

SYSTEMA PROFESSIONAL CHALLENGE KIT

Assembly Manual

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I. Assembly of Upper Receiver

Upper receiver assembly includes the barrel, which controls accuracy. Besides your normal collection of tools, make sure specialized tools such as a vice (or preferably the upper receiver clamp) are available.



I. Install Dust Cover

First, set E-Clip (UR-005) over groove on Dust Cover Shaft (UR-002).

NOTE

The dust cover's operation is different from the real gun. With the PTW, the dust cover remains closed during firing, and the dust cover spring should be installed so that it will held the dust cover in the "closed" position at all times. Please refer to photo.



Position Dust Cover (UR-003) and Dust-Cover Spring (UR-004) over Upper Receiver (UR-001-M4), then insert Dust Cover Shaft from front end (barrel side) through the upper receiver and dust cover, securing dust cover in place. Note the position of dust cover spring.



2. Install Forward Assist Knob

The forward assist knob has no specific function in the P.T.W.

Forward Assist Knob Set Pin (UR-009) is to simply prevent the Forward Assist Knob (UR-006) from springing out.

For assembly, insert Forward Assist Knob Spring (UR-008) into upper receiver, then insert Forward Assist Knob as shown (note the location of groove).



Once the groove is aligned inside the receiver, insert set pin from below the receiver. The pin is easier to install from below with the receiver upside-down because the receiver sits more securely this way.



3. Assemble Charging Handle

First insert Charging Handle Stop-Latch Spring (UR-012) and Charging Handle Stop-Latch (UR-011) into Charging Handle (UR-010). While pushing the stop-latch securely against the charging handle, insert the Set-Pin for Charging Handle Stop-Latch (UR-013) by using a pair of Teflon-based pliers.



4. Install Outer Barrel

Insert Outer Barrel Knock-Pin (BR-019) to outer barrel, then insert outer barrel to upper receiver.



From the front of the outer barrel, screw in Barrel Nut Assembly (ASS-BR-03). The barrel nut assembly consists of 4 parts (barrel nut, slip ring, weld spring, and e-ring). To properly install the gas pipe later, the notch / holes on these 4 parts and the hole in the upper receiver must align properly. Use a tool such as small screw driver to ensure proper alignment.



Tighten the barrel nut and ensure the holes' alignment in the last step (the path for gas pipe insertion) will remain correct even after the barrel nut is fully tightened. The photo shows the use of a barrel nut wrench. When using such wrench, do not over-tighten as it will be very difficult to remove the nuts later if needed.



TIP

To protect the surface finish, the use of an upper receiver clamp (shown here) is highly recommended. It is a device originally made for real guns, but will fit the PTW quite perfectly.

5. Assemble Front-Sight Post

Insert Gas Pipe (BR-014) into Front Sight Post (BR-005), align holes and press-fit Gas-Pipe Retaining Pin (BR-009) using pliers. Then insert Hand-Guard Cap (BR-013) over outer barrel.



Insert front sight post over barrel. The gas pipe should pass through the corresponding hole in the hand guard cap, barrel nut assembly (hole prepared in last step), and finally into the upper receiver.

Align front sight post with outer barrel, and insert two Front Sight Post Knock-Pins (BR-010) to secure the front sight post.

TIP

There is a set screw under the front sight post (see next step), you may loosely tighten this screw to position the front sight post, which will help you install the knock pins.



Fully tighten the screw under the front site post to secure it in-place.



Fix Front-Sight Post Swivel-Ring (BR-032) and press-fit (or using pin punch) Front-Sight Post Swivel-Ring Pin (BR-011).

6. Install Hand-Guard

Insert Hand-Guard (BR-032) while pressing down hand-guard slip ring. Be careful not to get your hand caught as tension of the weld-spring is very strong, just like the real gun.



7. Install Flash Hider

First, screw Flash Hider Ring (brass sleeve, BR-002) to the threaded tip of Outer Barrel (BR-020). Next, slide Flash Hider (BR-001) over the flash hider ring. While the flash hider is aligned properly (set screw hole facing down, install / tighten Flash Hider Set Screw (BR-004). Loctite "Blue" or other similar removable threading compound should be used to prevent the flash hider set screw from loosening during normal operation.



FINAL CHECK

Install Carrying Handle Assembly (ASS-CH-01) to upper receiver, and visually confirm that the front sight can be seen through the rear sight. If front sight cannot be viewed directly through rear sight, there is a substantial flaw in the front sight post setup or possibly the barrel assembly. The gun will not function properly and the upper receiver assembly procedures should be checked and disassembled / re-assembled if necessary.

Technical Highlights: SYSTEMA D.P.L.S. (Direct Pull Loading System)

1. Merits of Take-Down Feature

P.T.W. is designed with a take-down feature similar to real gun.

The reason to adopt such design was not to simply imitate real gun. Rather, it was to make P.T.W. capable of changing its bullet speed depending on the situation, by replacing cylinder assembly and corresponding battery of different voltage.

When P.T.W. is shipped out from factory bullet speed is strictly set at 93 m(\pm 1m). This shooting power is generated by our 7.2V / 2400mA battery.

However, if you are not satisfied with the bullet speed when using it outdoors, for example, prinking, you can quickly upgrade it by exchanging cylinder assembly with

“110m Cylinder assembly” (sold separately). Wide range of other upgrade parts, such as 130m Cylinder assembly (sold separately, 9.6V / 1600mA battery) are also available.

Usually, you have to replace a gear-set to change bullet speed, but our new product requires none of such work.

The structure that gives you desired power at once without requiring special tool.

That was the biggest reason why we persisted in a structure with a take-down feature equivalent to real gun.

Furthermore, you can oil the chamber more effectively to ensure smooth operation because cylinder assembly can be pulled out. This is possible because nozzle is always closed after every shot for both semi-auto and full-auto modes.

Similarly, cleaning inner-barrel, which is assembled by inserting into outer-barrel, is easy.



2. The “Quality” We Seek

In conventional system, the part to load bullets (tappet-plate) by forward and backward movements is susceptible to “bending” due to its shape when stress with load. However, as shown in the above diagram, in our new product, a vector of nozzle-pulling force is on the same line as the piston-head which is pulled by sector-gear, in other words, they are both on the same line as barrel. This is the most efficient structure concerning the load on motor.

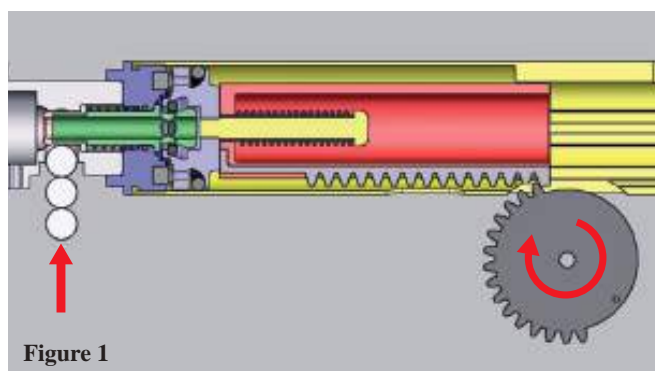
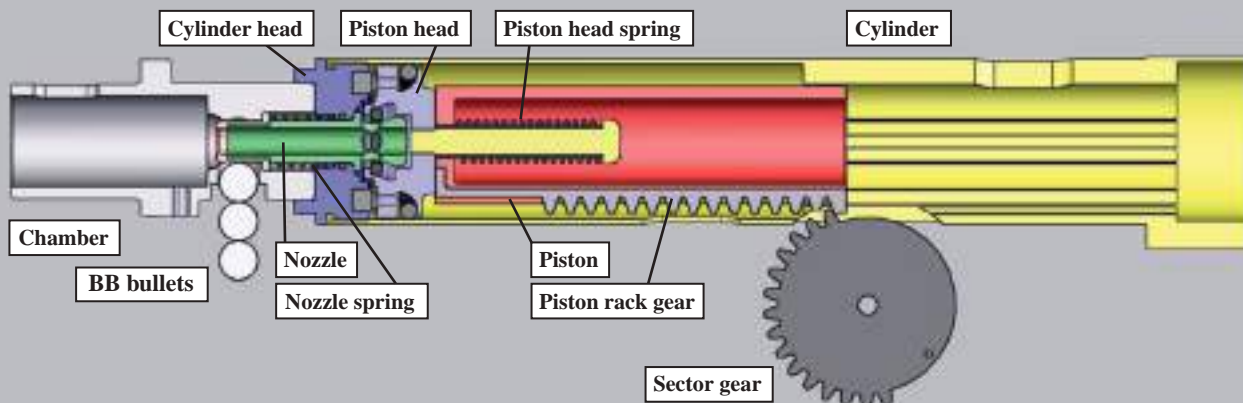
As a result, we were able to use a significantly lower gear-ratio compared to standard gear-ratio (gear-ratio we used to call “super torque-up” now became standard) and succeeded in achieving almost the same cycle rate with lower voltage battery. Naturally, value of electricity when gears are running is low, contributing to utility efficiency.

Improvement of friction loss in deceleration system with a 2-shaft-gear-box and pursuit for utility efficiency in bullet loading system together made its function very smooth and resulted in extremely direct trigger feel.

Enjoy the shooting sensation similar to real gun created by our two-stage trigger (a trigger mechanism that makes it easy to feel the last stage of pull due to slight slack at the beginning of the pull) and of trigger travel (range of stroke from the start of pull to just before firing) having exactly the same distance as real gun. This “feel” is the most important “quality” we wanted in this new model.

The objective we persistently pursuit each day is not “the quality to be talked about” but “the quality anyone can easily understand.”

Parts name

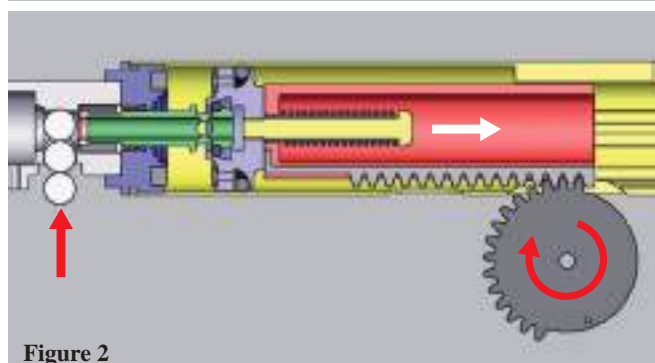


First set position (Figure 1)

The main spring isn't illustrated, but it positions the posterior end of the cylinder head like pressing from the main spring with the piston head.

The nozzle is in a position anterior to the nozzle spring and prevents moving BB bullets up from the magazine (clip).

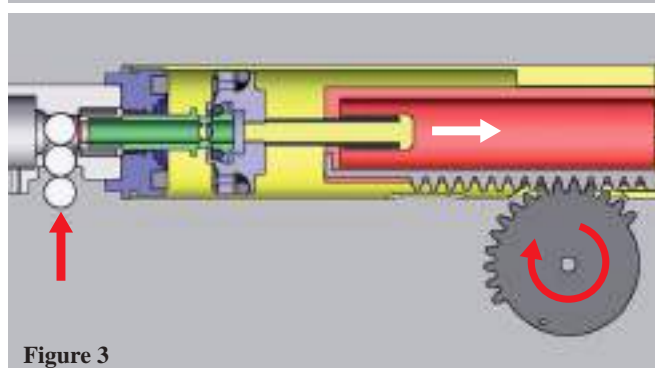
The figure shows that the piston rack and the sector gear start joining by rotation of the sector gear.



Nozzle slide back and feeding (Figure 2)

The whole piston starts backing down by the rotation of the sector gear. Since the inner diameter of the O ring inside the piston head is smaller than the outer diameter of the back end part of the nozzle, without opening the nozzle, it makes the nozzle slide back with pressing the nozzle spring.

As BB bullets are constantly pressing up by the spring of the inner magazine (clip), it rises up to a space which is generated by backing down the nozzle and positions a single bullet on the barrel line.

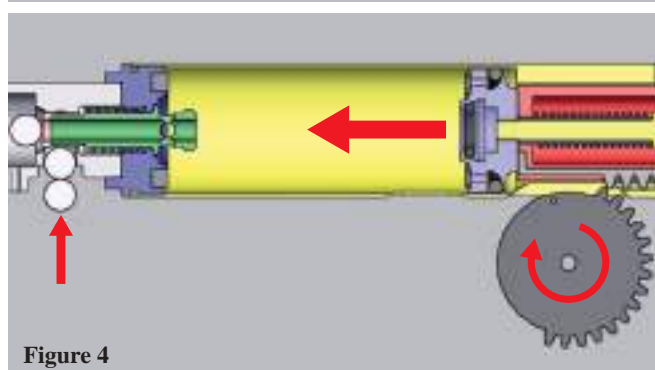


The nozzle spring and the piston head spring all coherence (Figure 3)

In addition, the Sector gear rotates and presses the main spring.

Under this condition, the O ring inside the piston head doesn't open the nozzle. Because of this, it also presses the piston head spring which has a stronger tension than the nozzle spring.

The figure shows the condition of all coherence of these two springs.



Just before the nozzle open and the piston release (Figure 4)

After the nozzle spring and the piston head spring reach all coherence and the sector gear rotates more and the piston slides back, the O ring inside the piston head opens the nozzle for the first time.

And then the nozzle goes forward by the nozzle spring and loads one BB bullet inside the chamber. Also, the piston head is attached more firmly to the piston by the tension of the piston head spring.

The figure shows the position just before being opened the piston rack by the sector gear.

Then, after the sector gear cuts off the connection with the piston luck, the piston goes forward and turns back with pressing air inside the cylinder by the main spring tension.

BB bullets are fired by this movement.

And in this case, the O ring inside the piston head connects the back-end part of the nozzle by the power of going forward of the piston.

The form of the inside of the piston head is a taper form and the O ring inside of the piston head is hard to open the nozzle and easy to connect.

If a shooter selects single-shot, these operation is performed once.

If automatic fire is selected, this series of operation is repeated.

II. Assembly of Cylinder Unit

The cylinder is where air is compressed and used to propel the BB (Ball Bullet). The cylinder is also responsible for loading the BB. Note that in this part, much adhesive will be used, and for long-term stability of any adhesive, thorough cleaning / degreasing is critical.

Obviously use of commercial degreasing agent such as break cleaner is the most effective, but even household detergent can be get the job done if rinsed thoroughly.

Finally, it is very important that all parts are dried completely before work begins.

1. Install Rack Gear

Apply instant-glue (Syanon 722 recommended) on Piston (CR-012) where Piston Rack-Gear (CU-011) is to be fitted, and press fit together. It is important that the piston is kept perpendicular to the rack gear, and the rack gear is inserted quickly before the adhesive dries.



Assemble Piston Head by first gluing Piston Head Bumper (black, flat rubber ring, CU-008) to Piston Head (CU-007) using instant glue. Then install Main O-Ring for Piston Head (CU-010) around the outside of piston head, and Small O-Ring for Piston Head (CU-009) inside the opening in front of the piston head. Refer to photo. Apply sufficient amount of Systema cylinder grease to where small o-ring is fitted.



Place Piston Head Guide Spring (CU-013) over Piston Head Guide (CU-014), and insert the piston head guide through the opening in the piston as shown. While pressing the piston head guide through the opening (the spring should not protrude), apply glue to the thread and tighten piston head onto the piston head guide.



2. Install Piston and Cylinder Head

Apply cylinder grease on inner surface of the Cylinder Case (CU-016). Then insert completed piston assembly as shown. after the piston is approximately 80% inserted into the cylinder case, it must be aligned with the anti-rotation groove inside the cylinder before it can be fully inserted. Use a small tool to guide the piston assembly into the groove from the rear of the cylinder.



Install the Cylinder-Head Assembly (ASS-CU-01) by fastening it onto the front of the cylinder case. Use a special wrench, or a large adjustable wrench, to properly secure the cylinder head assembly.

3. Install Main Spring and Spring Guide

Insert Main Spring (CU-017) from the back of the cylinder case, then insert Spring-Guide Assembly (ASS-CU-06) through main spring. Using the spring guide assembly to compress the main spring and screw the spring guide assembly into the cylinder case. Be careful not to allow the spring guide assembly to accidentally loosen and eject itself.



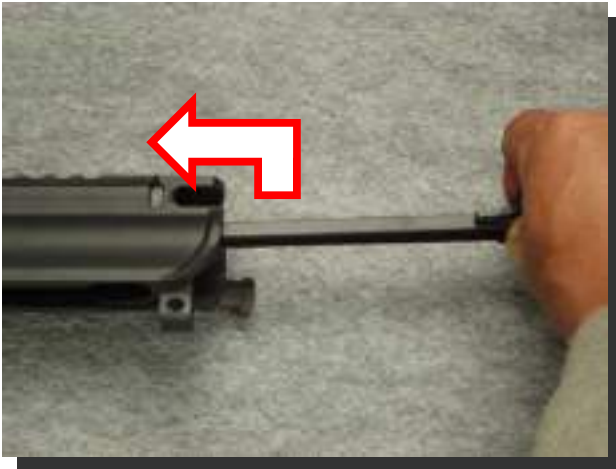
4. Install Inner-Barrel Assembly

Insert Inner-Barrel Assembly (ASS-BR-04/05) to upper receiver, noting the orientation of the BB feeding opening, as shown.



5. Install Charging Handle Assembly

Position charging handle assembly inside the upper receiver, align the notch of the charging handle against the opening of the corresponding slot inside the upper receiver, and push the charging handle into the opening / towards the top of the upper receiver. Then slide the charging handle fully forward and lock it in place.



6. Install Cylinder Unit

Insert completed cylinder unit into upper receiver. Note the orientation and alignment of the cylinder unit, the nozzle (cylinder head) should be facing forward (towards the muzzle), and the notch at the end of the cylinder case must line up and fully seat into the opening in the upper receiver (see photo). It is usually very tight to install the cylinder unit for the first time, however it will slowly develop a proper fit and becomes smoother to insert / remove as the PTW “breaks-in”.



Technical Highlights: Regarding Hop Structure Installed

SYSTEMA S.A.C.S. (Systema Accuracy Control System)

1. What is HOP-UP System?

In the field of modern air-soft gun, HOP-UP system which maximizes the range with fixed bullet power as essential technology.

HOP-UP system generates “lifting force,” phenomenon in fluid mechanics, on BB to gain more range.

The principle of lifting force is that by causing upward rotation to a sphere, the air density below the sphere will become greater than that of above to make the sphere float.

In reality, we know why head of golf club is angled and why home run ball is carried over to a stand because a baseball was hit slightly below the center.

This concept to “cause upward spin to a sphere” to generate lifting force has been applied to air-soft guns in various forms.

Most popular design is using a tall tab on upper wall of inner-barrel to rotate a BB when it is fired.

At present, “adjustable HOP-UP system” by “height of tab” is the mainstream.

2. Effects on Bullet Trajectory

Unfortunately, this amazing HOP-UP system is not flawless.

That is its effects on “bullet trajectory.”

The operator of gun is human being. The natural state of human consciousness expects certain trajectory when a flying object falls with the effect of gravity. In other words, a parabolic orbit is the most natural trajectory to us.

However, the downside of HOP-UP system is that a BB tends to hit a target higher than aimed line unless the distance to target is estimated correctly because the trajectory is significantly influenced by weakening forward energy of a bullet.

3. What We Consider Ideal Bullet Trajectory: Power and Distance

We have always believed that the shooting range should be gained by firing power as much as possible. If we may say, our “priority is bullet speed.”

This is different from saying our “priority is power.” We are not looking for “destruction power” that can hurt a man in merely a toy gun.

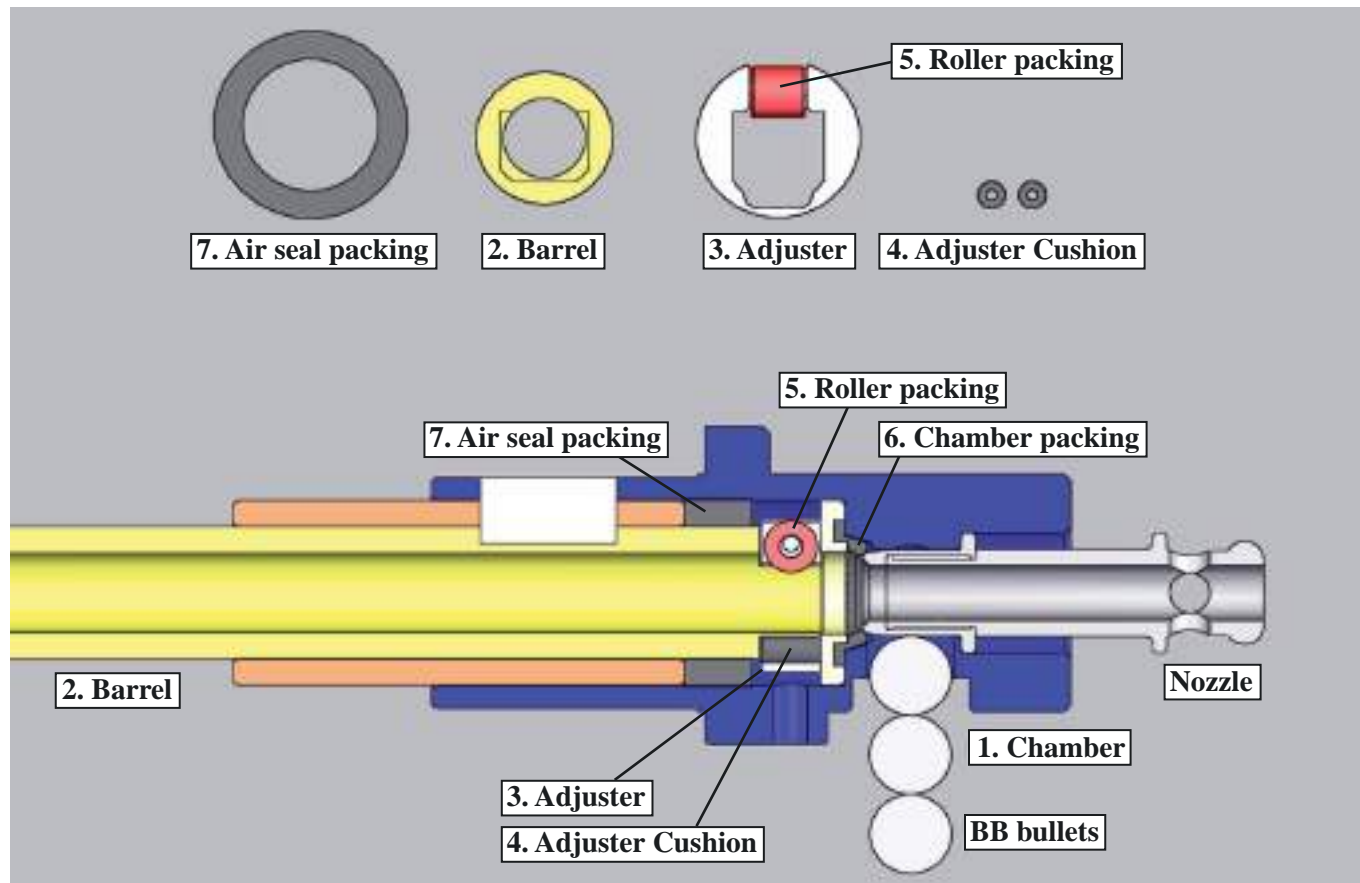
However, we do not like shooting by estimating bullet trajectory with our eyes. (That means we believe that gun should be aimed with sight.)

Consequently, what we came up with was “to shoot the lightest possible BB straight.”

In shooting games at the moment, use of 0.25g BBs is the mainstream for its ease to aim and to prevent effects of side wind. However, in a game where men shoot directly at one another, it is not the safest choice to use heavy weight BBs that retain large amount of energy after traveling 10 to 20 meters.



Parts name



1. Chamber

It is made of zinc die casting. The joining dimension of the sliding part of nozzle is designed very carefully.

Since it is designed to feed bullets at the nearest position to barrel line, if you remove magazines during the shooting, it is only one the BB bullet drops.

The outside diameter of blank (material for processing) is processed in order to join to the outer barrel. So it doesn't break down if you insert magazines a little roughly.

2. Barrel

It is made of brass. The joining dimension with outer barrel is only 5/100mm.

This very close setting allows us to avoid blurring due to the blow by piston at the full automatic shooting.

Therefore, it makes possible the significant improvement of grouping.

The inside diameter is set to 6.1mm.

3. Adjuster

It is the most important parts for this structure.

It supports roller packing with the shaft passed through from the side, and this parts itself smoothly moves vertically against barrel.

In addition, it is set to continuously apply tension downward by the resilience of rubber of adjuster cushion.

4. Adjuster Cushion

It is the parts to set adjuster to keep downward.

As shown in the illustration, with use of two pieces together, it minimizes horizontal "movement" of the adjuster and the barrel in which the adjuster is set.

5. Roller packing

Roller packing is upward rotated by contacting directly to BB bullets within the barrel.

There is a bigger hole than the shaft of adjuster to be set.

This shape makes BB bullets always move forward contacting the roller packing.

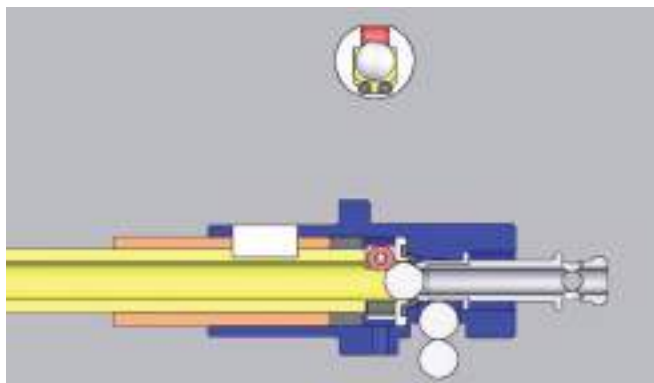
6. Chamber packing

It is inserted to the chamber after attached to the brass parts named chamber packing base. It is designed to increase degree of adhesion of nozzle as well as to soften the shock on nozzle because of our own structure of feeding bullets.

Since the lip part is designed to be very thick, you don't need to be excessively careful when you use barrel cleaner and so on.

7. Air seal packing

The packing avoids leaking compressed air from the spaced between the chamber and the barrel.



Completion of feeding/Standby position

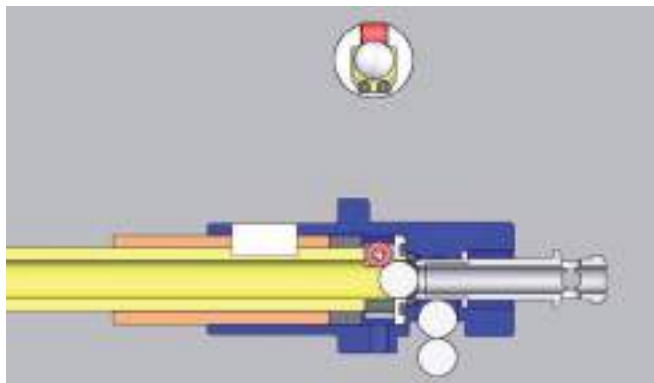
The BB bullet loaded in the magazine is blocked to move upward by nozzle.

The illustration shows the BB bullet is loaded into barrel by a back and forth movement of nozzle and is ready for shooting.

The front of nozzle is closely contacted to the chamber packing by the tension of nozzle spring in order to avoid leaking compressed air from the back cylinder.

The BB bullet remains still between chamber packing and roller packing set in adjuster.

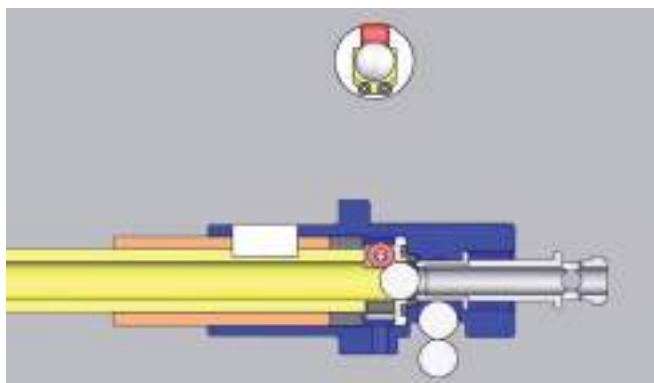
Roller packing has fallen within the space to the shaft of adjuster with own weight.



Shoot 1

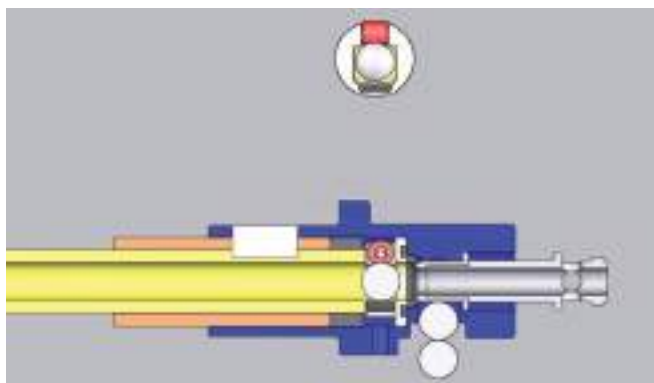
The illustration shows that the BB bullet is slightly pushed forward by compressed air from behind.

First, the BB bullet pressured from behind pushes the roller packing set in the adjuster.



Shoot 2

When the BB bullet moves further, the roller packing is moved upward rolling within the space to the shaft of adjuster.



Shoot 3

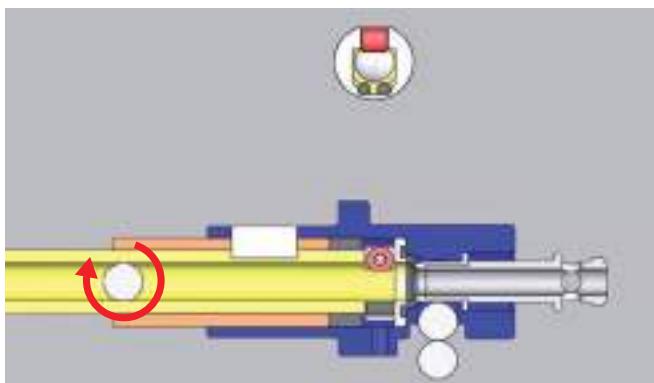
Since the BB bullet is not shot smoothly because of the roller packing's resistance, the pressed air density within cylinder reaches the highest.

The roller packing is set by the shaft which passes through the HOP adjuster.

However, since there is a space between this hole and external diameter, the BB bullet is not pressed excessively.

But still the dimension is too small for the BB bullet to pass through, so it changes the form of adjuster cushion which is less rubbery than the roller packing and slides the adjuster itself upward.

Finally the BB bullet can pass through.



Shoot 4

BB bullets are accelerated within the barrel by the upward rotation and then fired.

On the other hand, we use 0.2g BBs as standard in all of our tests.

That is not fully satisfactory yet, but there is no lighter BB with high precision available. (We think ideal weight is around 0.17 to 0.18 g.)

We are pursuing the utmost accuracy using apparently disadvantageous light-weight bullet to control trajectory.

4. Creating Extremely Weak But Accurate HOP-UP

For those reasons above, more sensitive control becomes necessary in the HOP-UP system if we seek stable bullet trajectory with light-weight BBs. The objective we persistently pursue each day is not “the quality to be talked about” but “the quality anyone can easily understand.”

5. Concept of “Time”

Please see the illustration on the previous page, there are two parts that operate when a BB is fired. They are roller-packing and adjuster.

The purpose of these parts is to minimize energy loss while ensuring that roller-packing touches a BB as much as possible.

In other words, the most important concept of this system is to touch the bullet as little force as possible, but as long time as possible.

Another characteristic is it reduced the influence of grease unevenly put on to a bullet surface in the conventional system. Lifting force was previously created by touching one point or line of a bullet whereas in our new system, roller packing touches the bullet while it rotates.

6. Firing

As some of you may have already understood, our HOP-UP is adjusted by “lowering.” In other words, original position is “maximum HOP-UP.”

To adjust HOP-UP, use included special hexagon wrench from beneath magazine-housing.

For those who are used to lever adjuster, our style may feel somewhat unsatisfactory, but we chose to avoid instability that results from increased number of parts because we don't expect many of you to make an adjustment so often. As described earlier, due to the existence of space between a BB and roller packing, degree of spin is fairly light. Even with rough adjustment, HOP-UP will be set within the acceptable range of the system. There is no need to be too nervous.

To repeat the major reason why we chose this style is that we merely expect “HOP-UP” system to have a supplementary role in correcting bullet trajectory.

We carried out numerous firing tests and the results were satisfactory.

BBs travel and form extremely natural parabolic orbit without much hint of HOP-UP effect, and their trajectory is apparently different from that of conventional system that only seeks increasing the shooting distance .

Some may not be satisfied with our system when you use it in War games situations . But we would like you to understand our basic principle that is “gun is aimed with sight to fire.”

III. Assembly of Gearbox

In this section we will assemble the gearbox. Those who are experienced in building conventional airsoft gearbox may find this completely new and intimidating, but don't be nervous. Components used in the PTW gearbox are manufactured with extreme precision, and if you follow the instruction, anyone can assemble this gearbox correctly. We even eliminated most of the shims in the system!

1. Install Planetary Gears

Planetary-Gear Shafts (GB-010, 4x) are pre-installed into the Left Hand Side Gearbox Case (GB-002). There is a D-shaped groove on one end of each planetary gears, properly oriented from the factory. Use the sun gear bearing, as shown, to check their orientation.

WARNING

The 4 planetary-gear shafts are press-fitted under extremely strict manufacturing control. Never pull out the shaft because you may not be able to reposition them correctly thereafter.

As shown in the right photo, insert Sector Gear Shim (GB-011) over the 4 planetary gear shafts. This shim is used to contain the grease on the sector gear, which helps avoid contamination of other components.



Finally, apply a VERY light amount of grease over the shim and on each shaft, then insert the planetary gears. Note that one of the gear provided are different then the rest (steel-lathed), and they must be arranged according to this photo to avoid possibility of premature failure.

2. Install Trigger Lock

Refer to the right photo and install Trigger-Lock (GB-016) and Trigger Lock Spring (GB-017). Apply a slight amount of grease to any contact surface between the trigger lock and the gearbox case.



3. Install Internal Sector Gear

Apply a very light amount of grease over the entire Internal Sector Gear (GB-007) - a very thin layer using cotton buds are sufficient - and install the internal sector gear according to the right photo. Pay attention to the orientation of the sector gear, the multiple small holes drilled into the side of the sector gear must be facing up.



4. Install Bearing Plate

Install Bearing Plate (GB-009) and Sun-Gear Bearing (GB-006) by first placing the sun-gear bearing over the top of the planetary gears as shown. It should sit perfectly onto the D-shaped notch over the planetary gear shafts.



Next, place the bearing plate over the sun gear, with its flat side facing the planetary gears. Each of the 4 planetary gear shafts should seat into the corresponding hole. Also note the orientation of the bearing plate, the cut-out should be facing the 8-o'clock direction as shown.

5. Assemble Bevel Gear

The Bevel Gear (GB-003) is the only gear that requires Shims (GB-024). First, very lightly coat the entire bevel gear with grease. Next, place one thick shims on both side of the gear, then place an additional thin shim on the "bevel gear" side (where the shaft sticks out longer). Refer to the Technical Diagram if needed.

Thereafter, install one Bevel-Gear Bearing (GB-004) to the left side gearbox case with a pin punch. Be careful not to damage the bearing.

Finally install the bevel gear (with its shims still attached) onto the gearbox as shown.



6. Install Trigger

Install Trigger (GB-014) and Trigger Spring (GB-015) according to the following photos.



TIP

Use a small amount of grease to “stick” the trigger spring to the trigger would make installation easier.

7. Install Helical / Sun Gear

First lightly grease both set of teeth on the Helical / Sun Gear (GB-005), as well as the hole in the gear.

Insert the gear through the sun gear bearing and bearing plate as shown. If it does not fit immediately, rotate the internal sector gear by hand while inserting the helical/sun gear.



8. Install Sun Gear Shaft

First, thinly grease the Sun Gear Shaft. The Sun Gear and Sun Gear Bearing (Bushing) are already machine-pressed together.

Then install the bevel gear bearing on the right Right-Side Gearbox Case (GB-001), and then place the right side gearbox case over the gearbox. Loosely fasten the 5 screws to hold the two half together.

Finally place the sun-gear shaft above its appropriate opening, keeping it perpendicular and fully inserting it. You may need to use a small hammer to drive it in, but make sure you only hit it very lightly and drive it in little-by-little to avoid damage to the shaft.



9. Adjust Gear Rotation and Install Gear Case Screw

Hold case in hand, and rotate helical/sun gear by hand. If it rotates smoothly, go to (10).

If not, refer to right photo and lightly hammer the lower front part of gear case left side with plastic hammer. Check gear rotation each time you hammer.

If after repeating the above procedure 5-6 times and gear rotation is still not smooth, try to rotate the internal sector gear by hand. If you feel any “catch” during rotation, disassemble the gearbox, remove the helical/sun gear, rotate it to a different position and re-install the helical/sun gear. Re-assemble gearbox and check rotation smoothness again.

Repeat the above steps until gear rotation becomes smooth. It may be time consuming, but with patient you will eventually find the right position. Thereafter, securely fasten the case screws.



10. Install Selector-Rack

Turn gearbox to the left side, and install Selector-Rack (GB-022) to the left-side gear box case as shown. (Your current gearbox won't have the control wires, this photo is just for reference of the rack's positioning). Make sure the selector is at the furthest left of the opening, which is the “SAFE” position.

You have now completely assembled the gearbox.



A FINAL WORD ABOUT GREASING

There is always a debate in the factory about how much grease is too much for this gearbox. This subject is particularly interesting because excessive grease will cause binding and decrease operating efficiency, hence resulted in substantially increased motor load. An over-greased gearbox can consume as much as 3-5 extra amp of current! So using the minimum grease required to effectively prevent wear-and-tear is usually the best way to grease this gearbox. Generally speaking, if you can see grease accumulating around the gears as you spin them (i.e. grease getting pushed aside), you've over-greased!

Technical Highlights: *SYSTEMA* Planetary Gear BOX

Background on Adopting Planetary-gears

It is the "Planetary-gear-box" that contributed most to P.T.W. in achieving exactly the same external dimensions as real gun.

The major characteristic of planetary-gear system is its higher gear-ratio. This is due to the capability of planetary-gears to rotate on the same axis as driving-gear, which allows joining multiple gears. It is often used in electric tools such as electric drills.

P.T.W.'s gear-box was not just designed to be compact. The other characteristic is having only two gear shafts. A gear-train works smoothly as designed only when each gear precisely holds its center position. To do this, we designed gear-set to create required gear-ratio, and to be able to double back the entire gear-set inward. As a result, we were able to shorten the length of gear shafts and reduced the number of shafts, and succeeded in improving the accuracy.

You can see this clearly by looking at "Right Photo." The system is more compact with only two shafts compared to three shafts previously.



We are now mass producing the planetary-gear-set, which was redesigned with four planetary-gears whereas our experimental planetary-gear-set had three planetary-gears, so that the system can withstand large anti-thrust load when high-rate spring is used.

Additionally, with this effort, we were able to minimize back-slash from both vertical and horizontal directions when gear-teeth engage, and achieved the ultimate transmission efficiency.

Now, let us explain the gear-box in detail by each part: **A Durable Gear Mechanism with Small Module**

1. Reverse Thinking

In a usual planetary-gear system, internal-gear is fixed to a case and decelerates between planetary-gears and sun-gear.

However, as a result of our reverse thinking, we fixed the planetary-gears and the system decelerate between sun-gear and internal sector-gears.

This resulted in higher gear ratio with one shaft, using the same number of gear-teeth.

This is an innovative structure, but also requires advanced processing technology when manufacturing these parts.

2. Dimension of Parts

In order to ensure accurate and stable gear rotation inside Gear-box, joint dimension of gear and gear shaft is crucial.

For all the bearing holes and shafts in this Gear-box, joint size is h7.

Size h7 is considered best to join parts that need space to slide, but it is often not used because it is expensive to secure the required high level of engineering precision.

The fact that we use this size is a typical example of "SYSTEMA way" that our principle is "to remove as much cost constraint as possible for our ideal."

3. What is Module?

Module is "a value of pitch circle divided by pi (π)."

To put it simply, it is a unit to describe the size of gear-teeth. If value is greater, teeth are

Larger and gear wheel is stronger.

Standard module in electric guns used to be 0.8 for transmission and 1 for piston-rack and sector-gears. We have an experience of successfully making a highly durable gear-set using helical-gear with helix angle at 45 degrees and module 0.5, when we were designing SYSTEMA gears of less noise and higher transmission rate.

Gear-set with smaller module is necessary to make a compact gear-box.

Again, we accomplished a gear-set with module 0.5, fully utilizing our know-how from helical gear-set development.

4. Application of Transfer-Gear

In case of standard gears, a shape called undercut is often formed on individual gear-tooth when a gear is placed in between a pair of synchronizing gears (or between axis).

Undercut is a shape where the base of gear-tooth becomes thinner, causing a serious problem in terms of durability.

We have been making gear-sets of various gear-ratios using a designing technology called “transferring” on the same dimension.

Using the same technology, we were able to minimize undercut and made gear-teeth stronger by changing the shape.

5. Choosing Materials

Without a question, the ideal material to make gears is chrome molybdenum steel.

The characteristic of this material is that its surface is hard and inner structure is quite tenacious. These properties are well suited for gear wheels of which wear-off and damage must be prevented.

On the contrary, its disadvantage is that it is extremely difficulty to lathe, and off course very expensive.

What we consider ideal is “a gear-box that does not break.”

As long as sector-gear intermittently cuts off the connection between rack-gear and piston, timing will always be off. This will cause damage to entire gear-box and a gun will become “unusable.” But that is not acceptable to us as we profess our product as “training weapon system.”

In order to deal with this trouble, we developed a structure that allows quick replacement, by keeping damage within piston-rack, a part of cylinder set. For this reason, we had to make the inner gear-box the strongest possible.

Again, cost was not our top priority. We chose the ideal material without hesitation. This process is particularly important in the case of chrome molybdenum steel which cannot be carburizing.

We cannot reveal the hardening temperature here, but the temperature is strictly controlled since the most appropriate temperature was finally determined after many trials and errors. There are many other efforts to minimize the deviation among production lots that cannot be described in words.

Each gun part is a product of SYSTEMA's know-how, accumulated through our experience of manufacturing parts.

6. Hardening

”Hardening,” or technology to harden metal by changing its composition with heat is another know-how we possess as an electric gun-parts manufacturer. This process is particularly important in the case of chrome molybdenum steel which cannot be carburizing.

We cannot reveal the hardening temperature here, but the temperature is strictly controlled since the most appropriate temperature was finally determined after many trials and errors.

There are many other efforts to minimize the deviation among production lots that cannot be described in words.

Each gun part is a product of SYSTEMA's know-how, accumulated through our experience of manufacturing parts.

7. Bearing-plate

In this Gear-box, Planetary-gears are stationary as described above.

But the problem now is that if we adopt a conventional design, only one end of each shaft can be fixated.

To solve this problem, we designed a part called "bearing-plate."

By strictly controlling sun-gear's periphery or pitch circle, we inserted a radial-bearing surrounding sun-gear. The role of bearing-plate is to provide support to this bearing and to fix planetary-gear shafts.

With addition of these parts, four planetary-gears are supported by both gear-box and bearing-plate, so thrust load on sector-gear is spread among other parts of the entire gear system.



Excellent design is useless unless engineering capability is there to support. These parts, shaft-holes of 90 degrees 4 partitions and center-hole for bearing insertion, are extremely difficult to make for its dimension specification. Furthermore, the material used is difficult to lathe for its hardness. The machining technology required to make these parts is superhuman. Not to mention the fact that only a limited number of bearing-plate can be manufactured per month due to such high level of required engineering technology.

Our products are brought to the market with innovative thinking not constrained by existing technologies and by collaboration with rare engineering technology.

8. Gear-Ratio (Choosing Deceleration Rate)

We intentionally make only one gear-ratio for this bear-box. The gear ratio compared with our other gear-sets, is slightly lower than super torque-up, providing more than sufficient safety margin.

As a result, its rotation is very similar to real gun, but uses 7.2V battery to maintain the standard rotation rate for toy gun.

We chose to design with only one gear-ratio to free you from complicated gear changing work. It neither requires shim adjustment, on which we received most questions from our customers when installing SYSTEMA parts.

Grease needs less changing, due to the use of internal-gear and the concealed structure (or covered structure) of inner planetary-gears.

It takes some time for grease to loosen in the beginning, but once the grease is beat inside internal-gear and mixed into the inner machine, you will enjoy extremely smooth rotation despite low gear ratio.

You will feel this smoothness particularly in "semi-auto" mode where feel of initial pull is important.

What do you think of our first original gear-box, developed by SYSTEMA, a company recognized by high precision gear designs?

We are confident that you will enjoy it.

IV. Assembly of Lower Receiver

Assembling the lower receiver is probably the most difficult process of the Challenge Kit. In our company, you won't be recognized as full-fledged until you can assemble a lower receiver.

Nonetheless, the most important point in this section is to follow the order of assembly. If you don't follow the order, you may have to redo some of the works! So make sure you follow the instructions step-by-step!

I. Install Trigger Guard Assembly

First, refer to right photo and insert Trigger-Guard Assembly (ASS-LR-01) to lower receiver, using the spring-loaded Trigger Guard Stopper Pin (LR-015) to held it in-place.



Next, press-fit Trigger Guard Set Pin (LR-018) with Teflon-based pliers as shown.

2. Install Magazine Latch

First, insert Magazine-Catch (LR-008) from left side of lower receiver. Next, place Magazine-Catch Spring (LR-010) over magazine-catch shaft from the right side. Then, screw Magazine-Catch Button (LR-009) on the magazine-catch shaft, over magazine-catch spring. After some screwing, press the magazine-catch button into the receiver until the magazine-catch sticks out from the left. Rotate the magazine catch clockwise several turns (as shown), then rest it into its original hole.



3. Glue Dummy Pin

There are total 6 pins to be glued: Trigger Dummy Pin and Hammer Dummy Pin (LR-019, 4x), and Full-Auto Sheer Dummy-Pin (LR-020, 2x). We recommend using Loctite 403, but any adhesive that does not leave any residual / coloration will be fine.

To glue the pins, dip a toothpick into the adhesive and use the toothpick to apply a very small amount of glue into the middle of each groove. Then place each dummy pin into their corresponding groove, and apply pressure until adhesive sets.



4. Glue Selector Cap

Using the same adhesive, apply small amount of glue into the ledge of the Selector-Cap (LR-021), and place it into its respective groove on the receiver. If needed, use a small plastic hammer to set it in place.

5. Assemble Pivot-Pin

Insert Pivot-Pin Spring (LR-004) and then Pivot-Pin Stopper-Pin (LR-003) into the corresponding hole from the front of the receiver. While holding both parts inside the hole, insert Pivot-Pin (LR-002) through the lower receiver as shown.



6. Install Motor

The trick to install motor correctly is to always remember this: Positive terminal at the front. If you look at the bottom of the motor, you should see a red mark over one of its terminal. That is the positive terminal. After the motor is installed, the red terminal should be facing for front (muzzle-end) of the gun.

To install motor, insert motor perpendicular to the lower receiver, and rotate it 90 degrees (as shown) to lock it in place. Remember the positive *red) terminal should be facing front; pay attention to it when you insert/rotate the motor.



Once the motor is in-place, insert the Motor Fixing Pins (LR-023, x2). If the pin do not fit in smoothly and tapping / hammering is required, make sure the motor is properly and evenly supported first. A piece of board under the motor to distribute the pressre would work. This is important because the motor is a structural part of the PTW, and it (or its joint to the lower receiver) must not be deformed.



V. Assembly Slide-Stock

In this section we will be assembling the slide stock. Since the stock bears a great amount of force during operation, it is important that it is assembled securely and professionally. Properly apply torque in various tools are key to making the slide stock rock-solid.

I. Install Stock-Tube

Prepare stock tube by installing Stock Tube Nut (SST-012) onto the Stock Tube (SST-011) with the four notches facing the rear. Thereafter, insert Stock Set Plate (SST-013) over the threaded part of stock tube.



Next, insert Take-Down Pin (LR-005) into the lower receiver. Then from behind the receiver, insert Take Down Pin Stopper Pin (LR-006) and then the Take Down Pin Stopper Pin Spring (LR-007) into their insertion hole, as illustrated.

Finally, screw stock tube into lower receiver. Pay attention to the positioning; the front end of the stock tube should not protude from the lower receiver. If the stock tube is too far forward, the receivers won't close. Typically the front of the stock tube should still be about 2mm recessed.

Once the stock tube is in position, use a stock tube wrench to loosely tighten the stock tube nut. Do not fully tighten the nut yet because you may need to loosen it and re-adjust the stock tube front/aft in the next step.



2. Adjust Stock-Tube Cap

The Stock-Tube Cap (SST-015)'s main purpose is to lock the upper receiver in-place when the receiver is closed. There is a hole in the middle of the stock tube cap where the click-ball of the cylinder unit fits into. Proper positioning of the stock-tube cap is important for proper operation, and it is adjusted using shims (look like large silver rings) included with the stock tube cap.



3. Assemble Slide Stock

Position the Slide Lock (SST-004) under the stock with the hole aligned, and securely hold it in place with your hand. Then place Slide Lock Pin Spring (SST-003) over Slide Lock Pin (SST-002), and insert the pin, from inside the stock, through the hole on the bottom of the stock and out through the slide lock.

With the threaded tip of the slide lock pin sticking out from the bottom, thread the Slide Lock Nut (SST-005) over it to secure the slide lock in place. The slide lock nut should be fastened to the shown position (refer to photo). Thereafter, press-fit the Fixing Pin for Slide Lock Nut (SST-006) into the opening between the slide lock nut / slide lock pin to prevent the slide lock nut from loosening.

Finally, install O-rings on Battery Stopper Cap (SST-008-7.2), and then twist the stopper cap into the slide stock's front opening as shown.



4. Install Slide Stock

While pushing the slide lock all the way downward (as shown), insert slide stock over stock tube.

Once the slide stock is in-place, glue the sponge-sheet (SST-007) over both sides of the stock. Never pull the sheet during installation or it will become stretched and will not obtain proper fit. Evenly and gently glue them starting from the edge of the sponge sheet and work your way across should result in good finish.



VI. Installation of Electrical Components

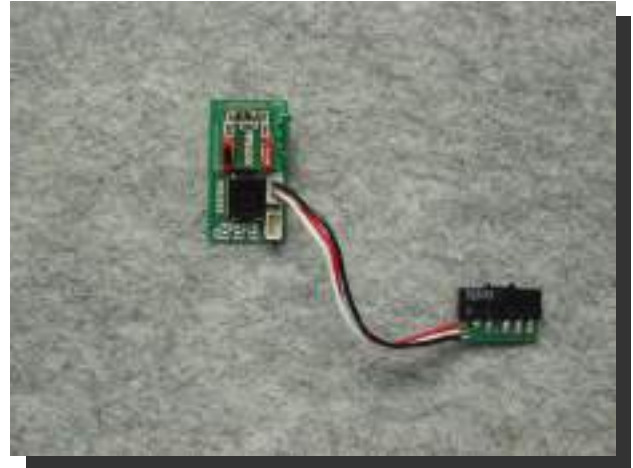
This is the longest section of the entire manual, which deals with installation of various electrical components - the control circuits of the PTW. Please note that any electronic components are sensitive to static electricity, so wearing either a good quality grounding lanyard or the included rubber gloves are highly recommended. In addition, in this section two wires must be soldered to the motor. Care should be taken to avoid serious burning injuries from the solder iron or other parts that has been heated up during the process.

1. Connect Electrical Control Unit

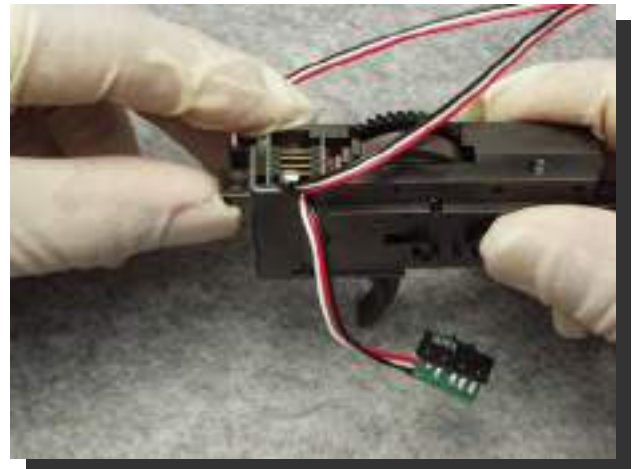
Locate the Selector Switch Board (EL-002), and connect the 3-wire lead (its mini connector) to the upper socket of the SYSTEMA/Electrical Control Unit (EL-001). (Upper socket is the one closer to the center of the circuit board.)



Finally, insert the Electrical Control Unit very carefully into the gearbox. Pay extra attention to now each control cable exits the gearbox from the side. You should try to arrange the cables as shown.



Connect one end of the Control Cable (EL-004) on to the lower socket of the electrical control unit. Note the use of rubber glove.



2. Install Selector Switch Board

Route the selector switch board control along the groove cut into the left side gear case. The cable must lay flat against the gearbox as shown, or the completed gearbox will not fit into the receiver.

With the cable properly situated, the 4 holes on the selector switch board (2 holes per switch) should line up with the 4 studs on the left side gear case. Push the switch board against the gearbox so that each stud is fully inserted into its corresponding hole in the switch board, securing it.



3. Install Gearbox

Insert motor as shown. Make sure the motor stays perpendicular to the gearbox at all times, and do not left out the selector rack gear (the silver piece). Also pay attention to not pinch any of the control wires.



Once the gearbox is fully seated into the lower receiver, secure the gearbox by fastening two Set Screws for Gear Box (GB-025) through the mounting holes of the gearbox, onto the lower receiver.

4. Install Switch Device

First, plug the control cable from the electrical control unit into the Switch Device (EL-003).



Then remove the stock tube cap, and push the battery plug, coiled cord, and the switch device (in this order) into the stock tube. Replace stock tube cap when done.

As illustrated, route the two motor wires through the small opening in the lower receiver (located behind the gearbox) into the grip/motor compartment. Also, tuck the control cable into the grooves as shown.

NOTE

It is generally preferred to route the negative motor wire through the right hole (the side where the take-down pin is sticking out), and the positive motor wire through the left hole.



5. Install Selector Lever

First ensure the selector rack gear is at the forward (SAFE) position. Use a small pin punch or tooth pick to make sure it is pushed forward fully.

Then slightly grease the Selector Lever (GB-018) shaft, and then insert it into the opening, while orienting it to the “SAFE” position (selector lever pointing the front / muzzle end of the gun). Once fully inserted, rotate it from SAFE to AUTO to ensure full range of movement.



Finally, insert Selector Click Ball (GB-021) and then Selector Click Ball Spring (GB-020) through the small, threaded opening at the top of the gearbox. Then fasten Selector Click Ball Screw (GB-019) over the hole, slowly tighten the screw until resistant is felt. The selector lever's resistant is adjustable by how tight you fasten the selector click ball screw.



6. Install Line Set Plate

Insert the small plastic plate called Line Set Plate into the groove as shown. It will prevent the control cable from popping out during operation.

WARNING

The control cable must be positioned as long in the body as possible, otherwise it may be damaged by the upper receiver tab when you assemble the two parts together.



7. Install Bolt Stop

Insert Bolt Stop Spring (LR-012) into the corresponding hole in the lower receiver. Then position the Bolt Stop (LR-011) over the bolt stop spring, aligning the hole with the retention pin holes on the lower receiver. Finally insert Set Pin for Bolt Stop (LR-013) through the corresponding hole from the rear (butt stock side) of the receiver, with the knurled end facing the rear. Use a pin punch to secure the pin in place.



8. Solder Motor Wires

Use a rubber band or electrical tape to temporarily secure the motor wire in-place. Then solder the wire as shown. Note the longer wire is positive which should be connected to the brush case next to the brush spring post painted red, and the shorter wire is the negative which is to be connected to the other brush case.



TIP

A common technique for expert soldering is called “pre-solder”. Pre-solder involves applying sufficient amounts of solders to both parts prior of them to be joined. When you are ready to join them, simply stack the two together and press with your solder iron. For example, we apply solder to the end of the motor wire first (left). Then we apply some more solder on the motor’s brush case (middle). There after, we just place the wire’s end over the terminal, and melt them together. Its that simple!



WARNING

Do Not Over-solder! If you apply too much solder on the brush case, it may overflow into the inside of the brush case, bonding the brush as well. The motor brush must move freely inside the brush case for the motor to work properly, as it needs to constantly self-adjust while making contact with the commutator. If you are inexperienced with solder, consider removing the brush and brush spring from the motor first (as shown), before you solder the wires.



9. Install Grip and Grip End

Gently slide the Grip (LR-022) over the motor, ensuring the motor wires do not get squeezed or pinched between the grip and the motor.



Once the grip is fully inserted, through the opening at the bottom make sure the positive motor wire is routed towards the side of the motor's bottom mount point. There is a small notch on either side of the grip end for the wire to rest. If the wire do not rest in said groove, it will be damaged.

Next, place Grip End (LR-025) over the bottom opening of the grip with the correct orientation (see picture) and fasten the grip end to the motor by using the 4 Group End Screws (LR-027).

Finally install Rotor Adjust Screw (LR-026) in the center opening of the grip end, but do not tighten. The newer motor that comes with the kit does not require adjustment anymore, and the rotor adjust screw is just there to cover the hole. Fasten the screw until the top of the screw is flush with the top of the hole.



VII. Testing Functions

A few tests to ensure proper function prior to fully assembling your PTW!

1. Check Function of Gearbox

With the upper and lower receiver still separated, install battery in the battery compartment (sliding stock), depress the bolt-release button, switch the gun to “SEMI”, and pull the trigger. The helical gear and sector gear should rotate. Be careful not to get your hand caught/cut on the gears!

A. Notice the rotation of the internal sector gear. It should be rotating the teeth towards the rear of the gun over the exposed area. If the sector gear rotate in the wrong direction, **STOP!** Disassemble grip end and check for motor orientation and wiring. The positive and negative wire may be reversed.

B. After each time you pull the trigger, the sector gear should stop at the same position with almost all of its gears hidden from view. If not, remove and disassemble gearbox, and check orientation of the internal sector gear.

After the semi-auto check, switch the gun to full-auto and pull the trigger. The gear should rotate for as long as the trigger is depressed, and as soon as the trigger is released it will stop the sector gear at the same position similar to semi-auto firing.

2. Joining Upper and Lower Receiver

Extend both the pivot pin and take-down pin as shown. Then align the front tab of the upper receiver with the hole of the pivot pin, and push pivot pin through the upper receiver until it locks in place.



During installation, if you have to hammer the pin in place, make sure the holes in the upper/lower receivers are perfectly lined up first to avoid damage to the receiver.

Finally, before you close the upper receiver, check the stock tube cap spacing again, and adjust the shims as needed. The receivers should “lock” in place securely without excessive force.



3. Close Receiver and Test Fire

Finally, with the cylinder unit fully inserted into the upper receiver, close the upper receiver as shown, and press in the take-down pin. Make sure there is no BB in the barrel /chamber, and test fire the gun without inserting any magazine in both SEMI and FULL mode. Unlike traditional AEG, the Systema rifle can be “dry fired” without any risk of damage, even though dry firing can exert as much as 4 times the force onto certain components within the gearbox (as oppose to when a BB is loaded). This is a standard durability test we do to every PTW before it is shipped to our customers.



4. Adjust Hop-Up

The Challenge Kit allows precise control of the hop-up by using a set screw, accessible from the magazine well. The hop up is already factory-adjusted for 0.20g BBs, so unless you will be using different weight BB, no adjustment is necessary. Nonetheless, if you want to increase the hop-up effect (more back-spin, BB sails higher), turn the set screw counter-clockwise. For less hop-up effect, turn the set screw clockwise. Only turn the screw 1/4 turns each time and repeat as needed.



That's it! Congratulations on successfully conquering the Challenge! I hope you will enjoy your new, state-of-the-art Systema rifle as much as we enjoyed making it.



VIII. Specialty Tools

In this section we will introduce you to a few unique tools mentioned in this instruction. We believe this is helpful because every tool is carefully chosen after many years of experience, and we use them every day to assemble our products!

1. Pin Punch

The first picture is conventional pin punch. They are fairly common tools although not many people have a full set.



This is a more specialized set with tapered head, they are useful to limit the depth of travel, useful for items such as the take-down pin.

2. Hammer

We use 3 types of hammers, because it is very important to apply the appropriate force depends on the strength of the parts being worked on. The plastic and rubber head hammers not only reduce the chance of damage to the parts, it also transfer less energy hence allow us to better control the force used.



3. Teflon-Based Pliers

We use this very often because it does not scratch or scar the surface of the item being worked on. You can also remove one of the base when you need more grip on just one end. It may be lavish, but it is quite convenient if you can own two pairs.



4. Upper Receiver Clamp

This clamp was originally designed to hold real gun in place, but it is an excellent tool during barrel installations. You do not have to worry about applying too much force on the upper receiver or damaging it.



5. P.T.W. Wrench

This is a product we imported from a U.S. firearm manufacturer, Bushmaster. It was originally designed for real gun's barrel nut and stock tube nut, and we added a special cut and attachments so that it can also be used to work on cylinders. It is truly a multi-talented wrench!



6. Adhesive

Choosing adhesive is important. We meet with adhesive makers frequently to evaluate new products and help them improve their existing adhesives. After years of use, we've found these adhesives to be of superior quality:

Cyanon 722, Loctite 403 and Loctite 702.



7. Grease

This is one of the best-selling Systema product, and its quality is well-known. With these two you can cope with most situations.



IX. Final Words

1. Convenience and Organization

This is a topic that should have been mentioned in the very beginning, but was forced to be put at the end due to layout reasons.

In our company, you can easily tell who is an assembly expert by observing one's desk.

Foundation for assembly work, or any other work, is organization. That is, placing tools you use with right hand on the right side and vice versa.

Skilled workers call it "Convenience."

It is simple. If a right-handed person tries soldering with soldering iron cord coming from left, he will have to work under significant stress.

Another point is clearing desk. Unless you can organize your work in steps, you will not be able to put away any material you do not need for the current task. Naturally, there will be fewer mistakes if you are organized.

"Convenience" and "organization": there are more than techniques you can learn from an expert.

2. Maintenance

Now that you assembled the whole P.T.W., we should assume you know which parts need maintenance work, but we will review it as the last thing on the agenda.

- 1. Wipe off all greased parts, and replace all grease completely. Never just add grease.**
- 2. Clean barrel often. Chamber-packing of P.T.W. is fairly durable for its thicker-than-usual design, nevertheless be careful when cleaning the packing.**
- 3. P.T.W. is made with significant amount of steel parts in order to make the weight and balance equivalent to real gun. These steel parts, in most cases, are finished with Parker Rising process (phosphoric manganese finish). For those surfaces, apply anti-rust oil such as CRC-556.**
- 4. Apply commercial silicon spray solely to chamber about once every 300 shots. This will maintain the gun in good operating condition.**

3. Troubleshooting

Although it is a self-assemble kit, it is still our product and we always strive to support our product as much as possible. If you do not understand the instruction or if the assembled gun doesn't work no matter what you do, please contact us in the following order:

- 1. Your first line of defense will be the dealer from whom you purchase your Challenge Kit from. Almost all authorized Systema Challenge Kit dealer have in-house expertise to troubleshoot the product. This is one of the main reason to support your local airsoft dealers, where you will receive much better support and convenience. Most of the time if it is a simple oversight that they can point out quickly, they will not charge you a fee.**
- 2. Contact the Systema PTW Owner's Club (online community, will be available soon). As a Challenge Kit owner, you are encouraged to join the online club already, so why not take advantage of the expertise there. Perhaps you can find someone locally that can help you troubleshoot your problem. You may even run into our engineer on the forum!**
- 3. Contact SYSTEMA directly, either our Japanese Headquarter or regional distributors. Please note that due to the nature of a self-assembled kit, we cannot guarantee that the finished product will always function 100% because we have no control of the assembly process. However we are still more than happy to help, just keep in mind that depends on the level of involvement, engineering time and/or replacement parts will be subjected to fee.**