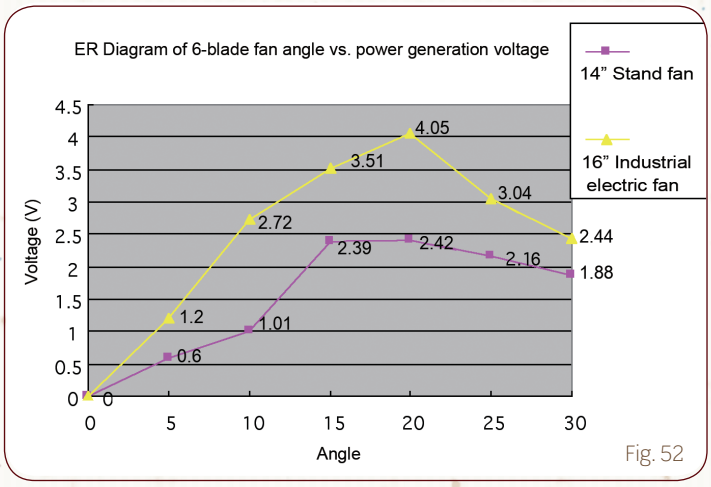


Fig. 52

Conclusion: The experimental values show that the short blades angled at 20 degrees obtain optimal results.

...for Turbine with 3 Long Blades

The universal connector hub serves as a basis for the angle measurements.			Gear ratio: 1:1	
Angle	14" House fan	16" Industrial fan	14" House fan	16" Industrial fan
10	1.40	1.56	not rotating	1.6
0	1.73	2.10	1.9	2.5
-10	1.55	1.65	1.76	1.89

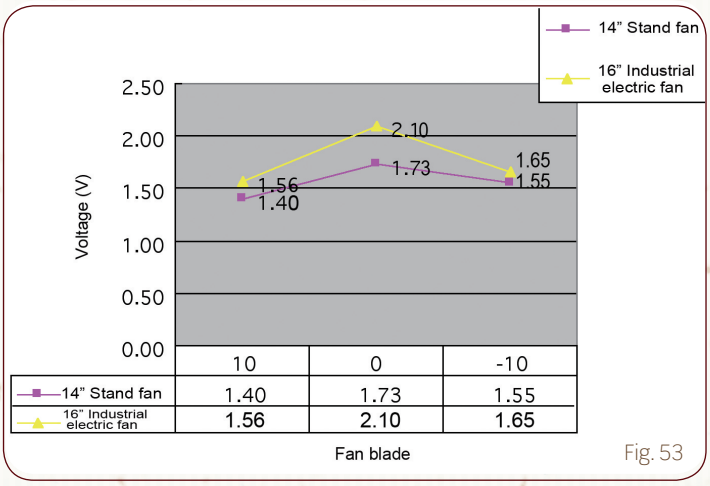


Fig. 53

Conclusion: The experimental values show that long blades angled at 0 degrees obtain optimal results.

Result Diagram from Charging Experiment

Perform a charging test after completely discharging R6/AA 1.2 V 1300 mAh and R6/AA 1.2 V 2400 mAh rechargeable batteries.

For this experiment, the strongest industrial electric fan and a turbine with 6 short blades, angled at 20 degrees, were used.

Fig. 54

Charging Time (Min)	Battery Testing	
	R6/AA 1.2V 1300mAh	R6/AA 1.2V 2400mAh
0	0	0
30	0.9	0.6
60	1.2	0.98
90	1.32	1.1
120		1.2
150		1.37

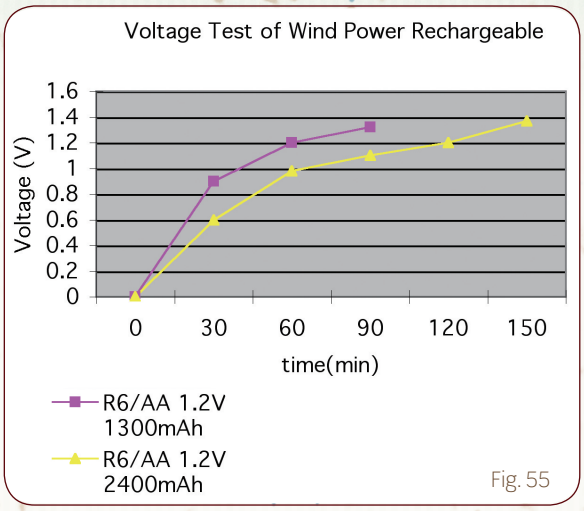
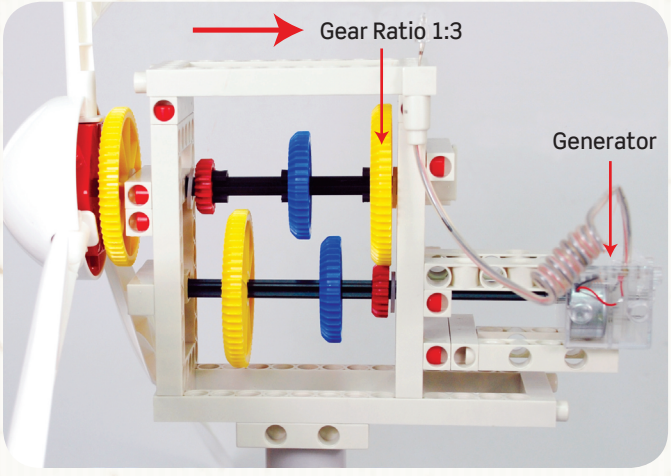


Fig. 55

Experimental Results for 16" House Fan



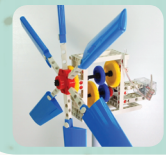
6 Short Blades | **Gear Ratio 1:3**

Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle	✓	✓
Weak		

6 Short Blades | **Gear Ratio 1:1**

Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle	✓	✓
Weak		

6 Short Blades | **Gear Ratio 3:1**

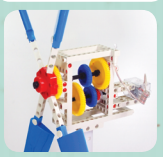


Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle		
Weak		

3 Long Blades | **Gear Ratio 1:3**

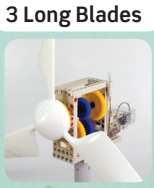
Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle		
Weak		

4 Short Blades | **Gear Ratio 1:1**



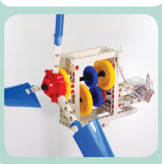
Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle	✓	✓
Weak		

3 Long Blades | **Gear Ratio 1:1**



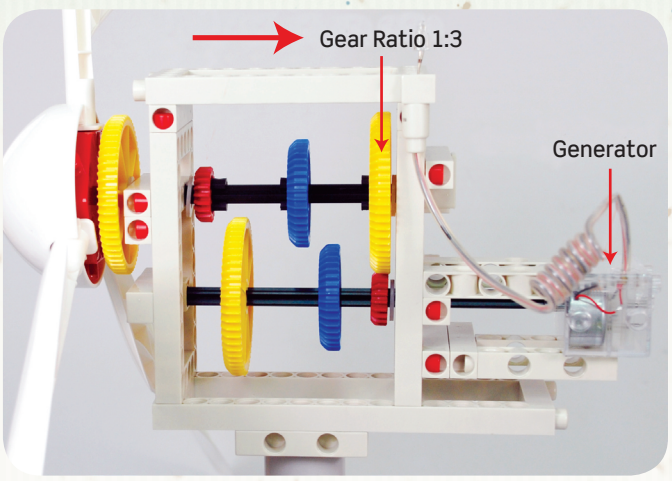
Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle		
Weak		

3 Short Blades | **Gear Ratio 1:1**



Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle		
Weak		

Experimental Results for 18" Industrial Fan



6 Short Blades	Gear Ratio 1:3	Wind Speed	Blades Turn	LED Lights
		Strong	✓	✓
		Middle	✓	✓
		Weak	✓	✓

6 Short Blades	Gear Ratio 1:1	Wind Speed	Blades Turn	LED Lights
		Strong	✓	✓
		Middle	✓	✓
		Weak	✓	✓

6 Short Blades	Gear Ratio 3:1	Wind Speed	Blades Turn	LED Lights
		Strong	✓	✓
		Middle	✓	✓
		Weak	✓	✓

4 Short Blades	Gear Ratio 1:3	Wind Speed	Blades Turn	LED Lights
		Strong	✓	✓
		Middle	✓	✓
		Weak	✓	✓

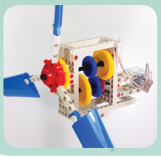
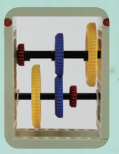
4 Short Blades	Gear Ratio 1:1	Wind Speed	Blades Turn	LED Lights
		Strong	✓	✓
		Middle	✓	✓
		Weak	✓	✓

4 Short Blades	Gear Ratio 3:1	Wind Speed	Blades Turn	LED Lights
		Strong	✓	✓
		Middle	✓	✓
		Weak	✓	✓

3 Short Blades	Gear Ratio 1:3	Wind Speed	Blades Turn	LED Lights
		Strong	✓	✓
		Middle	✓	✓
		Weak		

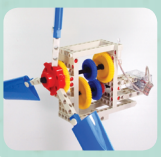
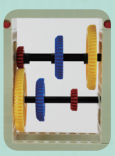
Experimental Results for 18" Industrial Fan

3 Short Blades | **Gear Ratio 1:1**

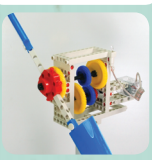
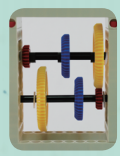
Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle	✓	✓
Weak	✓	✓

3 Short Blades | **Gear Ratio 3:1**

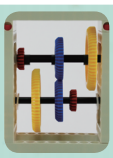
Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle	✓	✓
Weak	✓	✓

2 Short Blades | **Gear Ratio 1:3**

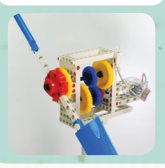
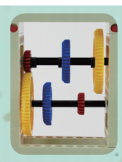
Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle		
Weak		

2 Short Blades | **Gear Ratio 1:1**

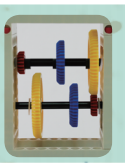
Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle	✓	✓
Weak	✓	✓

2 Short Blades | **Gear Ratio 3:1**

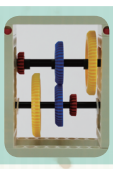
Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle		
Weak		

3 Long Blades | **Gear Ratio 1:3**

Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle	✓	✓
Weak		

3 Long Blades | **Gear Ratio 1:1**

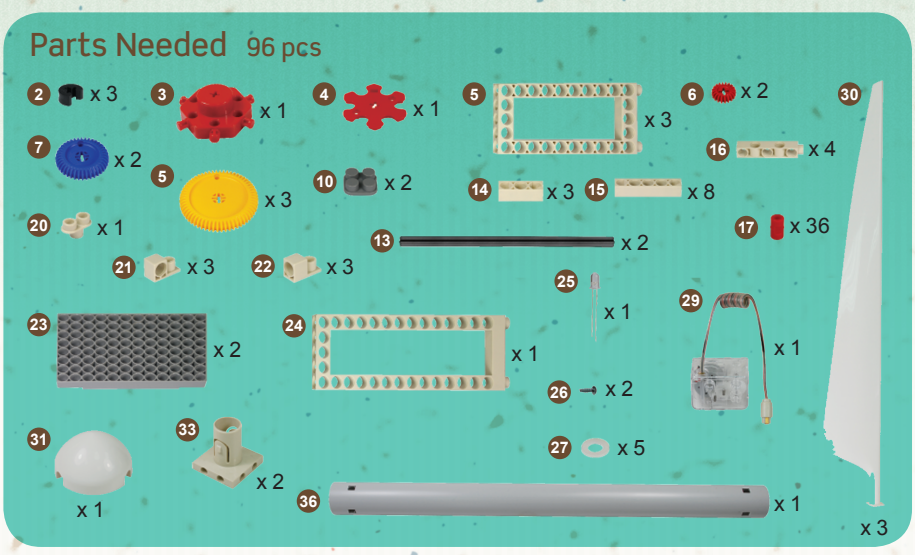



Wind Speed	Blades Turn	LED Lights
Strong	✓	✓
Middle	✓	✓
Weak		

WIND POWER 2.0 | MODEL 1 Windmill with Long Blades

Windmill with Long Blades

Parts Needed 96 pcs



Notes for Assembly

Adjust blade angles:

- Refer to Fig. 56: Hold the hub with your left hand and adjust the angles by turning the bottom end of the blade.
- To remove the universal adaptor from the hub: Insert the end "B" of the part separator tool between the universal adaptor and the hub, and tilt the tool to pry them apart (Fig. 57).
- If the windmill rotates clockwise, the LED will not light up. Please insert the LED in the opposite direction.

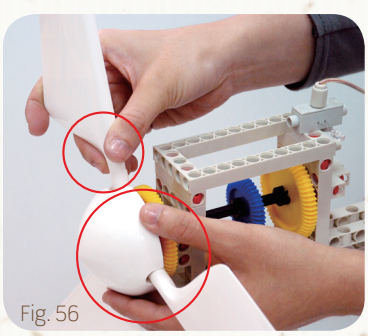


Fig. 56

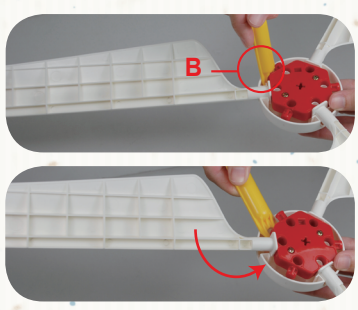
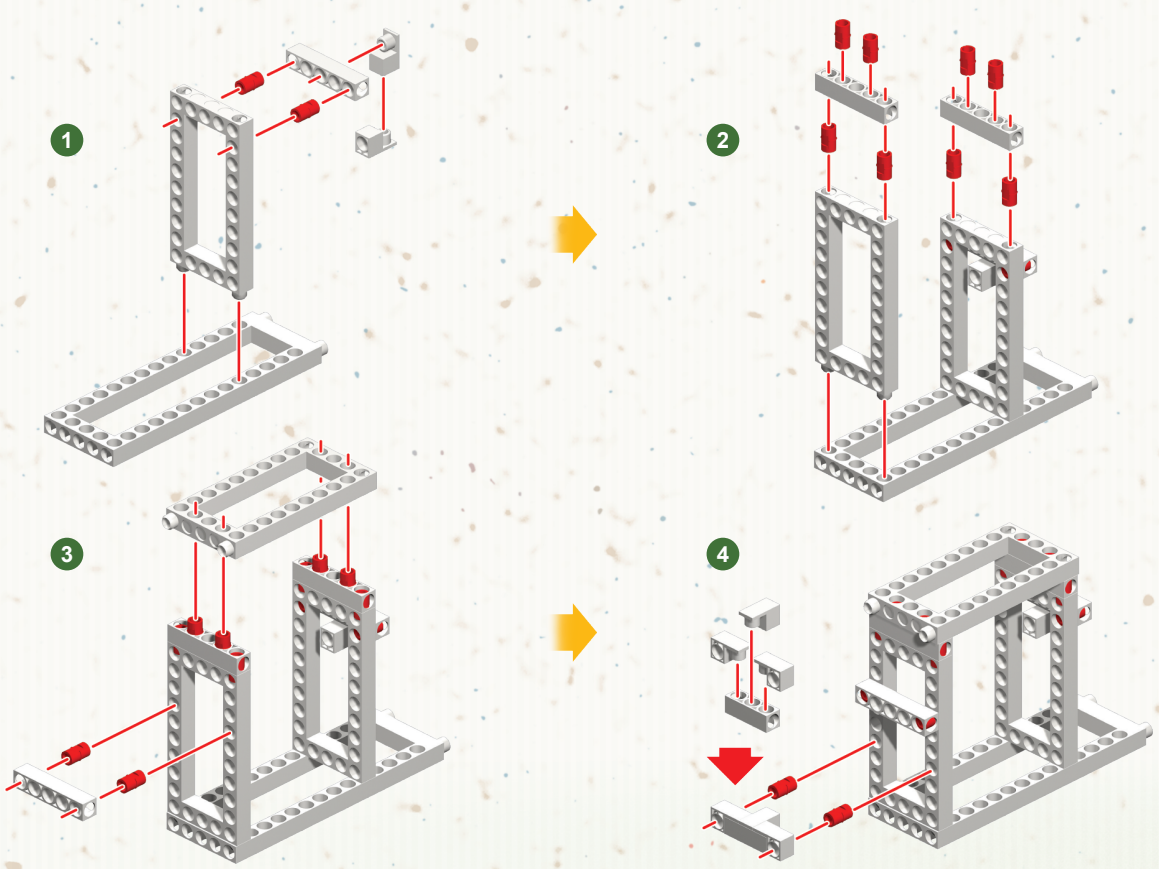
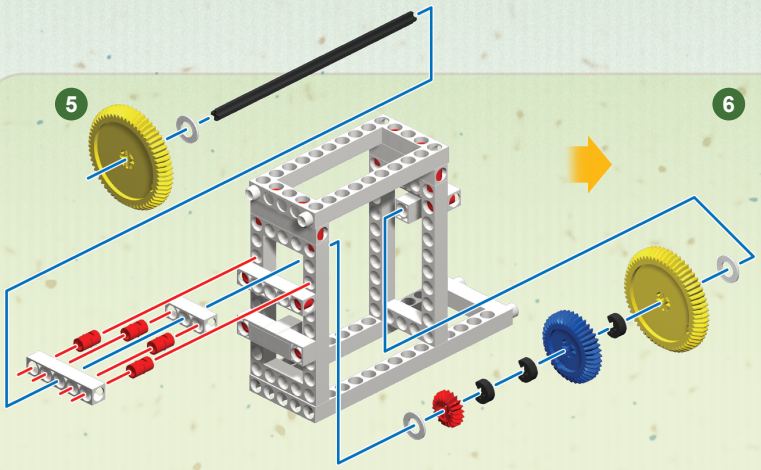
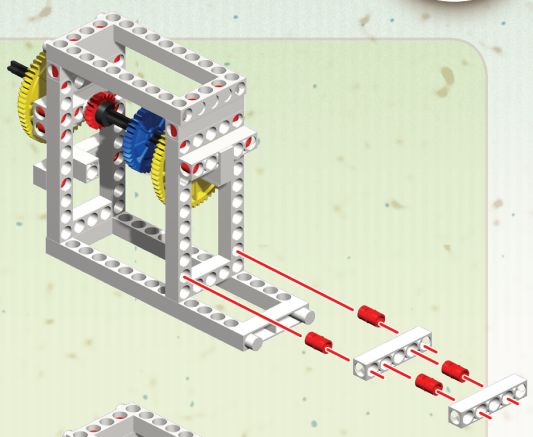
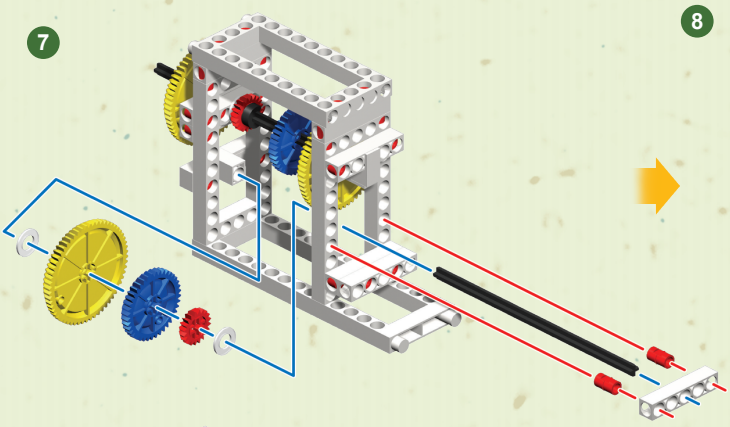


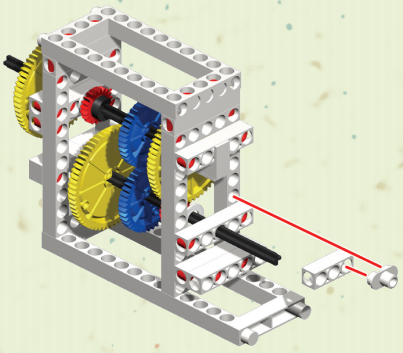
Fig. 57

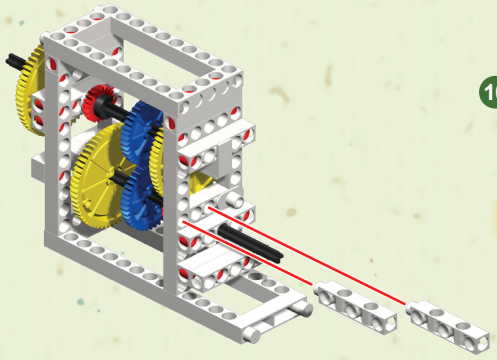


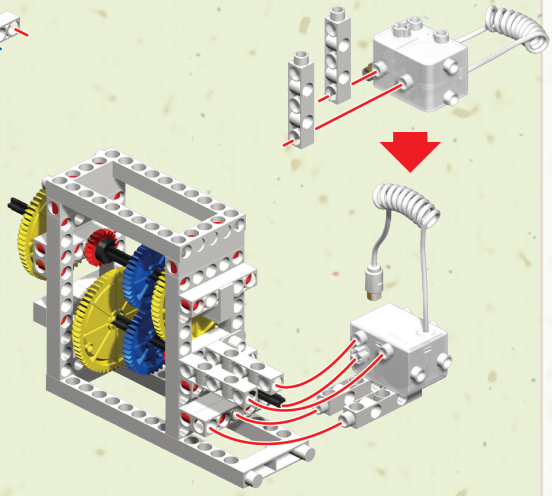




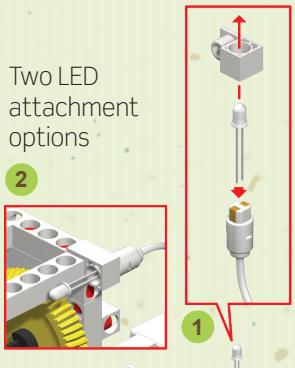


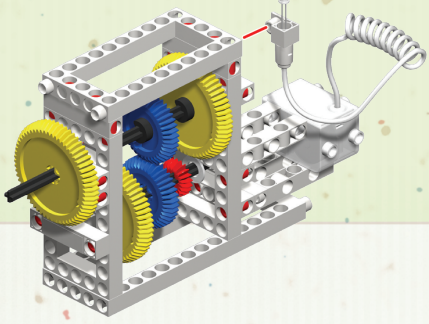


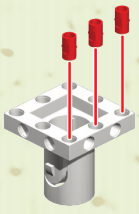


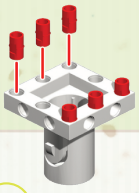


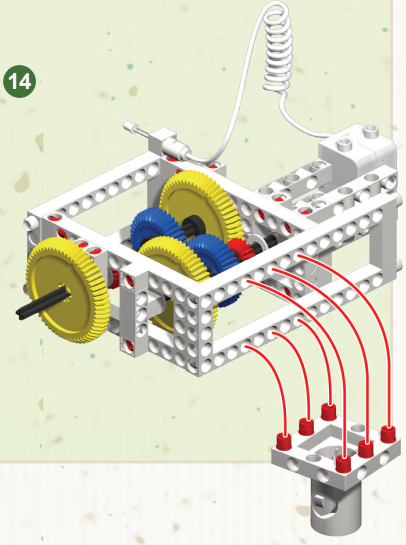
11 Two LED attachment options

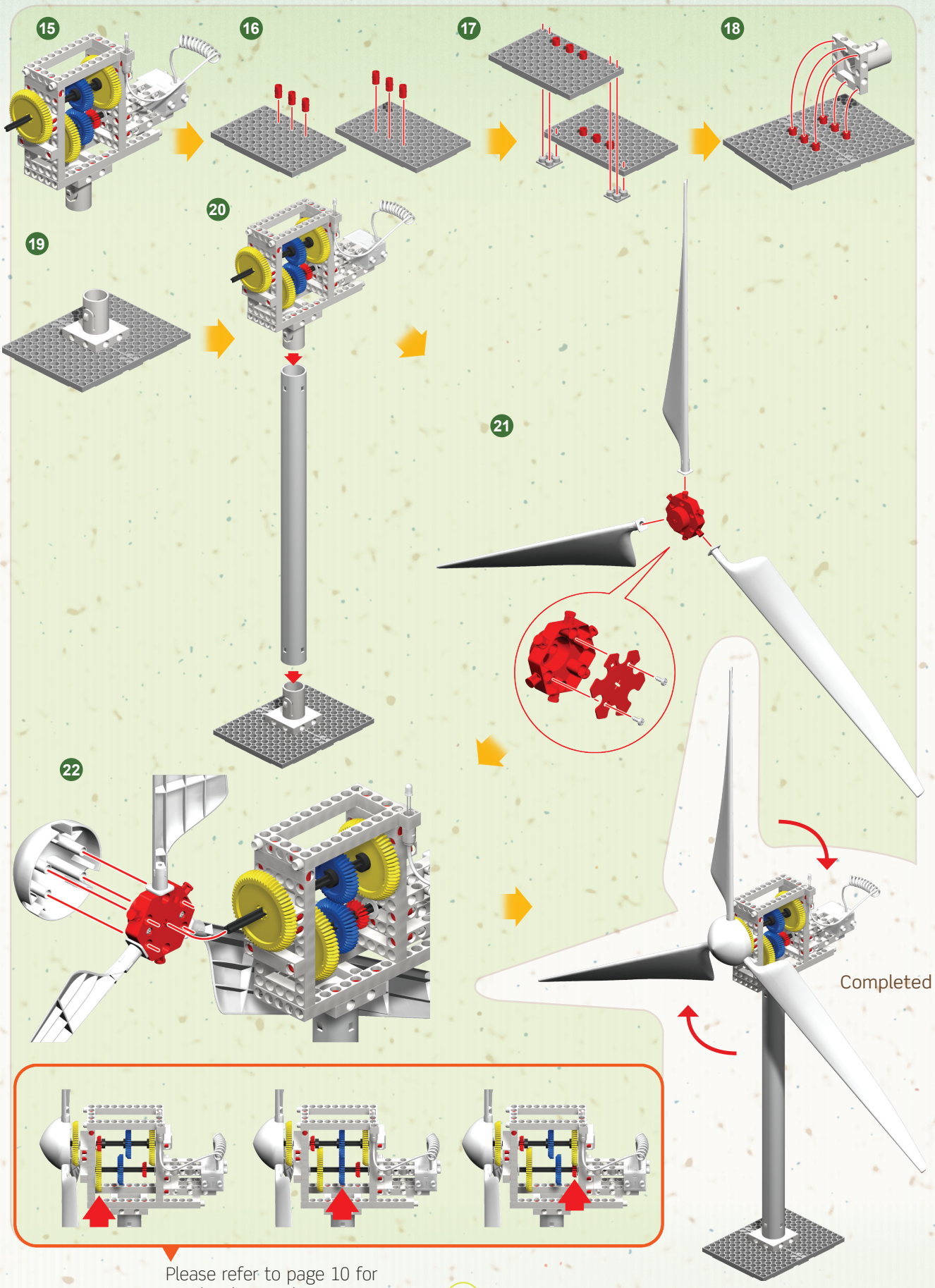










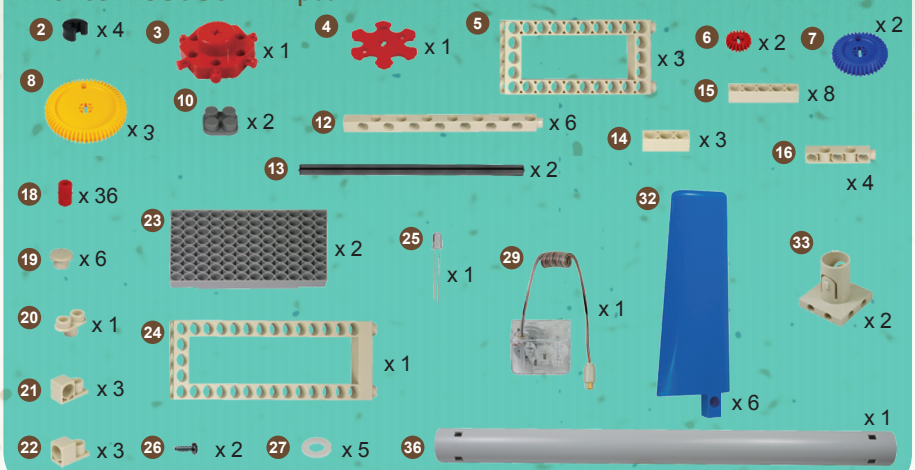


Please refer to page 10 for gearbox instructions.

MODEL 2 Windmill with Short Blades | WIND POWER 2.0

Windmill with Short Blades

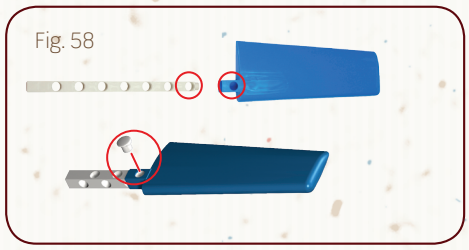
Parts Needed 111 pcs

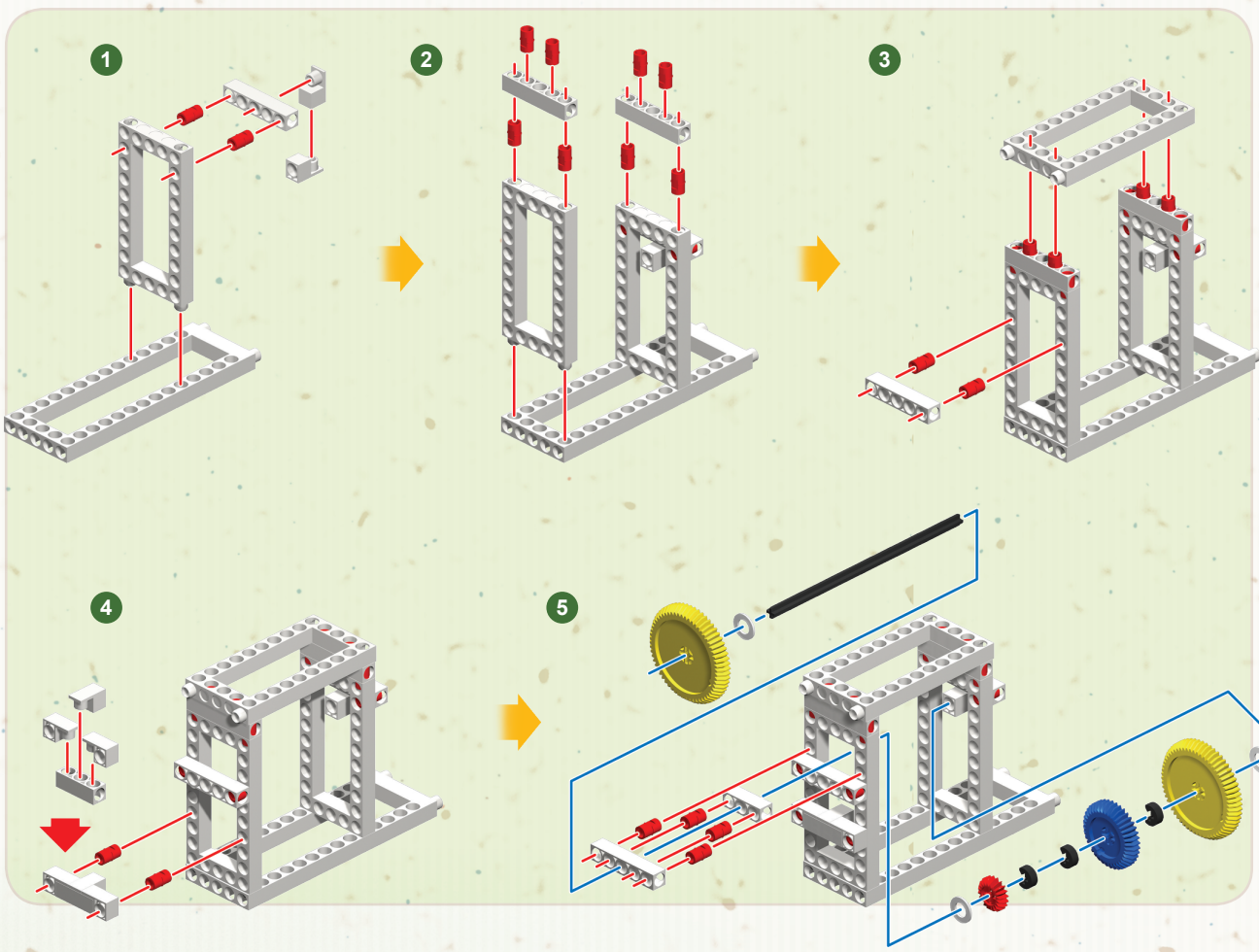


Notes for Assembly

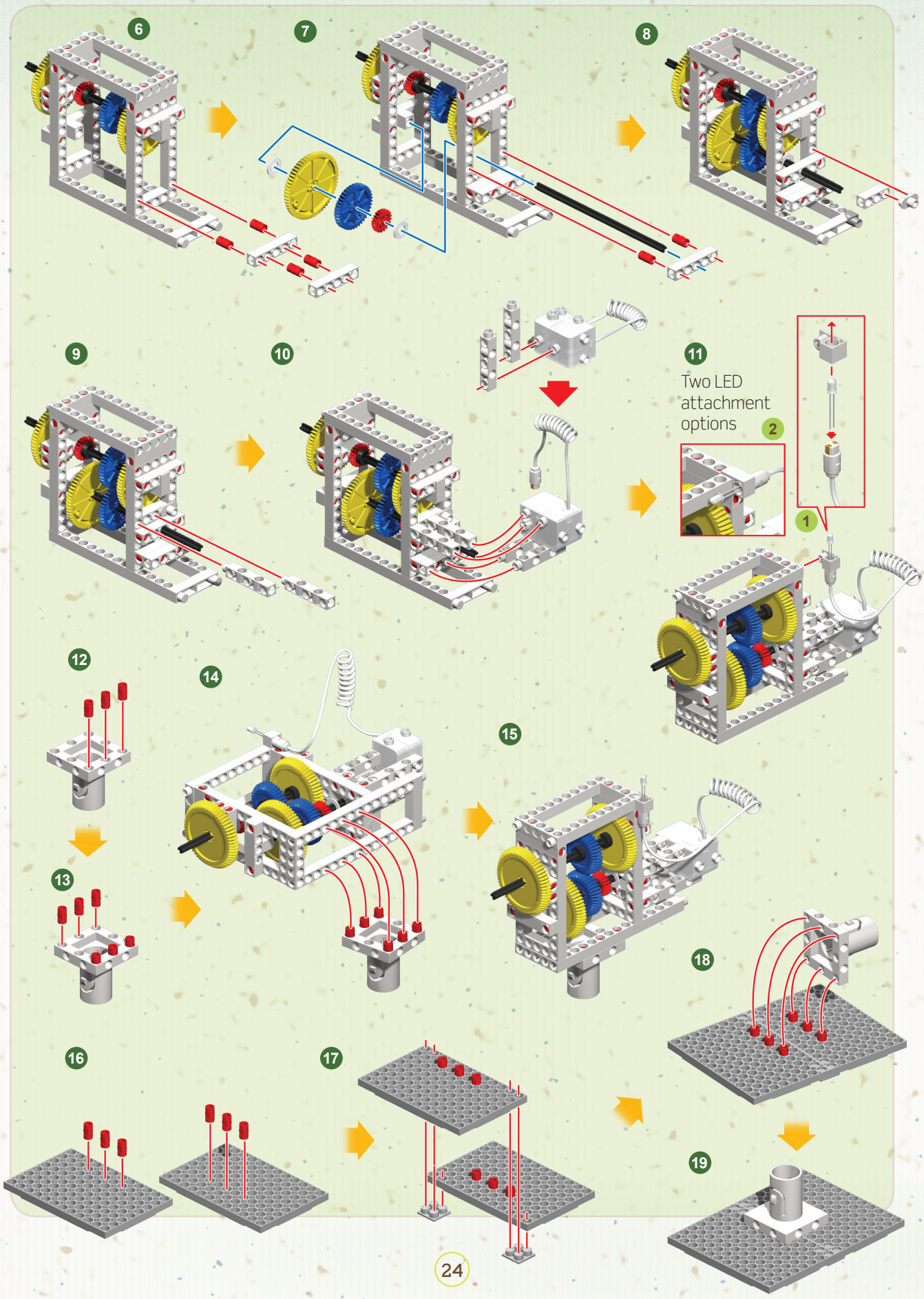
Connecting the short blades to the long rods

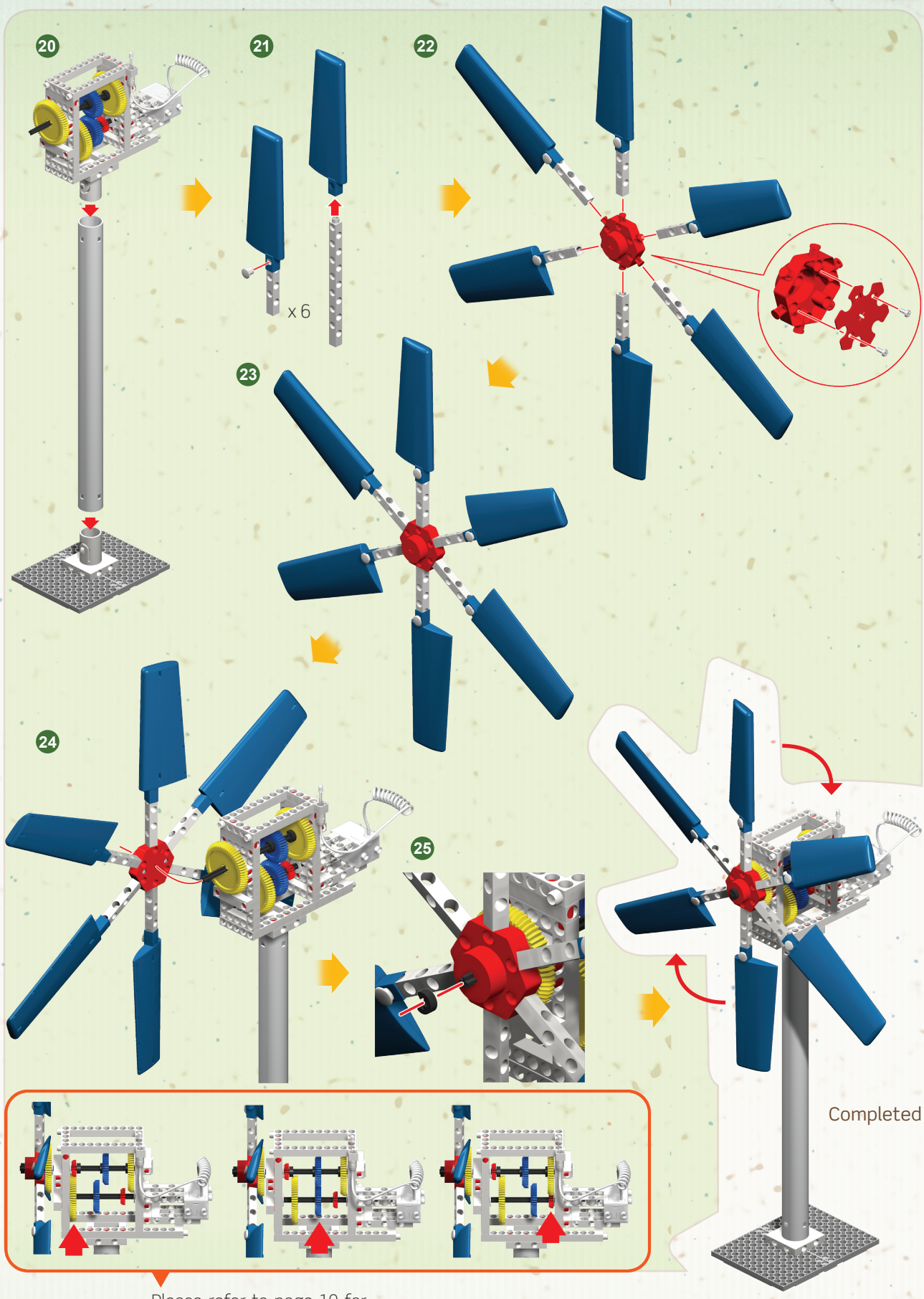
1. Insert the long rod (7-hole dual rod) into the short blade with the side of the rod where there is a hole closest to the end of the rod facing up to join them together. (Fig. 58)
2. Fasten the combination with the button pins as Fig. 58 shows.



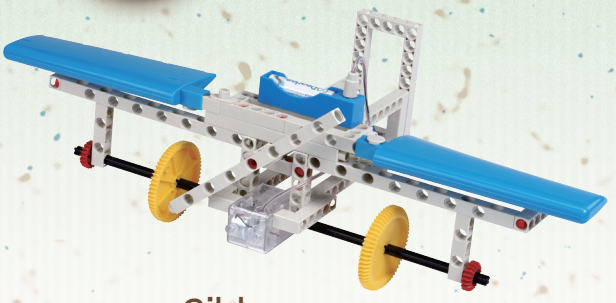


WIND POWER 2.0 | MODEL 2 Windmill with Short Blades



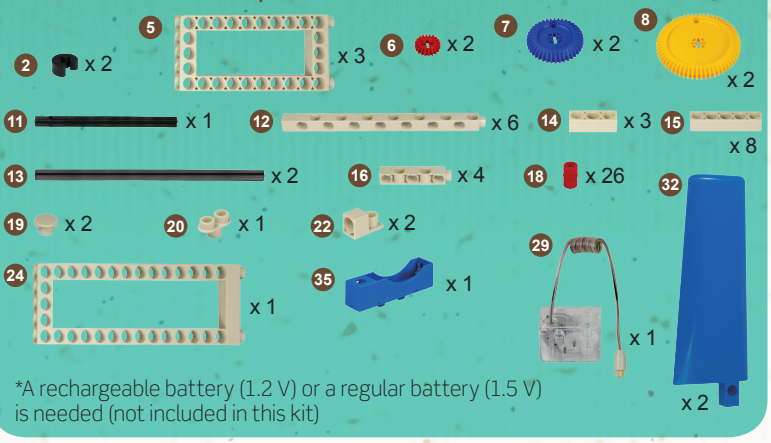


Please refer to page 10 for gearbox instructions.



Gilder

Parts Needed 71 pcs

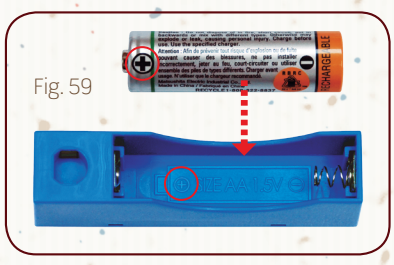


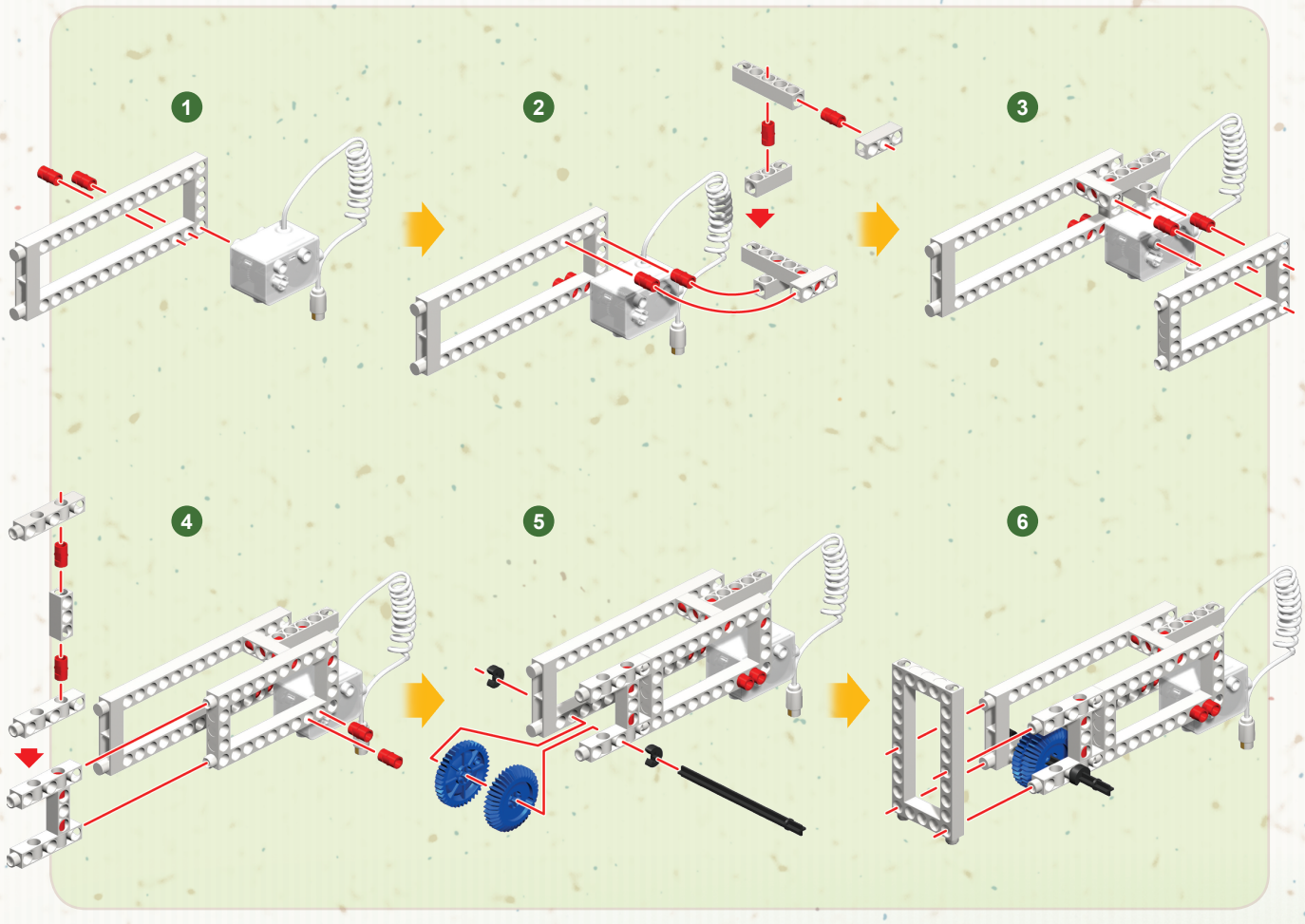
*A rechargeable battery (1.2 V) or a regular battery (1.5 V) is needed (not included in this kit)

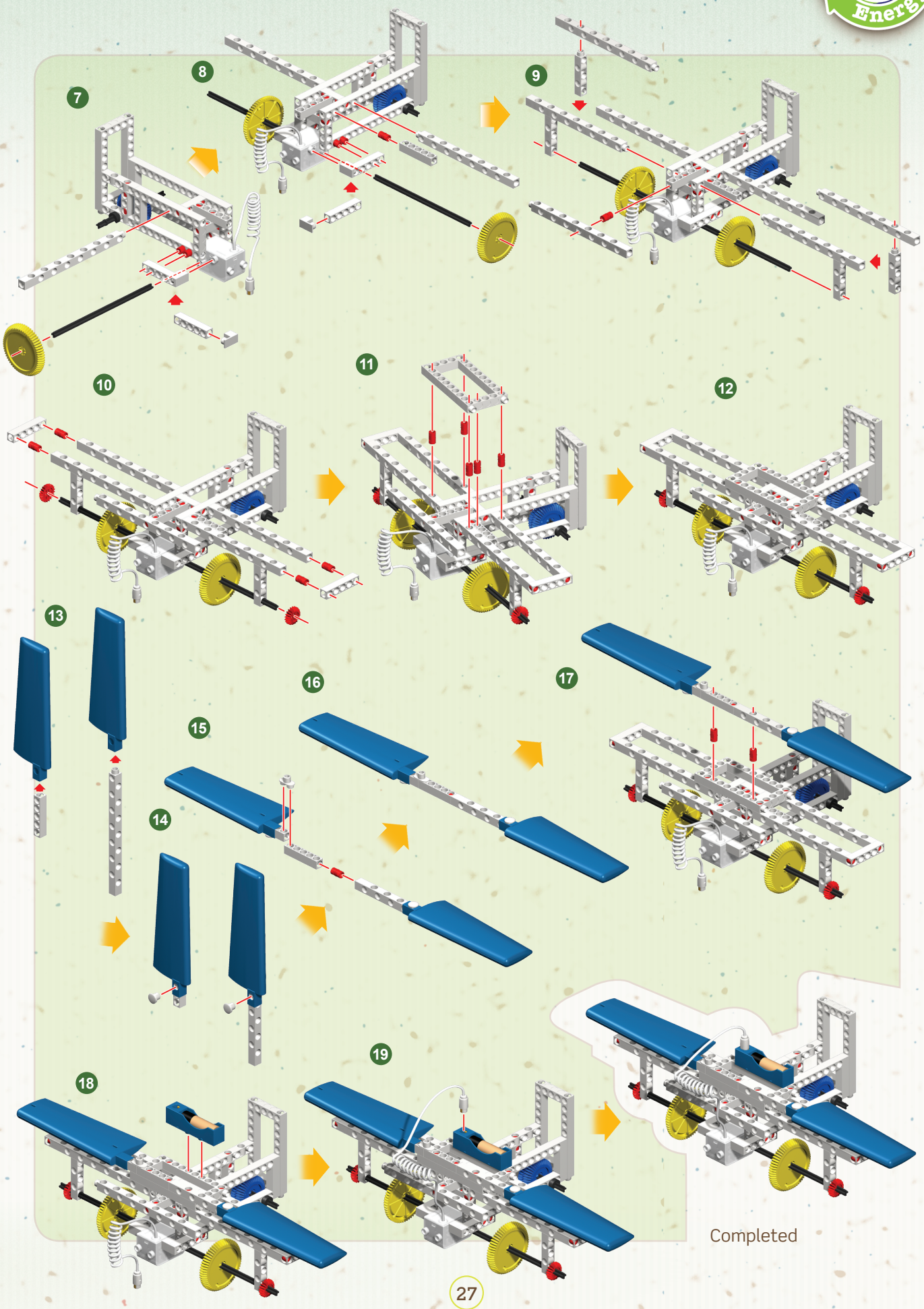
Notes for Assembly

Inserting the battery:

1. Charge the rechargeable battery with either of the windmills, and then insert the fully charged battery into the blue battery holder to power the models.
2. Match the positive pole of the battery to the positive pole of the blue battery holder and then insert the battery as Fig. 59 shows.

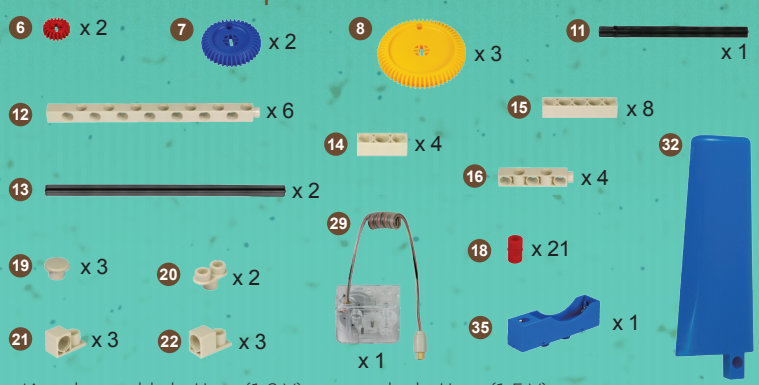






Completed

Parts Needed 69 pcs



*A rechargeable battery (1.2 V) or a regular battery (1.5 V) is needed (not included in this kit)

Notes for Assembly

Inserting the battery:

1. Charge the rechargeable battery with either of the windmills, and then insert the fully charged battery into the blue battery holder to power the models.
2. Match the positive pole of the battery to the positive pole of the blue battery holder and then insert the battery as Fig. 60 shows.

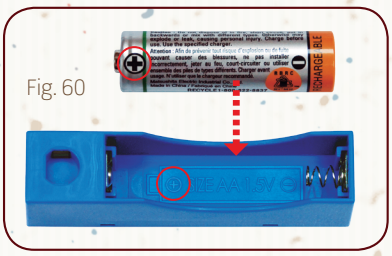
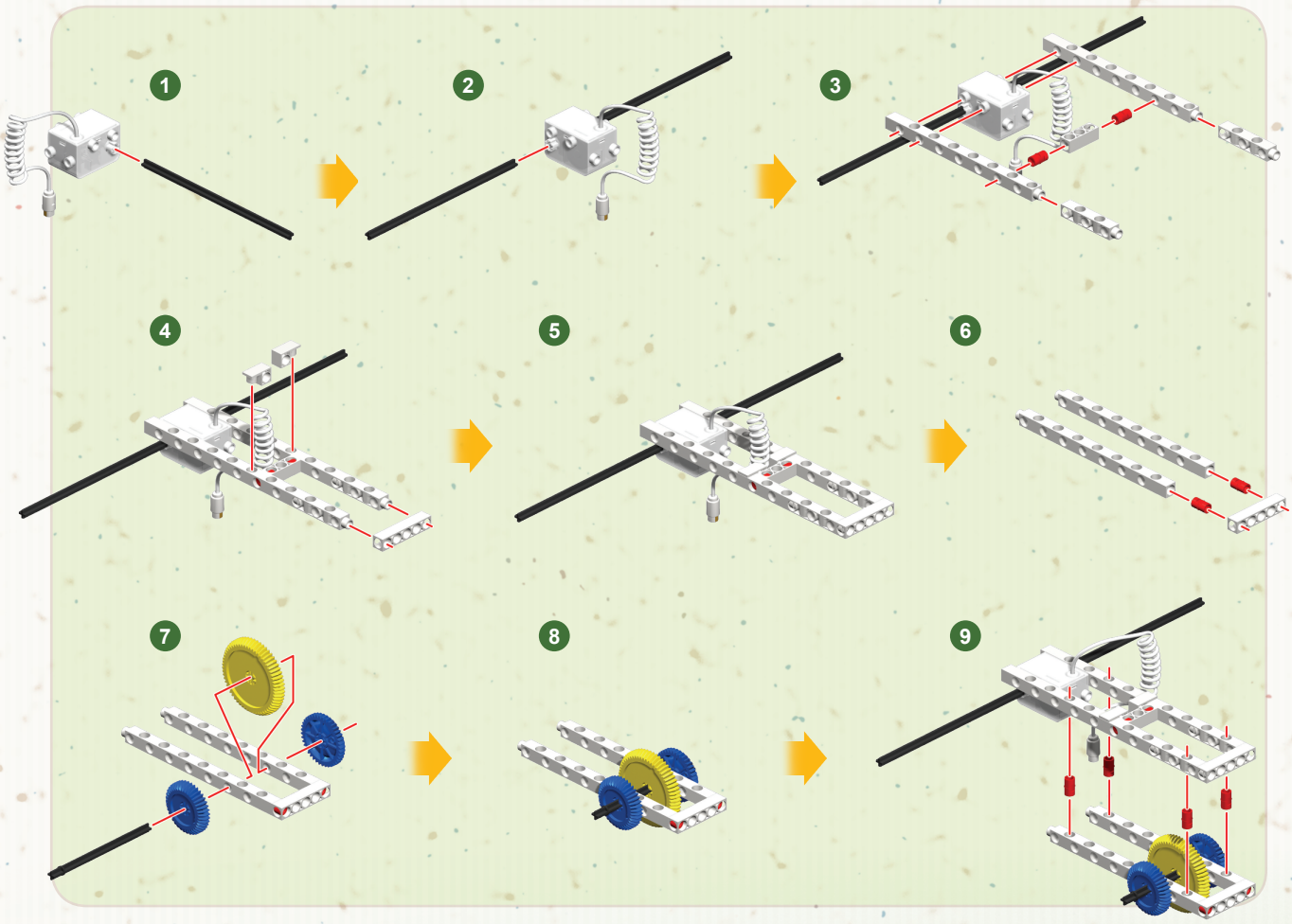
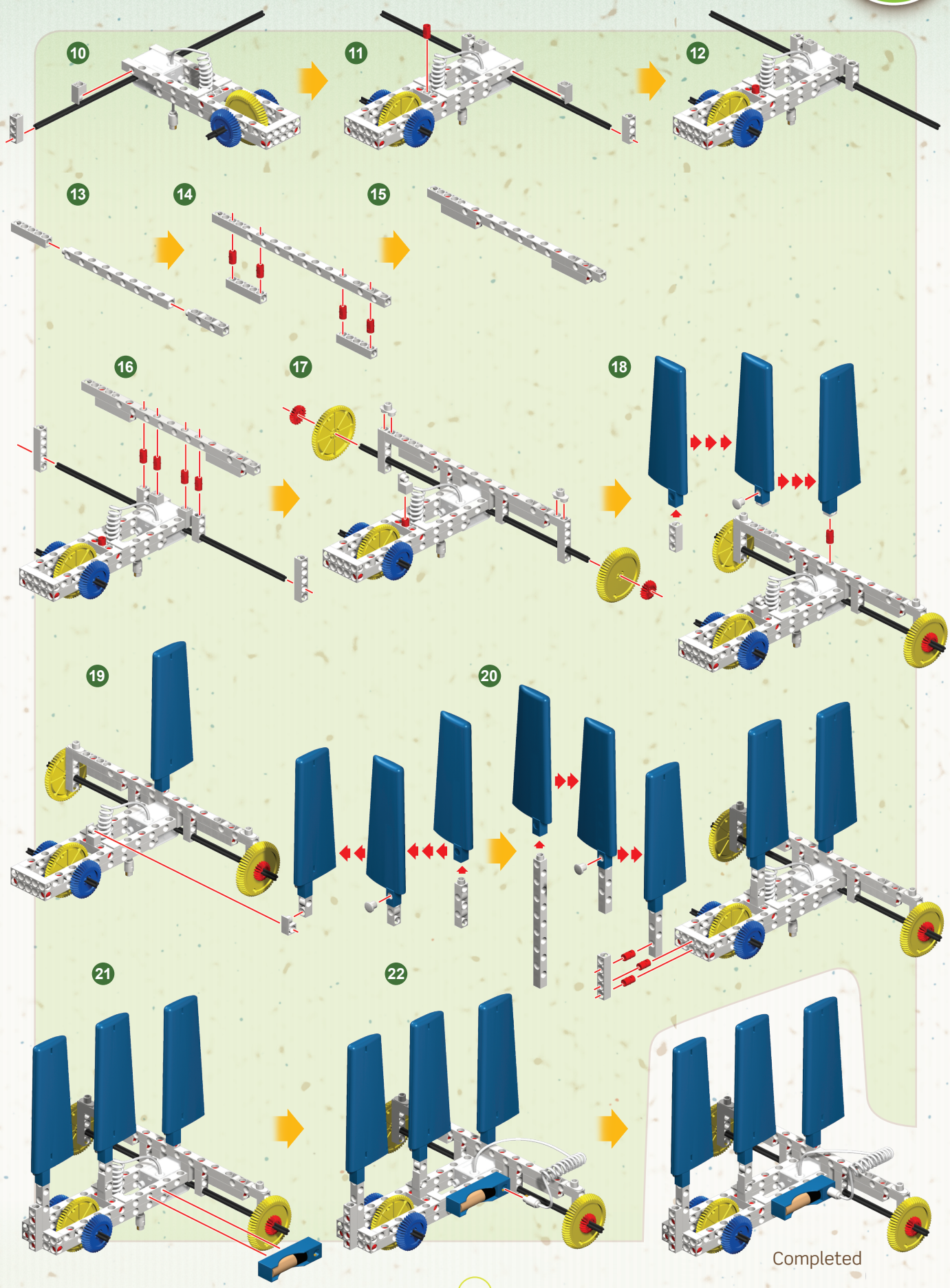


Fig. 60

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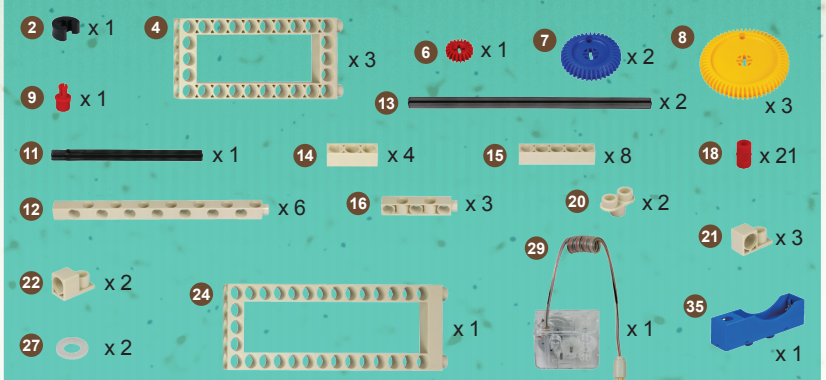
Completed

Tricycle

Parts Needed 68 pcs



*A rechargeable battery (1.2 V) or a regular battery (1.5 V) is needed (not included in this kit)

Notes for Assembly

Inserting the battery:

1. Charge the rechargeable battery with either of the windmills, and then insert the fully charged battery into the blue battery holder to power the models.
2. Match the positive pole of the battery to the positive pole of the blue battery holder and then insert the battery as Fig. 61 shows.

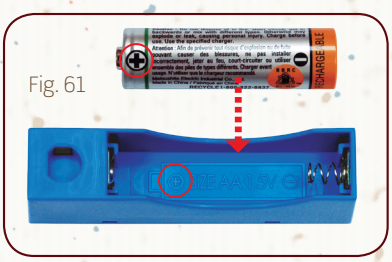
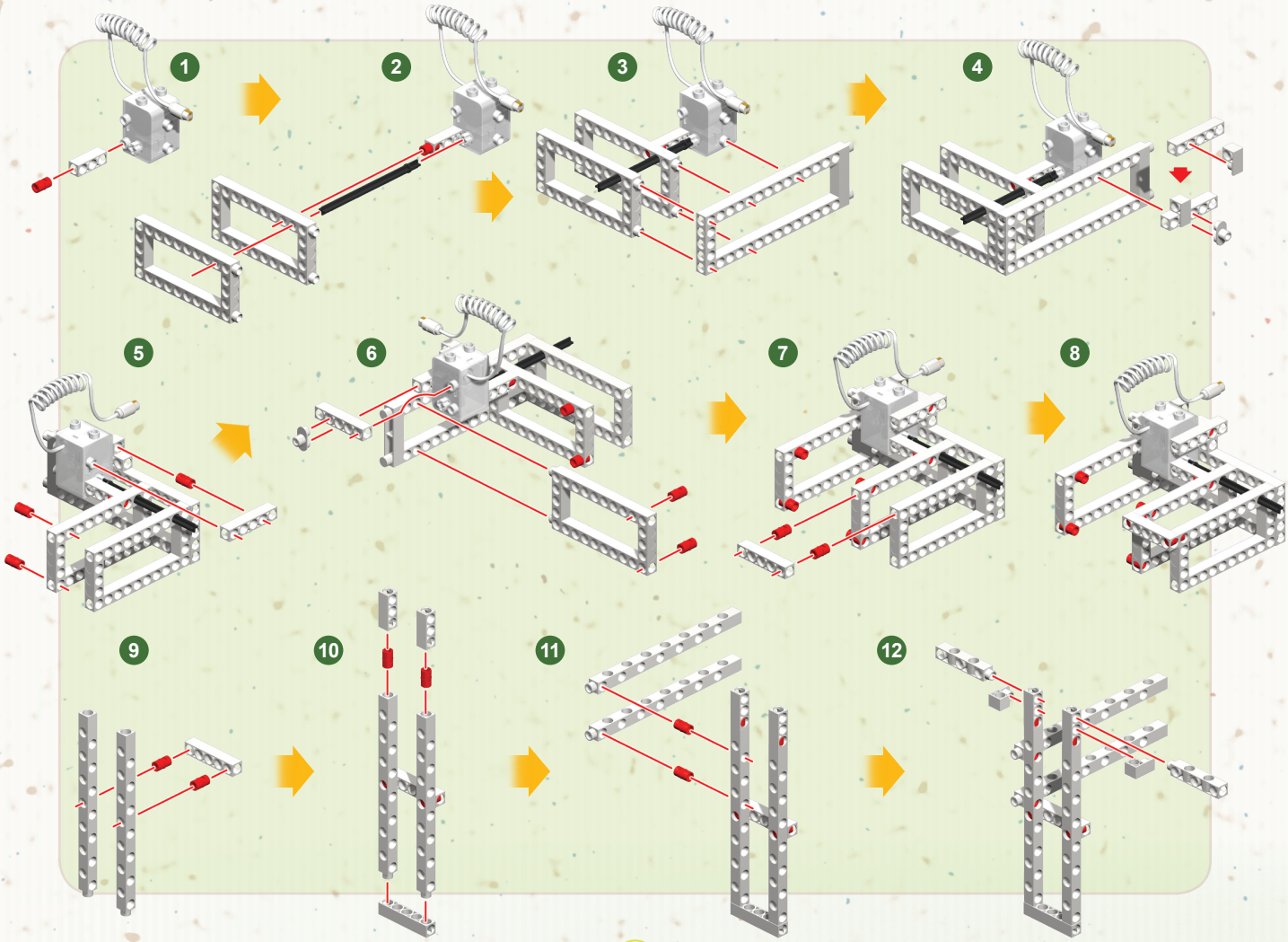
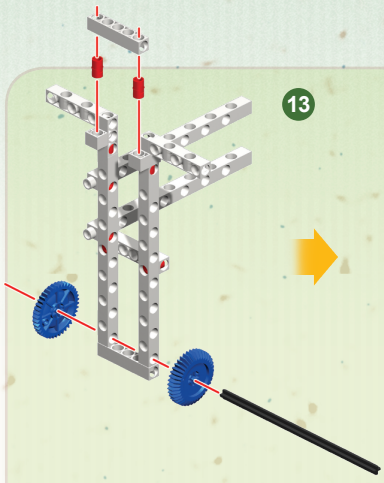
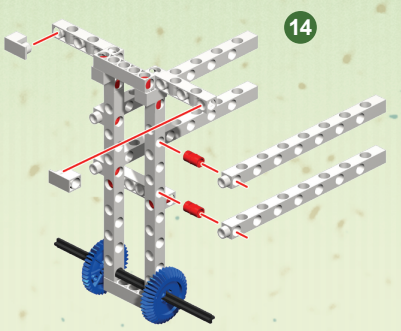
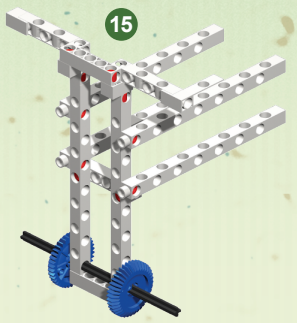


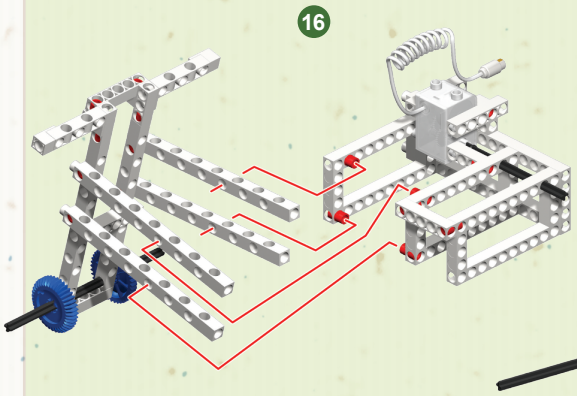
Fig. 61

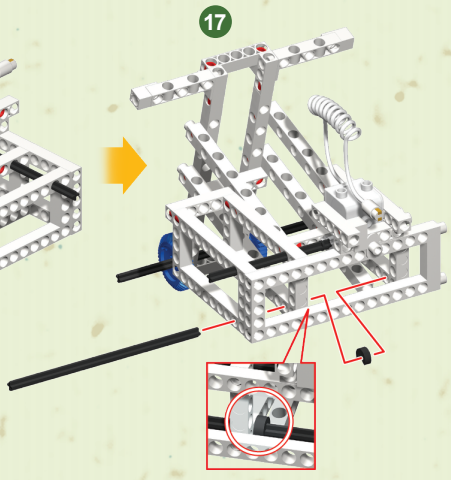


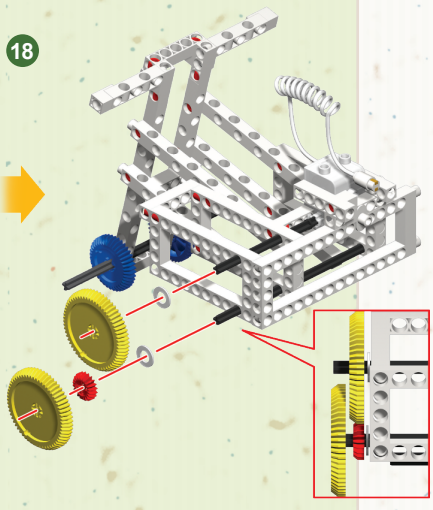


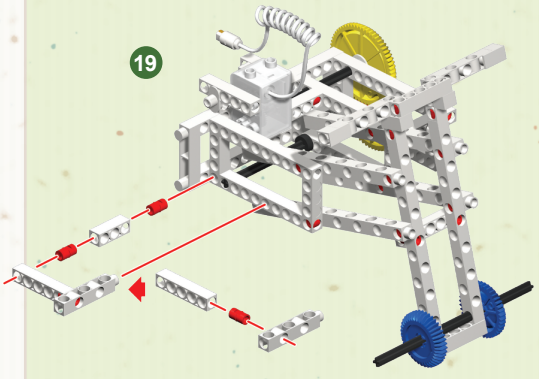


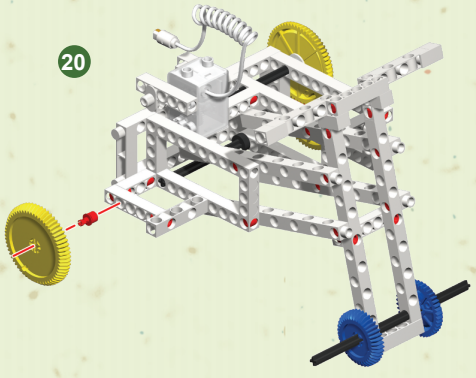


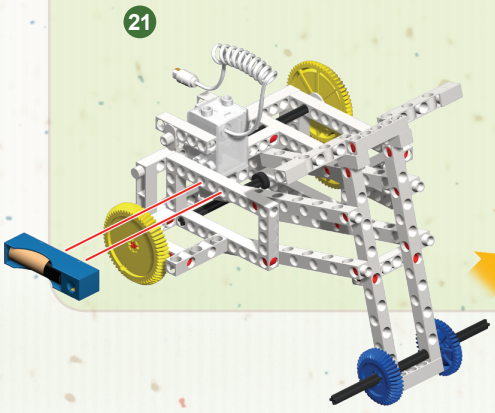


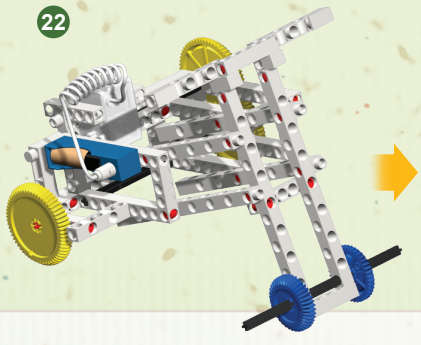


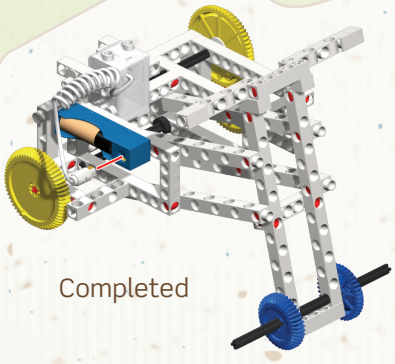








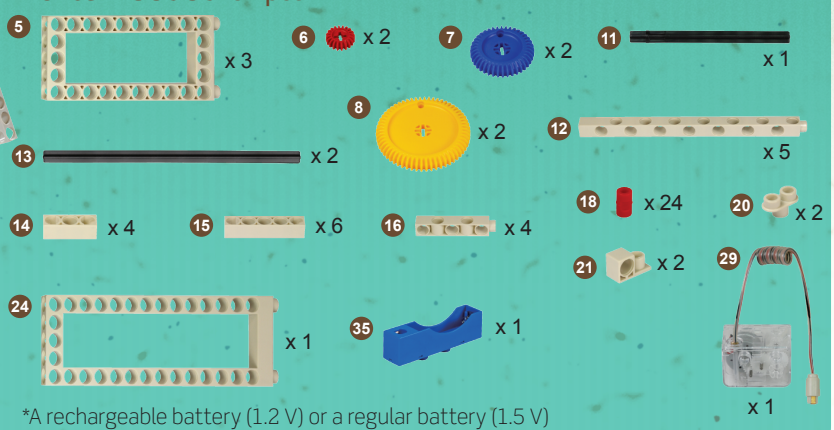




Completed

Jet Car

Parts Needed 62 pcs



*A rechargeable battery (1.2 V) or a regular battery (1.5 V) is needed (not included in this kit)

Notes for Assembly

Inserting the battery:

1. Charge the rechargeable battery with either of the windmills, and then insert the fully charged battery into the blue battery holder to power the models.
2. Match the positive pole of the battery to the positive pole of the blue battery holder and then insert the battery as Fig. 62 shows.

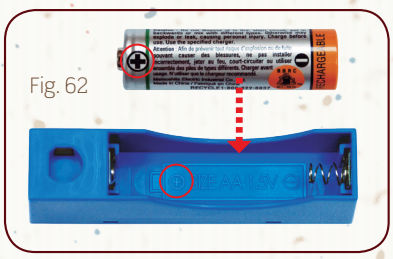
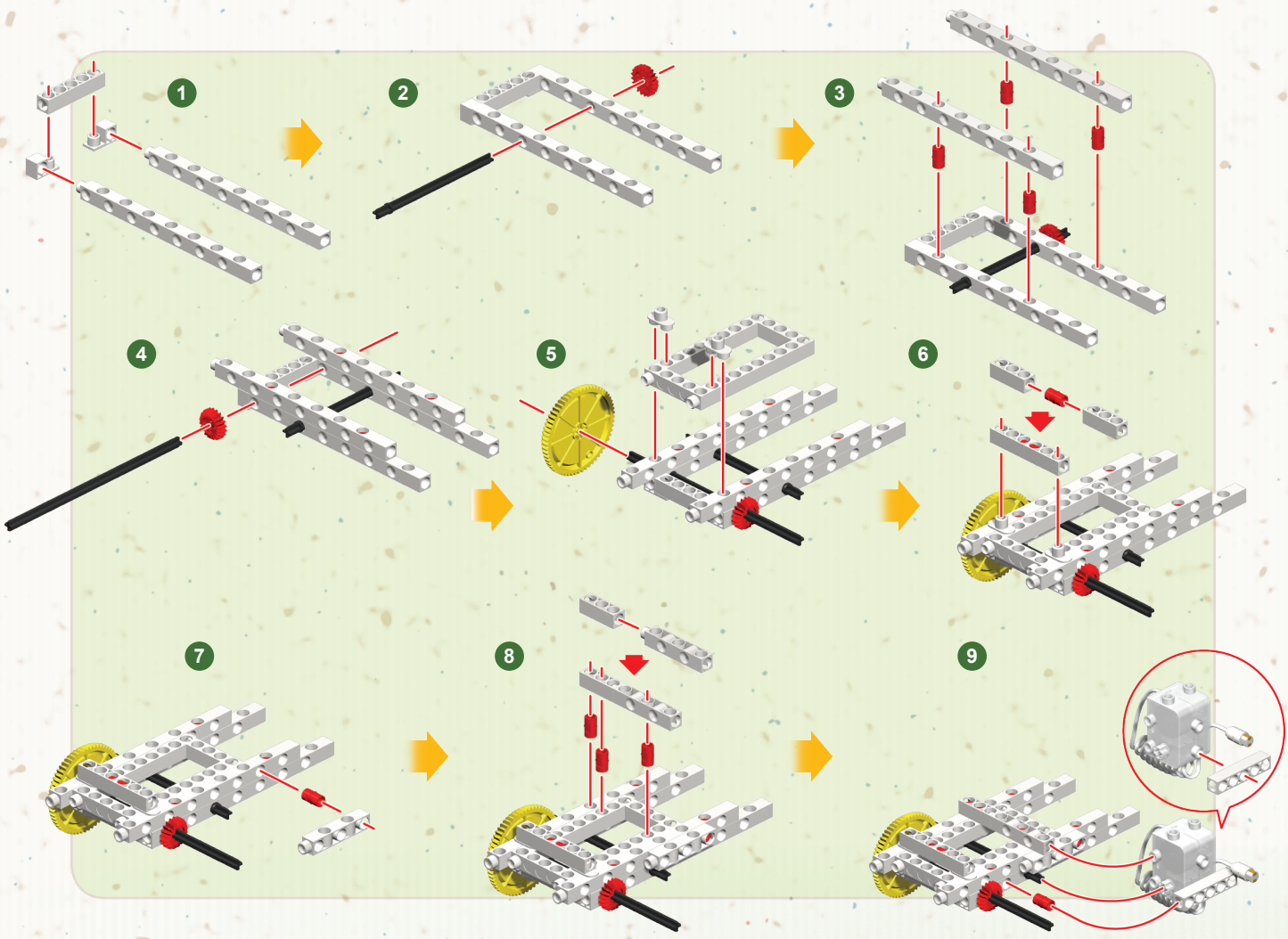
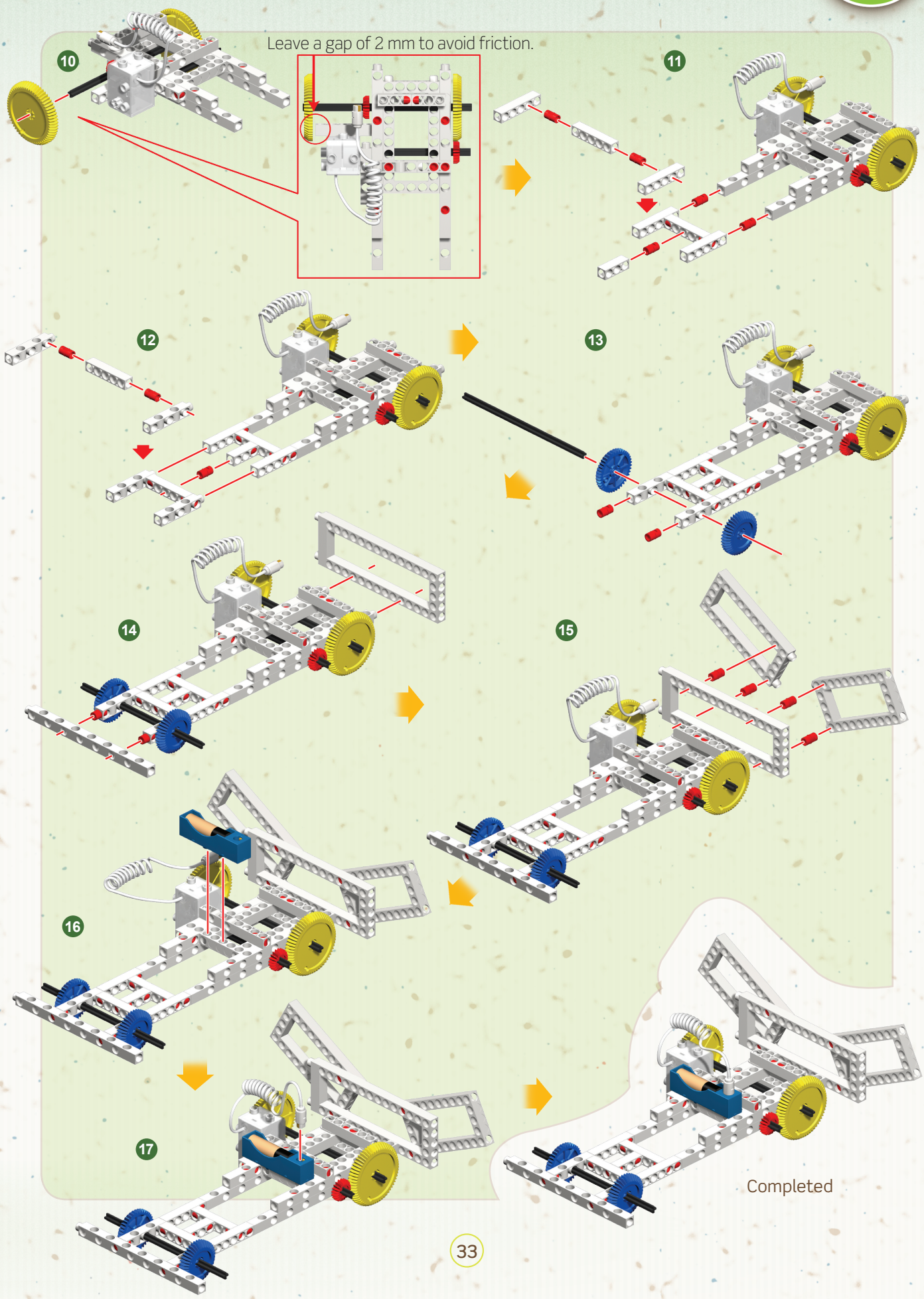


Fig. 62




Leave a gap of 2 mm to avoid friction.
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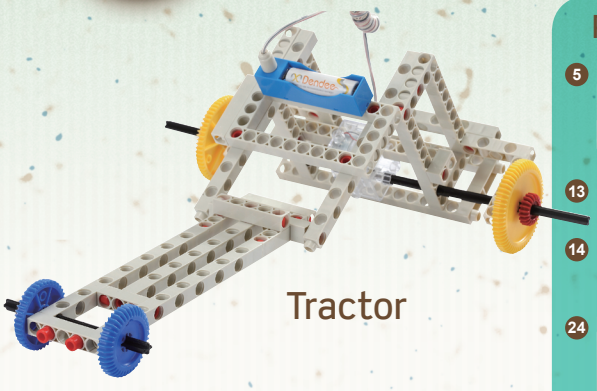
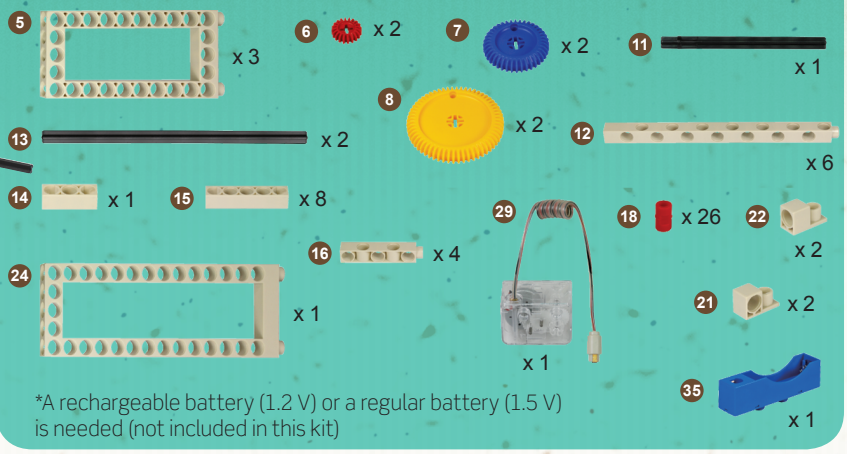
Completed

WIND POWER 2.0 | MODEL 7 Tractor



Tractor

Parts Needed 64 pcs



*A rechargeable battery (1.2 V) or a regular battery (1.5 V) is needed (not included in this kit)

Notes for Assembly

Inserting the battery:

1. Charge the rechargeable battery with either of the windmills, and then insert the fully charged battery into the blue battery holder to power the models.
2. Match the positive pole of the battery to the positive pole of the blue battery holder and then insert the battery as Fig. 63 shows.

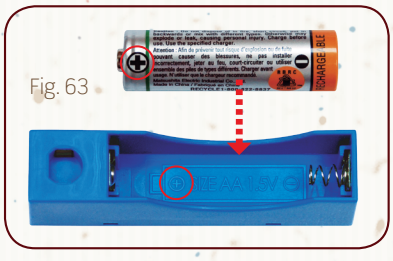
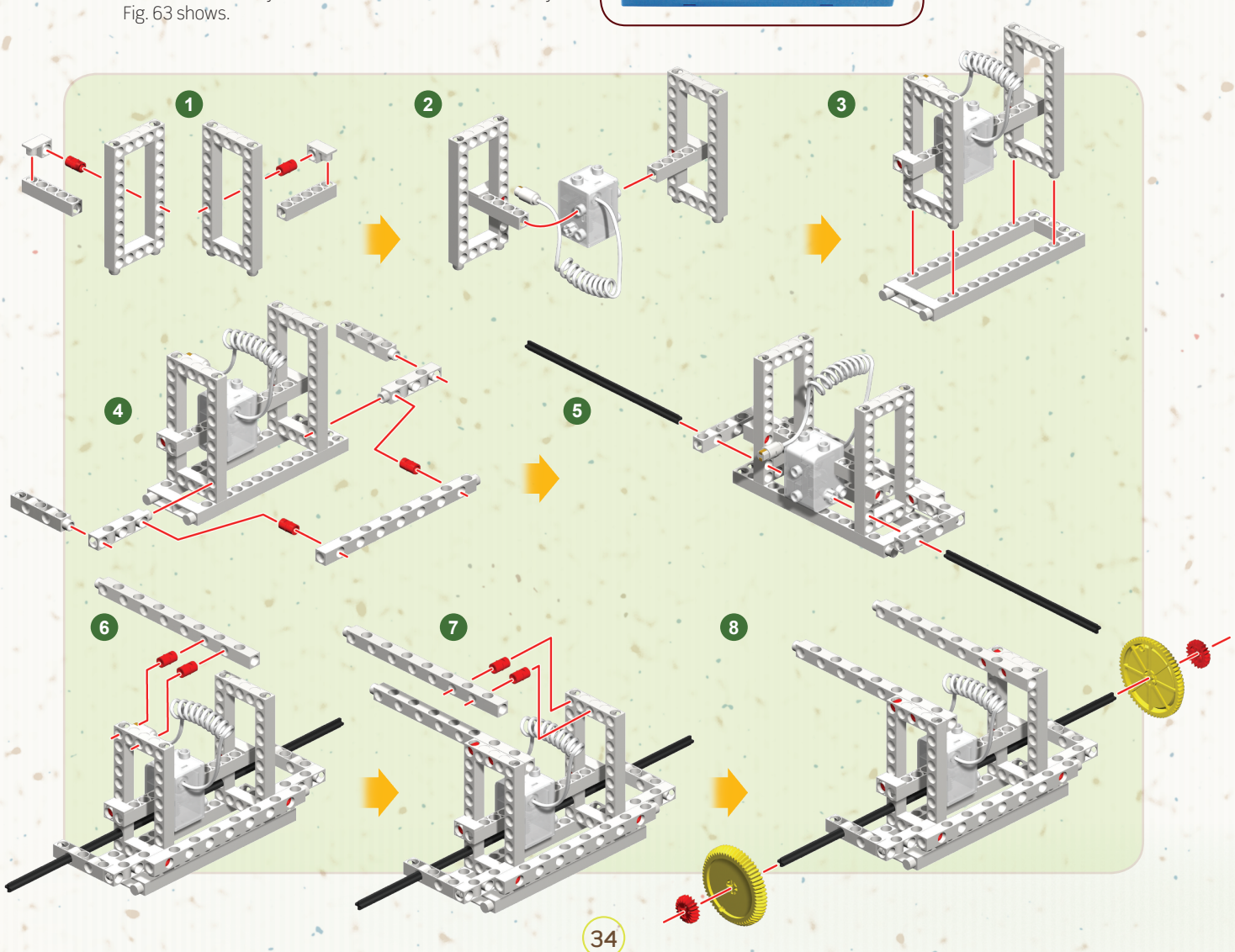
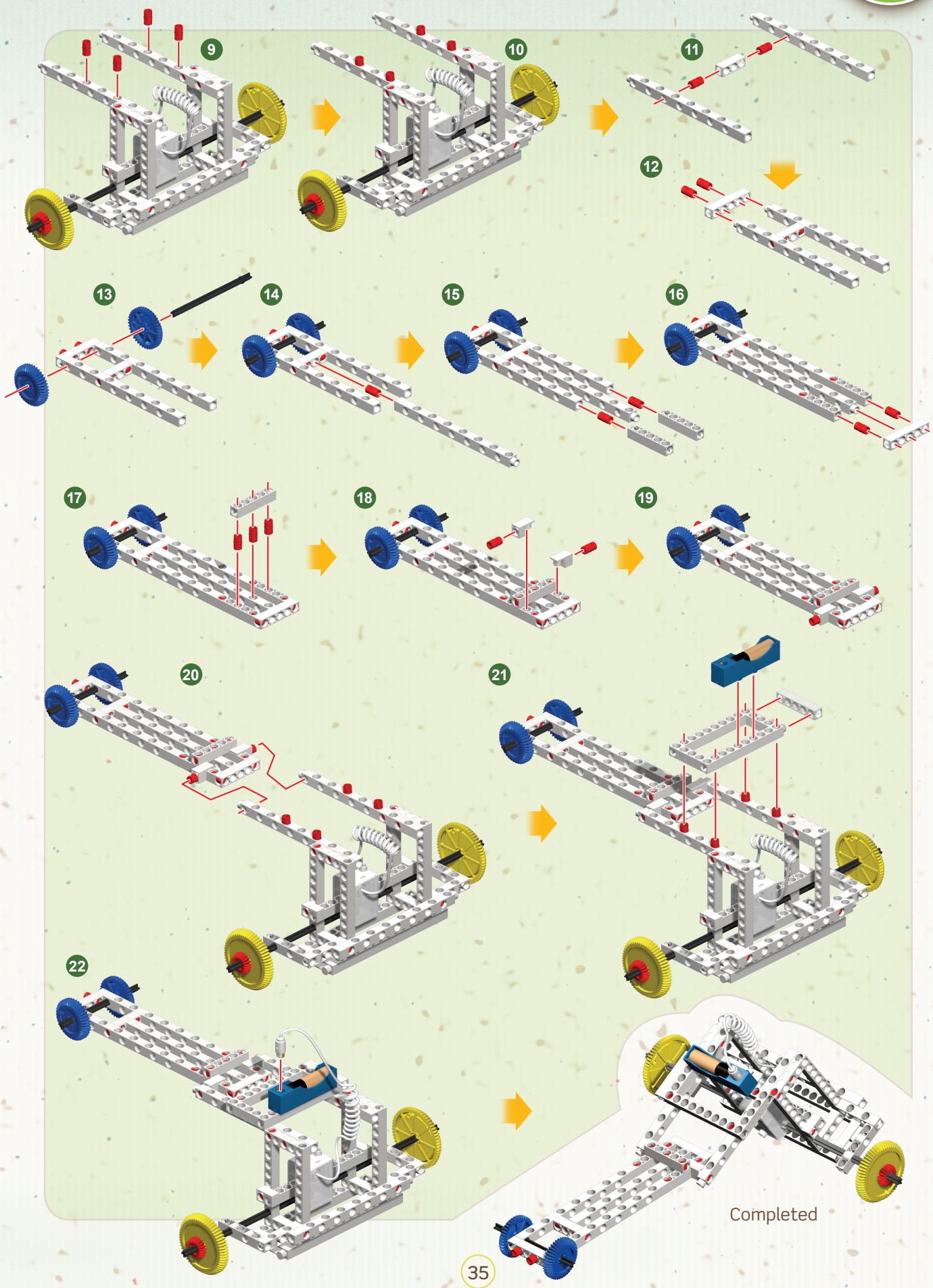


Fig. 63

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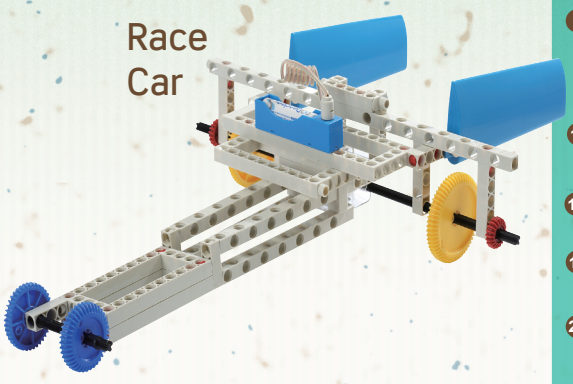
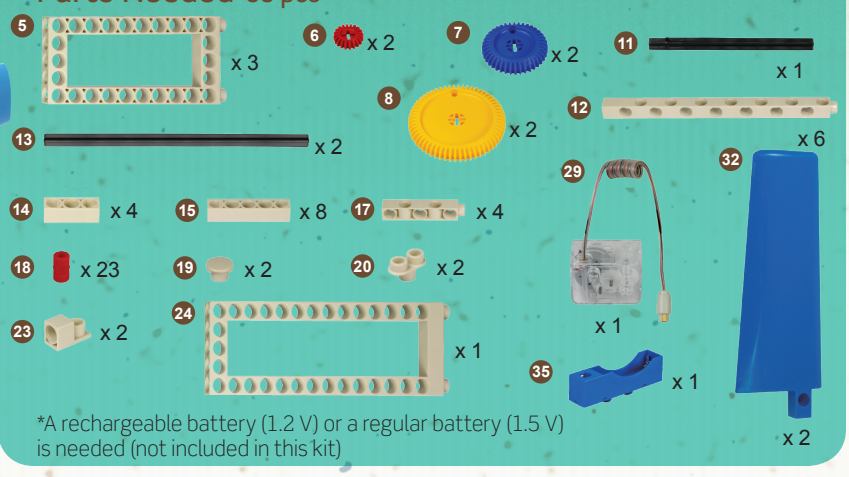
Race Car



Parts Needed 68 pcs

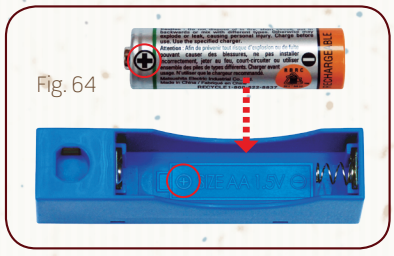


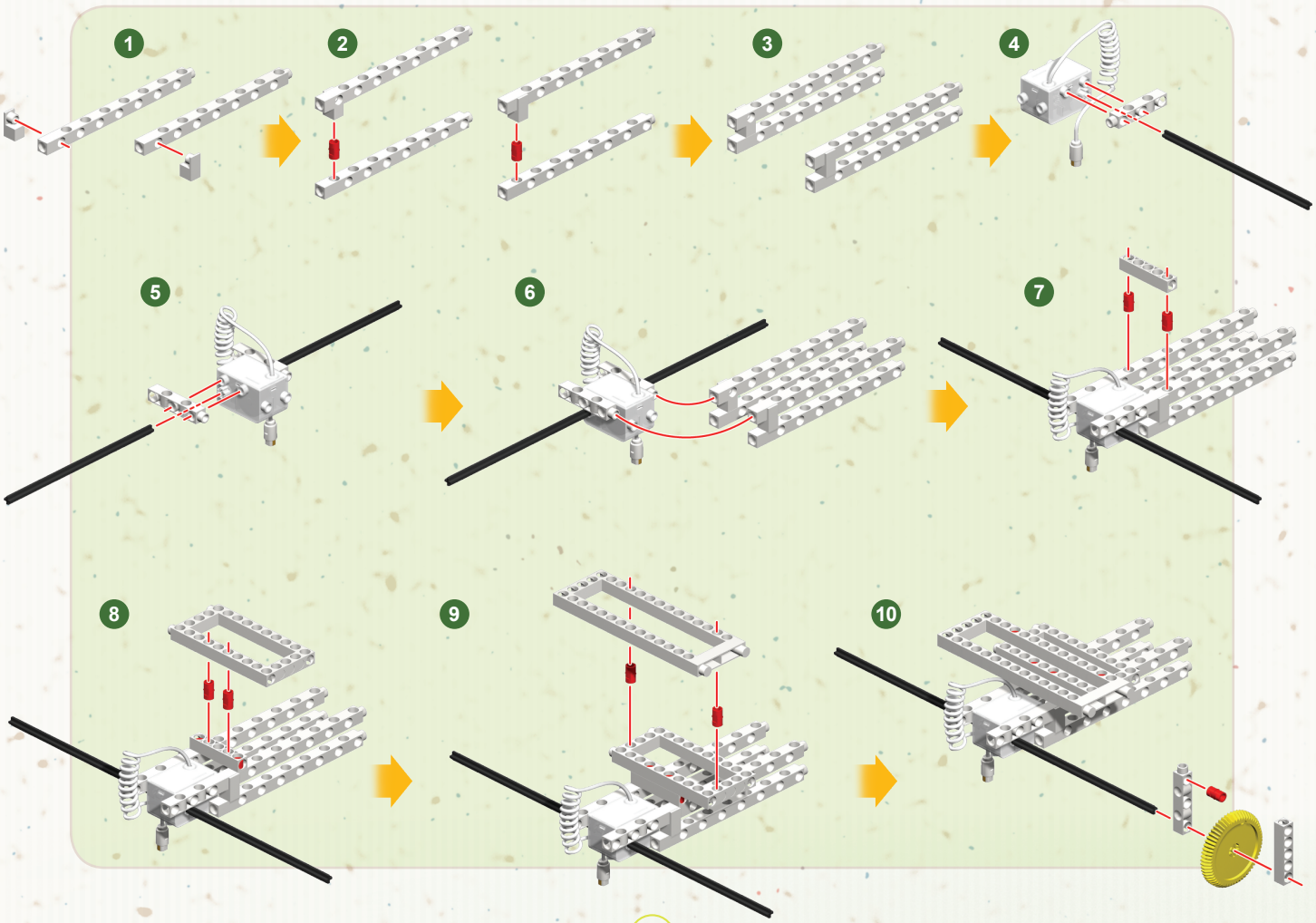
*A rechargeable battery (1.2 V) or a regular battery (1.5 V) is needed (not included in this kit)

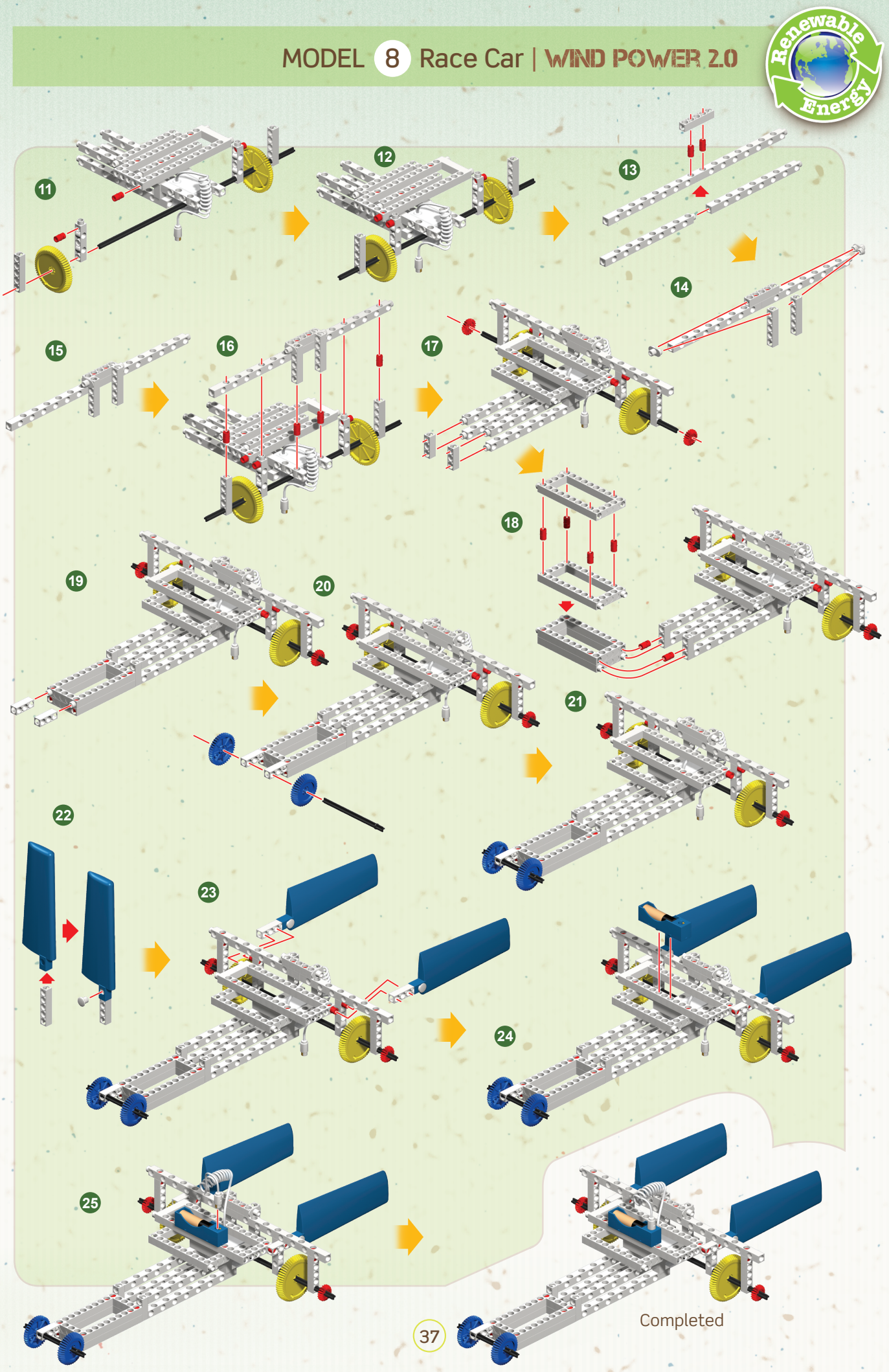
Notes for Assembly

Inserting the battery:

1. Charge the rechargeable battery with either of the windmills, and then insert the fully charged battery into the blue battery holder to power the models.
2. Match the positive pole of the battery to the positive pole of the blue battery holder and then insert the battery as Fig. 64 shows.






Renewable Energy
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