INSTRUCTION MANUAL

Model 400-TR

Force Transducer Output Tube Repair Kit

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1.0 Introduction

The model 400-TR output tube repair kit allows the user to replace broken or damaged output tubes on Aurora Scientific Inc. and Cambridge Technology Inc. force transducers. The kit can be used with transducer models 400A, 402A, 403A, 404A, 405A, 406A and 407A. The kit includes: a tube alignment jig, 10 output tubes, epoxy, a butane powered soldering iron kit, various Allen keys required during the repair and an X-Acto knife complete with a No. 17 chiselling blade.

2.0 Output Tube Replacement Procedure

2.1 Overview

The procedure for replacing a broken output tube involves removing the broken tube and the glue used to hold it in place and then gluing a new tube in its place. The most critical step of the procedure is removing the broken tube and glue. It is during this step that there is the greatest chance of breaking the force transducer flexure.

Field replacement of the output tube has been a problem in the past since the new tube must be accurately positioned so that it exits through the centre of the small hole in the transducer cover plate. The precision-machined alignment jig, included in the repair kit, solves this problem by holding the tube perpendicular to the flexure and positioning it in the correct location while it is being glued. This jig ensures that the new tube will exit through the centre of the hole in the cover plate when reassembled.

2.2 Tools Required

The toolkit includes several Allen keys required to remove the screws that hold the transducer cover plate onto the main body. The size of key depends on when your transducer was built. Cambridge Technology Inc. used #0-80 stainless steel socket head cap screws on all of their force transducers up to about 1994. These screws require a 0.050" Allen key. After about 1994 Cambridge used #2-56 steel socket head cap screws. These screws require a 5/64" Allen key. Aurora Scientific Inc. (which took over production of the force transducers in 1997) uses #1-72 stainless steel socket head cap screws. These screws require a 1/16" Allen key. The 5/64" Allen key is also used to tighten the clamp plate on the alignment jig.

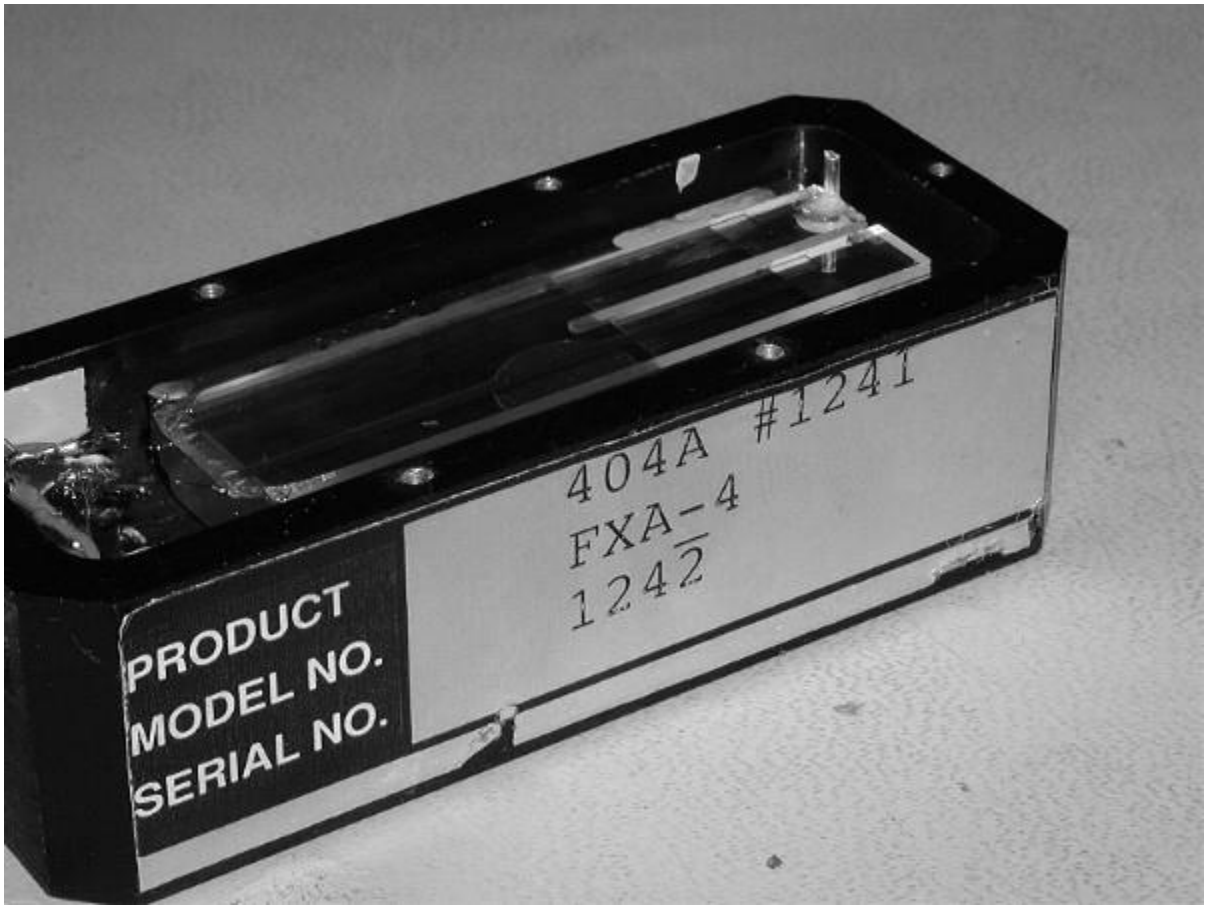
In addition to the tools included in the 400-TR kit you will also need:

1) A short length (about 2" (5 cm)) of wire about 0.020 – 0.030" diameter to be used to place the epoxy glue around the new output tube (you could also use a tooth pick as a substitute).
2) A small piece of cardboard to mix the epoxy on.
3) A mixing tool such as a Popsicle stick or a blade screwdriver to mix the epoxy.
4) A small blade screwdriver to adjust the potentiometers on the electronics circuit board.
5) A voltmeter to check the output of the instrument.

2.3 Removal of Broken Tube

CAUTION: Avoid touching the output tube with your finger. Although the unit can withstand sever overload and is very rugged, it is possible to overlook how easy it is to develop relatively high forces manually.

1. Unplug the transducer head from the electronics. Remove the transducer head from the experimental set up and place it on a clean workbench. .
2. Remove the six screws holding the cover plate in place. Remove the screw at the end of the housing closest to the output tube last.
3. Carefully remove the cover plate by lifting it straight up until it clears the broken output tube. Failure to remove the cover plate carefully can cause sever side loads on the remaining piece of output tube. These loads can result in the flexure breaking.
4. The transducer head should look similar to Photograph 1.

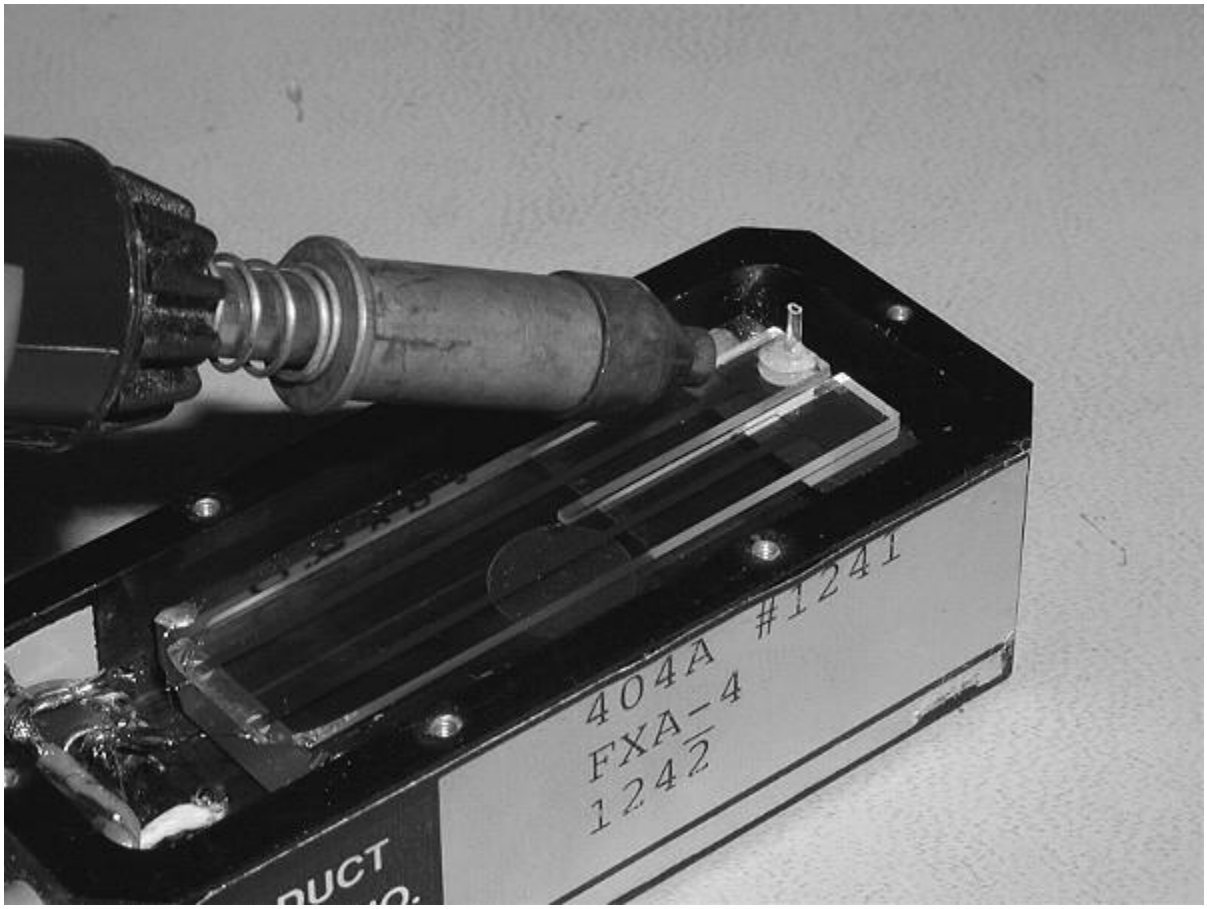


Photograph 1 Transducer Head with Cover Removed Showing a Broken Output Tube

5. Unpack the butane-powered soldering iron. The soldering iron is shipped with the **Heat Blower Tip** attached. This is the tubular tip with what looks like a small piece of screen in the end of the tip. The soldering iron comes filled with butane fuel. Butane refilling cans can be purchased at most hardware stores. Follow the directions on the can when refilling your torch. **Make sure that the torch has cooled completely before refilling.**
6. Light the torch. Turn the flow adjuster to the **mid position**. Hold the unit away from the face and body and using the flint ignitor direct the stream of sparks into

the open end of the tip. Wait a short time for the flame to self extinguish and to reach operating temperature. When functioning correctly the metal screen should glow bright orange/red and no flame should be visibly exiting the tip. Sometimes you need to turn the gas control to a very low flow setting (almost to the off position) to get the screen to start glowing.

7. Ensure that the gas control valve (on/off adjuster) is in the **low to mid position**. Do not use the soldering iron on maximum heat because you can damage the metallization on the glass flexure assembly. Direct the hot air towards the glue joint that holds the broken output tube onto the flexure see Photograph 2. Ensure that the soldering iron is held in a manner similar to that shown in Photograph 2 so that the heat is directed along the flexure towards the tube end of the flexure. Under no circumstances should you direct the heat straight down onto the flexure or towards the wire end of the flexure. Also as a precaution against overheating the glass it is suggested that you **gently** rest the blade of the X-Acto knife on the flexure just behind the output tube. By doing this the knife blade acts as a heat shield to prevent excessive heating of the glass. Direct the centre of the hot air flow above the glue and let the heat on the edge of the blower tip heat the epoxy. Allow the torch to heat the glue until some discoloration of the glue occurs. Heating the glue breaks the bond between the glue and the flexure.
8. While continuing to heat the glue use the chisel blade on the X-Acto knife to gently remove the glue from the flexure see Photograph 3. **Take special care. This step is the most critical one of the entire procedure and the most likely place where you can break the flexure.** Do not apply excessive pressure with the knife blade. If the glue is hot enough then the blade will gently slide along the glass flexure and under the glue joint lifting the glue off of the glass. If the glue does not come off easily then heat the glue longer. Watch the flexure as you are sliding the knife, if the flexure starts to rise up then stop moving the knife. Likewise if you see the flexure bend down and push against the substrate then release the pressure on the knife. **Under no circumstances should you apply lifting force to the glue. Slide the knife along the flexure and allow the chisel shape of the knife blade to lift the glue up.**



Photograph 2 Heating the Glue Joint

Photograph 3 Removing the Old Glue

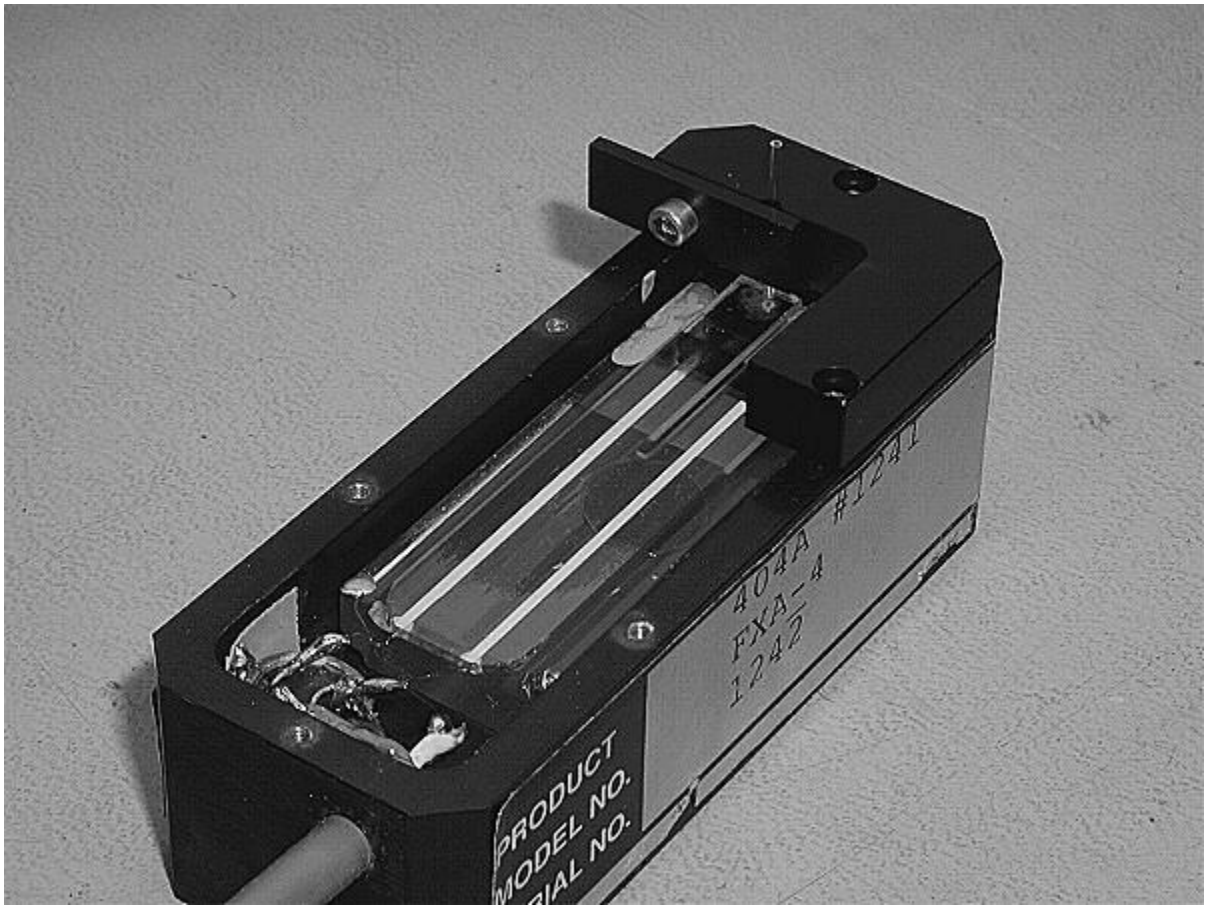
9. Once the glue has been removed inspect the surface of the flexure and use the knife along with the heat gun to remove any glue residue. If available use a cotton-tipped applicator moistened with methanol to **gently** clean the surface of the flexure. Note: **do not apply methanol to a hot flexure**, allow the assembly to cool before applying the cleaner fluid. Blow any dust or glue particles off of the glass assembly (using Dust-Off or a similar canned air supply). Be careful not to use excessive air pressure since the force of the air exiting an air can is sufficient to break the glass flexure. With models 403A, 405A and 406A it is recommended that you place your finger **lightly** on the flexure about mid-way along the flexure before blowing the end of the flexure with the canned air. Your finger prevents the flexure from rising up due to the air pressure and breaking.

2.4 Gluing a New Output Tube

1. Attach the tube alignment jig to the force transducer head with the cover plate

screws as shown in Photograph 4. On older Cambridge Technology transducers that used the #0-80 screws the screws are smaller than the mounting holes in the jig. For this reason carefully align the outside of the jig with the outer surface of the transducer head before tightening the screws. On the newer transducers built by Cambridge (that used the #2-56 screws) you will find that the holes in the jig are not large enough for the cover screws. In this case carefully enlarge the mounting holes in the alignment jig using a # 44 drill (0.086" diameter). Note: if you do not have facilities to enlarge the holes return the jig to Aurora Scientific Inc. with a note of explanation and we will enlarge the holes free of charge.

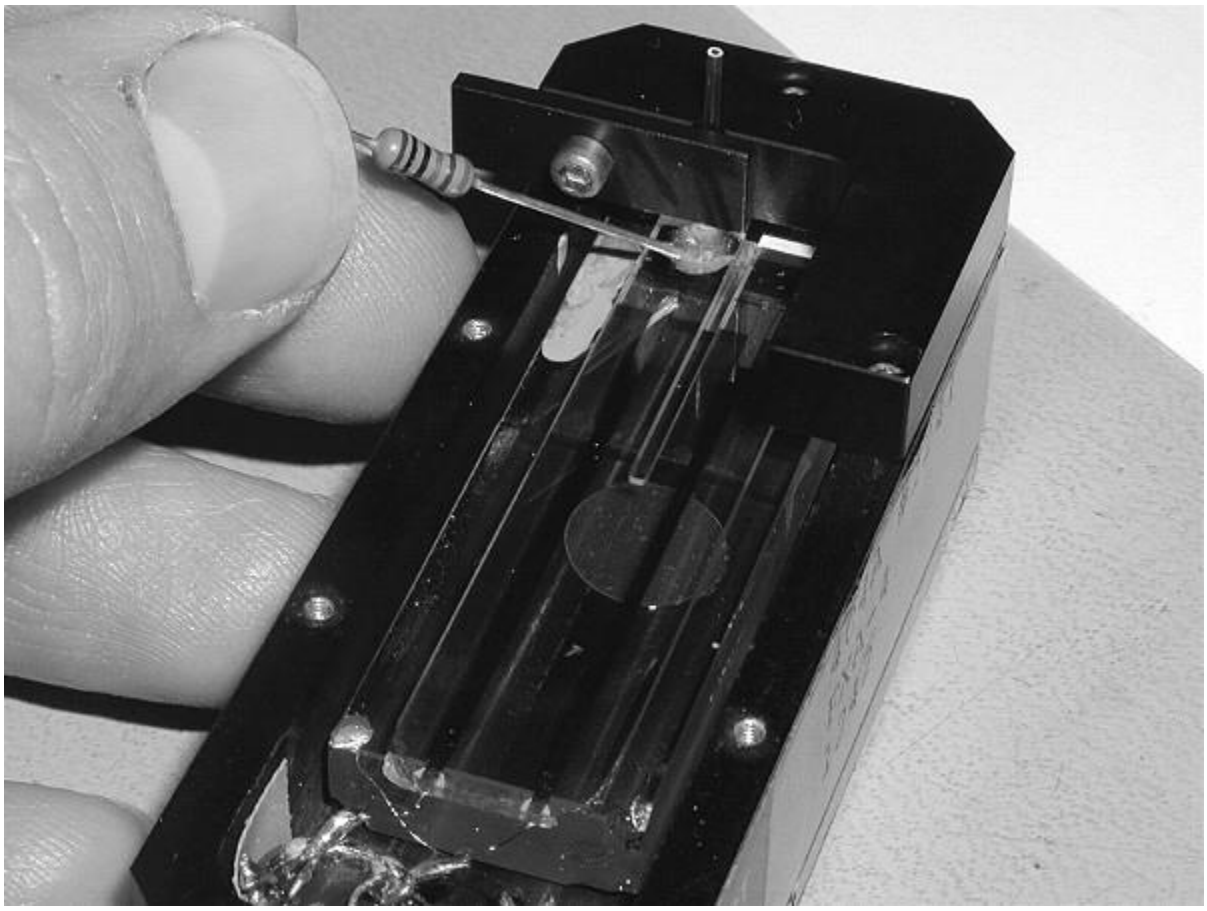
2. Loosen the output tube clamp screw on the alignment jig and insert a new output tube into the "V" groove. Allow the tube to drop **gently** onto the flexure. **Do not push down on the tube with your finger.** Inspect the tube and ensure that the tube is in contact with the flexure.
3. Gently tighten the output tube clamp screw to clamp the output tube to the alignment jig.
4. Mix a small amount of epoxy. Squeeze equal portions of resin and hardener onto a small piece of cardboard. A good method of ensuring equal proportions is to squeeze the glue from each tube in two long, thin parallel lines. It is relatively easy to ensure that both glue lines are the same length. Then, using a mixing tool, thoroughly mix the epoxy together. Note you should mix for at least 1 minute. The epoxy cures in 5 minutes so ensure that you are ready to glue before mixing the glue. Take care not to get any epoxy on your skin. Epoxy is a strong sensitising agent.



Photograph 4 Tube Alignment Jig Attached to Transducer Head and with a Tube in the Clamp

5. Using a short length of wire (about 2" (5 cm)) apply a **small** amount of epoxy to the base of the output tube see Photograph 5. Using the wire distribute the epoxy around the base of the output tube. **Take care not to get any epoxy down the sides of the flexure or on the small gap between the two flexure arms.** Any epoxy in these areas can glue the flexure to the substrate thus rendering the transducer useless. Note very fine strands of epoxy will often form between the applicator wire and deposited epoxy. These strands of glue can fall down the sides of the flexure and glue the flexure to the substrate. Consequently remove the wire from the deposited epoxy slowly thus allowing time for these strands to break before they get long enough to cause problems. An alternate approach to applying the glue is to loosen the tube clamp and raise the tube above the surface of the flexure. Then apply a small amount of epoxy directly to the flexure immediately below the output tube. Now lower the tube into the glue and gently rotate the tube about its axis. You may then lift the tube about 1 mm off of the surface of the flexure and then lower the tube back into place. The rotation and lifting actions help to distribute the glue around the tube. Ensure that when you lower the tube into the glue that you do not use

excessive pressure since you can easily overload the transducer by applying force with your finger. Tighten the tube clamp and allow the glue to harden.



Photograph 5 Applying the Epoxy Glue

6. Allow the epoxy to harden for at least 30 minutes, we recommend 1 – 2 hours.
7. Carefully remove the output tube clamp screw and the clamp plate from the alignment jig.
8. Carefully remove the two screws holding the alignment jig to the transducer head. Slide the jig away from the output tube.
9. Replace the transducer cover. Carefully hold the cover parallel to the transducer head and sight through the output tube hole in the cover. Align the output tube with the hole and gently lower the cover in place.
10. Re-attach the cover using the cover screws. Insert the screw at the end of the transducer head closest to the output tube first. Then insert the screw on the opposite end of the head. Finally replace the four side screws. Align the cover so that the tube exits from the centre of the hole and tighten the six screws. If the cover cannot be replaced without the tube touching the edge of

the hole then the alignment jig was not attached properly. Remove the new output tube and the glue as explained in section 2.3 and then re-glue a new tube.

3.0 Calibration

After replacement of the output tube the transducer should be re-calibrated. If the transducer is to be used in tension (the normal mode of operation for muscle physiology) then mount the transducer head in such a way that the output tube points downward and is perfectly vertical. A small hook must be attached to the output tube to be used to suspend weights (refer to the transducer instruction manual for instructions on attaching the hook). If the transducer is being used in compression then mount the head so that the output tube points vertically upward. In this case calibration weights can be placed directly on the top of the output tube therefore no hook is required.

1. Connect the transducer to the electronics and plug the power cord in.
2. Centre the OFFSET knob on the front panel (5 turns from either end). Attach a voltmeter to the output and observe the output voltage of the instrument. If the voltage is within 0.100 V of zero then you may choose to skip to step (13) below. If the voltage is greater than +/-0.100 volts proceed to step (3).

CAUTION: THERE ARE HAZARDOUS VOLTAGES PRESENT WITHIN THE CABINET OF THE ELECTRONICS WHEN THE UNIT IS PLUGGED IN.

3. Unplug the power cord from the electronics box. Remove the top cover from the electronics box. This will allow access to the circuit board. On older transducers remove the cover by first removing the screws located inside the feet on the bottom of the case. Once the screws are removed lift the top cover off. On newer units, remove the single screw located on the top back edge of the box and slide the cover backwards and off of the case.
4. Locate the zero and gain adjustment potentiometers. The zero pot (labelled R15) is located just left of the centreline of the electronics board (when viewed from the front of the instrument). The gain pot (labelled R9) is located right of the zero pot.
5. Center the front panel offset knob (set it to 5 turns from either end).
6. Plug the transducer head into the electronics box. Plug the electronics box into the correct power source. **CAUTION: DO NOT TOUCH ANY CONNECTIONS NEAR THE BACK OF THE INSTRUMENT CASE. ENSURE THAT ANY TOOLS ARE KEPT WELL CLEAR OF THE BACK OF THE CASE. THERE ARE HAZARDOUS VOLTAGES PRESENT WITHIN THE CABINET OF THE ELECTRONICS WHEN THE UNIT IS PLUGGED IN.**
7. Attach a voltmeter to the output connector on the front panel of the electronics.
8. Turn the instrument on and allow it to warm up for 5 minutes.
9. Turn the zero pot on the circuit board until the output voltage reads 0.000 volts.
10. Place the appropriate weight shown in Table 1 on the output tube and adjust the gain pot on the circuit board to read the voltage shown in Table 1.
11. Remove the weight and re-adjust the zero pot as stated in step (7).

12. Repeat steps (7) through (9) until the output with and without the weight are correct. Since the gain affects the zero and vice-versa it usually takes several adjustments of both pots until the transducer is calibrated correctly.
13. Once the gain and zero pots are set properly check the calibration. Apply a series of known weights to the output tube and record the voltage output. The output can be used to check linearity and to calculate the output scale factor.

Table 1 Calibration Weight, Output and Scale Factor for Series 400A Force Transducers

Model #	Calibration Weight [mg]	Output [volts]	Scale Factor [mg/volt]
400A	200	0.400	500.0
403A	50	1.000	50.0
404A	500	0.500	1000.0
405A	100	1.000	100.0
406A	20	4.000	5.0