001-Component-build

Build the following Contraptor components before assembly:

http://www.contraptor.org/make-linear-rail-v2#assembly

http://www.contraptor.org/make-linear-bearings-v2#assembly

http://www.contraptor.org/make-sliding-elements#assembly

http://www.contraptor.org/make-belt-clamp#assembly

http://www.contraptor.org/make-shaft-mount#assembly
**002-Motor-preparation**

Install a pair of nylon screws (10-24 3/4") and add neoprene washer to each screw.

Install and tighten the pulley as shown.

Repeat for each motor.
003-Sliding-element-preparation

Slide sliding element onto a long angle piece and check/correct the fit using the friction adjustment screws. General guideline for belt drive is that sliding element should slide down easily when the rail is held vertically. This may not be always achievable without introducing some lateral play.
004-Sliding-element-preparation

Remove belt clamp retainer and attach the belt clamp angle to the sliding element, using 10-24 1/2" screw and a nut. The retainer can be reattached to the clamp angle or set aside.

If you plan on attaching anything to the sliding element on the angle facing walls, install mounting screws now as you will not be able to access the inside of the angle facing walls once the sliding element is installed on the angle rail.
005-Idler-pulley-assembly

Install a pair of shaft mounts on angle-2, using 10-24 3/8" screws.
Add R188 bearings to the shaft mounts and install 1/4-20 3" screw, leaving about 1/16" gap between the head of the screw and shaft mount. Tighten the steel nuts against the plastic nuts to fix them in place.
007-Idler-pulley-assembly

Add pulley but do not tighten, it will need to be removed later.
008-Motor-assembly

Assemble the motor end as shown, using angle-3, channel-2 and pair of angle-1s. Use 10-24 1/2" screws with channel-2 and 3/8" screws with angle-1s.
009-Motor-assembly

Attach the motor mount with 10-24 1/2" screws and install rubber grommets into the mounting holes of the motor mount.
Install the motor. The plastic screws should be turned with a flat screwdriver so that the grommets don't pop out.
011-X-axis-assembly

Put the sliding element on the angle and attach pair of angle-1 to angle-18 as shown.
012-X-axis-assembly

Attach angle-18 to motor assembly as shown, making sure the motor shaft is square with the angle-18.
013-X-axis-assembly

Attach idler pulley assembly to the angle-18 and tighten the nuts, making sure the idler screw/shaft is square with the angle-18.
014-X-axis-assembly

Remove belt retainer from the sliding element.
Remove the idler pulley, wrap the belt around the motor pulley and install the idler pulley (with the belt on) back on the idler screw.

Make sure the belt is tight. If not, remove the idler pulley; loosen the idler pulley assembly, move it farther apart from the motor end and re-tighten. Test the belt tension again until satisfactory. You may also need to move the motor end assembly.
Once tension is as desired, wrap the end of the idler screw in ~7/8" length of electrical tape. Standard 3/4" wide electrical tape wraps exactly one turn on 1/4-20 thread. This will reduce the eccentricity of the pulley.
Install idler pulley with the belt onto the idler screw. You may need to apply a bit of force, but try not to crumple the electrical tape.

Tighten the set screw on the idler pulley.
018-X-axis-assembly

Reinstall the belt retainer. Position sliding element as desired and clamp the belt with the belt pad and 6-32 3/8" screw.
019-Y-stage-alignment-fixture

Assemble the mirror pair of X beams as shown.
Connect the X beams using pair of angle-9s as shown. Ensure that the fixture is square and that distance between angle-9s is 19".

**020-Y-stage-alignment-fixture**
021-Y-stage-alignment

Turn the fixture over. Attach linear bearings to the alignment fixture using 3/4" screws and nuts, placing 1/4" long spacers in between. It is recommended to pad the spacers with a layer of washers on one of the linear bearings - this will bring the linear bearings a bit closer to each other.
Double check that the fixture is square. Attach linear bearings to the X axis using 3/8" screws, ensuring that X axis is parallel to the alignment fixture. Start with the motor end and attach screws one at a time.

Known issue: there isn't yet a reliable procedure for squaring X axis with Y rails. Need to investigate why, possibly due to twist/skew of X axis when installed on the rails.
023-Y-stage-alignment

Remove Y stage alignment fixture.
024-Y-stage-alignment

Install belt clamp on the linear bearing at the motor end.
025-Frame-rear-assembly

Assemble part of the rear frame as shown, using 3/8" screws.
026-Frame-rear-assembly

Assemble the rest of the rear frame. The distance between 2 vertical angle-2s should be 16".
027-Frame-rear-assembly

Attach the motor mount with 10-24 1/2" screws and install rubber grommets into the mounting holes of the motor mount.
Install the motor. The plastic screws should be turned with a flat screwdriver so that the grommets don't pop out.
029-Frame-front-assembly

Attach a pair of angle-1s to angle-18 as shown.
Install a pair of shaft mounts on angle-18, using 10-24 3/8" screws.
031-Frame-front-assembly

Add R188 bearings to the shaft mounts and install 1/4-20 3" screw, leaving about 1/16" gap between the head of the screw and shaft mount. Tighten the steel nuts against the plastic nuts to fix them in place.
032-Frame-front-assembly

Add pulley but do not tighten, it will need to be removed later.
033-Frame-assembly

Attach linear rails to the rear of the frame as shown. Slide the rail out of the way to insert and tighten the screws.
Slightly push the open end of the rails towards each other and slide X axis onto the rails. Both motors should be on the same side of the frame.
035-Frame-assembly

Move X axis all the way back and ensure that the fit is not too tight. If the fit is too tight, the X axis will tend to spring back forward from the end of the Y axis.

If the fit is too tight, remove X axis; unscrew both angle-2s to which the rightmost rail is attached and move the rail with attached angle-2s inwards about ~1/32”. Use the edge of the vertical angle-2 as a guide against the edge of the frame rear. Tighten the angle-2s and test the fit again.
036-Frame-assembly

Attach front of the frame to the linear rails and finger tighten. Ensure that the distance between the front end of the rails is the same as between the rear end of the rails (16") and tighten.
037-Frame-assembly

Verify whether X axis has slack and how much. Grab rails with your hands and try to skew the X axis by pushing/pulling linear bearings in the opposite directions.

If you see wheels losing contact with the rails, this is definitely too much slack, and the rails need to be farther apart.

Depending on the application for the plotter, various amount of X axis skewing movement may be acceptable, for example for pen plotter it may be OK to have +/- 1/8" in either direction.

Adding second belt to the opposite linear bearing can help address issues with skewing X axis.
038-Frame-assembly

Remove the belt retainer from the linear bearing.

Remove the idler pulley, wrap the belt around the motor pulley and install the idler pulley (with the belt on) back on the idler screw.

Make sure the belt is tight. If not, remove the idler pulley; loosen the frame front assembly and move it farther apart from the frame rear. Re-tighten and test the belt tension again, until satisfactory.
Once tension is as desired, wrap the end of the idler screw in ~7/8" length of electrical tape. Standard 3/4" wide electrical tape wraps exactly one turn on 1/4-20 thread. This will reduce the eccentricity of the pulley.
040-Frame-assembly

Install idler pulley with the belt onto the idler screw. You may need to apply a bit of force, but try not to crumple the electrical tape.

Tighten the set screw on the idler pulley.
Install belt retainer and clamp the belt with the belt pad and 6-32 3/8" screw.
042-Frame-assembly

Attach a pair of angle-4s to the Y axis angles as shown.
043-Base-assembly

Attach a pair of angle-1s to the angle-12 as shown.
044-Base-assembly

On a flat surface, attach a pair of angle-6s as shown.
045-Base-assembly

On a flat surface, attach four angle-6s as shown.
Flip the base assembly over and attach four angle-3s as shown.
047-Plotter-assembly

Place a flat piece of material (such as plywood or plastic) about 12" wide and at least 10" long on top of the base. In this picture, a 12x12 piece of acrylic is used.
048-Plotter-assembly

Place the plotter frame on top of the flat piece so that the front of the frame is aligned with the front of the base.

The front edge of the material should slightly stick out from under the plotter frame.
049-Plotter-assemble

Attach the base to the frame, with flat piece in between, using four 1.5" or 2" screws, and finger tighten.