hy-gain

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Hy-gain Rotator Service Manual

For HAM-IV and T2X Series Rotators

Rotator Troubleshooting & Tips

INTRODUCTION

This document outlines some very important troubleshooting information and tips about Hy-gain HAM-IV and T2X antenna rotators. In here, you will find out how to checkout your Hy-gain rotator, testing techniques, how to disassemble and re-assemble the rotator along with other important pieces bits of information.

Checking the Control Unit

To check the control unit, plug the AC line cord into a 115-volt AC power wall outlet. Without the rotator connected to the rear of the control unit turn the POWER switch to the ON position, the meter light will illuminate. If the meter light does not light, then with the bulb, power switch, main power main fuse, or a combination of these may be defective. The meter needle will remain on the far left hand "S".

To check the power circuit, connect an AC voltmeter between terminals No. 1 and No. 2 on the rear panel and see that approximately 30 volts is indicated when the BRAKE release lever is depressed. If the voltage is present, then you can move on to another test. If the voltage is not present, then this is an indication of a failure in the Main Power circuitry. You can narrow your search down to the main power input circuit, the brake switch or main power transformer, or any of the associated wiring.

Connect an AC voltmeter between terminals No. 1 and No. 5 and you should read approximately 30 volts with the BRAKE release lever and CW lever depressed. If the voltage is present, then you can move on to another test. If the voltage is not present, then this is an indication of a failure in the clockwise rotation circuit for the rotator. You can narrow your search down to the clockwise rotation switch, brake switch and associated wiring.

Connect an AC voltmeter between terminals No. 1 and No. 6 and you should read approximately 30 volts with the BRAKE release lever and CCW lever depressed. If the voltage is present, then you can move on to another test. If the voltage is not present, then this is an indication of a failure in the counter-clockwise rotation circuit for the rotator. You can narrow your search down to the counter-clockwise rotation switch, brake switch and associated wiring.

Check the meter to make sure that it is operating properly while turning the rotator. The needle should move slowly and smooth across the meter scale while the rotator is turning. Any erratic movement of the needle is an indication of a problem and must be checked. There are a few tips for troubleshooting this type of problem in the **TROUBLESHOOTING TIPS** section on PAGE 4.

Checking the Rotator

On the older rotators with the 8-lug terminal strips on both the rotator and control unit, connect the eight terminals of the rotator to the corresponding eight terminals on the control unit using the cable obtained for installing the rotator. Connect terminal No. 1 on the rotator to terminal No. 1 on the control unit and so on. The two (2) heavier wires in the cable should be used for terminals No. 1 and No. 2 (refer to the schematic). **CAUTION---SHORTS BETWEEN THE TERMINALS OR GROUNDED LEADS MAY BURN UP THE POT STRIP IN THE ROTATOR.**

With the rotor in an upright position without the lower mast support assembled, operate the rotator by means of the control unit CW and CCW and BRAKE levers in both directions. The operation of the BRAKE lever of the control unit releases the brake mechanism inside the rotator. This is audible to the operator.

Checking the Rotator from the Ground

One may possibly avoid bringing the rotator down from the mast by making electrical checks from the position of the control box. On the older rotator systems this is done by disconnecting the eight wires from the screw terminals and tagging each wire carefully No. 1 through No. 8 to correspond with the terminal numbers from which they each removed. From the schematic diagram, it is apparent that the resistance of the cable wires will be added to the resistance of the motor windings and the potentiometer strip in making the resistance checks.

Lead wires No. 1 and No. 2 of No. 18 AWG wire have approximately 0.64 ohms resistance per 100 feet and lead wires No. 3 through No. 8 of No. 22 AWG will have approximately 1.6 ohms of resistance per 100 feet. Use a low resistance ohmmeter to check the values shown in the Table 1 to an accuracy of 10 percent after adding the resistance of the lead wires involved.

To Check	Read Resistance	Between Terminals
Brake Solenoid	.75 Ohms + leads	1-2
½ Motor Winding	2.5 Ohms + leads	1-8
½ Motor Winding	2.5 ohms + leads	1-4
½ Motor Winding + Switch	2.5 ohms + leads	1-5
½ Motor Winding + Switch	2.5 ohms + leads	1-6
Entire Motor	5.0 Ohms + leads	4-8
Right Limit Switch	0 Ohms + leads	5-8
Left Limit Switch	0 Ohms + leads	4-6
Entire Pot Strip	500 Ohms +/- 50 Ohms	3-7
Pot Arm to + End	0-500 Ohms	
Pot Arm to – End	0-500 Ohms	

Table 1

Servicing the Control Unit

Disconnect the AC line cord of the control unit from the AC power source and remove the 8-wire control cable. Be sure to ***tag each wire*** with the corresponding terminal number that it was removed. This applies to older models only.

The control unit can be checked without removing the cover by using a volt-ohmmeter to check the values across the terminals on the rear of the unit. Set the volt-ohmmeter to measure resistance (ohms). The resistance reading across terminals No. 1-2 should be .75 ohms. Read the same values across terminals No. 1-5 with the clockwise lever (right-hand) depressed and across terminals No. 1-6 with the counter-clockwise (left-hand) lever depressed. The resistance reading across the input AC line cord with the ON-OFF switch in the "ON" position and the BRAKE lever depressed should be about 3.8 ohms.

Set the volt-ohmmeter to measure 30 volts AC. With the AC line cord connected to the AC power source and the ON-OFF switch in the "ON" position and the BRAKE release lever depressed, read approximately 30VAC across terminals No. 1-2. Set the volt-ohmmeter to measure 13 volts DC. With the rotator in the full CW limit stop and the ON-OFF switch in the "ON" position read 13 +/- 10% across terminals No. 3-7.

The electrolytic motor starting capacitor must be of proper value to give adequate motor torque. If a new capacitor is not available for check by substitution, the user can make a quite reliable check by using the power transformer in the control unit and an auxiliary 1 ohm 10 watt resistor.

To make this capacitor check, remove the cable from the terminals and tie terminal No. 2 to No. 4. Connect one end of the resistor to terminal No. 1 and the other end to terminal No. 8. Turn the "ON-OFF" switch to the "ON" position and depress the BRAKE release lever. If the capacitor is okay, it will draw sufficient current to cause a voltage drop of 1.4 to 1.6 volts to be present across the resistor. Measure with an AC voltmeter.

Disassembly of the Rotator

1. Remove the rotator from inside the tower, if tower mounted. If mast mounted, remove the rotator from the mast, then remove the bottom mast support from the bottom of the rotator.

2. Support the bottom of the rotator using a couple of 2x4 pieces of wood under each side. This will prevent the ball bearings on the lower race from falling out of the rotator. The rotator should be sitting right side up. A towel or tray is useful for catching any loose ball bearings if they happen to fall.

3. Remove the four screws that secure the upper and lower castings together and carefully raise the top casting to expose the potentiometer and drive mechanism.

4. Carefully remove the upper ball bearing retaining ring. Keep it circular, and lay it down on a clean surface to prevent from losing the ball bearings and to keep them clean.

5. Inspect the inside of the top housing for small scratches or burned spots on the ribs. These are an indication that a limit switchblade or connection is rubbing during rotation. See that the pot strip is clean and not burned at either end. See that the pot body is secure and that the pot arm or wiper is clean at the point of contact with the pot strip. Use only fine rouge cloth to polish the contact arm or the potentiometer strip. Check the limit switch to see if the wires are secure and the insulation is undamaged. Contacts should be clean. Check for 1/32" clearance between the switchblades and the motor—particularly alongside of the lock washer under the motor fastening. Greater clearance gets the blades too close to the top bell housing ribs.

6. If the drive ring gear happens to be near the end of rotation, operate the top spur gear to rotate the mechanical stop on the drive ring gear away from the area of the limit switch. See that the mechanical stop arm (that is positioned between the two limit switches) will soon open each electrical contact before it hits the corresponding mechanical stop. Also, see that the stop arm is not deformed and that the electrical contacts are clean and not corroded or tarnished.

7. Rotate the top spur gear several revolutions to determine that the motor and its bearings are operating normally. Look for broken teeth in any of the gears in the gear train and the motor pinion gear. The gear should be firm and must not turn freely. If the gear turns freely, then the motor brake pads need replacing.

8. Lift the motor and brake mechanism out of the brake housing. Carefully remove the lower ball bearing retainer ring and place it on a clean surface. If the rotator is a T2X, also remove the 3rd set of bearings from the very bottom of the rotator.

9. Remove the drive ring gear from the base housing. Remove the ring gear by first pulling up on the side opposite the gear train. Then raise the entire ring slightly upward, with the side away from the gear train higher, so that it will slide out from under the spur gears. Examine closely for evidence of broken or worn teeth. If the ring gear arm is under the gear stack, it will not come out.

10. In the older rotators, examine the inside of the screw terminal strip to see that there is proper clearance between the solid lugs and frame and that there are no faults in the insulation. Pay particular attention to the insulation at the point where the wires are held in metal clips.

11. Examine the splines in the brake housing for signs of metal shavings or even missing splines.

12. To separate the motor, pot and gear train assembly from the brake assembly, unsolder the solenoid leads from terminals 1 and 2. Remove the screws holding the terminal strip to the casting. Remove the four (4) large screws in the base. Be careful to clear the wires and terminal strip through the casting opening.

13. The brake latch mechanism, accessible only after step 12 disassembly, slides down into grooves in the casting and provides the top bearing surface for the brake wedge. The latch itself, held down by small compression springs, should prevent the brake wedge from retracting up into the casting from the outside. When the plunger retracts into the solenoid by pressure applied on the latch pin, where the retracting springs are attached, the wedge is withdrawn and may then be pushed clear into the casting.

14. To remove the potentiometer, pry the spring fasteners with a sharp instrument. Remove the hex nuts. Unsolder leads. Mounting studs are a part of the motor end bell assembly. Be sure that the pot strip is clean and that there is no corrosion or dirt on the pot arm or wiper. Use only fine rouge cloth as an abrasive to clean the pot arm or the strip winding. In replacing the potentiometer, be sure the connections are on the side that overhangs the side of the motor that is above the gear train, and the ground strap is in place.

15. To replace the motor, first remove the pot per step #14, and then unsolder the black motor lead from the screw terminal #1. On the later model HAM-IV rotators, the black motor lead attaches to a solder lug that attaches to the motor mounting plate. Then remove the red motor lead from the inside of the left limit switch lug, and the blue motor lead from the inside of the right limit switch lug. Remove the nuts and washers holding the motor on the studs, and then pull the motor up and out. In replacing the motor, be sure to see that the round hole in the motor is next to the limit switch. If you place the elongated hole in the motor next to the limit switch, you will not be able to wire the motor to the limit switch properly. Use a double lock nut on this stud near the limit switch, to provide clearance with the leads. Use a special internal-external toothed lock washer over the stud that works over the elongated hole in the motor. Be sure that the pinion is away from the spur gear before tightening this fastening over the slot. If the pinion is too close

creates unwanted stress on the motor and will decrease rotator performance.

16. When it is necessary to closely inspect or replace gears, it is possible to remove the motor, limit switch, pot, and the terminal strip without unsoldering more than the solenoid leads from terminals #1 & #2. Remove the motor fastenings from the mounting studs. Work the motor up and out, exercising care in pulling the leads and terminal strip through the window in the gear housing. Remove the motor mounting plate to expose the gear train. Carefully note the positions of the gears and washers so you can re-install the gears back into the same places they came from.

Final Re-Assembly of the Rotator

The following instructions assume that the brake mechanism is assembled and operative. The motor and gear train along with the potentiometer and limit switch are assembled, wired and operative.
It is not likely that the brake wedge will be exactly positioned in relation to the splines in the brake housing to permit proper assembly unless the brake mechanism is retracted. For this reason it is necessary to operate the brake mechanism electrically during step #8 of the assembly of the rotator.

1. Apply a small amount of low temperature, high quality, and lightweight grease around the ball bearings, ring gear and spur gears. Only an even film of grease is desirable (about one thimble full) to lubricate a completely dry rotator. Excessive grease will only run out at high temperatures or cause power loss and sluggish operation in low temperatures. Apply a few drops of lightweight, No. 10 oil to the motor bearings.

2. Rotate the upper spur gear until the inwardly protruding tooth on the ring gear engages the channel shaped stop arm and pushes it far enough to the right to just open the right hand limit switch contact (it is assumed that the rotator is viewed from the side of the left limit switch). This situation represents the extreme counter-clockwise end of rotation. Rotate the potentiometer arm to its extreme counter-clockwise position against the top brass stop.

3. Secure the upper bell housing upside down by the mast support in a vise with the open end of the "V" toward the bench. The boss that drives the potentiometer arm that is located in the bottom part of the bell housing is now to the left of center.

4. Clean the inner portion of the housing and apply a small amount of grease to the ball bearing race. Then carefully insert one ball bearing retainer assembly with the flanged rim up and against the outer edge of the casting.

5. Grasp the operating mechanism by the flat base, steady the ring gear, invert the mechanism and lower it into the housing. In doing this, note that the serrated portion of the potentiometer arm must engage the driving boss in the housing and the three driving lugs on the ring gear engage the mating lugs in the top housing. This situation will result automatically if the previous instructions were followed. Check this by rocking the rotator back and forth about ¼".
6. Determine that the top bearing surface is clean and apply a film of grease on the top ball bearing race and the top bearing assembly. Then apply the top bearing assembly to the race with the rim downward.

7. If the rotator is a HAM series, then lubricate the bottom shim and install it. The shim will only install one way, with the flat side face up. If the rotator is a T2X, then lubricate the 3rd bearing race and 3rd set of bearings. Install the 3rd set of bearings onto the 3rd bearing race with the rim downwards.

8. Clean the brake housing and apply a thin film of grease to the bearing race only. Lower the brake housing into place so that the **assembly holes will approximately line up with the threaded holes in the upper housing. DO NOT MECHANICALLY FORCE AN EXACT ALIGNMENT OF THESE HOLES WITHOUT ELECTRICALLY RELEASING THE BRAKE MECHANISM.**

9. Connect the control terminals No. 1 and No. 2 only to the corresponding terminals on the rotator while it remains clamped in the vise. Momentarily operate the lever on the control box to retract the brake. This will permit the brake housing to be freely rotated for exact alignment of the holes. With the power applied to the brake, insert the four (4) assembly screws and tighten them down to a reasonably tight position. Keep the brake retracted electrically while tightening all four (4) screws. Release the brake electrically and use a heavy screwdriver with a wrench to completely tighten the four (4) assembly screws. Torque the screws to 85 inch pounds.

10. It is suggested that all eight wires be connected from the control box while the rotor is still on the bench and that its complete operation be checked.

TROUBLESHOOTING TIPS

Field experience has shown that most operational difficulties with the HAM series rotators are traceable to broken, shorted or grounded wires—usually at the terminal strips. Time spent in cutting the leads to exact lengths, tinning, forming and wrapping around terminals, cutting insulation to exact length and clamping to prevent strain on any single wire, will pay big dividends later in long trouble-free performance. **PUT IT UP RIGHT---AND LEAVE IT UP!!!**

Should trouble occur, first follow the suggestion on Page 2 for "Checking the Control Unit" and "Checking the Rotator from the Ground". Compare resistance values with the schematic diagram to localize the trouble. The following "symptoms" and "treatments" may also be helpful.

Mechanical Play

To prevent binding under adverse operating conditions, a small amount of play is designed into the rotor. Even a degree or so of rotary play will permit several inches movement at the end of a wide antenna boom, or at the tips of the elements. Frequently the slight motion of the antenna array in the gusts of wind is due more to the natural flexing of the elements and masts, than it is due to actual play in the rotor mechanism.

Antenna Rotates in Heavy Wind

This is usually a matter of the mast slipping in the support. For large arrays it is often necessary to drill a 3/8" hole through the clamping plate, mast and mast supports and pin them together with a non-corrosive fastening. A false indication of suspected "slipping" can be obtained by comparing the meter readings at different times when the beam has not been "rotated officially". If the rotor is actually turning, the brake latch is not engaging properly. Since it is pulled into place by springs and only retracted electrically, it will be necessary to disassemble the rotor per instructions on Page 2 and follow suggestions on step 13 regarding the latch mechanism.

Lack of Power

Lack of power is such that the antenna rotation is slow or sluggish. Be sure that the heavy leads in the terminal cable are used for terminals No. 1 and No. 2, as these leads must carry a large amount of current to handle power for both the brake and motor. Use method on Page 1 to check the motor from the ground. Check the motor start capacitor. Check the transformer for AC output. If the electrical circuit is okay, then check for mechanical binding. Pay particular attention to the bearings and alignment of the mast on an inside tower mount. The mast alignment must be as close to perpendicular to the tower as possible. As a last resort, dismantle the rotator to check gears, bearings and all other mechanical components inside the rotor.

Also, look for hardened grease on the bearings, bearing surfaces, on the gears, as this will slow the rotator down while turning.

No Meter Indication

The brake and motor operate independent from the meter indicating system. If the pilot lamp burns at proper brilliancy, the instrument transformer is okay and output is not shorted. Check for about 12-13 VDC across terminals No. 3 and No. 7 with the power switch ON. If the voltage is present, then check for 500 +/- 50 ohms across these leads to rotor with the rotor cable disconnected from the control box. If 500 ohms is present from terminals No. 3 and No. 7, see if readings from No. 3 to ground and No. 7 to ground total 500 ohms. If this is so, connect an auxiliary meter from terminal No. 3 to ground and see that voltage runs from zero to about 12 volts as antenna is rotated from left to right extremes. If the 12-13VDC is not present, then replace D1.

No Rotation—Indication OK

Either the thermal cutout switch in the main power transformer has opened to protect the motor or capacitor from excessive heat of prolonged operation or there is actually trouble on the motor circuit.

After allowing time enough for the thermal cutout switch to restore service (about 10 minutes), proceed with the suggestion above for "**Lack of Power**".

Grounded Leads and Wires

Any cable leads that are grounded can burn out either the line fuses or the small fuse in the DC circuit. For a full explanation, refer to the schematic. If lead No. 3 is grounded, it shorts out part of the potentiometer, so that as rotation progresses to the other end, the DC voltage is applied across a decreasing portion until the current is so high that it burns out the resistance strip in the potentiometer. Note also that any grounds put on overload on the power transformer that cause the line fuse to blow, or overload the rectifier circuit so that the 1/8 amp fuse blows.

Meter Fluctuations

An intermittent condition in any component in the rectifier or meter circuits within the control box, as well as in the cable or potentiometer circuit in the rotator itself can cause meter fluctuation or error. Placing a test DC meter across terminals No. 3 and No. 7, and comparing the action of the test meter with the panel meter may localize possible causes of such trouble.

Shaking or moving the meter wires around, can uncover bad connections.

If the test meter fluctuates along with the panel meter, either a component in the rectifier circuit is intermittently defective, or an intermittent trouble-ground is drawing excessive current. To further localize such a condition, leave the test meter on terminals No. 3 and No. 7 and remove the corresponding leads to the rotator. This removes the load from the DC circuit so the test meter will show about 12 volts. The panel meter sensitivity will be cut about in half, so that it will show about ¾ scale. Fluctuation of the test meter will now point to trouble in the DC rectifier circuit. Fluctuation of the panel meter only, will point to intermittent trouble in the meter, multiplier resistors or the calibration control.

Where the meters are steady in the preceding tests, and there is fluctuation with the rotator leads connected, it indicates trouble in the lead wires or the rotator itself. The resultant fluctuations usually cause the meter to pulse UPWARD from a given reading. Any dirt, grease or corrosion that breaks or interferes with the ground return from the potentiometer wiper will cause the needle to fluctuate from a true reading toward the center scale point. In such cases it is necessary to open the rotator per the disassembly instructions on Page 2. The ground connection for the potentiometer is carried through the pivot point directly to the rotator frame.

SPUR GEAR ASSEMBLY

Figure 2 is an assembly blow-up diagram of the entire SPUR GEAR ASSEMBLY for the T2X, HAM-IV, HAM-V and most of the earlier rotator in the HAM and T2X series rotators.

Gear Nomenclature

Figure 1 below shows how the spur gears should be spaced when properly assembled. The spur gears should be centered on the pinion gears when assembled. Proper centering of the spur gears on the pinion gears prevents the gear faces from rubbing, which in turn causes binding. To obtain proper centering of the spur gears, each gear is shimmed up on the gear shafts using thin steel washers installed under the pinion gears. Over time, the original mechanical tolerances may no longer be true, when the rotator is disassembled. So, the spur gears may need to be shimmed up or down a little more from the original assembly.

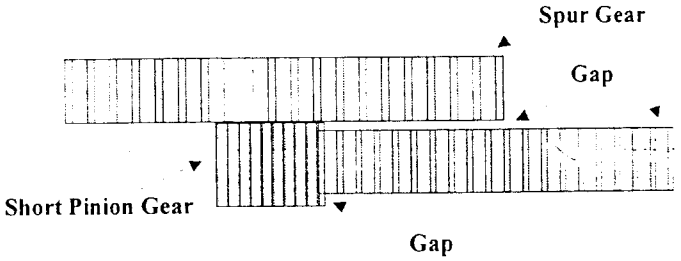


Figure 1

Descriptions and Procedures

The numbers on Figure 2 serve two purposes. First of all they show the assembly sequence of the parts. Secondly, they are the Item Numbers for the Parts List below.

Item Numbers 7, 9 and 10 (P/N: 5011200-1) are identical spur gears with rather small pinion gears attached to the bottom side.

Item Number 6 (P/N: 5011100-1) is a spur gear with a rather long pinion gear attached to the bottom side.

Item Number 3 consists of two spur gears (5010700-1) "sandwiched" together. There is no pinion gear on Item No. 3.

Item Numbers 1 and 8 are identical flat steel washers used for shimming.

Item Number 12 are identical steel washers used to shim the motor mounting plate away from the gear train.

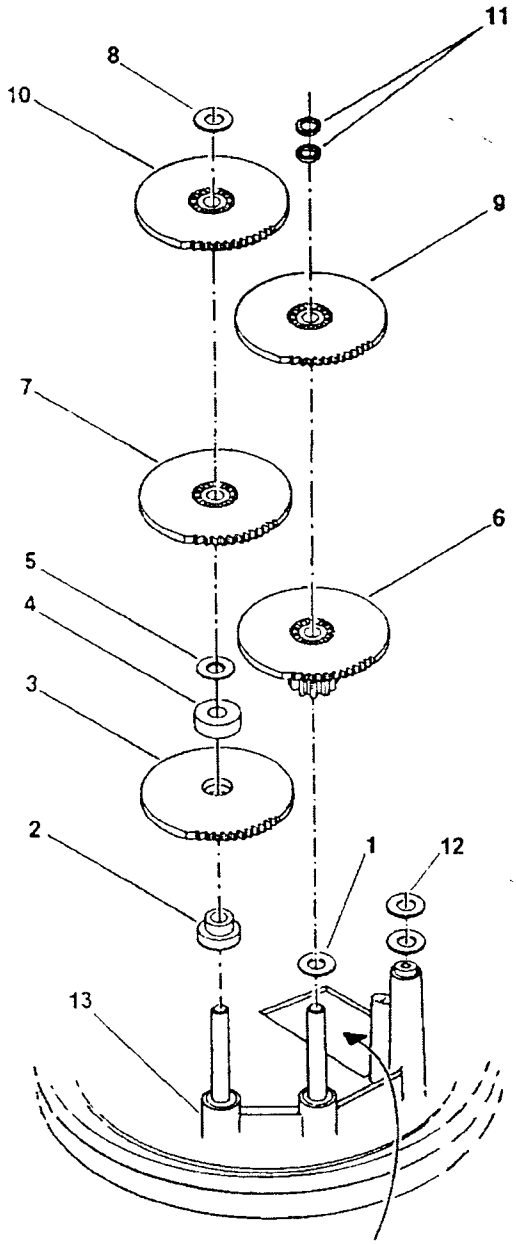
The pinion gears for this application are always oriented on the shafts with the pinion gear side "down".

Item Numbers not described here are described in the Parts List.

When assembling all the gears and their associated components on both shafts, follow the numerical sequence shown in Figure 2 on the next page.

PARTS LIST

Item No.	Part Number	Description	Qty.
1	5112000	Flat Washer, .252", Steel	2
2	5037900	Bushing	1
3	5010700-1	Spur Gear	2
4	5037800	Spacer	1
5	5112100	Flat Washer, .252", Brass	1
6	5011100-1	Gear/Long Pin. Assy.	1
7	5011200-1	Gear/Short Pin. Assy.	3
8	5112000	(Same as Item 1)	
9	5011200-1	(Same as Item 7)	
10	5011200-1	(Same as Item 7)	
11	5034101	Spacer	2
12	5112300	Washer, Shim	6
13	5037002	Base and Shaft Assy.	1



PLACE THE OPENING FOR ELECTRICAL LEADS TO THE RIGHT.

Figure 2. Gear Train Assembly

Spur Gear Assembly Procedure

This is the section where the gear train assembly is done. Before starting the procedure below, all of the components in Figure 2 must be thoroughly cleaned that has removed all of the old grease and dirt using a good grease cutting solvent. If the components are not cleaned, there is no sense in re-assembling the gear train. Take the extra time required to clean the components before assembly!!

The actual assembly procedure follows:

1. Apply a thin coat of low-temperature, high quality and lightweight grease to the base of the gear shafts and the shafts them selves.

2. Apply a thin coat of same grease to the bottom of the flat steel washer, Item#1 in the parts list. Slip the washer onto the right gear shaft as shown in Figure 2.

3. Apply a thin coat of same grease to the flat bottom of the bushing, Item#2 in the parts list. Slip the bushing onto the left gear shaft as shown in Figure 2. Apply a thin coat of grease to the entire top of the bushing.

4. Apply a thin coat of grease to the flat surfaces of the spur gears, Item #3 in the parts list. Sandwich the two gears and install them onto the bushing, Item #2 as shown in Figure 2

5. Apply a thin coat of same grease to both flat surfaces of the spacer, Item #4 in the parts list. Slip the spacer onto the left gear shaft as shown in Figure 2. Apply a thin coat of grease to the entire top of this spacer once installed.

6. Slip the flat brass washer onto the left gear shaft as shown in Figure 2. Apply a thin coat of grease to the entire top of this washer.

7. Apply grease to the spur gear, Item #6 in the parts list. Be sure to coat down into the teeth of the long pinion and both flat surfaces. Slip the spur gear onto the right gear shaft as shown in Figure 2, ensuring to mesh the teeth of the long pinion with both spur gears, Item #3, and that the bottom of the long pinion is seated down against the flat washer, Item #1.

8. Apply grease to the spur gear, Item #7 in the parts list. Be sure to coat down into the teeth of the short pinion and both flat surfaces. Slip the spur gear onto the left gear shaft as shown in Figure 2, ensuring to mesh the teeth of the spur gear, Item #6, and that the bottom of the short pinion is seated down against the flat brass washer, Item #5.

9. Apply grease to the spur gear, Item #9 in the parts list. Be sure to coat down into the teeth of the short pinion and both flat surfaces. Slip the spur gear onto the right gear shaft as shown in Figure 2, ensuring to mesh the teeth of the spur gear, Item #7, and that the bottom of the short pinion is seated down against the top of the long pinion gear, Item #6.

10. Apply grease to the spur gear, Item #10 in the parts list. Be sure to coat down into the teeth of the short pinion and both flat surfaces. Slip the spur gear onto the left gear shaft as shown in Figure 2, ensuring to mesh the teeth of the spur gear, Item #9, and that the bottom of the short pinion is seated against the spur gear, Item #7.

11.

Ham IV/T2X Wiring Information

1 Black Ground
2 White Solenoid(yellow)
3 Green Pot-left contact(CCW)
4 Blue Limit Switch Inner Right Side
5 Orange Limit Switch Outer Left Side
6 Yellow Limit Switch Outer Right Side
7 Brown Pot-Right Contact(CW)
8 Red Limit Switch Inner Left Side

Ham IV/T2X Wiring Information

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3 Green Pot-left contact(CCW)
4 Blue Limit Switch Inner Right Side
5 Orange Limit Switch Outer Left Side
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4 Blue Limit Switch Inner Right Side
5 Orange Limit Switch Outer Left Side
6 Yellow Limit Switch Outer Right Side
7 Brown Pot-Right Contact(CW)
8 Red Limit Switch Inner Left Side

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2 White Solenoid(yellow)
3 Green Pot-left contact(CCW)
4 Blue Limit Switch Inner Right Side
5 Orange Limit Switch Outer Left Side
6 Yellow Limit Switch Outer Right Side
7 Brown Pot-Right Contact(CW)
8 Red Limit Switch Inner Left Side

Ham IV/T2X Wiring Information

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2 White Solenoid(yellow)
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4 Blue Limit Switch Inner Right Side
5 Orange Limit Switch Outer Left Side
6 Yellow Limit Switch Outer Right Side
7 Brown Pot-Right Contact(CW)
8 Red Limit Switch Inner Left Side

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4 Blue Limit Switch Inner Right Side
5 Orange Limit Switch Outer Left Side
6 Yellow Limit Switch Outer Right Side
7 Brown Pot-Right Contact(CW)
8 Red Limit Switch Inner Left Side

Ham IV/T2X Wiring Information

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2 White Solenoid(yellow)
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4 Blue Limit Switch Inner Right Side
5 Orange Limit Switch Outer Left Side
6 Yellow Limit Switch Outer Right Side
7 Brown Pot-Right Contact(CW)
8 Red Limit Switch Inner Left Side