Orion OR-2300 Rotator System Resurrection

Figure 1 - Orion OR-2300 rotator system

Quite recently, I had the dubious privilege of refurbishing a Club-owned Yaesu G-5500 Az-El rotator system. This repair started out as a blown fuse in the controller and ended up with the motors in both of the rotator motion units requiring rewinding and one of the units needing a replacement of its position-reporting potentiometer. I did the work, wrote my usual article on the repair, and then at the request of the Club President, I assembled a slide show presentation detailing the processes of troubleshooting (diagnosis) and repair that I had followed. This presentation will be made to the Club at a session in January, which may already have happened by the time that you read this.

To make a long story as short as I can, the scheduling of that upcoming session was announced at the GCARC December General Membership Meeting. The announcement, in turn, led directly to my being asked to undertake the rehabilitation of an older (circa 1991) Orion OR-2300 rotator system.

This Orion OR-2300 system (Figure 1) belongs to GCARC member **Darrell Neron AB2E**, and it has considerable sentimental value to him. Because of that perceived value and because I enjoy a challenge, I decided to attempt the Herculean task. You see, this rotator system had been stored inside polyfilm bags which were in turn inside a cardboard carton. The whole shooting match had been in storage in Darrell's garage, where unfortunately, a flood had saturated the system. In fact, the water level was several inches deep and remained at that level for a while, trapped inside the polyfilm bags and having plenty of opportunity to cause extensive damage to the rotator system.

When Darrell first e-mailed me about the job, he sent along an attachment – a downloaded scan of the basic owner's manual for the system. The last page of that document was a copy of the unit schematic, but it was so poor a scan that the schematic was pretty much unusable. With what little bit that I could make out, it appeared that the active components in the controller are a single transistor, a single triac, and a quad op-amp, though *none* of the semiconductor component types were labeled on the schematic. However, the circuit appeared to be fairly straight-forward, and I reasoned that the motion unit should be nothing too unusual. I decided to go ahead with the job.

Darrell dropped off the unit and the printed manual on a Friday morning, and I started right in on the controller, figuring that the rotator motion unit was designed to be out in the elements, and so had probably suffered the least damage. It turns out that I was wrong, but more about that later.

He told me that he had powered the unit up, and that apparently the panel illumination came on, but that nothing else operated. I would never have even suggested powering it up without exploring it first, as it is easy to do irreparable harm to a compromised unit by powering it up when there are short-circuit types of faults present or probable. However, he had already done it, so there was no sense in crying over spilled milk. I would just have to take it as I find it and go on from there.

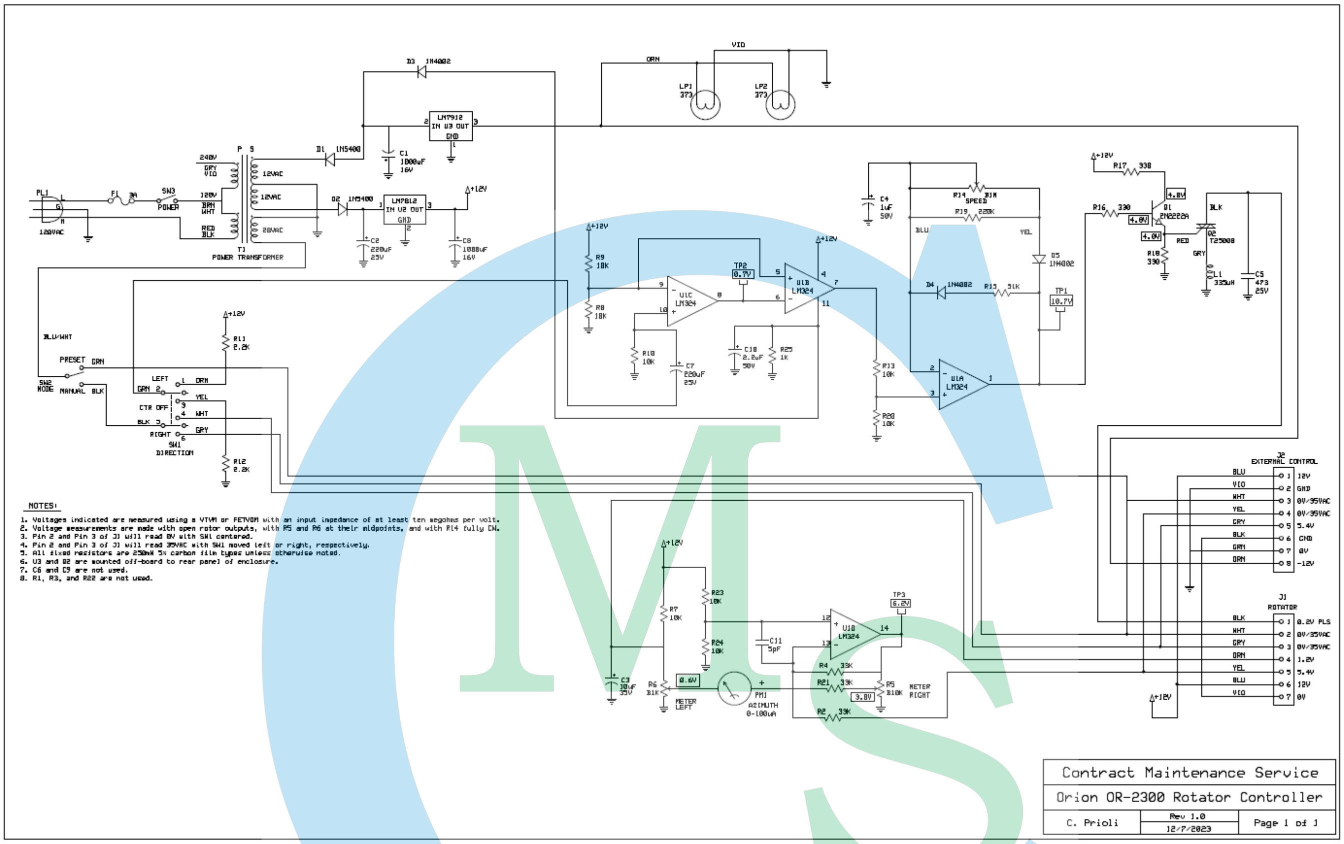

Figure 2 - Orion OR-2300 controller schematic diagram

I determined that the very first thing to do was to develop a proper and legible working schematic for the entire unit, starting with the controller (Figure 2). To that end, I opened up the controller and set to work documenting the circuit paths as well as all component values and device types. There is a T2500B triac and an LM7912 negative twelve-volt three-terminal voltage regulator integrated circuit (IC) mounted to the rear panel of the enclosure. The power transformer was obviously a dual (primary) voltage type of transformer with two secondary winding sets. The rear panel of the enclosure also supports a fuse holder with a three-ampere standard glass fuse installed therein. It turned out that I would end up drawing the schematic in an ongoing manner while making some of the repairs, but I finally did get the schematic completed.

When I first opened up the controller enclosure, I immediately noticed the presence of fine white corrosion almost everywhere, and especially on the printed circuit board (PCB) and inside the panel meter (Figure 3). I decided to look into the panel meter first, because if the meter was a total loss, and if I was unable to repair or replace the meter, there would be no sense at all in going any further. The meter is the key to knowing the azimuthal position of the antenna, and in fact in determining if the antenna is moving at all as the controls are exercised.

The meter turned out to have a mass of corrosion surrounding the movement and filling the narrow air gap between the moving armature and the magnetic core. This meter was toast – there was almost no chance that I would be able to salvage the meter movement, so I set out to source a replacement for it.

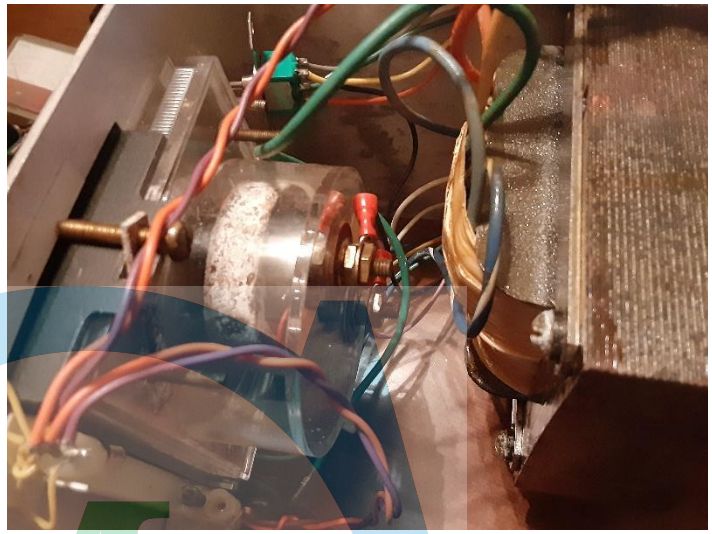

Figure 3 - Corrosion inside panel meter housing

In order to examine the meter's internal condition, I had removed the movement from its housing. There were no markings of any kind on the movement, so now I took a closer look at the meter housing. The name *"Hoyt"* was embossed on the back of the housing, so I started there. I went online and did a Google search for *"Hoyt meters"* and quickly found that the company is still in operation and located in Penacook, New Hampshire, doing business as *Hoyt Electrical Instrument Works, Inc.* A quick phone call to their sales line garnered the information that the meter was actually a standard Hoyt Model 2035 0-100µA DC ammeter with a custom dial face plate. This was derived from a fine print Hoyt contract number on the original meter dial face as well as a *"100µA DC FS"* legend that was there. The sales agent with whom I spoke led me to that contract number fairly quickly, which aided in a rapid identification of the meter. With the 0-100µA Model 2035 meter being a readily available and in-stock part, there was no reason not to continue with the controller repairs. When the new meter would eventually arrive, it would be necessary to swap the original Orion meter dial face onto the new meter, but that is a simple task. The two most important aspects of this meter replacement are (1) that the current rating of the meter matches that of the original meter, and (2) that the physical dimensions and arrangement (form factor) of the new meter also match the original meter, so as to make possible the swap of the dial faces.

The next items up for consideration were the front panel controls. As received, the controller's rotation direction switch was missing its actuator lever. This switch is a DPDT paddle-actuated rear-of-panel mounted double-momentary toggle switch. I identified a suitable switch brand and model number and ordered a replacement switch and an appropriate actuating paddle lever for the switch. As I continued, I also found that the knob on the speed control potentiometer was stripped internally and could no longer grip the shaft of the control. In doing so, I quickly discovered that the reason that the knob got stripped in the first place was because the control had fetched up. The speed control potentiometer is a one megohm 24mm linear device with a split knurled shaft. The original knob was a plastic push-on type that had stripped out internally from being turned against a really tight control. While I could probably have cleaned up the control with some DeoxIT® X10S lube and some time and patience, it was much more expedient to simply replace the control, as it is a common and fairly inexpensive item in the overall scheme of things with this rotator system. The replacement potentiometer went in without a hitch, together with the new knob.

It should be noted that as built back in 1991, this controller used a pair of #373 14-volt midget screw base lamps for panel meter illumination. At some point in time, these lamps were replaced by miniature T1-3/4 size wire-lead lamps. As it turned out, only one of these two lamps was operational. Since I had the #373 lamps on hand, I went ahead and installed a pair of them back into the existing sockets and removed the previously-added wiring to the wire-lead lamp modifications. I also put a spare pair of lamps into a polyfilm bag and taped it inside the enclosure cover, together with a pair of spare three-ampere fuses.

Figure 4 - 373 lamp

Next up was the PCB. Upon removal and inspection of the board, I found considerable damage to the PCB and to its componentry (Figure 4). This PCB is installed in the unit in the vertical plane, seated into a card slot mounted on spacers to the controller enclosure floor. The PCB naturally has mating contact “fingers” along what becomes its lower edge, which then mate into the spring contact seats of the card slot. Several of the PCB traces to these contact fingers were heavily corroded, and one of them was corroded completely through, leaving an open circuit on the PCB. Cleaning off the corrosion was simple enough, using a soft brass wire brush, a firm toothbrush, and some 99.9% isopropyl alcohol (IPA). Once the corrosion was gone, some deft work with the soldering iron restored continuity to the contact finger on the edge of the PCB, leaving the tinned surface as the actual new contact material.

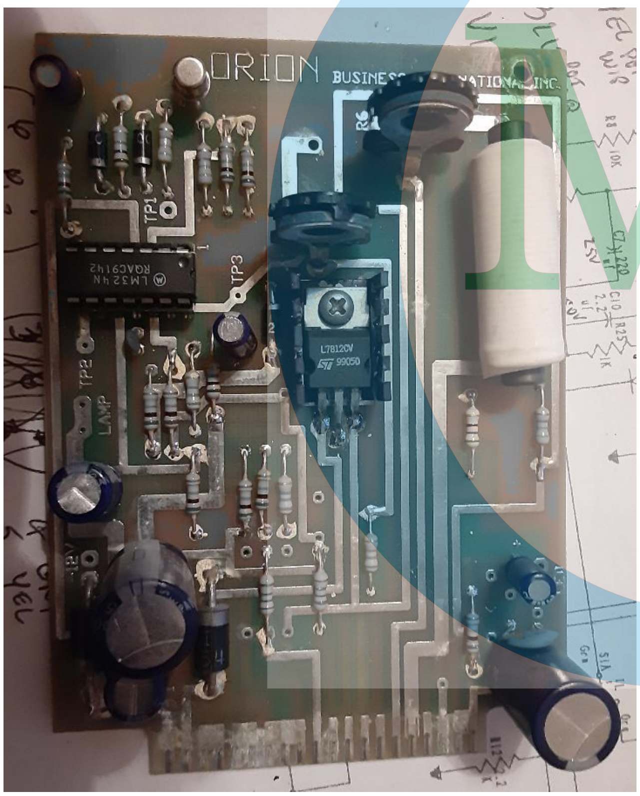

Figure 5 - Corrosion on controller PCB

Corrosion had attacked the leads of several of the diodes on the PCB, as well as the leads of the 2N2222A transistor. As an interesting side note, the leads of this transistor were gold-colored, and might have been assumed to be of gold construction. In reality, however, gold leads would *not* have corroded as these did, so the leads were obviously not made of gold. The diodes affected were two 1N5401 types and two 1N4002 types. In addition, the LM7812 voltage regulator IC had its input pin corroded through and required replacement. Around a dozen of the various resistors on the board were damaged to the point of warranting replacement, which I did. Last but not least were the seven aluminum electrolytic capacitors on the PCB. Two of the seven capacitors had failed, as evidenced by their bulging end surfaces. I replaced all of the electrolytics as a matter of expediency and because of their common age. Finally, the two calibration thumbwheel trimmer potentiometers for the meter were also corroded to the point of being unreliable when rotated. I replaced both of them, one a 1KΩ value and the other a 10KΩ value.

Once the PCB was repaired and ready for re-installation, it was time to turn my attention to the card slot. There were several individual contact sockets that had fairly heavy corrosion within

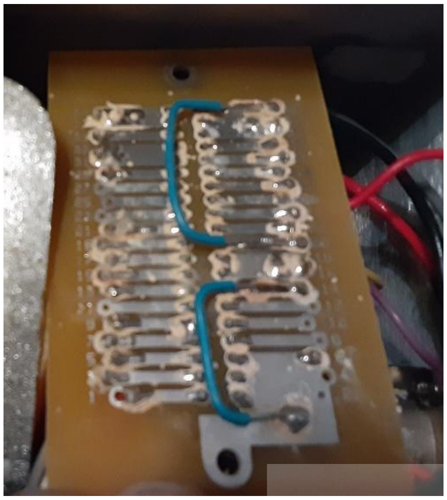

Figure 6 - Card slot PCB foil side

the sockets. Some attention with the wire brush and a can of compressed air took care of that corrosion. I next took a look at the underside – the foil side – of the PCB (Figure 6) to which the card slot connector was mounted. Here too there was considerable corrosion, all of which needed to be cleaned off the board. Once again, the brass wire brush and some 99.9% IPA did the trick. Once again, some touch-up work with the soldering iron served to repair the damaged traces on the PCB.

The rear panel of the controller enclosure has two round connectors installed there – one is a standard eight-pin 270° DIN socket, and the other is a Nanaboshi NJC-207-PM seven-pin male keyed connector shell. The DIN connector is the interface to the controller's remote-control pendant, while the Nanaboshi shell is the body through which the rotator motion unit is connected. While the business end (the pin side) of the Nanaboshi connector was in fairly good shape, there was heavy corrosion on the solder side of that connector body. The DIN shell was corroded badly on both sides. As a result, both of these connectors required replacement as a part of the repair process.

Once the controller was well in hand and waiting for parts to arrive, it was time to start in on the rotator motion unit. The motion unit is a cast aluminum affair with an overall triangular shape, driven by a 28VAC split-phase induction motor through a worm drive, reduction gearing, and an output spur gear arrangement. This assembly incorporates a pair of snap-action micro-switches utilized as limit switches in series with the motor windings. In addition, there is a pair of 460-553µF non-polarized starting capacitors rated at 120VAC. The rotator driven (output) hub is keyed to the output shaft via a quarter-inch square key. The output shaft is supported by a bearing at its upper end and by a bronze bushing with a thrust face at its lower end, and passes through a lip-type oil/grease seal at its exit from the housing. The worm gear is pinned directly to the drive motor shaft. The intermediate reduction gear is also bearing- and bushing-supported.

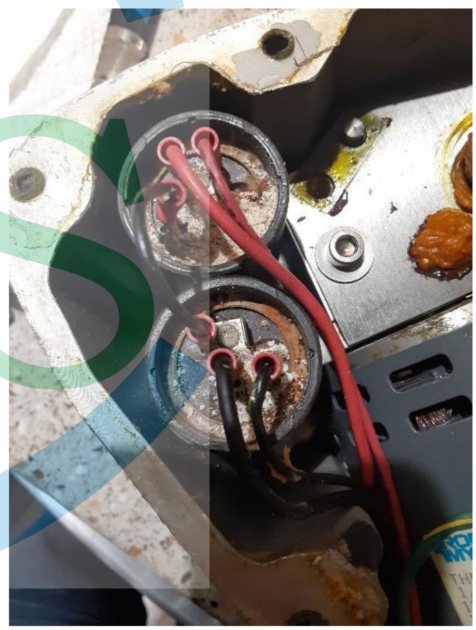

Figure 7 - Capacitors as found in motion unit

Upon opening the motion unit housing, it was immediately evident that a serious amount of water had gotten into the housing for several reasons:

- the capacitor terminals were corroded to the point of having become separated from the capacitor bodies (Figure 7);
- the two capacitors had water inside of them;
- the motor connection-end support bracket was severely rusted;
- there was water inside the worm gear enclosure; and
- there was a considerable amount of corrosion to the motor aluminum end frame components and attaching hardware (Figure 8).

It is actually quite interesting that despite the amount of water inside the motion unit housing, there was little or no water encroachment into the gear-shaft support bearings. This is most likely due to the tight fit between the shafts and their respective bushings and the fact that there was adequate grease packed into and around most of the bearings. As a result, only one of the motion system bearings required replacement, that being the needle bearing set for the top of the output spur gear drive pinion.

On the negative side of the balance sheet for the motion unit is the fact that the drive motor was seized, which is of course further indication of the extent of water contamination in the housing. Disassembly of the unit was hampered by the seized motor, as the normal disassembly process involves rotating the motor shaft to “walk” the worm gear out of mesh with its mating spur gear as the motor is extracted from its installed position.

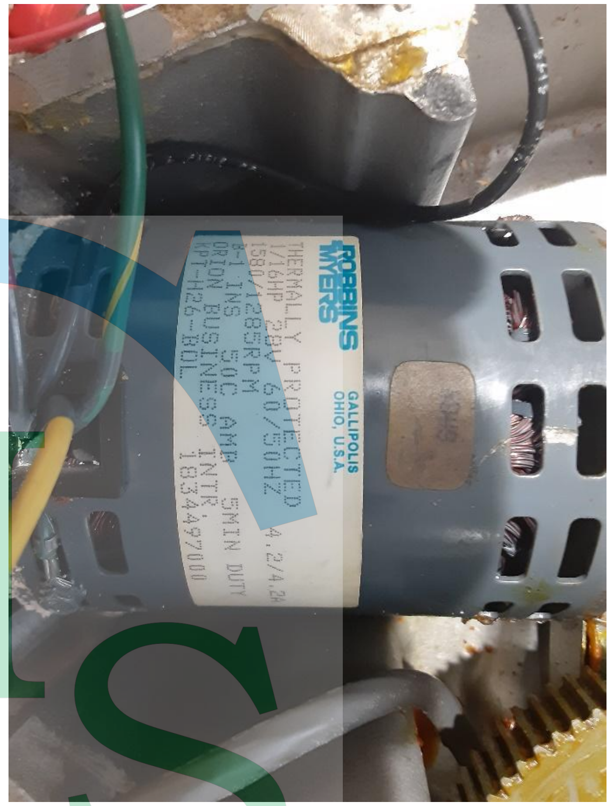

Figure 8 - Drive motor - note corrosion on end frame at left

Working at it carefully but with determination, I finally got the motor out of the housing. At that point, it was a simple matter to remove the mating spur gear, which completed the disassembly process. Then it was time to begin cleaning the housing halves and all of the gearing components. It was important to remove all of the remaining lubricant from the housing due to contamination of the lubricating grease by rust particles and corrosion by-products, as well as whatever water remained there.

Overhaul of the motor proved to be fairly straight-forward with no real surprises. I began by driving out the roll pin that secured the worm gear to the motor shaft, and then removed the worm gear and its support frame from the shaft. It is important to maintain the original positional relationship of the worm gear to its housing, as determined by the placement of shim washers at either end of the worm gear. I cleaned, stacked, and taped the shim pack from each end of the worm gear, marking each one as to its position on the shaft, and then set them aside for the duration.

With the worm gear removed, I removed the securing hardware that attaches the motor end frames to the stator housing. I marked the end frames and stator housing so that they would be reassembled in the same relative positions. Some gentle persuasion with a mallet released the end frames from the stator housing easily enough, but I had some slight difficulty in getting the connection-end end frame to come off the armature shaft, because of the condition and fit of the end-frame bearing to the shaft. The shaft end frame came off readily enough, but the armature was seized in the stator assembly and would not slide out. Again, some gentle persuasion with a mallet was applied. Once the armature broke free, I was able to remove it from the stator housing.

The armature and the stator would require considerable cleaning to remove the rust that had accumulated on those parts, and I still had the connection-end end frame stuck on the armature. This situation was resolved by supporting the end frame carefully near its center hub and gently driving the shaft from the bearing. Again, once it started moving, it came off easily enough. In a similar manner, I removed the shaft-end bearing from the armature shaft by supporting the armature under the bearing perimeter and gently driving the shaft out, taking care not to damage the shaft.

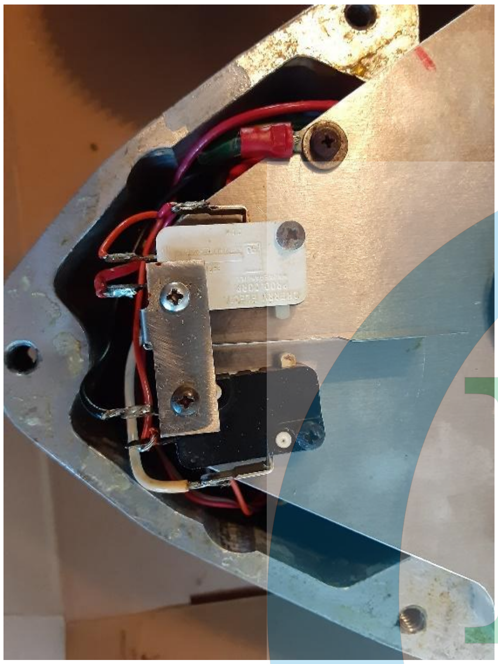
Figure 9 - Limit switches installed to support plate

The bearings were both rust-damaged internally, running very roughly when rotated. I sourced two new bearings at a local auto parts warehouse and set them aside to be installed after the armature had been cleaned of its rust deposits. To clean the rust from the armature, I used a combination of scraping the buildup with the edge of a knife, and then wire-brushing the surface with a wire wheel in my Dremel tool. I then cleaned the inside of the stator housing using another wire wheel with an extended shaft in the Dremel tool. This was more difficult because of being inside the stator and the fact that it was not possible to effectively scrape away most of the accumulation as I could on the armature. Eventually, the rust deposits were completely removed, and apart from some discoloration of the metal, there was little indication of the condition that the parts had shown. It was time to begin reassembly of the motor.

I started that process by installing the new bearings onto the armature shaft, which was a tight slip fit requiring just a little bit of force. With the new bearings in place, the armature was slipped inside the stator, and the end frames were put back in place, aligned to the marks made earlier. Each end frame is secured to the stator housing by a pair of diametrically-opposed “L” clamps that each receives a single machine screw through a hole in the end frame periphery. With the end frames secured in place, the motor was tested for rotation, to find that it spun freely. Next up was the electrical test of the motor. I accomplished that via use of a pair of capacitors from my inventory to serve as starting capacitors, and with power supplied by my VARIAC®. Use of the VARIAC® allowed me to dial down the AC to the correct level for the motor, which was 28VAC. The motor spun up nicely with the correct voltage applied, so I was happy with the motor rebuild up to this point.

All that remained for the motor was to re-install the worm gear and its support housing back onto the motor shaft. The shim packs were put back into place on either end of the worm gear as the gear was installed into its housing. This required setting the first set of shims onto the end of the shaft as it just starts to protrude through the one end of the housing. Then the worm gear is set in place and the housing slid further onto the shaft to pass into the worm gear bore. Finally, the second set of shims is slipped between the worm gear and the far end of the housing, and then the housing is slid the rest of the away onto the shaft. That job is finished by installing the roll pin back into the gear and shaft.

What should have been a simple task turned into an ordeal. The roll pin in use is tiny – one-sixteenth of an inch diameter by about a half inch long – and it should have gone right into the aligned holes in the gear and the shaft. What *really* happened was something else entirely. I had a devil of a time keeping the holes aligned as I drove the pin in, and as a result I bent the pin not once, but three times! This is because the gear would easily rotate on the shaft as the pin was driven in, causing misalignment of the shaft and gear pin bores. I was successful with the fourth pin and aside from my pride (and three bent roll pins), no harm was done. It turned out that the easiest way to get the pin to go in was to ensure that the holes stayed aligned, which meant inserting the tip of a small pin punch from the opposite side of the shaft. The punch would then maintain the alignment of the holes, allowing the pin to go straight in. It took some figuring out to come up with an arrangement that would work. I ended up sacrificing the length of a small pin punch tip, cutting it off to about three-eighths of an inch. I used a punch that had already ended up bent previously, so I was not worried about losing a good punch. Anyway, I then inserted the short pin punch into the worm gear and shaft, securing them in place by stretching a rubber band around the worm gear housing and the handle end of the punch, so that the rubber band served as a spring loop and held the punch into the aligned holes. Then it was a simple matter of inserting the new roll pin and driving it home, which pushed the punch out against the rubber band's tension.

Figure 10 - Roll pin and pot drive gear under output spur gear

With the motor now able to rotate normally, it was a simple matter to build up the gearbox again. I removed the damaged pinion bearing and installed the new one in its place. All of the open bearings were then packed with fresh bearing grease, and a generous amount was applied to the meshing surfaces of the gears. The worm gear housing, perhaps the area where the gear pressure forces are at their greatest, was properly packed again with the bearing grease.

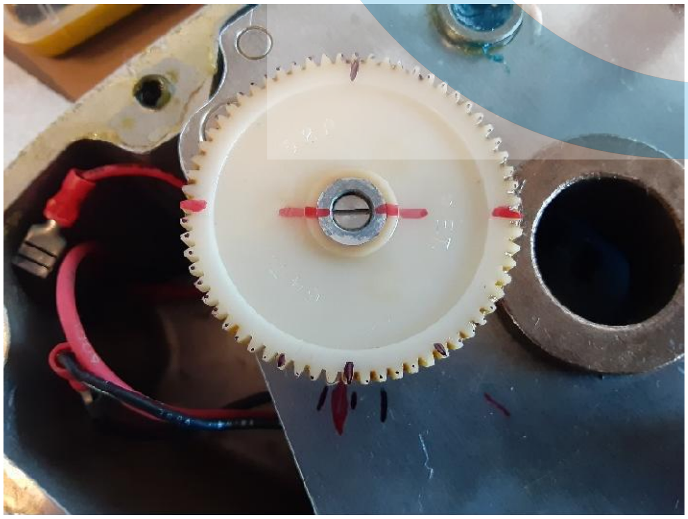

Figure 11 - Potentiometer gear with timing marks

Both limit switches were slow in returning to their normal positions after actuation, probably due to internal corrosion. As a result, both switches required replacement. I had the appropriate switches in stock, as they are a common type of pin-plunger actuated snap-action microswitch. I de-soldered the wire leads from the switches and transferred the wiring to the new switches, installing them to the intermediate bearing support plate (Figure 9).

Possibly the most important aspect of assembling the rotator motion unit is the proper timing of the driven output gear to the position-reporting potentiometer (or *"pot")*. The potentiometer is mounted through the intermediate bearing support plate with the body of the pot below the plate and its shaft protruding upward through the plate, and with its locating pin properly positioned in the hole provided for it. Installed to the pot shaft is a fine-toothed gear, which meshes with and is driven by a mating gear on the underside of the output spur gear. If the timing relationship between these two gears is not set correctly, damage to the pot will occur as the output gear is so driven that the pot reaches the rotational extent of its travel before the output gear activates the limit switch and stops rotating.

Figure 12 - Timing markings on output spur gear

The output spur gear has a short heavy roll pin driven into a hole about an inch in from the edge of the gear (Figure 10), on what becomes its lower face when the gear is installed. This roll pin protrudes proud of the gear face by about a quarter of an inch. The sole purpose of this roll pin is to engage the limit switch actuating lever and then to cause the activation of the limit switch(es) as the gear continues to rotate. The circumferential position of this pin becomes quite important when the gear is installed, as it is a crucial element in the output gear to potentiometer driven gear timing system.

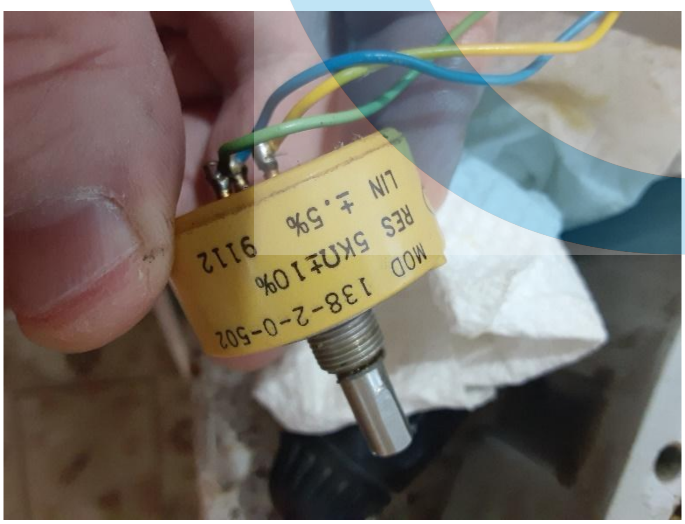

Figure 13 - Position-reporting potentiometer

Proper timing of this gear pair is accomplished by first carefully identifying and then marking the midpoint of the potentiometer's rotational travel. Then, with the pot established at the midpoint of its rotation, install the output spur gear in such a manner that the switch activation pin is diametrically opposite the center point of the gap between the limit switches, which puts the pin in direct (though not directly observable) alignment with the limit switch actuating lever. The best way to handle this issue is to transfer the location of the roll pin to the upper face of the output gear (Figure 12), using a Sharpie® marker to mark the gear face.

In a similar fashion, mark the potentiometer driven gear with two diametric lines or mark pairs – one in line with the slot in the end of the pot shaft, and the other at ninety degrees to the first diametric line or mark pair. Use the ninety-degree line or mark pair to make three alignment marks on the upper surface of the intermediate bearing support plate, adjacent to the pot driven gear. Start by rotating the (installed) pot driven gear fully clockwise and make a mark on the intermediate plate in line with the ninety-degree line or mark on the pot driven gear. Next, rotate the pot driven gear fully counter-clockwise and repeat the marking process on the intermediate plate. These two marks will end up just about four gear teeth apart. Carefully make a longer mark halfway between the two marks that you just made on the intermediate plate (Figure 11). This longer mark will indicate the pot driven gear's rotational midpoint. Make sure going forward that the pot driven gear remains positioned so that its opposite ninety-degree line or mark is in alignment with that longer midpoint mark.

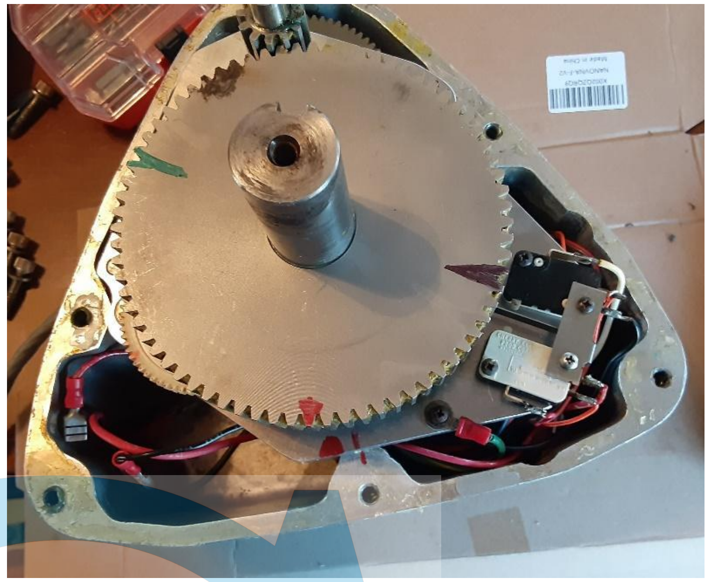

Figure 14 - All timing marks aligned

Now it is time to make a timing mark for the installation of the output spur gear. This is most easily done by using a steel rule to extend the line of the limit switch actuating lever across the intermediate bearing support plate to its opposite edge, and then making an alignment mark there that coincides with the extended switch actuating lever line. If you examine the photo in Figure 14 carefully, you will see that there is also a group of red marks adjacent to the point on the circumference of the output spur gear that is closest to the edge of the intermediate plate immediately to the left of the limit switch cluster. These are reference marks that I made when disassembling the unit prior to making any repairs. It should be noted that upon reassembly and proper timing, these marks were once again aligned (Figure 14), as is to be expected.

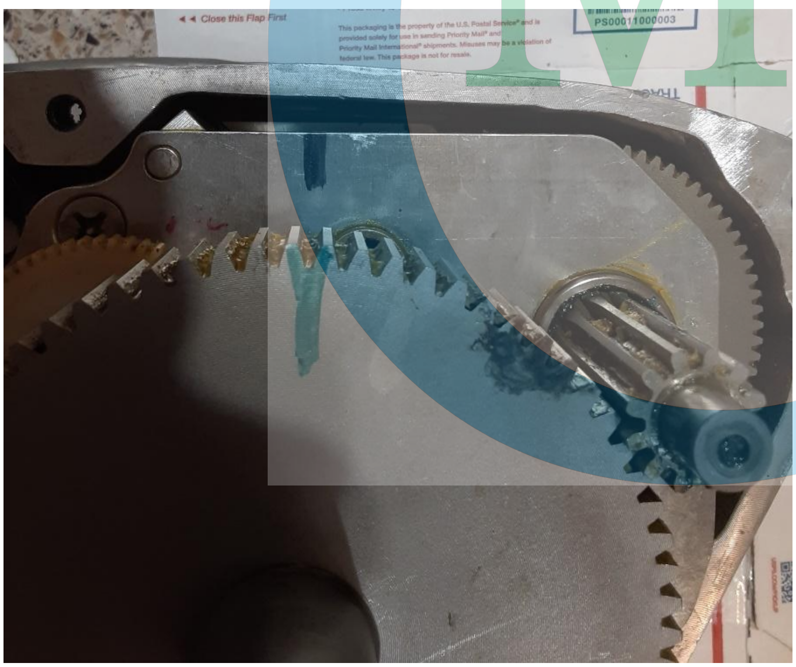

Figure 15 - Extended switch center and transferred roll pin timing marks aligned

With the lever-aligned mark made on the intermediate plate, it is now time to install the output spur gear. Apply an adequate coating of bearing grease to the teeth of the potentiometer driven gear's mating drive gear, on the underside of the output gear. Apply a heavy film of bearing grease to the thrust surface and inside diameter of the bronze bushing into which the output gear will be inserted. Position the output gear so that the timing mark that you made on its upper surface is aligned with the extended switch lever timing mark on the intermediate plate, and lower the gear carefully into place, engaging its lower shaft stub into the bronze bushing. It may be necessary to rotate the potentiometer gear *very* slightly – less than a tooth's width – to align the gear teeth into proper mesh, but be sure to verify that the gear is still in alignment with the rotational midpoint mark on the intermediate plate. If necessary, lift the output gear slightly and look underneath it at the pot gear marking, using a bright and focused flashlight to see clearly.

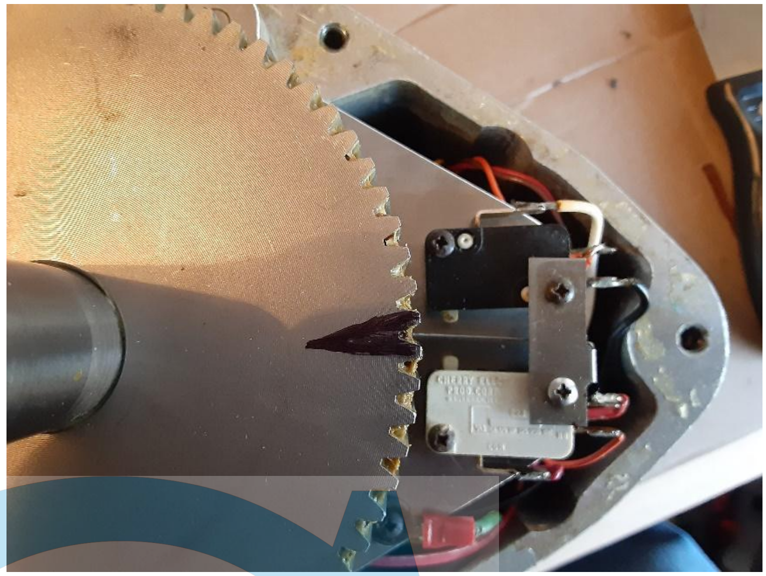

Figure 16 - Switch lever timing mark aligned

At this point, the motion unit gearbox was assembled as far as possible, lacking the new capacitors to permit complete assembly. I placed the upper housing shell in place and ran the retaining capscrews into place. To further ensure that no foreign objects could get into the unit, I also set the output hub and key in place and installed the hub retainer. Then I set the motion unit aside to await the new parts.

The first of the replacement parts to arrive were the motion unit's motor start capacitors. As already mentioned, these capacitors are fairly hefty, being rated at 460-553µF as originally installed. The replacements that I sourced were Cornell Dubilier (CDE) part number PS46015B capacitors. These capacitors are rated 460-552µF at 110/125VAC, measuring 1.8125" x 3.375" and each has a pair of dual 0.25" quick-connect lugs for wiring connections. These capacitors are exact-fit replacements for the original capacitors installed in the motion unit. The cylindrical Bakelite™ housings are equipped with molded features that enable the use of CDE mounting brackets to secure the capacitors in place, but these brackets are not used in this installation. Instead, a dollop of RTV sealant is applied to each capacitor's closed end, and the capacitors are then pressed down into place in the housing. The housing surface must first be prepped with some denatured alcohol to remove all traces of grease or oil, so that the RTV sealant will bond to the metal and hold the capacitors in place. Several hours are needed for the RTV to cure sufficiently to allow connection of the wire leads without breaking the capacitors free.

A discussion of the normal mode of operation of this rotator motion unit is in order here. The wire color scheme found in this unit may seem strange at first glance, but it actually works out once the circuit is analyzed. The cable used as the lead-in cable includes a total of eight wires – six 22AWG wires (YEL, BLU, GRN, ORN, RED, BRN) and two 18AWG wires (WHT, BLK). The YEL, BLU, and GRN wires are used for the position-reporting potentiometer, which we will discuss shortly. For now, let's discuss the motor wiring, which are the RED, BRN, WHT, and BLK wires.

The motor has four connecting wire leads as follows:

- motor clockwise (right) (RED);
- motor counter-clockwise (left) (BLK);
- motor common (YEL); and
- motor ground (GRN/YEL).

The GRN/YEL motor ground wire is connected directly to the motor end frame at the motor end, and to the intermediate bearing support plate at the opposite end. The remaining three wires are connected to the controller output wires, which are the RED, BRN, WHT and BLK wires in the cable.

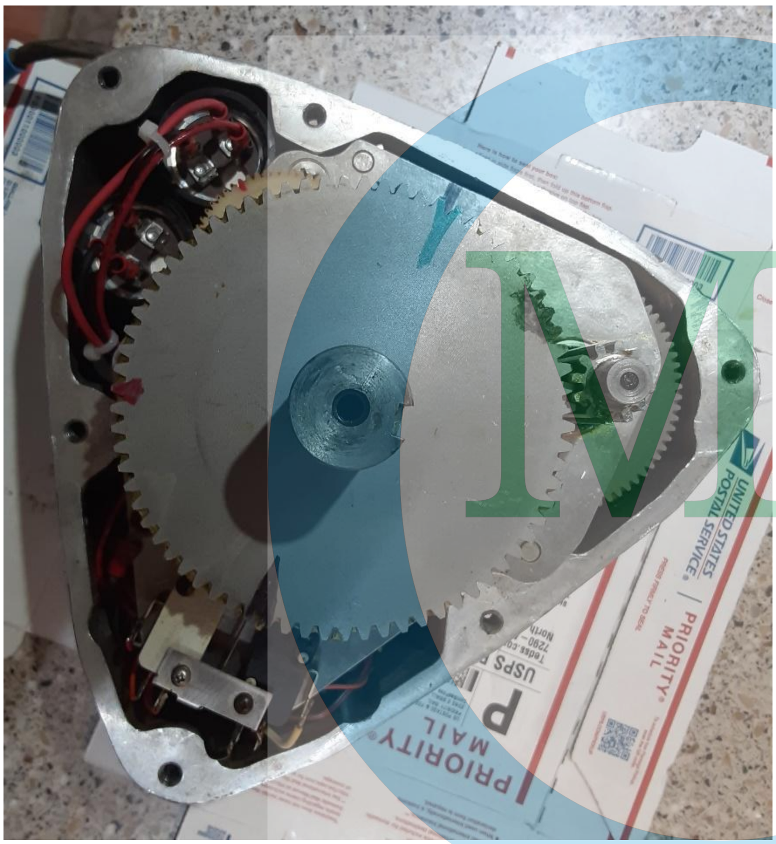

Figure 17 - Output spur gear installed and timed

The motor common wire is the YEL wire coming from the motor, and is crimp-connected to the BLK 18AWG wire in the cable coming in from the controller. This is a direct connection back to the controller. The motor clockwise and motor counter-clockwise wire leads are connected to the two capacitors by way of the normally closed (NC) and common (COM) circuits through the limit switches. The motor counter-clockwise (CCW) lead, which is the BLK wire from the motor, is fed by the WHT 18AWG wire in the cable. The motor clockwise (CW) lead, which is the RED wire from the motor, is fed via the combination of the RED and BRN 22AWG wires. The combination of two smaller wires is used to accommodate the current required by the motor, which on its other winding set is powered via an 18AWG wire. Not a very common wire scheme, but it does the job when the cable does not contain a sufficient number of heavier-gauge wires.

In order for the motor to run in the clockwise direction, the motor circuit is as follows.   Refer to Figure 29 at the end of this article as you read the following explanation. Starting from the controller output, and therefore the motion unit input cable, the circuit is in from the controller on the RED and BRN wires in parallel to the COM terminal of the CW limit switch, then out of the limit switch on the NC terminal via a RED wire to one side of the CW capacitor. Connected to the same dual quick-connect on the capacitor is the RED motor wire, which directly applies the incoming 35VAC to one winding set of the motor. At the same time, current flows *through* the capacitor and out on a jumper wire to the CCW capacitor, where it again flows through that capacitor and out to the motor on the BLK motor lead, which is likewise connected to a dual quick-connect on that capacitor. The current applied to the second winding set via the BLK wire in this case is out of phase with the current applied directly to the opposite winding, which causes the motor to start turning in the CW direction. The return to the controller is via the YEL motor common lead which is connected to the BLK 18AWG cable wire.

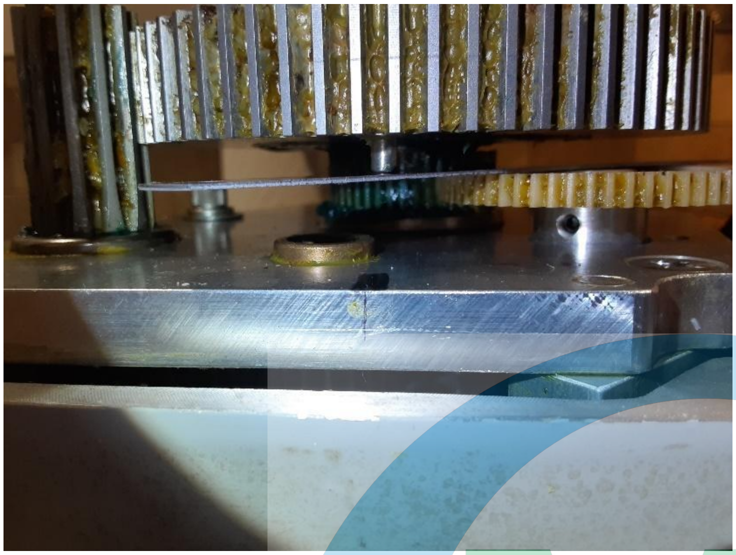

Figure 18 - Roll pin clearance to potentiometer gear

Counter-clockwise rotation is achieved in basically the same manner, except that the incoming 35VAC is supplied via the WHT 18AWG wire from the cable through the CCW limit switch to a BLK wire to the CCW capacitor dual quick-connect, where it then flows to the motor on the BLK motor lead connected to the same dual quick-connect, feeding that set of motor windings. In a manner similar to that of the CW circuit, current also flows through the two capacitors in series and to the second set of motor windings, again out of phase with the directly-fed current, and causing the motor to begin to turn in the CCW direction.

When the output spur gear rotates far enough for the protruding roll pin to touch the limit switch actuating lever and thus to operate the limit switch for that direction, the incoming current path will be broken and the motor rotation will cease. In that case, the only motion possible would be in the opposite direction through the opposite limit switch, which is still in its NC condition.

The rotational speed of the drive motor is controlled by the user via potentiometer R14, a one megohm linear potentiometer on the front panel. That pot and part of the LM324 quad operational amplifier, through the 2N2222A transistor Q1 and the T2500B triac Q2, handle the translation of the user speed input into active circuit control for the motor speed. The motor common wire is returned to the controller through the triac. A 335µH coil L1 is in series with the triac, making the ground path for the motor common, and a 0.047µF capacitor C5 is across the triac to shunt off noise.

Now let's go back to the position-reporting potentiometer (Figure 13). According to the Owner's Manual that was brought to me with the rotator, the potentiometer is wired with the BLU wire to the high resistance end, the GRN wire to the low resistance end, and the YEL wire to the wiper. However, upon opening up the motion unit, it was wired differently, with the YEL to the high resistance end and the BLU wire to the wiper. The GRN wire was in the position indicated in the manual, at the low resistance end of the potentiometer. Because the active resistance between these two dislocated wires is measured between the wiper and the upper side of the pot, it really does not matter which wire is in which position. It *would* have made a difference if the upper and lower ends had been swapped, but that is not the case here.

When installing the driven gear onto the position-reporting potentiometer shaft, be sure to seat the gear all the way down on the shaft. It should end up with the gear hub face almost flush with the end of the shaft. This is important because of the limited clearance between the limit switch actuating roll pin and the upper face of the driven gear. When the gear is properly installed, there should be about three sixty-fourths of an inch – about 0.047” – as evidenced in the photo in Figure 18 , where I have laid a 0.045” thick steel rule across the gear face and under the end of the roll pin.

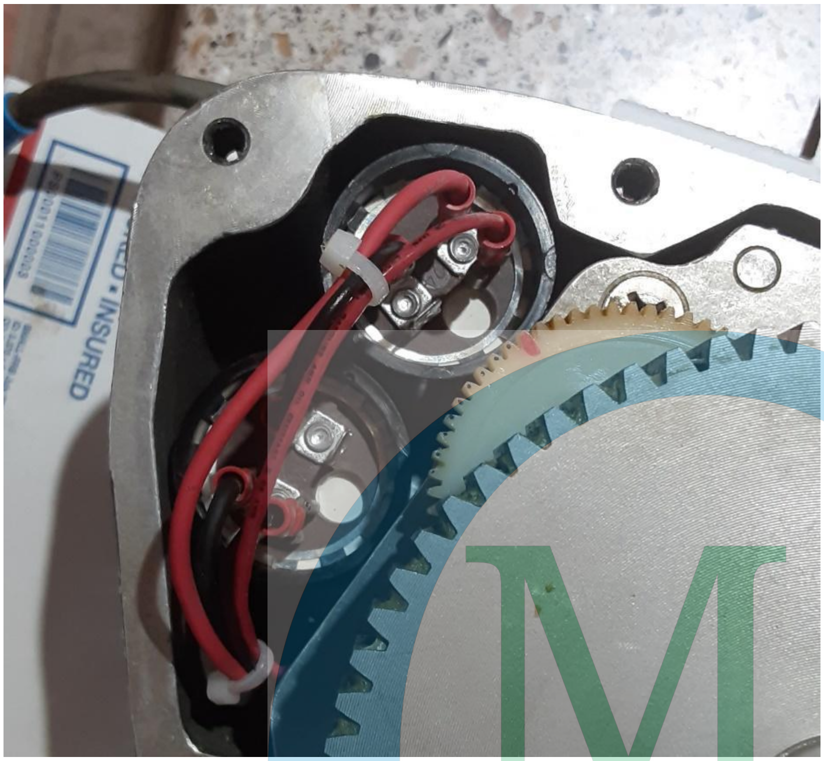

Figure 19 - Capacitor leads connected

After the RTV under the capacitors has cured, the wire leads from the limit switches and the motor can be connected to the capacitors. One capacitor will get both RED wires, connected together on one of the dual quick-connects. The other capacitor will get the two BLK leads, again both connected together to one of the dual quick-connects on that capacitor. A jumper wire is then connected between the empty dual quick-connects on the two capacitors, effectively connecting the capacitors in series. Because these capacitors are non-polarized, it does not matter which connector is chosen for each connection, so long as the leads are connected correctly on each capacitor, as shown in the photo in Figure 19*.*

Inspect the mating surfaces of both halves of the motion unit housing castings, making sure that there is no damage that would preclude direct and complete face-to-face contact of the halves when joined. If any such damage exists, carefully and lightly file the high spots down, being sure not to go below the line of the mating face. Carefully remove any paint and/or sealant that may remain on the mating surfaces, and then thoroughly clean both mating surfaces with denatured alcohol to remove any oil or grease residue that would prevent bonding of the RTV sealant that will be applied there shortly.

Apply a liberal coating of bearing grease to the meshing teeth of the output spur gear, both at its drive pinion and at the potentiometer drive area. Apply a film of bearing grease to the thrust face of the output spur gear, around the output shaft, and apply a film of bearing grease to the pilot end of the drive pinion. Next, apply a liberal amount of grease to the insides of the bearings in the opening of the upper half of the housing, as well as a light coating into the pocket bearing that will accept the pilot on the end of the drive pinion.

Give the mating faces a final wipe-off with denatured alcohol, and then apply a *very* thin bead of RTV sealant to the lower mating face – the one with the gearset inside it. Lower the upper housing half into place carefully, without touching the mating surface, and set it in place on the lower half. Install the socket-head capscrews and split lock washers, tightening the capscrews incrementally and in a criss-cross pattern so as not to warp the housing. A thin line of RTV sealant should have been extruded out all along the parting line where the two housing halves meet.

Install the output driven hub to the output shaft, being sure to insert the square key in the aligned keyways. Then install the hub retainer cone and the single socket-head capscrew and lockwasher that secure the cone to the output shaft. Tighten the capscrew properly, and the motion unit assembly will be complete. All that remained was to replace the cable connecting plug. As soon as the connector arrived, I installed it to the cable.

Figure 20 - New direction switch

Next to receive my attention was the remote-control pendant. This is a unit used for preselecting an azimuthal direction for the rotator motion unit. It is a fairly simple unit, as is evidenced by the schematic diagram that I drew of the pendant (Figure 23). Primarily, it utilizes an LM358 op-amp, a pair of relays, and one each NPN and PNP transistors, a 2N4403 and a PN2222A respectively. The preset azimuth control is a 5.5KΩ linear potentiometer, which is the only control present. The pendant is connected to the controller rear panel by way of an eight-pin DIN connector on a length of eight-wire cable. I found considerable corrosion inside the pendant enclosure, particularly on the underside of the PCB. That corrosion was easily removed with the brass wire brush, a stiff toothbrush, and some 99.9% IPA.

Figure 21 - Direction switch paddle lever

Some DeoxIT® X10S lube served to free up the potentiometer, which I chose to do because of the scarcity of an exact replacement pot on the current electronics parts market. I cleaned up the carbon track of the pot with some DeoxIT® Gold, and it then worked like new. I probably could have easily gotten by with a common 5KΩ pot as a replacement, especially as the most common pots are 20% tolerance, but the original was easily lubed and cleaned, so I chose to leave it in place.

The pendant cable was in good condition, but the DIN connector was corroded badly between the pins. As a result, that connector required replacement, which I did (Figure 22). I next turned to the pendant PCB. Here again I found two electrolytic capacitors with bulged ends, so I replaced all four electrolytic capacitors in the pendant unit. I re-assembled the pendant and installed a new set of self-adhesive rubber bumpers as feet for the unit, putting that part of the job to bed.

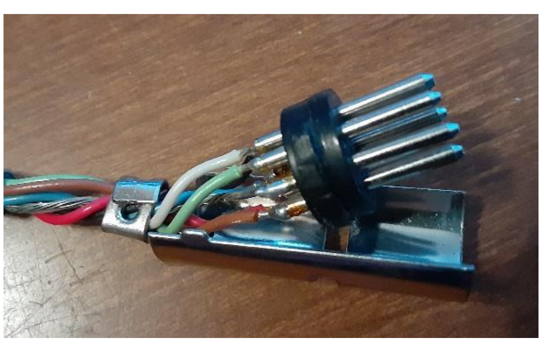

Figure 22 - Pendant DIN plug replaced

The controller front-panel direction control switch is a DPDT paddle-operated rear-of-panel mounted toggle switch (Figure 20), which has a pivot frame mounted to the switch bushing to support the operating paddle (Figure 21). The paddle is a separate part number from the switch, as this same switch body can be used with a number of different actuator types offered by the manufacturer. Because the paddle lever was missing from this unit upon its delivery to me, I ordered both a switch and its mating paddle lever so that I could be sure that the two parts received would work together. The are dimensional differences between the products of different manufacturers, and the original switch was not carrying any obvious manufacturer's markings. This made it difficult to obtain the exactly correct paddle lever; hence the replacement of both parts of the switch system.

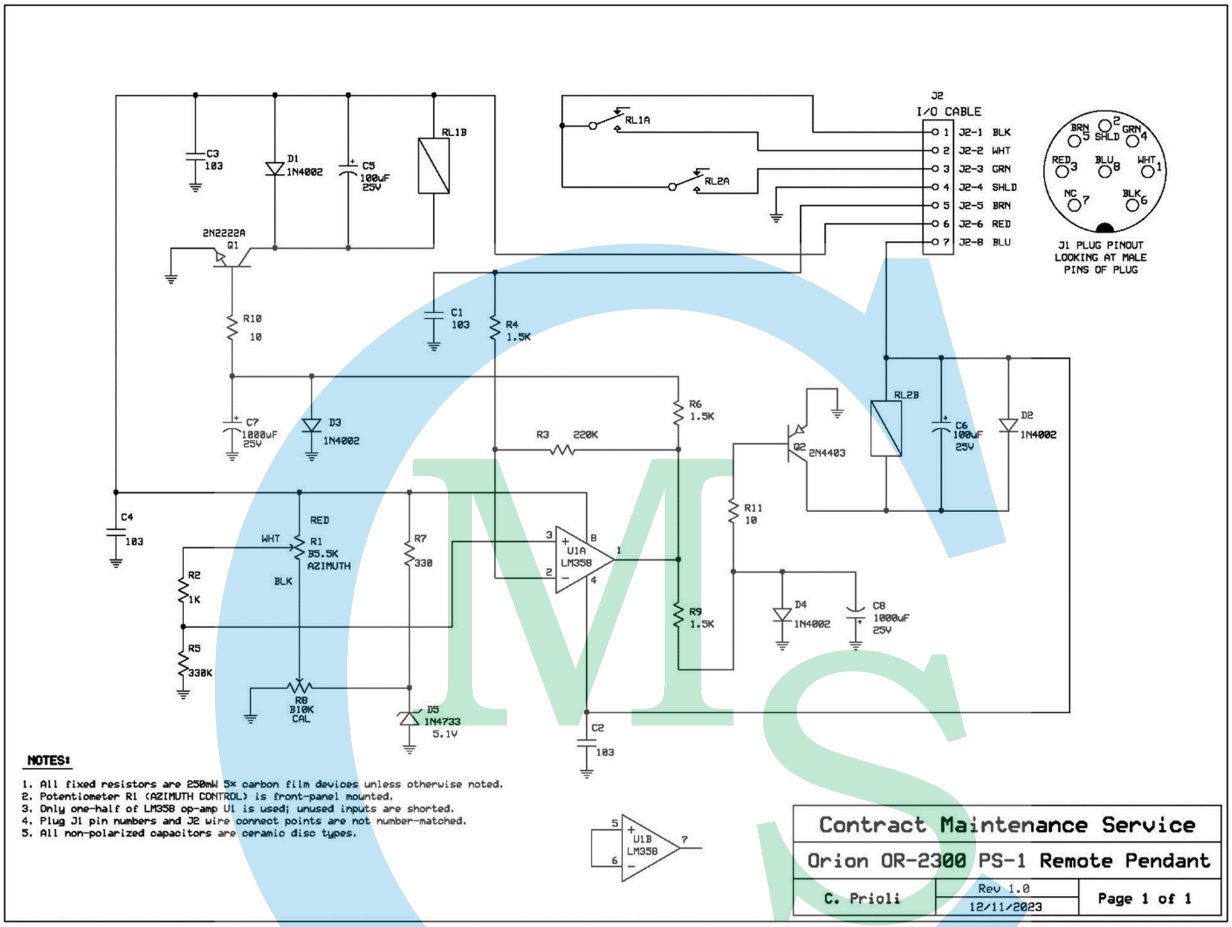

Figure 23- Orion OR-2300 PS-1 remote control pendant schematic diagram

Before the switch is mounted to the front panel, snap the actuator paddle into its support bracket on the switch, being sure to push it straight in at the center so as to engage the switch lever stub into the hole in the center of the back of the paddle lever. The switch should then operate properly as the paddle is moved to the right or to the left.

The switch, being a DPDT switch, has two rows of three wire terminals. Each set of three wire terminals in a row make up the complement for one of the two internal switches in the assembly. In essence, a DPDT switch of this type is like two SPDT switches side-by-side and operated by a single lever. It is important to understand that this switch is a double momentary switch, meaning that it is spring-loaded to return to its center position whenever it is actuated and then released. This is crucial so that the motion unit's rotation will stop automatically when the switch is released.

The important aspect of replacing this switch is to be sure to get the various wires back into their original positions, so that the two circuits through the switch operate together in harmony as designed. In this case, one of the two switches has a WHT wire, a BLK wire, and a GRY wire, with the BLK wire on the center or common terminal. The opposite switch has an ORN wire, a GRN wire, and a YEL wire. On this switch, the GRN wire is on the common (center) terminal, and the ORN is at the same end of the switch as is the WHT wire while the YEL wire is at the opposite end of the switch as is the GRY wire.

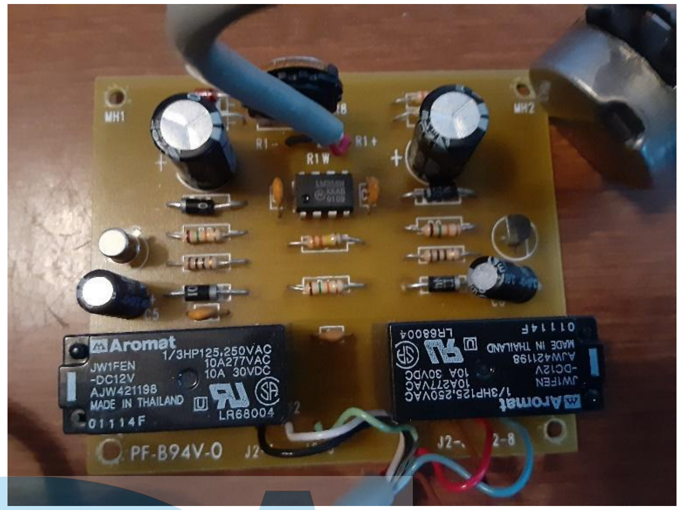

Figure 24 - Pendant PCB post-repair

The GRY wire carries the RIGHT or CW motor rotation current, and therefore must be located to the left when the switch is installed, and as viewed from the front of the controller. After the wires are all transferred to the new switch, install the new switch to the screw studs projecting from the front panel, being sure to place the spacer tubes onto the studs and to install the split lock washers under the hex nuts. Center the switch in its front panel opening as you secure the hex nuts, so that the switch paddle lever does not rub on either side of the opening. It can be tricky to get these hex nuts tight, as the screws are free to spin in their holes in the font panel. This can be helped a little bit by simply pressing inward on the heads of the screws when tightening the hex nuts, right through the panel overlay. The pressure on the head of the screws will help to keep the screws from spinning, allowing the hex nuts to be tightened securely.

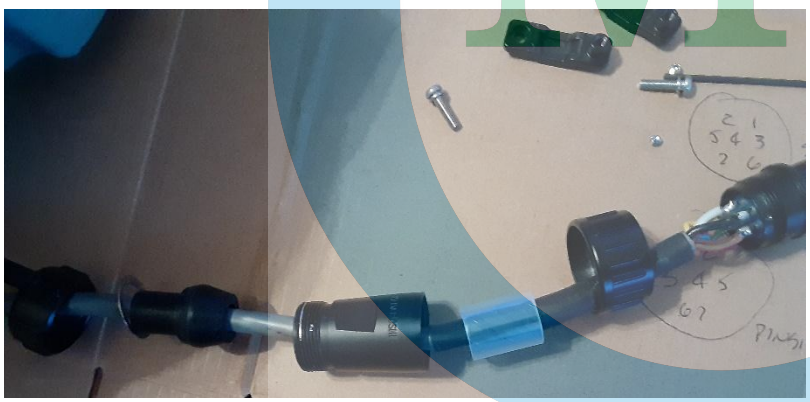

Figure 25 - Motion unit connector prior to assembly

Installation of the panel meter involves removal of the two clamping screws that secure the meter frame to the front panel from behind. These screws are threaded into small steel bars that engage a slot on each side of the meter frame. The meter sits into the frame against the rear of the front panel, and the frame extends out over the meter as a hood. The clamp bars are slipped into the slots on the rear side edges of the frame and are then jacked tightly against the frame slots by the tightening of the screws, pulling the frame rearward against the front panel. Along the top of the meter frame is a sheet metal frame that supports the panel illumination lamps, one on either side of the meter. This lamp frame is also secured by its lower extensions being clamped under the meter securement screws.

When the new meter arrived, I opened up the front of the meter by removing its crystal (lens), to allow access to the dial face plate. I then removed the standard dial face plate from the new meter, replacing it with the original dial face plate from the factory meter in the controller. The crystal was then snapped back into place on the meter, aligning the *zero-set* cam into the *zero-set* slot on the movement. Finally, the meter zero position was adjusted, and then the meter was installed into the controller.

The final repair to the controller was the replacement of the motion unit connector on the rear panel of the controller. This is a Nanaboshi JWC-207-RF receptacle with seven pins in a 20mm housing. This was a straightforward swap wire by wire from the old connector to the new connector, being sure to connect each wire to the correct terminal of the connector. The connector shell is secured to the rear panel of the controller via four 4-40 x ½” machine screws with lock washers and hex nuts. Nothing difficult there, and that completed the controller repairs.

Figure 26 - Motion unit connector assembled

Live testing was a simple matter of connecting the motion system input cable to its rear panel connector on the controller, and then exercising each of the controls in turn to assure their proper operation. However, there was one calibration that was necessary due to the replacement of the meter calibration potentiometers on the controller PCB. The procedure for this calibration, outlined below, is detailed in the controller Owner’s Manual.

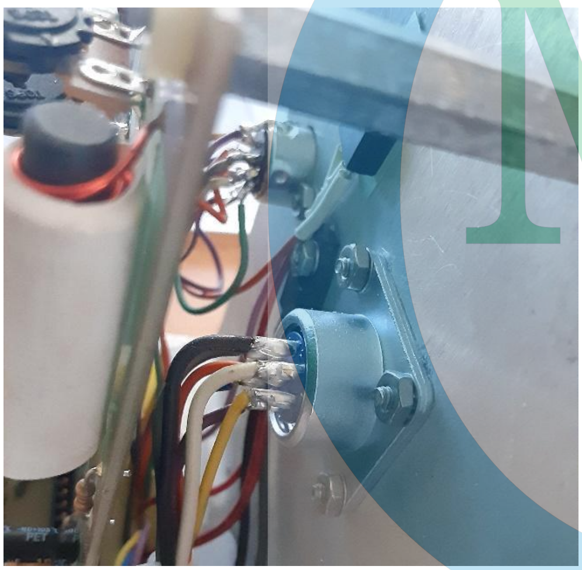

Figure 27 - Controller motion unit connector solder side

The calibration process has the technician setting the 10KΩ pot (R5) to its center of travel. This pot influences the right side of the meter sweep. Next, the 1KΩ pot (R6) is adjusted fully clockwise. This pot influences the left side of the meter sweep. Now the rotator is turned fully clockwise (to the right) until it reaches the limit switch and stops. At this point, R5 is adjusted to provide some “overlap” or passing of the *South* indication on the meter face. Move the rotator fully counter-clockwise (to the left) again until it reaches that limit switch and stops. Adjust R6 to again achieve some overlap of the *South* indication on the meter face by approximately the same amount that it was overlapped on the right. Repeat these steps, adjust R5 and R6 sequentially, until the overlaps on the right and left are equal. Now turn the rotator right until the meter indicates *South* on the right side of the meter, and mark the physical orientation of the rotator. Turn the rotator left until it again reaches the reference mark just made, which will be 360° of unit rotation. Adjust R6 until the meter points to *South* on the left side of the meter, and then turn the rotator right until it again reaches the reference point. Now adjust R5 until the meter indicated *South* on the right side of the meter. Repeat these last adjustments of R5 and R6, turning the rotator each time, until no further improvement of the indication is possible. Finally, it is important that the rotator mount is then physically rotated and installed so that the reference mark is actually oriented directly to the planetary south, in order for the rotator meter indications to be meaningful.

The final aspect of this overhaul was the assembly of a new rotator cable to carry the operational current and the positional signals between the motion unit and the controller. Darrell provided me with about a two-hundred foot length of the appropriate cable, to which I installed the two weatherproof connectors that I had ordered in. These connectors were also Nanaboshi JWC-207 series connectors, one with male pins and one with a female receptacle. This cable is a direct connection lead between the controller and the motion unit, and is best assembled from a single length of cable so as to reduce possible corrosion points in the cable system.

Figure 28 - Controller motion unit connector receptacle view

This turned out to be an interesting and rewarding repair job, made more so by the age of the equipment and the success in bringing it back to useful life. The owner will get to use and enjoy this nostalgic system for many years to come, and I have the great satisfaction of having made that enjoyment and a second life for the system possible.

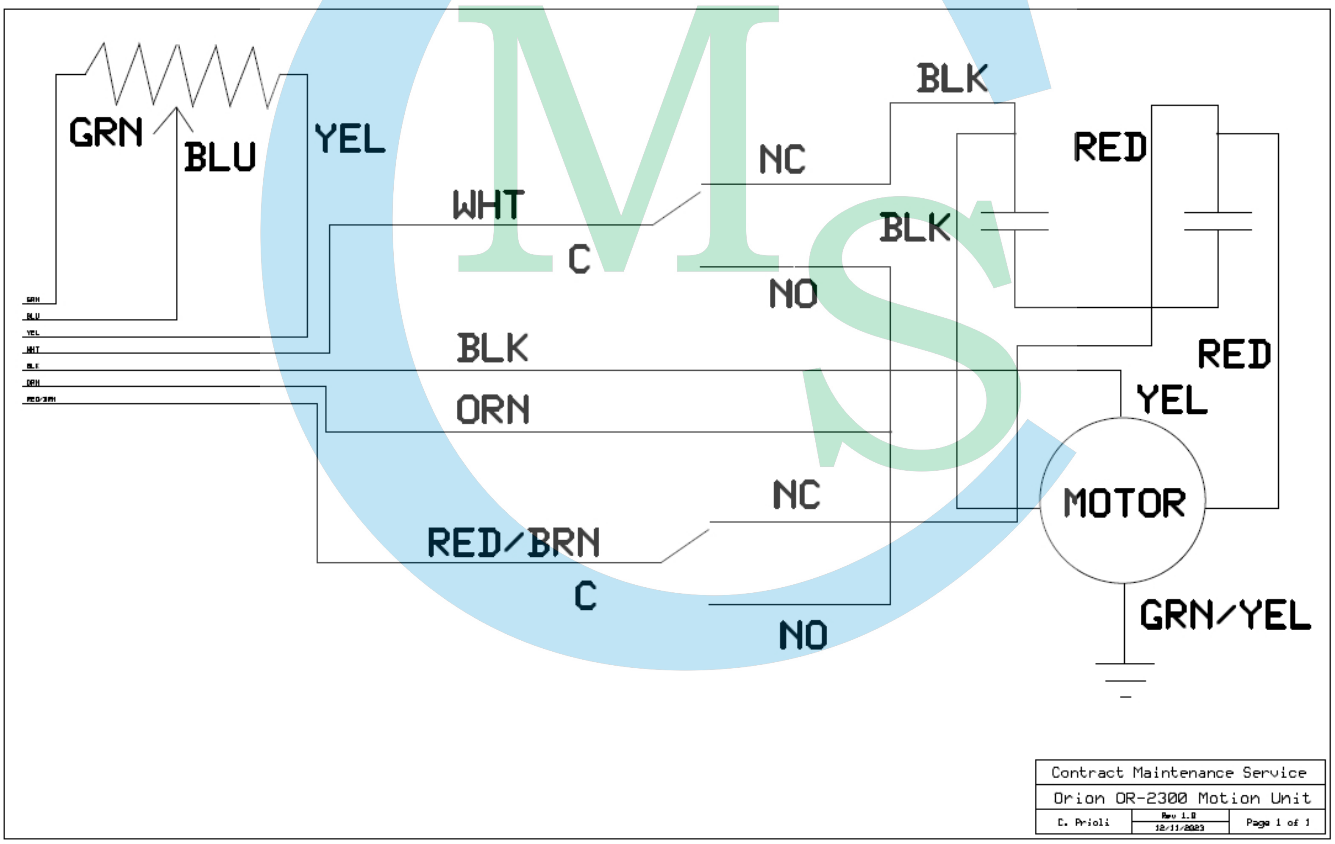

Figure 29 - Orion OR-2300 motion unit schematic diagram