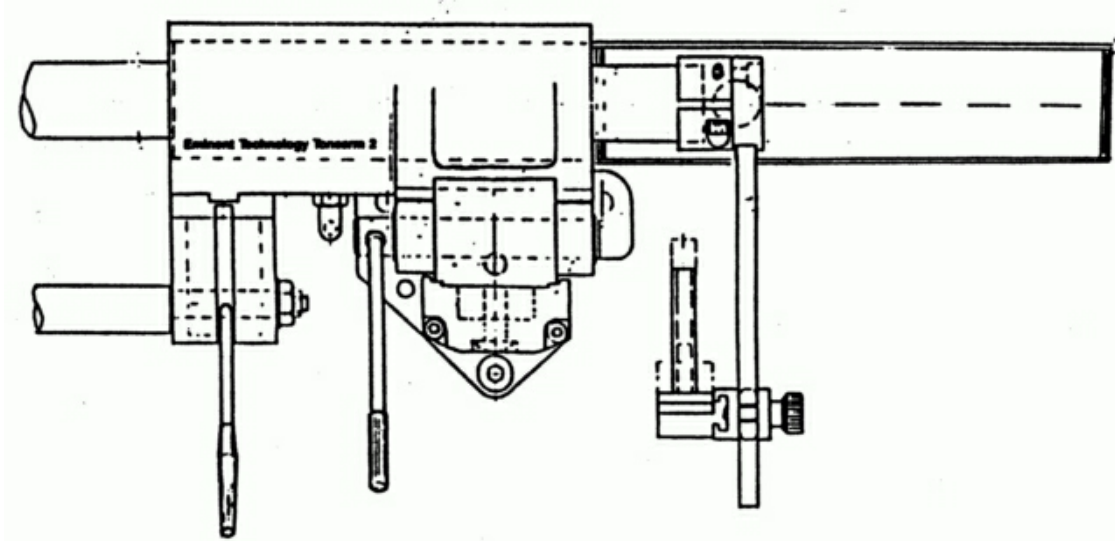


FLUID DYNAMIC DAMPING FOR THE ET-II



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INTRODUCTION

This kit includes a properly engineered fluid dynamic trough for the ET-2 Tonearm, which will operate on any turntable without interfering with any feature or adjustment ability of the tonearm. Installation is simple and straightforward, and does not require tonearm removal from the turntable or any special tools.

Be very careful when handling the silicone fluid, which is included with this kit. Be sure not to get any on the air bearing portions of the tonearm. If you accidentally get the silicon fluid on your hands, be sure they are clean before handling any part of the tonearm.

If you accidentally SPILL silicone fluid on the air bearing, do not operate the tonearm until that part is thoroughly cleaned. First, clean the part with a household spray cleaner, (409, Fantastic, Windex, etc.) using paper towels. Then use alcohol and paper towels, bath tissue, or cotton balls rubbing the bearing thoroughly. Silicone fluid will not damage the bearing. The inside portion of the manifold may have to be cleaned if the bearing is moved with silicone fluid on its surface. Consult the ET-2 Owners Manual or the factory if you have any questions.

The silicone damping trough is carefully designed to and positioned so that it is unlikely that fluid will get on your hands or any part of the tonearm during normal use.

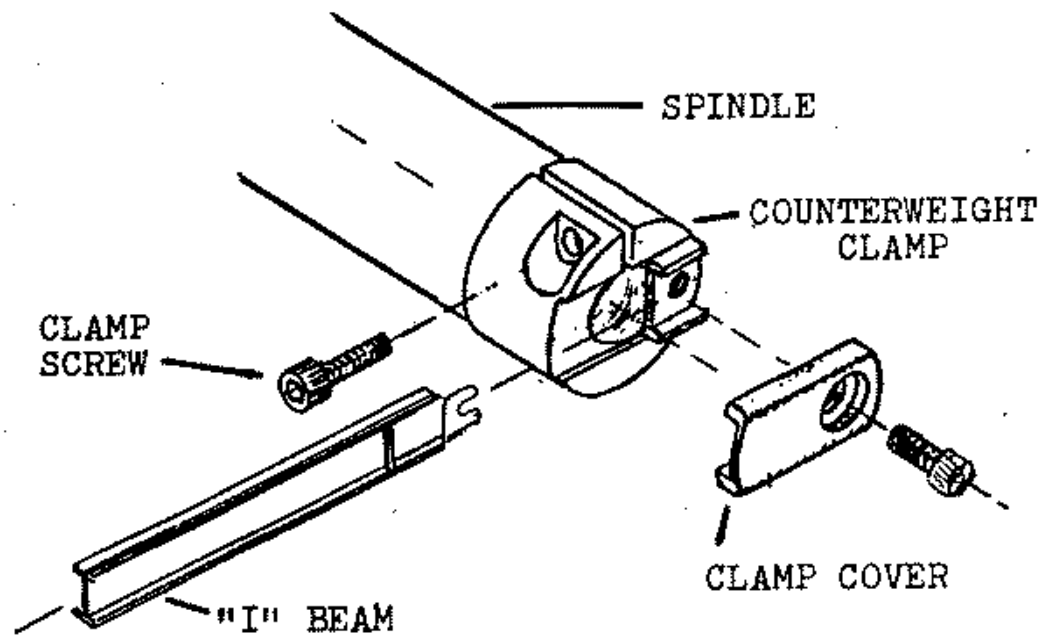
The rigid semi circular trough is constructed of an anodized aluminum alloy. The shape always maintains a constant distance between the paddle and any surface of the trough over the full travel of the tonearm.

INSTALLATION

We recommend that the user not install the fluid damping trough until you become thoroughly familiar with the use and features of the ET-2, and feel completely comfortable using the tonearm. You should know how to level the tonearm and set the tracking force before installing the damping trough.

We believe that the damping trough can be installed on any turntable/ET-2 combination without any performance limitation. If you have specific questions about any installation, feel free to contact us. The air pump should be turned off during installation.

During all of the installation procedures, put your cartridge stylus guard in place on the cartridge and leave the cuing lever in the up position. No adjustments will be made to the cuing assembly.



In order to install the kit you must first remove the counterweight assembly from the backside of the air bearing spindle. This is done by loosening the top screw on the counterweight clamp. Loosen this screw about one full turn and pull the clamp off of the end of the spindle. Do not overtorque these screws when re-assembling this part. The 3/32" allen wrench which is supplied with the ET-2 is the only tool required for installation.

After the counterweight clamp is removed from the air bearing spindle you must remove the I-beam from the clamp. This is also done by removing the clamp cover screw and pulling outward on the I-beam. The I-beam should pull out exposing a stainless steel fork spring on its end.

The I-beam should then be re-installed in the new supplied counterweight clamp/paddle assembly. Install the new clamp cover leaving the screw loose. Then slide the fork spring of the I-beam under the clamp cover and tighten the screw.

Install the new counterweight clamp/I-beam assembly onto the spindle. Be careful with the wires to make sure that they are not being pinched on the underside of the counterweight clamp as it is being pushed onto the spindle. There is, by design a tight fit between the spindle and the counterweight clamp. When the clamp is in place and pushed onto the spindle until it stops, you can tighten the clamping screw. This screw should only be tightened until it offers a slight resistance.

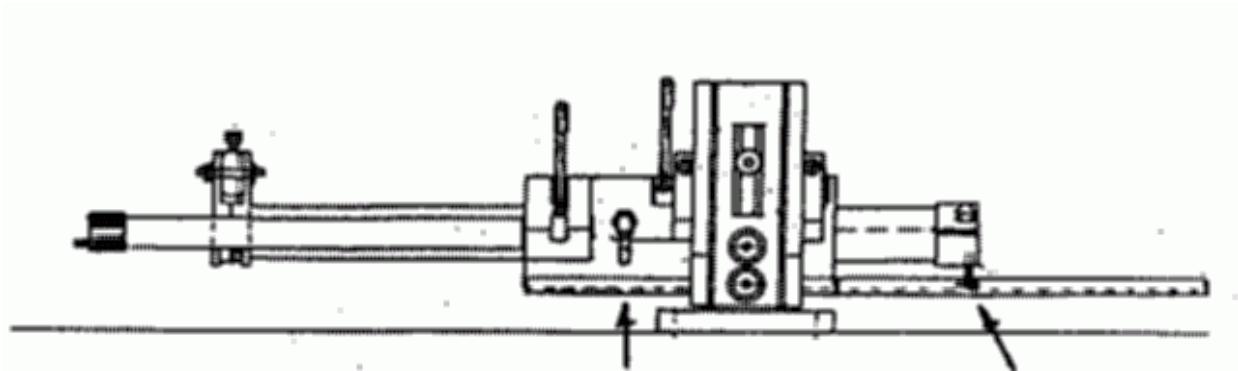


A very rigid coupling occurs with only a small amount of torque on this screw because of the close tolerances. Overtorquing this screw can distort the air bearing spindle and crack the counterweight clamp.

If the fork spring breaks off the I-beam during the above process it can be glued back into place using ordinary “super glue” (cyanoacrolate) and then re-assembled.

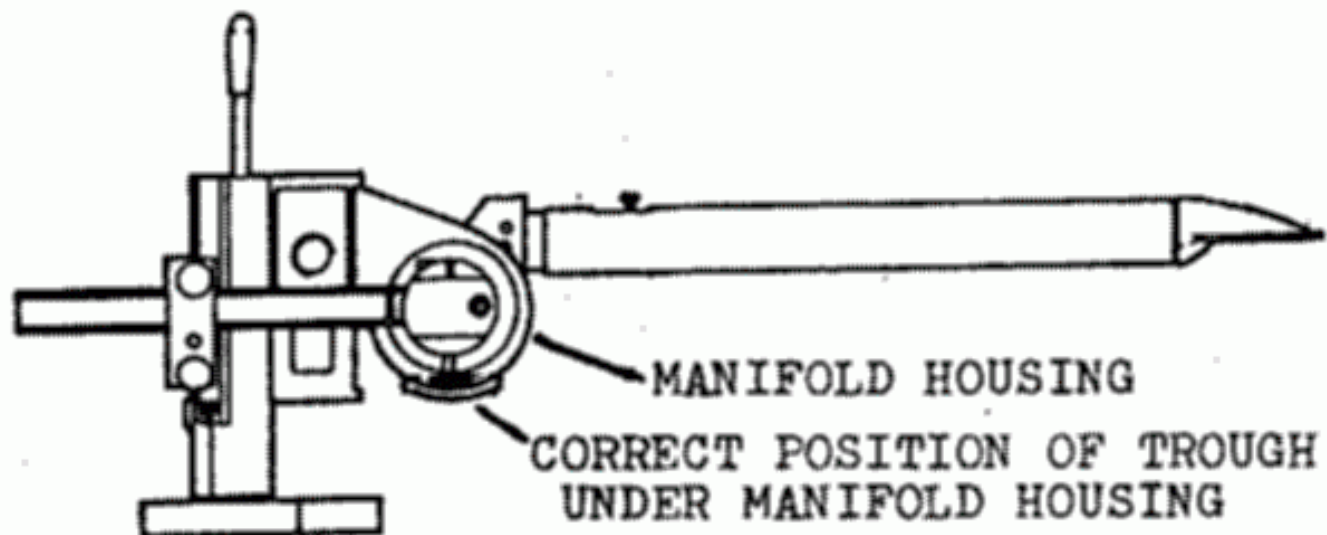
The counterweight I-beam should be positioned by rotating the counterweight clamp on the spindle until the I-beam is parallel to the tonearm tube. It can be positioned up or down slightly with respect to the tonearm tube, but generally parallel is the best position.

A very aggressive adhesive has been applied to the trough along the side, which is to be attached to the underside of the manifold housing. When the wax paper is removed exposing the adhesive on the trough it is ready to be put in place.

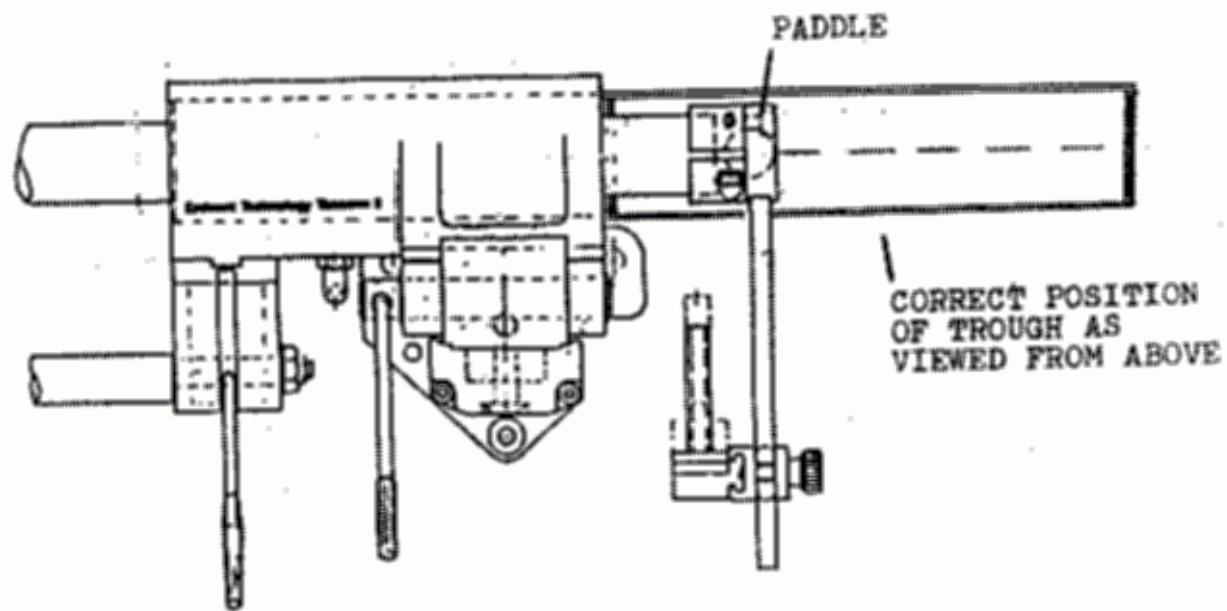


DAMPING TROUGH WITH ADHESIVE

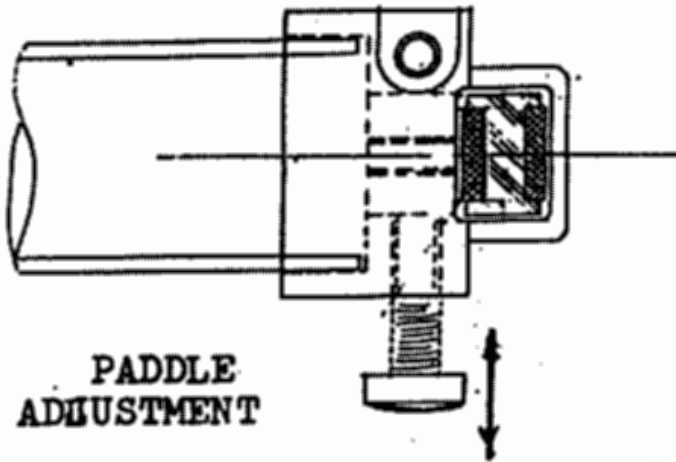
PADDLE



Study the drawings carefully and position the trough on the underside of the manifold housing as shown. If the tonearm is viewed from above, the trough should be positioned directly under the spindle and parallel to it. The inside fluid stop should be directly up against the manifold housing. When the above two conditions are met, light finger pressure under the trough will secure it to the manifold housing. It can be repositioned if necessary. Heavy finger pressure clamping the trough to the manifold housing will almost permanently secure the trough to the housing.



The paddle is threaded into the counterweight clamp and can be raised or lowered by rotation. Turn the paddle until it is positioned about 1/16" above the dry trough across the full travel of the tonearm. (It is OK to move the air bearing back and forth without the air pump operating.)



ADDING FLUID

Enough fluid is supplied for several refills. Initially, about 1 cc of fluid should be uniformly spread along the trough. An additional $\frac{1}{2}$ cc of fluid may be required to establish contact between the paddle and the fluid over the full travel of the spindle.

SETTING THE TRACKING FORCE AND LEVELING THE TONEARM

If the counterweights were not removed or repositioned along the I-beam, then the tracking force should be the same and no adjustment is necessary. Fluid damping of a tonearm does not affect the tracking force.

The additional mass of the damping trough adds about 18 grams to the mass of the tonearm. This additional mass may affect a lightly suspended turntable so it is recommended that the level be checked. Use the procedures described in the tonearm owner's manual. Please note that the tonearm now responds much more slowly due to fluid damping. **YOU ARE NOW READY TO ENJOY MUSIC AGAIN!**

TECHNICAL DISCUSSION

The compliance (spring stiffness) of a phono cartridge and the effective mass of a tonearm create a spring-mass system with a corresponding natural frequency. For a typical tonearm/cartridge combination, the resonant frequency of this spring/mass system generally falls below 20 Hz. On the surface it would seem that this does not create a problem. However, the rise in frequency response of this system for most arm/cartridge combinations is quite substantial (usually on the order of 8dB with a very high Q) and would not be tolerated in any other associated piece of equipment (speakers, electronics, etc.) The effects that result from this rise in response are in some cases subtle and in other cases substantial.

PHASE SHIFT

If a tonearm/cartridge system has a substantial rise in response below 20 Hz as most do, the phase response at the low end will be shifted and phase shift will occur beginning at 2 to 3 times the resonant frequency down to F_r . The time in which low frequency signals come from the tonearm will be shifted slightly with respect to mid-range frequencies within the audible range and substantially shifted up to several periods at resonance. This is difficult to measure with a tonearm, but easy to measure in a loudspeaker and the two responses are directly related. We find it interesting that this as a tonearm performance parameter has never been discussed. We do not know the audible effect of a purely phase shifted low frequency response. The ET-2 with the damping trough will exhibit almost perfect low frequency phase response.

WOW AND FLUTTER

Wow and flutter, FM distortion and surface irregularities in the LP should all be grouped together because, as we will see, they are all tied together.

When you cut a pure tone (say 1kHz) onto an LP and then play it back on a turntable/tonerarm/cartridge system, you would hopefully want 1kHz to come back. Something close to 1kHz comes back, but rapidly being shifted up and down around 1kHz. If the frequency is shifted up to 1001Hz and down to 999Hz within a short period of time, the amount of shift is .1%. If the shift occurs less than 10 times a second, it is considered as flutter. The two measures are generally lumped together and called wow and flutter.

“Weighting” is applied to the measurement to reduce the measurement’s sensitivity to very low and very high rate of frequency shift. The actual amount of frequency shift is much greater than the number implies. The weighting network is supposed to create a number related to a subjective ability to hear wow and flutter.

Reviewers have incorrectly attributed wow and flutter to the turntable. Since the advent of the belt drive turntable, wow and flutter has been purely a function of tonearm geometry, the phono cartridge compliance with the elastomeric damping, and surface irregularities in the LP. In our own lab we have measured many high quality turntables using a rotary function generator directly connected to the platters of the turntables.

The measured results are usually an order of magnitude better than the results using a tonearm and test record (conventional wow and flutter method). Further proof exists if you take two tonearms, one straight line and one pivoted and mount them both on the same turntable. The straight line tonearm will give a wow and flutter reading with the same cartridge/test record of about $\frac{2}{3}$ to $\frac{1}{2}$ that of the pivoted arm (.03% < .07% to .05%). This is because the straight line tonearm has a geometry advantage and lateral motion does not result in stylus longitudinal motion along the groove of the record.

Another proof is to take two different cartridges, one high compliance and one low compliance, and take measurements with both using the same turntable and tonearm. The reading of wow and flutter will be different. All wow and flutter readings are higher than the rotational consistency of the turntable.

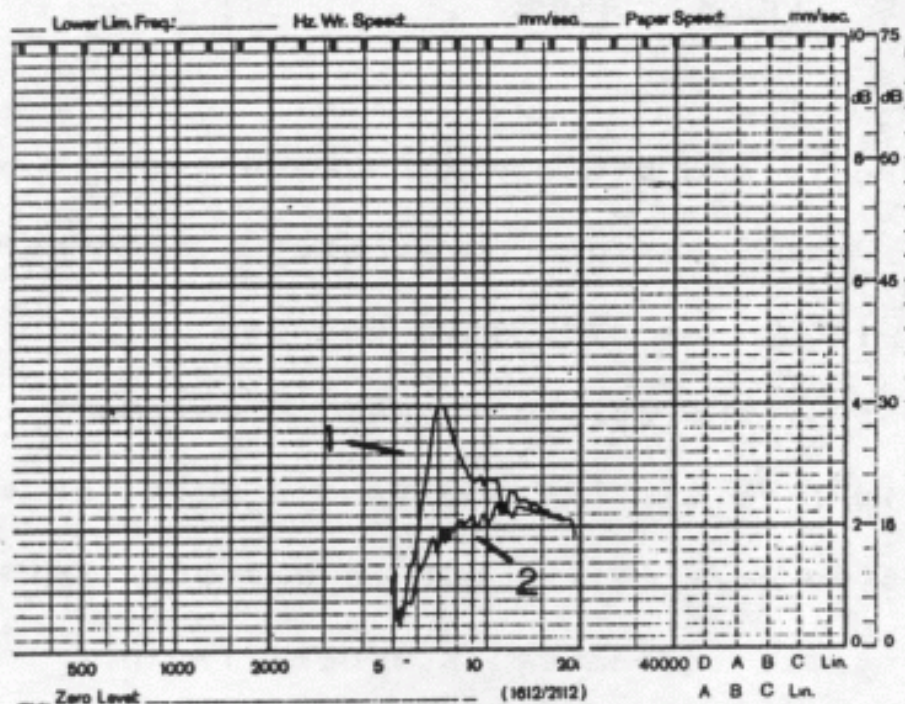
A damping track applied to a tonearm (straight line or pivoted), will reduce the measured wow and flutter usually 10-30% and sometimes as much as 50%. ET-2 wow and flutter readings with a typical cartridge and good turntable will usually measure (.02 to .04%) which is extremely low for an LP system. With the damping track installed flutter readings with the ET drop still lower and with one test record we measured readings as low as .007%.

Surface irregularities on the vinyl of the LP record are the primary cause of rumble or random low frequency noise, which causes the tonearm/cartridge spring system to start oscillating. This oscillation occurs continuously during playback. It is a primary cause of wow and flutter and FM distortion in phono playback. Surface irregularities occur not as a part of the record cutting process, but result from the molding process used in making the record.

You can see visually small ripples on the surface of an LP as it is turning. These continuously excite the tonearm resonance.

TONEARM MEASUREMENTS

A low frequency sweep was performed twice on the tonearm, once without the damping trough and once with the damping trough. The cartridge used was of very low compliance and the tonearm was set up so that a high amplitude high Q resonance existed. The results of the test show a reduction in the amplitude of the resonance of about 8 dB (horizontal). Not shown is the vertical resonance which was 15Hz with this cartridge and was reduced about 2 dB.



1. Measurement without damping trough

2. Measurement with damping trough

5 Hz TO 20Hz SWEEP
HORIZONTAL

PADDLE SHAPE

The design of the paddle and its position mean that it will be much more effective for damping horizontal resonances than vertical. Vertically, it is not as effective because of the ratio of vertical displacement of the stylus to paddle movement is about 7 to 1 (horizontally it is 1 to 1). If the paddle were made wider it would be more effective vertically, but in general this is not necessary because the vertical resonances are generally not of large amplitude. The paddle shape can be modified to alter the trough's effectiveness to both vertical and horizontal resonances.