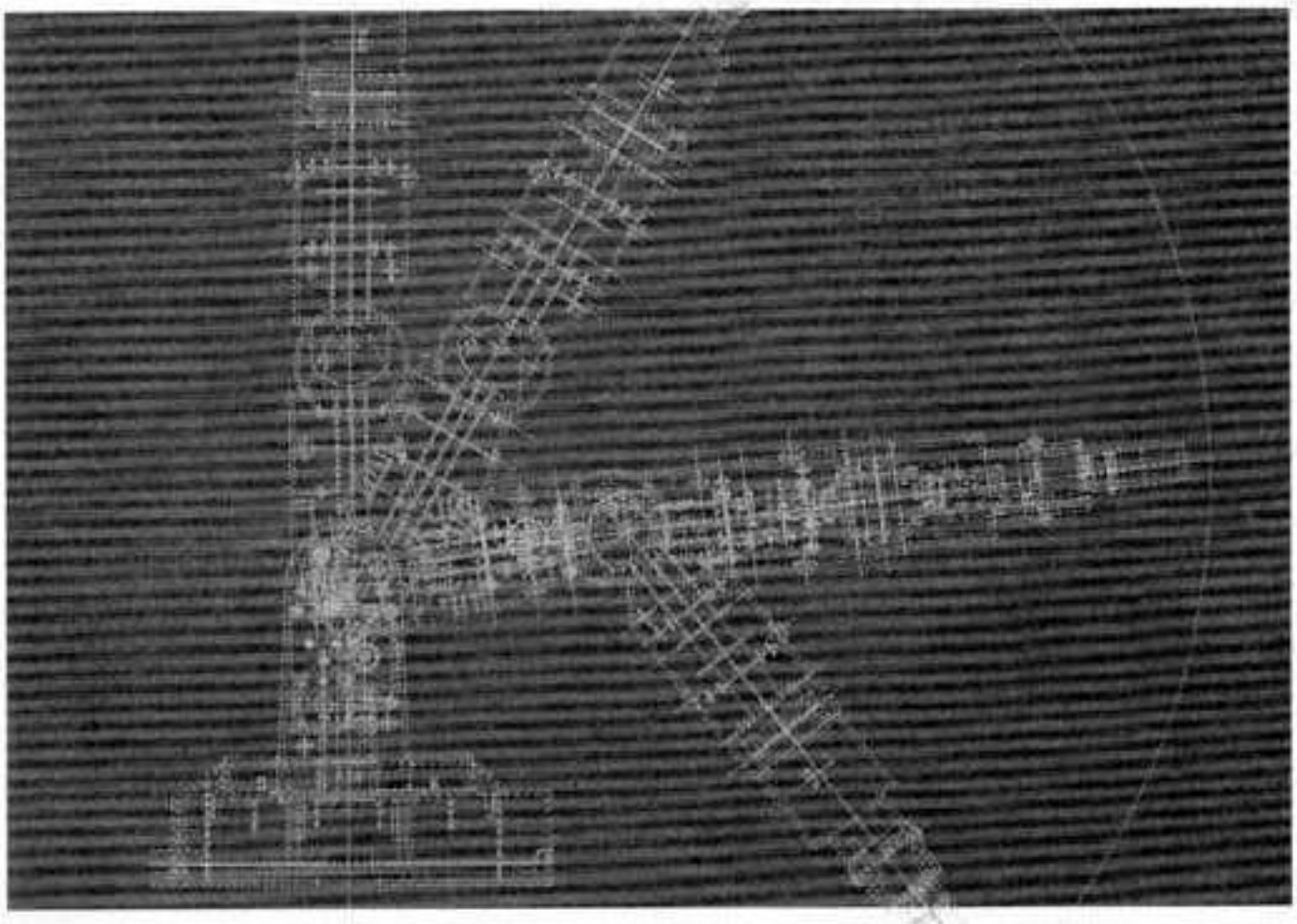
999E-03

Lot No.

MOVIT®

ROBOT ARM

MR-999E



Distributor :

© EK JAPAN CO.,LTD.1999

● Contents

PRECAUTION

- ◆Read this instruction manual carefully before getting started. Have your parents or someone who can help you read the instruction manual with you. Keep this instruction manual for future reference.
- ◆Be careful when handling the tools such as a penknife and a diagonal cutter.
- ◆Handle the small and sharp parts carefully.
- ◆Keep the product out of reach of small children. Do not assemble the product where small children can reach and touch it. They may get injured or put the parts / small vinyl bags into their mouth. Immediately dispose of the packaging materials and the left over parts sensibly.
- ◆Do not short-circuit the printed circuit board, electronic parts, or power supply terminals. It will result in overheating of the parts and batteries, causing injury and fire.
- ◆Do not insert the wires into socket outlets. It will cause damage and injury.
- ◆Keep fingers out of the moving sections, such as wheels, legs, gears and motor shafts.
- ◆Do not hinder the movement of moving sections by force. Remove the hindrances in the moving sections, such as a piece of thread, before operating. Otherwise, the motor will overheat, causing injury and fire.
- ◆The specifications and forms of this product are subject to change without prior notice

● ROBOT ARM (MR-999E)
Product Information

ROBOT ARM has five separate movements to grab / release, lift / lower, rotate wrist and pivot sideways controlled by five switches of wired controller. ROBOT ARM introduces the fundamentals of robotic sensing and the basic principles of mechanics. The transparent arm and LED lights allow you to observe gear mechanism and its movement. The manual contains detailed description of its components and instructions on assembling ROBOT ARM together with an explanation of the mechanism involved and a brief history of robots.

Specifications

Five axis of motion:

Base to rotate left and right : 350 degrees
Shoulder moving range : 120 degrees
Elbow moving range : 135 degrees
Wrist rotate CW & CCW : 340 degrees
Gripper open and close : 0~50 mm

Product Dimensions:

Maximum length outwards : 360 mm
Maximum heights upwards : 510 mm
Maximum lifting capacity : 130g (4.6 oz.)

Control Box:

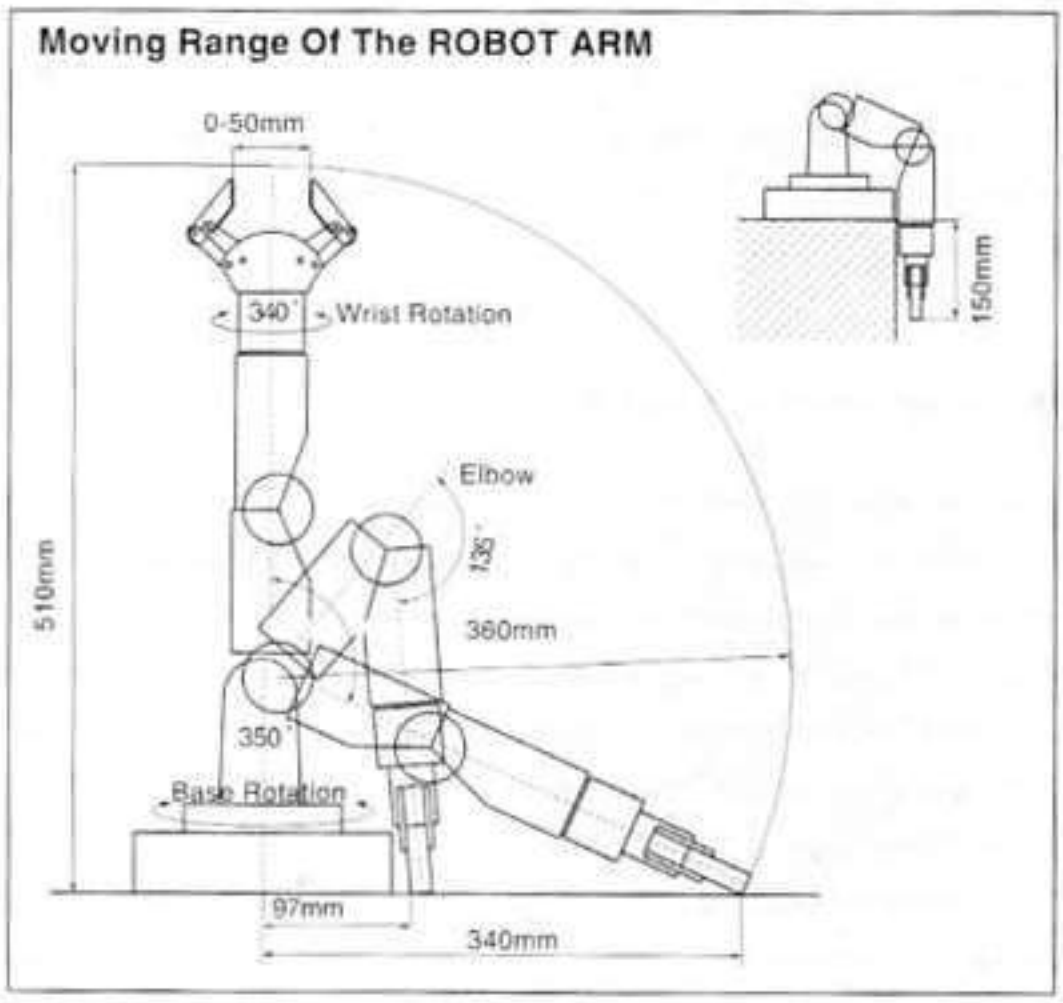
5 switch controller

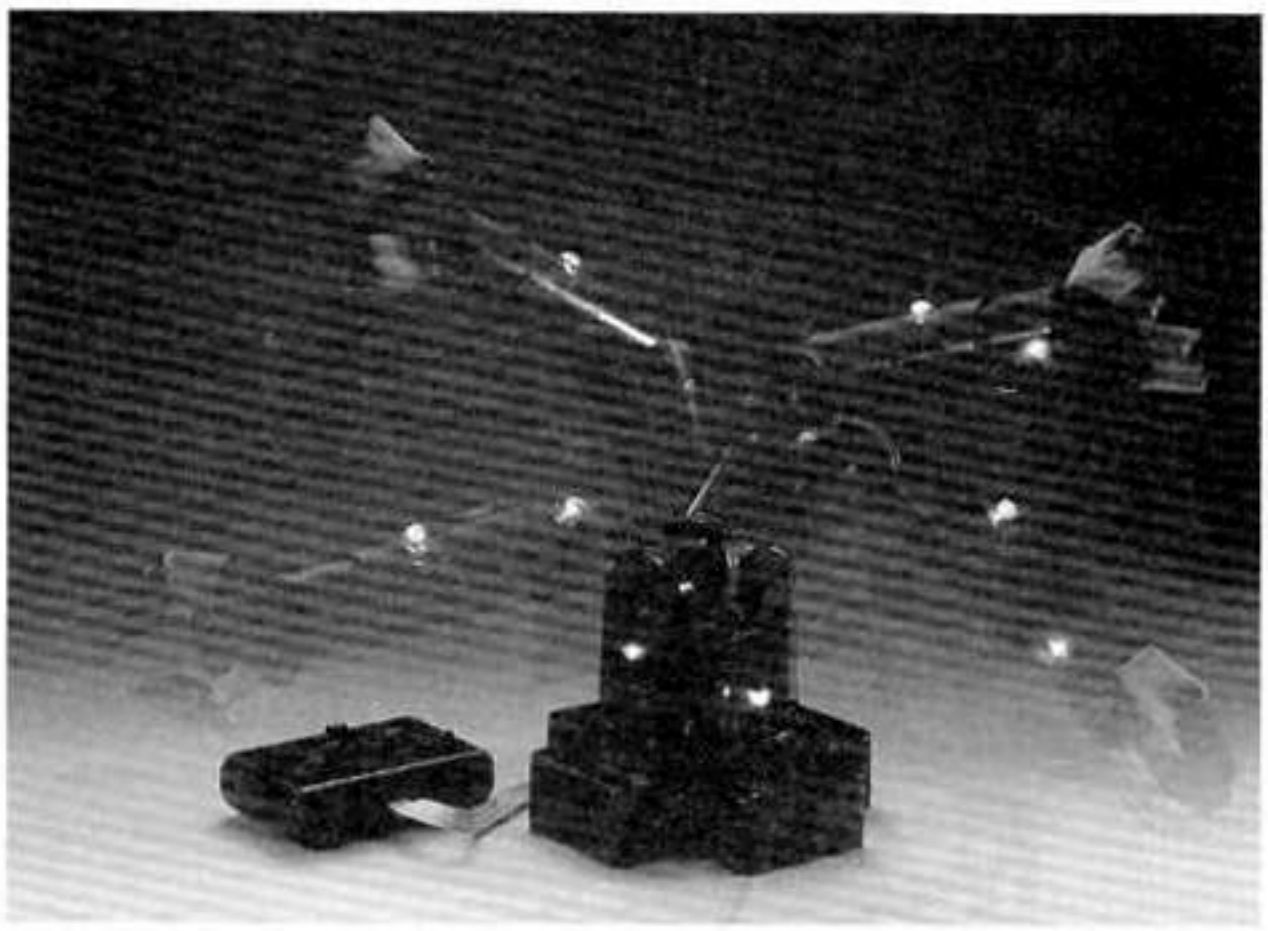
Power Source:

"D" battery X 4pcs (not included)

Do not mix old and new batteries. Do not mix alkaline, standard (carbon-zinc) or rechargeable (nickel-cadmium) batteries.

Moving Range Of The ROBOT ARM





I. A Story About Robots

1. What is a robot?

The word "robot" is used among ourselves as a natural thing. The fictitious and actual existence of robots is widely known, and in reality robots play an active part in various fields, especially in industries.

But, when asked about robots, we are likely to have a hard time giving a clear answer to the question of what robots really are. A dictionary will give you descriptions about robots such as

(1) A man-made doll automated by means of complicated and delicate devices. Artificial man. Automaton.

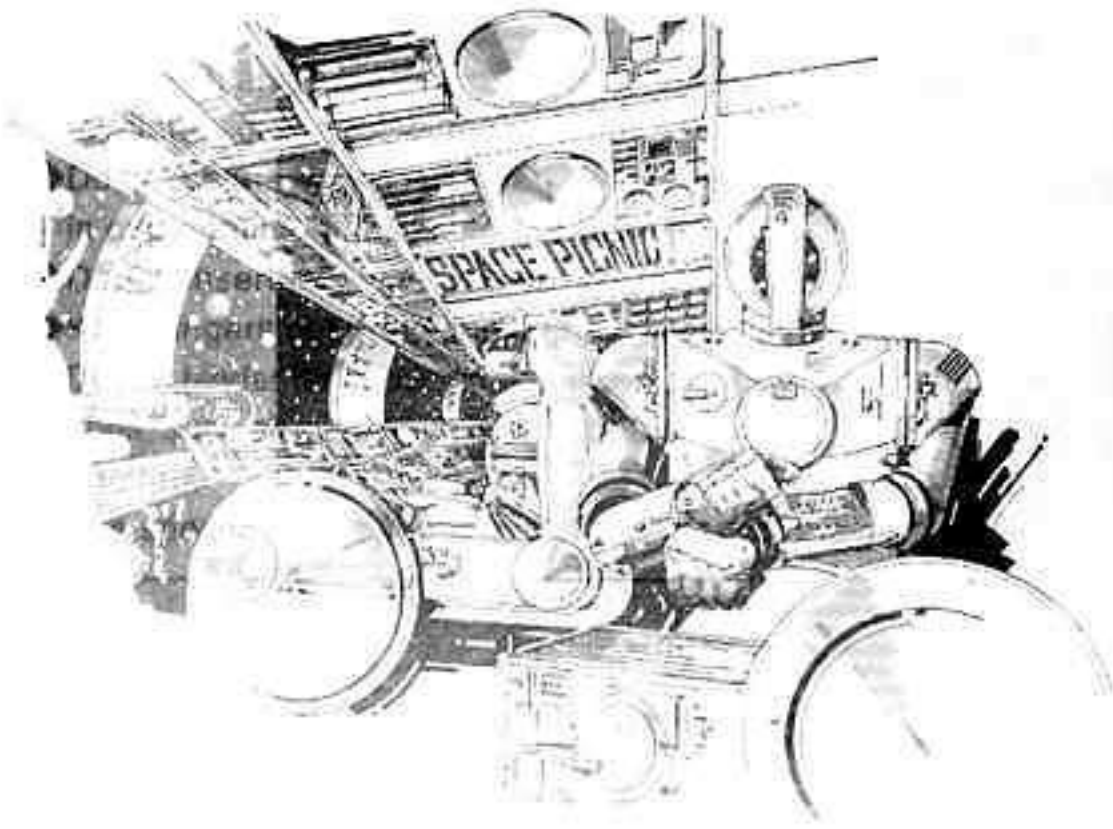
(2) Machines capable of automatically operating without the need of human ability by employing the devices as described above.

All these descriptions tend to make us feel somewhat uncertain about robots, but there is no way of getting rid of this uncertainty. "Robot" as a whole is not scientifically defined yet, except in such partial areas as industrial applications. Setting aside a strict meaning of robot, we have a hint as we go for you, which might give you an image about the definition of robots. So relax and read the following.

● The definition of robot ●

In recent years, the definition of a robot is generally used to mean an unmanned system or automation, as often seen in industrial applications, deep-sea and planetary probes. Historically speaking, a robot used-to-be shaped like humans, and referred to as machines and electric systems that were capable of performing similar actions as humans. It is these robots that play active roles in comic magazines, animation and science fiction. Because they are artificially created, they are called "artificial man." And since they look like humans in appearance, they are often called "androids" or "humanoids." A "cyborg," created by combining organisms and machines, can be called a robot in a broad sense. "Automata" and other similarities could be considered a robot in its earliest stage.

The origin of the word "robot" is derived from a drama "RUR" (1920) by Czech dramatist Karel Capek. A character in the drama produces a number of artificial men, and they replace humans in the workplace. It was the first time that the word "Robot" was used to express this artificial man. The word "Robot" originally came from a word "robota" meaning "forced labor" in the Czech language. From this point of view, perhaps the word has a close sense of meaning toward the industrial robot today. The robot appearing in this drama is not a mechanical man, but an organic composite man.

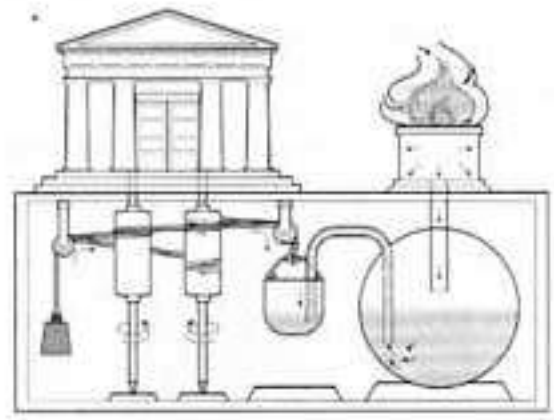


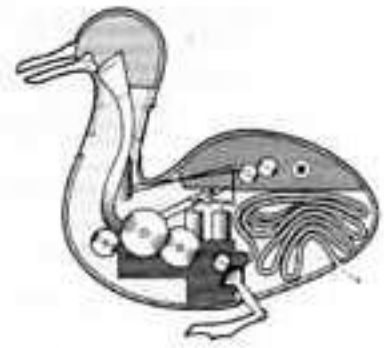
Europe

2. History of robots

(1) Developing imagination in literature , play and ideology

It was in 1920 that the word robot was created. Enthusiasm of humans for robots is still alive in the history, myths and literature from olden times Before Christ. Humans had a wish to produce tools and device that would work and operate in place of people. Humans created things, starting with a gold beautiful girl, who appears in a Greek myth (B.C. 8th century), and a bronze devil "TALOS" (B.C. 3rd century). Heron in ancient Greece worked out a device similar to an automatic door found today. It was a shrine door, which automatically opened when a fire at an altar in the shrine burned up and closed when the fire went down. An automatic device was also invented by him, from which holy water came out when a coin was thrown into the device. In the 18th century, a French man, Beaukerson, created an artificial duck. This duck was able to take a bath, eat, cry and produce excrement. There were many other people including engineers and inventors, who created various kinds of dolls which could write, draw pictures and blow a bugle.





These automatic dolls and devices were made by engineers simply to satisfy their pleasure, and were said to be successful tools in the sense that they were useful for decorations and surprising people. However, they were not applicable for direct production in the industry. It should be noted that the people, who designed and produced the automatic dolls and devices, were not dedicating themselves only to the creation of such tools. Beaukerson manufactured looms which made it possible to weave patterns. But, it is not certain how much effect the manufacturing techniques used in the automatic dolls had on the making of the looms.

In the 19th century, literary works were published on the subject of the robots. These works can be seen as a sign of the beginning of orthodox robot literature, such as those that use a quasi-scientific style of writing and that depict man-made creatures rebelling against humans.

The windup doll to serve a tea made in Japan in 1776.

(2) Development of science, technology, and robots

In the 20th century, with the progress of science and technology, the automatic dolls were developed into more sophisticated mechanisms. Though differing in quality from today's robots, the robots in those days started using mechanical and electrical technologies in combination (not identical to mechatronics of today). For instance, at the world exposition held in New York in 1927, a U.S. company called Westinghouse displayed a robot named "WILLY." The robot was capable of walking, speaking, winking and identifying colors. They were constructed to somehow manage to reproduce functions endowed by humans, but their actions were limited in motion, falling a stage short of practical application.

In the early part of 1940 when a problem arose to develop robots as a result of the progress of science and technology, Isaac Asimov presented his "Three Principles for Robot Engineering." This eliminated abstraction and contradiction in the robot SF and exhibited clear logic.

Those three principles were:

① Robots must not hurt humans or neglect humans when they are being hurt.

② Robots must obey orders given by humans, as long as such directions do not go against Item ①.

③ Robots must protect themselves as long as they do not go against Item ① and ②.

These principles convey an ideal image of the technological products.

(3) Progress up-to-date

Today, no robots can exist without the development of computer systems and control technology. Computers and control technology developed along with energetic studies were made during World War II. Accompanied by the development of wireless communication technology during the war, the performance of vacuum tubes was improved at a rapid pace. All these developments can be said to have laid the foundation of present-day robot technology.

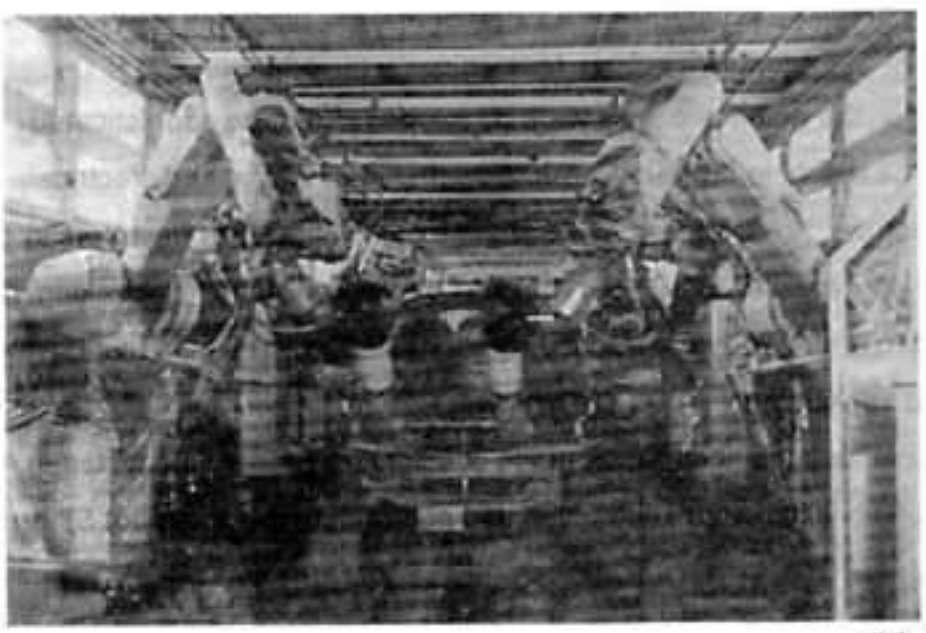
However, at the stage where vacuum tubes were employed in computers, it was not possible to produce robots like we use at present. Today, there are many requirements being made for robots. One is that they should not function only to provide one service repeatedly, but to allow easy replacement of programs for different work cycles. That is to say, each robot (machine) is required to have a computer, so that machines can be controlled individually. It is a computer that occupies a part of the robot and functions as the brain. Therefore, the technological level of computer systems has had a great influence upon robot engineering. For these reasons, it would be impossible to produce robots, which are currently in use, with the level of technology of computers operated by vacuum tubes.

The first step to overcome the weak points of vacuum tubes was the development of transistors and diodes. Transistors can take the place of functions that vacuum tubes provide, and moreover, they emit little heat. They can be miniaturized in size to be much smaller in comparison with the size of vacuum tubes. With all these technologies, computers have been rapidly miniaturized, increasing their reliability.

In the 1960s, integrated circuits (IC) were made for the first time. A single IC chip had functions equivalent to several dozens of transistors. These new products made it possible to eliminate negative factors, such as contact failure, further enhancing their reliability. It was about this time when full-scale industrial robots were put on the market and started to be used in auto manufacturers in the United States. With the advent of highly integrated circuit chips including LSI and VLSI, the operation speed of the computers was greatly improved, bringing about further advances in miniaturization. These advances helped push robot development and later posed the new issues related to robot technology, in the search for devices equipped with functions corresponding to the five human senses to "see, hear, touch, smell and taste" -- namely, "sensors."

As mentioned above, the word "robot" was created by Capek in his drama called "RUR." You may notice something interesting in developments between imaginary robots and science and technology. For examples, developments between a bronze casting technique of in the Greek Times and the devil "TALOS," and between a bronze watch-making technique in the modern times and a beautiful clockwork-operated doll (in the first ballet played in 1870) help illustrate the relationship between technology and imagination. The robot by Capek reflects a theory of the times, indicating that life originated from mud in the seabed. Imaginary robots and a nuclear fusion reactor, including super-computer loaded SF robots as seen today, ranging from the mythical era to the present time, have been all imagined based on the most advanced science and technology of the times.

In other words, looking at the robots, you can learn about the level of the most advanced technology at a particular time in history.



*1

*2

3. Robots - Present and Future

● Present-day robots

Robots originating from an idea were brought into a reality through technical developments. There are some robots which resemble humans, but the robots available at present appear to be different from humans in nature.
The following are descriptions of some current robots:

＊3

(1) Industrial robots

Industrial robots , in general , are machine systems that provide services taking the place of humans in the industrial world, but which are still vague in their definition and scope.
It was from the 1950s to 1960s when industrial robots started, to be produced full scale for commercial applications. Technically speaking, the operating mechanisms with robotic arms are now available from simple to highly sophisticated multi-joint structures. They are available from large-sizes which can carry heavy weights to small-sizes similar to human arms and the upper half of the body. The controllers are now loaded with microprocessors as a standard, and various developments are in progress for robot languages and control software.

＊4

(2) Other types of industrial robots

In addition to factories, various types of robots are being developed, such as limited-service robots for the use in severe working conditions, such as space, deep sea and nuclear reactors. Robots for applications in agriculture and fisheries are being used. In the commercial and service industries, robots are being studied for the use in washing windows and cleaning floors in buildings.

(3) Intelligent robots

Intelligent robots are those which can conduct work in place of humans, and are incorporated with successful results. The research on the intelligent robots seeking "To what extent the intelligent robots can be technologically realized," was started with the first international conference on the intelligent robots, which was held in the United States in 1969. But, the fact remains, no one has yet put a full-fledged intelligent robot into practical use.

(4) Other types of robots

Some robots are already working closely in our life, not only in the industrial world. One of these robots is called a "plastic training organism simulator." They are robots in the form of a human body, which are designed to train artificial breathing and heart massage. These robots have internal sensors using pressure gauges and magnetism to give indications of life and death. There are robots developed for medical students which give pulse rate, blood pressure for training anesthetic technique, respiratory sounds, and make it possible to provide training for injections and intravenous drips.

＊5

There are many other robots being produced. Toy robots, for instance, have been made since old times. They were produced to work using mechanical parts such as gears. But in the 1980s, programmable robots with built in computers began to appear on the market. A variety of types of robots have been developed; such as those capable of walking on their own feet like humans, performing highly sophisticated hand, finger and snake type movements.

In 1996, HONDA MOTOR CO.,LTD introduced "P2," which has two arms and two legs like humans and can walk not only on level ground but on a bumpy or steep road and, can even go up and down the stairs. "P2" is one of the most human type of robots ever produced. SONY CORPORATION also announced a pet robot in 1997. Differing from the usual practical robot, it has been developed as the entertaining robot which can communicate with a human. It gives suggestions for the new relationship between robots and people.

On the other hand, compared to these large robots, small robots are also being developed which can move smoothly like creatures with sensors and actuators .

＊6

＊7

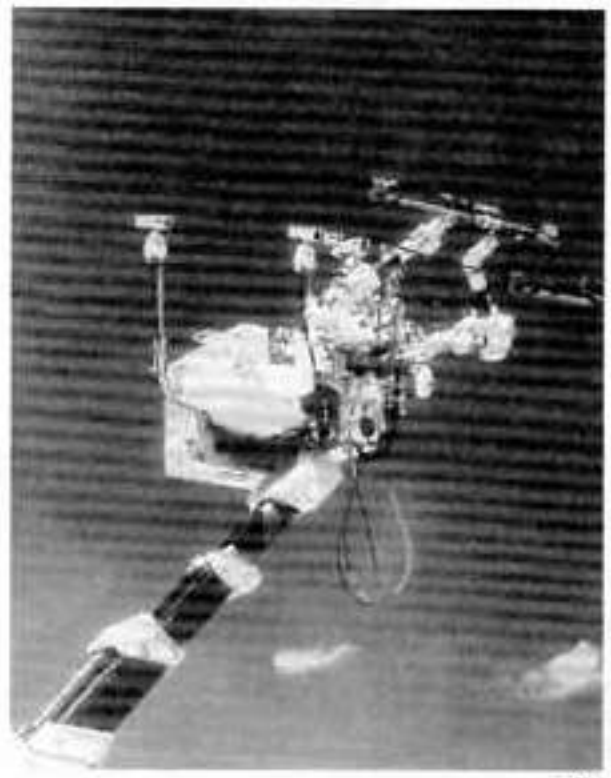
● Future of robots

There are strong expectations for the realization of many new robot applications. A few examples are: robots involved in welfare services assisting handicapped people, escorting visually handicapped people, and helping bed-ridden people. However, what we should not forget in the development of welfare-related robots is that robots are only aiding devices. Robots do not have the warmth and compassion of humans and living things. Emotions are something that would be difficult to produce.

Also, robots are expected to be put into practical use, for example, to save lives in a fire. They include robots, which are equipped with functions to go into raging flames and poisonous gases, find the origin of a fire, put it out, and guide people left behind to a safe location.

＊8

As described above, robots are increasingly expected to work in dangerous areas, but no compromise should be made for their safety. Thinking lightly of the safety of workers, we should not use robots only as means of pursuing cost effectiveness. Instead of seeking effectiveness in the industry, we ought not to minimize the relationship between technology and humans, and culture and technology. It is necessary to recognize that rapid progress in robot technology will bring about unstable factors to the world, along with efficiency and convenience. Development and utilization of robots should be made to materially and mentally enrich the lives of humans, labor and society.



＊9

Printed with permission, ----------

＊1 : TOYOTA MOTOR CO.,LTD
＊2 ＊4 ＊5 ＊9 : YASKAWA ELECTRIC CORPORATION
＊3 : "Future Machines in Motion" written by Syuji Kajita / published by POPURA;CO.
＊6 ＊7 : HONDA MOTOR CO.,LTD
＊8 : SONY CORP

● Chronological Table of Robots ●

*Marked with ○ in the following list indicate robots appearing in literature and movies, and ● indicate robots which have been actually designed and manufactured.

8th C. B.C.:	○	Gold Pretty Girl (Greek myths; Epic of Homeros "ILIAS")
5th C. B.C.:	○	Mechanical God (Greek tragedy; "HIPPOLYTOS", "ORESTES" by Euripides)
3rd C. B.C.:	○	Bronze devil "TALOS" (Greek myths; Epic of Apollonios Rhodios "ARGONAUTIKA")
1st C. B.C.	●	"BACCHUS TEMPLE" by Heron (Designed by Heron, who was an engineer in Alexandria)
1300's	●	Flapping chicken (Watch technology employed from Switzerland)
1509	●	Auto artificial lion (Designed by Leonardo Da Vinnci/Italy)
1600	●	Mechanical doll by Brusselly (Brusselly)
1600	●	Girl doll "FRANSINE" by Descartes (Descartes/France)
1627	○	Original industrial robot in THE NEW ATLANTIS ("THE NEW ATLANTIS" by Francis Bacon)
1662	●	TAKEDA KARAKURI (KARAKURI puppet show by Takedaoumi/Japan)
1716	○	Mud giant "GOLEM" (Legend of Judaism)
1738	●	Duck by Beaukerson (Made by Jack De Beaukerson/France)
1770	○	Biochemical android "HOMMNCULUS" (Appearing in the second section of "FAUST" by J.W.V. Goethe/Germany)
1773	●	Four auto dolls by father and his son Dros (by Jake Dros & Henri Louis/France)
1775	●	Cup-delivering doll (By Nobuchika Wakai/Japan)
1796	●	Tea-delivering doll ("KARAKURIZUI" created by Nobuchika Wakai, written by Yorinao H. Hosokawa/Japan)
1815	○	Auto dancing doll "ORINPIA" ("DER SANDMANN" written by Ernst T. A. Hoffman/Germany)
1818	○	Monster by FRANKENSTEIN ("FRANKENSTEIN" written by Mary. W. Shelly/England)
1845	○	Superman robot by Edger A. Poe (written by Edger A. Poe)
1800's	●	Funny auto doll of Laubel Uhdom (Created by Laubel Uhdom/France)
1868	○	Steam engine built-in robot ("Steam Man in the Plain" written by E. S. Ellis)
1883	○	Wooden doll "PINOCCHIO" ("PINOCCHIO" written by Carlo Collodi)
1886	○	A word "android" was first used.("L' Eve future" written by Villies de L' Isle-Adam/France)
1893	●	Steam man (George More/Canada)
1893	○	Chess doll ("Maxim' s Doll" written by Ambrose G. Bierce/USA)
1920	○	Almighty robot ("R.U.R." written by Karel Capek/Czechoslovakia, * A word of robot was first used.)
1926	○	MARIA ("METRO POLIS" written by Thea V. Harbous/Germany)
1927	●	Robot "TELEBOX" (Manufactured by Westinghouse Electronics Co., Ltd./Exhibited at the New York Exposition in the USA)
1927	●	Robot "GAKUTENSOKU" (Made by Makoto Nishimura/Japan, Expressions on the face are changed using air pressure.)
1928	●	Robot "ERIC" (W. H. Richards/England)
1932	●	Robot "Alpha" (Halley May/England)
1933	●	Instructor robot (Appearing at the advanced century exposition held in Chicago)
1934	●	Robot "WILLY" (Manufactured by Westinghouse Electronics Co., Ltd./Exhibited along with many other robots at the expositions in San Francisco and New York.)
1937	●	Robot "Savoir IV" (Hoover/Switzerland)
1942	○	Three principles of robot ("I. ROBOT" by Isaac Asimov)
1952	○	Robot which protects human cultural inheritance ("City" written by Cliford D. Simak/Robots and dogs, which protect human cultural inheritance, live in a pastoral community life on the earth where humans ceased to exist.)
1954	●	Patents for industrial robots (G. Devol/USA)
1958	●	Devol's playback robots were commercialized.
1960's	●	Full-scale industrial robots were placed on markets, promoting their use in the US auto manufacturers
1970's	●	Autonomous mobile robot (In recognition of environments, studies launched on autonomous mobile robots) (Jet Propulsion Laboratory, Stanford University/USA)
1980~1981	●	All-out research & development on direct drive robots (Carnegie, Melon University/USA)
1996	●	Announcement of "P2" which has two arms and two legs like humans (HONDA MOTOR CO.,LTD).
1997	●	Announcement of a Pet Robot (SONY CORP).

II. Assembly

1. Necesarry Tools

#2 Screwdriver(+)

Long Nose Plier

Penknife

Marking Pen

Transparent Tape

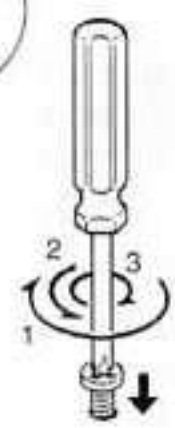
"D" Alkaline Batteries (not included) 4pcs

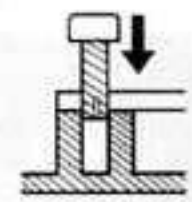
2. Before Assembly

Tapping Screws

The tapping screw has the same property as a wood screw, that is, the tapping screw can make "thread cutting" and screw at the same time.
Compared with normal screw, the thread of the tapping screw is coarse and the pointed end is split, thus making it easier for "thread cutting."
Be careful not to screw and unscrew too often as this will enlarge the hole.

A good way of tightening the tapping screws.

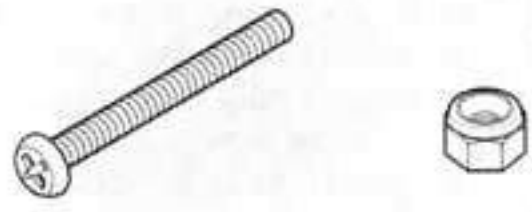




1. Screw in.
2. Loosen a little.
3.Screw in again.

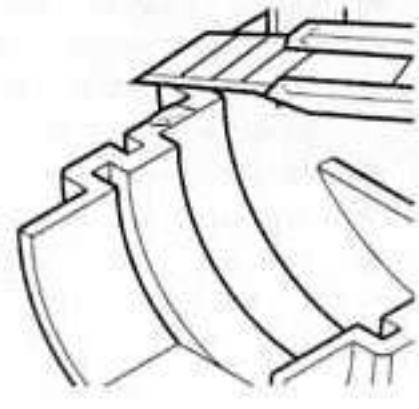
Tightening of Nuts and Screws

Tighten all the nuts and screws firmly or they may come loose. After tightening nuts, apply a small drop of fingernail polish onto the nut and screw to keep them from coming loose. This will also allow removal of the nuts and screws if needed.
DO NOT USE "LOCKTITE." Use of "Locktite" or other material that permanently locks the nuts and screws will void any warranty.

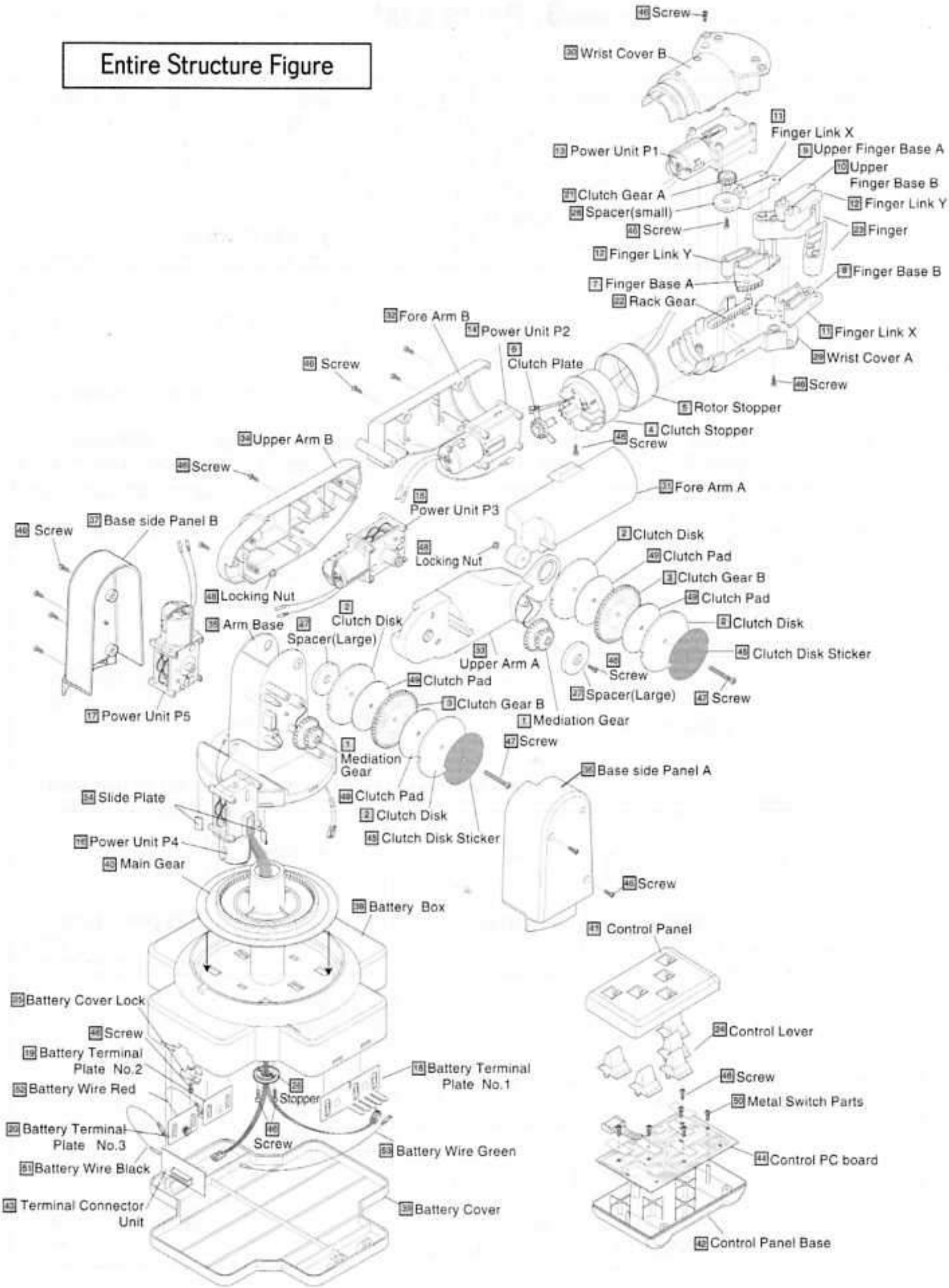


Molded Parts

Molded Plastic Parts may have the unnecessary projections called "Gate," the refuse made by pouring plastic into a mold , or "Burr" formed by the joint of a mold.
They are awkward not only in appearance but also in function so please scrape them off thoroughly with a penknife or a file.



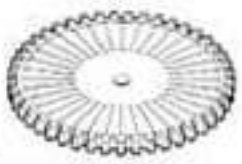
Entire Structure Figure



3. Parts List

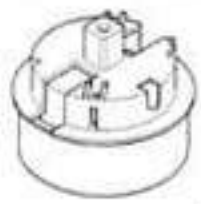
1 Mediation Gear 2pcs

2 Clutch Disk (Metal) 4pcs



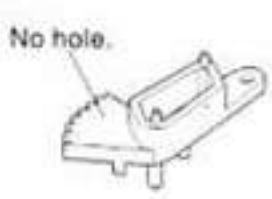
3 Clutch Gear B 2pcs

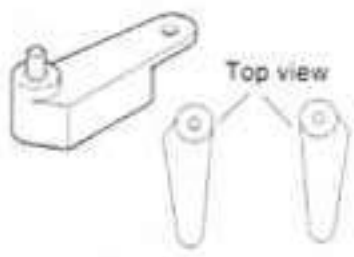
4 Clutch Stopper 1pc



6 Clutch Plate 1pc

5 Rotor Stopper 1pc





7 Finger Base A 1pc

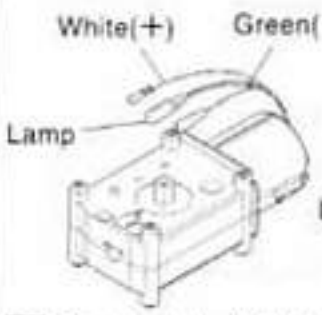
8 Finger Base B 1pc

9 Upper Finger Base A 1pc

10 Upper Finger Base B 1pc

11 Finger Link X 2pcs

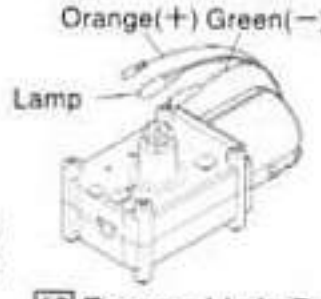
12 Finger Link Y 2pcs



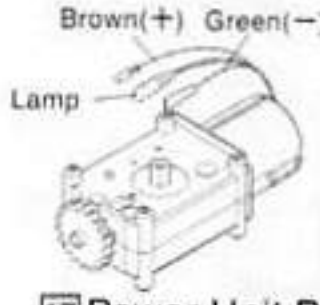
13 Power Unit P-1 1pc

14 Power Unit P-2 1pc

15 Power Unit P-3 1pc

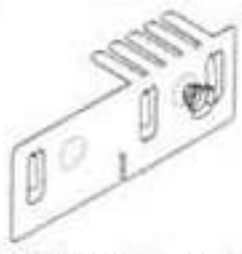


16 Power Unit P-4 1pc



17 Power Unit P-5 1pc

※ Power Units have been oiled. Be careful not to get any on your hands.



18 Battery Terminal Plate No.1 1pc

19 Battery Terminal Plate No.2 1pc

20 Battery Terminal Plate No.3 1pc

21 Clutch Gear A 1pc

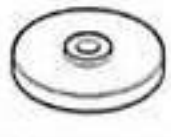
22 Rack Gear 1pc

23 Finger 2pcs

24 Control Lever 5pcs

25 Battery Cover Lock 1pc

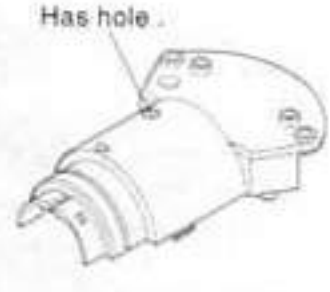
26 Stopper 1pc



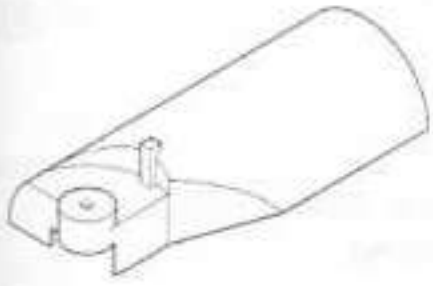
27 Spacer (Large / Black Plastic) 2pcs

28 Spacer (Small / Black Plastic) 1pc

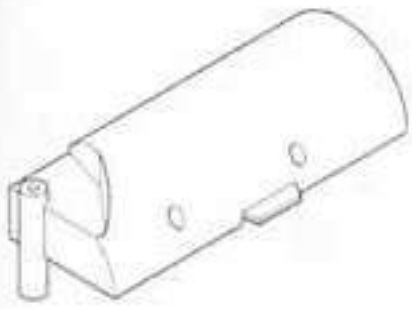
29 Wrist Cover A 1pc



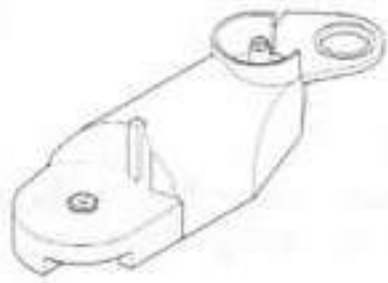
30 Wrist Cover B 1pc



31 Fore Arm A 1pc



32 Fore Arm B 1pc



33 Upper Arm A 1pc

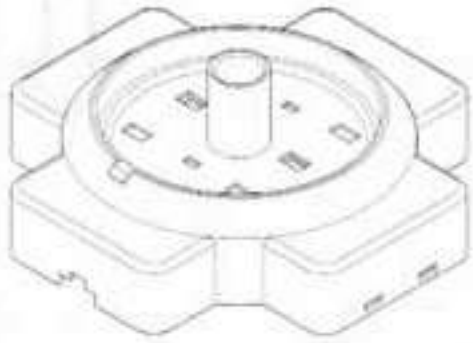
34 Upper Arm B 1pc

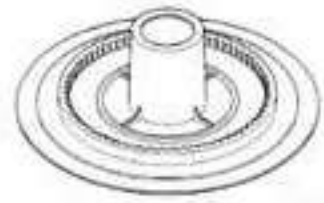
35 Arm Base 1pc

36 Base Side Panel A 1pc

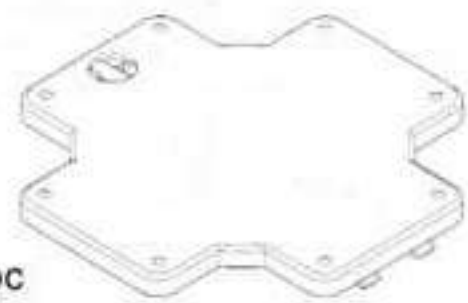
37 Base Side Panel B 1pc

38 Battery Box 1pc



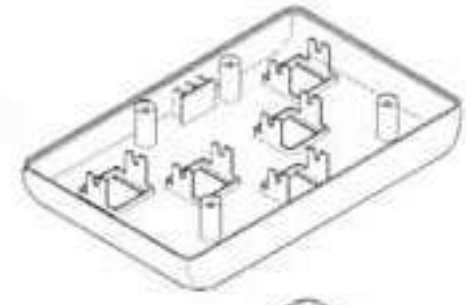


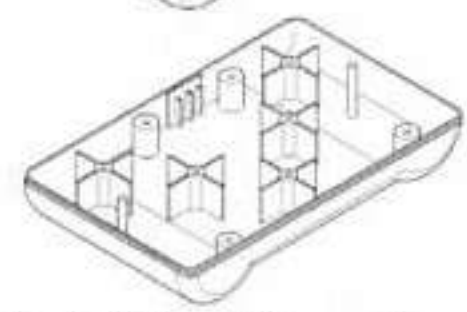
40 Main Gear 1pc



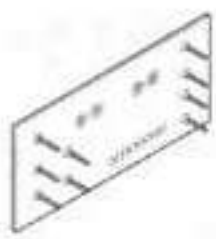
39 Battery Box Cover 1pc

41 Control Panel 1pc

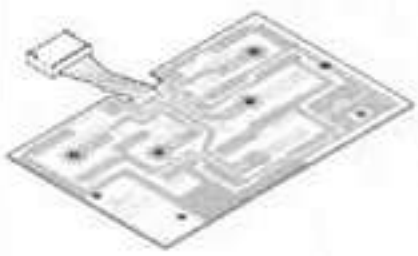




42 Control Panel Base 1pc



43 Terminal Connector Unit 1pc



44 Control PC Board 1pc

45 Clutch Disk Sticker 1pc

46 M3 × 12 Tapping Screw 29pcs
(Extra screws are included as spare parts.)

47 M3 × 25 Screw 2pcs

48 Lock Nut 2pcs

49 Clutch Pad (Felt) 4pcs

50 Metal Switch Parts 5pcs

Battery Wire
51 Black
52 Red
53 Green each 1pc

54 Slide Plate 2pcs

4. Assembly of Mechanical Parts

1. Assembling the Wrist

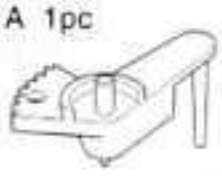
Parts to use

11 Finger Link X 1pc

12 Finger Link Y 1pc

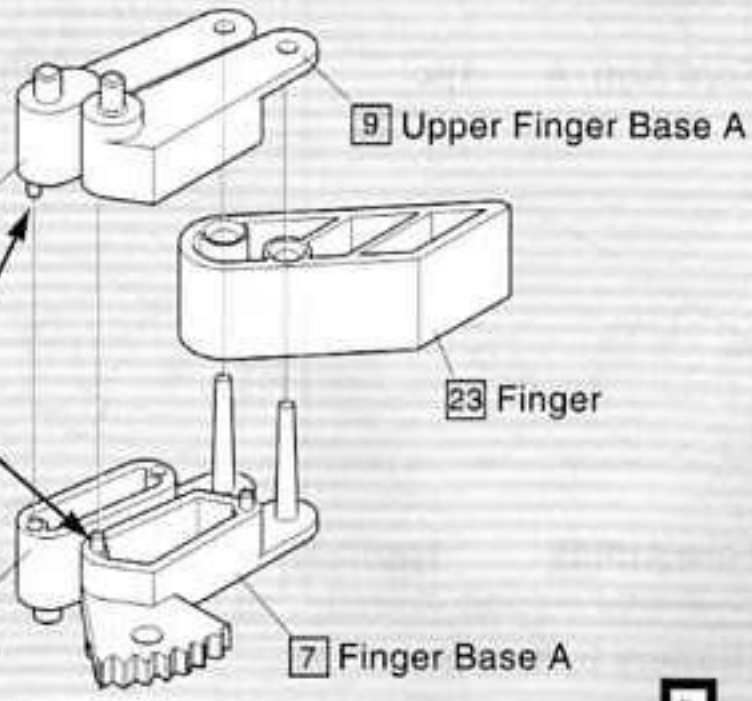
9 Upper Finger Base A 1pc

7 Finger Base A 1pc



23 Finger 1pc

① Assemble Finger, Upper Finger Base A, and Finger Link X onto Finger Base A and Finger Link Y as illustrated.



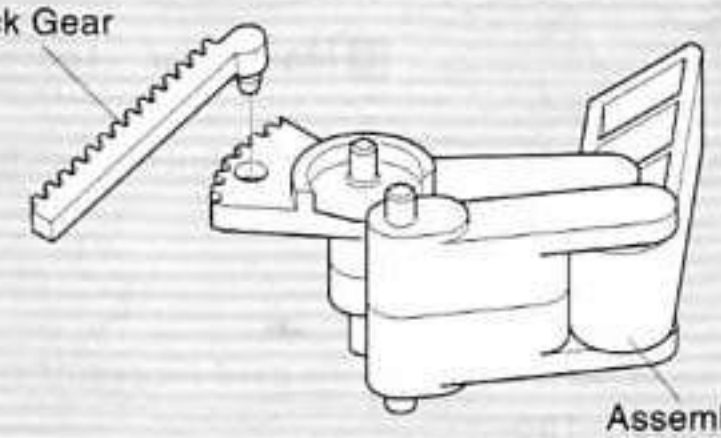
Please note it doesn't affect the assembly nor function even if the projections get broken when separating Links and Bases.

Turn over

22 Rack Gear 1pc

· Assembled Unit in step ①

② Fit the Rack Gear into the Finger Base A.



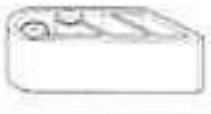
11 Finger Link X 1pc

12 Finger Link Y 1pc

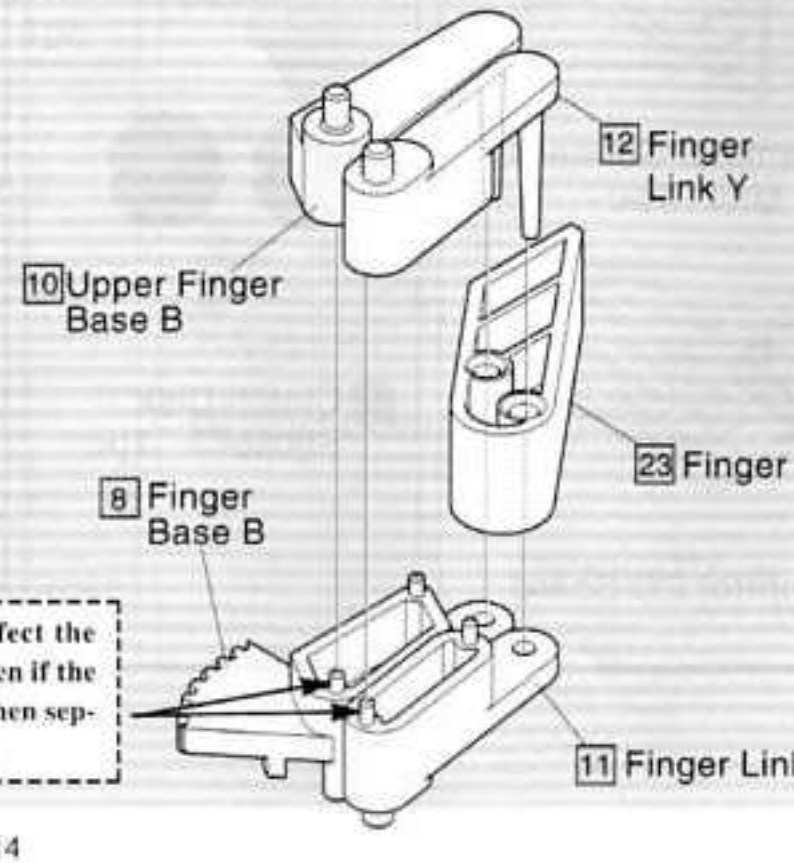
10 Upper Finger Base B 1pc

8 Finger Base B 1pc

23 Finger 1pc

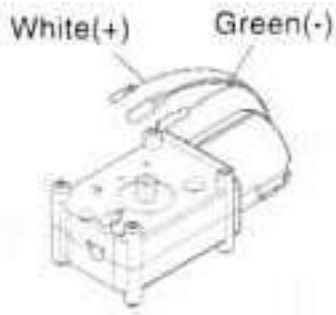


③ Assemble Finger, Upper Finger Base B and Finger Link Y into Finger Base B and Finger Link X as illustrated.

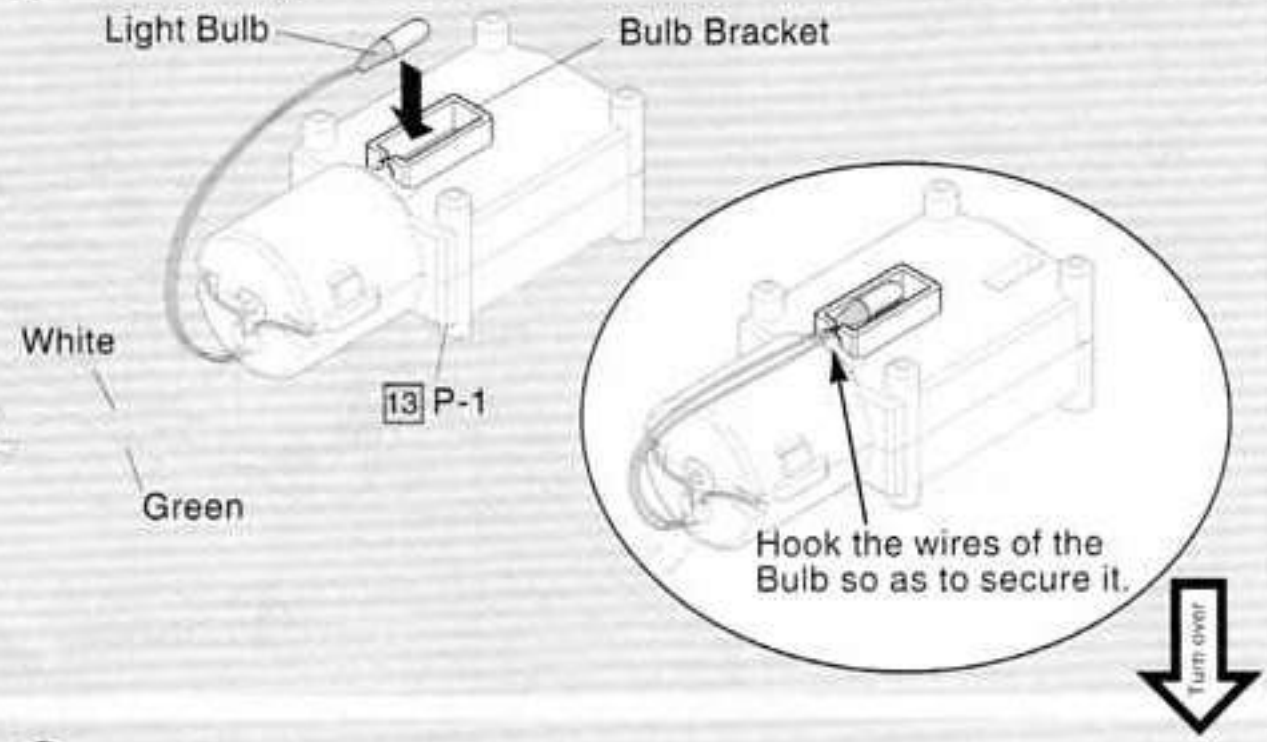


Please note it doesn't affect the assembly nor function even if the projections get broken when separating Links and Bases.

13 Power Unit P-1 1pc



④ Insert the Light Bulb as illustrated.



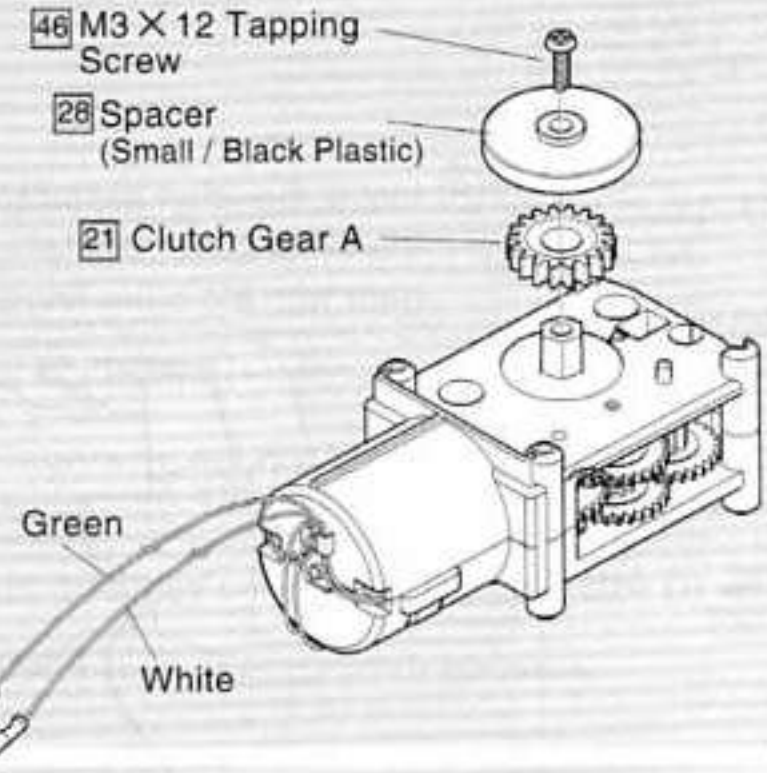
46 M3 × 12 Tapping Screw 1pc

28 Spacer (Small / Black Plastic) 1pc

21 Clutch Gear A 1pc

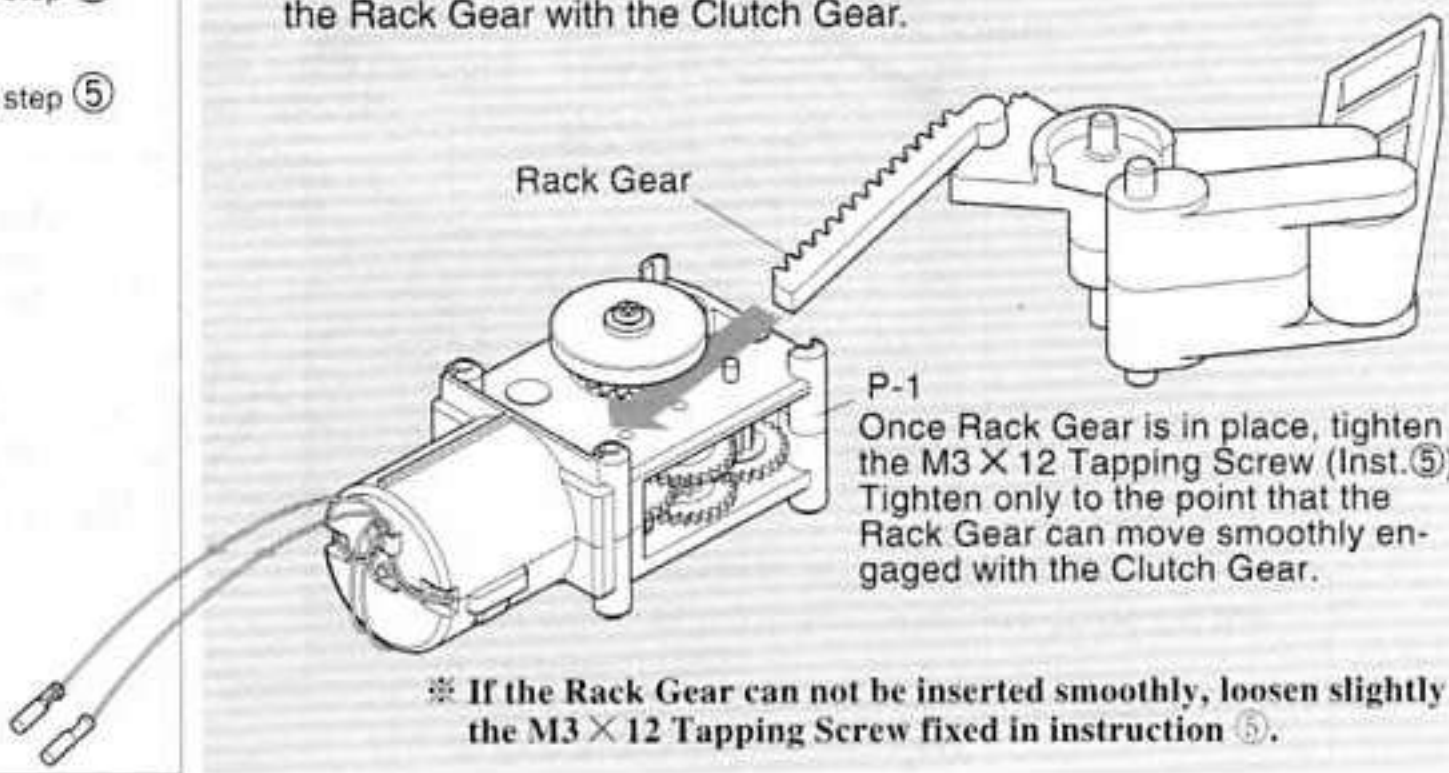
- Assembled Unit in step ④

⑤ Install the Clutch Gear A and Spacer (Small) to the Drive Axle on the P-1 with the tapping screw (M3 × 12).
Do not fully tighten the screw at this point.



- Assembled Unit in step ②
- Assembled Unit in step ⑤

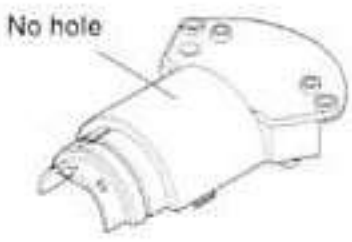
⑥ Install the assembled finger section in step ② to the assembled P-1 in step ⑤. Make sure to engage the teeth of the Rack Gear with the Clutch Gear.



Once Rack Gear is in place, tighten the M3 × 12 Tapping Screw (Inst.⑤). Tighten only to the point that the Rack Gear can move smoothly engaged with the Clutch Gear.

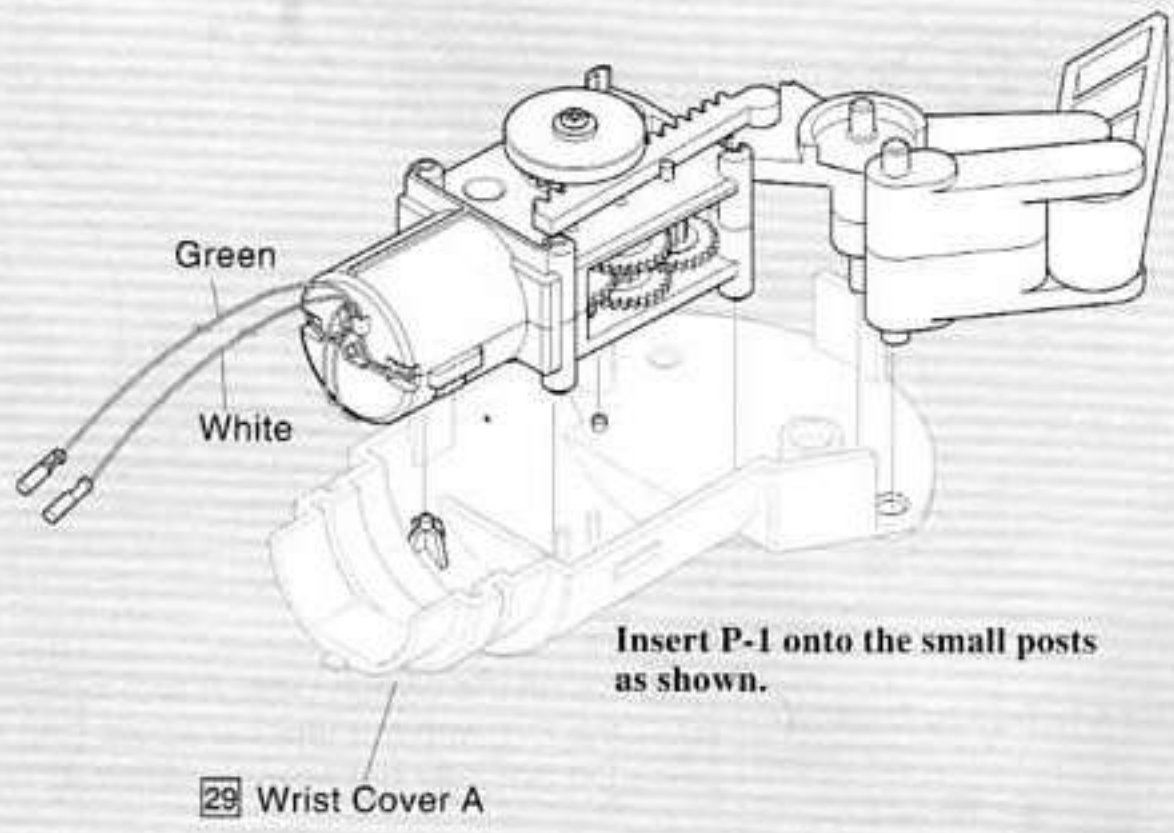
※ If the Rack Gear can not be inserted smoothly, loosen slightly the M3 × 12 Tapping Screw fixed in instruction ⑤.

29 Wrist Cover A 1pc



- Assembled Unit in step ⑥

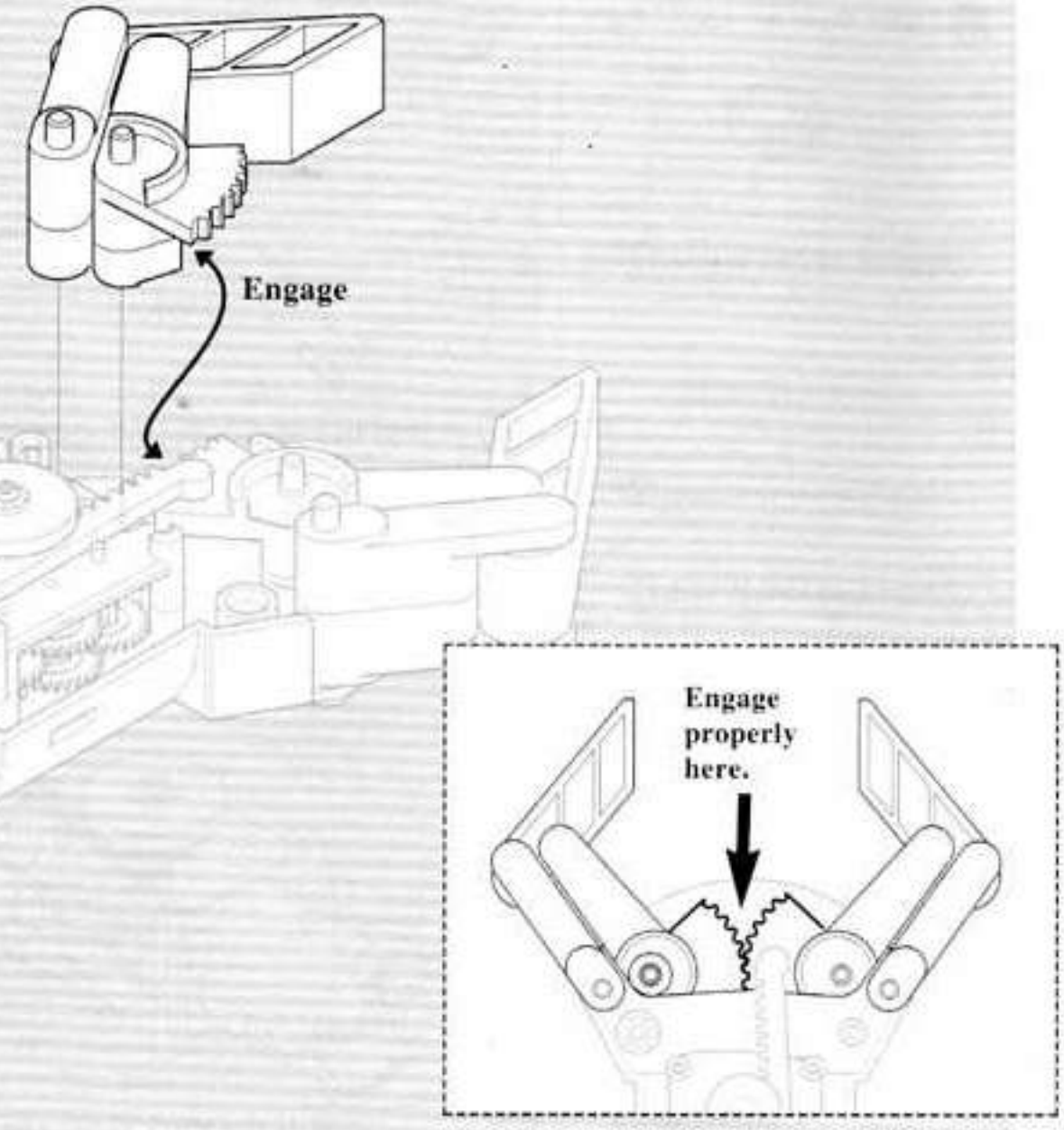
⑦ Mount the assembled section of instruction ⑥ onto the Wrist Cover A.



- Assembled Unit in step ③

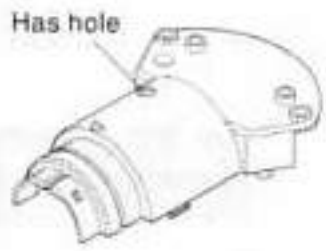
- Assembled Unit in step ⑦

⑧ Install the other assembled finger section in instruction ③ to the Wrist Cover A. Make certain to engage the teeth of the gear with the other finger gear as illustrated.



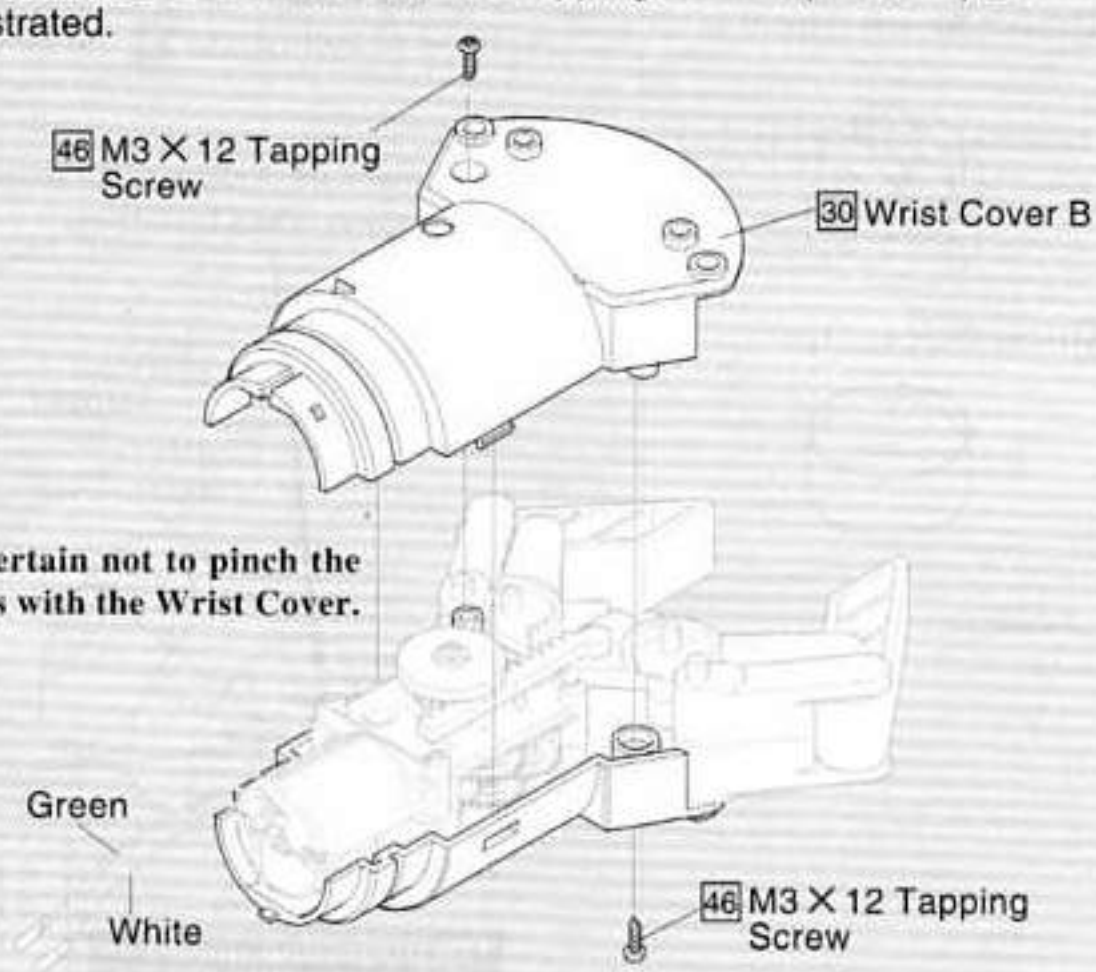
46 M3 X 12 Tapping Screw 2pcs

30 Wrist Cover B 1pc



· Assembled Unit in step ⑧

⑨ Join Wrist Cover B together with assembled wrist section of instruction ⑧ and fasten with the Tapping Screws (M3 X 12) as illustrated.



※ **Be certain not to pinch the wires with the Wrist Cover.**

· Assembled wrist

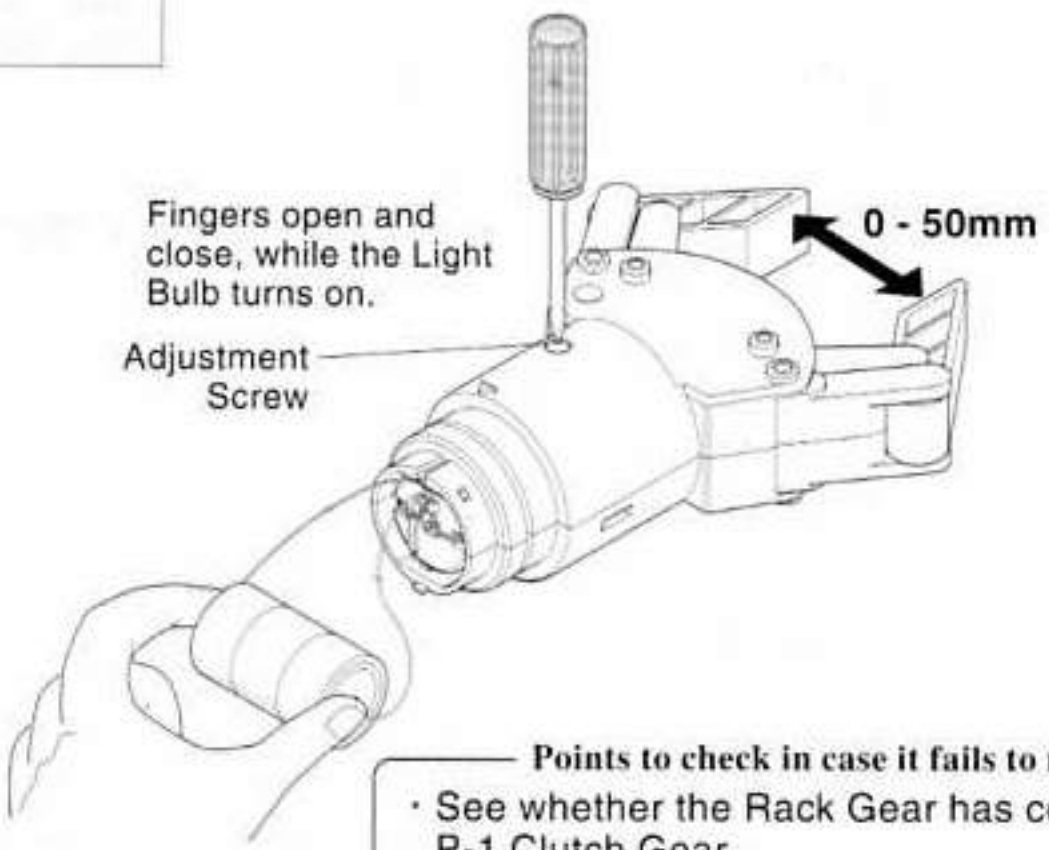
· Screw Driver (+)

· "D" battery 1pc (not included)

⑩ Connect a dry cell to the P-1, and adjust the clutch. Check to see if the Fingers open and close and the light turns on.

- The Fingers will close when the green wire is connected to (-) and the white wire (+); they will open when the wires are reversed.
- If the Fingers do not move smoothly when the motor is running, try to tighten the Adjustment screw by small increments.
- When they start to move, complete by adjusting the screw to the point that they can grab a dry cell (size D) without dropping.

※ **Be careful not to tighten the screw too much.**

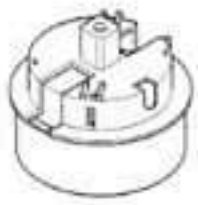


Points to check in case it fails to move

- See whether the Rack Gear has come off the P-1 Clutch Gear.
- See whether the Gears on Finger Bases-A and B are properly engaged.

2. Assembling the Fore Arm

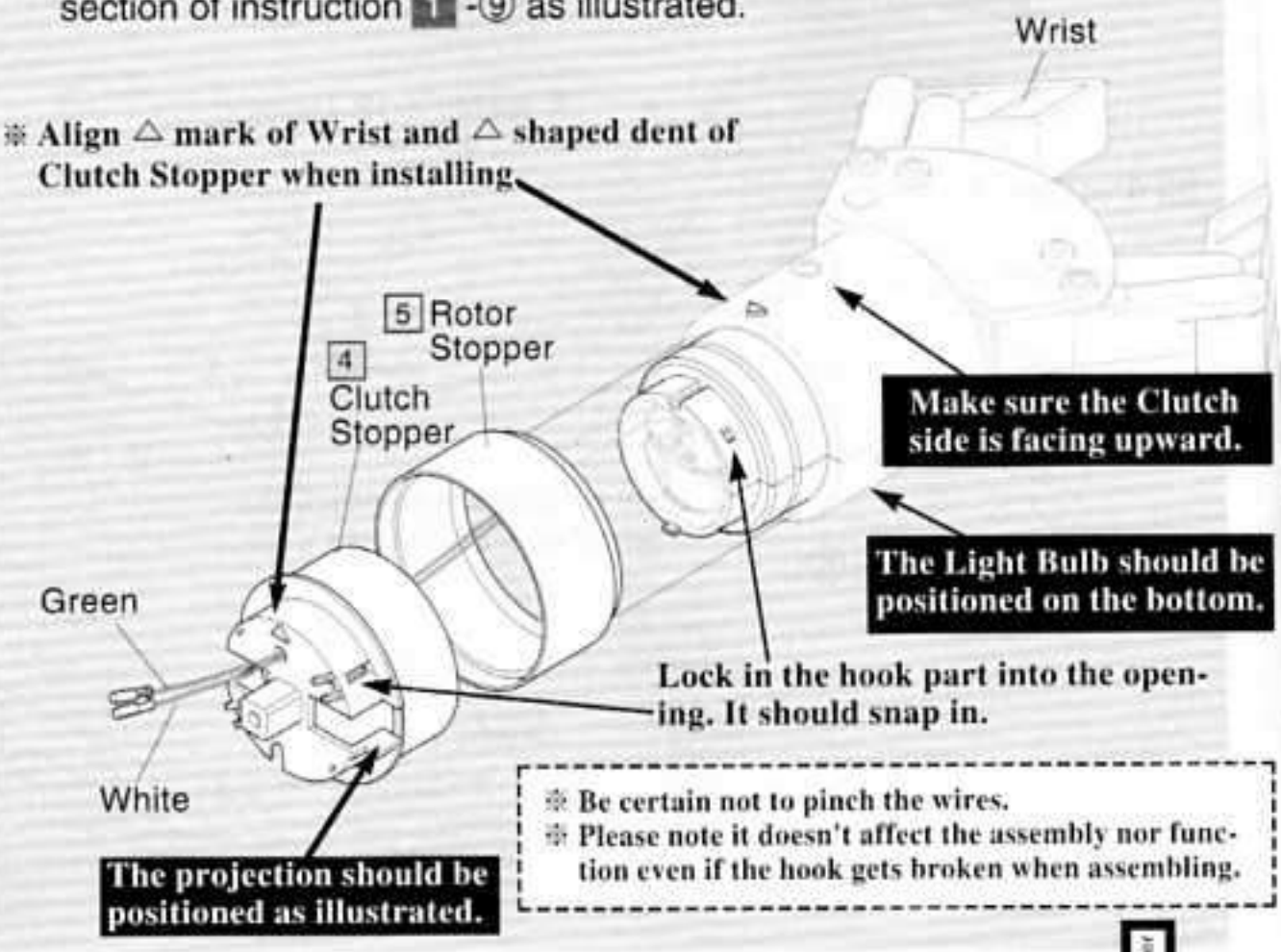
4 Clutch Stopper 1pc



5 Rotor Stopper 1pc

· Assembled wrist

① Install the Clutch Stopper and Rotor Stopper to the assembled wrist section of instruction 1 -⑨ as illustrated.

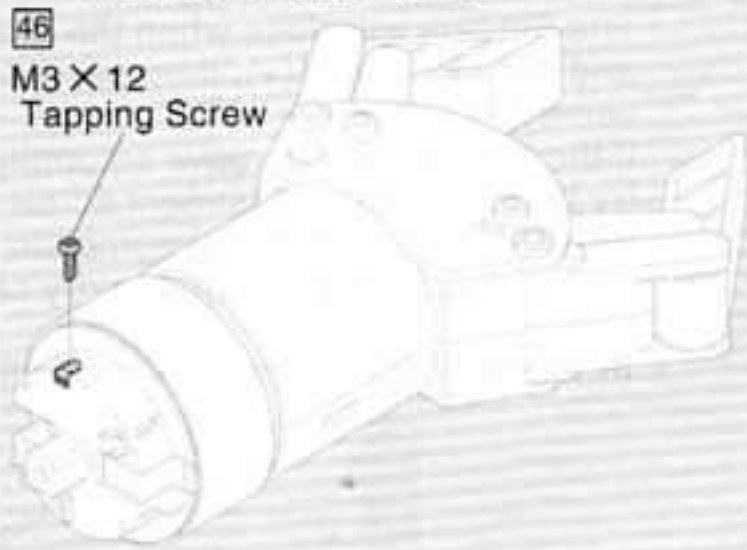


※ Be certain not to pinch the wires.
※ Please note it doesn't affect the assembly nor function even if the hook gets broken when assembling.

Turn Over

46 M3 × 12 Tapping Screw 1pc

② Turn over the Wrist ①. Fasten the Clutch Stopper and the Wrist with a Tapping Screw.



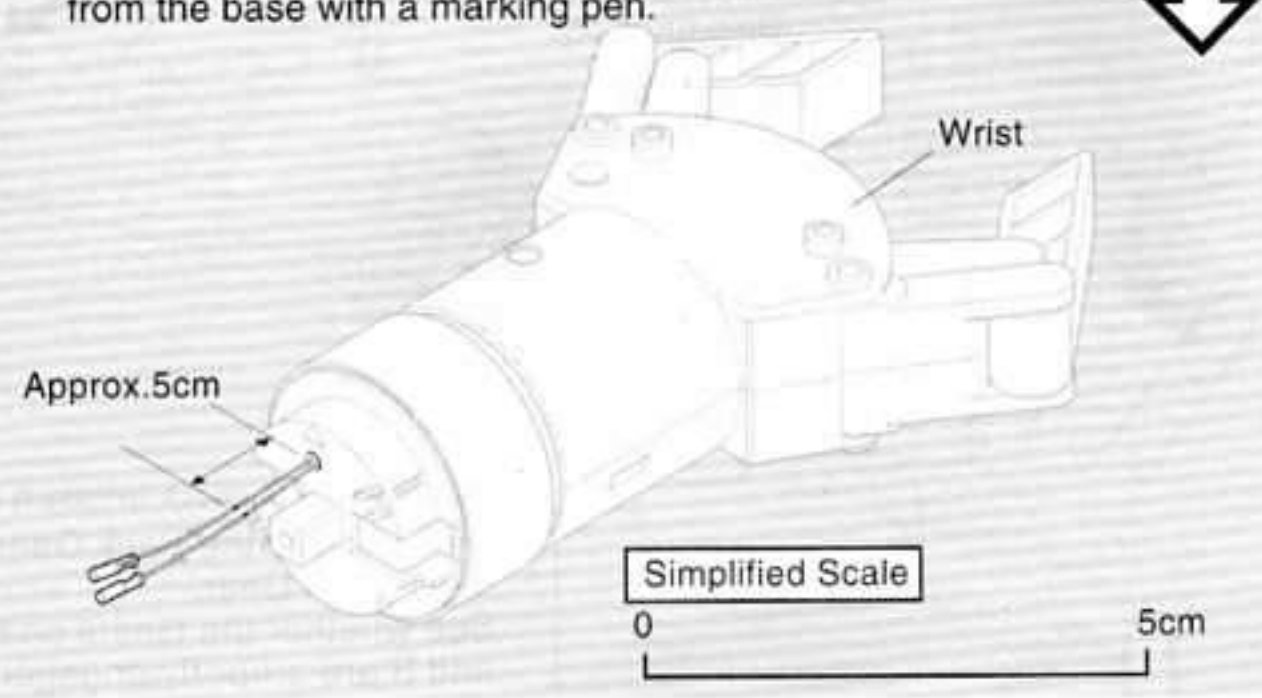
※ Screw in the tapping screw completely so that the head of the screw is slightly below the surface of the Clutch Stopper so that it will not interfere with the movement of the Wrist.

※ Be certain there are no wires below the screw when tightening the screw.

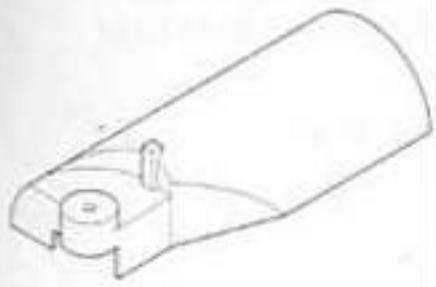
· Assembled Unit in step ②

· Marking Pen

③ Mark on both of the two wires of the Wrist at approx.5cm from the base with a marking pen.



31 Fore Arm A 1pc



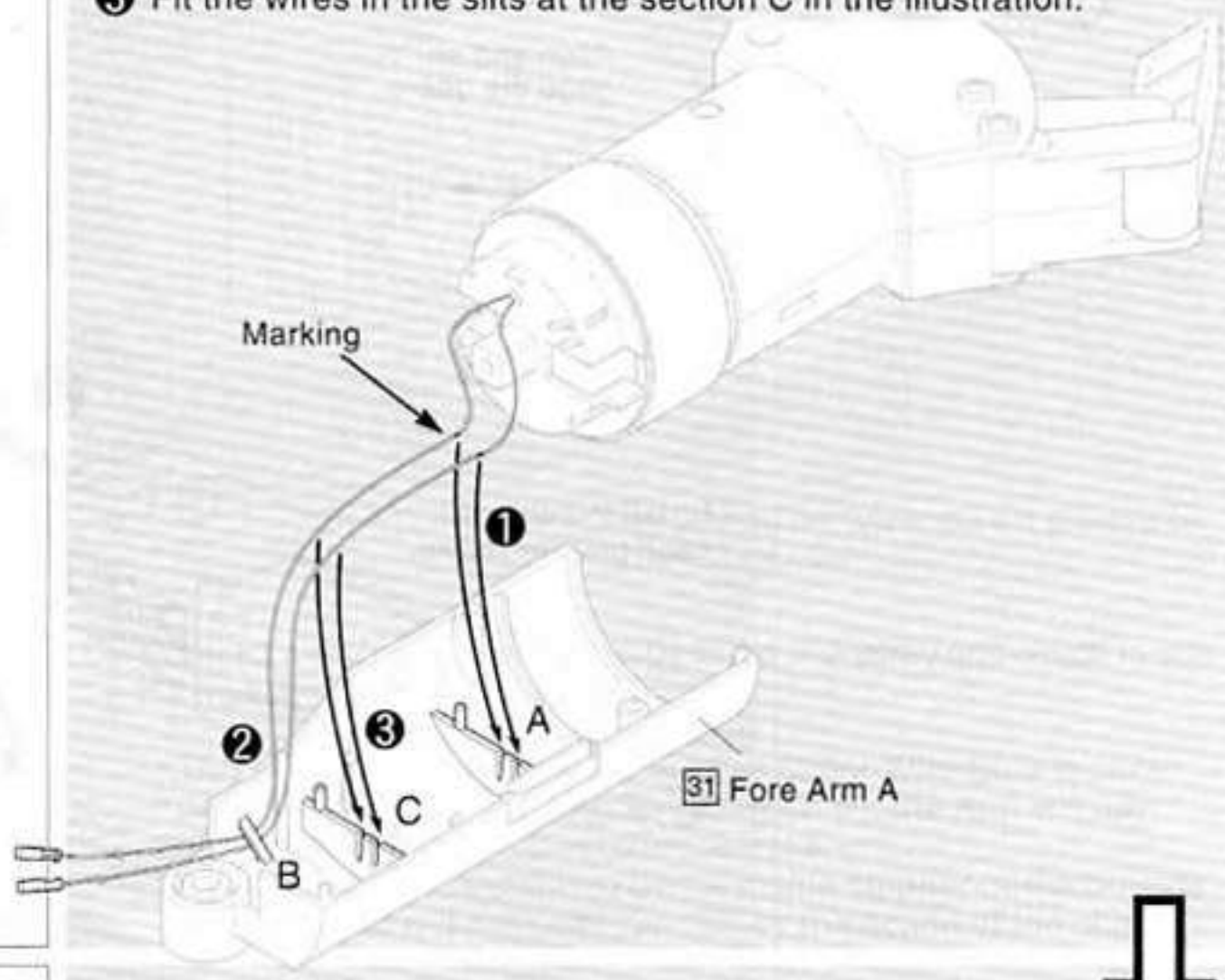
· Assembled Unit in step ③

④ Lay the wires of the Wrist on the Fore Arm A as illustrated in the order as follows.

❶ Fit the marked point of the wires in the slits of the rib (section A in the illustration) in the Fore Arm A.

❷ Put the wires through the opening in section B in the illustration and pull them a little to remove the slack.

❸ Fit the wires in the slits at the section C in the illustration.

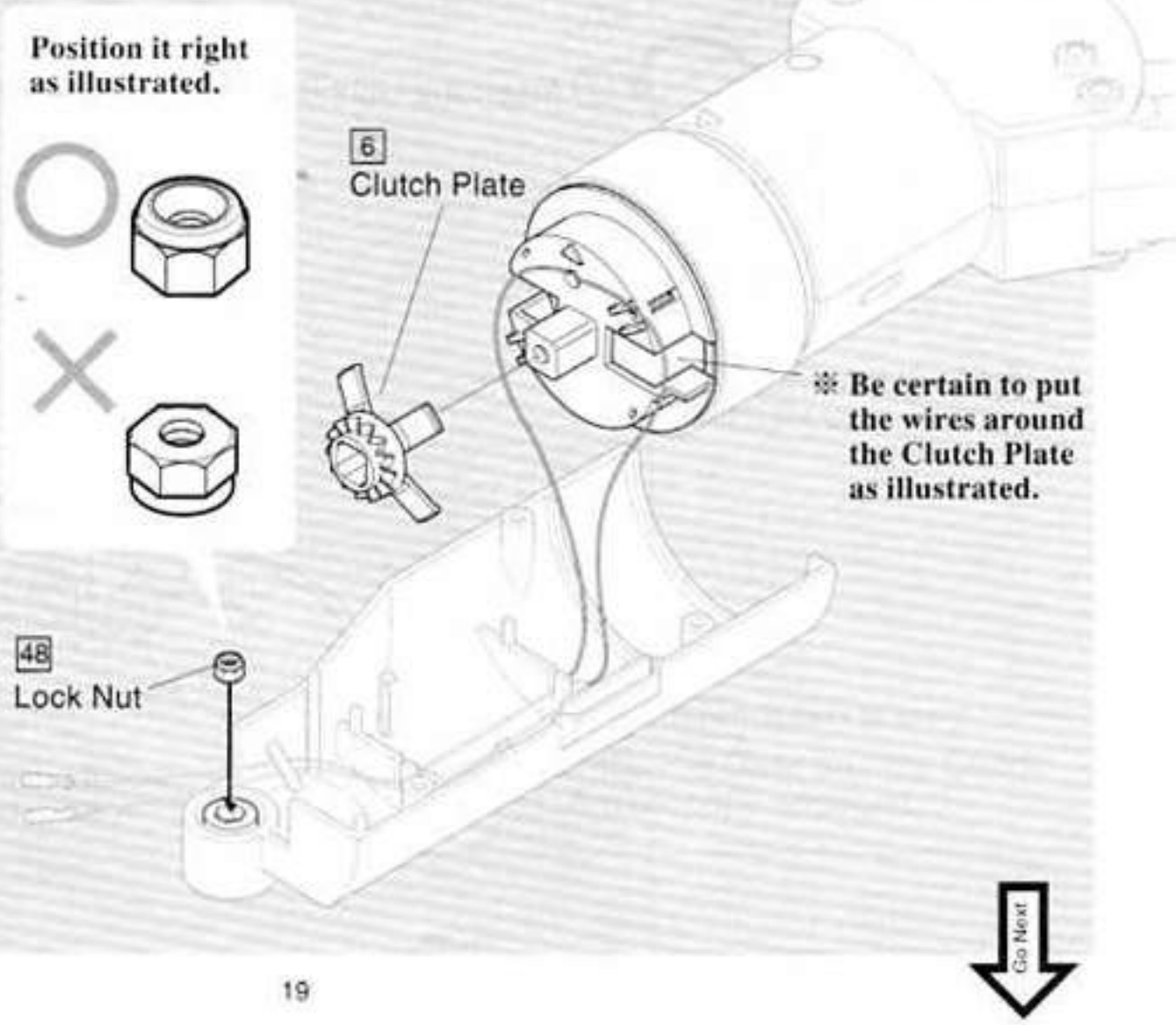


6 Clutch Plate 1pc

48 Lock Nut 1pc

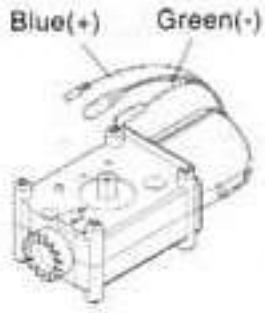
· Assembled Unit in step ④

⑤ Install the Clutch Plate to the Wrist section as illustrated and put the Lock Nut in the hexagonal hole of the Fore Arm A.



Go Next

14 Power Unit P-2 1pc

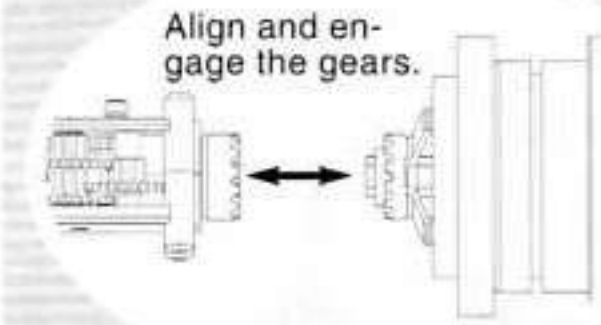


· Assembled Unit in step ⑤

⑥ Fit the P-2 and the Wrist into the Fore Arm A.

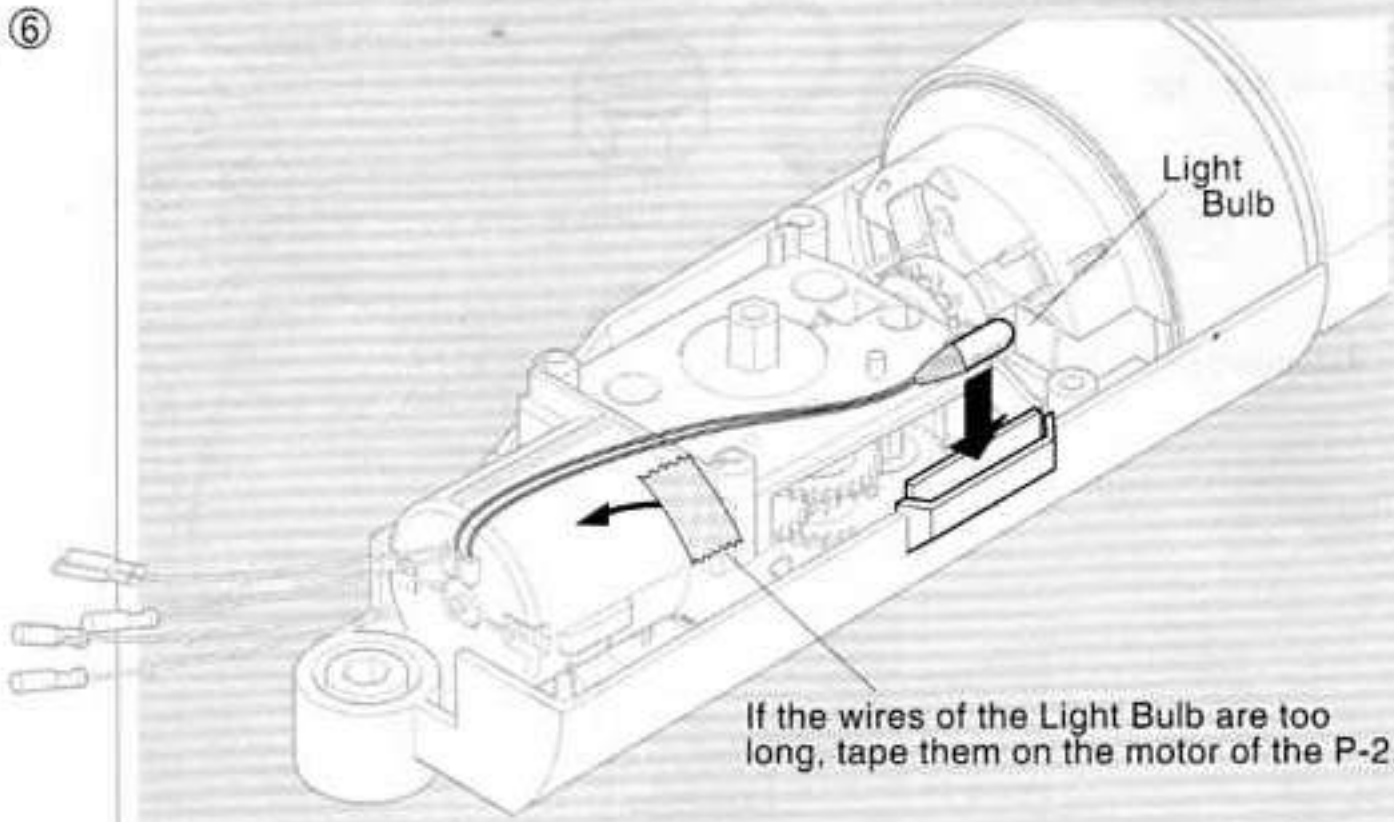
❶ With the P-2 and the Wrist oriented as shown, align the gear on P-2 with the gear on the Clutch Plate so that they engage properly.

❷ P-2 is secured by the hooks in the Fore Arm A.



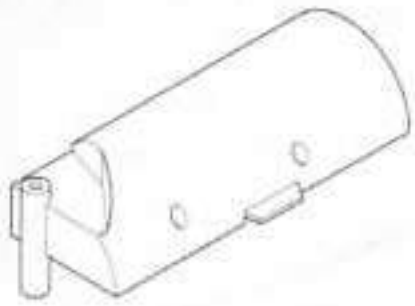
· Assembled Unit in step ⑥

⑦ Insert the Light Bulb into the Fore Arm A as shown.



Go Next

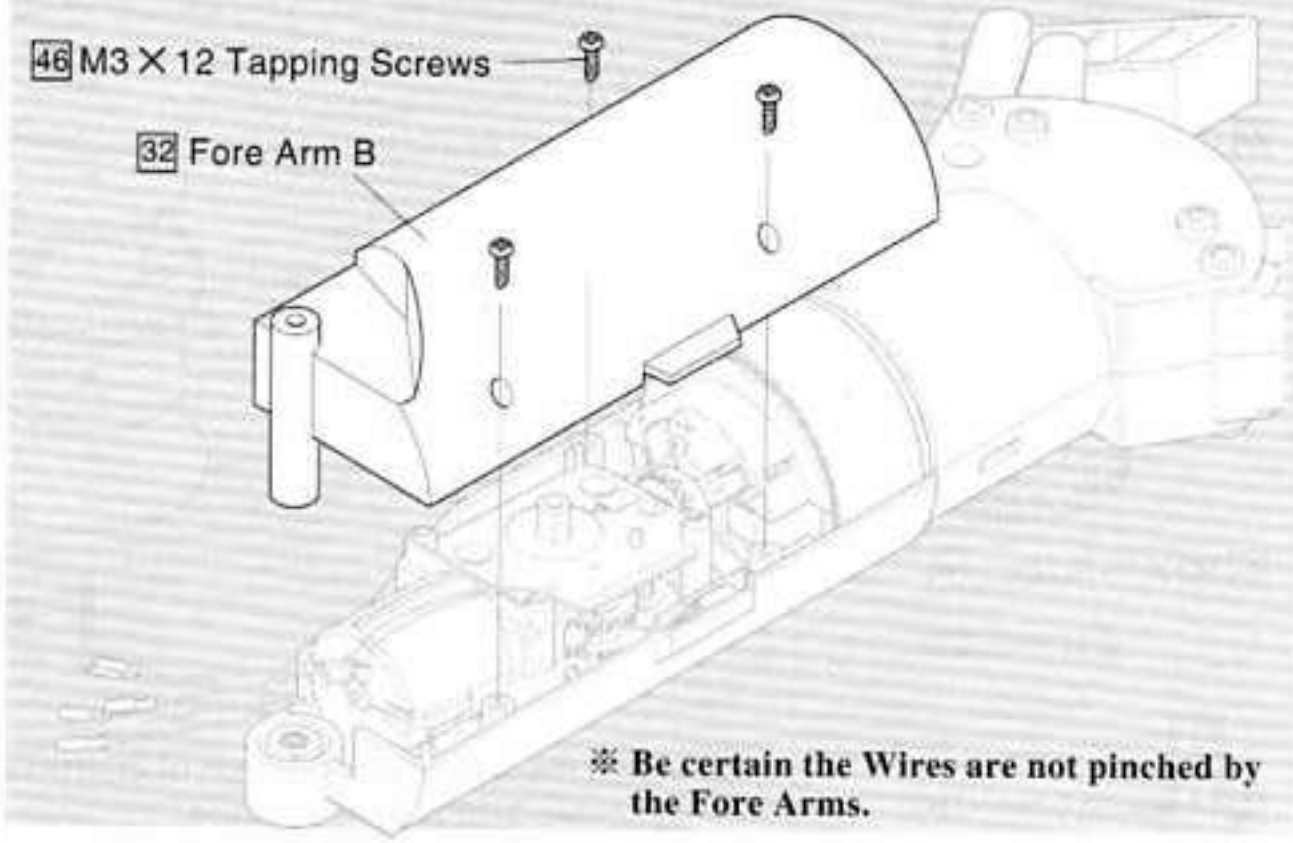
32 Fore Arm B 1pc



46 M3 × 12 Tapping Screw 3pcs

· Assembled Unit in step ⑦

⑧ Mount the Fore Arm B as illustrated and fasten with three Tapping Screws. Align all parts so that the Cover fits tightly.



※ **Be certain the Wires are not pinched by the Fore Arms.**

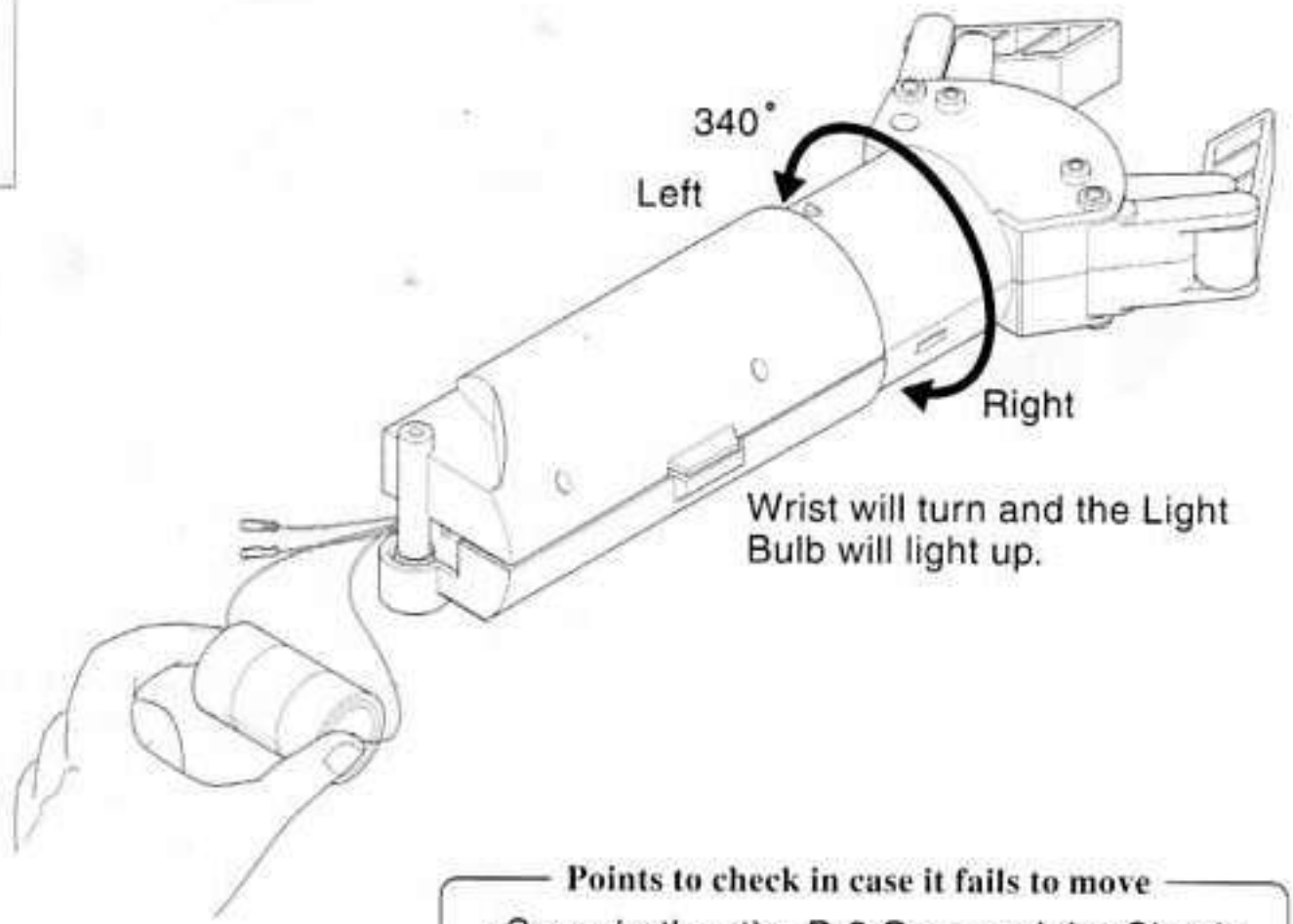
· Assembled fore arm

· "D" battery 1pc (not included)

⑨ Connect a dry cell battery (Size D) to the P-2 wires and check to see if it makes the correct movements.

· The Arm will turn right when the P-2 Motor Wire Blue is connected to (+) and the Motor Wire Green (-); the Arm will turn left when they are connected in reverse.

· If the movement is stopped by the inside stopper or the outside influence P-2 will click and run idle by the action of the clutch.



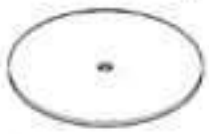
Points to check in case it fails to move

· See whether the P-2 Gear and the Clutch Plate Gear are properly engaged.

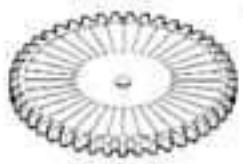
3. Assembling the Upper Arm

2 Clutch Disk (Metal) 2pcs

49 Clutch Pad (Felt) 2pcs

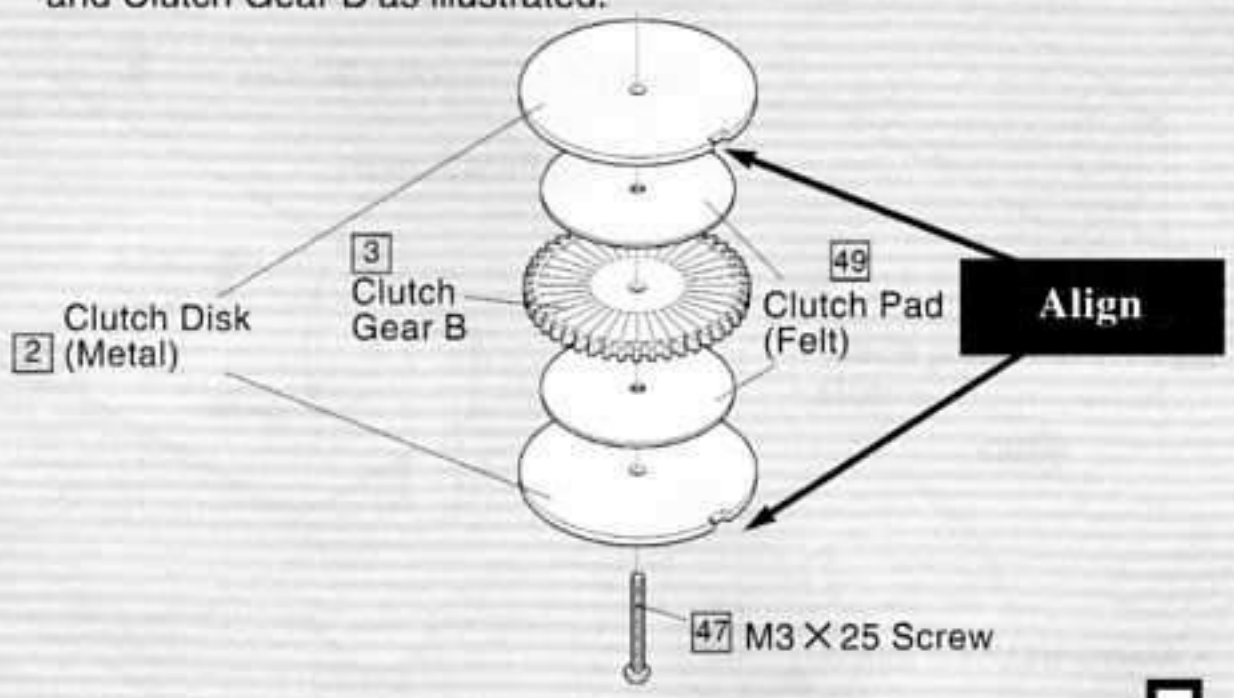


3 Clutch Gear B 1pc



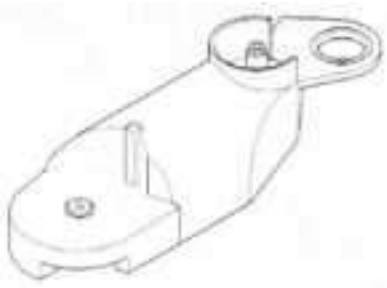
47 M3 X 25 Screw 1pc

① Insert the screw (M3 X 25) through the Clutch Disc, Clutch Pad and Clutch Gear B as illustrated.



1 Mediation Gear 1pc

33 Upper Arm A 1pc



45 Clutch Disk Sticker 1pc

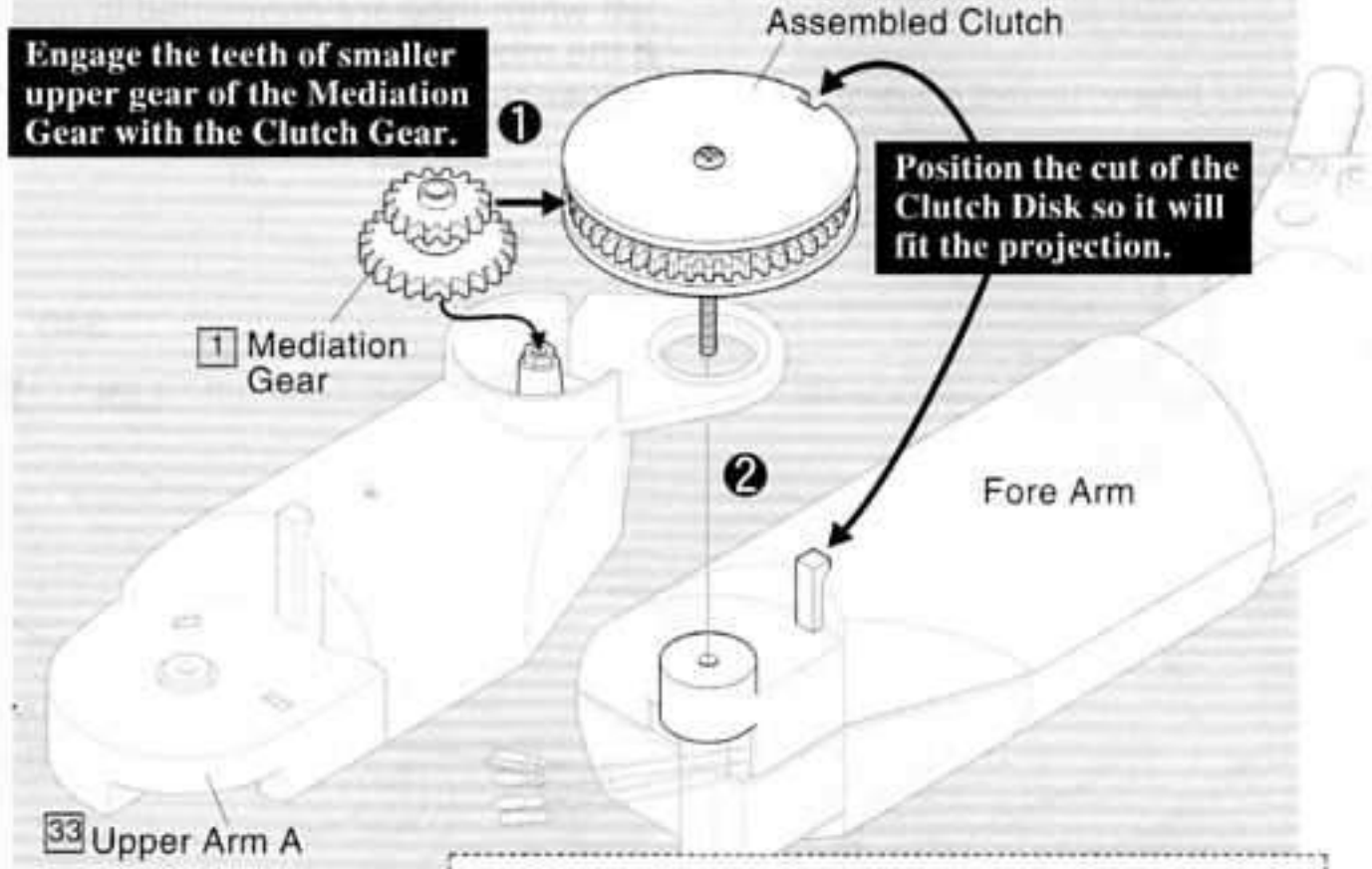
· Assembled fore arm

· Assembled Unit in step ①

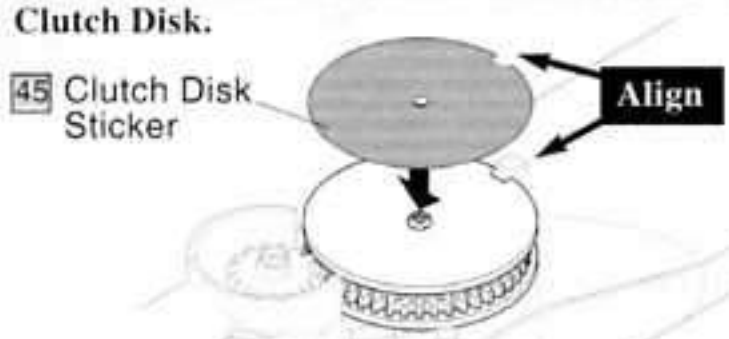
② Install the assembled Clutch of instruction ①, Mediation Gear to Upper Arm A as illustrated.
Do not tighten the screw of the Clutch completely.

❶ Engage the teeth of smaller upper gear of the Mediation Gear with the Clutch Gear.

❷ Install the Mediation Gear to the Upper Arm A and the Clutch Gear to the Fore Arm as keeping their teeth in mesh.



※ Stick the Clutch Disk Sticker on the surface of Clutch Disk.



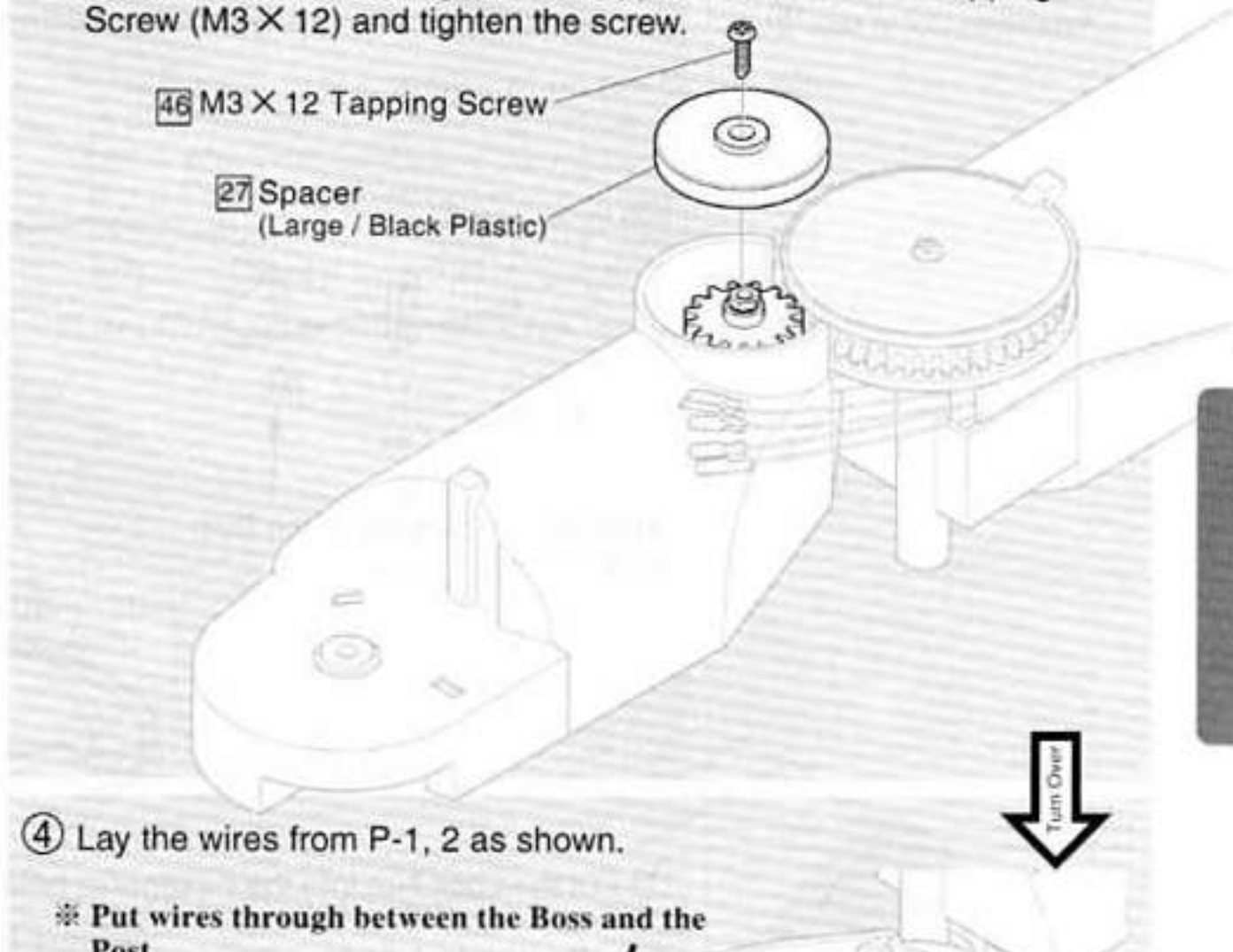
Go Next

27 Spacer
(Large / Black Plastic) 1pc

46 M3 X 12 Tapping Screw
1pc

· Assembled Unit in step ②

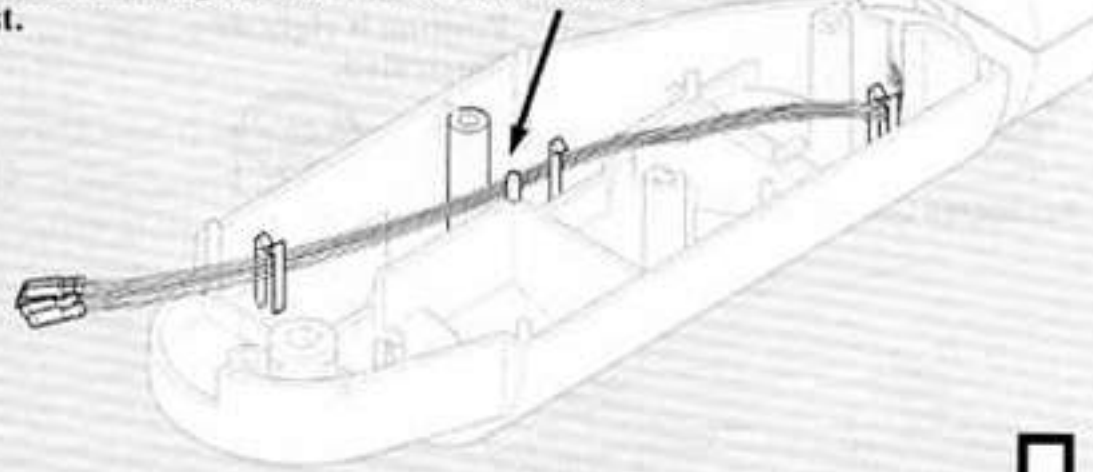
③ Fasten the Spacer (Large) to the Upper Arm A with the Tapping Screw (M3 X 12) and tighten the screw.



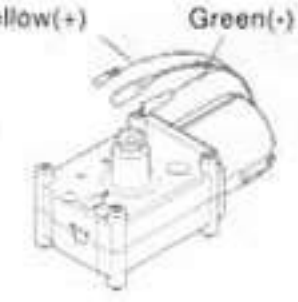
· Assembled Unit in step ③

④ Lay the wires from P-1, 2 as shown.

※ **Put wires through between the Boss and the Post.**

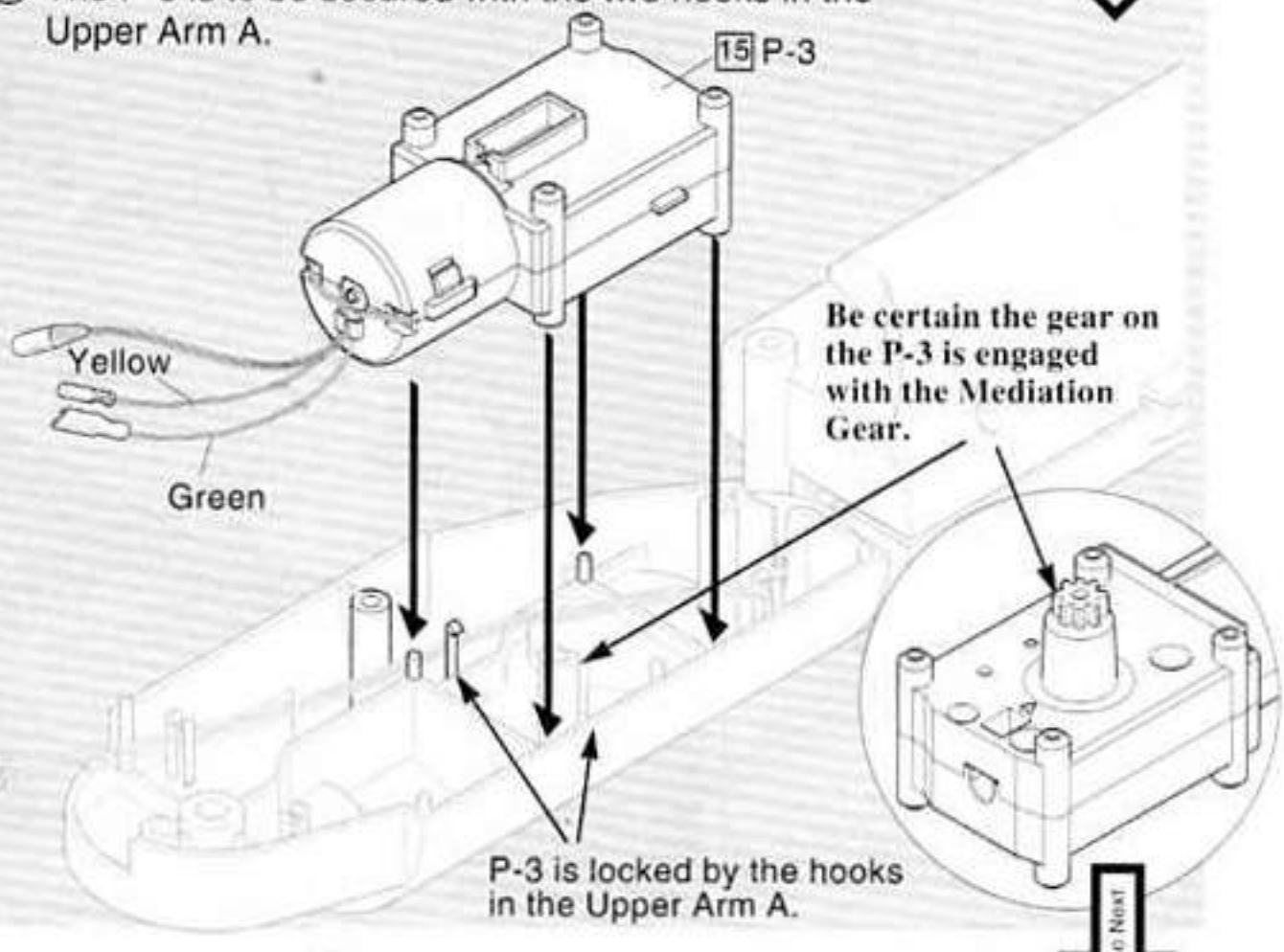


15 Power Unit P-3 1pc



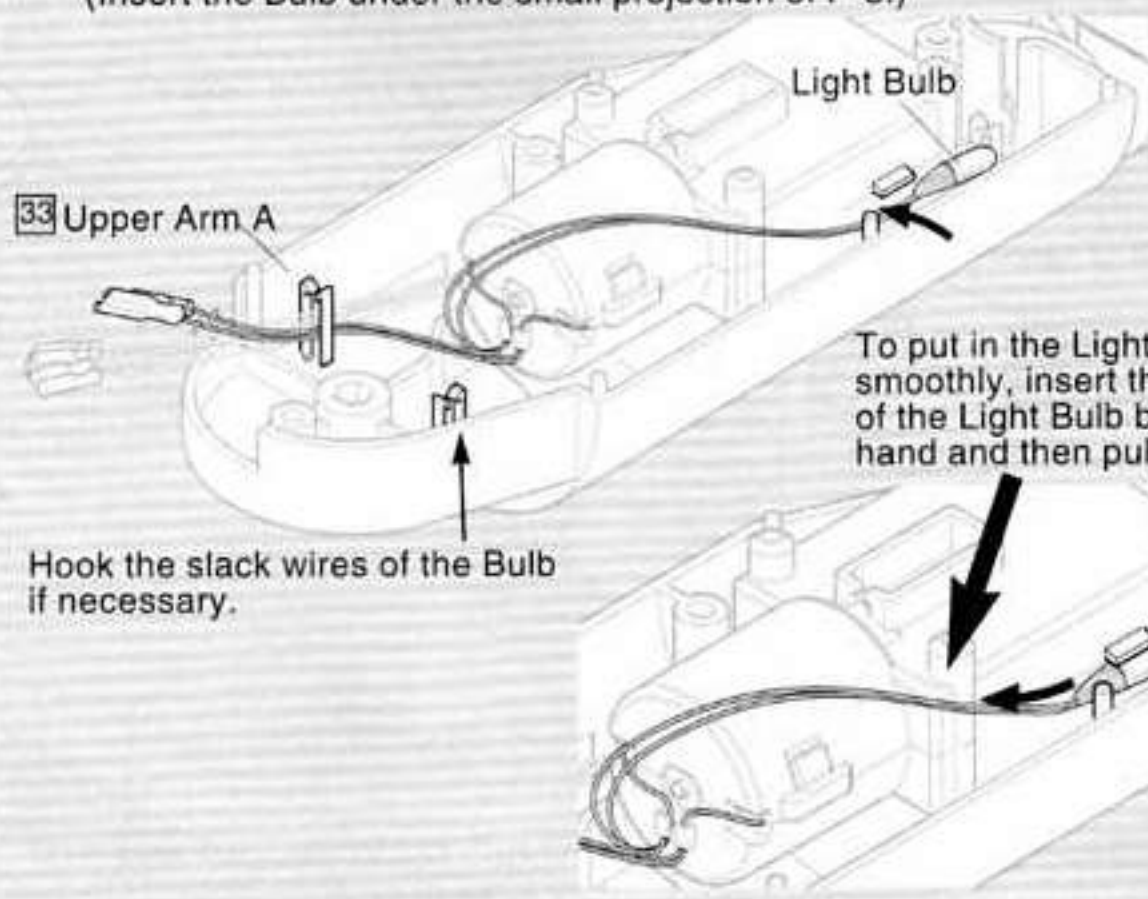
· Assembled Unit in step ④

⑤ The P-3 is to be secured with the two hooks in the Upper Arm A.



- Assembled Unit in step ⑤

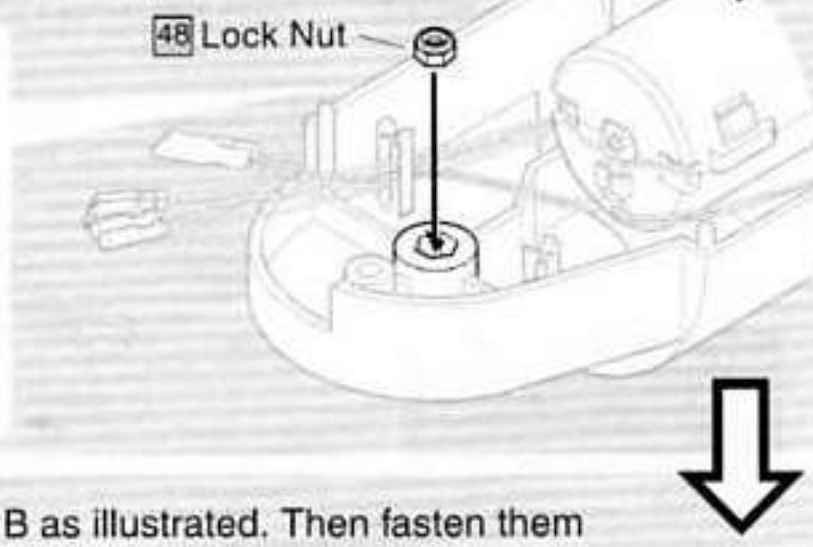
⑥ Set the Light Bulb as illustrated.
(Insert the Bulb under the small projection of P-3.)



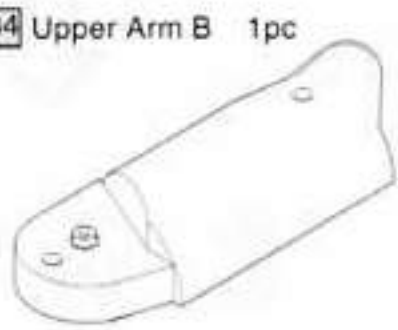
48 Lock Nut 1pc

- Assembled Unit in step ⑥

⑦ Put the Lock Nut into the hexagonal hole of the Upper Arm A.



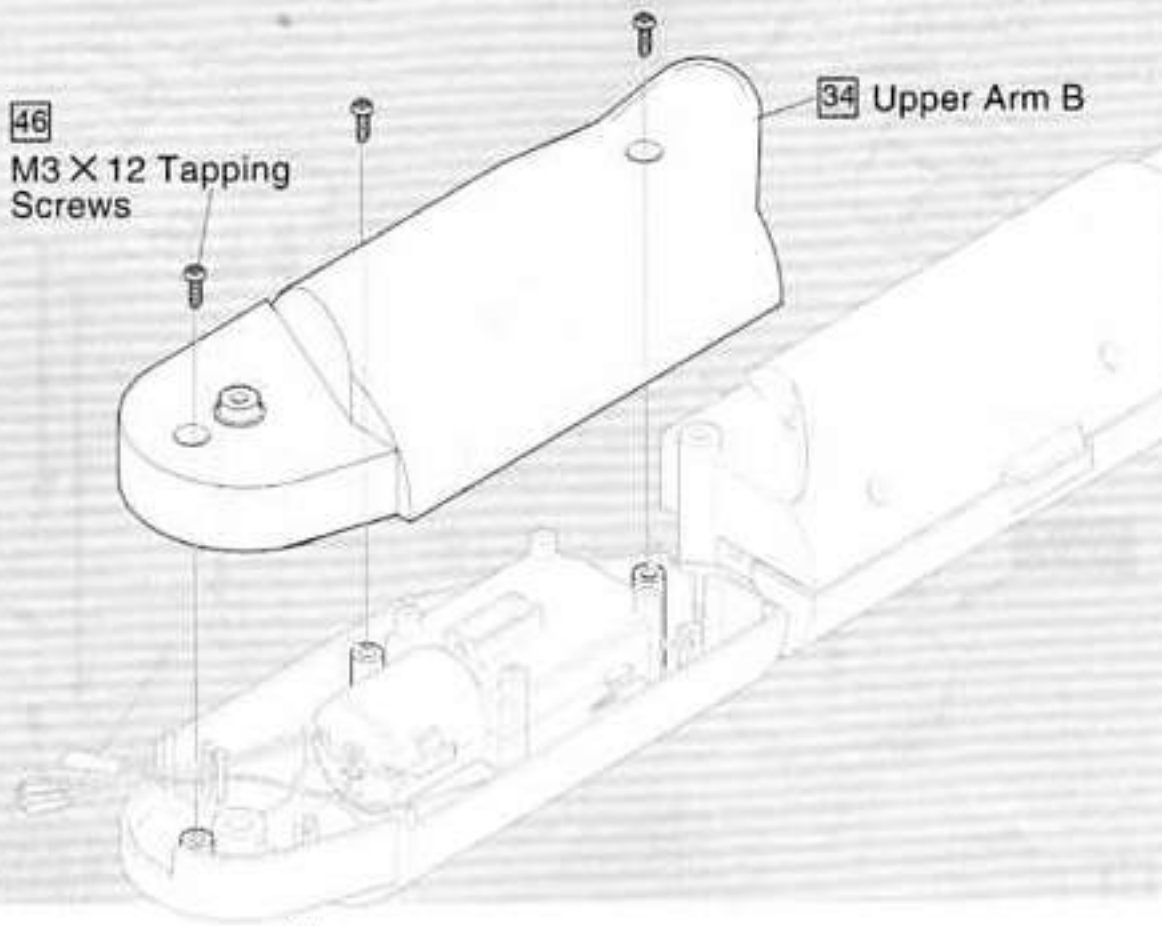
34 Upper Arm B 1pc



46 M3 X 12 Tapping Screw 3pcs

- Assembled Unit in step ⑦

⑧ Mount the Upper Arm B as illustrated. Then fasten them with the three Tapping Screws (M3 X 12).



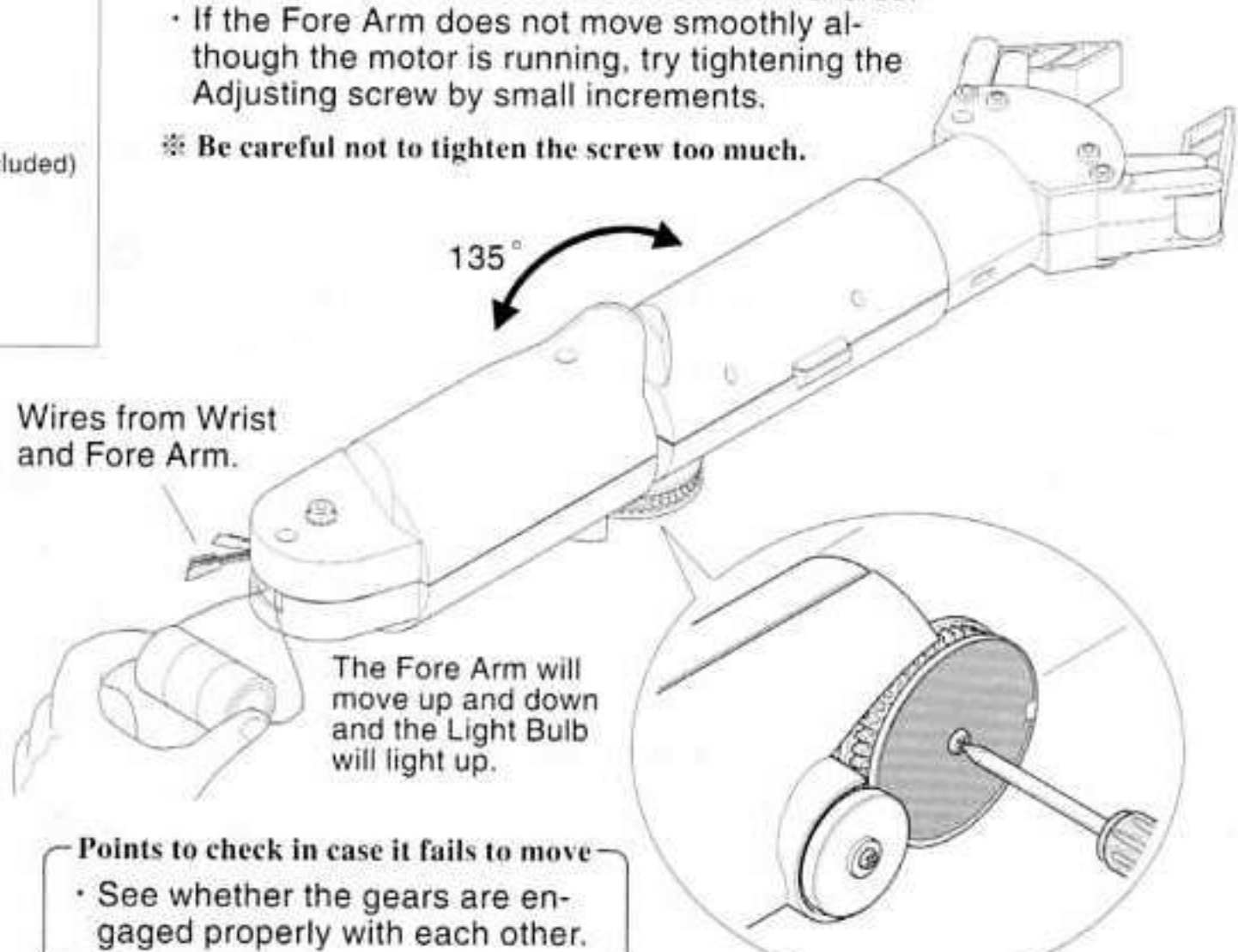
- Assembled upper arm

- Screw Driver (+)
- "D" battery 1pc (not included)

⑨ Connect a dry cell battery (Size D) to the P-3 wires and check to see that it makes the correct movements.

- The Fore Arm will stretch when the Green wire is connected to (+), and the Yellow (-); it will bend when the wires are connected in reverse.
- If the Fore Arm does not move smoothly although the motor is running, try tightening the Adjusting screw by small increments.

※ **Be careful not to tighten the screw too much.**

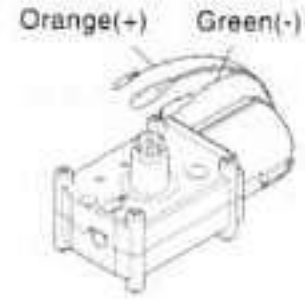


Points to check in case it fails to move

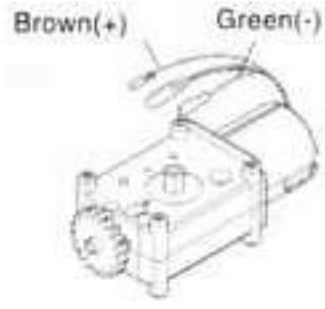
- See whether the gears are engaged properly with each other.

4. Assembling the Armbase

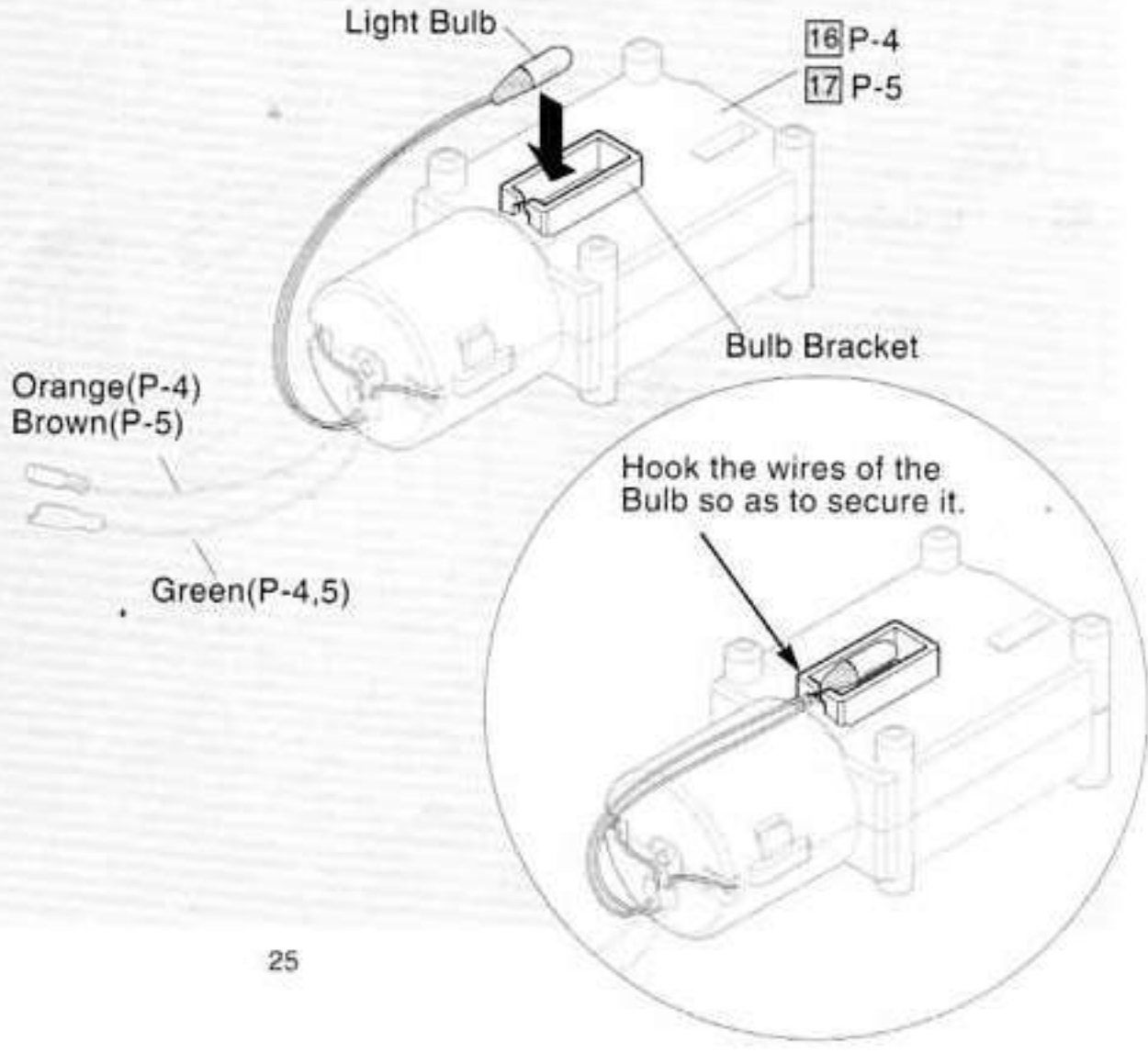
16 Power Unit P-4 1pc



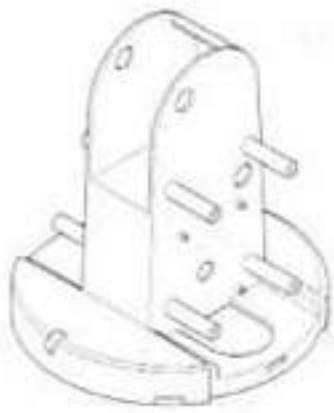
17 Power Unit P-5 1pc



① Store the Light Bulb of P-4,5 as illustrated.



35 Arm Base 1pc

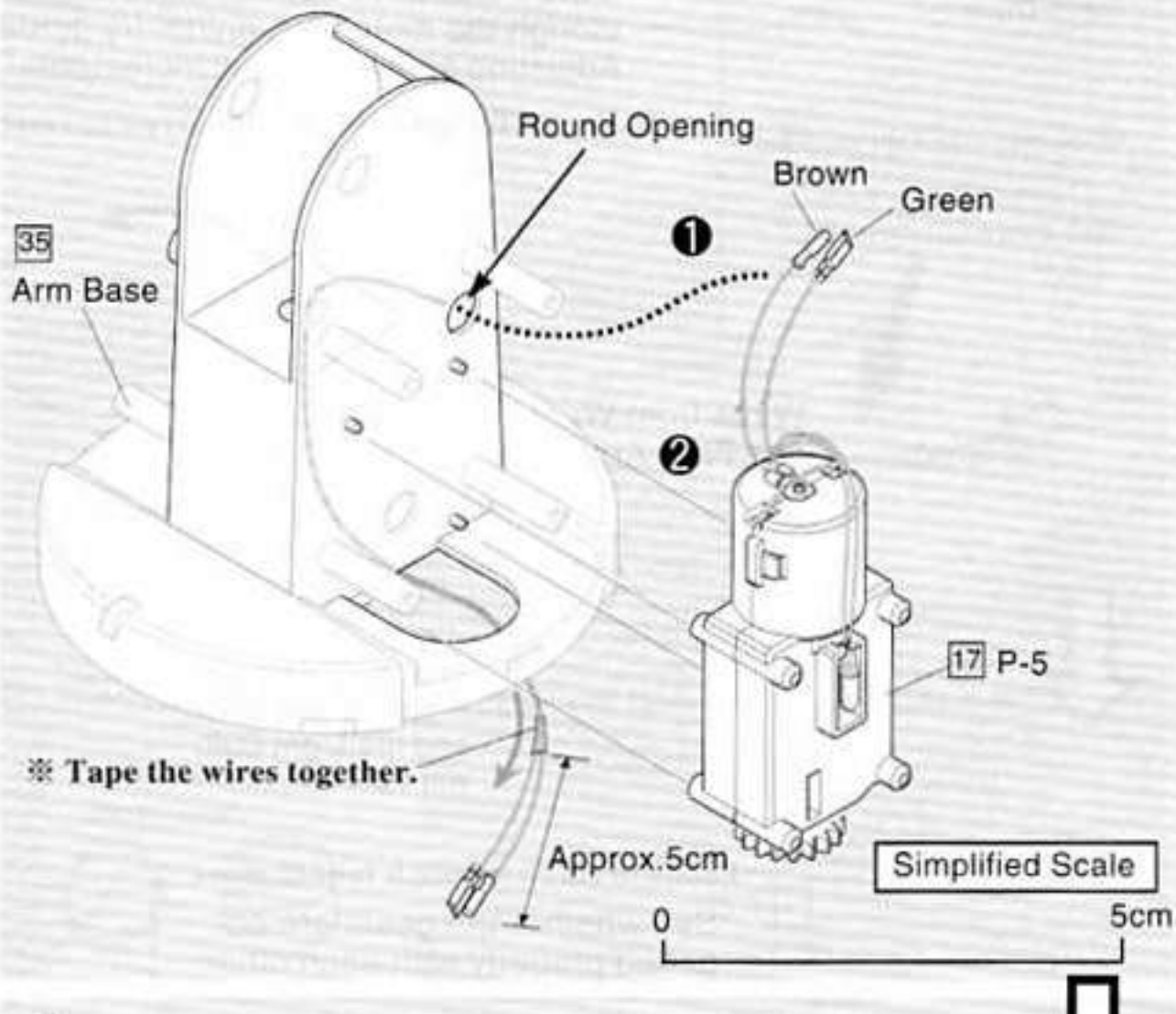


· Assembled Power Unit P-5 in step ①
(Color of wire: Brown and Green)

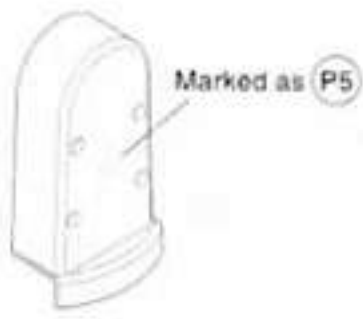
② Attach the Power Unit P-5 to the Arm Base.

❶ Insert the Motor Wires through the round opening and down through round tube and out the bottom.

❷ Install P-5 onto the small pegs to hold the Power Unit in place.



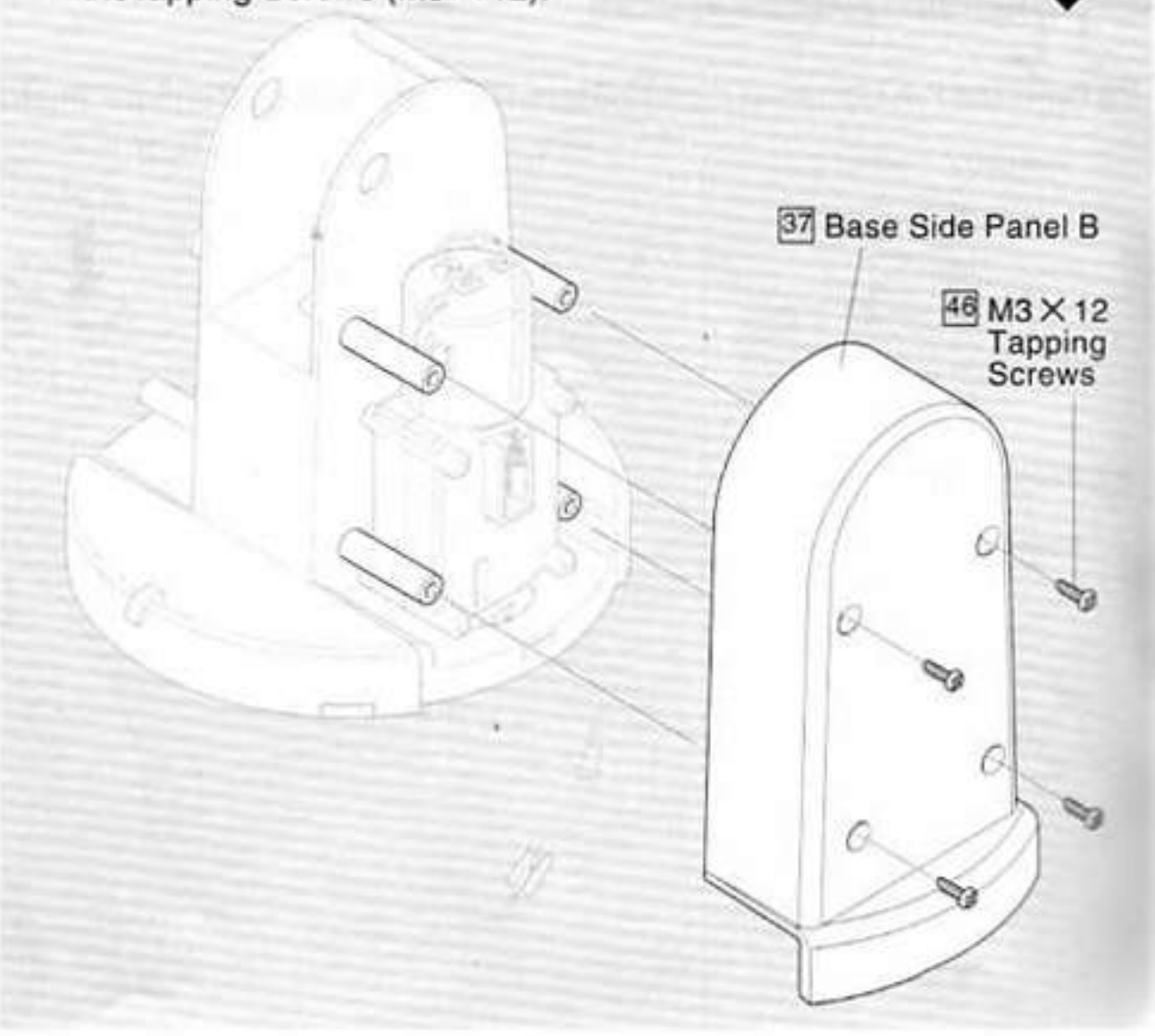
37 Base Side Panel B 1pc



46 M3 X 12 Tapping Screw 4pcs

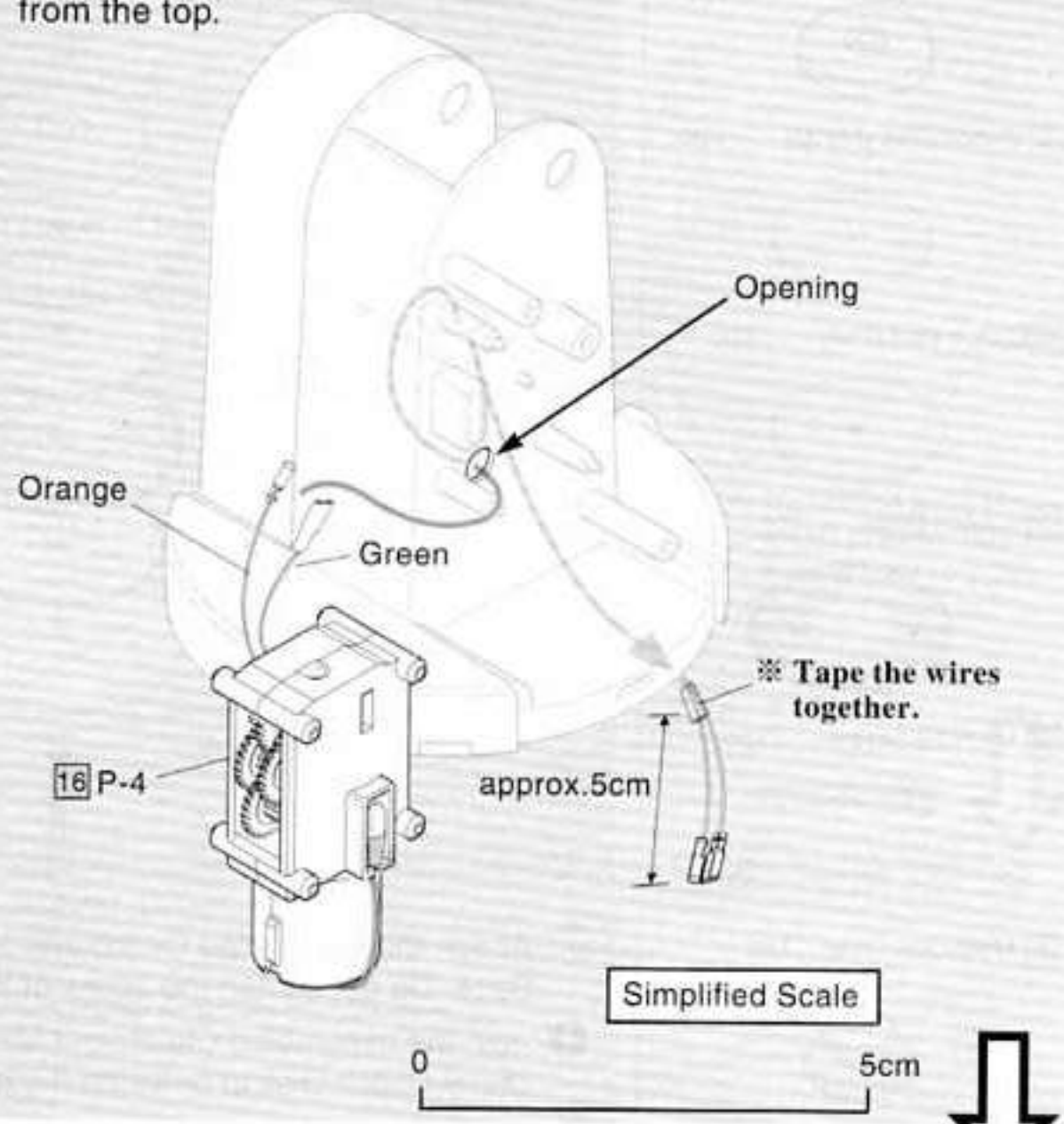
· Assembled Unit in step ②

③ Attach the Base Side Panel B to the Arm Base with theTapping Screws (M3 X 12).



- Assembled Power Unit P-4 in step ①
  (Color of wire: Orange and Green)
- Assembled Unit in step ③

④ Insert the P-4 Motor wires through the pointed opening and then pass them through the round tube in the center of the Arm Base from the top.

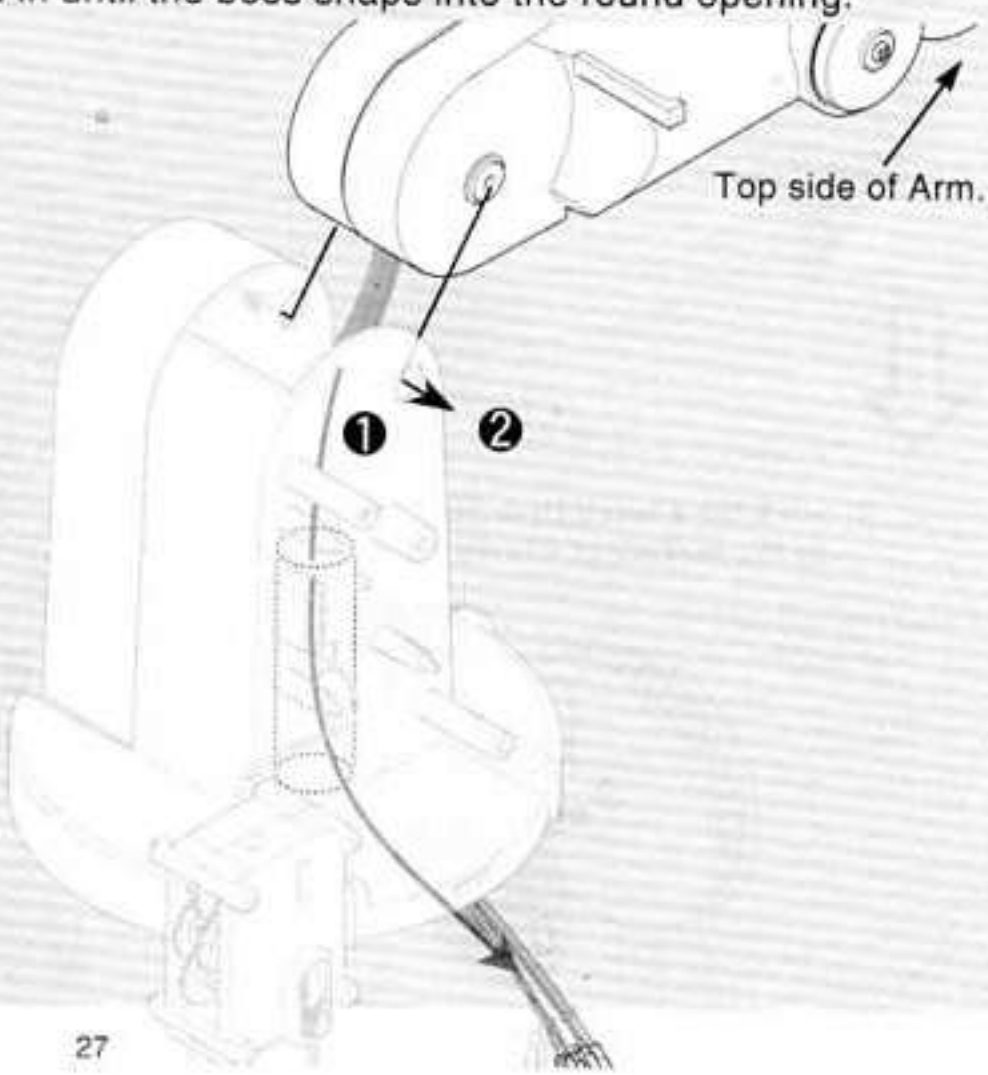


- Assembled upper arm
- Assembled Unit in step ④

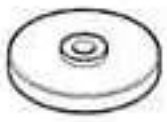
⑤ Insert the completed Arm (Wrist to Upper Arm) to the Arm Base.

❶ Pass all the Motor Wires through the round tube in the center of the Arm Base.

❷ Gently separate the sides slightly and slide the Assembled upper arm in until the boss snaps into the round opening.

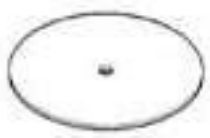


27 Spacer (Large / Black Plastic) 1pc

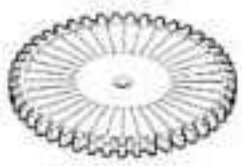


2 Clutch Disk (Metal) 2pc

49 Clutch Pad (Felt) 2pc



3 Clutch Gear 1pc



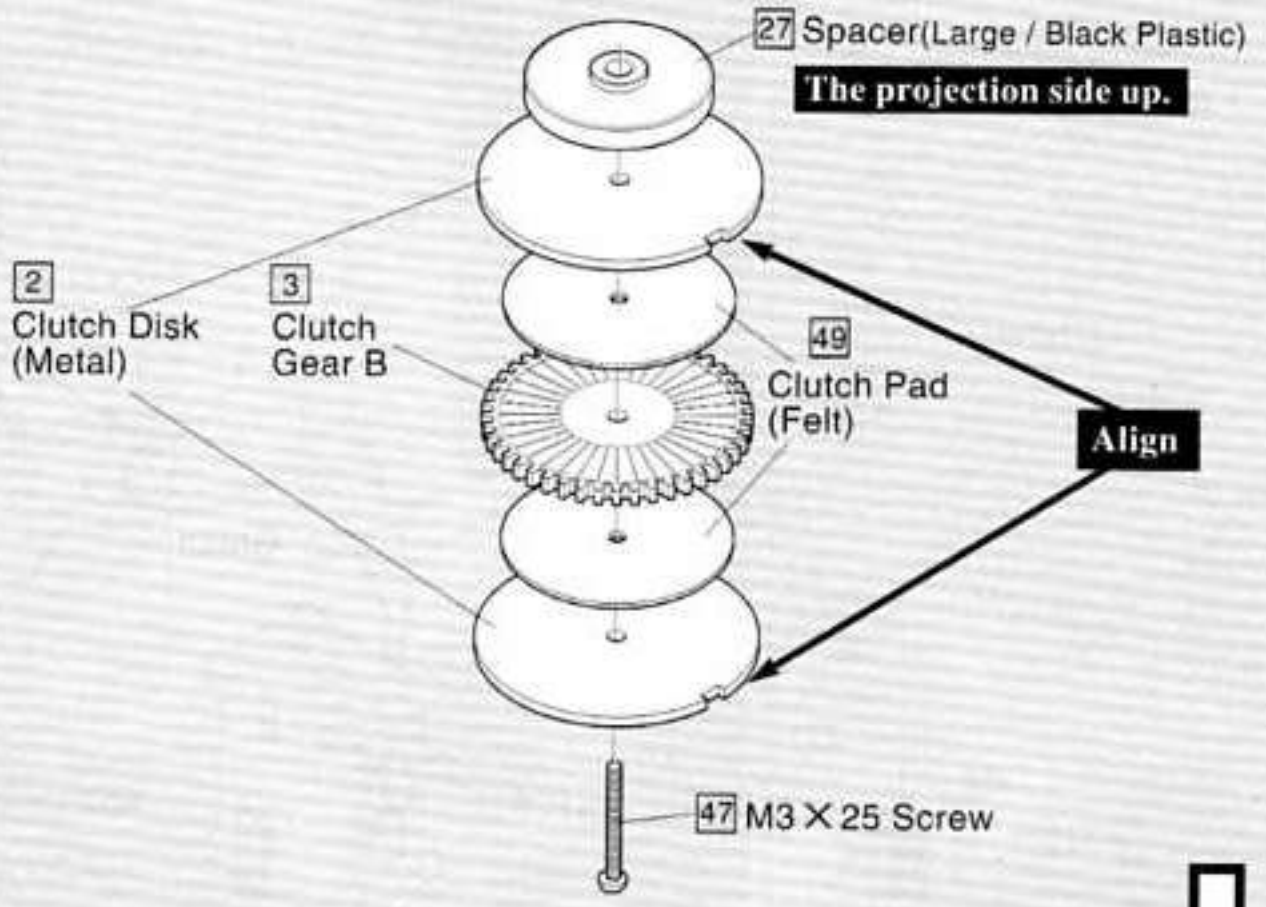
47 M3 X 25 Screw 1pc

1 Mediation Gear 1pc

45 Clutch Disk Sticker 1pc

- Assembled Unit in step ⑤
- Assembled Unit in step ⑥

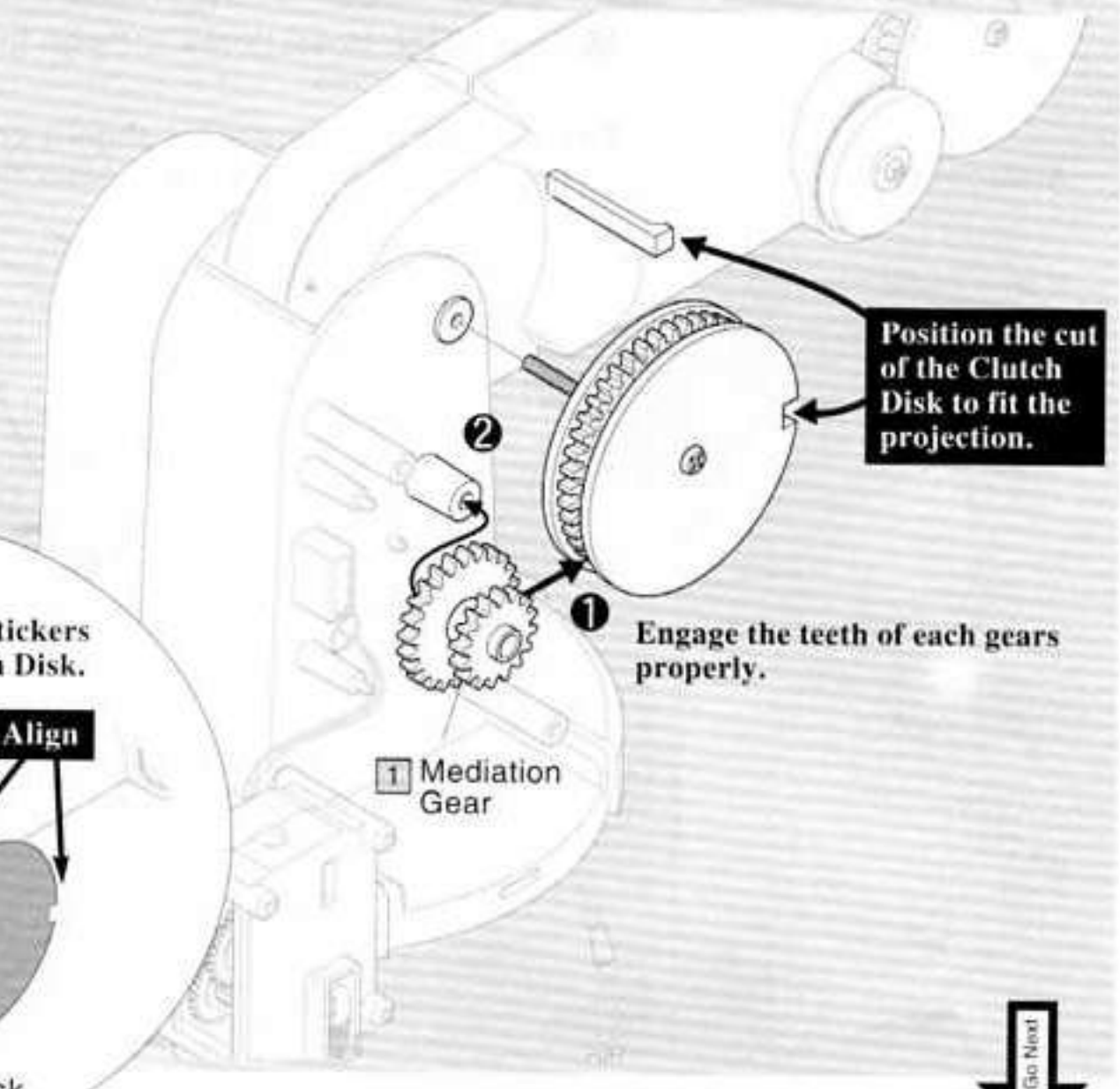
⑥ Insert the screw (M3 X 25) through the Clutch Disc, the Clutch Pad, the Clutch Gear B and the Spacer as illustrated.

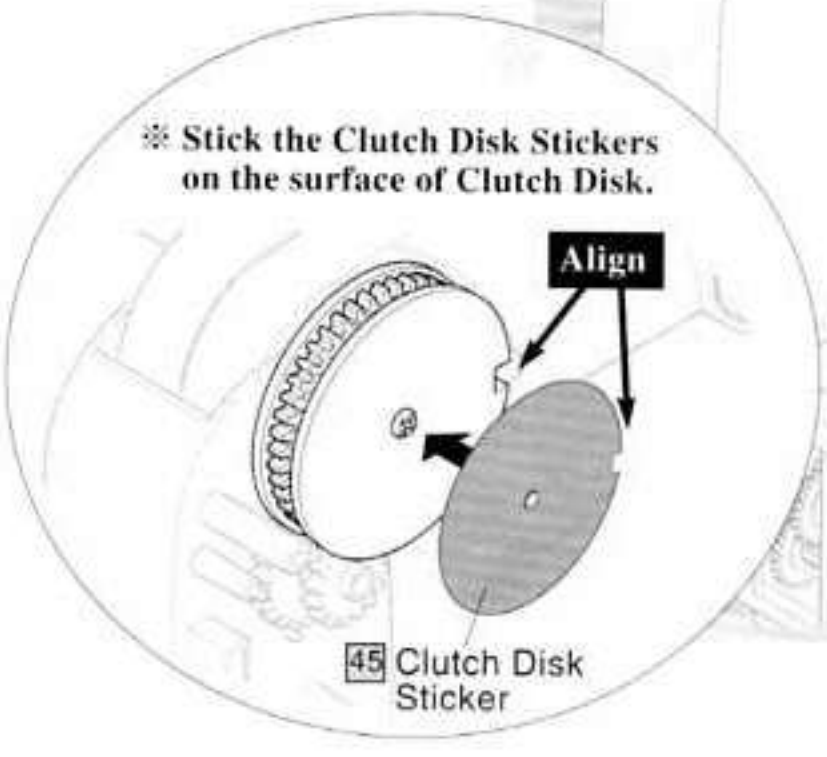


⑦ Attach the assembled Clutch and Mediation Gear to the Arm Base. Do not tighten the screw of the Clutch completely.

❶ Join the assembled Clutch and Mediation Gears by putting the metal Clutch Disk in between the large and small Mediation Gears.

❷ Then install both together onto the Arm Base.

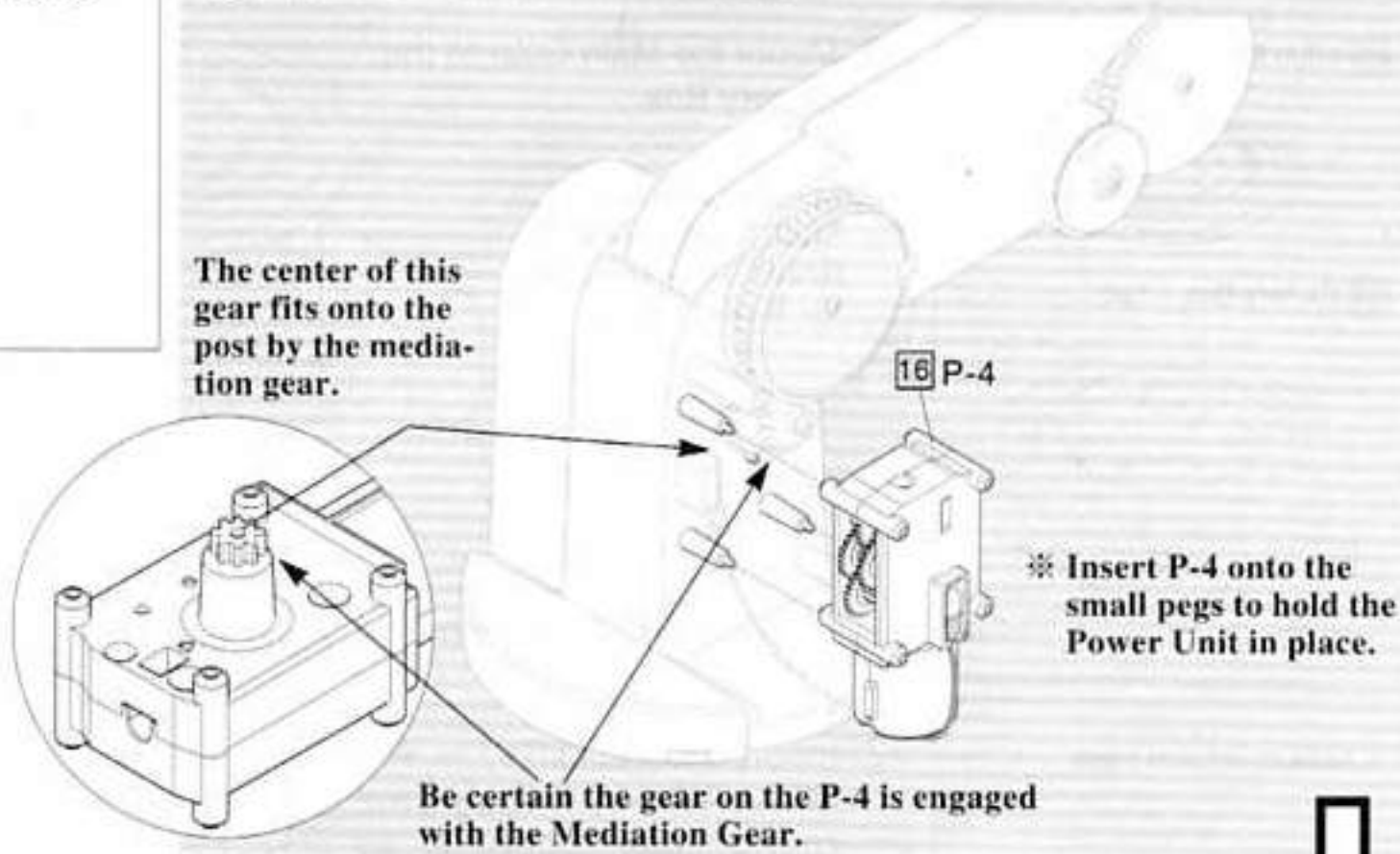




Go Next

· Assembled Unit in step ⑦

⑧ Attach the P-4 to the Arm Base.

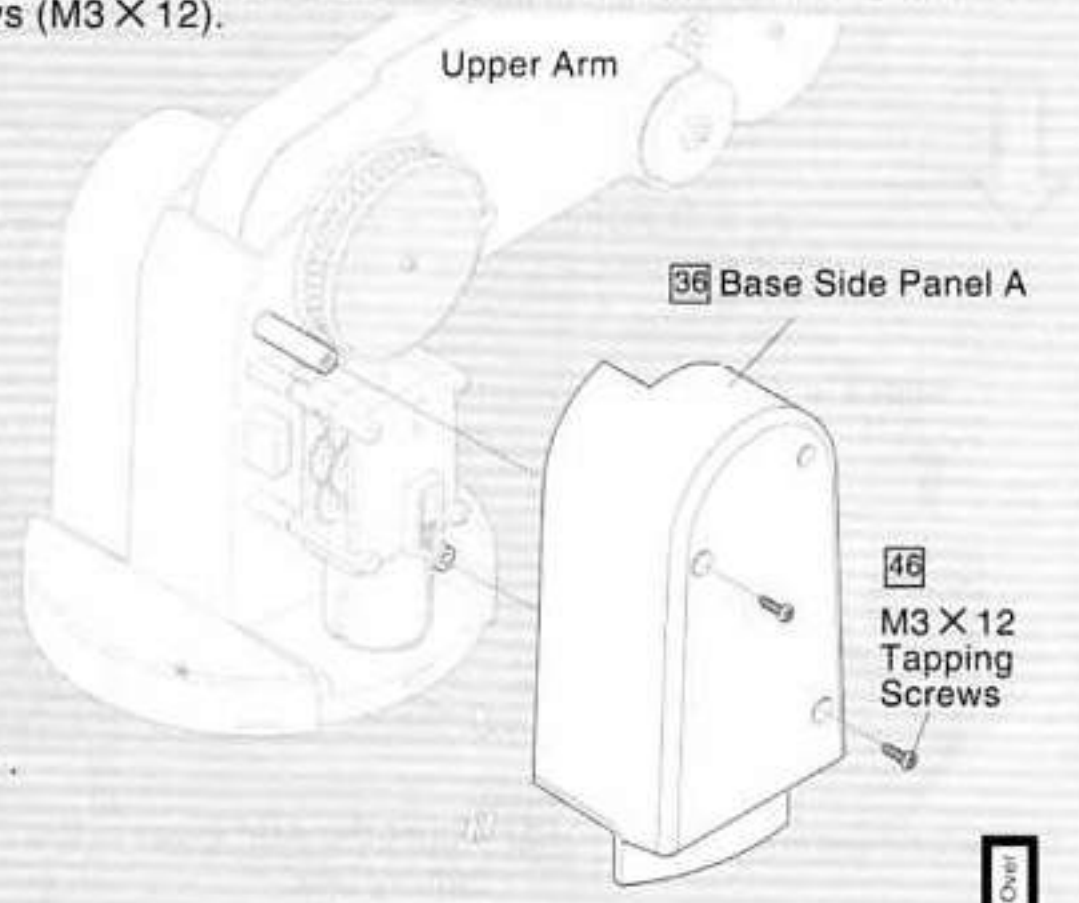


36 Base Side Panel A 1pc

46 M3 X 12 Tapping Screw 2pcs

· Assembled Unit in step ⑧

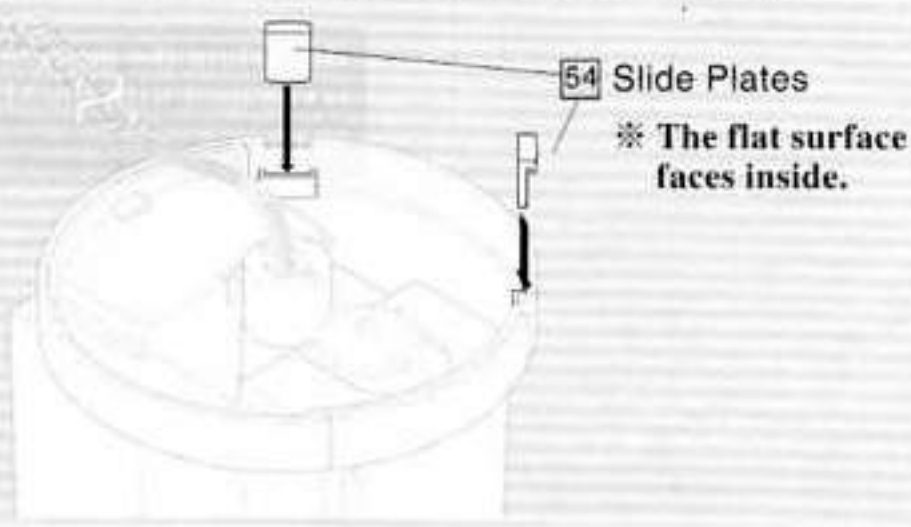
⑨ Attach the Base Side Panel A to the Arm Base with the Tapping Screws (M3 X 12).



· Assembled Unit in step ⑨

54 Slide Plate 2pcs

⑩ Turn over the Arm Base and insert the Slide Plates as shown.



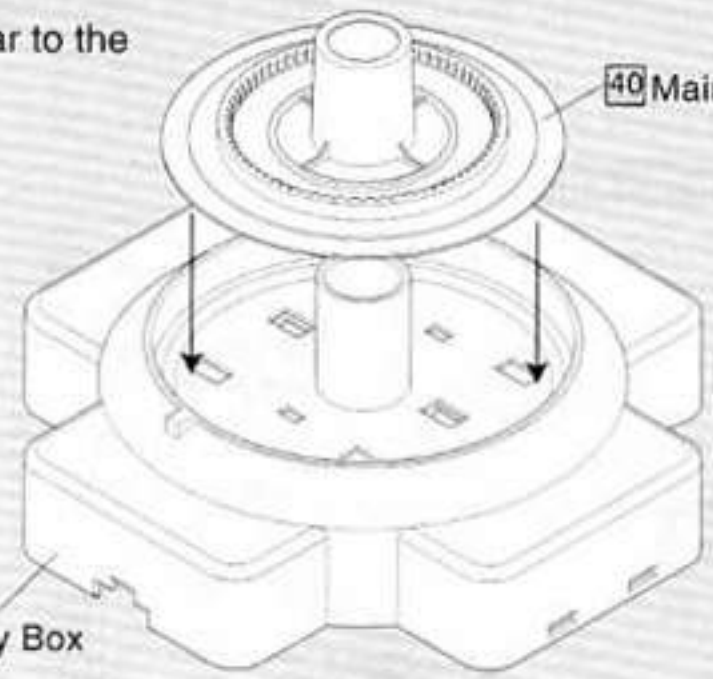
5. Assembling the battery Box

40 Main Gear 1pc

38 Battery Box 1pc

① Mount the Main Gear to the Battery Box.

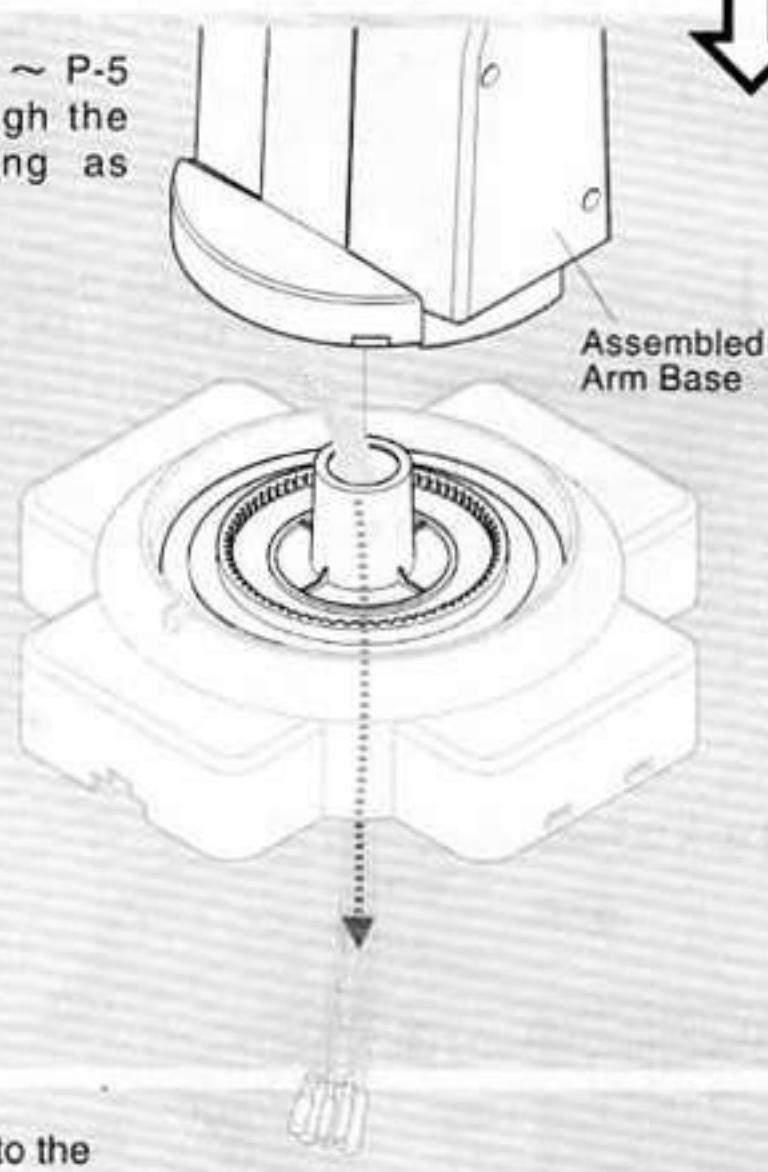
※ **Make certain the Main Gear is seated firmly and evenly on the Battery Box.**



- Assembled arm base

- Assembled Unit in step ①

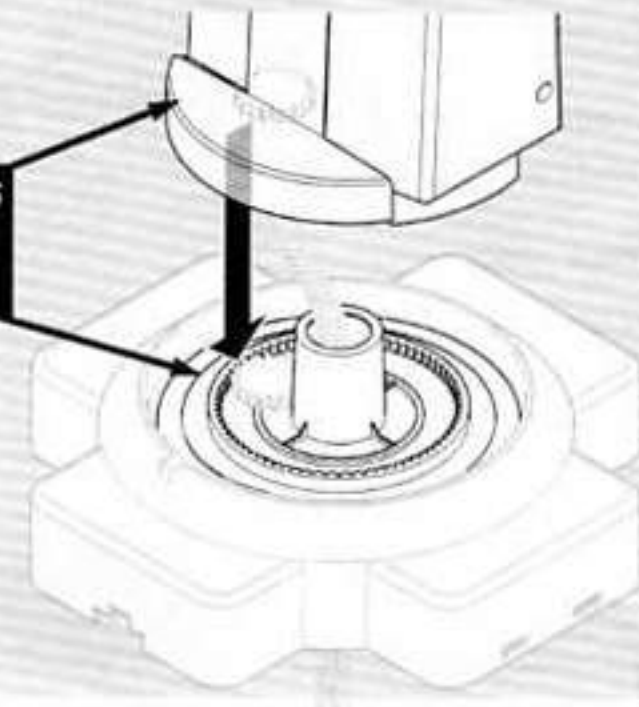
② Insert the Wires(P-1 ~ P-5 Motor Wires) through the round tube opening as illustrated.



- Assembled Unit in step ②

③ Mount the Arm Base to the Battery Box.

Be certain the gear on P-5 is engaged with the Main gear.

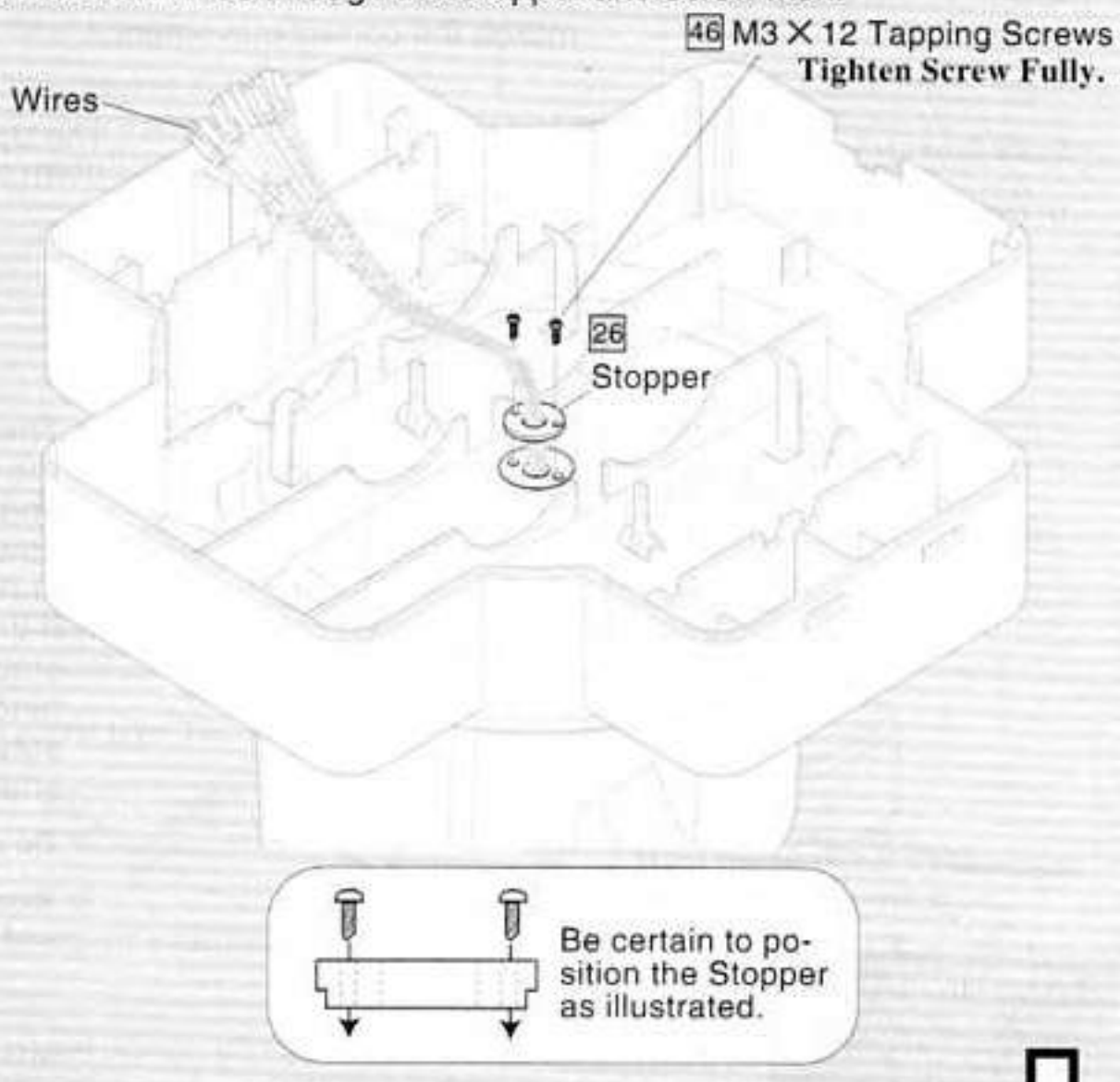


26 Stopper 1pc

46 M3 X 12 Tapping Screw 2pcs

· Assembled Unit in step ③

④ Insert all wires through the Stopper and screw it on.

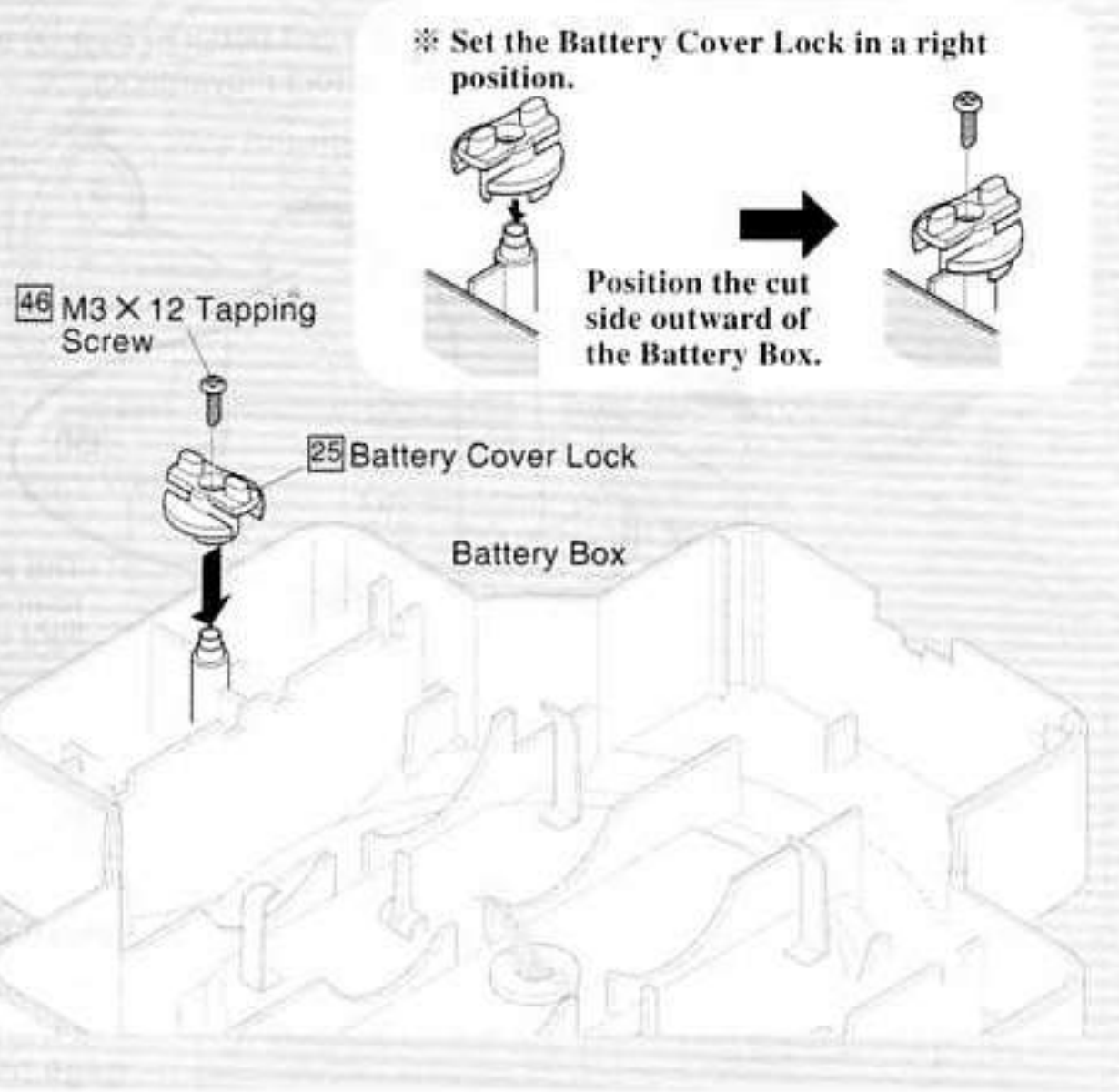


25 Battery Cover Lock 1pc

46 M3 X 12 Tapping Screw 1pc

· Assembled Unit in step ④

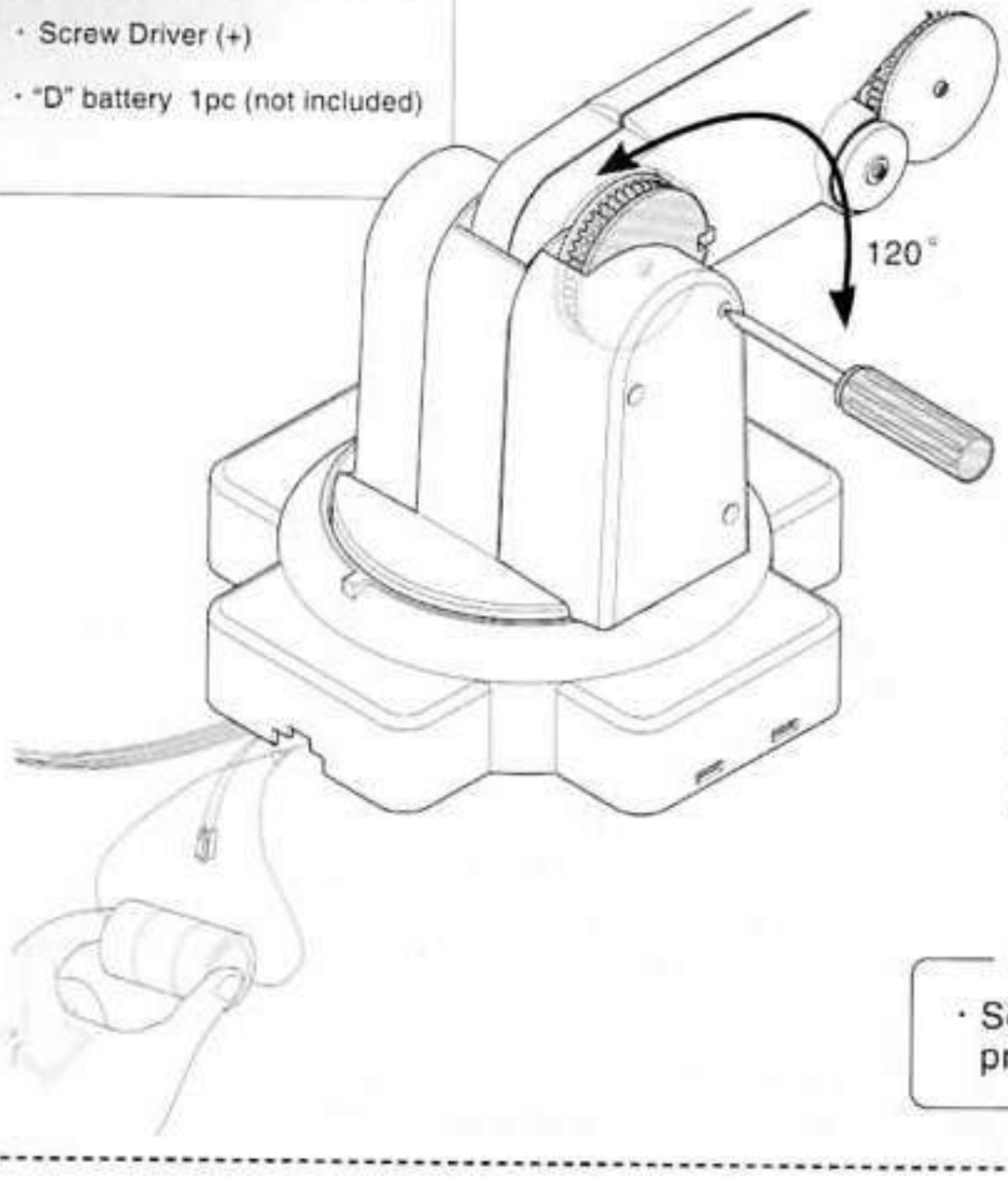
⑤ Fit th the Battery Cover Lock into the Battery Box as illustrated and fasten with the Tapping Screw (M3 X 12).



- Assembled Unit in step ⑤

- Screw Driver (+)
- "D" battery 1pc (not included)

⑥ Connect a dry cell battery (Size D) to P-4, and check to see that it makes the correct movement.



The Upper Arm will move up and down and the Light Bulb will light up.

- The Upper Arm will move up when the Green wire is connected to (-) and the Orange wire (+); it will move down when the wires are connected in reverse.
- If the Upper Arm dose not move smoothly although the motor is running, try to tighten the Adjusting screw of the Shoulder Clutch by small increments.

※ **Do not tighten up too much.**

※ **Remove the adhesive tape on the orange and green wires after the test.**

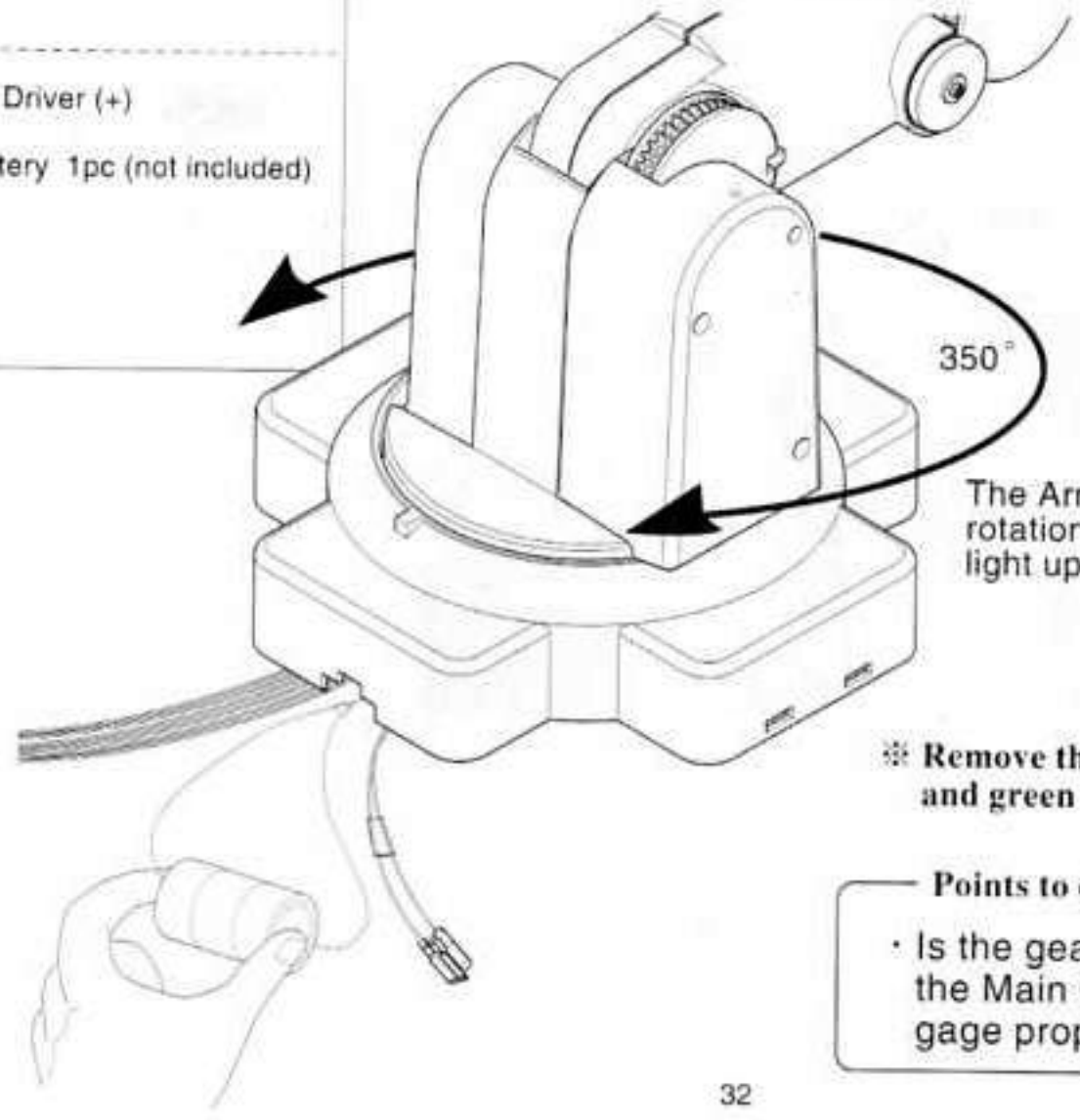
Points to check in case it fails to move

- See whether the gears are engaged properly with each other.

- Assembled Unit in step ⑤

- Screw Driver (+)
- "D" battery 1pc (not included)

⑦ Connect a dry cell battery (Size D) to P-5, and check to see that it makes the correct movements.



- The Arm Base will turn counterclockwise when the Green wire is connected to (-) and the Brown wire (+); it will turn clockwise when the wires are connected in reverse.

The Arm Base will make a 350° rotation and the Light Bulb will light up.

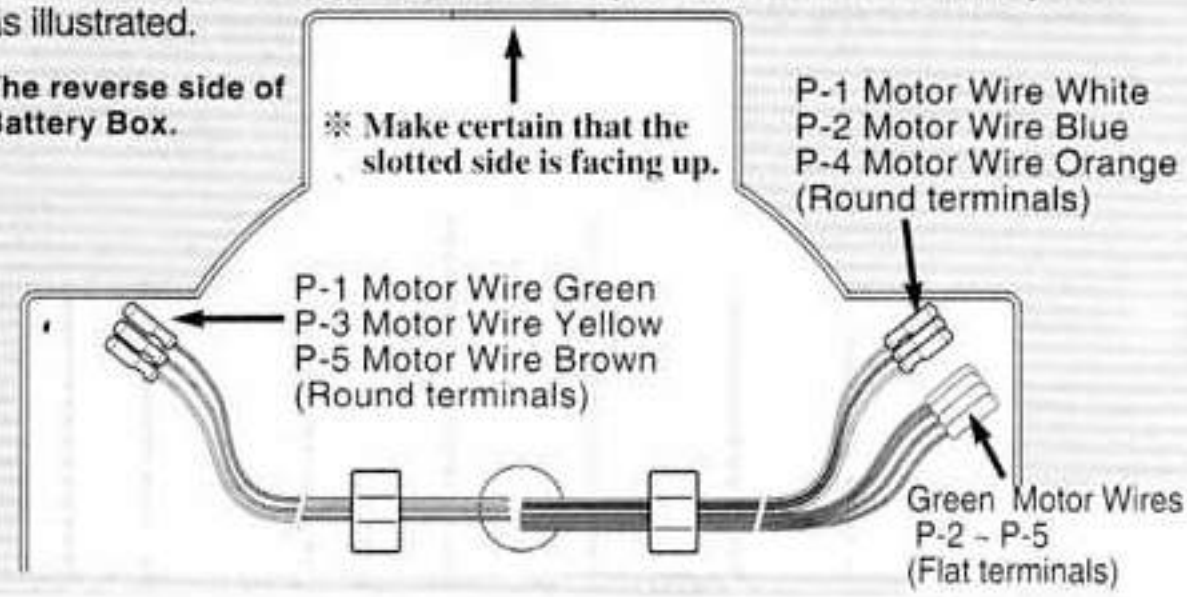
※ **Remove the adhesive tape on the blown and green wires after the test.**

Points to check in case it fails to move

- Is the gear on P-5 properly seated on the Main Gear so that the gears engage properly ?

· Assembled Unit in step ⑤

⑧ Insert the wires through the tunnel-shaped bracket on the Battery Box as illustrated.

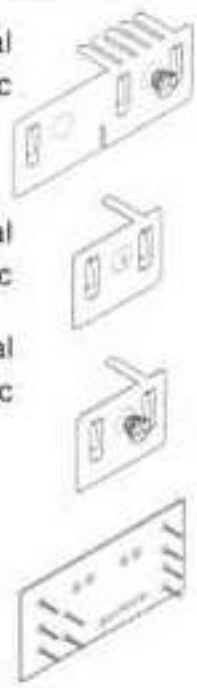


18 Battery Terminal Plate No.1 1pc

19 Battery Terminal Plate No.2 1pc

20 Battery Terminal Plate No.3 1pc

43 Connector Terminal Unit 1pc



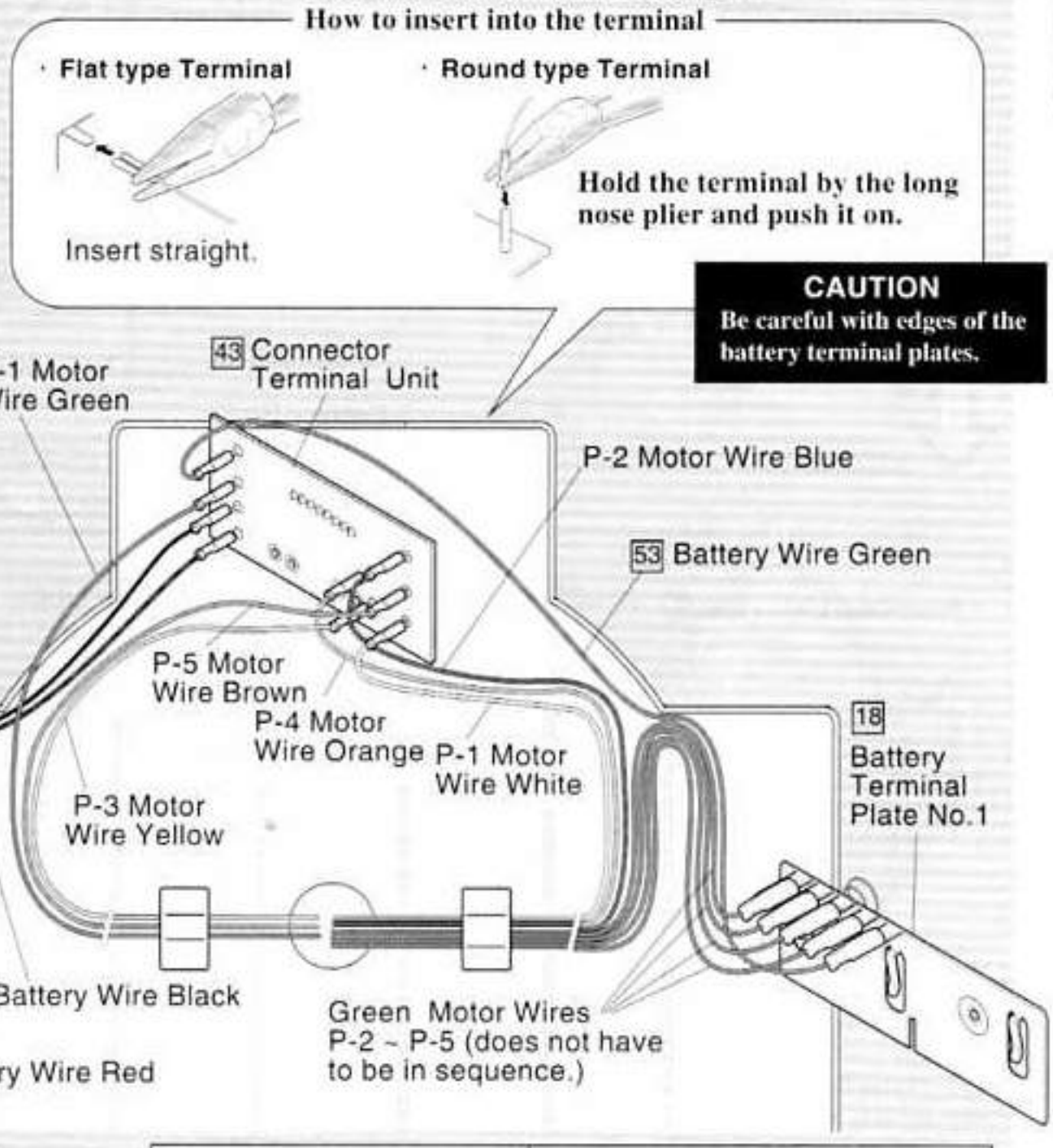
Battery Wire

51 Black 1pc

52 Red 1pc

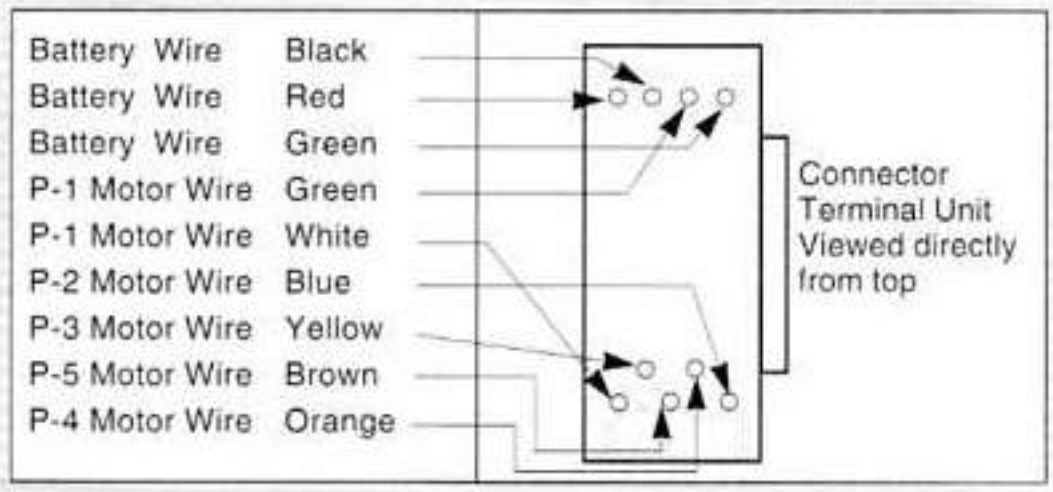
53 Green 1pc

⑨ Connect each wires as shown. ※ See the wiring list.



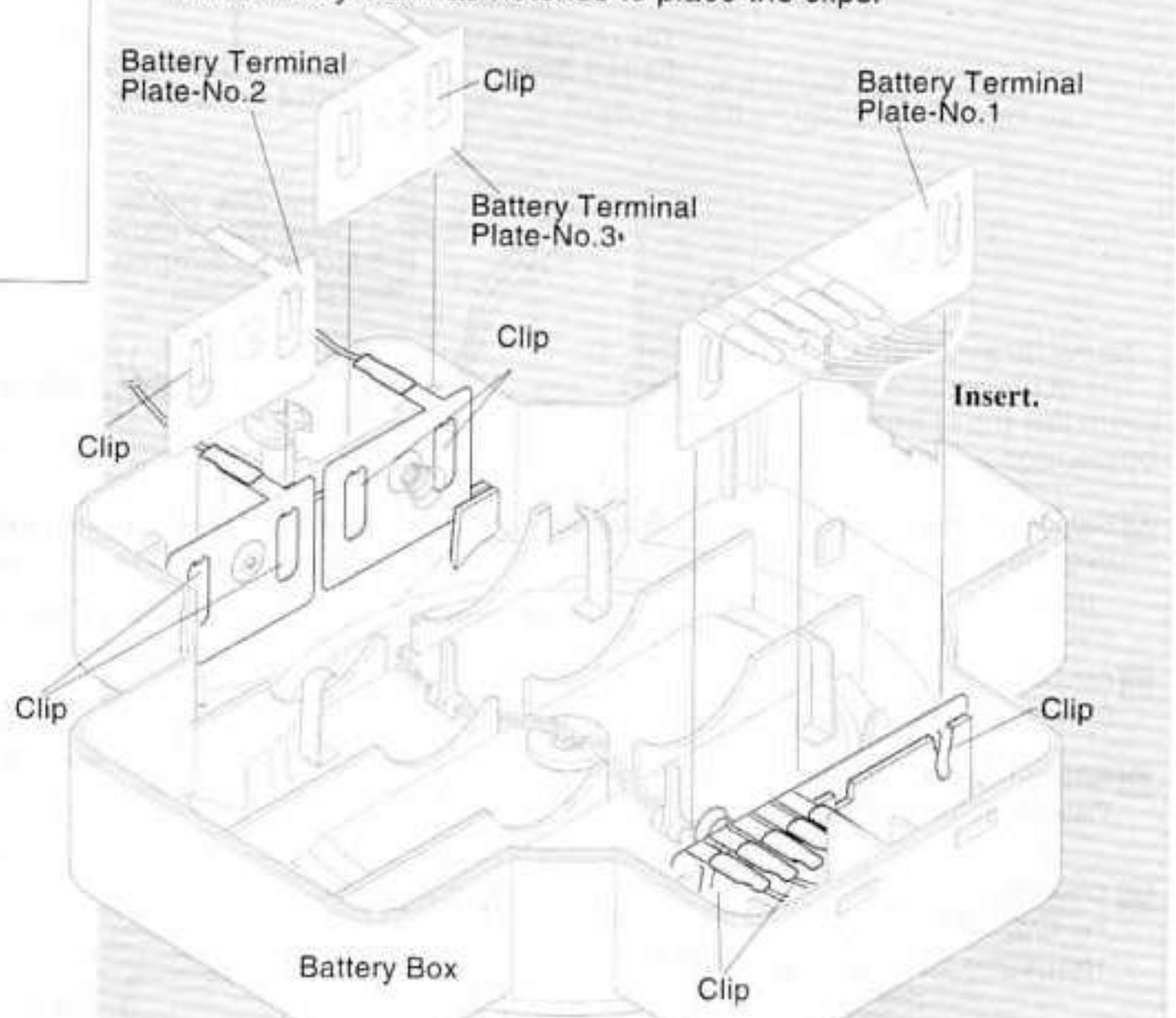
Wiring list

P-2 Motor Wire	Green	Battery Terminal Plate No.1
P-3 Motor Wire	Green	
P-4 Motor Wire	Green	
P-5 Motor Wire	Green	
Battery Wire	Red	Battery Terminal Plate No.2
Battery Wire	Black	Battery Terminal Plate No.3
Battery Wire	Green	Battery Terminal Plate No.1



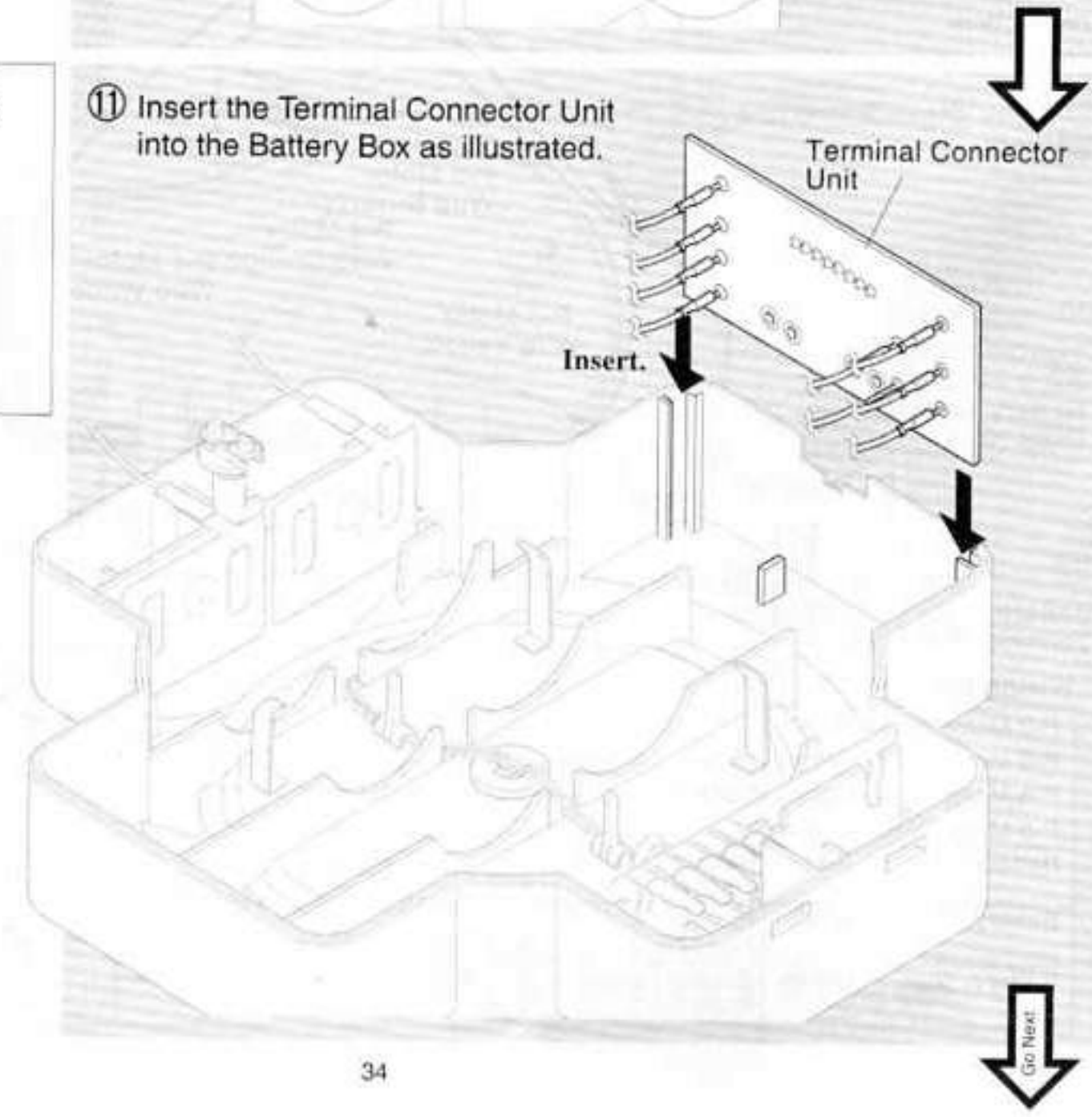
· Assembled Unit in step ⑨

⑩ Clip on the Battery Terminals to the Battery Box as shown.
The Battery Box has notches to place the clips.



· Assembled Unit in step ⑩

⑪ Insert the Terminal Connector Unit into the Battery Box as illustrated.

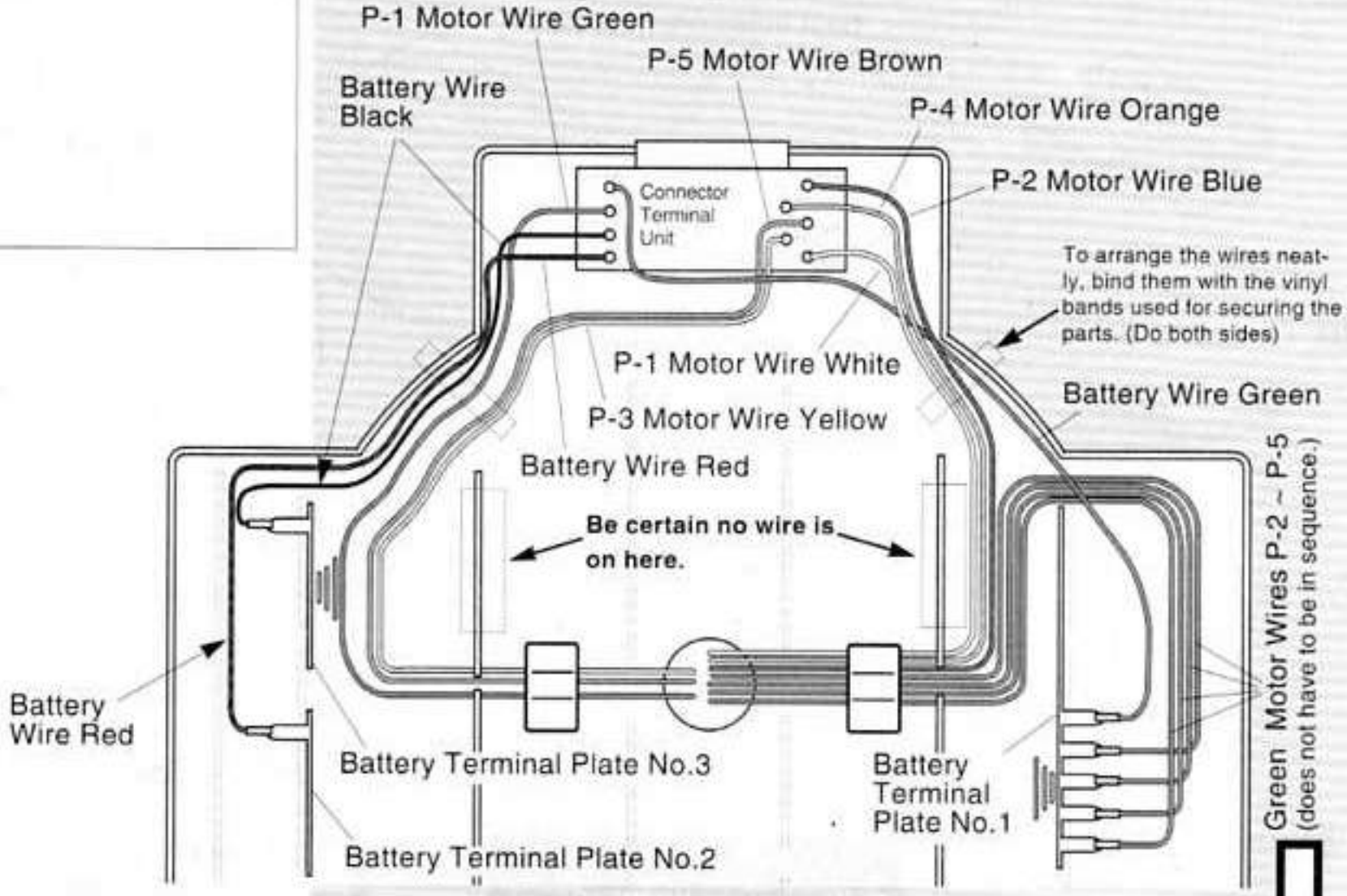


Go Next

· Assembled Unit in step ⑪

⑫ After wiring, arrange the wires as shown.

※ **Make certain that the wires are arranged neatly so that they do not interfere with the batteries .**

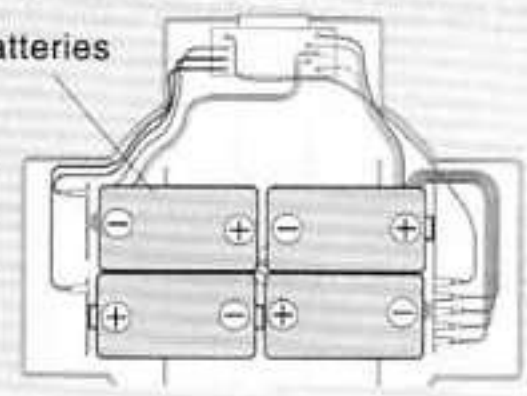


39 Battery Cover 1pc

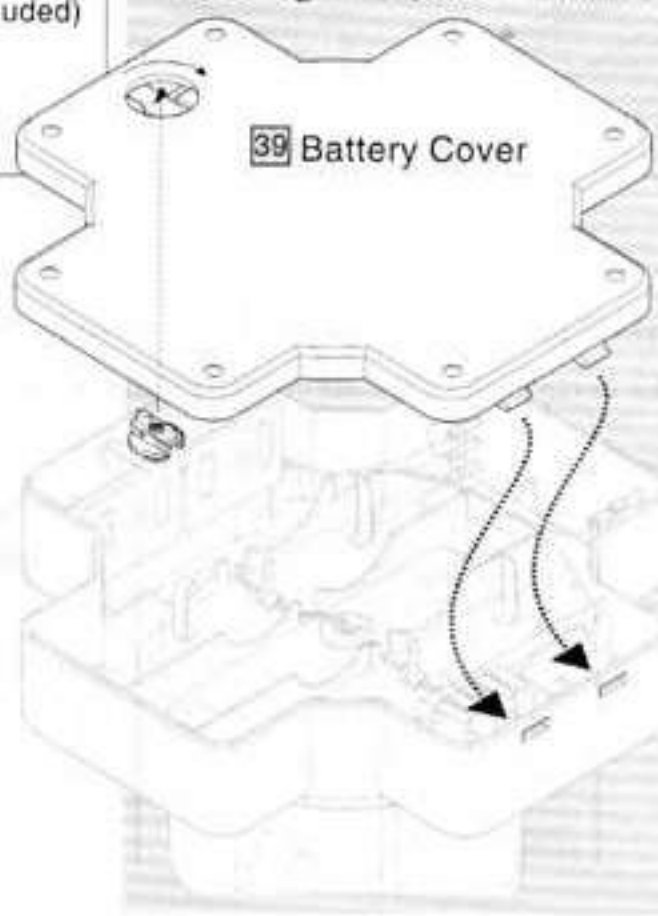
· "D" battery 4pcs (not included)

⑬ Add batteries before attaching the Battery Box Cover onto the Battery Box in order of ❶ to ❷.
Turn the Battery Cover Lock 90° clockwise to lock the Cover.

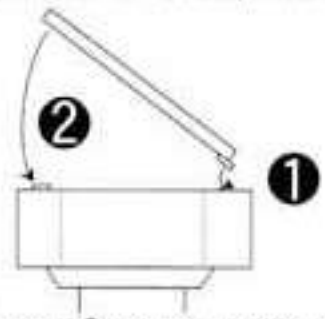
"D" Alkaline Batteries



※ **Be sure to check the polarity of the battery.**
※ **Do not mix old and new batteries. Do not mix alkaline, standards (carbon-zinc) or rechargeable (nickel-cadmium) batteries.**



Bend the Connectors on the Battery Terminal Plate so that the wires do not interfere with the clips of the Battery Cover.

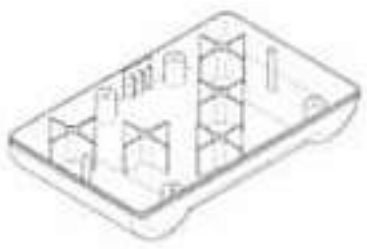


❶ Put the Battery Cover slantwise to slide the tabs into the respective slots.

❷ Close the Battery Cover as gently pushing it toward the slots.

6. Assembling the Control Box

42 Control Panel Base 1pc



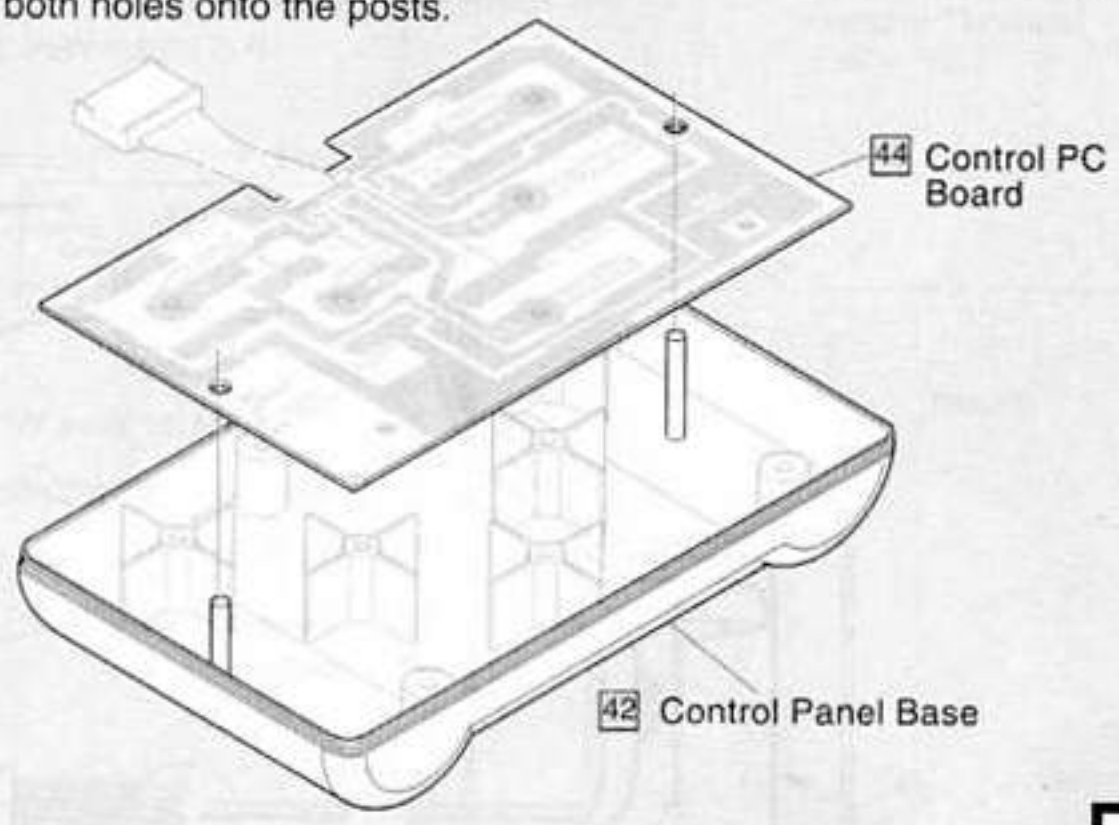
44 Control PC Board 1pc

50 Metal Switch Parts 5pc

46 M3 × 12 Tapping Screw 5pcs

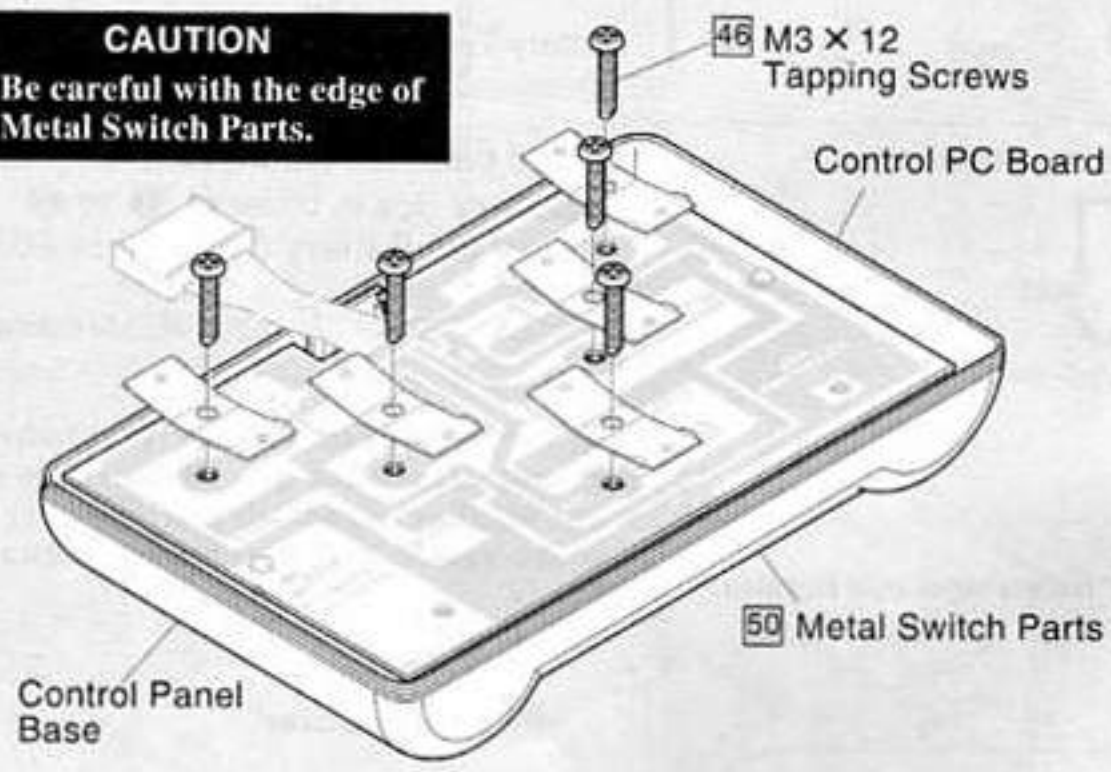
・ Assembled Unit in step ①

① Install the Control PC Board on the Control Panel Base, fitting both holes onto the posts.

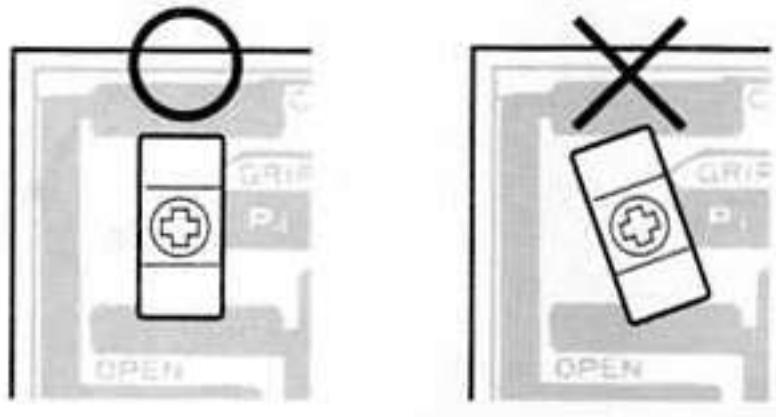


② Secure the Metal Switch Parts on ① by Tapping Screws.

CAUTION
※ Be careful with the edge of Metal Switch Parts.

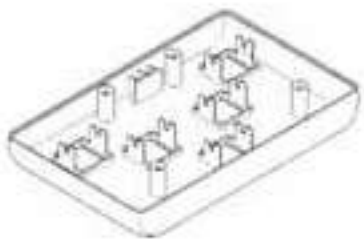


Screw the 5 pcs of Metal Switch Parts upright as illustrated.
※ Make certain they are straight and not at an angle.

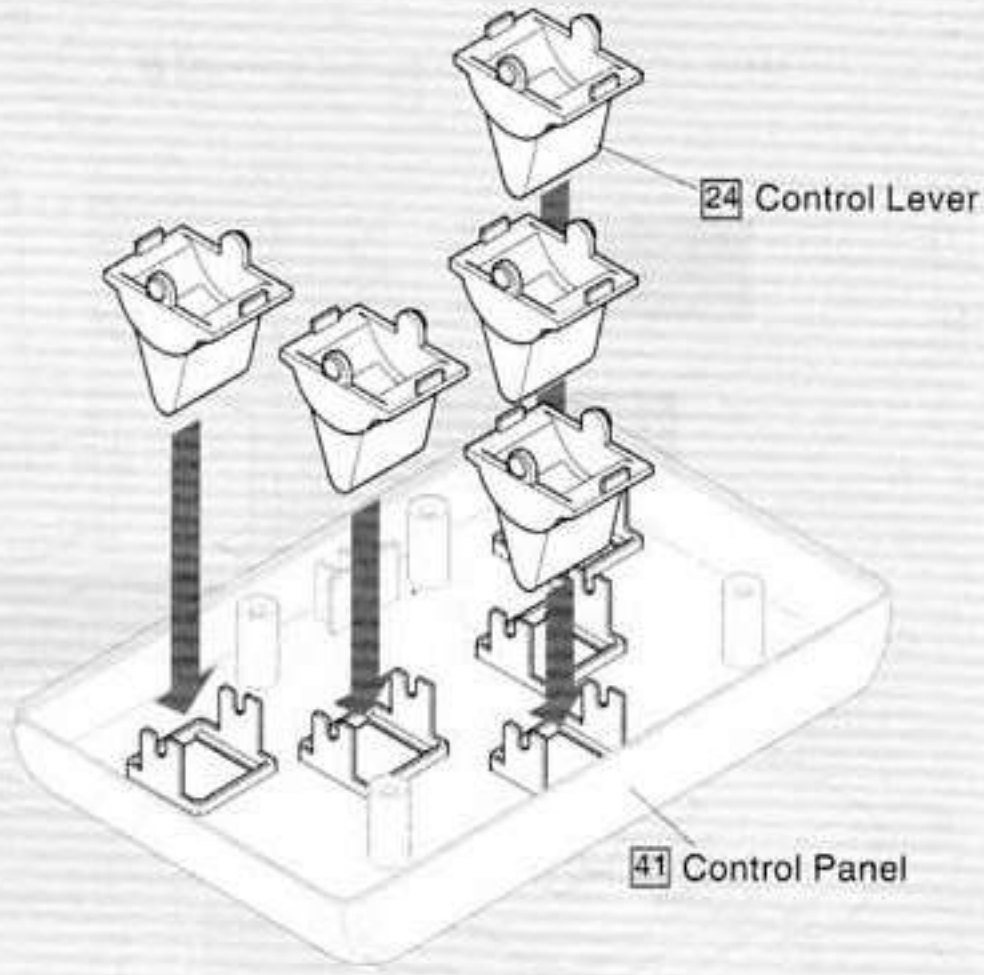


24 Control Lever 5pcs

41 Control Panel 1pc



③ Put the Control Lever into the Control Panel.



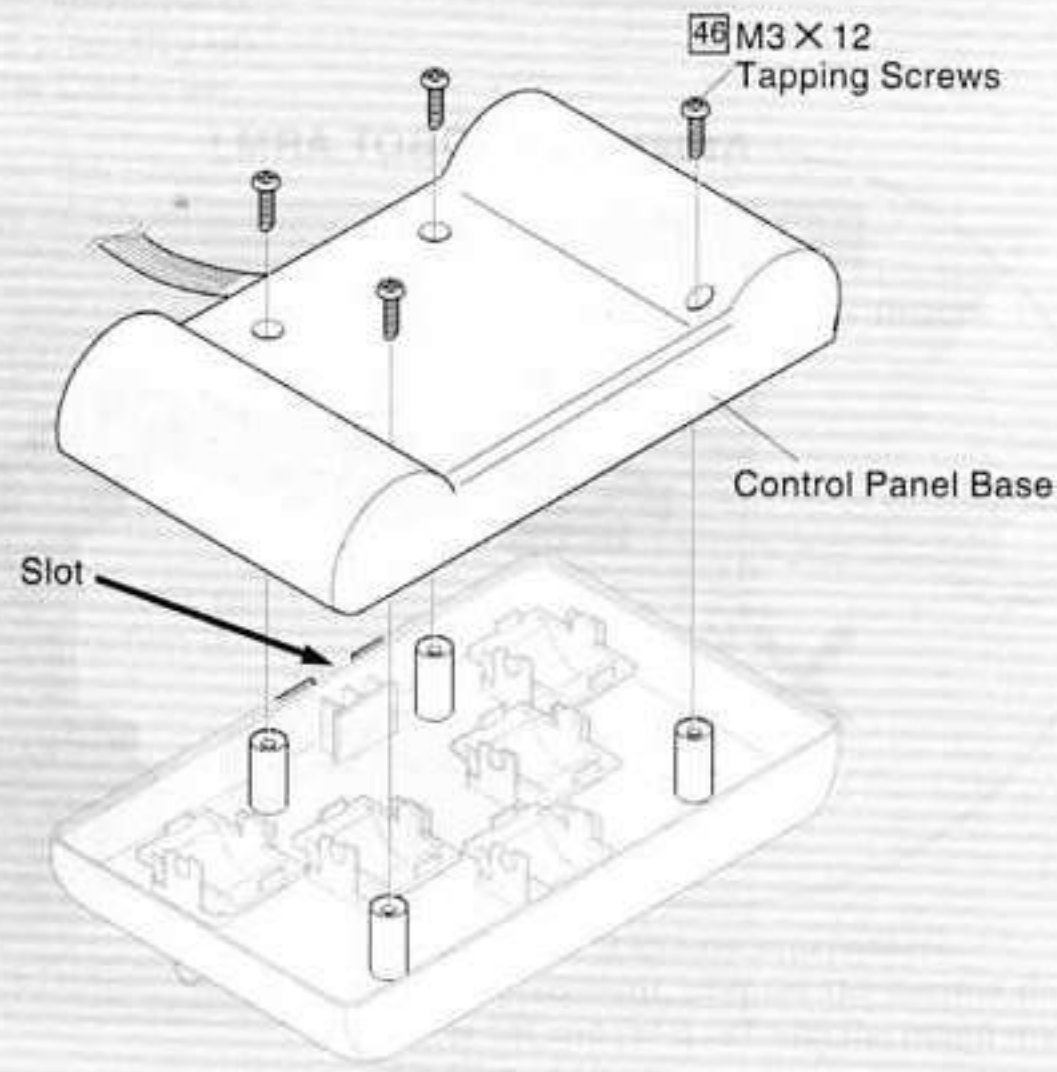
46 M3 X 12 Tapping Screw 4pcs

· Assembled Unit in step ②

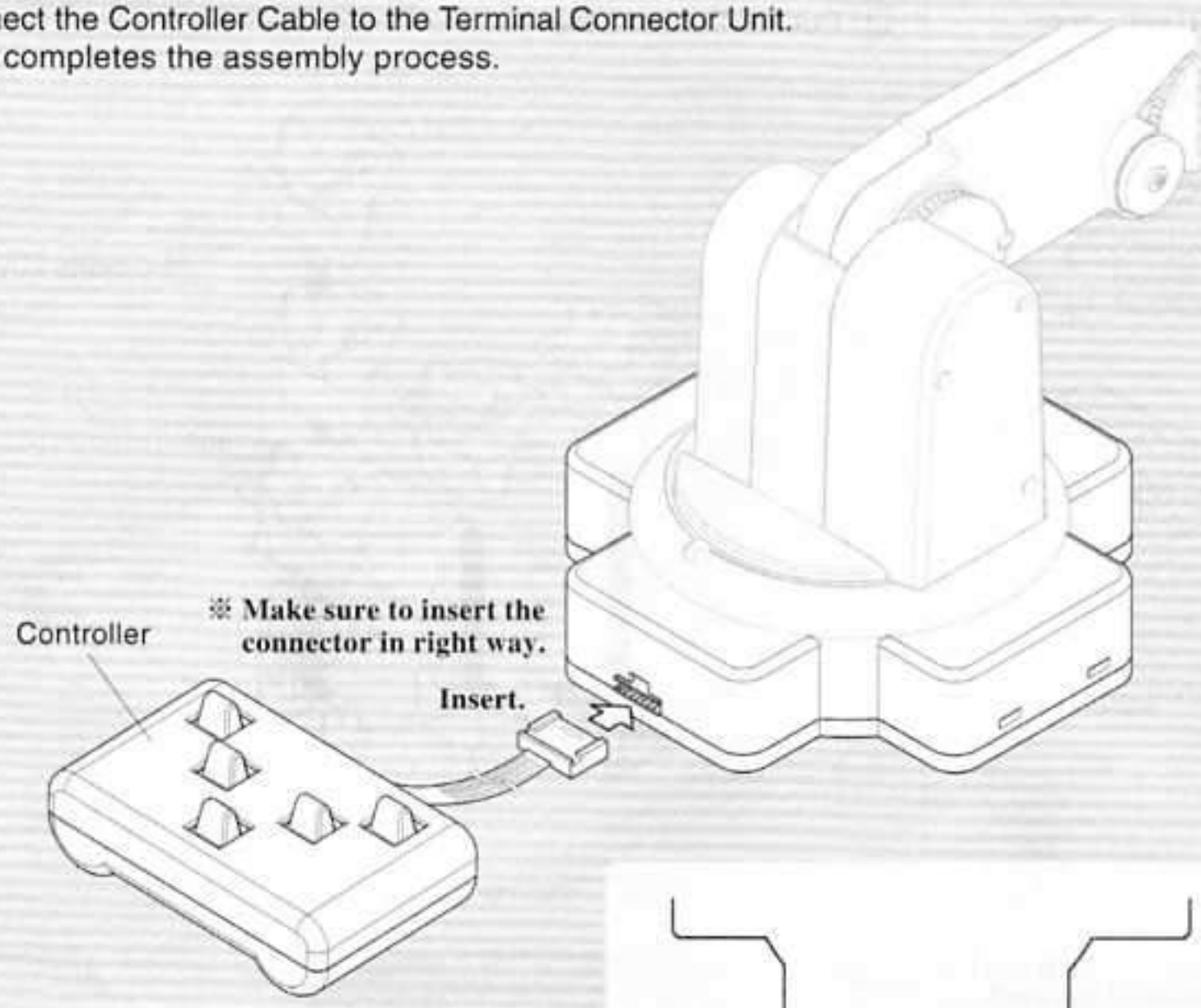
· Assembled Unit in step ③

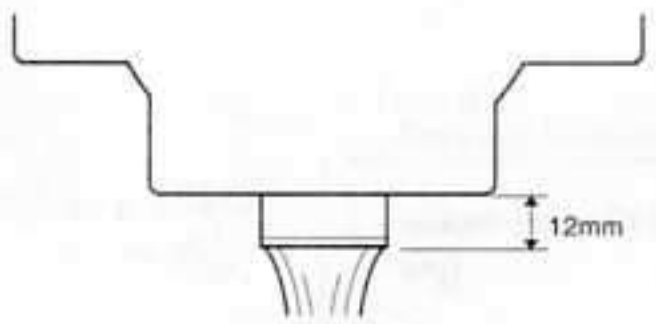
④ Place the Control Panel Base of instruction ② onto the Control Panel and screw them together with Tapping Screws.

※ Fit the control cable in the slot of the Control Panel. Be careful not to pinch the cable when attaching the Control Panel Base.



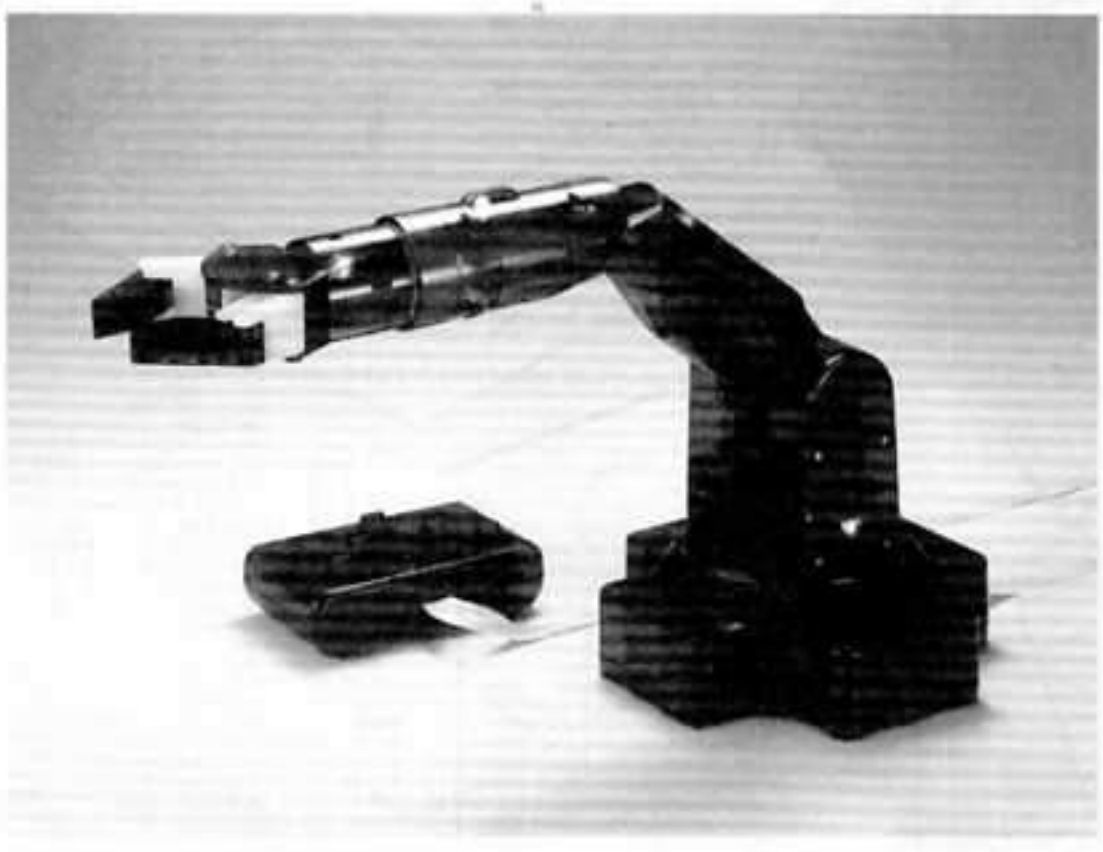
⑤ Connect the Controller Cable to the Terminal Connector Unit.
This completes the assembly process.





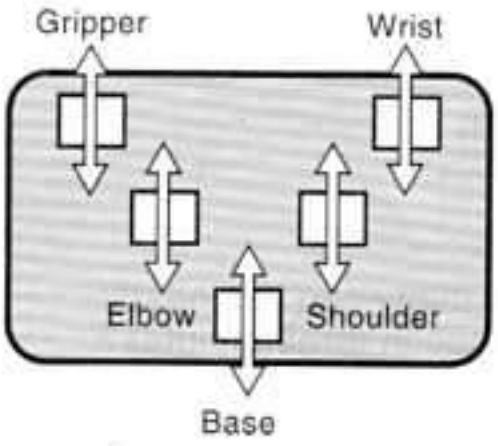
· Connect completely as illustrated.

Assembled ROBOT ARM !

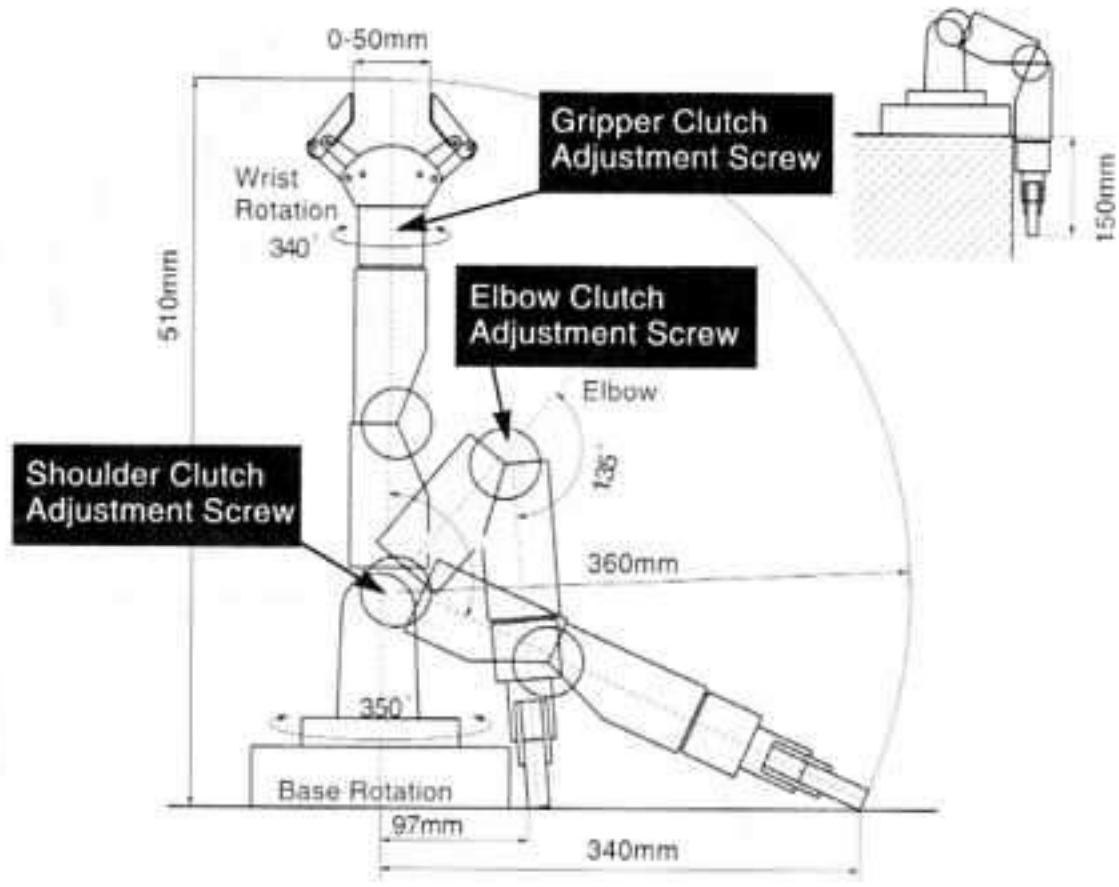


5. Movement and Usage of Each Section

●Names and functions on the Controller



●Moving Range Of The ROBOT ARM.



6. Final Check

The Elbow and Shoulder may not move smoothly after assembly. Further adjustment with the Adjustment Screw may be necessary. Make the adjustment as follows:

① Turn the Elbow Clutch Adjustment Screw in small increments with the Fingers holding nothing and stop it at the point the Elbow moves smoothly up and down by the Elbow Switch of the Controller.

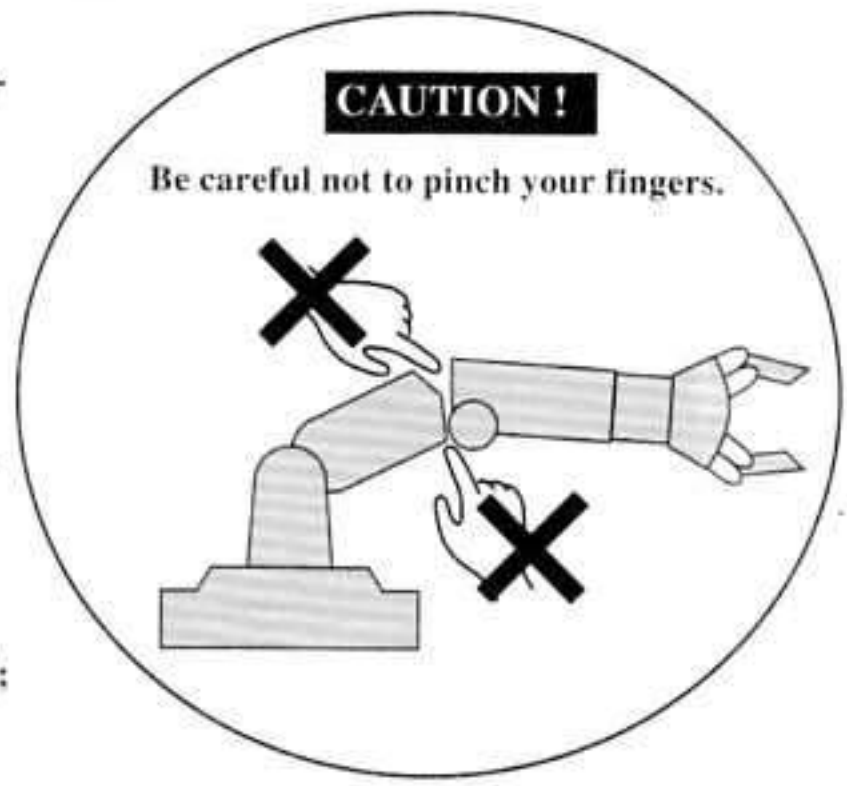
② With the Elbow stretched out, adjust the Shoulder Clutch Adjustment Screw in the same procedure as in ① above.

③ Operating the controller, have the Fingers grasp a size "D" Battery or something that weights approximately 130g. If the Fingers do not have enough power to hold the the "D" size Battery, adjust the Finger Clutch Adjustment Screw.

④ With the Fingers holding the "D" size Battery, repeat the adjustment procedure of instruction ① and ②.

※ **A very important role of the Clutch is to protect the mechanism by slipping when too much power is exerted; therefore, DO NOT TIGHTEN the Adjustment Screw more than necessary.**

※ **The Clutch may become loose in time, readjust them if they become loose.**

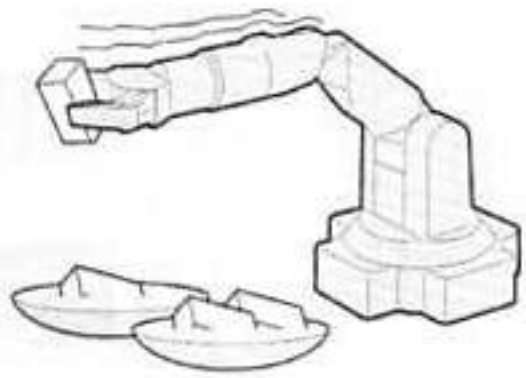


※ **Clutch Pads (Felt) are expendables. For replacement, prepare the normal thin-made felt and cut it out with the round shape by diam of 40mm .**

7. How to play

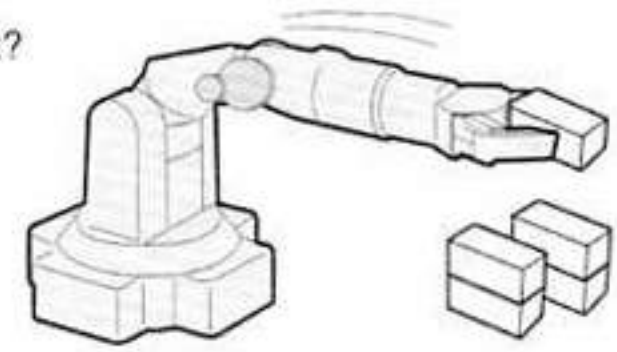
Time Trial

★How many minutes does it take for you to put all things into the other plate?

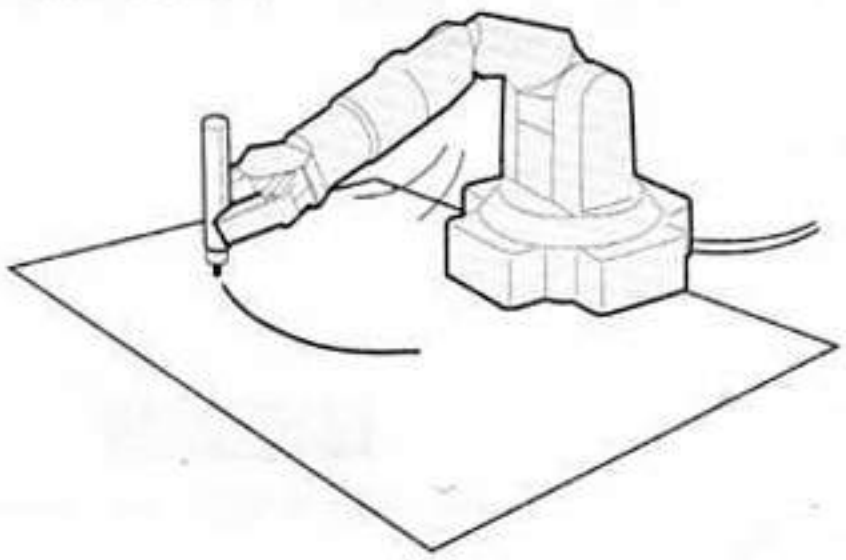


★How many can you neatly arrange in three minutes?

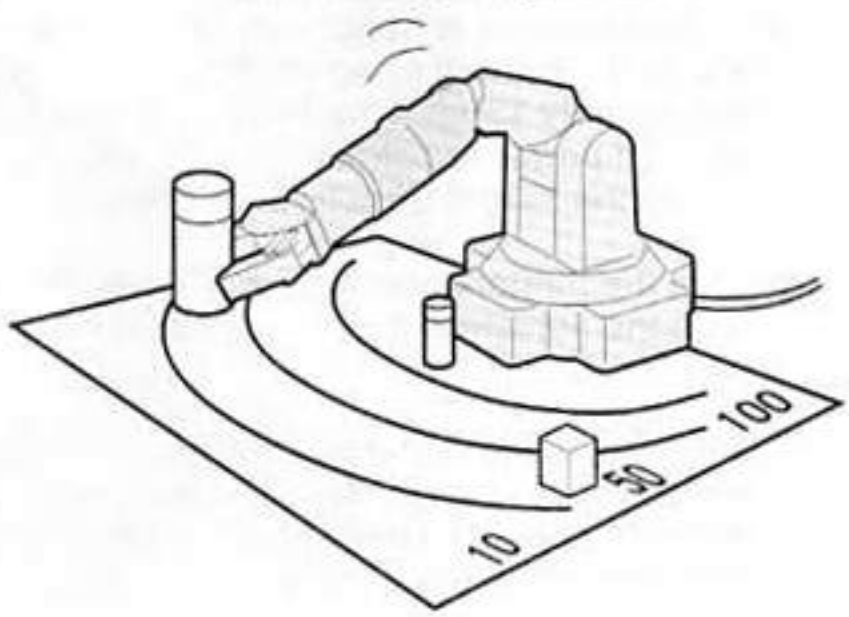
★How many can you stack?

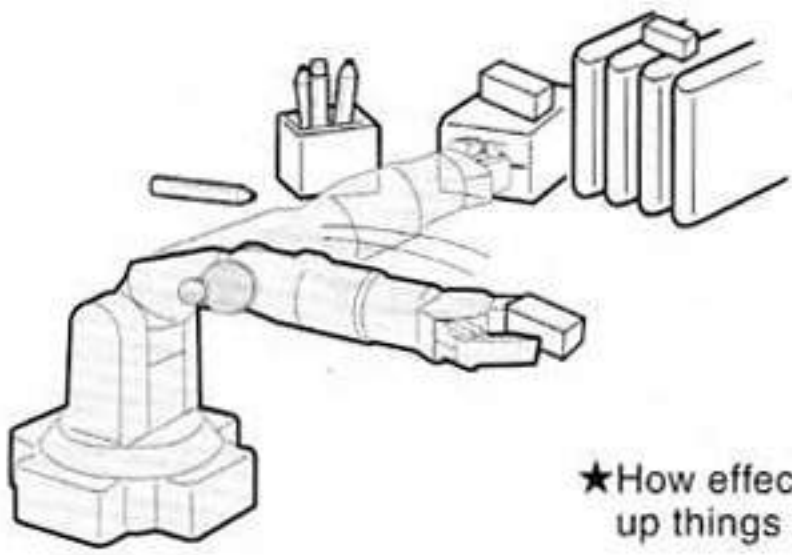


★Have ROBOT ARM hold a pen and let it draw a picture.



★Let it draw circles as shown below and set the scores for each circle like the illustration. Challenge to make a good score by putting things in the circle of high score.

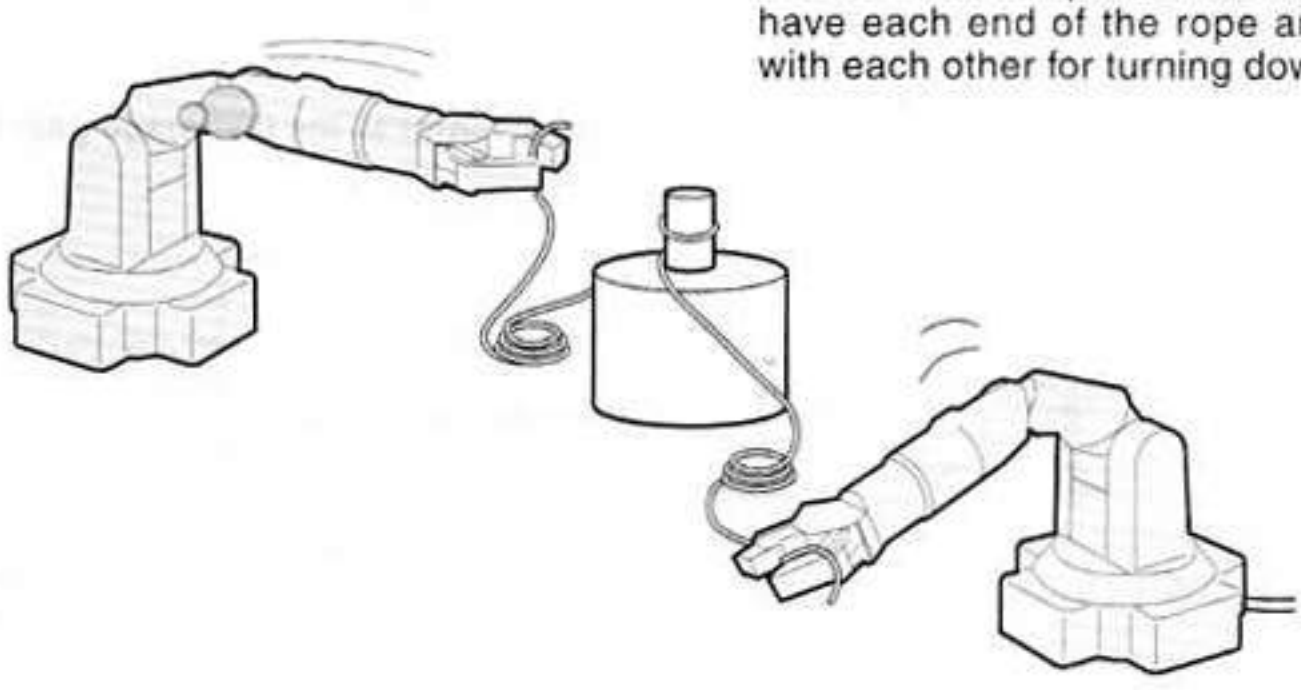




★How effectively can you operate it to pick up things in various position on the desk.

The game played with two ROBOT ARMs.

★Set the pole between two ROBOT ARMs and tie it with a rope. Let the ROBOT ARMs have each end of the rope and compete with each other for turning down the pole.

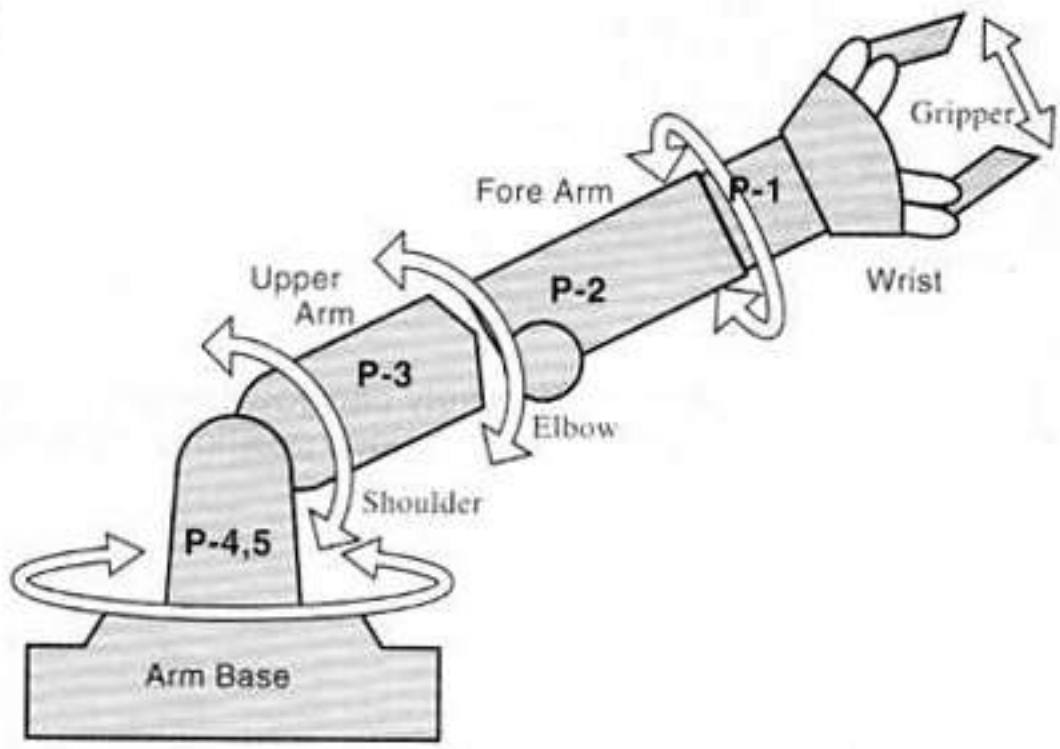


● Let's play the games of your own inventing.

Ⅲ. Mechanism of ROBOT ARM

1. Mechanism of Body

(Figure 1)

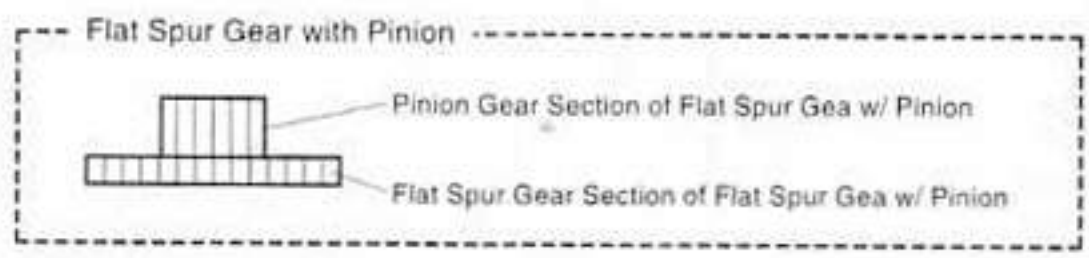


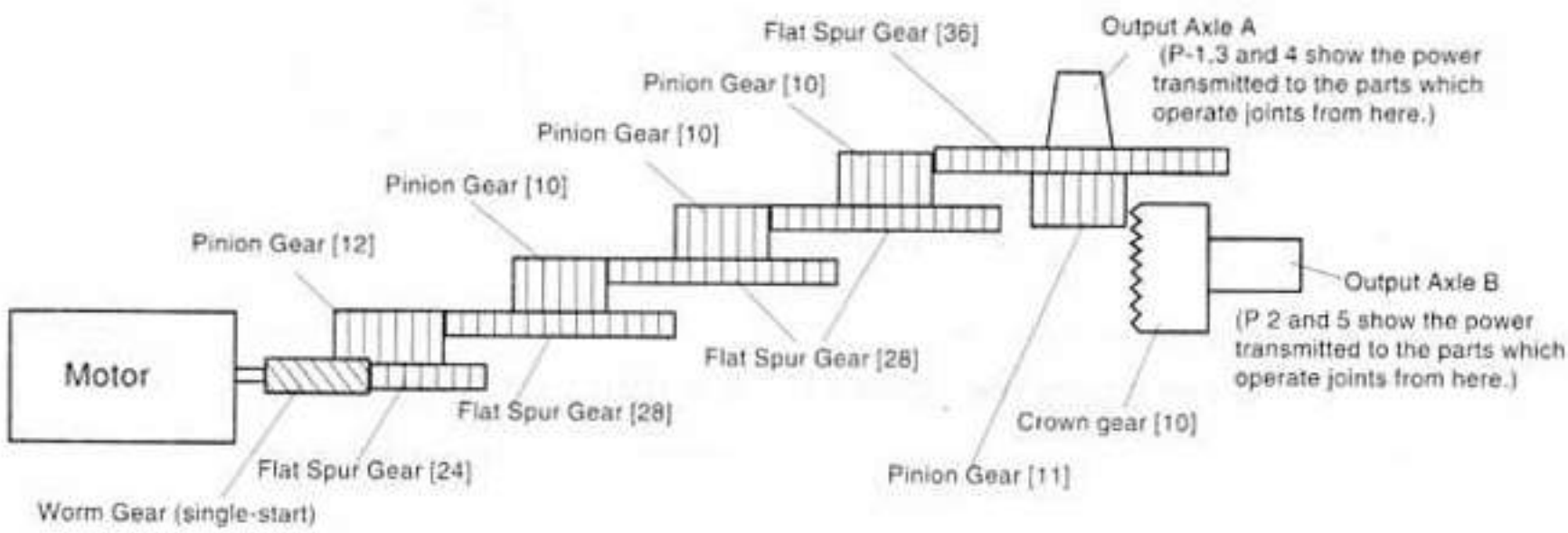
This machine is comprised of a mechanical section and a controller for it. We will give some instructions on how the mechanical section transmits the power from the motor.

The mechanical section in this machine operates in similar movements to grippers, wrists, elbows, shoulders and a waist of a human. The way of generating the power for driving these sections is shown in P- 1, 2, 3, 4 and 5 (Power Unit) respectively.

●This is the process of how the power is transmitted from the motor to the last-stage gear in the gear box (Power Unit).

(Figure 2)





The figures in [ ] indicate the number of teeth on the gears.

2. Mechanism of Parts

● What is a gear?

A gear is a device to transmit power from one axis to another. This can be easily understood if you think where gears are used. In most cases, several gears are used in arrangement.

First, there is a motor (that has a function of moving things) and, in the last place, the shafts for model wheels and legs (which are objects to be driven) are tightly pressed in.

Then, why don't we directly connect the motor to the wheels? This is the point where gears have a very important role to play.

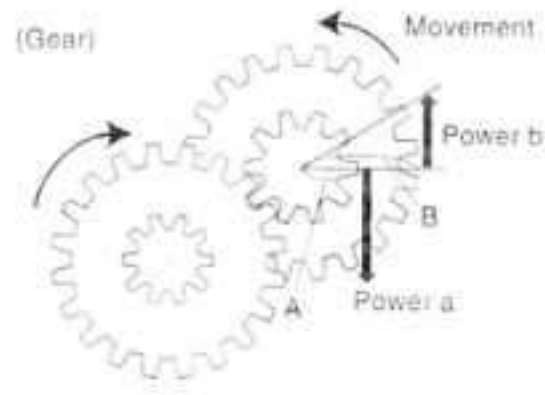
Generally, gears are employed for speed reducing devices, to allow small motors to provide greater power to be able to move heavy things. Reduction of speed is literally decreasing of speed. What makes it possible to produce greater power by simply reducing speed?

A gear is in fact a "lever." You may think a gear does not have a shape of a lever. But, perhaps you can understand if you think that levers, using an axis as a fulcrum, are arranged in numbers. (Figure 3)

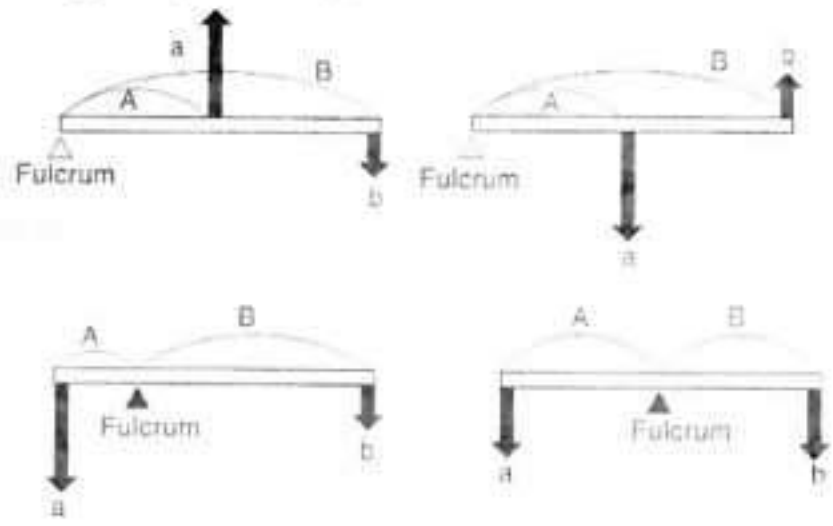
Now, let's look into the functions of a lever. A lever has two arms split at the fulcrum. Relations between power and movement of the lever are illustrated in Figure 4.

A lever suffers a loss in terms of movement (distance and speed) if it gains profit in terms of power. To the contrary, if a lever gains profit in terms of movement, it suffers a loss in terms of power. The relations in power and movement between long arm and short arm are constantly balanced. In other words, they are inversely proportional.

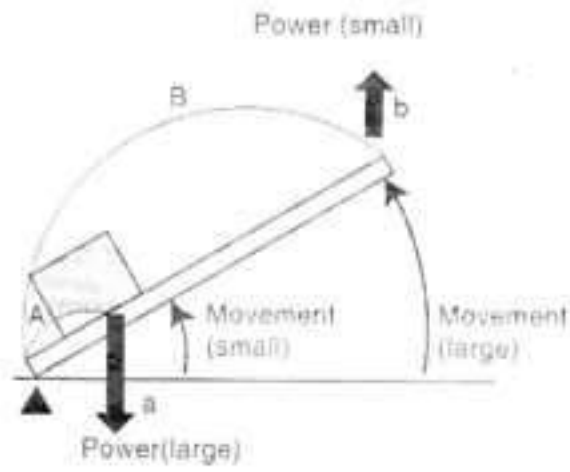
(Figure 3) Relations between power and movement of the lever



(Figure 4) Various types of lever



(Figure 5) Relations between power and movement of the lever



* Lifting a heavy object with a small power

Length A x Power a = Length B x Power b
A, B: Length of an arm
a, b: Magnitude of power
Power: Long arm (small)
→ Short arm (large)
Movement: Short arm (large)
→ Long arm (small)

● Functions of the Gear

There are several methods available for transmitting power; a few methods are through gears, belts, chains, rods and cams. The gear box in the ROBOT ARM literally transmits power by using gears. Now, let's look into the functions of the gear. There are four major functions to the gear.

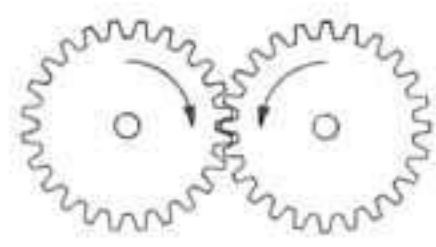
1.Transmission of the Power

The power generated in the motor is transmitted to the joints by means of cranks.

2.Conversion of Rotational Direction

As illustrated in figure 6, when a clockwise-rotating flat gear is engaged with another flat gear, the gear should make a counter-clockwise rotation. Also a rotational axis of the gear is converted by 90 degrees between the first-stage worm gear and the flat gear (Figure 7).

(Figure 6)



3.Conversion of Rotational Speed

When gears having teeth in different numbers are used together in transmitting the power, rotational speed is converted (to either higher or lower rate) between the gears. The motor employed in this machine has an RPM (rotation per minite) of nearly 10,000. The motor is uncontrollable under this condition due to its excessively high speed. So the current speed has to be converted into an easily-controllable rotation.

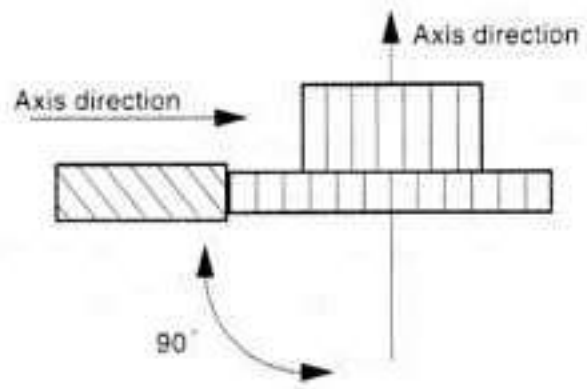
4.Conversion of Rotational Force (Torque)

In transmission of the power by gears, it is possible to increase or decrease the rotational speed and torque.

The torque of the motor in this machine has only a few gcm, which is very small as compared with the weight of the main body. Because of this, the power from the motor would not be strong enough to operate the joints if applied as it is. To reduce the rotational speed and to achieve sufficient power to drive the joints, gears are arranged.

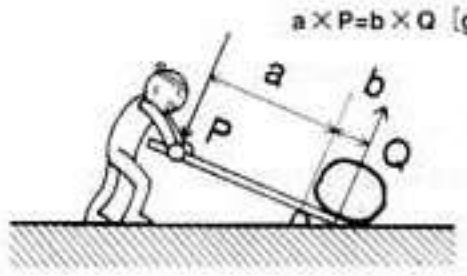
Relations between rotational speed and torque are made inversely proportional. Therefore, the final torque can be determined, if the speed reducing ratio is known. For example, if the number of motor rotations reaches a 1/100 speed, the torque at this rate becomes 100 times higher.

(Figure 7)



● What is torque?

The unit of measure for torque is g.cm, therefore we use weight and length to calculate it. This is a mathematical concept combining rotational and directional power. Referring to the "Lever and Fulcrum Concept" will make torque easier to understand. Gears use this concept.



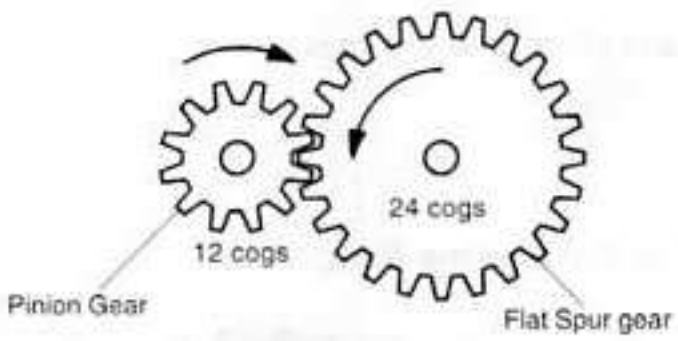
● Worm Gear, Pinion Gear, and Flat Gear

When a worm gear is used in transmitting power to the next gear, it is possible to change the rotational speed and torque. Let's look into the transmission of power by using both flat gears. For instance, assuming that the first-stage pinion gear has 12 cogs and the next-stage flat spur gear has 24 (Figure 6), one rotation of the first-stage pinion gear causes the next gear to rotate 1/2. That is, the rotational speed has been reduced to 1/2. From the fact that the torque is inversely proportional to the rotational speed, the torque has been doubled. In contrast, if single-start worm gear is used in the first gear and a 24-tooth flat gear is used in the next, the next gear makes a 1/24 rotation each time the worm gear makes one rotation. (When each rotation of a worm gear causes the next gear to advance by one tooth, the worm gear is called single-start gear, and when the next gear advances by two teeth, it is called double-start gear.) In other words, the rotational speed is reduced to 1/24 and the torque is increased by 24 times greater.

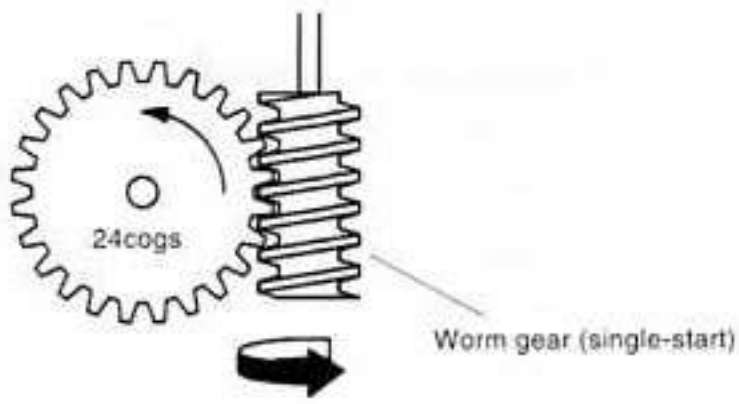
In this way, worm gears are very convenient in decreasing the speed and increasing the torque in a limited space. Worm gears have characteristics that a rotation axis is not in parallel between the first and next gears and that power transmission is not possible, in reverse, from the next to the first gear.

The aforementioned is a rough explanation about the power unit (the gear box) used in this machine. Next, we want to study how the power is transmitted from each of the power units to operate joints. Instructions are given in order from P-1 to P-5.

(Figure 8)



(Figure 9)



3. How Power Unit Works

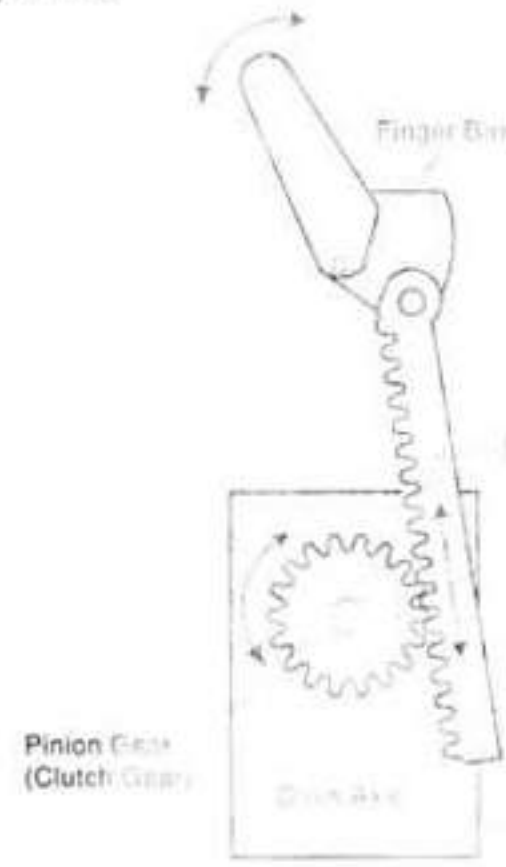
● P-1: Operation of the Finger Sections

For opening and closing operations of fingers, a device called "rack and pinion" is used. The gear in a straight-line called the rack gear and the pinion gear are engaged so that they convert a rotational movement into a straight-line movement, or do this inversely. This mechanism is applied to the car steering structure and the mountain railway which can go up the steep slope. The power is transmitted to the fingers through the clutch gear engaging the rack gear at the Power Unit P-1. In this process, the rotational movement is converted into a reciprocating movement of opening/closing of the fingers.

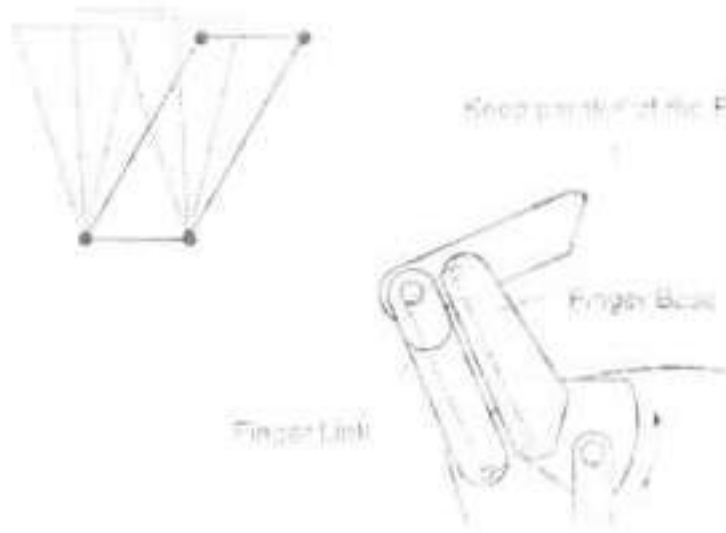
However, under this condition, the fingers' opening/closing motion remains a movement of a fan contour, which makes it difficult to grasp. To secure the grasping, it is desirable for the finger tips to open/close in parallel. This parallel motion is also created by a mechanism called a parallel crank, a kind of a crank (link) mechanism.
The mechanism of a parallel crank is based on a parallelogram. It is so constructed that the opposite side always makes a parallel movement when one of its sides makes a motion. In ROBOT ARM, one of its sides functions as a Finger Base and its opposite sides functions as a Finger Link.

Incidentally, the parts functioning as a parallel crank will not move when the fingers open or close fully. This happens as excessive force may ruin the mechanism if the Gear Box continues to run. Therefore, the drive axle of Power Unit and the clutch gear slip and the drive axle run idle when excessive force is applied. It can be adjusted by the proportion of tightening the screws when the drive axle starts to run idle.
Thus, the mechanism which disables transmission of more power than limited to prevent excessive force is called a torque limiter.

(Figure10)



(Figure 11)(Parallel Crank)



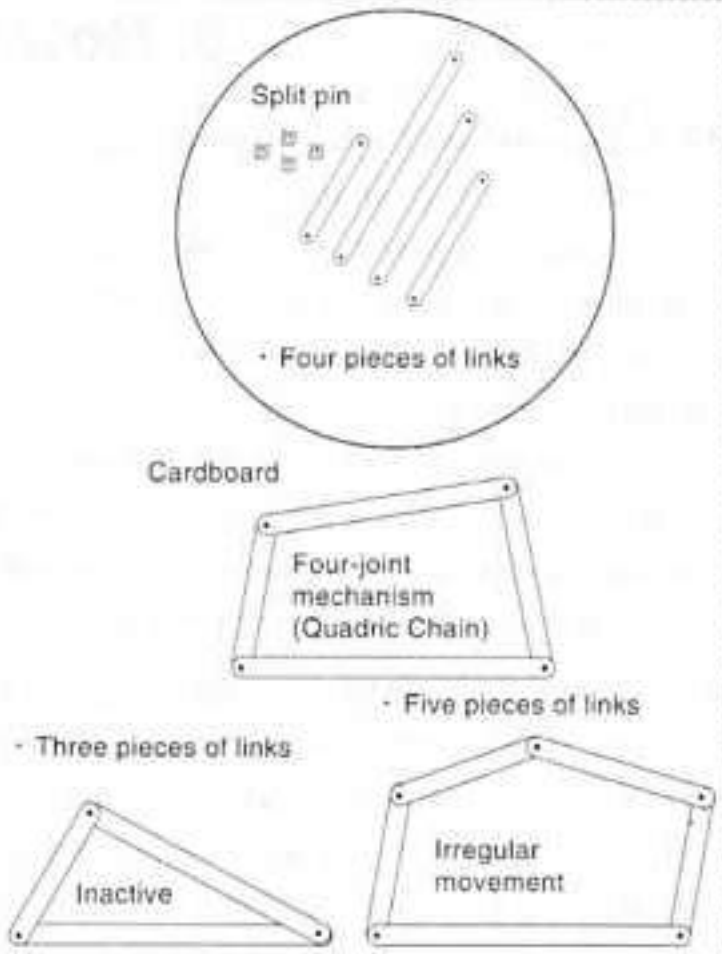
● P-2: Operation of the Wrist

The power for rotating the wrist is transmitted from the crown gear fitted at the tip of the Power Unit P-2. The rotation of this crown gear is in direct relation to the rotation of the wrist. But, for protection of the wiring to the Motor P-1, the crown gear is stopped from further rotation by a stopper, after making some rotations.
If the wrist was kept from rotating by the stopper, the motor would continue to run. Therefore, the torque limiter is also used to protect them from breakage by excessive force. Here, a clutch plate is playing an important role. In the normal rotation of the wrist, the clutch plate transmits the power to the wrist from the Power Unit. But when the wrist is stopped from rotating by the stopper or when the wrist is kept from rotating due to applied force from outside, the clutch plate is pushed toward the wrist (in the opposite direction of the Power Unit) because of the rotating force of the crown gear in the Power Unit. This causes the clutch plate gear, currently in mesh with the crown gear, to disengage from it, keeping the crown gear in motion with no power transmitted to the clutch plate.

(Figure 12)

● Link (Four-joint mechanism)

A link refers to something in the shape of a stick. It is quite safe to call it a stick, but in machinery, a link is a well-known name, so we'll use the name here.
It would be much easier to understand by actually creating and operating a device. So, if possible, prepare a piece of thinly-cut cardboard and a split pin. Connect the end of the link with a pin.
This link is called "link mechanism," and a combination of four links is called "four-joint mechanism" or "Quadric chain." In the link mechanism, links having different length, width and shape provide different operations. Here we'll take up length, which is the most basic to the link.
By the way, why do we need four links? The reason is that three links could in no way be operated. And five or more links could work somehow, but in an irregular movement. All these are out of principle of the machine that should have a regular movement, therefore being impossible to incorporate in the machine for components. Pantagraphs in trains, and a steering mechanism (Ackermann mechanism) installed in the front wheels in automobiles, all employ link mechanism.

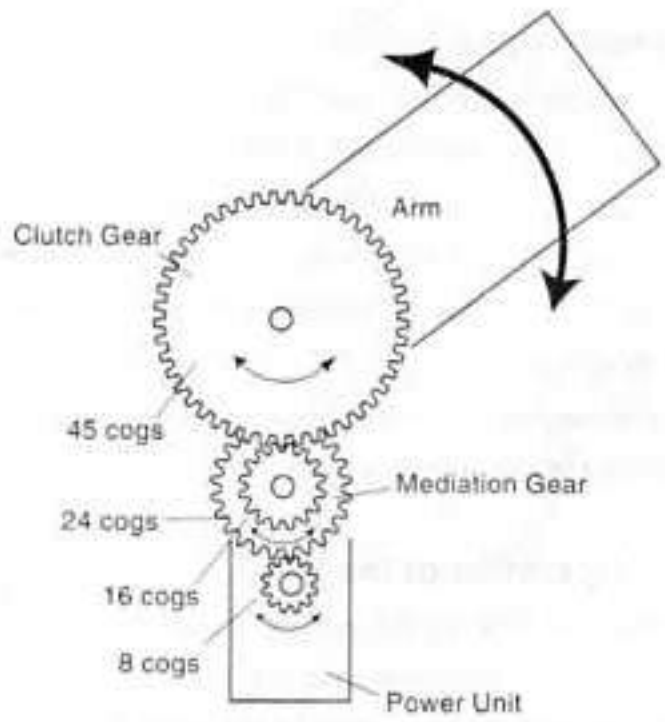


(Figure 13)

● P-3:Operation of the Elbow / P-4:Operation of the Shoulder

The operation of both Elbow and Shoulder is a part of rotating movement so that it is transmitted from the rotation of Power Unit. However, as the Power Unit is not powerful enough and the rotating speed is too high, additional gears are used to reduce the speed. The gear which comes from Power Unit has 8cogs, Mediation Gear 24cogs and 16cogs, and the clutch gear which drives the arm directly 45cogs.
Therefore, the rotating speed is reduced to 8/24=1/3 between Power Unit - the one of Mediation Gear, and to 16/45=1/2.8125 between the other Mediation Gear - the clutch gear. It is calculated to 1/3 × 1/2.8125=1/8.4375 between Power Unit - the clutch gear, and thus, the torque (the power which makes a rotation) is increased by 8.4375. The torque limiter, which makes the clutch gear run idle, is also used here.

[Gear Mechanism of the Elbow and the Shoulder]



(Figure 14)

● P-5: Operation of the Base

The movement of the Base is produced by the engagement of a 16-cogs Flat Gear (which comes out of Power Unit P-5) and a 74-cogs Internal Gear (on the Main Gear). In P-1 - P-4, the Power Unit is fixed stationary, and mechanism in the subsequent process is operated. In P-5, however, the Main Gear is fixed stationary and P-5 itself travels. As many as 10 cords are running through the rotating section so that a stopper is installed to hold rotation not to make more than one. In the previous section, the Main Gear was described as stationary. To be more exact, the Main Gear is simply placed on the Battery Box (functioning as a bench in this case). When the P-5 reaches a point, where its father traveling is limited by the Stopper, the Main Gear makes idling to prevent excessive force from being applied to the Power Unit.

Ⅳ. Spare Parts List

Part No.	Description
007001M	Power Unit P-1
007002M	Power Unit P-2
007003M	Power Unit P-3
007004M	Power Unit P-4
007005M	Power Unit P-5
007006M	Mediation Gear
007007M	Clutch Gear B
007008M	Clutch Disk (Metal)
007009M	Clutch Stopper
007010M	Rotor Stopper
007011M	Clutch Plate
007012M	Finger Base A
007013M	Finger Base B
007014M	Upper Finger Base A
007015M	Upper Finger Base B
007016M	Finger Link X
007017M	Finger Link Y
007018M	Clutch Gear A
007019M	Rack Gear
007020M	Battery Cover Lock

Part No.	Description
007121M	Stopper
007022M	Spacer (Large)
007023M	Spacer (Small)
007024M	Finger
007025M	Control Lever
007026M	Wrist Cover A
007027M	Wrist Cover B
007028M	Fore Arm A
007029M	Fore Arm B
007030M	Upper Arm A
007031M	Upper Arm B
007032M	Main Gear
007033M	Arm Base
007034M	Base Side Panel A
007035M	Base Side Panel B
007036M	Battery Box
007037M	Battery Box Cover
007038M	Control Panel
007039M	Control Panel Base
007040M	Slide Plate

Part No.	Description
007041M	Battery Terminal Plate No.1
007042M	Battery Terminal Plate No.2
007043M	Battery Terminal Plate No.3
007044M	Terminal Connector Unit
007045M	Control PC Board
007046M	Decoration Sticker
007047M	Clutch Disk Sticker
007048M	M3 × 12 Tapping Screw
007049M	Clutch Pad (Felt)
007050M	Metal Switch Parts
007051M	Battery Wire (Black)
007052M	Battery Wire (Red)
007053M	Battery Wire (Green)
4400257	M3 × 25 Screw
4410089	Lock Nut

When ordering parts, please include the following:

1. Name, adress and phone number.
2. Model name and Model number.
3. Part number, descripton, and quantity.

For spare part prices, please contact us.
(Our Company details are on front of this manual.)

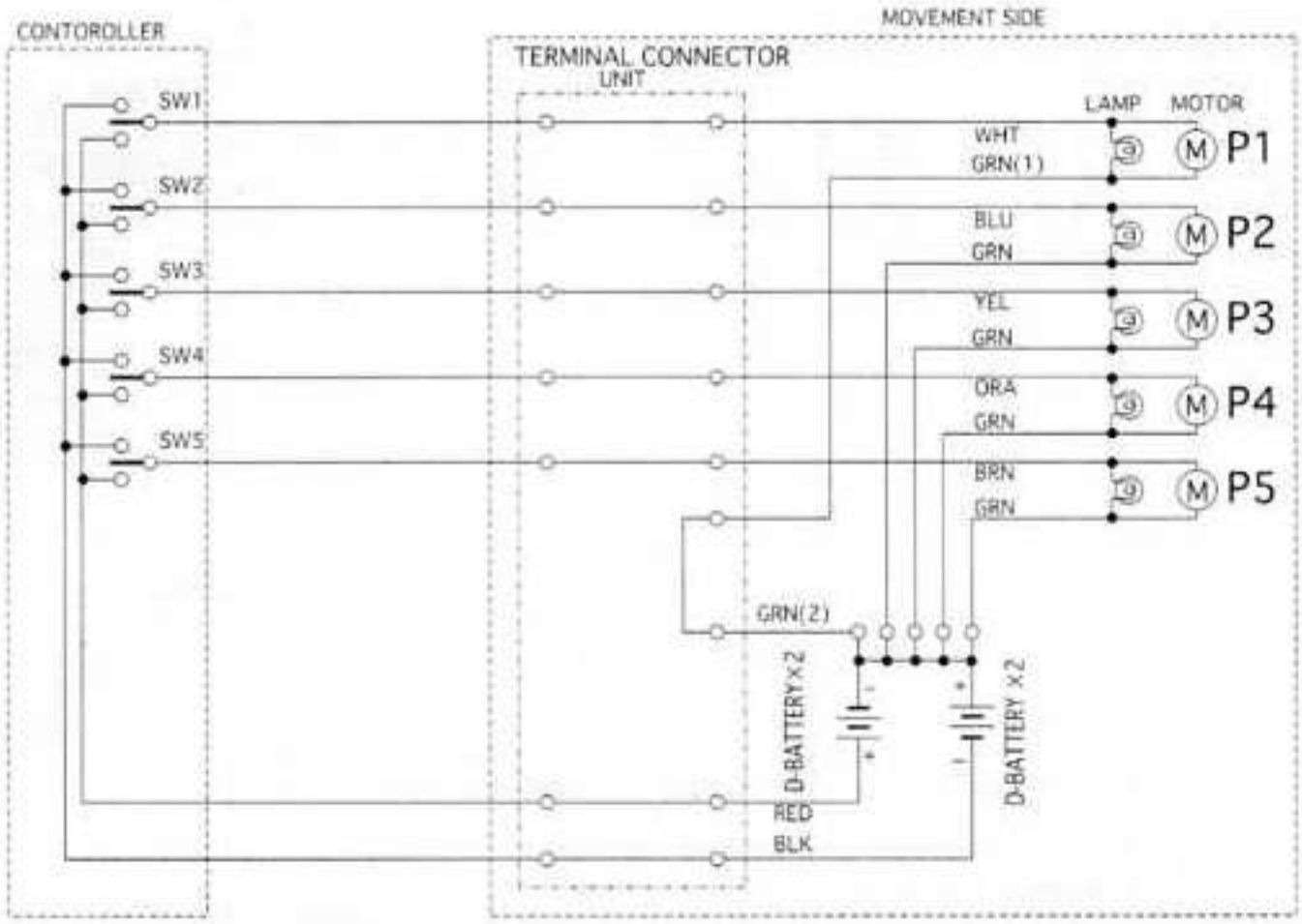
Manufactured by
ELEKIT®
EK Japan Co.,Ltd.
FUKUOKA, JAPAN.

NOTICE
①MOVIT and ELEKIT are registered trademarks of EK Japan Co.,Ltd.
②All rights reserved. Reprinting any of this instruction manual without our permission is prohibited.
③The specifications, form, and contents of this product are subject to change without prior notice.
④We are not liable for disadvantage or damage caused by improper use or assembly.
EK JAPAN CO.,Ltd.

Recycled paper is used for this instruction manual.

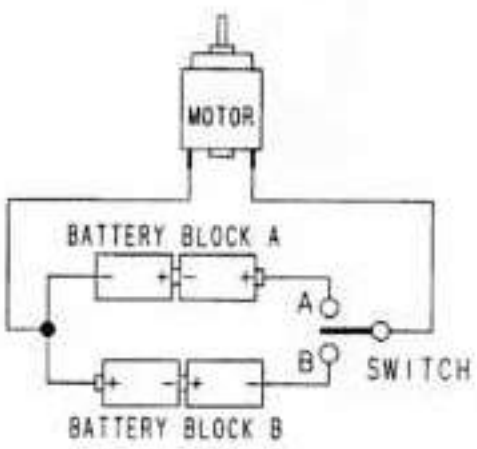
4. Electronic Circuit Schematic

(Figure 15)

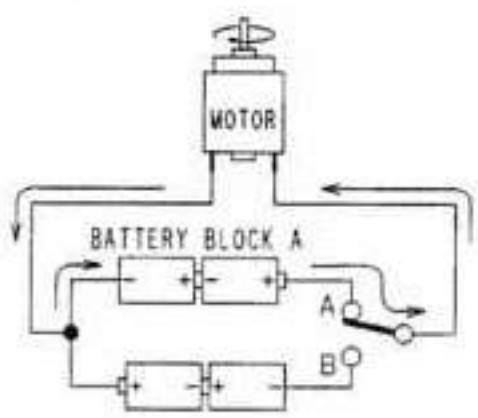


In the direct-current motor, the rotational direction can be changed by reversing the polarity (+ and -) on the battery (connected to the terminals). As shown in Figure 15, this robot employs a method in which two-system batteries, which are oriented in an opposite direction, are used to connect the motor to either one of the batteries by using a switch. Figure 17 shows a posture of setting the switch to the A side. This makes the motor connected to the A-block. When the switch is turned to the B side, the motor is connected to the B-block as in Figure 18. The current comes out of the plus side of the battery and returns to the minus side, as seen in Figure 17 and Figure 18 that the direction of the current flowing in the motor is reverse.

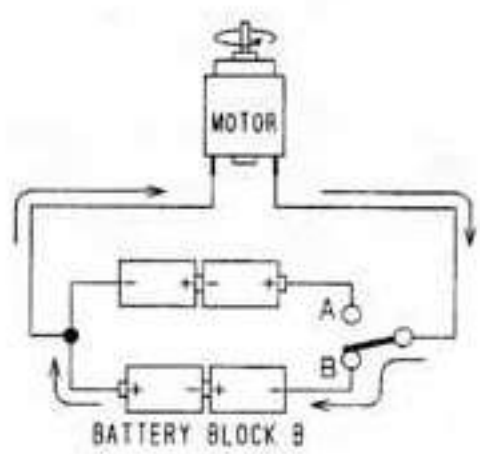
The robot is equipped with 5 motors, and accordingly 5 pairs of switches are installed.



(Figure 16)



(Figure 17)



(Figure 18)