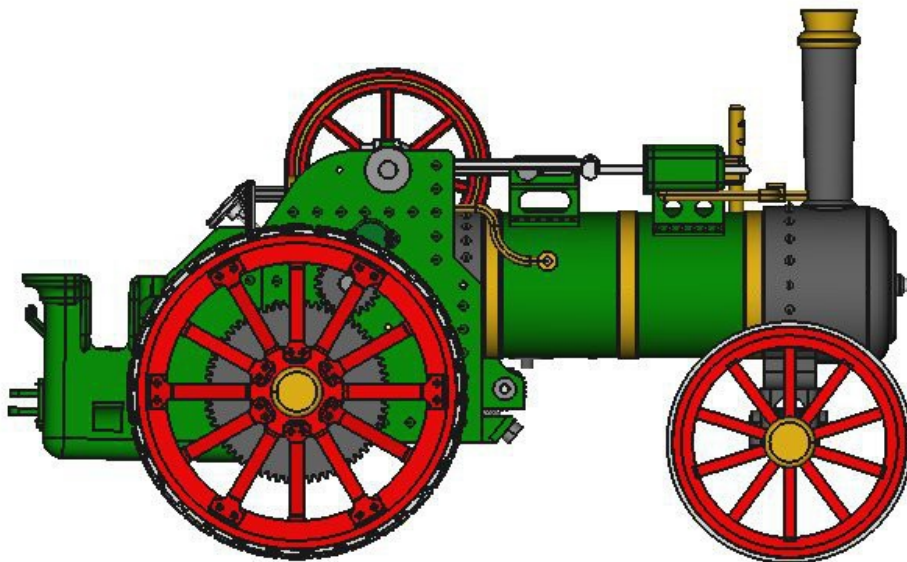
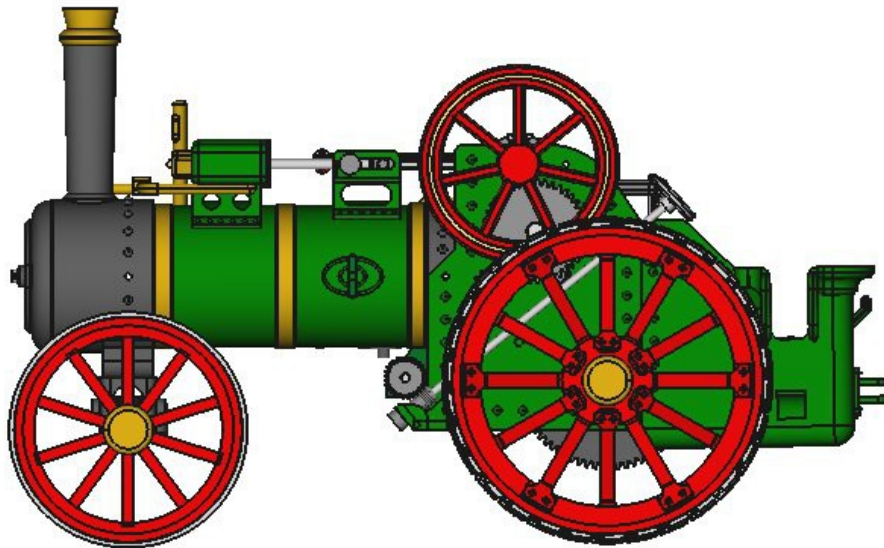


**3D Printed  
Radio Controlled, Working  
Traction Engine**

By Ron Provis



**Assembly Guide**

# PREAMBLE

This model is based on pictures of real size machines but does not represent any particular example. It is approximately 320mm long, 142mm wide, 200mm high at the top of the chimney. I have tried to include a reasonable amount of detail without making thing to complicated. Having said that, it is not a project for the absolute beginner. The size of each component has been limited to accommodate most 3D printers.

Everything has been designed to fit together without the need for too much cleaning up of the parts after printing, this will of course also depend on how well your printer is set up. I did not need support material to print any of the parts, but the rear flange was a close call.

You do not need to fit a motor or a radio control system if you just want a nice looking model, and in theory this could be fitted at a later date, but some disassembly will be needed to do this. There is a bit of hardware required to complete the model, this includes some steel rods, bearings and rather a lot of very small self tapping screws, these can be obtained online or from your local hardware store or model shop.

## TOOLS REQUIRED:

Small cross head screwdriver.

A hacksaw to cut the steel rod to length.

A set of small files will be useful.

Sharp modelling knife. (Always handy)

You will also need some fine sand paper to clean up any rough edges, I found the wet or dry stuff works best (use it dry).

I used good quality PLA in 5 different colours, it is well worth paying a little bit extra for your filament. The completed model will not win any races, but it does have a lot of pulling power for its size. Some added weight inside the boiler part can be added to help with steering as the front wheels may not have enough grip on some surfaces. An optional set of rubber tyres can also be printed if you have a printer that can use rubber filament.

Printing all of the parts will keep your printer busy for a day or three, this will give you time to assemble some parts while the next lot is printing. Choose your own colours and group the printer files into folders for each colour before you start printing, then place each file into a done folder when it has been printed. This method will help to keep things organized.

If you intend to install a radio control system, then you may want to obtain some additional parts before starting the assembly. You will need a small speed controller for a brushed type motor, one micro servo, and a 2 channel transmitter, receiver and batteries.

The drive is provided by a commonly used motor and gearbox combination that is used in most Arduino robot projects, these are inexpensive and can be sourced online from Amazon or eBay. The little speed controller can also be found there, only use the type without a brake function.

There are two different lengths of M2 self tapping screws used in the construction, 6.5mm and 9.5mm, again these are very inexpensive if you buy them in packs of 100.

Full details of all the hardware required is listed at the end of this document.

For the parts that need to be glued, I recommend that you use a two part clear epoxy glue, never use super glue type adhesives as they will leave a white mark around the bond.

Throughout this guide a long screw refers to the M2 x 9.5mm screw, and a short screw refers to the M2 x 6.5mm screw.

# Assembly

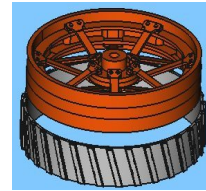
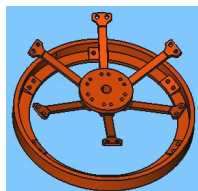
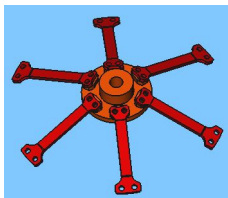
The model is built by constructing four sections (modules) that will finally be screwed together. Some additional parts will be fitted in place after the four sections are screwed together.

## THE REAR SECTION:

A good place to start is with the rear wheels. It looks complicated but they go together quite easily.

Fix 6 spokes to each hub half section using short screws, the smaller end of the spokes fits onto the hub.

Then place one of these assemblies into one of the outside rims aligning the screw holes. Use long screws to fix these parts to a centre rim part that has lugs for the screws.



Now place the other side rim on the other side aligning its screw holes with the centre rim and feed the spokes on the other hub assembly between the first set of spokes from the opposite side, you will need to move this around a bit to get all of the spokes to go through. Now fix this part in place with long screws.

You will notice that the two halves of the hub are not fixed together, but they should be perfectly aligned and held in place by the spokes.

The outer rim with the angled tread is pressed onto the wheel after all of the screws have been fitted.

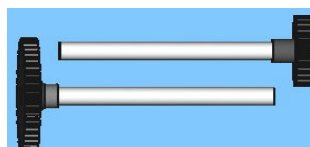
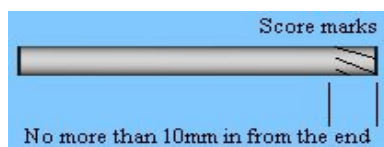
You may need to sand off any high spots to get this part to fit. It is designed to be very snug and should not need any glue to hold it in place. There is a left and right version of this part.

These outer rims can be replaced by the optional rubber tyres if you can print with rubber filament.

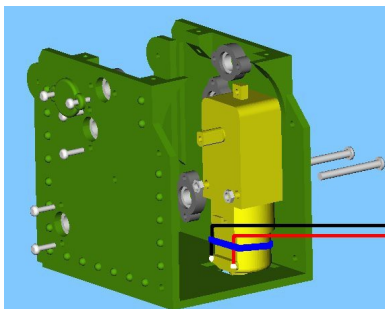
The main frame supports the motor module, bearings, drive shafts and gears, this includes a manual clutch system that allows the drive to the wheels to be disengaged.

Start by cutting two 66mm lengths of 6mm steel rod to length to form the clutch input and output shafts, and one 138mm length to form the rear axle.

Each of the short lengths of rod is going to have a printed gear glued on one end, so while you have your hacksaw handy it is a good idea to make some light diagonal score marks at one end of these two shafts so that the gear will stick firmly in place. Slightly round off the ends of all three rods using a file to help when fitting the gears and wheels. Clean the shafts to remove any grease and filings.



Now glue the clutch input gear onto the scored end of one shaft and the clutch output gear onto the scored end of the other shaft, both gears should have the flange facing inwards and the outside edge of the gears must be flush with the end of the shaft. Clean off any excess glue from the shafts and put all three shafts to one side for now. (The longer shaft will be used later for the rear axle).



Remove this connector and solder wires onto the motor. Or use a JST connector on the the motor.

Fit six MR106ZZ bearings into the 6 printed internal bearing blocks. Use long screws to fix them into the frame, trapping the bearings inside as shown below. Note that the top right hand bearing also has a hole cover on the outside that is fitted at the same time.

Remove the little plastic strap that holds the motor into the gear box drive unit, this will not be needed. Solder a JST connector onto the motor terminals or, alternatively you can remove the motor connector on the speed controller and solder the two wires directly onto the motor terminals. Be careful with this as the motor terminals are not very strong. The red wire must be to the right. Secure the wires with a small cable tie as shown above.

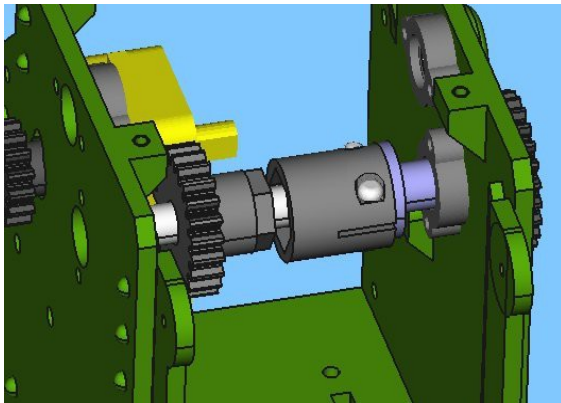
Fix the motor unit in place with two 3mm nuts and bolts, these need to be at least 24mm long. There is a bump on one side of the gearbox that should locate in a recess on the side of the frame. The switch on the speed controller can now be fixed in the bottom of the frame with two short screws. Use some double sided sticky tape to hold the speed controller in the bottom of the frame, just behind the motor unit.

Before assembling any gears into the frame, put two long screws into the dog socket part and the fixed gear part, rotate the screws back and forth as you screw them in to tap a thread into the plastic. Do not tighten them all the way just yet.

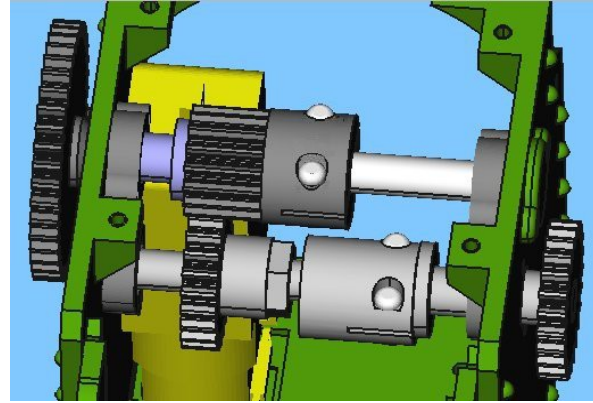
Slide the shaft you made earlier with the smaller clutch output gear into the middle right bearing and fit the output gear spacer, dog socket, and dog gear onto the shaft before locating the end of the shaft in the opposite bearing.

Now tighten the screws to clamp the dog socket onto the shaft. The shaft should not have any sideways movement but still turn freely in the bearings. The dog gear must be free to slide from side to side on the shaft and lock into the dog socket. This arrangement is known as a dog clutch.

OUTPUT SHAFT



INPUT AND OUTPUT SHAFTS



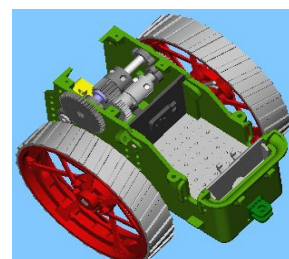
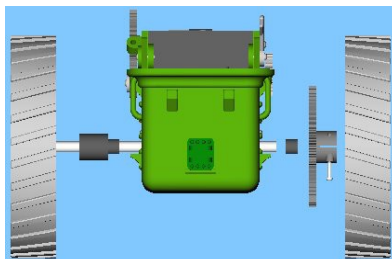
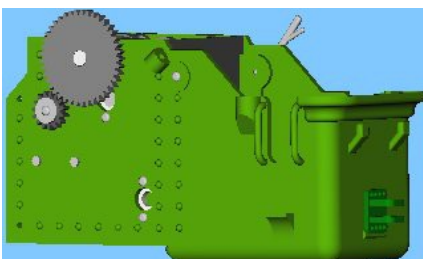
Now fit the clutch input shaft you made earlier with the larger gear into the upper bearing on the opposite side, sliding the input gear spacer and fixed gear onto the shaft. Tighten the screws to hold the gear and shaft in place without side play. Make sure everything turns freely and that the dog gear can still slide from side to side.

The motor output gear can now be pressed onto the gearbox shaft that exits the left side of the frame, it should be a snug fit, use the printed washer and a short screw to hold it in place. You do not need to fit this gear until later if you want to test the movement of all the parts by hand.

#### WARNING:

The gears are quite powerful when driven by the motor, so be careful not to trap your fingers.

Attach the rear cabin to the main frame using two short screws in the base and two long screws at the top. The top screws are also used to attach the top steering rod support and the brake lever. Slide the firewall into the grooves at the back of the main frame, do not glue this, the battery wires from the speed controller should run through the slot at the bottom of the firewall. Now glue the rear flange and trailer hitch onto the cabin.





Press the rear axle into one of the rear wheels, this is going to be the LEFT wheel, this DOES matter if you care which direction the tread on the wheels is going to face. It should be quite a tight fit, if it is not, then use a bit of glue to fix it in place. The axle should be flush with the outside of the hub.

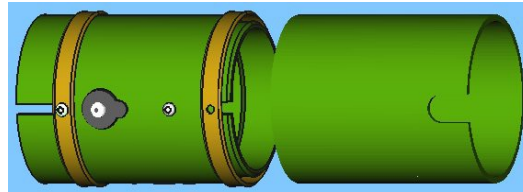
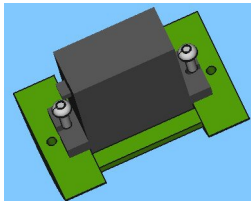
Now slide the left axle spacer onto the shaft with the thicker end against the wheel and slide the axle through the bearings at the bottom of the frame. Fit two long screws into the large wheel gear flange, rotate the screws back and forth as you screw them in, do not fully tighten them yet.

Now push the small right axle spacer followed by the large wheel gear with the flange facing outwards onto the axle. Tighten the screws to fix the axle in place with little or no side play. The gear should have engaged with the clutch output gear. Now press the other wheel onto the axle, You may need to hold something against the other end of the axle when doing this. Again use some glue if it is not a tight fit.

The battery pack should not be more than 8.4 volts and no less than 4.8 volts, I used a 4.8 volt rechargeable battery pack. This is fitted in the bottom of the cabin unit under the footplate. For now just place the removable footplate into the cabin unit. This completes the rear section.

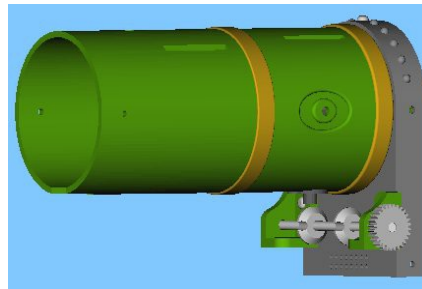
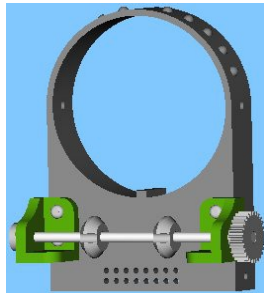
#### THE BOILER SECTION:

Before gluing the two sections of the boiler together, fit the servo tray and servo for the steering into the rear boiler section. Use two short screws to hold the servo onto the tray and another two short screws to hold the tray inside the boiler, one of the outer boiler bands must be fitted at the same time as it is also held in place by one of the servo tray screws.



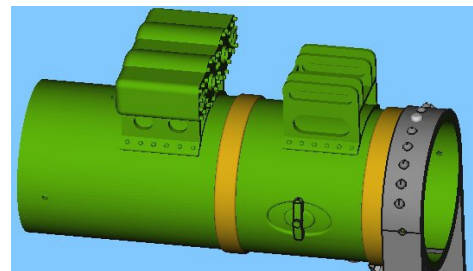
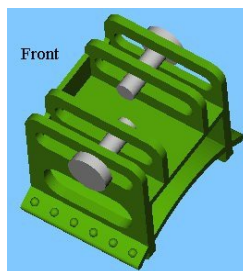
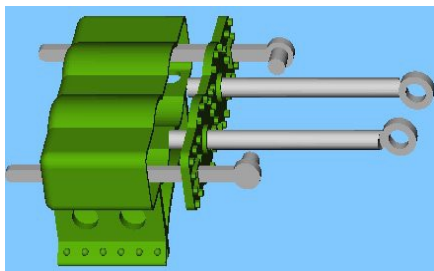
Use another boiler band to hide the joint when gluing the two boiler parts together. Secure this band with glue making sure the hole in the band is at the bottom.

Cut two lengths of 3mm steel rod, one 72mm long and one 128mm long and round of the ends with a file. Put the longer rod to one side for now. Fit the left and right chain rod brackets with four short screws onto the firebox front. Insert the short length of rod into the brackets while pushing two chain grippers onto the rod. Now push the chain rod gear and a rod retainer onto the ends of the rod as shown.



Insert the boiler into this assembly, this should be a snug fit. Secure with one short screw at the top only, the side screws will be fitted later.

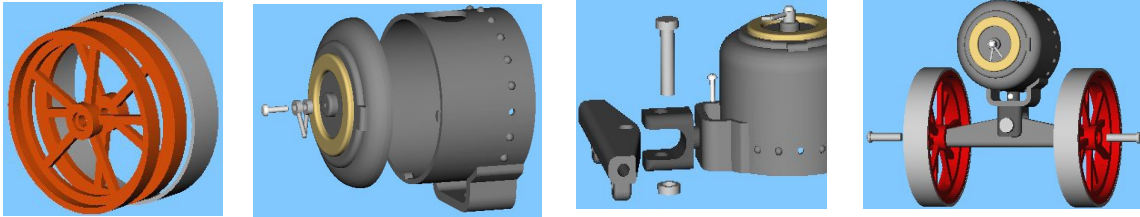
Before gluing the cylinder head plate onto the cylinder block, make sure the piston and valve rods will slide freely in the holes and slots. Clean up the parts as necessary. The linkage pins must also slide in the slots of the linkage bracket without binding.



Glue both units into the top of the boiler as shown, note that the closed end of the linkage frame must face the front. Glue the small inspection hatch clamp onto side of the boiler to complete this section.

### FRONT SECTION:

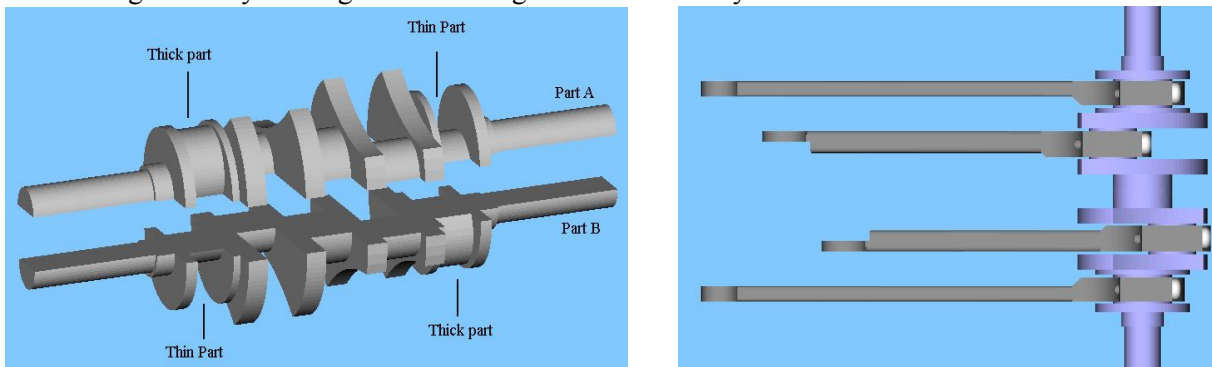
Each of the front wheels has 3 parts, 2 identical halves placed back to back and an outer rim which holds the two halves together, one half should be rotated so that the spokes are interleaved with equal spacing. The outer rims also have an optional rubber tyre replacement. No glue should be needed. Glue the front of the smoke box and name ring in place and let the glue set hard. Now fit the two small handles using a short screw.



Use a short screw to hold the steering post in the bracket at the bottom of the smoke box. The axle beam is located using a printed pivot bolt and pivot bolt retainer. Two M5 x 20mm pan head bolts are used to fit the wheels onto the axle beam, these should be tightened just enough to let the wheels turn freely. This completes this section. The chimney stack will be glued in place later so that it can be properly aligned.

### THE FRAME TOP SECTION:

Note the two halves of the crankshaft are not the same and must be glued together the correct way around, this is very important! The two halves must also be perfectly aligned. Sand the flat surfaces before you do any gluing and try fitting a bearing on each end to hold the two halves together, the bearings need to be a push fit, not too tight and not sloppy. You can use these bearings to help align the two halves when you glue the halves together. Try not to glue the bearing onto the shaft as you will need to remove them later.

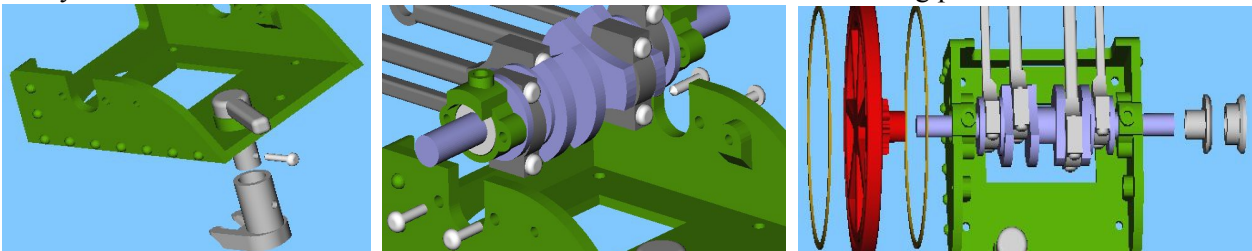


After the glue has set, the crankshaft will need a bit of careful cleaning up along the seam to help the crank and cam rods move freely when fitted. I used a sharp modelling knife to do this. Before fitting the rods onto the crankshaft, screw the end caps onto each of them using long screws, roll up a small length of sandpaper and rotate this inside the big ends, remove the screws and fit the rods onto the crankshaft as shown. Make sure they all move freely, it will not matter if they are a bit loose. The thicker part of the rods must face towards the centre of the crankshaft.

Fit the clutch lever into the frame top section, then push the clutch fork onto the shaft and secure with a short screw. The lever should rotate freely.

Assemble the crankshaft bearing blocks and bearings as shown, and use four long screws to fix the crankshaft into the frame top. If these screws are too tight the crankshaft may not turn freely.

The flywheel has a circular indent on each side that can be filled with a thin ring printed in a different colour.

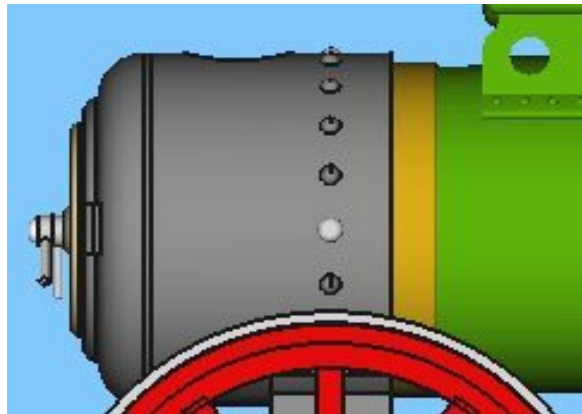
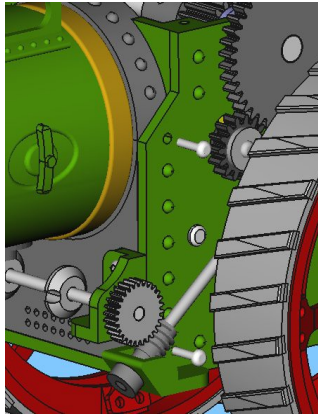


You will probably need to take some sandpaper to these rings to get them to fit into place. The flywheel is designed to be a press fit onto the end of the crankshaft, if it is not tight enough to turn the crankshaft, then just add a dab of glue on the end of the crankshaft to fix it in place. The two parts of the PTO pulley that fit on the other end of the crankshaft should also be a press fit. This completes the fourth section.

### JOINING THE SECTIONS TOGETHER:

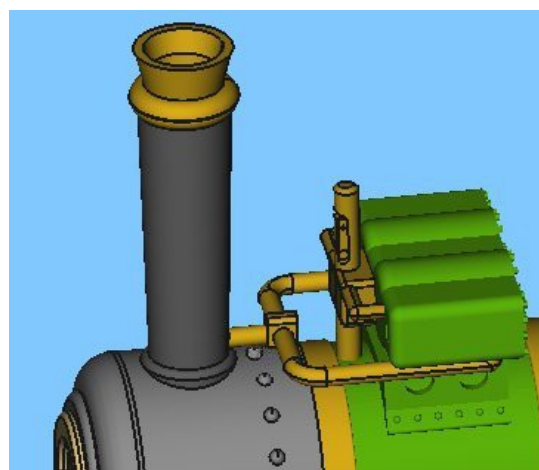
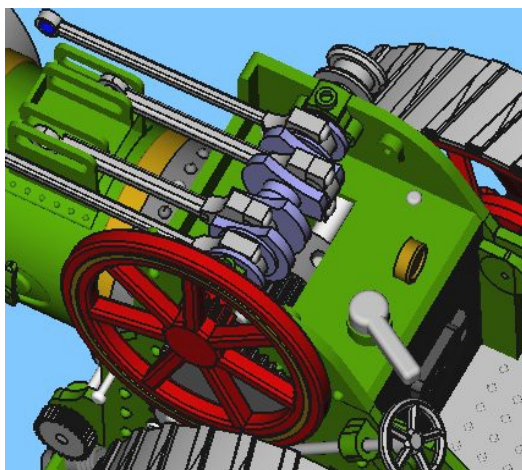
Before joining the first two sections together you will need to insert the speed controller and the servo connectors into the receiver unit. The receiver must be inserted into the boiler from the end where the servo is fitted and located in the front of the boiler. You may need to temporarily remove the servo to do this. The little receiver I used did manage to slip over the top of the servo without removing it. Some double sided sticky tape will hold the receiver in place with the antenna wire at the front.

Use four long screws to join the boiler section and the rear section together, note that the worm gear support is fitted at the same time with one of the screws as shown. Now press the worm gear onto the long 3mm rod that you made earlier, the extended flange of the worm gear facing the end of the rod. You will need about 4mm of rod extending beyond the worm gear. Insert the rod into the top steering rod support and then into the worm gear support. Now press a rod retainer onto the bottom of the rod and the steering wheel onto the top.



Push the final boiler band onto the front of the boiler and attach the front section using two short screws. Now use a dab or two of glue on the boiler only to fix the boiler band in place resting against the front section, be careful not to get any glue on the front section as you may need to remove this later. Make sure the hole in the boiler band is at the bottom.

Fit the frame top section using four short screws, make sure the clutch fork slides over the dog gear.



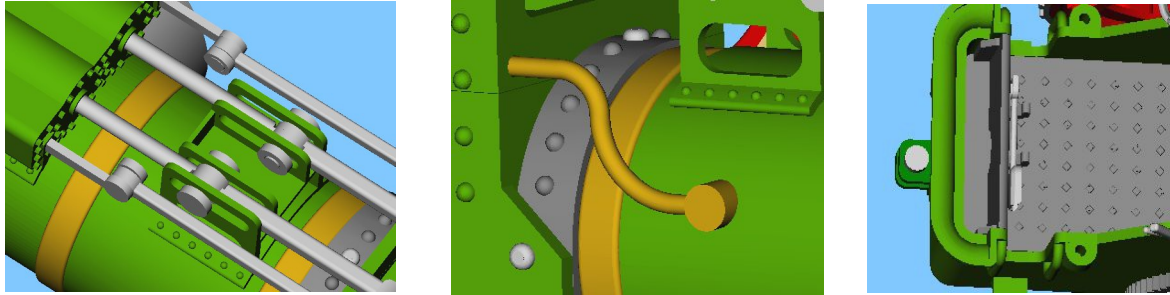
The drive to the wheels should only be engaged when the lever is moved to the left. The pressure gauge is glued into the hole on the top frame.

Glue the chimney stack and chimney top onto the front smoke box section making sure the hole near the bottom of the chimney is facing to the rear, check the vertical alignment before the glue sets.

The outlet pipes must only be glued under the cylinder block with the pipe at the front just sliding into the chimney stack. The whistle block is glued to the front of the cylinder block with the lower pipe located in the indent on the boiler.



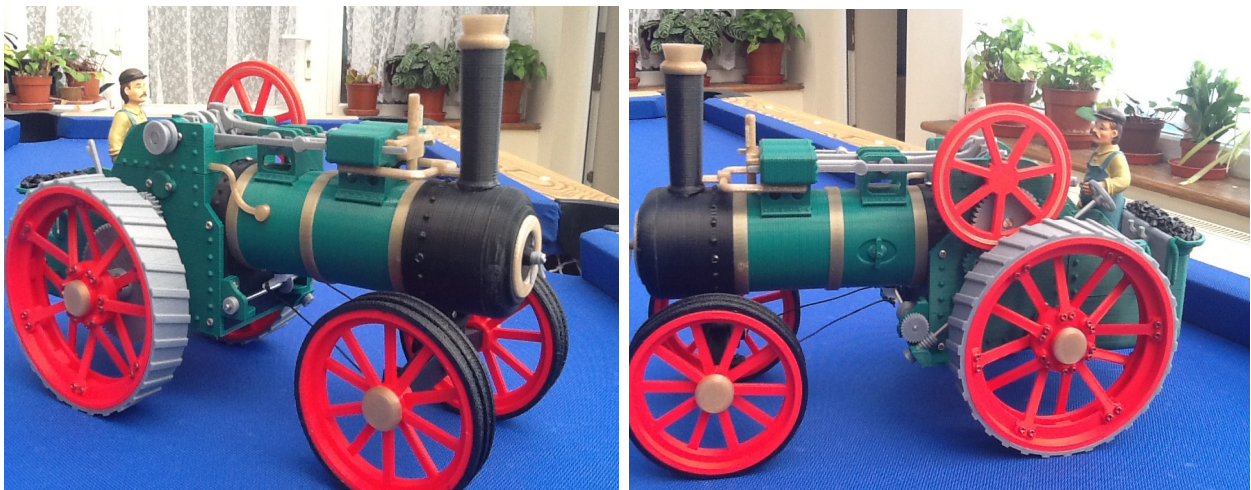
Slide the valve and piston rods into the cylinder block, connect the piston rods with the crank rods using the pivot pins that are pushed through the linkage frame. The flat valve control rods have their own pin that connects to the cam rods. Secure them with the small retainer rings. The retainers should be a push fit, use a dab of glue on the outside of the retainer if it is not tight enough.



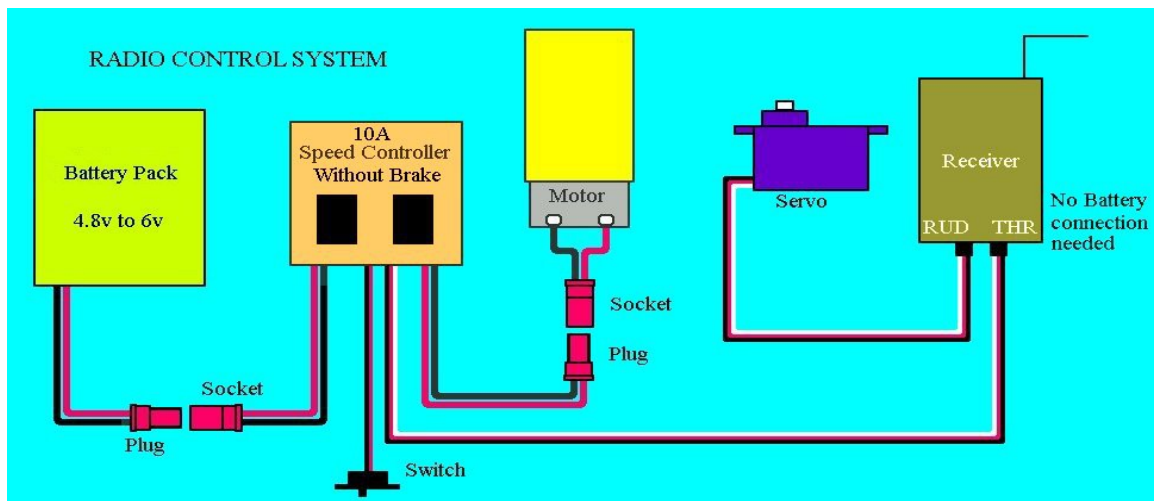
The pressure pipe should be glued to the boiler but not glued at the other end which fits into a hole on the fire box front, this allows the two sections to be separated. The four hub caps just press onto the wheel hubs. There is also a coal shovel that fits in the cabin section and a pin for the trailer hitch. You will need some small chain or fine cord to connect a two way servo arm to the front axle beam. Or use the steering chain rod if you have not installed radio control.

Connect a battery with a JST connector and you are ready to go!

Two pictures of the actual model. I have added a driver figure and some imitation coal. The rubber tyres have only been fitted on the front wheels. Note that Fred only uses Nutty Slack in his fire box!




















If you make one of these, please upload some pictures to Thingiverse. I would love to see some different colour schemes.









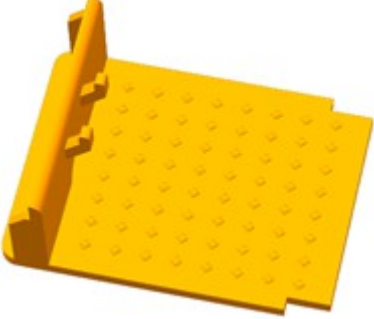
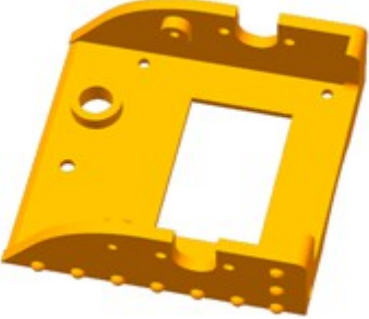

### PRINTED PARTS LIST




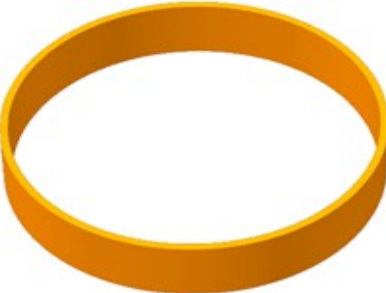





PART NAME	QUANT		COMMENT
Axle Pivot Retainer	1		
Axle Pivot Pin	1		
Boiler Band	3		
Boiler Part A	1		
Boiler Part B	1		
Bracket Left	1		
Bracket Right	1		
Brake Lever	1		




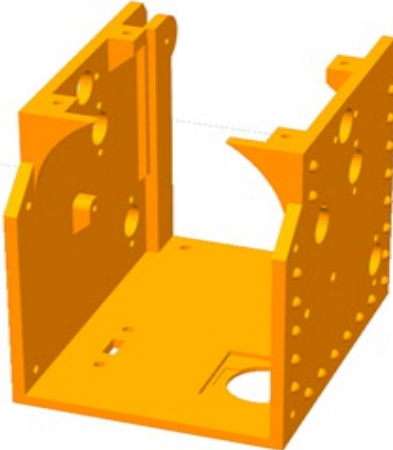








Cabin	1		
Cam Rod Cap	2		
Cam Rod	2		
Chain Gripper	2		
Chimney Stack	1		
Chimney Top	1		
Clutch Fork	1		
Clutch Input Gear	1		
Clutch Lever	1		

Clutch Output Gear	1		
Coal Shovel	1		
Crank Rod Cap	2		
Crank Rod	2		
Crankshaft Bearing Block	2		
Crankshaft Part A	1		
Crankshaft Part B	1		
Cylinder Block	1		
Cylinder Head Plate	1		
Dog Gear	1		
Dog Socket	1		
Firebox Front	1		






















Firewall	1		
Fixed Gear	1		
Flywheel Ring	2		
Flywheel	1		
Footplate	1		
Frame Top	1		
Front Axle Beam	1		









Front Name Plate	1		
Front Tyre Option	0 or 2		Optional front rubber tyre to replace normal rim.
Front Wheel Half	4		
Front Wheel Rim	2		Normal front wheel rim.
Hitch Pin	1		
Hub Cap	4		Fits any of the wheels.
Input Gear Spacer	1		Do not confuse this with the output gear spacer.
Inspection Hatch Clamp	1		
Internal Bearing Block	6		

Left Axle Spacer	1		
Link Pin Retainer	2		Fits on the piston rod link pins.
Linkage Bracket	1		
Main Frame	1		
Motor Gear Washer	1		
Motor Gear	1		
Outlet Pipes	1		
Output Gear Spacer	1		This is a bit bigger than the input gear spacer.
Piston Rod Link Pin	2		
Piston Rod	2		
Pressure Pipe	1		
PTO Pulley Inner Part	1		



PTO Pulley Outer Part	1		
Rear Flange	1		May need support material on some printers.
Rear Tyre Option	0 or 2		To replace the rear rims that have angled tread.
Rear Wheel Hub Half	4		
Rear Wheel Rim Centre	2		
Rear Wheel Side Rim	4		

Rear Wheel Spoke	24		
Right Axle Spacer	1		
Rod Retainer	2		
Servo Tray	1		
Shaft Hole Cover	1		
Smoke Box Front	1		It is actually round.
Smoke Box Handel	2		
Smoke Box	1		This is also round.
Steering Gear	1		
Steering Post	1		
Steering Wheel	1		
Top Steering Rod Support	1		
Trailer Hitch	1		

Tread Rim Left	1		
Tread Rim Right	1		
Valve Control Rod	2		
Valve Rod Retainer	2		
Wheel Gear	1		
Whistle Block	1		
Worm Gear Support	1		
Worm Gear	1		



## HARDWARE LIST

PART NAME	QUANT	COMMENT
6mm Steel Rod	270mm	Minimum Total Length.
3mm Steel Rod	200mm	Minimum Total Length.
MR106ZZ Miniature Bearings	8	Buy a pack of 10.
M2 x 9.5mm Self Tapping Screws	Lots	Buy a pack of 100.
M2 x 6.5mm Self Tapping Screws	Lots	Buy a pack of 100.
Motor/Gearbox Combo	1	Search online for ( Arduino Robot Motor ).
10A Brushed Motor Speed Controller	1	Buy the type without a brake function.
Miniature Model Chain, 4mm link	250mm	Usually sold by the meter, or use some fine cord.
M5 x 20mm Pan Head Bolt	2	To hold front wheels on.
Radio Control System	1	2 Channel Min with one micro servo.

*Images in parts list by Geoff Walker*