14

ROBOT WITH A GRABBING HAND

Until now, we've built robots that move (the Tire Robot, Mushi Mushi #1, and Mushi Mushi #5), but we haven't built a robot with a hand to grab objects. Of course, the human hand is so complex and dexterous, it would be impossible to build a LEGO robot with the same structure. Still, we can build a very simple hand that will get the job done.

The Theory

Because I built two robot arms before I designed and built this one, I've called this one "Robot Arm #3." Robot Arm #3 (shown in Figure 14-1) is the result of trial and error in the form of numerous experiments. Following are the major engineering decisions that I had to make.

Most of the parts for the robot arms are included in the RIS, but you will need both an extra motor and an extra worm gear.[1] If you don't have an extra motor, no problem: I'll show you how to build the arm without it.

Let's begin with an explanation of this robot's hand, arm, and arm joint.

Using the RCX's Weight to Balance the Arm

As Figure 14-1 shows, the RCX rotates with the arm (as opposed to being mounted on the arm's base). Although I first considered building a separate platform for the RCX, I decided that doing so would make it difficult to build a strong enough turntable to support a long, heavy, robotic arm. Instead, to balance the robot, I mounted the RCX opposite the arm to counterbalance the arm's weight.

[1] To obtain extra motors, you can buy the RoboSports extension kit or Power Pack Motor Set #8735 from the LEGO catalog (800-453-4652) or you can search eBay or Pitsco DACTA on the Internet.

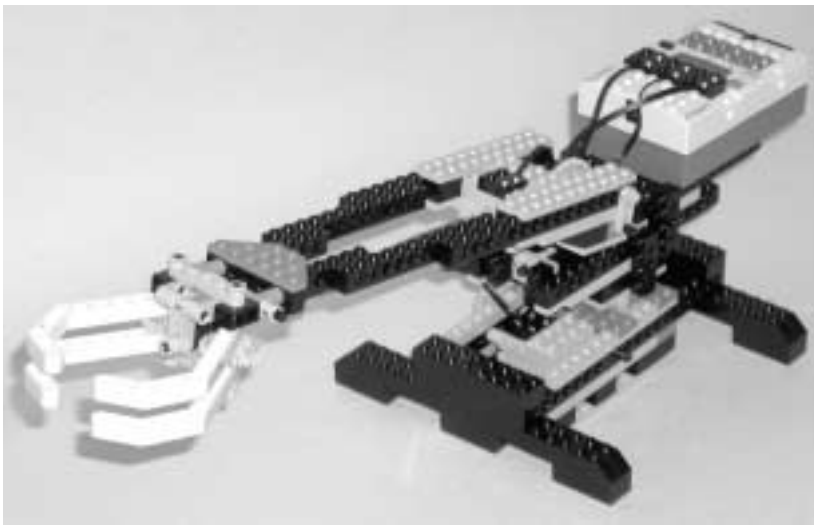


Figure 14-1: Completed Robot Arm #3

Maintaining Position

Because a worm screw can maintain a gear assembly's position when a motor stops, it's very convenient in the construction of a robotic arm. I used worm screws to maintain the positions of the opened/closed hand, raised/lowered arm, and rotated turntable.

The Hand and Wrist

The portion of the hand you'll build in Step 3 of the Assembly Instructions below (the fingers that sandwich the worm gear) forms the mechanism that opens and closes the hand. This mechanism has one worm screw sandwiched between two 24-tooth gears.

The assembly procedure for this part is unique: The studs of a 1x2 beam are inserted in the holes of a 1x4 liftarm (part #2825, as shown in Step 2), then the entire structure is secured with a 1x5 liftarm (part #32017).

This assembly procedure creates a simple, compact hand that can open and close. But rather than build such a simple hand, I chose to put a bit more effort into this part because I wanted a movable wrist. Thus, I've combined joints and liftarms and used very few beams or plates. The resulting part fits together like a puzzle, and the area around the hand is very clean.

Using Ribbed Tubing to Extend the Rotating Axle

The next challenge we face is deciding where to place the motor that opens and closes the hand. If we were to place it at the end of the arm, balancing it would be difficult. To avoid this potential problem, I've extended the rotating axle with ribbed tubing as shown in Figure 14-2.

Using ribbed tubing has a couple of other side benefits. For one, because the axle for opening and closing the hand and the motor's axle are not aligned along a straight line, the flexibility of the ribbed tubing lets you kill two birds with one stone: It extends the motor's rotating axle and can bend to overcome the alignment problem of the motor's and hand's axles. Second, the ribbed tubing protects the hand from breaking in case the motor contin-

ues to turn and apply pressure to the hand after the hand is closed, because the tubing allows the axle to continue to turn freely. So we've killed three birds with one stone!

NOTE

One small disadvantage with this assembly is that this frictional part must be adjusted precisely. I found that inserting the axle about 1.5 cm into the ribbed tubing was just about right, but that distance may differ for you.

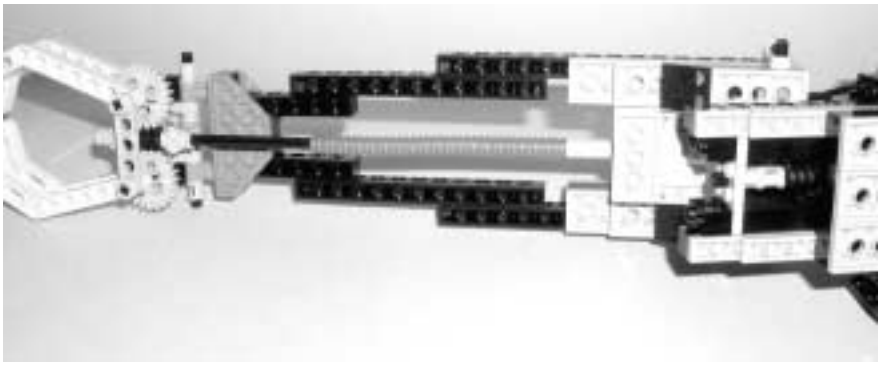


Figure 14-2: Using ribbed tubing to extend the rotating axle

Arm Joint

The arm joint is assembled with beams, as shown in Steps 4 and 5. Because the stacked 1x2 bricks and 1x2 beams (Step 4) are not very strong by themselves, we'll attach vertical beams in Step 5 to reinforce this structure.

Building a Turntable

We need a turntable-like mechanism to move our arm. Although some LEGO sets have the turntable part (Figure 14-3), the RIS does not. We'll therefore build our own turntable assembly to suit our purposes.

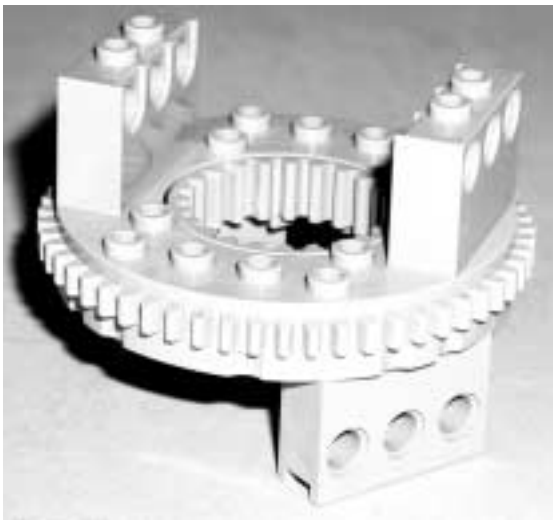


Figure 14-3: Turntable

One consideration when designing the turntable assembly is that its upper and lower parts must turn smoothly. Another is that it must be able to support significant force, because the stress on the axle is extreme when both the force of the arm's upper part and the arm's turning force are applied to the axle. We'll also want to distribute the arm's weight to reduce its need for support.

We could solve this latter problem by ensuring that the arm's top assembly contacts the lower assembly across a larger area than only the axle. However, the studs on the bricks present a stumbling block.

We could use tiles (LEGO bricks with no studs) instead of bricks, but there aren't any in the RIS. A small change in perspective, though, solves this problem. Because the sides of a normal brick have no studs, we can use their sides to distribute the arm's weight. Figure 14-4 (Steps 19 and 20) shows the assembly that I built based on this concept.

NOTE

The turntable assembly's combination of a small turntable (parts #3680 and 3679) and a 40-tooth gear ensures that, when weight is applied, though the axle may come loose the gear and turntable will distribute the weight over the arm's base. The sides of the 1x2 beams also help to distribute the weight more widely by providing a larger base.

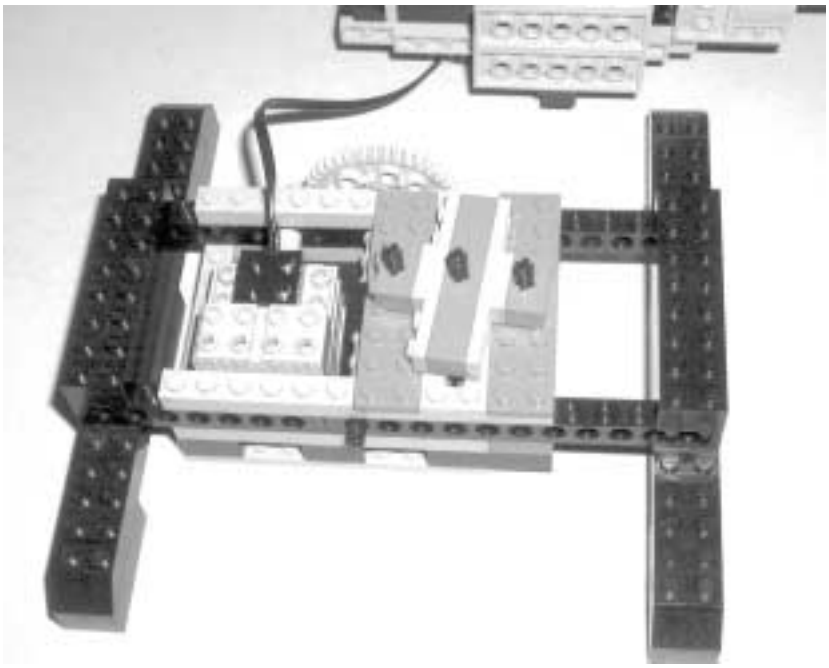
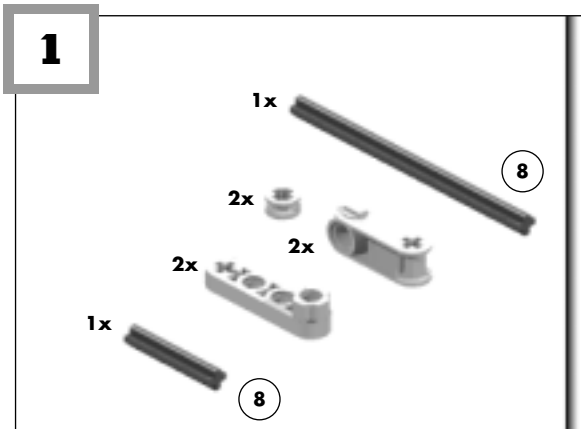


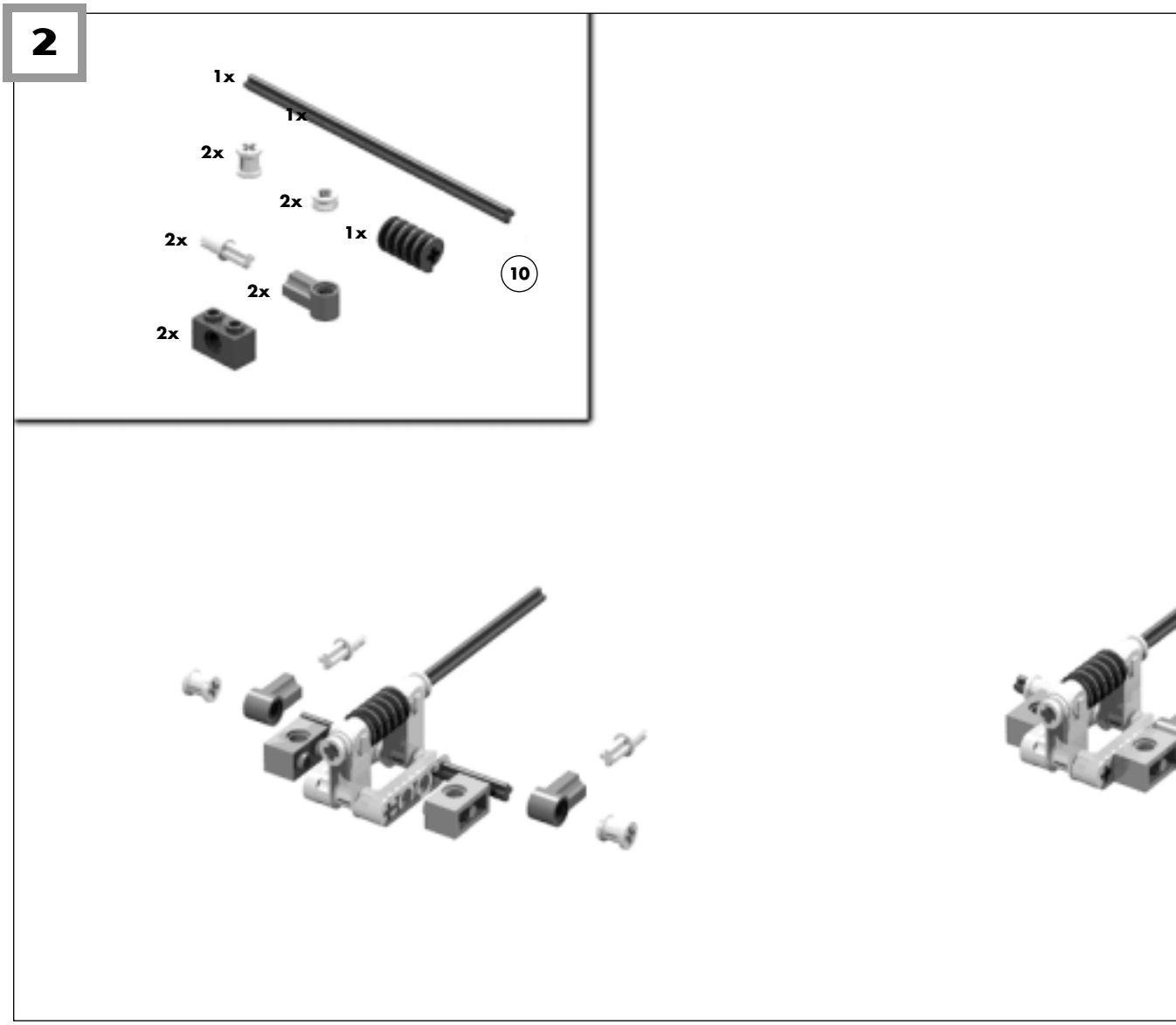
Figure 14-4: Turntable assembly

BUILD THE ARM JOINT AND FINGERS

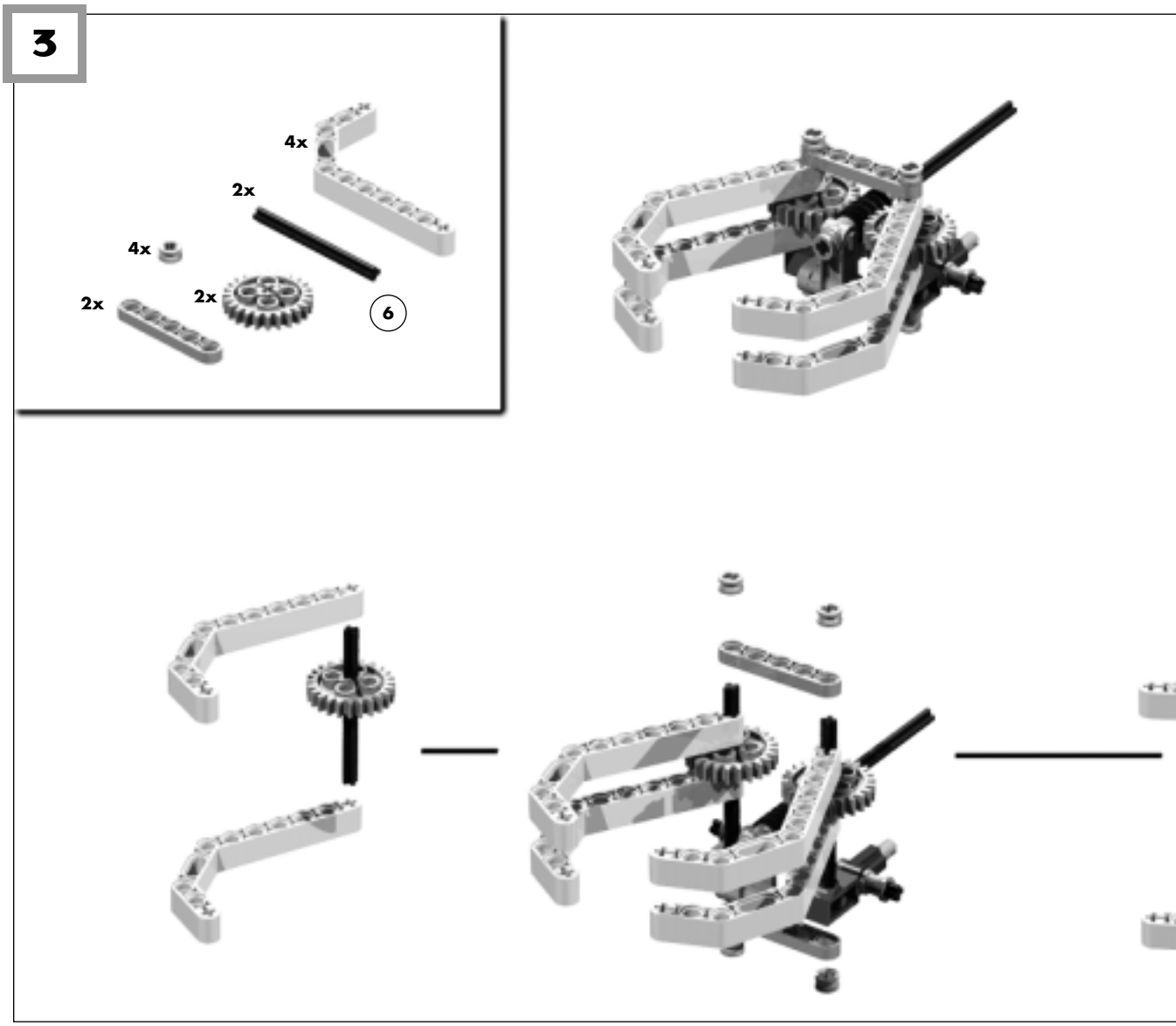
1



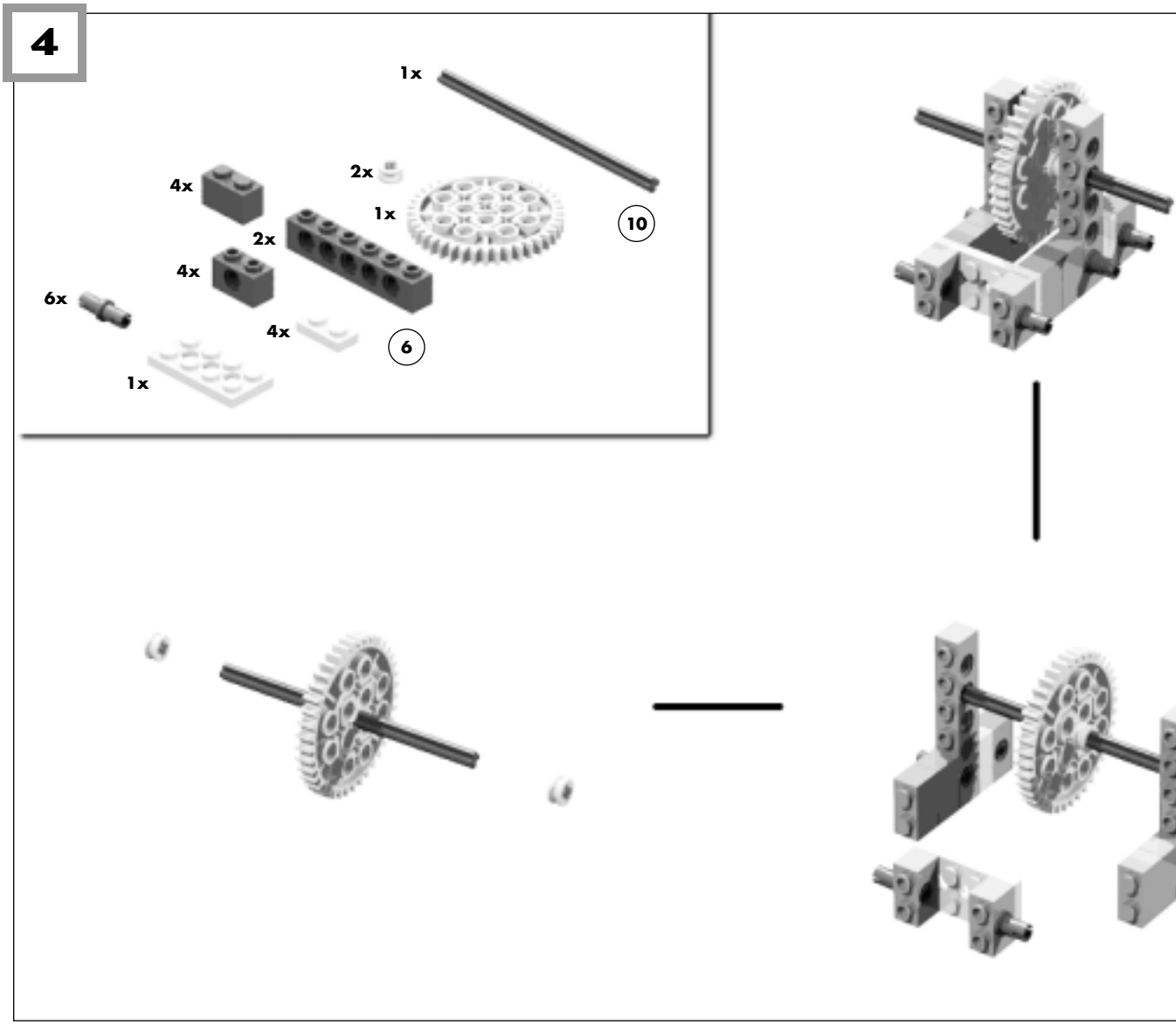
Build the wrist joint as shown.



Build the finger joint bearing by inserting the worm screw through an L10 axle; then attach 1x2 beams on both sides of the assembly.

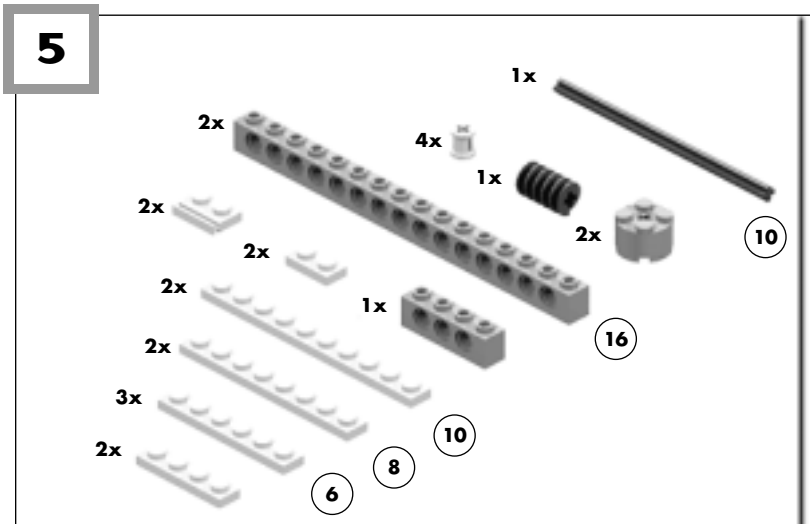


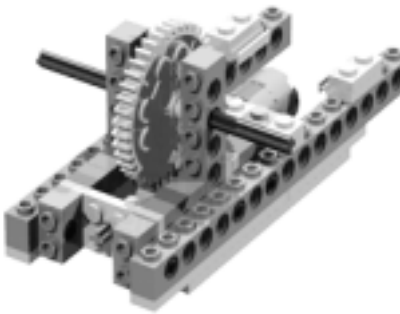
Build the fingers, then attach 24-tooth gears to them so that the gears sandwich the worm gear.



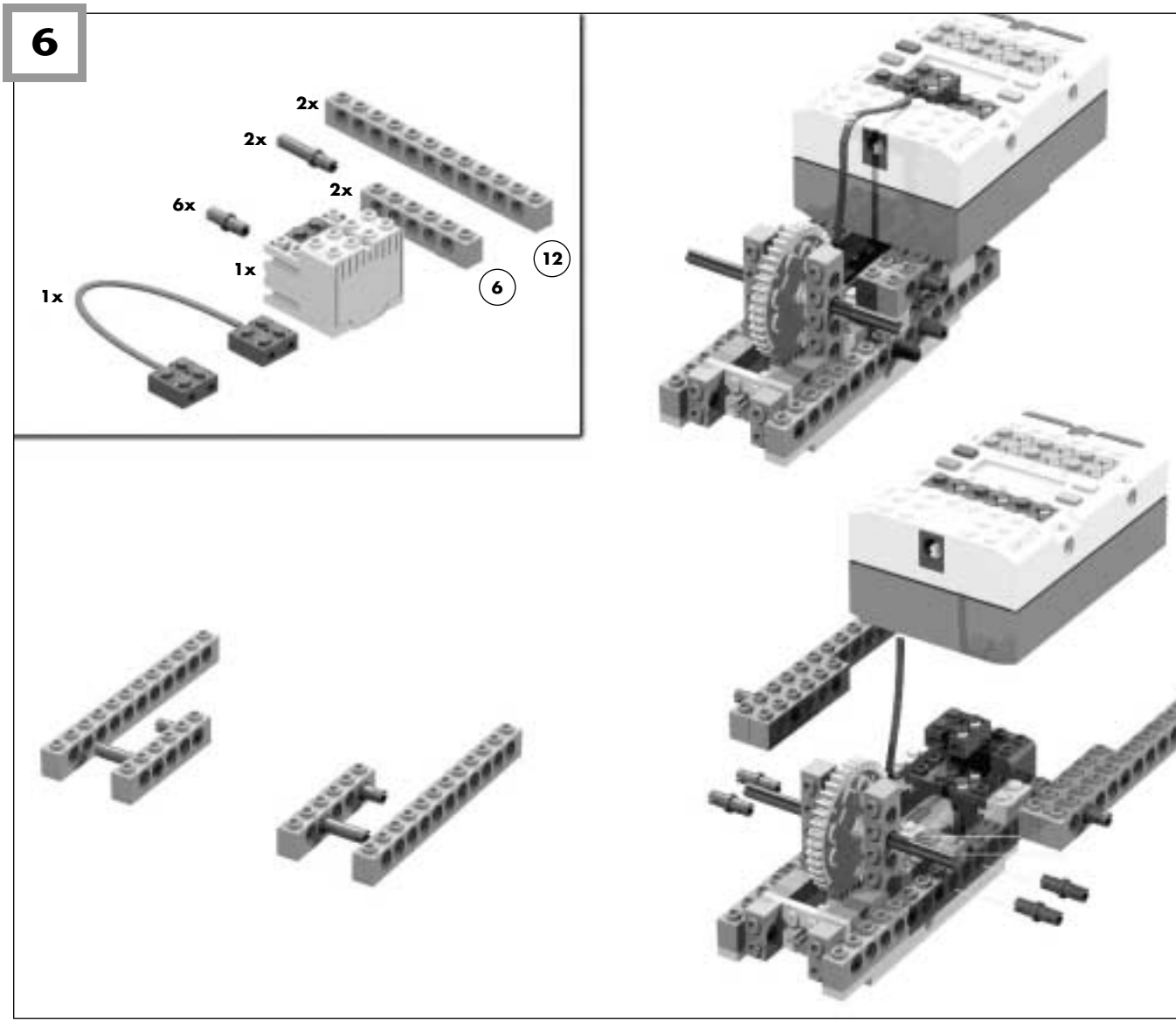
Build the joint assembly.

5





Use 1x16 beams to reinforce both sides of the arm joint you built in Step 4, then add the other pieces as shown.



Attach the motor then the RCX to the arm joint.