Repairing the *most common* problems on the LX200 Dec/RA drive.

There have been lots and lots of discussions on the problems faced when your LX200 Dec or RA drive doesn't work correctly. The most common of these is 'runaway', or a 'buzzing' of the motor, and the second-most common being a drive that is completely dead.

In this discussion, we'll see if we can cover some ways that you can use to be able to make many of the repairs on these units yourself. There are three things you should know, right from the start.

First, the more familiar you are with electronics and electronic tools, the easier will be the troubleshooting and repair. This discussion is geared toward those with a minimum of electronics background, so for you more experienced people, bear with me.

In order to do the trouble shooting and repairs, you're going to have to be comfortable with using a soldering iron, and also know how to use a multi-meter for checking for continuity, resistance values, and DC voltages.

In the event that you just don't know anything at all about electronics, I'd like to make a suggestion for you. Check with a local electronics supply house in your area and see if they can put you in touch with a local Amateur Radio club.

'Hams', like amateur astronomy hobbiests, are a special breed of people. There are those with minimal skills in electronics, but also those with lots of background and experience, just like 'Astronuts'. Also like the amateur astronomer, nearly all of them will go way out of their way to help someone that needs help, be it in their own hobby or some other. I'm quite sure that you'll easily find several people locally, that would be more than happy to assist you in the electronics needed to repair your scope. It surely beats having to send the parts or the complete scope, back to the manufacturer!

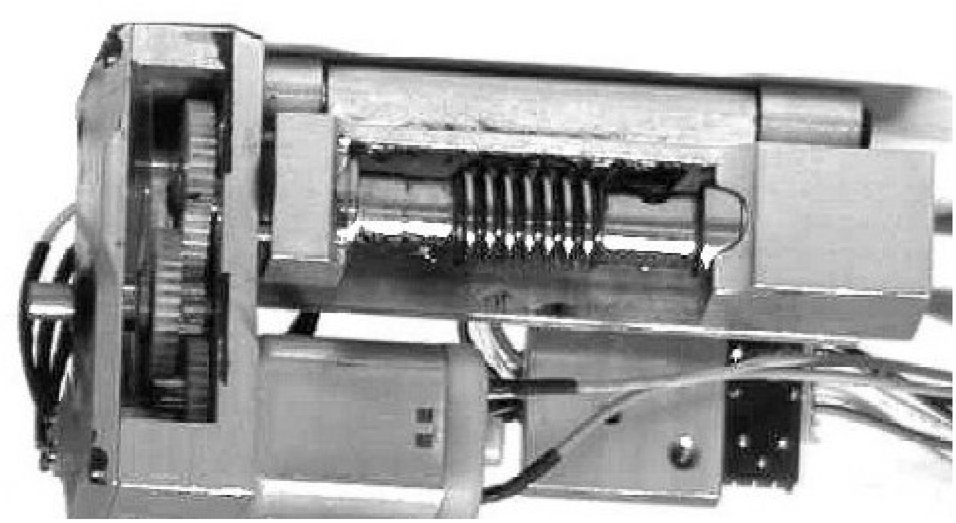
The second you should know is, if you are going to be in need of parts, you're going to find that the online store for Radio Shack <www.radioshack.com> is one of the most convenient places to go to get most of the needed parts. (There are lots of other places as well, but this is a nice, familiar store to most people in the United States.)

The final thing you should be made aware of, is the fact that nearly all questions related to Dec and R.A. drive problems that aren't covered in this discussion, are thoroughly covered in the Meade-Astronomy Topical Archives: <**http://www.mapug-astronomy.net**> as well as in the personal site of 'Doc G' Greiner at: <**http://www.mapug-astronomy.net/ragreiner**>. In fact, there is also a very useful schematic drawing of the drive electronics at Doc G's site as well. This schematic is well worth having. It can be directly accessed at: <**http://www.mapug-astronomy.net/ragreiner/Drive.gif**>

Beginning at the Beginning

How the Dec and RA units 'do what they do'

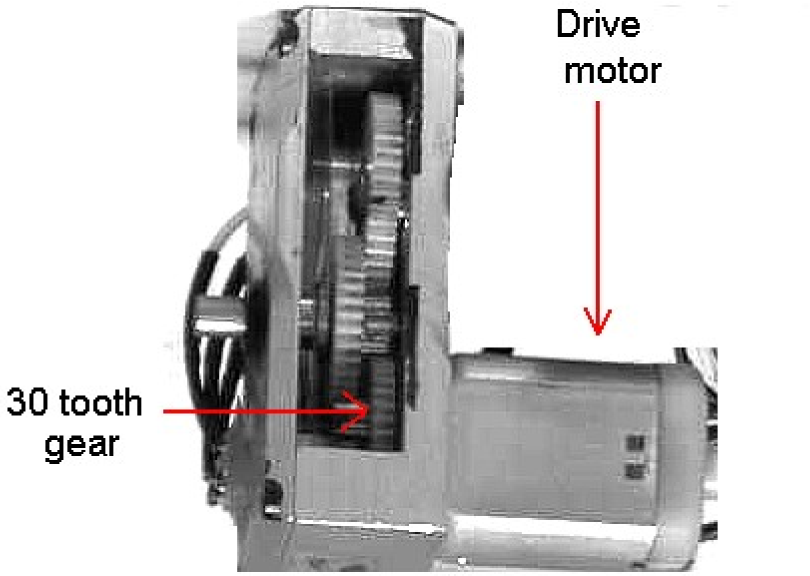
In order to properly trouble shoot and repair these units, we have to have a good understanding of how the mechanics and electronics work, and how the two work together. That's what the following part of this discussion is going to attempt to explain.



This is a view of the gear box for an RA drive assembly. It's identical to a DEC drive assembly except for two small points. The first difference is that the R.A. assembly uses a 'magnetic sensor' that will be soon discussed, and the second difference is that the cable coming from the main logic board has a different type of connector at the far end, than does the DEC assembly.

At the bottom of the image, you can see the small DC motor that drives everything. It has two leads attached to it that lead back to the main logic board in the scope, where the proper voltages are applied to it, depending on the direction and speed that it should be rotating at any given time.

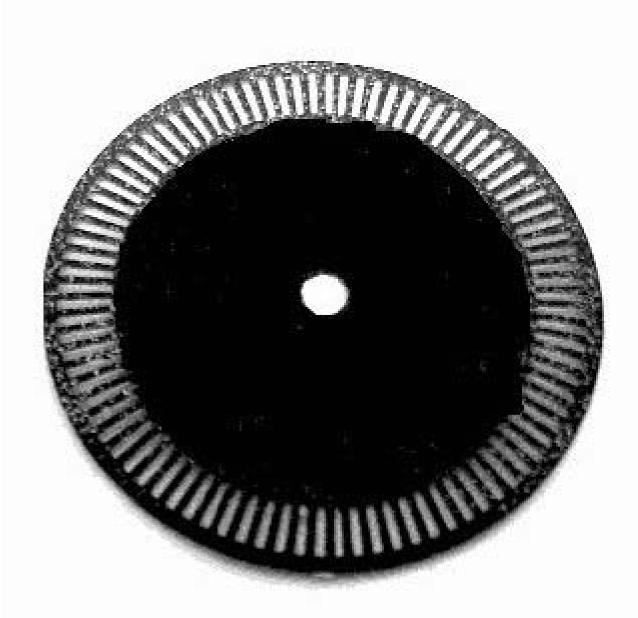
The motor is attached to the assembly by two screws, so that a small 8-tooth gear on its shaft, enters right into the gearbox area, and meshes with a 30 tooth gear. You can't quite see the gear on the motor shaft, but the 30 tooth gear with which it meshes is visible. (You can't see it in real life, either. It's blocked from view by the case.)



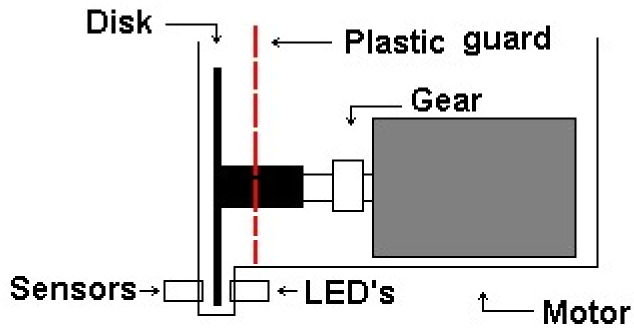
The gear box, by way of the gears shown, reduces the speed of the motor by 60:1 by the time it gets to the worm shown in the previous picture. From there, the speed is again reduced by a ratio of 180:1 by the worm and worm gear. Thus, there is an overall speed reduction of 10,800:1, and and a torque increase of 10,800. No wonder such a small motor can drive such a heavy load!

Not only do these little assemblies drive the RA and Dec, but they also monitor how fast each motor is going and in which direction. ***THAT*** is the area where things get a bit complicated when it comes to repairing the 'runaway' problem.

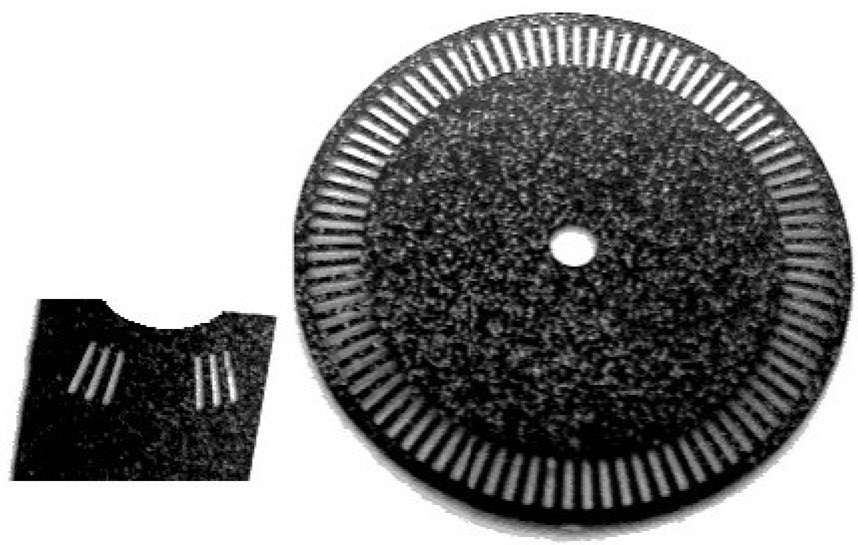
On the shaft of the motor, not only is the small gear mounted, but there's also a 'disk'. It looks like this:



This 'disk' has a lot of slots in it .... 90, to be exact... that are used in the detection of speed and direction as just mentioned.



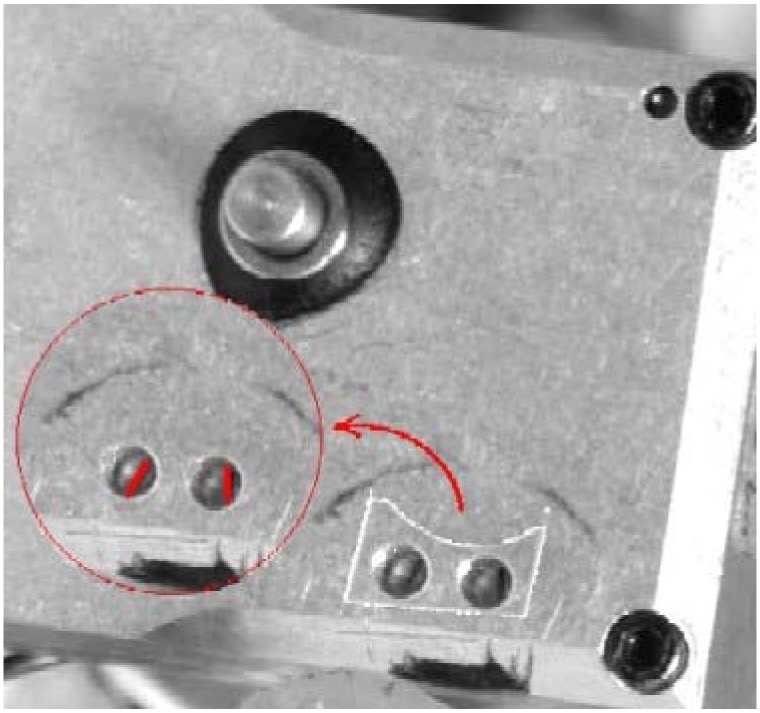
Here's a side view drawing of how the disk is attached to the motor shaft inside the gear box housing. The drawing also shows several extra items. One is a light source, or Light Emitting Diode (LED), the second is a light sensor that can detect the light coming from the LED, and the third is a plastic guard that keeps any grease on the gears from getting over to the sensor area. Actually, there are two sensors and two LEDs, side by side. The light shines through the slots in the disk as it rotates, and on to the light sensors .... almost.



Working in concert with this disk is a 'mask'. The mask has two sets of slots in it. The two sets are offset from each other, as you can see. At first blush, it would appear that the slots in the mask are identical to those in the disk except for the offsets between the two sets. Actually, this is true, but the important thing here, is the fact that the offset between the two groups is quite precise. It causes the two sets of slots to be offset by an additional 1/2 the width of a slot.

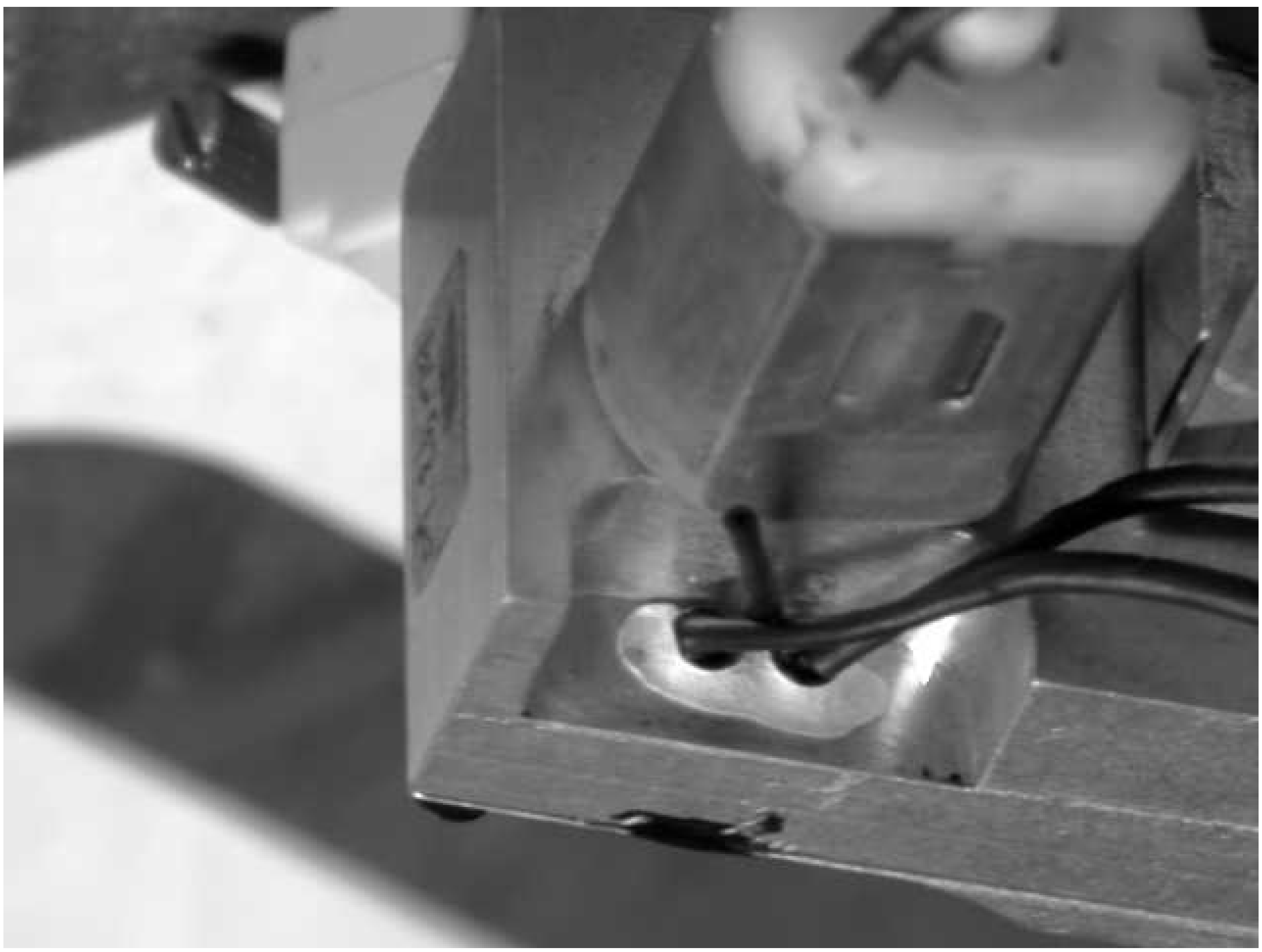
The method in which these parts, as well as the light sources and light detectors, work like this:

The mask is mounted so that each set of slots is directly over one of the holes that the light sensors are in.



Here is a view of the side of an RA gear box. The two holes shown, are the two holes in to which the light sensors are mounted. The slotted mask is installed just ***inside*** of the side piece as indicated by the white outline drawn over the holes. If you look closely, you can see two of the slots of the mask. The inset shows the slots in red, to highlight them.

From the drawing earlier, it should now be apparent that the light that is supplied by the two LEDs will shine through the rotating disk, and as the slots in the disk align with the slots in each sensors' mask, light will fall onto the light sensor.

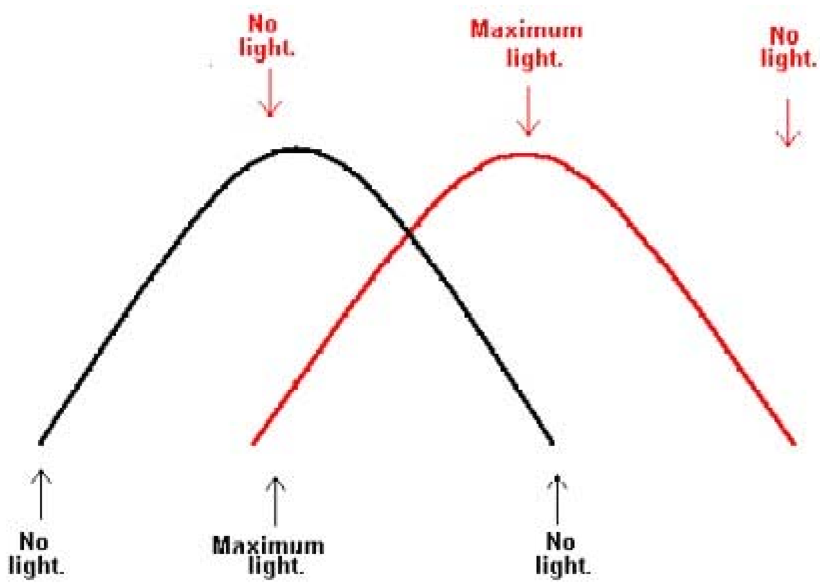


Above, we see the opposite side of the gear box. We can see the location of the two LEDs that supply light through the disk and masks, to the light sensors. They're just below the motor.

Beginning at the Beginning -- part 2

Remember that because of the slight offsetting of the mask slots, the light will be detected by each light detector just a bit out of step from each other.

If we graph the light as a slot of the disk passes each sensor and mask, it would look the following:

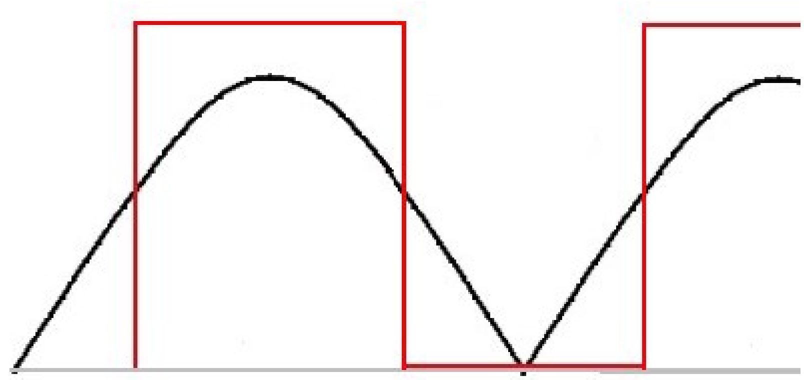


As the slots in the disk begin to align with the slots in one of the masks, the light intensity would begin to increase, as in the black curve. At that time, the slots in the disk haven't begun to align with the slots in the mask for the other sensor.

Time passes (very ***little*** time!) and the light represented by the black line continues to increase. Just as the light in the first sensor reaches a peak, the slots in the disk begin to align with the slots in the mask for the second sensor, so the amount of light represented by the red curve, begins to increase.

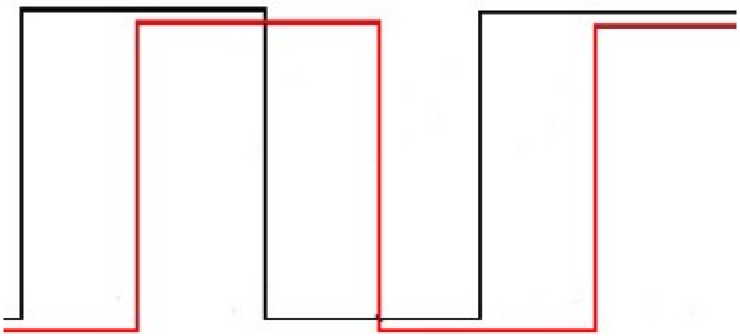
After a period of time, the light in the first sensor has just become fully blocked again, and the light in the second sensor reaches its peak at that same time.

If the light falling onto the sensors is converted into a voltage, then this plot of light intensities would also represent the voltages created. That's exactly what DOES happen.

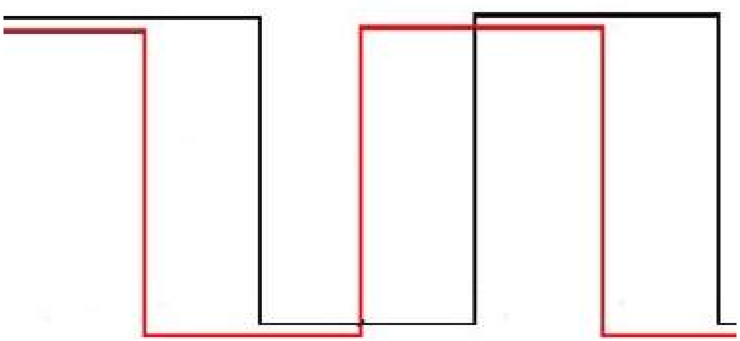


The next step that takes place, is that the voltage from each of the light sensors is fed into a circuit called a 'comparator', and if the voltage is ***below*** a certain level called a '***trigger level'*** ..... which we'll assume to be about half way between zero and maximum possible....... then the circuit will give us a 'low' voltage out. (Zero volts, for all practical purposes.) If the voltage is

above that level, it will give us a 'high' or ***plus*** voltage out. When set ideally, the output will be 'low' for about as long as it is 'high', as shown above. This shape is traditionally called a 'square wave' for obvious reasons (I hope!).



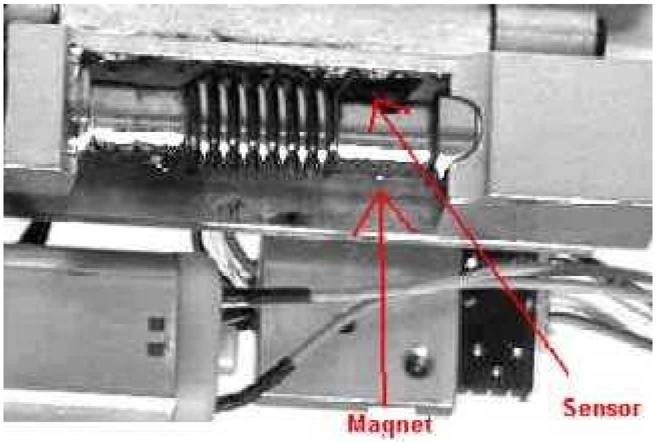
The drawing above shows both of the signals from the light detectors after having been converted to a square wave by their respective comparators. In this image, it's evident that the two pulses are shifted in time from each other. The rising edge of the red image is happening right in the middle of the center of time of the black one. Since in electronic terms, one full signal is considered to be 360 degrees before it repeats itself, we say that the two signals are 90 degrees out-of-phase.



If the motor is running in the opposite direction, then the pulses will be generated with the opposite relationship, where the red square wave now leads the black one, as shown above. Using this relationship of the square waves ... which square wave leads which ... the electronics on the main logic board can detect in which direction the motor is turning. The frequency of the square waves indicates the speed at which the motor is turning.

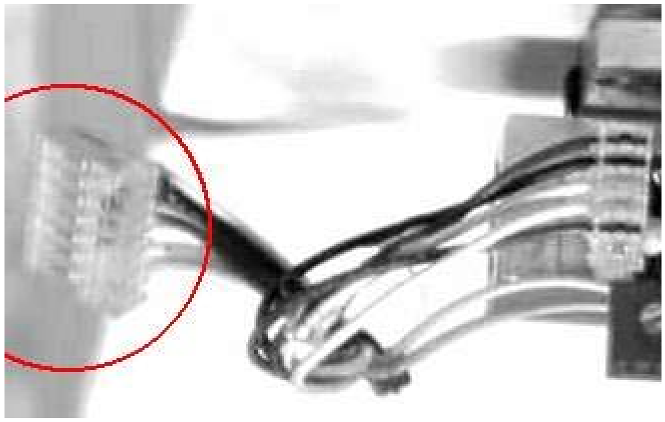
Loose ends ....

Before we leave the mechanical area of the gear train, we'll show the two differences between the R.A. gear train and the DEC Gear train.



On the R.A. gear train only, there is a small magnet mounted inside a hole on the worm shaft. You can just barely see the tip of it protruding from it's mounting hole. Also, glued to the housing, right next to the magnet, is a magnetic sensor, called a "Hall Effect Sensor" that will detect when the tip of the magnet passes it.

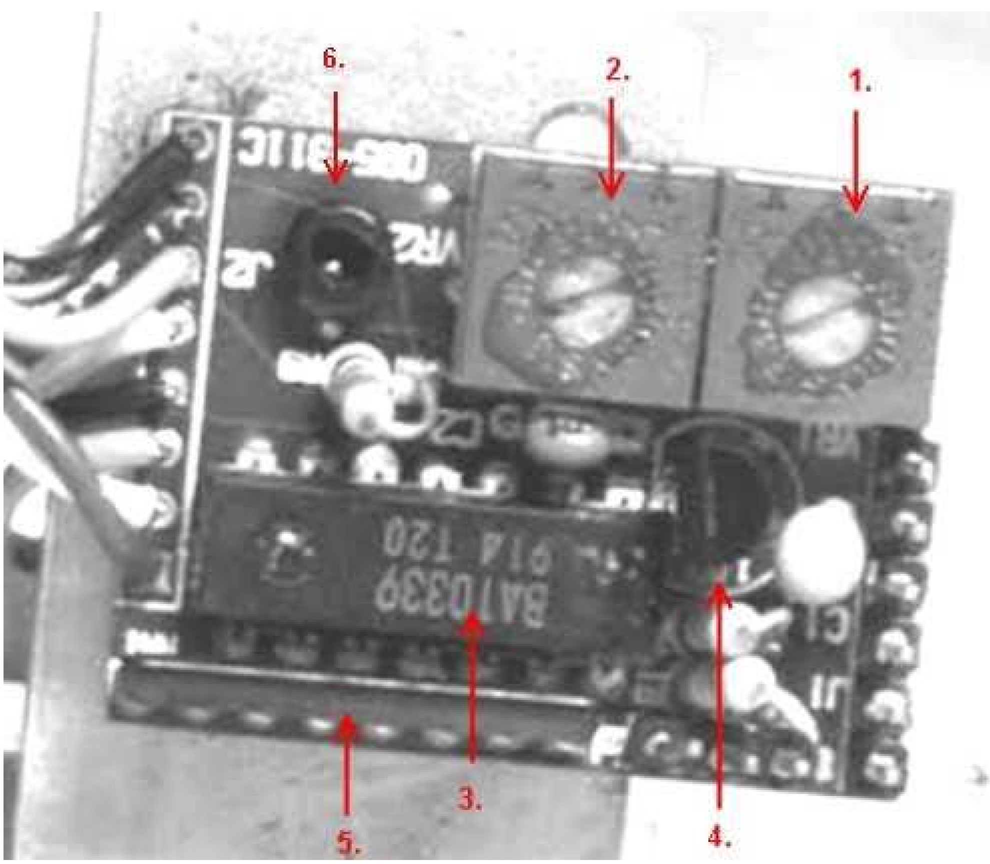
During the power on sequence, after the proper direction and speed of the motor is detected, this magnet is then detected. It's used primarily for knowing when to begin a "Periodic Error Correction" training session, and when to begin to play it back, so that the two places are always at the same point.



The second difference has to do with the cable coming from the main logic board to the assembly. The far end of the cable on the R.A. assembly has a seven pin connector that attaches to the mother board directly, shown above. On the DEC assembly, the far end is a standard 8 pin RJ45 type of male connector that plugs into a socket on the right fork arm.

Onward to the Electronics Board

We can now look at the final general area of the drive units; the small electronics board that's mounted on it, and its components.



In this first picture (shown with the board upside down because that's how it looks when it's mounted) , there are five components that are pointed out so that you'll begin to know the layout of the board. The components are:

1. Variable resistor, or potentiometer #1. This resistor will be used to allow us to adjust the triggering level for comparator #1. (We'll call it the comparator that gives us the BLACK square wave shown earlier.)

NOTE*: The numbers used for the comparitors is arbitrary. They were selected simply as a convenience and have no electronic significance.

2. Variable resistor, or potentiometer #2. This resistor will be used to allow us to adjust the triggering level for comparator #2. (We'll call it the comparator that gives us the RED square wave.)

3. This component contains the two actual comparators that are used in the circuit, comparators #1 and #2. There are four of them in this package, but only two are used.

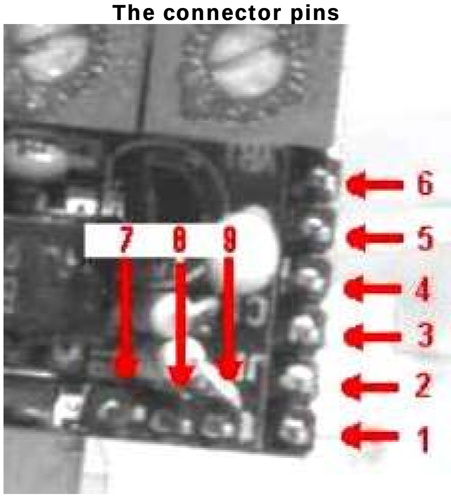
4. This is a +5 volt voltage regulator. The main voltage for the scope, either +18 or +12, depending on the operation of the scope, is fed into this little chip and +5 volts comes out. The voltage is used to power the LEDs and light sensors that are connected to the board.

5. This is a 'resistor pack'. That means that multiple resistors are housed in one package. I show this because some people with limited electronic experience may only be familiar with individual resistors.

6. This is the allen screw that holds the board in place. Beneath it is a small insulator. If the screw is removed in order to service the board, watch for this small circular insulator. It must be put back in place to keep the components from shorting out on the metal plate it mounts on.

There are several more components ... resistors and capacitors ... also on the board, but in general, you won't be dealing with them for normal failures.

The connector pins



The connector pins are labelled down the right side of the image. This list isn't just for general information; you'll want to know their specific purpose when you trouble shoot and repair the unit. The purpose of the pins are:

1. Output signal from comparator #1. It is the 'square wave' signal that's sent back to the main logic board to be used for determining motor speed and direction. (By the description of it's use, this should be a hint to you that it has a *LOT* to do with motor runaway !!)

2. Output signal from comparator #2. It supplies the same information from comparator #2 as does pin #1 for comparator #1.

3. This pin is used only on the R.A. drive assembly, and sends a signal back to the main logic board from the magnetic pickup. When the magnet activates the magnetic sensor, this line will supply a 'low', or zero volts. The rest of the time, it is 'floating', or disconnected.

4. The + 12/+18 volts from the power supply is brought to our board on this pin.

5. This is the 'ground', or zero volt line from the power supply.

6. This line also is the 'zero volt' line from the power supply. However, on any boards that I've seen that are used in the R.A. unit , there is no wire connected to it. This would explain why the mother board connector end of the cable only has seven connections on it.

Notice that there are no pins available for motor connections. Instead, they go directly from the motor, around the connector, and into the cable.

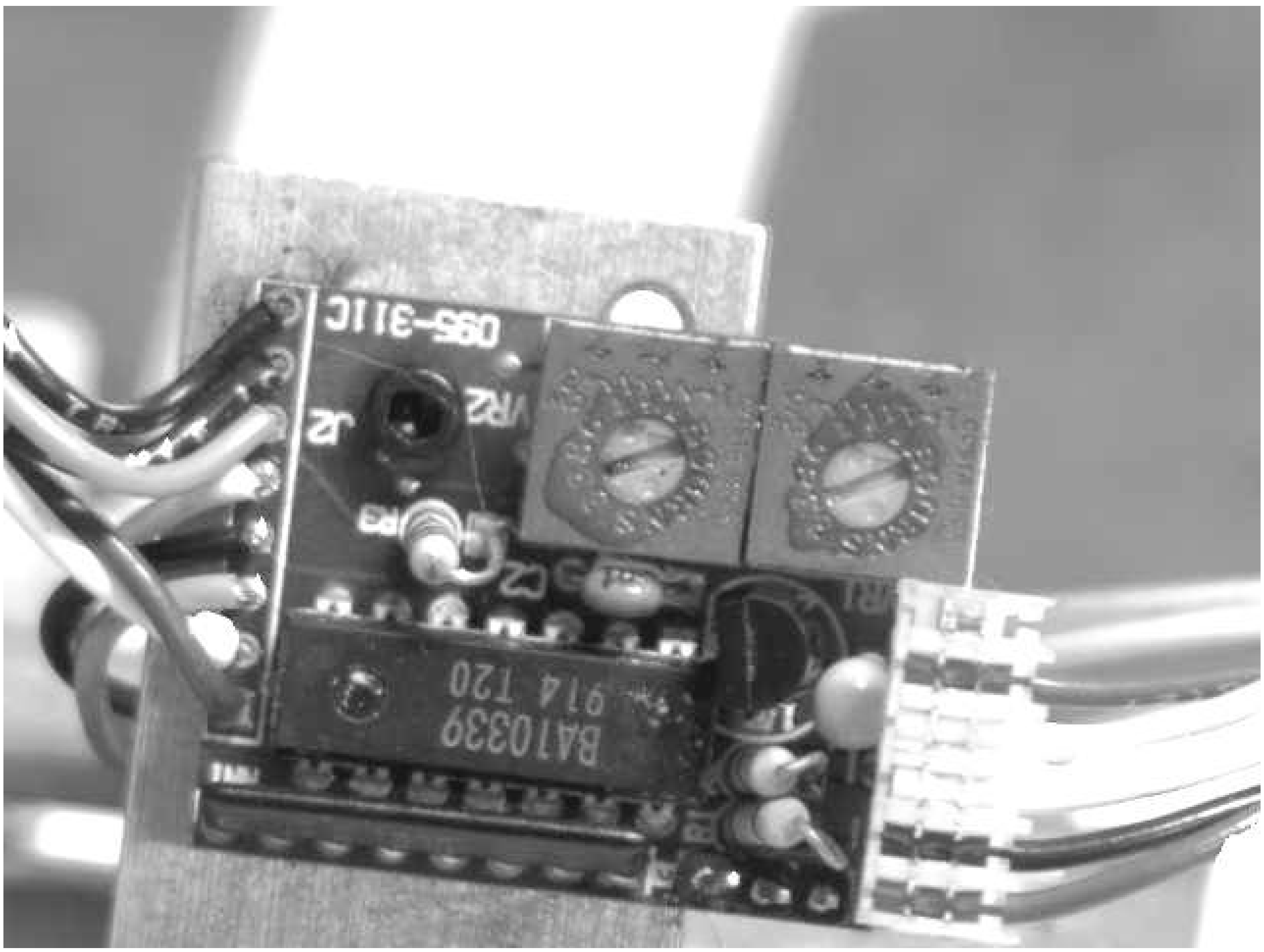
Test point pins

7. Another ground, or zero volt line. It's a convenient place to attach a meter or the ground from an oscilloscope.

8. The output from the light sensor that is the input signal to comparator #2.

9. The output from the light sensor that is the input signal to comparator #1.

Board shown with output/input connector attached.



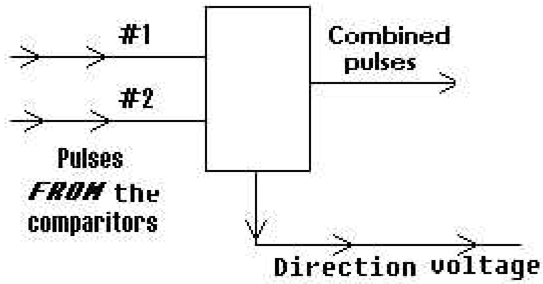
This view is simply to show you the complete board, with the six pin input/output connector attached. (A potential source for problems in itself!!)

How the Main Logic Board 'does what it does'

At his point, we're going jump over to a portion of the main logic board and see how that part works, as ties in with the DEC and R.A. drives, and how they 'talk' to each other. To trouble shoot the scope with any intelligence, we really should know how the timing pulses from the comparators get used to control the scope. When we understand that, a lot of this stuff makes more sense.

Direction and Speed Detection

Let's begin with the circuit that handles the square waves that the main logic board receives from our comparators. In concept, here's what happens:



Both sets of comparator square waves are fed into a circuit that does two things. First, it combines the comparator pulses in such a way that there are actually ***four*** pulses created from one set of square waves. It does this by using the edge, either plus going or minus going, to generate a new pulse. Since each square wave has a leading and a trailing edge, the circuit can create the four necessary pulses.

Second, that same circuitry will 'look' at the relationship between the square waves, as to which signal is leading which. Using this information, the circuitry generates one of two voltages accordingly. We'll assume in this example that if the square waves from comparitor #1 'lead' those from comparator #2, a plus voltage is generated. For the reverse situation, zero volts is generated.

This circuit, then, can detect and create signals that represent the speed and direction of its motor, as we've mentioned before. This feature is then used in the next 'big picture' operation of the scope.

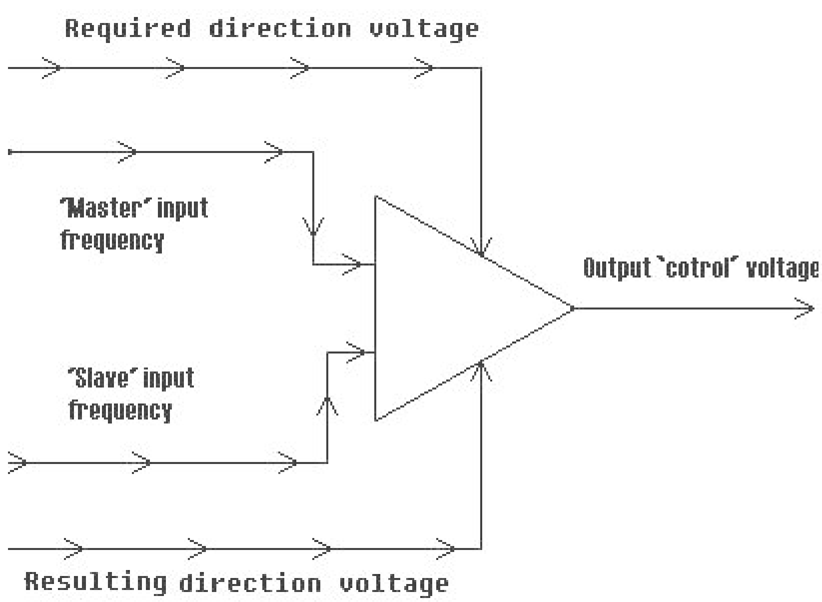
The Phase Locked Loop

When the scope is supposed to make one of the motors move, it does so in a fashion very similar to the principle of the 'phase locked loop'. That's a circuit that's been around for many years, and has been used in automatic frequency controls, FM radio demodulation, disk drive seeking control, and a host of other speed and frequency control techniques. Here's how a Phase Locked Loop works, in general.

A 'master' internal signal is generated, the frequency of which, specifies just how fast something is supposed move. That signal is fed into one input of the Phase Locked Loop (PLL). Another input to the circuit, the one that's being controlled, also inputs a signal that represents how fast it's actually moving. The circuit compares the two frequencies, and if they aren't the same, it generates a voltage that is proportional to the difference in frequency.

Another input from the 'Master' is a DC voltage that specifies in which direction the controlled unit is to move.

The 'Slave' unit also develops a DC signal. This tells the PLL in which direction the Slave unit is actually moving.



When the operation begins, the Slave unit isn't moving at all, so it can't send any input frequency pulses. The control voltage would be rather high in this case, because the frequency difference of the two inputs is high. Then the device begins to move, thus sending back pulses. Immediately, the frequency difference becomes less, so the control voltage will reduce somewhat.

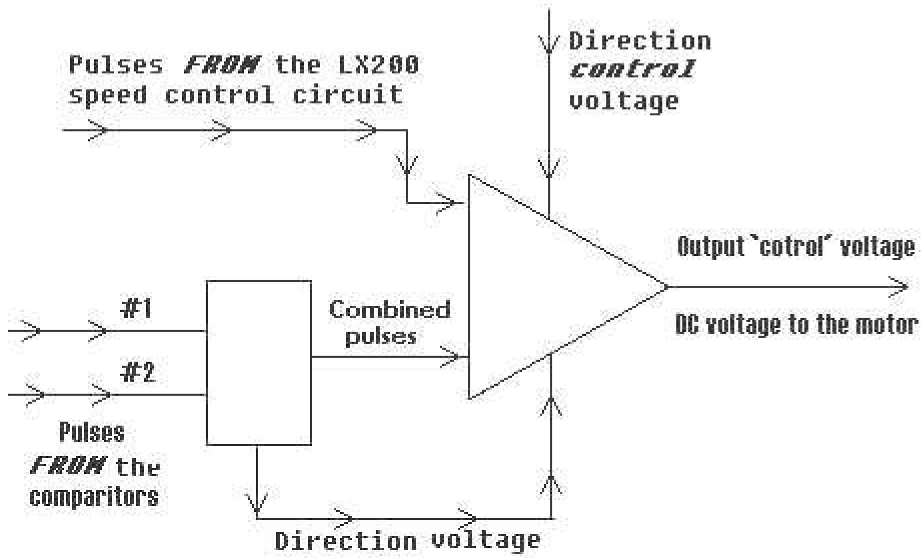
As the unit continues to increase in speed, the frequency difference continues to become less and less, and the control voltage is reduced accordingly, until the Slave is moving at the desired speed. At that time, the control voltage would stabilize, and the device would continue to move at the necessary speed.

If the device happened to slow down, the Slave input frequency would decrease, and the voltage to the device would increase, bringing the speed up again.

If the device began to run too fast, the Slave frequency would become higher, and the PLL would reduce the control voltage until the two frequencies are again the same.

Combining the Two Circuits

The LX200 puts both of these circuit concepts together to control the motor speeds.



As you can see, the circuit isn't really all that complex. It works just like the 'Master/Slave' drive above, but the 'control' voltage now, is the voltage applied to the motor, the "Slave' input frequency is actually the combined signal of the two comparators, and the 'direction' voltage from the motor is the resulting voltage from the circuit that analyzes the comparator square wave phases.

Of course, there is a similar circuit for each motor.

When you look at the concept of the circuitry, you realize that it is elegantly simple. The main electronic board determines in which direction, and at what speed, a particular motor is to move. That having been established, the circuitry generates a frequency that will match the speed requirements and a direction voltage, both of which are sent to this circuit. From there, this same circuit can control all of the motor drive functions for virtually all operations.

For instance, if the R.A. drive is to run at Sidereal rate, the frequency and direction are generated accordingly and the R.A. runs at this rate. If you wish to increase or decrease the speed momentarily, you press the 'East' or 'West' button and the control frequency changes accordingly. The rest is up to this circuit.

In a similar fashion, when 'Periodic Error Correction' is played back, the changes that have been stored will take over the R.A. frequency control and supply any of three frequencies as necessary; Sidereal, twice Sidereal, or none (for an Easterly move).

As a bonus, the pulses from the comparators are also fed to a special counter, and by counting the number of pulses, the scope always knows in which direction it is pointing, to sub-arcsecond accuracy.

Perhaps now, you can see that what ***has*** to be the cause of nearly all motor runaway conditions, is that the comparator pulses aren't being properly delivered to the circuit correctly. If either is missing, the frequencies aren't going to match, so the motor will run away.

'Buzzing' of the motor is caused by the same situation. Apparently, when the comparator outputs are improper, it can make the 'direction' line fluctuate, causing the motor to alternate between forward and backward. I've seen the exact same problem with the comparators cause one symptom, then the other, by switching the scope off and back on. Not always, but often.

A 'dead' motor is not at all likely to be caused by comparator signal failures. As you can see, the circuit should only keep voltage from the motor if either there is no proper path for the 'control' voltage to get to the motor, or if the preceding scope circuitry is telling the scope not to move the motor. In that situation, the problem no longer qualifies as 'most causes' of motor runaway or dead motor.

Now that we've seen how the mechanics and electronics work together and in what fashion, we're prepared to approach the main subject of this discussion; fixing the thing!!

Setting Up for Analysis and Repair

When you approach a problem for analysis and repair, there are several ways of setting up for it. It's going to be a matter of what the problem is and what it takes to fix, that will determine the best method for your particular situation.

In some cases, you can just approach the problem with the suspect unit in place on the scope. That way, all voltages are immediately available to you and it takes no significant setup time.

The next most-easy way of setting up is to remove the drive assembly from its normal position and set it out closer to you for work, while still having the input/output cable connected to it's source. I use this method quite often when dealing with a problem on the R.A. drive, because it's harder to reach anything on it when it's still mounted in place. It can give you quite a bit more room this way, and nearly all failures will still show up in this fashion. (Runaway, dead motor, etc.)

The third method is to remove the unit and it's cable, and take it to an easier place to work. If you do that, you will need to supply a source of power for the motor and board. This isn't as hard as it might sound, because I often use a simple 9 volt transistor battery for powering the electronics, and one or two 1.5v 'AA' or 'AAA' batteries for powering the motor. The two work quite well for nearly all problems.

Finally, if you wish to get rather exotic, you can also make a setup where you have two continuously variable power sources. Again, these could be powered by simple batteries.

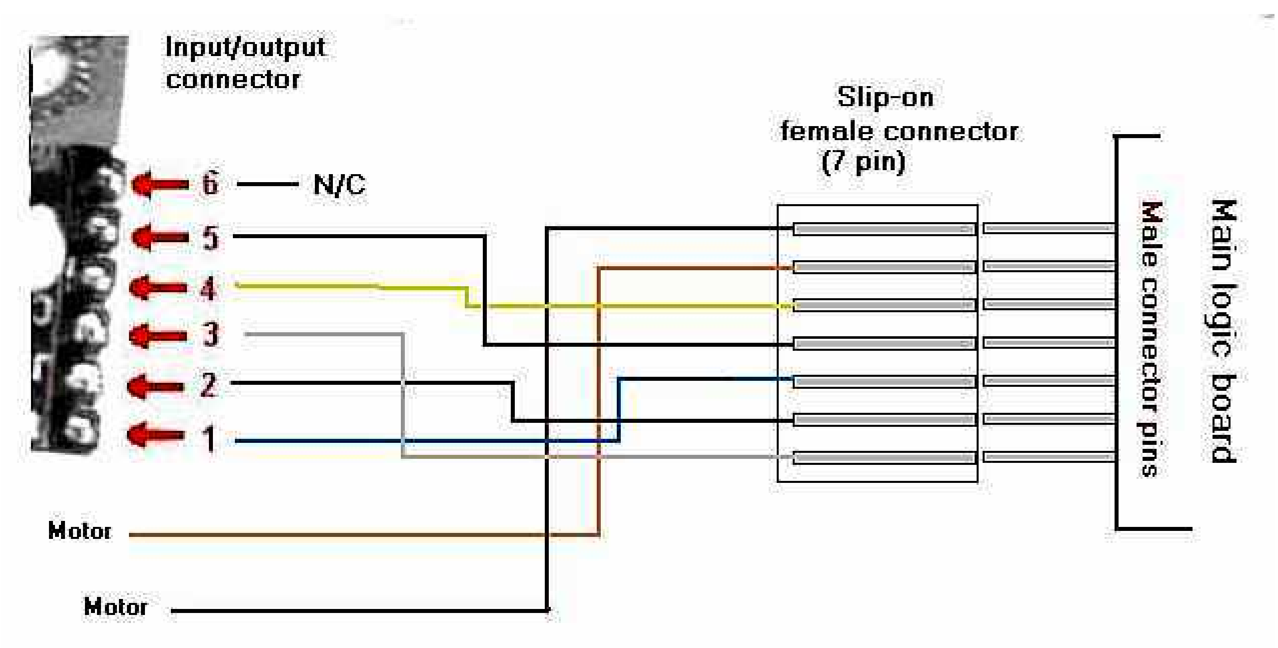
The third way, using just the two batteries, is probably the most versatile for the average trouble shooter. It only leaves you with the question of how to easily connect the batteries up properly. I'll explain what I feel is the easiest way, and from there, you can modify the technique according to your own needs.

The Cabling for the Units

There is a significant difference in the way that the R.A. and the DEC drive units are wired. Being able to follow a lead from one point to the other will make things a LOT easier when you're trouble shooting and repairing. It also can dictate the best way of troubleshooting a similar problem found on both units.

I always recommend that you physically follow a wire from it's source to it's destination and never, ever trust to a wiring diagram or someone else's description of wiring. Still, I'll show you how the units are wired, from the input/output cable connections, down to either the main logic board or the control panel, depending on which unit you're dealing with. But remember; "never, ever trust to a wiring diagram or someone else's description........, etc.", so check it out for yourself!!

The R.A. connection

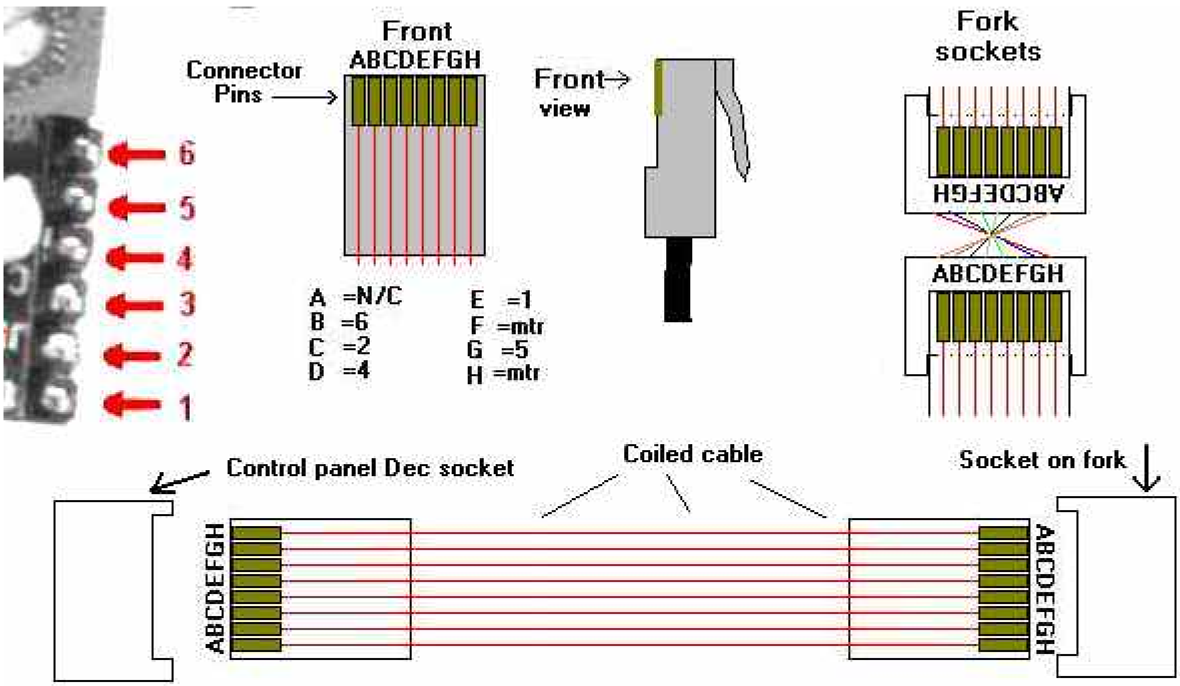


In this drawing, the input/output connector pins are labelled on the left, and the wires that run from them to the main logic board connector are shown.

The main logic female connector is drawn oriented so it's as you would see it with the bottom of the scope removed, and looking directly at the connector! The connector top shown, would be on your left, however.

NOTE!! Do NOT trust that the color coding for the wires is correct!! The colors are the same as on the ones that I have, but they could be different for you. Either physically follow them out to where they go, or use your meter on continuity to confirm which colors go where! Also, when doing this ... or ANY... continuity check, be sure that the cable is unplugged! False continuity readings can otherwise result.

The DEC Connection



This is a drawing of all of the connections, from the Input/Output board, down to the control panel socket.

The very first things I want you to look at, are the representations of the 8 pin connectors in the middle of the picture. We need to be sure we're looking at the same thing and calling it the same name whenever we're talking about connections. The drawing on the left is a face-on view of a typical 8 pin RJ-45 connector. You're looking at the FRONT of it, remember, so what you can also see, are the actual, gold colored contacts. If you took a pin, you could actually touch one if the metal contacts if you'd like.

Okay. That's the FRONT of the connector. Right next to this view, is a side view of the same connector. The FRONT of it is facing to the left, and the gold contacts at the ends of the wires again, could be touched with a pin, from the left side. On the RIGHT side, is the clip that locks this male connector into a female connector when it's plugged in.

Finally, notice how the gold connectors are labelled. They are labelled so that, when viewing the connector from the front, the LEFT-MOST pin is labelled as 'A'. To its right, is pin 'B', and so on. No confusion about how certain companies label their pins with '1' being to the left when held up in a certain way, but as '8' when viewed under ultra violet light. The rules here are simple. "When viewing the connector from the front, with the cable feeding in from the bottom, the leftmost pin is pin 'A'." Bruce Johnston's law.

On the far left are the pins for the input/output connector, with pin #1 being at the bottom, as always. It also happens to be the pin where Comparitor #1 output connects to, to send it's signal back to the main logic board, via the control panel.

Beneath the drawing of the RJ-45 connector, there is a chart. This chart specifies which alpha pin number is connected to which numeric input/output pin. Pin 'A' says 'N/C', meaning that there is no connection to it. This pin would doubtless be used if the Dec drive had to supply a magnetic pickup output, as does the R.A. unit.

Next, over to the right side of the drawing, we see where this RJ-45 connector plugs into one of the female connectors on the fork. Again, our rules for the alphabetic labelling of the pins is maintained.

But then, something odd happens. Between the two female connectors on the fork, between the input and output connectors, the wires are **SWAPPED!** Rather than just passing directly through the fork in the shortest possible path, they crisscross. Whatever signal came in on INPUT pin pin 'A', will **LEAVE** on pin 'A' of the OUTPUT cable. Likewise for all signals and pins.

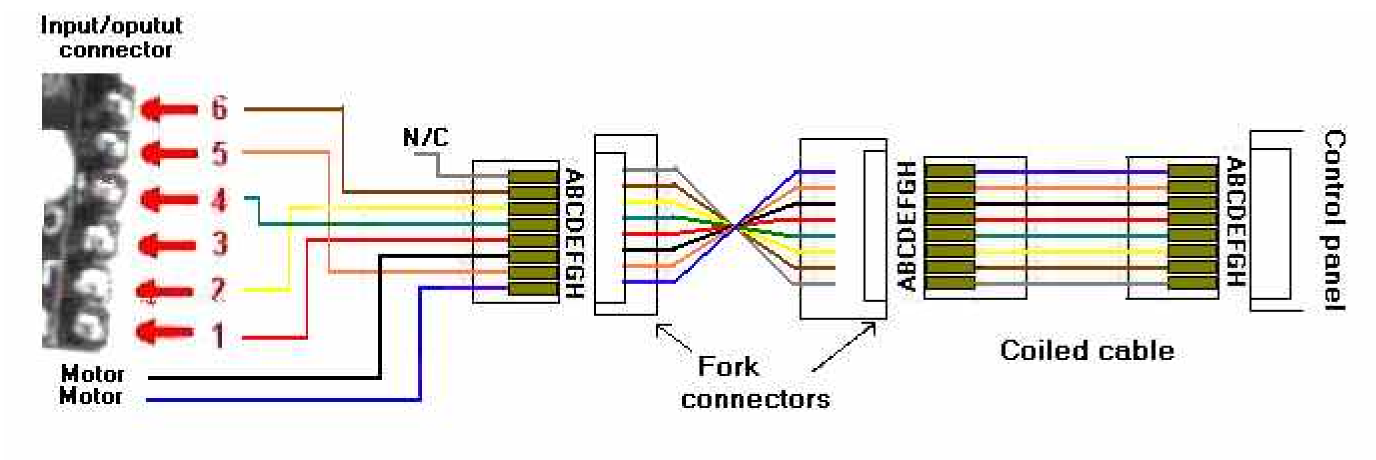
This may sound just fine. 'In' on 'A'; 'Out' on 'A'. What could be easier? We'll see about that.

The cable that gets plugged into the output plug, is the coiled cord that connects to the control panel into the 'Dec" female connector. Still, so far, so good.

The coiled cable is of the type that is a 'straight through' cable, meaning that there are no twists or turns in it along the way. If you follow the lines, you can see that now, whatever comes IN on pin 'A' at one end, runs directly down through the cable, and connects to pin 'H' at the other end, where it then plugs into the control panel.

So? What do we care? After all, I said early on, that a name is just a name, or words to that effect. This is true, just so long as we remember how things are connected. No problem at all...... yet.

Just to make things easier for you to look at, and because looking at cables and connections is such fun, I'll redraw all of the above into a more compact drawing for you.



There. Now it's easier to see the whole thing from the input on the input/output pins, completely over to the control panel. Any given line can be followed from source to destination quite easily.

NOTE!! Do NOT trust that the color coding for the wires is correct!! The colors are the same as on the ones that I have, but they could be different for you. Either physically follow them out to where they go, or use your meter on continuity to confirm which colors go where! Also, when doing this ... or ANY... continuity check, be sure that the cable is unplugged! False continuity readings can otherwise result. **(Does this sound familiar?)**

It's very important at this time that we dwell briefly on a subject that pops up on the internet from time to time. One that, if improperly dealt with, could have potentially damaging consequences.

There seems to be at least a possibility, that somewhere along the line, Meade may have changed the wiring of the first cable, as well as the crossover of the wires that takes place between the female fork connectors. I am unable to find any information at this time that would confirm it, but it is possible.

The reason I say that it is possible, is because on occasion, when a person is having DEC drive problems, a suggestion is made that he/she dismount and unplug the DEC drive unit and plug it directly into the control panel as a test. If it turns out that this is a valid test, then there definitely LX200's out there that are wired different from what I show here. If that's the case, you should confirm which type you have, and that it's the 'other' one, before plugging the DEC unit directly into the control panel.

Let's see why it can be so important: Let's assume that the above drawing matches our DEC unit. If it does, then follow Input/output pin # 4 back to the source. This is the pin that supplies the +12v/+18v to our card. If we follow it back, it connects to pin 'E' on the control panel. Pin 'E' then, is our DC supply voltage.

If we plug our Dec unit directly into the control panel, pin 'E' will match the pin 'E' on our unit, and we'd be connecting the DC voltage supply directly to The OUTPUT of comparitor #1! Not a good idea!

Also, the upper of the two motor control wires works its way back to pin 'C'. Connecting our plug in directly, we apply the motor DC voltage to the output of the OTHER comparitor. As you can see, if you have the type of scope that is drawn out here, you do NOT want to plug your DEC unit directly into the control panel!

I will continue to try to find out what I can about the possibility of a different scope wiring, but in the meantime, I must continue with the assumption that the above drawings are the only correct drawings. If other information arises, I'll modify this writeup accordingly.

Meanwhile, on to more pressing matters.

Powering the Motor

Special note about the motor voltages:

The motor actually receives its power in a way that may seem unusual to some, and this needs to be pointed out before you begin checking any motor voltages. It isn't exactly like the sample above showed you.

Under normal operation, when the motor is supposed to be in the 'stop' condition, there will actually be voltage applied to the motor, but that voltage will be the same value on both sides of the motor. A motor that has 'no' voltage applied to it would actually have about 9 volts applied to both sides at the same time, making the 'difference' between the two voltages become zero.

When running at Sidereal speed, the voltage on one side may be, for instance, +8.5 volts while the other side is at, perhaps, + 9.5 volts. This would result in a voltage 'across' the motor of 1 volt. At a higher speed in the same direction, the voltage on the first side may have dropped to + 7 volts, and the other side risen to +11 volts, giving the voltage across the motor a value of 4 volts.

When the motor is to run in the opposite direction, the same conditions exist, except that the higher and lower voltage values will be on the opposite sides.

By using this technique, the telescope can have 'opposite' voltages applied to the motor to make it turn in opposite directions, while still only having a single power supply, such as a 12 volt battery. One side could have up to +12/18 volts on it, while the other side would have a voltage of zero volts. Then, when high speed slewing in the opposite direction is needed, the first side would have the zero volts and the second side have the +12/18 volts.

The technique used for supplying voltage to the motor is very important to know, when you're trouble shooting a 'no voltage to the motor' condition. Otherwise, you might happen to have one side of your meter at ground potential, connect the other to a motor that is not turning, read a voltage, and come to a wrong conclusion that the motor should be turning rapidly, when actually, both sides have the same voltage and you didn't happen to spot that fact.

You won't be making use of this technique when supplying voltages to the motors, so the only time you'd run into this possible confusion is when you're actually using telescope power to supply the voltages used during testing.

NOW on to how to the subject of powering the motor!

If you're working on the R.A. assembly away from the scope, the easiest way of supplying the motor with the 1.5v battery voltage is to follow the two wires from the motor, down the cable to the main logic board end. Slide the connector off of the main logic board. Then take two short lengths of rather firm wire and stick each into the two connector holes for the motor. To the two wires, solder or wrap, the two wires from a battery snap. This is the same type of connector as is used for connecting to a 9v battery. (Radio Shack P/N 27-325).

Next, take one or two 'aa' batteries and put them into a battery holder (Radio Shack P/N 27-382) and connect the snap to the battery. Presto! 1.5v or 3v power to your motor!

On the other hand, if you're working on the DEC assembly, it's probably easiest to go right to the motor and either skin back a small part of the insulation, or just take two pins and stick them into the insulation until they make contact with the wire inside. Then connect the battery clip wires there. Be sure that the cable from the Dec unit to the fork arm is unplugged. You don't want battery voltage going backward into the control panel.

Powering the Board

To supply power to the board, remove the female input/output connector from the small board, take the same kind of battery snap as above and wrap the red wire to the input/output connector pins , pin # 4, and the black to pin #5 and/or #6. Connect the 9v battery to the clip and you'll have all the power you need for troubleshooting and testing!

Again, I want to emphasize that these are simple methods to get power where you may need it. You may prefer a somewhat more sophisticated method, but this gives you a good beginning point.

Also, remember that you only do these things when you need power. Much of the troubleshooting can be done with no power at all, or possibly only power to the motor.

A final note on supplying power: You could make special connectors that can plug either the R.A. or DEC cable directly into. These connectors would be wired up so that they could not only supply power easily, but I also have the individual wires from the circuit board available, for connecting a meter or oscilloscope. However, unless you expect to be either experimenting or fixing a LOT of problems, it really isn't worth the effort.

Troubleshooting and Repair

1. No power to the motor.

The simplest thing to do first for this problem, is to eliminate the motor itself as the culprit.

The R.A. Drive as the failing unit.

If the problem is in the R.A. drive, this is especially easy to do, once you've taken the bottom off of the scope and have access to the connectors for the drive. Turn off the scope (***ALWAYS*** disconnecting power to the scope!) and dismount the unit. Disconnect the connector from the main logic board and follow the two motor leads back to the connector. Then simply apply battery power to at the connector pins as described earlier. If it runs, the problem is earlier on in the circuit. If not, closely inspect the solder joints on the motor, as well as those right at the mother board connector itself.

Connect your meter to the same two female pins that the 3 volt battery was just in, and switch the meter to 'continuity'. If you read 'open', then wiggle the wires right at the connector, and also up at the motor.

If you still show no continuity, you'll just have to move right up to the motor itself and strip away some insulation from both of the posts for the wires, right at the motor. Connect the meter across the posts. If you still read infinity, you've got yourself a bad motor. (VERY unlikely!)

If the motor shows some continuity, one of the wires between the connector and the motor is bad. FIX IT!

There very few places for this problem to show up without the source becoming apparent quickly.

On the other hand, you may have decided to leave the unit connected to the scope for power while chasing this problem. If so, you still need to get to the motor leads with a multimeter to see if it truly is getting power... and remember the information above. You should be looking for voltage BETWEEN the motor leads, and ***NOT*** from the motor to ground!

Note: If you use telescope power to test for a motor voltage, don't be surprised if your reading is .5 volts or less. That's close to the proper voltage supplied to the motor at Sidereal or guide speed.

Another side point about 'no motor power': You may also want to confirm that there truly is no power by removing the tape covering the gear train, and watching the gears near the motor when you power it on. You should see the gears turn one way briefly, then the other, *VERY* slowly. If you see that happen, you have power to the motor. The point here is, you may think you have no power to the motor only because you don't see movement of the gears. If so, make sure that it is a motor problem and not a 'user error'.

Okay, you've found that the motor itself is good... or you skipped that step.. so you move on to the next step.

Still talking about the R.A. drive, you can measure the voltage being applied, by going to the connector pins on the main logic board. The same ones that you'd have applied the battery to. (Don't forget to connect the cable connector back up to the small electronics board if you removed it.)

The Dec Drive as the Failing Unit

For the DEC motor, because of the type of connector at the other end of the cable, you will need to take a different approach.

1. Unplug the DEC power cable from the control panel. Using your multimeter, attach one lead to one of the motor wires.

2. Take a straight pin and attach the other meter lead to the pin.

3. One contact at a time, check for continuity between each of the eight pins on the RJ-45 connector and the motor lead. You should find one that reads very close to zero Ohms. If you find one, go to step 4. Otherwise go to step 5.

4. Move the meter lead at the motor to the other motor wire. Once again, one contact at a time, check for continuity with one of the contacts on the RJ-45 connector. (NOT the same contact!)

5. If either of the previous tests didn't show you a continuity of close to zero volts, then unplug the fork arm end of the DEC cable from its connector. Repeat the test.

What you've done is, you've checked for an open in either of the cables. If the first cable showed a failure and the second one didn't, you need to plug and unplug it from the control panel and fork arm several times, then repeat the test. If it still failed, then you probably have a bad cable or RJ45 connector. (See further down for possibly repairing the cable.)

Radio Shack doesn't have a replacement cable for this as far as I know, but Digikey does. (www.digikey.com). The Digikey part number is ***H1882-07C.*** It isn't an identical cable, but it's a very nice substitute.

Radio Shack does carry an 8 conductor, straight through cable, but it's flat, and really too long, but if you're in a pinch, you could pick one up at your local Radio Shack store and use it temporarily. (Radio Shack P/N 940-0476. The same one as listed below.)

If both cable tests failed, then you either have a bad connection in the connector on the fork arm or you have a bad cable from there, up to the DEC drive motor. If it's the cable, and if you're not comfortable with crimping RJ-45 connectors on, then I suggest you get with someone who is, and replace the RJ-45 connector on the end of the cable. This requires someone with some experience at crimping this type of connector, because it can be tricky. Also, Radio Shack doesn't sell an inexpensive RJ-45 crimping tool.

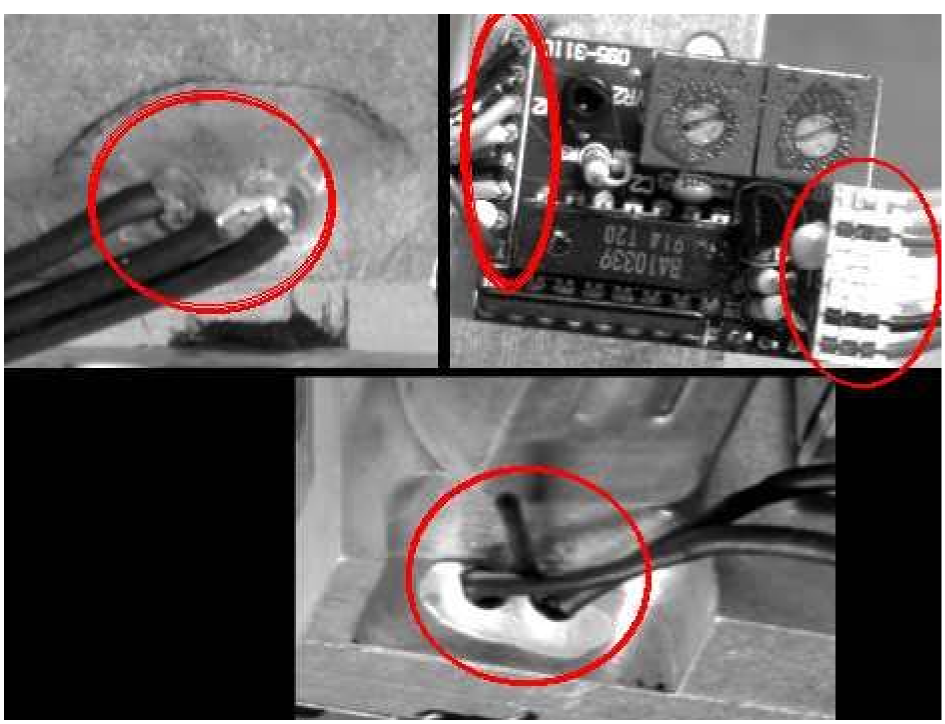
What I would recommend if there is nobody that can replace the connector for you, is to simply buy an 8 conductor wire with the connectors already connected to both ends. (Radio Shack P/N 940-0476, and other similar ones that will work.) Cut one end to the desired length and on the cutoff end, solder each wire to its proper place on the board connector.

Don't trust that the color code on the wire that you bought will match the original one; it probably won't. What you'd do is to look at pin 1 on the original to see it's color, then look at the new one to see what color is connected to pin 1. After writing them all down, remove the old wire from the connector and connect the new wire in its place. Just ***SOLDER*** the new wire onto the original board connector! You'll find that this connector probably should be soldered anyway!

If for any reason, you can't see the color of the wires in either the new or old connectors, use your multimeter and measure which one goes where. Be sure. It's better to be safe than sorry.

2. Motor Runaway

We've seen that if for any reason, the comparators don't supply the main board with the proper pulses, the circuitry will cause motor runaway. The primary cause of this condition is broken wires or poor connections.



Here are the locations where broken connections are most likely to occur, be it for the R.A. or DEC drive units.

1. The three wires connecting to the light sensors, shown in the upper left.

2. The two wires connecting to the LEDs, shown at bottom.

3. Two places on the small board, shown in the upper right image. The left side, where the external components are connected to the board, and the right side, where the wires are attached to the input/output connector.

As you can see, that pretty much covers wherever a wire is making a connection!

When motor runaway occurs, the first thing to always do is to carefully inspect these connections. If you find one that is broken or loose, you've no doubt found your problem. Wiggle the wires. Flex them. Move them around. Chances are extremely good that you'll find a bad connection or cold solder joint at one of these places. (If you ***CREATE*** a bad connection by doing this, no loss. It was ready to break anyway!)

NOTE 1*: You could greatly reduce the chances of ever developing motor runaway if you were to do two things in these areas before you ever develop problems. The first would be to use some hot melt glue and liberally apply it to all of the solder points. Apply enough so that the glue will encompass some of the uncovered wire. This will give it some extra support and help prevent wire breakage.

The second thing applies to the solderless input/output connector. Grab a soldering iron and some solder, then solder the wires to their connectors! The solderless type of connector as is used for this connector, is best used where there is no strain on any of the wires or connectors. By its very nature, there is always stress on these particular connections. You need not make the connections neat or pretty; just be certain that there is a good physical bond between each wire and its connection.

If you wish, you could eliminate the solderless connector altogether and solder each wire to its terminal on the board, but it isn't necessary. A good bond between wire and connector will be fine.

NOTE 2*: I think it is worthwhile at this time, to point out that from my personal experiences, as well as those that I've seen show up over time on the 'net, that poor connection between the wires and their connectors in this particular junction, accounts for the majority of intermittent motor runaway problems. That is, those problems that never really seem to get repaired completely, until they're sent back to the manufacturer for repair.

The second-most common spot for intermittent problems will be pointed out further on in this discussion.

Fixing the problems

Fixing the first problem

Okay! We've found our first problem! We've found that there is a wire broken in the bundle of wires on the left side of the board where the external components connect to the board. How do we best repair this particular problem?

The first thing to do is to remove the board from its mounting by removing the single allen screw holding it into place. (Be sure to watch for the small circular insulator under the screw.) Flip the board over and you have access to where the ends of the wires pass through the board. Then, using some 'Desoldering Braid'.. (Radio Shack P/N 64-2090) .. press the very end of the braid against the solder holding the remaining wire piece in place. Heat the braid with your soldering iron and, as the braid heats, it will begin to draw the melting solder from the hole and into the braid.

You may well have to move the braid a bit as it absorbs solder, but continue to do so until you can at last manage to remove the excess wire from the hole with some needle nose pliers.

In case I've gotten ahead of myself and you aren't familiar with desoldering braid, it is a very finely braided copper wire that when held against melted solder, will soak it up like a candle wick. The braid is quite inexpensive, and in general, will do a much better job than will a more expensive 'solder sucking tool', that is used to 'suck' the solder away from an area.

Back to the repair: With the hole now cleaned of excess old wire, you can strip a small portion of wire from the remaining wire. Then, apply a small amount of solder to the exposed end to give it some strength, and insert it into the hole you've just cleaned. Apply a small amount more of the solder from the bottom side of the board and you've fixed your runaway problem!

You'll notice that we didn't even identify which wire it was that was broken. That's because common sense tells us that we aren't likely to have two wires broken at the same time. Even if we do, it needs to be fixed anyway, so repair that one before looking for more.

This approach is used for any of the wires in the bundle of wires on the left side of the board. Find the broken wire, remove the board and flip it over, suck away any excess solder so as to get a nice, clean, open hole for the wire, then strip a small portion off of the original wire, 'tin' it and insert it into the newly cleaned hole, and solder it into place.

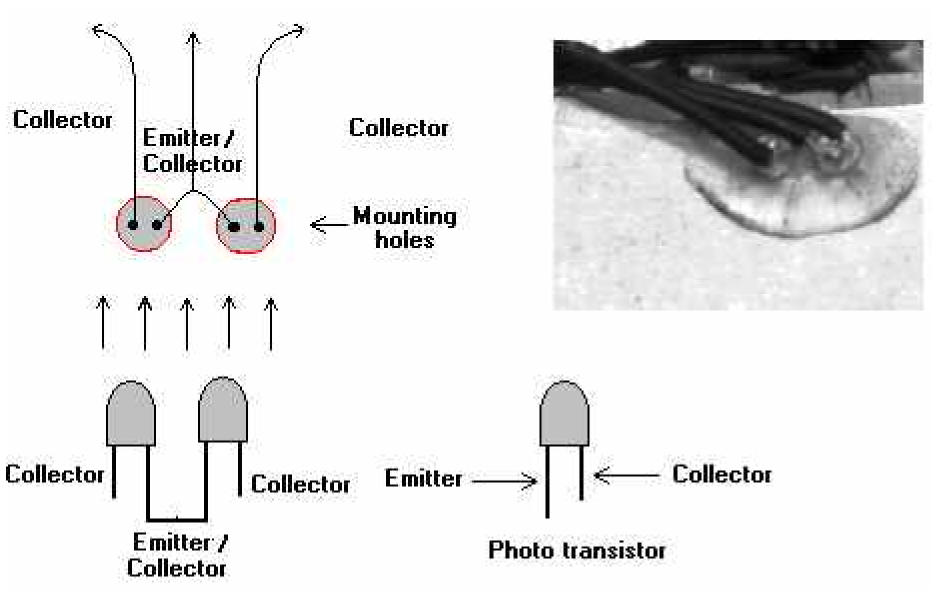
You might find that while making the repair, you accidentally broke off too much of the original wire to be able to get the slack in the wire that you need, in order to re-mount the board. If that's the case, simply use some extra wire and solder, then tape, some wire to the original wire and go from there. Personally, I suggest you use a smaller, more flexible wire if you need to extend the original. That may well be a part of why the wire broke in the first place; it was too stiff. For repairs on these units, I generally just buy a four wire telephone cord and strip out one of the individual wires. But that's a trivial matter as to what kind of wire to use.

Fixing the second problem

Rats!!! As luck would have it, your next problem is the first in a series of problems that strikes fear in the heart of every LX200 owner!! You've found that a wire is broken again, but this time, it's a wire that attaches to one of the light sensors!!!!! Worse yet, the wire is broken off right at the sensor!!! NO WAY can this be soldered!!! The situation is hopeless!!

Fear not, because with a little bit of luck, we can fix the problem with a minimum of hassle and be running again in no time! (Even with absolutely ***NO*** luck on our side, we can still fix it. It just takes one or two extra steps, is all.)

What you need at this time, is a good replacement part for the photo diode, or light sensor, that is broken. We'll use a more modern replacement part for the photo diode. We'll use an infrared photo transistor to replace the old part. It's even the proper size, too; 3mm in diameter. Just to standardize the parts in the repaired unit, replace both of the sensors at the same time. They're inexpensive enough; $0.49 each, American. (Radio Shack P/N 900-6133).



Here, we can see what we need to know about the new sensors, in order to use them. First, we can see that each sensor has a longer and a shorter leg. The longer leg is the 'emitter', and both of the emitters will be soldered together. The remaining leg is the 'collector' and will be mounted in the mounting holes as shown. That is, the left sensor will have its collector mounted to the left side of the sensor, and the right sensor will have its collector mounted to the right side of the right hole.

With the original parts, they, being diodes, had a 'cathode'.... the equivelant of our new 'emitter'... and an 'anode', which is now being replaced by the 'collector' on the new units. For all practical purposes, the two units will be connected up, and will function identically, as the old units. What's in a name, after all?

Before you do anything else, follow the wires from the old components, up to where they connect on the board. We see that, like the components that will replace them, they have a common lead. That is, their 'cathodes' are soldered together.

The wire that runs from the junction of these two leads, presently connects to the second hole down on the left side of wires on the small board. The left-most component has it's left leg connected to a wire that connects to the 7th, or next-to-last connector on the board. The right-most component has it's right leg connected to a wire that connects to the 8th, or last, connection on the board. You can't see the board in this picture, but I thought I'd be nice and tell you, in case you had problems following the original wires out.

When you're done, the wires and the mounting of the new components will look just like the original did. Same wires going to the same holes, components fitted into the same holes on the housing as before. Also when done, the components will even look the same as far as how they're glued into place.

The replacement process is quite simple. First, remove the small electronics board and flip it over, as in the previous example. Using the desoldering wick, unsolder and remove the three wires that feed down to the sensors. Next, remove the existing sensors.

<u>NOTE</u>*: ***If at all possible, you want to remove all of the remains of the sensors and glue without having to disassemble the gear box. Depending on the type of glue that was used, you'll likely find that alcohol or acetone applied with a q-tip will aid in loosening the glue and allow for complete glue removal. Take the extra couple of minutes to make sure you've got all of any broken pieces of sensor removed. Even use a straight pin or a small crochet hook to dig out all of the excess sensor and glue. You don't want any of it sitting inside the hole between the actual sensor and the mask that covers the hole on the inside.***

Temporarily mount the sensors into the holes for them and confirm that you have plenty of room to solder the three new wires to them. Be especially sure that you have the two 'emitter' leads soldered together before you solder the wire to it.

As you mount the sensors into the holes and after having already soldered the wires into place, coat the 'wire' ends of the sensor blocks liberally with epoxy, hot melt glue, or whatever type of bonding agent you wish to use. Insert the sensors only about ***1/2*** the length of each sensor, into its mounting hole and let the glue dry. You only want to insert about one-half the length of the sensor into the hole because the sensor body itself, is long enough to be pushed a bit too far into the hole, and make contact with the light mask. That, you don't want.

Be gentle when first inserting the transistors into their holes. The metal mask inside is thin, and it wouldn't take much stress on the sensor against the mask, to deform it.

When the glue has dried, it should look much like the original layout, shown in the previous drawing, with lots of glue covering the metal portions of the contacts.

As before, I suggest you add a bit more hot melt glue than is necessary, for holding the components into place. That way, if one of the leads should ever break again, you'll be able to peel back some of the hot melt glue and be able to access the broken metal tab directly, without having to replace it.

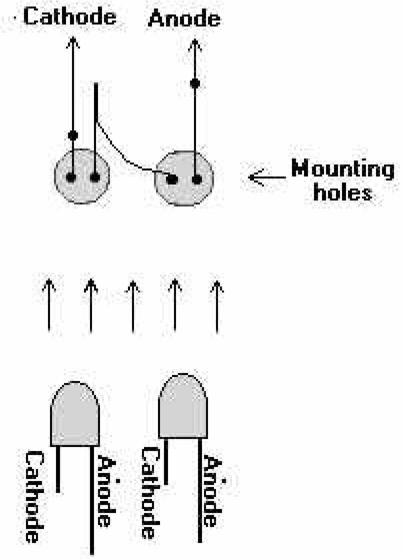
There is just one more thing that has to be done in order to be up and running, but let's kill two birds with one stone. Let's see about replacing another part first, since this 'minor' little detail has to be done in that case, too.

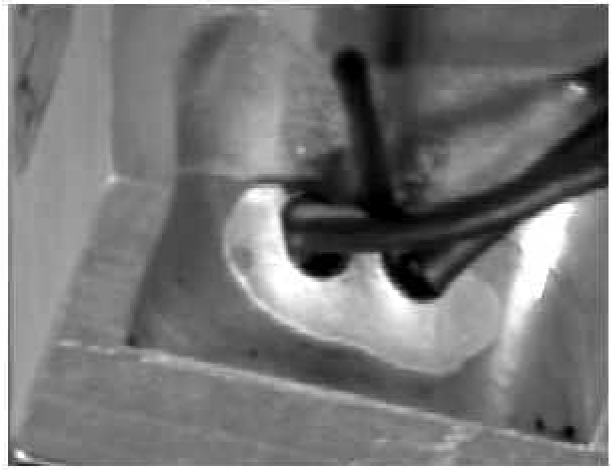
Fixing the third problem

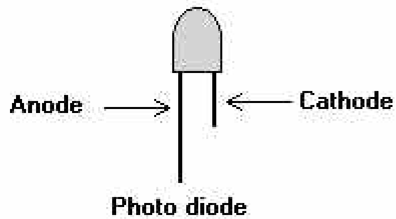
Once again, your troubleshooting for motor runaway has led you to discover yet another broken wire. And as was the case for the previous problem, this wire again, is broken off much too close to the component to allow for soldering a wire directly to it.

In this case, the wire was soldered to one of the LED's. They are mounted, you recall, right beneath the drive motor for the unit.

As before, we'll fall back to Radio Shack to find a suitable replacement part, and also as before, we replace both of the parts at the same time, just to conserve uniformity in the parts. A quick search shows us that a 3 millimeter infrared LED is available to us (Radio Shack P/N 900-1573) at a reasonable price ..... $0.69 each, American. Perfect. It not only meets our optical and electronic requirements, but again, is the correct size for fitting into the mounting holes.







The components in this problem, and the drawing for them, looks very much like the previous problem with the photo transistors. There are only a couple of differences between them.

For one thing, there are only two leads coming from the small board down to the components. Each of the wires connects to the OUTER wires on the components after the central two are soldered together. That's correct; there is no wire connecting to the junction of where the two components are soldered together.

The second major difference is in what the lead lengths on the components represent. On this component, the ***short*** lead is the 'cathode' and the long one is the 'anode'. Now, I realize that these names aren't the same names as those used on the photo transistors, but on the photo transistors, I said that the 'emitter' was the equivelant of a 'cathode' and the 'collector' was the equivelant to an 'anode'. The primary point here is, watch closely as to which connector... short one or long one... connects to where.

The third difference is, the 'anode' of the **LEFT** component connects directly to the 'cathode' of the **RIGHT** one! Since we agree that the name difference isn't of concern to us, we must be certain in this case, to connect the proper wire to the proper component connection and back to the proper place on the board. As in the previous example, the safe thing to do is to write down which wire on which component, connects to which connection!! (Whew!)

All of that having been said, this should require no more work for replacing the components that it did for the previous trouble.

Adjusting the comparators

You've replaced some components for the previous two troubles, so what you must now do is to adjust the outputs of the comparators to give you that nice, square wave signal that was discussed earlier on. This is true any time you make a significant change to any of the components, so I'm going to go over the 'new technique' for doing so, right now.

But let me digress just long enough to expand on an earlier comment. I had said that having bad connections on the input/output cable was one of the primary causes of intermittent motor runaway. The operative word here is 'intermittent'. The SECOND-most often cause of intermittent motor runaway for no apparent reason, is because this adjustment is incorrect, and the comparators aren't delivering the good, clean pulses back to the main board as they should.

In the past, proper adjustment of the comparators has always been one that has required the use of a dual trace oscilloscope. However, due to the nature of how the comparitor circuit is designed when it isn't hooked up to drive an actual circuit, I've found a very simple way of making the adjustment, using nothing but your multimeter, set on the "***DC VOLTAGE***" setting. (It's been tested pretty thoroughly and compared to the results of when using an oscilloscope, so I'd say you're pretty safe here and shouldn't feel as if you're being used as a sacrificial lamb.)

In order to make this adjustment, you MUST be powering the board and the motor using our method #3. That is, there must be a +1.5 volt or +3.0 volt battery powering the motor, and there MUST be a 9 volt battery powering the small logic board! The unit can NOT be connected to telescope power, and all leads other than the power leads must NOT be connected to anything!

We really don't care which direction the motor turns, and that's why I haven't specified any that particular motor pin be connected to a specific side of the battery.

I am assuming that when this adjustment is being made, that the multimeter you are using, is an 'auto ranging' meter. That means that in order to measure DC voltage, for instance, there is but one setting for this operation and that you don't have to switch to different voltage scales as the voltages change. It isn't absolutely necessary to have this feature, but it makes things a lot easier, and todays multimeters are almost all auto-ranging types; even the very inexpensive ones.

Let's set things up for making the adjustment before we connect the batteries. First, connect one side of the multimeter to test point #7, which is zero volts. Second, put the other connector from the multimeter onto pin #1 of the input/output connector. Easy enough. (Don't worry if your meter is hooked up backward somehow. If it is, your voltage readings will just be 'minus' voltage readings, and we don't care about that. All we care about is the absolute voltage value.)

Connect the motor battery up, then the 9 volt board power battery. Next, watch your voltage reading on the multimeter. It's bound to be quite off because we've just changed some components. Now, with a small screwdriver, turn the potentiometer for comparitor #1. Watch to see if it goes up or down in value. You're adjusting to get a reading of 1.21 volts. The adjustment may seem a little sensitive, but no problem; just slowly close in on the voltage setting until you get the 1.21 volt reading.

Next, disconnect the 9 volt battery and move your meter lead from pin 1 of the input/output cable, to pin 2 of the same cable. Leave the other end connected to test point 7, the 'ground'. Connect the battery once again and now adjust the potentiometer for comparitor #2 until you again get a reading of 1.21 volts. Once you've got it, you're all set!

Disconnect the batteries and their leads and you're all set!

What if ??? ....

If you can't seem to get a voltage reading, or if you get a reading that won't adjust, obviously there is something wrong. The first thing to do is to look at whatever it is that you've just repaired. Are the wires attached correctly? By any chance, when you soldered a wire, either onto a component or onto the board, did you short out another point with the solder? This would most likely happen for a connection on the small board since the connections are quite close together.

If all looks well, connect everything back up, but instead of putting your second meter lead on one of the comparitor outputs, attach it to the test point near the ground point, on the pin that represents the output for light sensor #1. Again adjust the potentiometer for comparitor #1 and see if the voltage changes. It should, since you're now reading the output from the photo transistor.. or photo diode, depending on what was replaced... as it is fed into the comparitor. It should be able to be varied from relatively low up to fairly high.... 3 volts or so.

Also check the same situation for photo transistor/diode #2, to see if that one will give a reading. If BOTH transistors show no reading, then it's likely that there is no light being emitted by the LEDs. If they both continuously read 3 or 4 volts approximately, then you have to suspect that there is a wiring error.

If worse comes to worse and there seems to be no output from the photo diodes or photo transistors, you may have to dismount them from their mounting holes and disconnect the wires. You can then put your multimeter across the two pins of the photo diode/transistor, and with the meter set on the 'resistance' (Ohms) scale, you should be able to measure a resistance that varies as you point it at a bright light. If not, switch the meter leads around to the opposite connections. The diodes/transistors will only act like variable resistors when the meter is hooked up in one of the two directions.

Those tips should help you to isolate down what the problem may be. But also remember; the odds of you having done anything seriously wrong is very low. Chances are, your 'fix' and the adjustment, will work right from the start.

Technical note: For slightly more advanced technicians, I want to explain why the 'meter' method works as it does. If this part doesn't matter to you or is confusing, then just skip it. The circuit works, and that's what's important.

The output from the comparitor circuit is an open collector circuit, that is fed by two transistors. The voltage dropped across a typical silicon emitter-collector is approximately 1.2 volts. Thus, the total voltage dropped across the two transistors is slightly over 2.4 volts.

The output square wave of the comparitor swings between 2.4 volts and just slightly above 0 volts as the signal toggles, when the component is not loaded. When the duty cycle is 50%, the average DC voltage reading will be half way between the two extremes, or 1.21 volts. This results in a symmetrical, 50% duty cycle square wave, which is what the desired wave shape should be.

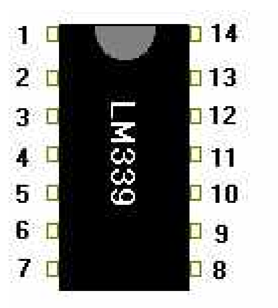
Other problems

You've seen what causes most of the 'dead motor' and 'motor runaway' problems, but sometimes it isn't one of the more obvious broken wires. In that case, the logical next step is to use your meter and check out all of the wires coming from our small board, to the end of its cable. By using the included drawings, it should be an easy task to follow each wire out from beginning to end. In so doing, you'll most likely find nearly all of the remaining problems.

If that doesn't turn out to be the case, then a good place to start narrowing things down is to again connect the unit to the two batteries, then look for the proper voltage at the outputs from the comparators. If one of the two is really wrong, and if minor adjustment of the potentiometer doesn't correct it, split the circuit in half.

For instance, as mentioned earlier, if one of the comparitor circuits is really, really bad, move your meter back a step, and look at the voltage on the proper test point, showing the voltage coming from its photo sensor. If that's bad, then back up toward the sensor and, if necessary, use a straight pin and poke it into the insulated wire right at the sensor, to see if the signal is there or not. If so, the problem is between the two, meaning the comparitor chip itself.

While the comparitor chip seldom fails, it could be that while trouble shooting, you shorted out some point and the chip got blown. (I've done that, so I know.) The comparitor chip is changed in a manner similar to the other components and wires on the board. You flip the board over and, with the desoldering wick, you remove the solder from the pins, one by one. This can take some time, because you have to soak up enough solder to be able to completely remove the chip and still have open holes to insert the new chip. Fortunately, Radio Shack does sell a replacement chip for this one, and the cost is $.99 American. (Radio Shack P/N 276-1712).



This is what the integrated circuit chip looks like, and when you replace it, the primary thing you need to know is that the small semi-circle at the top of the chip is the identifier so that when you replace it, if you put the new chips semi-circle in the same direction, it'll be properly aligned.

The second thing you should know is, this chip is heat sensitive, so use the minimum amount of heat from your soldering gun when you melt the solder to solder the individual pins in, and pause between each pin, so it will have a chance to cool down.

FOr those of you that have a lot of experience with handling integrated circuits and static electricity, you know how to handle these chips. For those of you that don't, let me just say that it would be a good idea to have some part of your body grounded when you handle this chip, so as to not damage it by static electricity that can develop. That's all I intend to say about static and electronic components. So much for ISO 9000 standards!

"....To boldly go where (few) have gone before ...."

I'm quite sure that you didn't catch a little tidbit that I threw at you earlier on. I said, when we were discussing the replacement of the sensors and LEDs, "with a little bit of luck, we can fix the problem with a minimum of hassle". What I failed to mention was, what was it exactly that we needed a 'little luck' for? The repair seemed to go quite well, so what was the 'luck' all about?

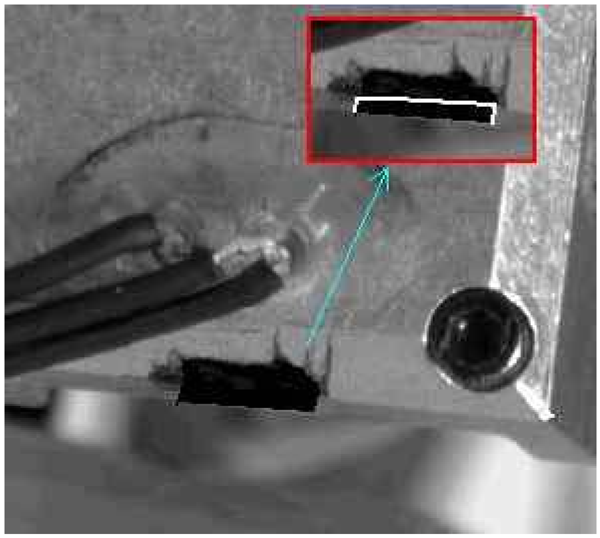
The 'luck' was... we were able to get the sensors completely out!! But what if we hadn't been able to? What if a part of one of them... or a part of one of the LEDs... just didn't cooperate? What would we have been faced with?? We'd have been faced with........... ***GOING INSIDE THE GEARBOX!!!!***

And as most people have heard at one time or another, this area is only for the brave of heart! It takes a minimum of having a background in Quantum mechanics and General Relativity, as well as experience in celestial navigation and making fudge brownies, before one dare tread into this chamber of horrors!!!!

But what did ***I*** know? I wasn't aware of how hard it was to adjust that mask that falls out, so I went inside, did what I was going to do, adjusted the mask, and closed it up! Only later did I discover that it wasn't easy! After I'd already done it pretty easily!

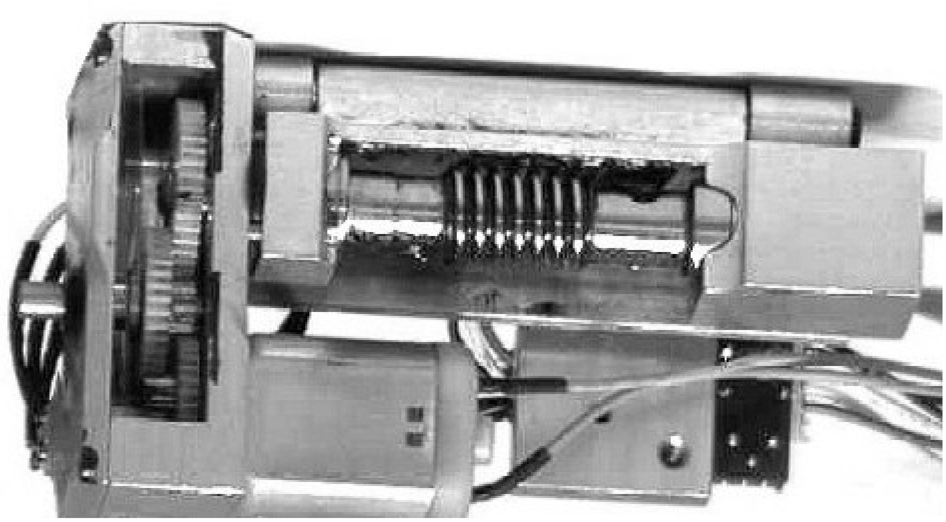
That being the case, I thought I might show how a person can go inside the box, and if necessary, remove the mask or the disk, so as to push the remaining pieces of sensor or LED out of it's holes, then finish the repair. Then, maybe , we can bring this long winded discussion to an end!

Before you begin to open the gear box, there's a possibility that you can do something that will help a lot in the alignment. I call it 'insurance policy #1".



At the bottom of the gear box, on the outside, just below the sensors, you ***might*** see the very end of the mask, sticking out a bit. (The black tab.) If so, use a straight pin or razor blade to scribe a line on it, right along the bottom edge of where the side frame rests. Also, scribe a mark where the two sides of the mask align with the frame. They would be a big aid in relocating the mask back to its original position.

If the edge of the mask doesn't stick out at all, that's okay. We just won't have that extra insurance policy.



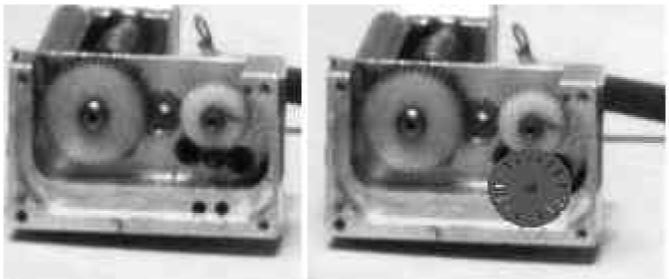
This image is of the R.A. assembly. If you're working on the DEC assembly, before you begin disassembly, remove the DEC knob from from it's shaft, then either file or sandpaper the shaft smooth. You want to remove any burrs on the shaft, left by the knob holding screws.

What you're about to do is to remove the four hex screws that hold the left (as shown) end plate to the unit. When they're removed, the end plate will still be held in place by two aligning pins, so it won't just drop off into your hand.

Although it's difficult to see in this image, you may be able to make out the strip of plastic that's just to the left of the leftmost gear. It runs from the front of the opening to the rear. I mention this plastic strip, just so that as you slide the left plate off .... it has to be slid to the left until it clears the metal gear shaft... you know what's what.

All you want to do is to remove the holding screws, then slide the plate to the left until it clears the shaft. The only 'gotcha' that you should be aware of as you remove the plate, is that the shaft that passes through the plate where the bronze busing is, may want to try to slip along and come off, too. If it begins to slide, simply push it gently back into the gear housing. That was the reason for smoothing the shaft before beginning, so that the shaft doesn't catch on the bronze bushing.

The gears and the timing disk are now exposed for you to see. With a small amount of luck, the timing mask is still sticking to the plate you just removed. If so, we'll put insurance policy #2 into play. If not, we'll do fine without it.

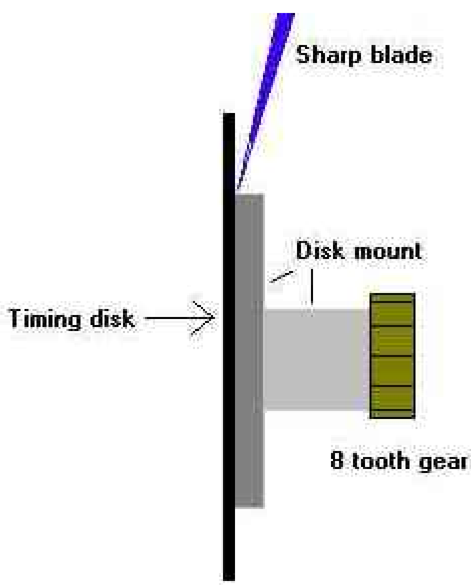


This shows the gear train with the cover removed... and without that pesky gear on the shaft that might have given us trouble when removing the side.

In the left image, you can see the two holes at the bottom right, where the LEDs are mounted, and in the right image, they are covered by having our timing disk in place. See? No problems yet, are there?

Depending on what reason we disassembled the unit, will determine what we do next. We'll assume that what we need to do is to get some remaining plastic out of the holes from the LEDS, beneath the timing disk. That means we need to remove the timing disk to get access to the holes. No problem at all!

Removing/replacing the timing disk.



To remove the timing disk from it's mount, you heat the face of the disk with a soldering iron. After a few seconds, you use an Xacto blade or a single edged razor blade or anything similar and sharp, and begin to slide it between the disk and it's mount. Heat, then slide the blade in. Heat, then slide it again. Rotate the unit a little by gently turning one of the gears a bit, and repeat.

It may take a bit of time, so don't get impatient. Each time you 'cut' into the glue that bonds the two items, you'll make a little more progress. Heat and slide the blade in. The glue, when heated, will soften and get very sticky, so expect it.

Before long, you'll have separated the two far enough to have them completely apart.

Clean the glue off of the timing disk and the mount, with alcohol or acetone or any other substance you think will dissolve and cut through the sticky glue. Once again, it can take a few minutes to get both surfaces completely clean, but do it anyway. Get all of the old glue off.

If you took the timing disk off because you needed to get access to some remaining chips of the LEDs, you have easy access now, to their mounting holes. Clean the holes with the same kind of glue remover as before.

To mount the disk back into place, first just hold the disk back up to where it will mount. You'll see that there is a hole in the center of the disk that is the same size as the hole in the mount. That means that all you need do is to apply a good glue to both surfaces, then align them together and press them together for the time needed.

For this bond, I use 3M Super 77 spray adhesive. It gets tacky quickly, and it seems to have the consistency of the bonding agent that was removed. I'm sure that most hardwares or building supply houses will sell this adhesive or something very similar. I bought the spray can version of it, and applied it with a toothpick, rather than spray it directly on. I didn't want to take a chance of getting into any of the slots. Besides, I already had some of this stuff in spray can form from another project, so I used what I had.

See? Removing and replacing the timing disk is a snap!

Removing/replacing the timing mask

There are several ways of removing and replacing the mask. Or should I say, of replacing it, since removing it is quite easy.

If you found that when you opened the unit, the timing mask was glued into place... insurance policy #2 ... then what you want to first do is to take a sharp pin and etch the outline of the mask onto the plate that it's mounted on, before removing it. That pretty much takes care of how to align it in that situation.

If that's not the case, then how about insurance policy #1? Were you able to scribe marks on the mask while the unit was still closed? If so, then sit the mask back into place so that the marks all line up, and again scribe the outline of the mask onto the plate. Again, that solves that.

No luck with either method? Then let's cover several ways of aligning the mask, depending on circumstances and which one you prefer. From here on, we'll assume your mask just fell out of alignment before you could do any marking.

If you need to remove the light sensors for a previous repair, then do so now. With them out of the way, it makes things a bit easier.

Now, regardless of whether or not your light sensor holes are available to you or not, take a small dab of white grease, if you have some, and put a small dab on the **CENTER HOLE** of the timing disk! You could also use a crayon or any other thick marking material if you don't have the white grease. Just something that will leave a mark for you.

Slide the plate back on the shaft, and move it up into position, aligning pins aligned and everything. Now slide it back off again. But this time, you'll see a small smudge on it that shows where the center of the timing disk aligns with the plate.

You may not have noticed before, but the slots in the mask, just like those in the disk, are pointed right at the center of where the timing disk is. That makes sense, since all slots are meant to be aligned with each other.

When you get it off, use a scribe or sharp pin, and mark a spot right in the center of the grease glob is, or whatever it was that you used to mark the center of the timing disk.

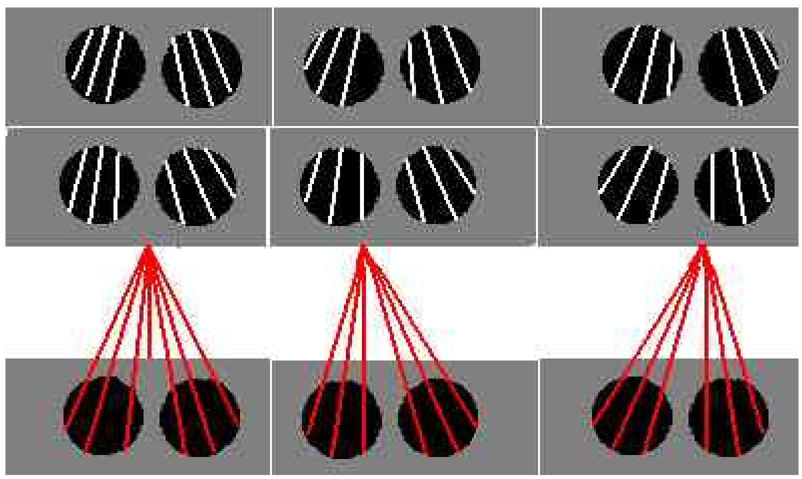
Method #1: The light sensor holes are empty

With the light sensor holes available for us to look through. that makes things even easier.

First, sit the mask approximately into place for where it's going to be mounted. Then, take a small piece of adhesive tape and tape just one corner of the mask into place. Don't get any tape on the slots.

Next, move the mask around so that it looks as if it's pretty much covering the two holes equally and then, by just looking, set it so that it appears that all six of the slots in the mask are aiming at the scribe that's for the center of the timing disk. Push the tape a bit more firmly.

Next, look at the unit from the other side, looking through the holes for the light sensors. With only a small piece of tape holding the mask, you can still move the mask around, while looking at the slots through the holes. Get the slots so that each set of slots appears to be relatively centered on it's hole, and more importantly, that all of the slots point to the point that's the center of the disk.



In these examples, for instance, the three mask alignments at the top are more than good enough to give good pulses, even though they aren't exactly aligned in their holes. If they were, it would be even better.

The second row of masks would not work as well, because although they appear to be relatively centered in their holes, their slots don't point to the center of the timing disk.

It may be a bit hard to see the difference, but if you look at the last row, you can see that the leftmost mask points to the center, as desired, while the second one points to the left of center, and the right one points to the right of center.

Strive to make the slots point at the mask center, and also have the slots as close to the center of the mounting holes. Once you have the slots aligned in this fashion, turn the plate over and glue the mask into place. It's done!

I once again use the 3M adhesive above. I apply a small dab to the very tip of a toothpick, then gently spread it on a SMALL area of the mask and adjoining plate. After it dries some, I'll do another spot. Keep the glue from building up so that it doesn't interfere with the rotation of the timing disk.

Side point here: Once you get enough glue on to hold the pieces firmly, scribe the outline of the mask on the plate. You don't want to have to do this again if it isn't necessary.

Aligning the mask from the inside

The final alignment method you need to see, is when the holes already have the light sensors mounted, which keeps you from looking through them to see the slot alignment.

In all likelihood, you could probably just sit the mask into place, aim the slots at the center point of the disk, glue it down, and you'd be fine. The only real difference is, from the inside, you can't completely see all of the holes that you want to align the slots to. You can, however, more easily see the mark for the center of the timing disk.

I'll show you TWO different methods, both equally easy and accurate, that can be used for aligning when viewing from the inside. From there, you can probably improvise other, even better methods.

Method #1:

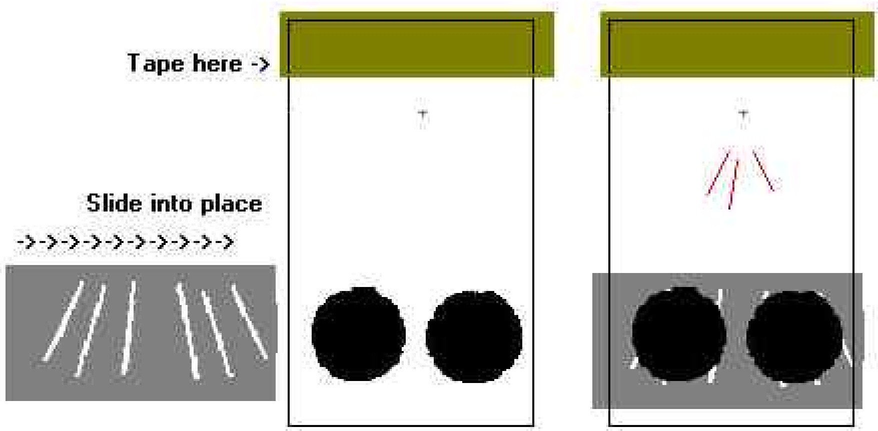
The first method needs no drawing for it. Simply take a thin piece of transparent plastic that's slightly larger than the mask. A piece of plastic no thicker than a sheet of paper, from an office supply store will work. Lay the plastic down on a flat surface and trace the outline of the mask onto the plastic sheet. Also trace the cutouts for where the slots are. Then, take the plastic sheet and cut out the piece that you traced, exactly. It will be the same size and shape as the actual mask.

Then, using this transparent 'mask' lay it down over the holes, center it up on the holes, and be certain that the slots are aiming at the center point for the disk. Tape it somewhat into place, and then trace the outline of the plastic mask onto the metal piece. Finally, lift the plastic sheet off and replace it with the real mask. Glue it into place and you're done. See? Easy.

Method #2:

Another method is to take the same kind of plastic sheet and cut a strip from it that is slightly narrower than the mask, but taller in height. Tall enough, in fact, that it is taller than the holes AND the pivot of the disk.

Next, lay the plastic strip down so that it covers both holes, as well as the pivot point, and tape it to the plate at the top of the plastic. Using a permanent type of 'magic marker', carefully darken the plastic over the two holes that house the photo sensors.



Slide the mask under the plastic and align the slots with the blackened spots that represent the holes. Align the slots so that they again, aim at the pivot point of the disk. Then glue the two edges of the mask. Once the two edges have dried enough, remove the plastic and glue the remaining edges.

It should be very apparent that the key to aligning the mask properly, is to simply concentrate on having the slots in the mask aim at the center point of the disk. If that condition is met, then all of the slots, both in the mask and in the disk, are automatically in alignment. All that's left for you to fine tune, is to set the mask so that the slots in the mask make maximum use of the space allowed for light, through the mounting holes.

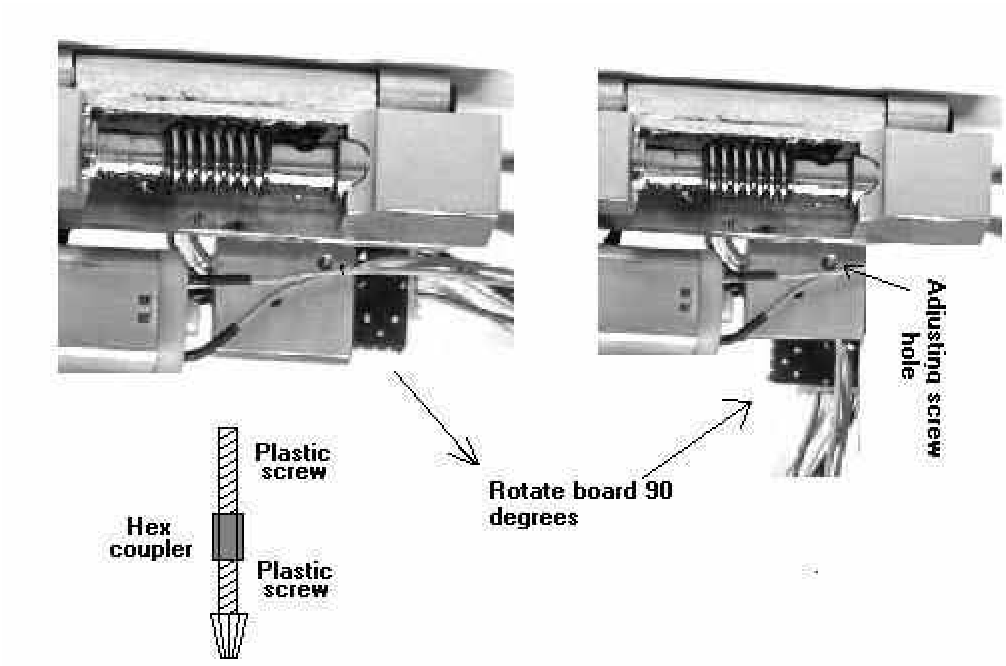
Supplemental tips

Tip #1

This isn't directly related to having to fix anything inside the Dec or R.A. units, but has to do with having to adjust the screw on the R.A. unit that controls the distance the separation between the worm and worm gear. If the spacing is too small, the gears may bind at certain points in the cycle. If it's too great, the gears may separate too far and the gears may unmesh.

The strange part is, the scope may be working fine for quite some time, and suddenly conditions occur where this distance must be adjusted. Unfortunately, to get at the adjusting screw, you must remove the drive base cover, then remove the R.A. gear assembly, then make an educated guess on whether or not the adjustment is correct. After re-installing the gear box, you can see if the clearance is right, but if not, out comes the gear box and some tweaking of the adjustment screw is done, then it gets re-installed. Pain in the neck!

This tip may save some of this hassle in the future.



Once the unit has been opened and the R.A. unit removed, rotate the electronics board 90 degrees if necessary, so as to gain access to the adjustment screw from the bottom of the unit. Then remove the allen screw and replace it with a long, plastic or nylon screw of similar thread type.

When I did this, the only available plastic screws were too short for my purposes, so I also bought a plastic hex coupler that allows two screws to be joined together. Cut both of the heads of the screws off and couple them together, then thread one end into place.

A nice little 'handle' for the screw can be made, by buying a 'twist on wire connector', used for manually splicing or connecting two wires together. There are sizes available that fit on the nylon thread with no extra work.

You now have a long screw that can be threaded into the adjusting screw hole, and can be accessed in the future by simply removing the screws from the control panel and lifting it out. The screw can then be adjusted by your fingers as needed while the scope is still mounted on the wedge or tripod.

As I said, this is nothing earth shattering, but it may help you in the future.

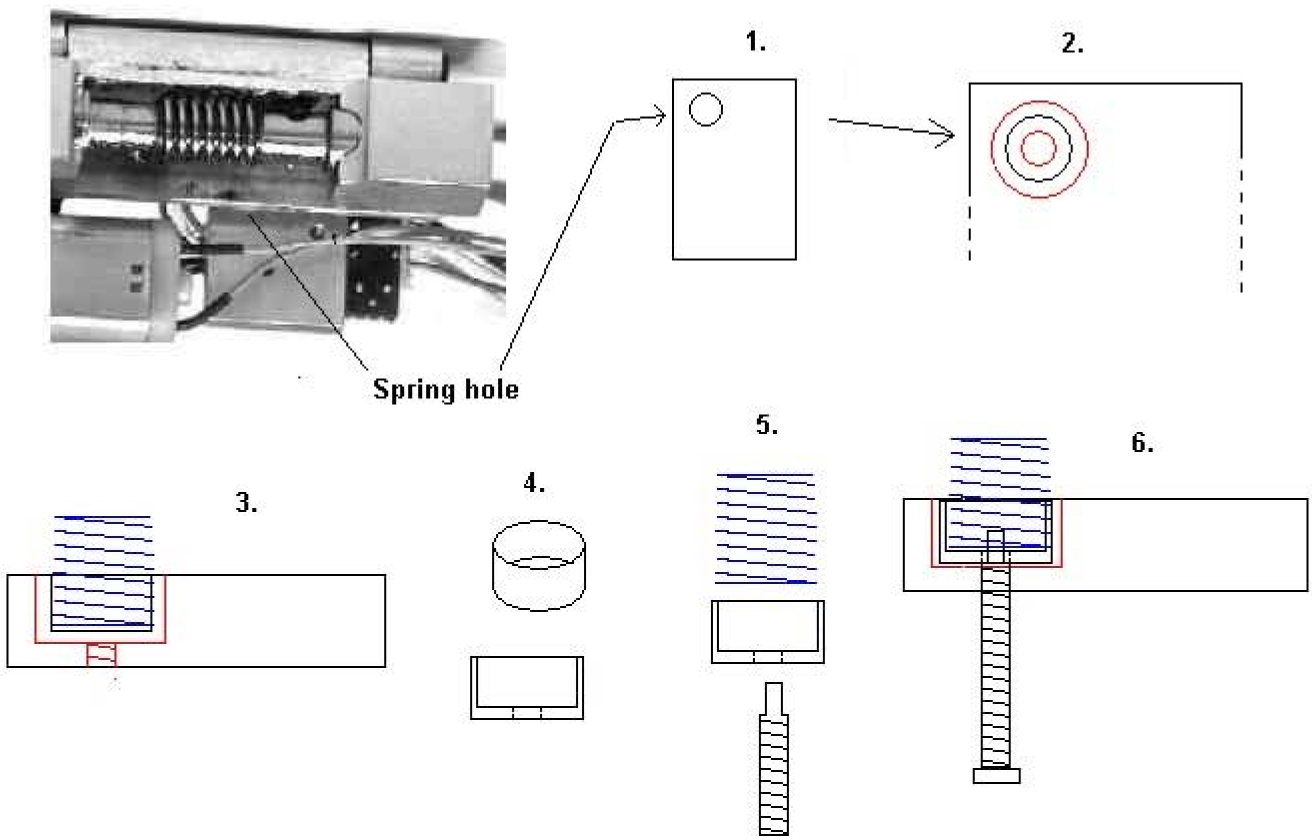
Note: If you find that you need to make the screw adjustment because there is a 'tight area' on the worm gear, then whether or not you make the adjustment, you still have a condition that will effect the 'GOTO' accuracy of your LX200. You might want to go to the following link, to aid in correcting this 'Go To' problem. **<Improving `Go To' accuracy on the LX200>**

Tip #2

Here's another change in the same area that might be of some benefit to you.

It seems to often happen that you may find that for whatever reason, the spring tension on the spring that meshes the worm to the worm gear on the R.A. drive, has changed, or just plain needs better adjustment. As with the previous tip, it means removing the bottom of the scope, then the R.A. drive unit and either compress or expand the spring to change the tension. Then you put the gear box back in and try it. Again, a pain in the neck. That's especially true if you have to 'guess' at the amount of spring tension you really need, and do it several times.

If you want to take the time to make the following modification, then as in tip #1, you can simply unscrew the four screws holding the control panel in place and reach in to adjust the spring tension.



The upper left image shows the area in which the tension spring sits. It sits in a recessed hole in the bottom plate of the unit and pushes up against the upper unit. Drawing '1' shows only the lower plate .... the part needed to be modified ... and the recess in which the spring sits.

In drawing '2' you can see by the larger red circle, that I milled the recess a bit larger. The smaller hole, the red one right in the center, is where I drilled and tapped a threaded hole so that it would accept the same size of nylon screw as was used in tip #1.

Drawing '3' is a side view of the newly enlarged recessed hole and the small tapped hole. As you can see, there is a significant clearance now, between the side of the new recess, and the original spring.

In drawing '4', you can see a small 'cup' that I made. This is just large enough to freely fit into the new recess. Also, there is a hole in the middle of the bottom of this 'cup' that is even smaller than the tapped one previously made in the metal plate. This 'cup' was made so that the original spring could nicely sit inside it. Using the resulting size if the 'cup' is how I determined just how big to make the recessed hole. I wanted the 'cup' to freely sit inside of it. This 'cup' looks like a miniature bottle cap.

In drawing '5', you can see that I took one of the nylon screws and filed a portion of the end of it down. I made it just small enough so that the reduced section would fit into the hole drilled into the 'cup' with a portion of the tip extending up and into the 'cup'

In drawing '6, you see it all put together. If the screw is screwed in, it raises the 'cup', which pushes the spring up, where it is compressed against the upper section, increasing spring tension. If screwed down, it reduces the spring tension that is meshing the worm and worm gear together.

A nylon screw is used in both tips, because we don't want any metal down in the area of where the wires and connectors from the control panel when it's back in place. Just as in tip #1, one screw wasn't quite long enough. On this one, I just took two screws and locked them together by screwing them both into a single nylon nut and tightening them to quite snug. Either method will do.

I trimmed any excess length off of the screw and put the control panel back in place. Now, I can make either of the adjustments as I wish, without dismantling the scope. Just pull the control panel, reach in, and tweak away!

Closing thoughts.

You've covered a lot of territory if you managed to follow this discussion from beginning to end. Hopefully, the journey was worth the effort, and hopefully, there will now be a LOT fewer people that will have to send there electronics or 'scope in for repair from now on.

As time passes, I hope to add more ideas and tips on how to fix problems related to the drive electronics and mechanics. It's really surprising how a unit that only measures about 4" x 2.5" x 1.5", with a circuit board that's only about 1" x 1.5", can be the cause of so much frustration and so many problems, but I guess that's just a part of the hobby.

Best of luck, clear, dark skies, and..

Enjoy Astronomy!!!!!!

Bruce A. Johnston