PART III

TURNTABLES

Tonearm Design and Other Things

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The last article discussed the effects that the turntable's mechanical drive system has on the tonearm. As we see in Fig. 1, vibrations travel from the drive mechanism through the turntable chassis to the base of the tonearm, then from the tonearm base (A) through the tonearm (B) and finally reaching the phono pickup (C). We already know that these same turntable drive vibrations can also reach the phono pickup via the turntable platter. However, we will concern ourselves only with those turntable drive vibrations that are picked up by the tonearm base and how they interact with the pickup.

Since the connecting link between the tonearm base and the tonearm itself is the tonearm's pivot system, this pivot system must be designed to decouple the tonearm base from the tonearm proper. It would also be a good idea to make the base as massive as possible (if it is stationary, its mass will not contribute to the mass of the arm at the pickup) and to damp, as much as possible, the mechanical vibrations coming from the turntable drive (Fig. 2).

Tonearm pivot and bearing designs generally fall into one of several commonly used categories. The simplest design is, of course, the unipivot system (Fig. 3A). Others are (Fig. 3B) the double gimbal, (Fig. 3C) lateral shaft and bearing with vertical knife edge pivots, or (Fig. 3D) the lateral shaft and bearing with a vertical, cylindrical pivot and bearing. The pivot and bearing designs generally are cone or cylindrical pivots working in conjunction with ball bearings, sleeve bearings, or cone bearings.

Keeping in mind that we want to decouple the tonearm base vibrations from the arm proper, it becomes obvious that the contact area between the tonearm pivot and the base bearing should be as small as possible. Looking at the various types of pivot arrangements available, it is easy to see which of them will provide maximum decoupling of the arm base from the tonearm itself—the unipivot. It is optimum for many reasons; it does an excellent decoupling job, it is the only pivot system which operates with a constant zero mechanical tolerance, it has the lowest friction both laterally and vertically, and it allows the pickup to be easily adjusted for vertical azimuth (Fig. 4).

To review, then, we have discussed keeping the mechanical vibrations away from the base of the tonearm by using a turntable which utilizes a rigid, massive main plate. We have seen the importance of isolating whatever mechanical vibrations do get through to the tonearm base. These vibrations must not enter the tonearm proper for there are other mechanical vibrations coming from the pickup end of the tonearm on a direct collision course with those vibrations coming from the tonearm base (Fig. 4). It sounds very complicated but it really isn't and neither are the solutions.

Let us look at the tonearm itself (Fig. 6). On the left in our drawing is the pickup mount (A) which is connected to the tonearm proper (let us call it a tube since this is easier to illustrate, though we should remember it could take any of several design configurations). The tubular arm ends on the right side (C) and is mounted into a massive block (D), whose action will be described shortly. What shape should the tube be? Straight or "S" shaped? Strangely enough, whether a tonearm is straight or "S" shaped, it will still act as though it were a straight arm (Figs. 7A and B). The lever factor of the arm tube is governed, not by the "S" (Fig. 8), but rather by the straight pivot-stylus distance between points A and B (Fig. 9). If the "S" in the tube is rigid between points A and B, then the lever factor is exactly the same as if a straight tube were used between points A and B. As a matter of fact, it really doesn't matter what the shape of the arm is between points A and B; it could be "S", "V", "U", or any other shape but it would still react as a straight tube tonearm. However, if the "S" in the arm is in some way flexible, then the ratio of the distance between Points A and B and the curving length of the "S" would vary. But if the tonearm were flexible, one would not consider it a good tonearm for use in any quality system. To repeat, if the tonearm flexes in any direction, it cannot be considered for use in a high quality system. A tonearm must be absolutely rigid over its full length if it is to properly transport the pickup.

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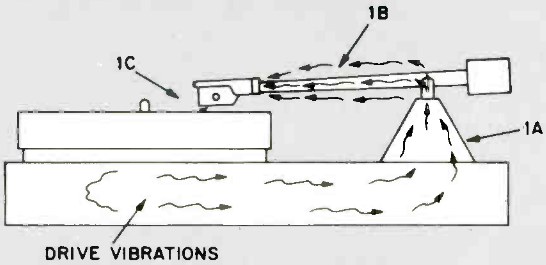


Fig. 1—Vibrations from the drive system can easily travel through the tonearm base (A), through the tonearm tube (B), to the pickup (C).

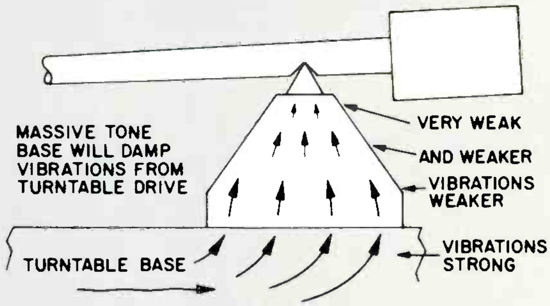
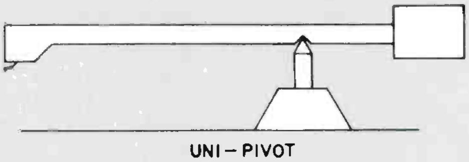


Fig. 2—A massive tonearm base will damp vibrations from the drive system.



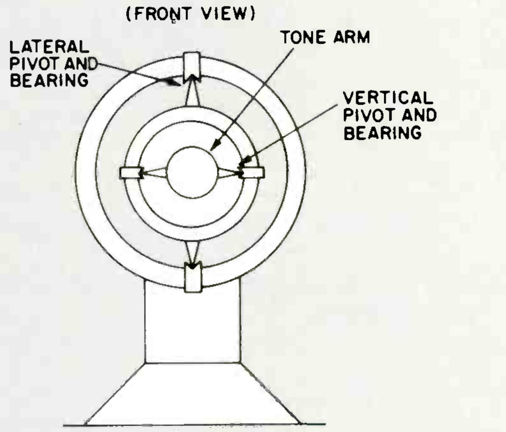
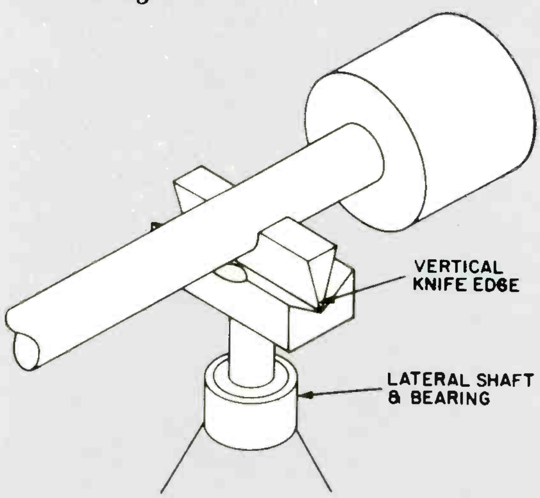
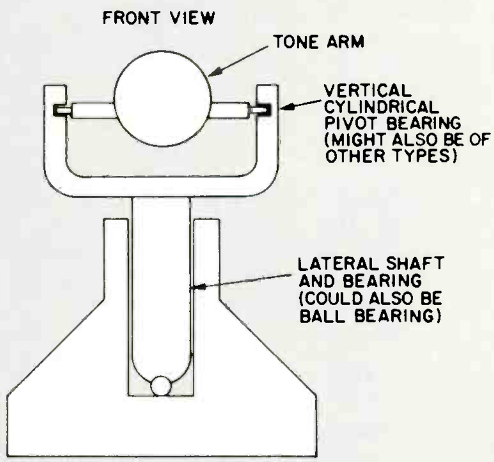
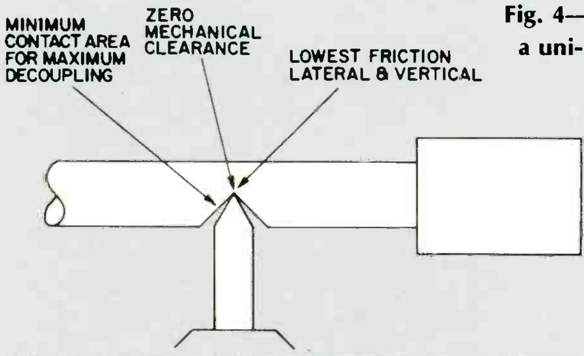


Fig. 3—Tonearm suspension systems; A, a uni-pivot design; B, a double-gimbal design, C, a knife-edge design, and D, a cylindrical pivot and bearing design.







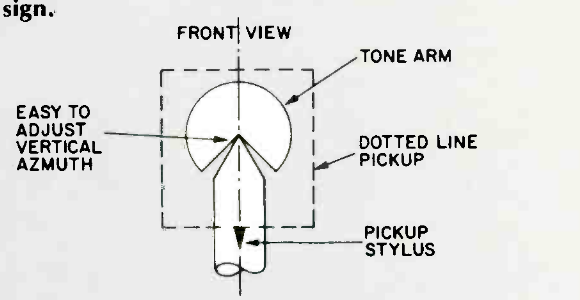


Fig. 4—Advantages of a uni-pivot design.

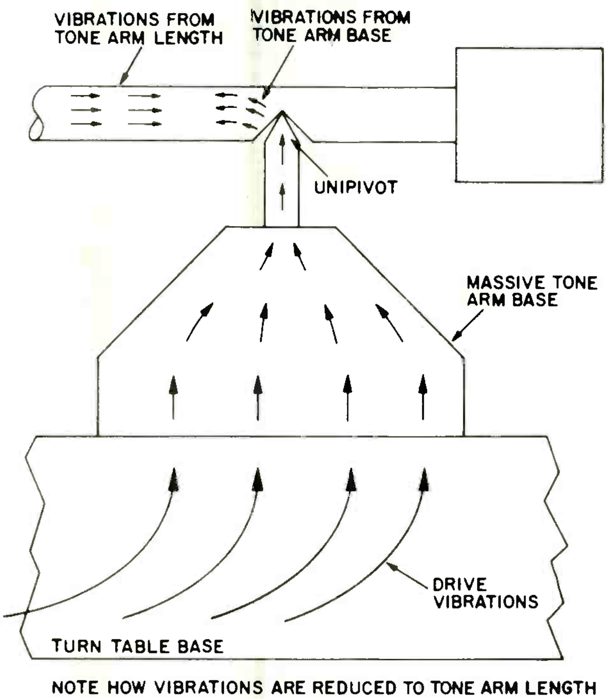


Fig. 5—Movements and levels of vibrations.

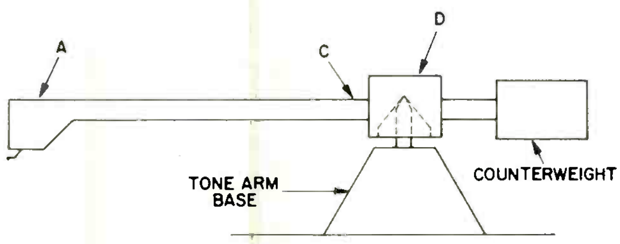


Fig. 6—Sections of a tonearm include A, the cartridge mount; B, the tonearm tube; C, entry point of the tube into the pivot block, D, and E, the counterweight.

Fig. 7—Comparison of "S" shaped arm (A) with straight arm (B) using offset pickup mounting.

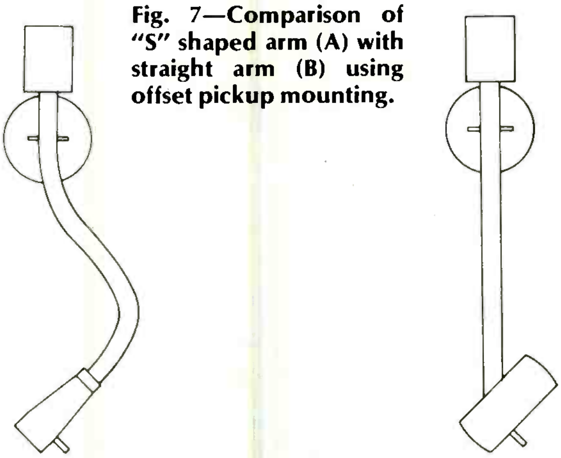
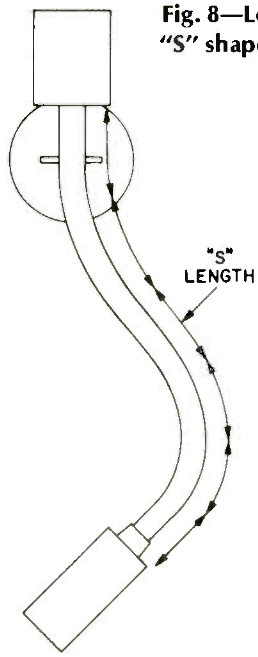


Fig. 8—Length of "S" shaped arm.



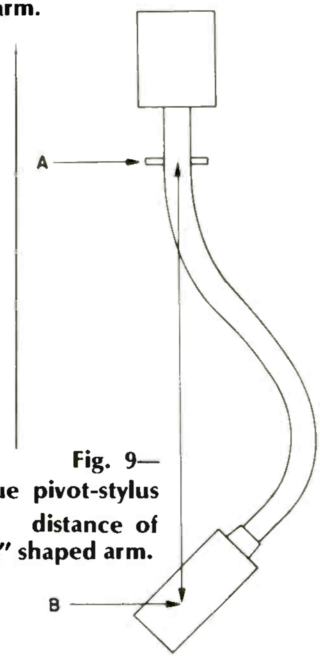


Fig. 9—True pivot-stylus distance of "S" shaped arm.

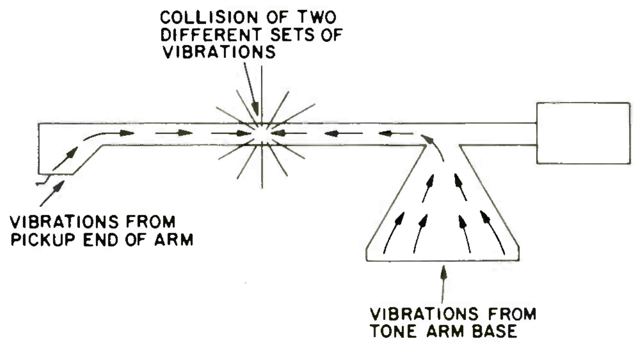


Fig. 10—Conditions which set up cycles of composite distortion products.

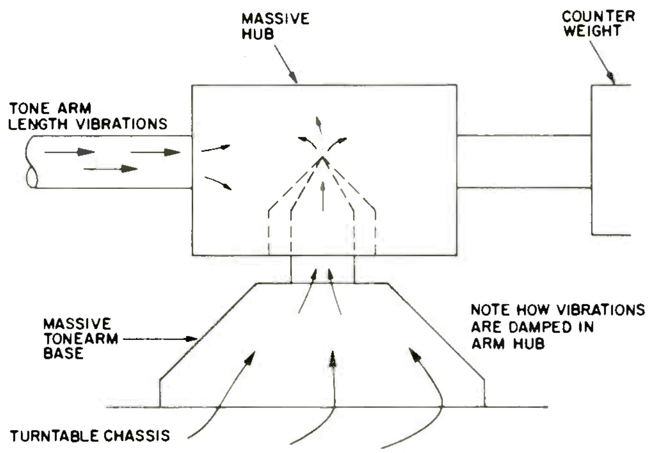


Fig. 11—Use of massive pivot hub and base greatly damp vibrations.

If the effective arm length is actually determined by the rigid length between points A and B, then why are tonearms designed with "S" shapes? Generally the "S" design is used either for proper mass distribution around the vertical and lateral pivots, to make the vertical pivot angle and the arm offset angle coincide, or in an effort to standardize the headshell configuration. In addition, the "S" shape is used to determine the offset angle for the various arm designs. Standardization is to be admired, but at the same time we must be wary of the design limitations which restrict state of the art design. Please do not assume, however, that a straight tonearm is better; it may not be.

There are many other factors in tonearm design that determine whether a tonearm is top notch. As a matter of fact, one of the best arms today is an "S" shaped arm. If the "S" shaped arm is rigid and of the proper mass (*Note:* proper, which is not necessarily light) and the straight arm flexes, then the "S" shape would be better.

The tonearm itself, whether it be tubular or otherwise, must be rigid, and yet it must be nonresonant. In addition, the arm proper should not, if possible, act as a conductor of vibrations! Since the arm (Fig. 10) receives vibrations of the pickup's mechanical action and the residual vibrations of the tonearm base, it can be easily seen that the two vibrations coming from opposite directions will meet on a collision course somewhere along the arm's length. This results, of course, in the composite of the two signals reversing direction after their collision and going back to the opposite ends of the arm tube. The vibration going to the pickup end intermodulates with the signals the pickup happens to be producing at that moment and a distortion product results. If the pickup mounting shell is not as rigid as the Rock of Gibraltar, then this mechanical resonant condition is amplified. The other composite vibration travels to the rear or pivoted end of the tonearm tube, and if the arm is light weight at that end, rattling of the pivots takes place. New mechanical vibrations from both ends start traveling the length of the tonearm tube to once again collide somewhere along the arm, and this situation cycles over and over again, creating distortion galore. Fortunately, there is a manner in which this problem may be minimized.

Let us again trace the mechanical vibrations from the cartridge end; however this time we will visualize the tonearm tube of a material which does not flex or resonate. Certain woods are a perfect material for a tonearm, since wood is rigid, light, damps its own resonance, and is beautiful. Aluminum is also excellent if fabricated properly; it should be in a soft state, coated on one side, large diameter, and thin walled. With today's technology, it is a simple matter to taper an aluminum tube, making it super rigid. Coating such a tube internally damps surface resonances, and using it in a soft state further reduces surface resonances. Anodizing the metal allows the aluminum to stay soft but makes the outer surface sapphire hard which further stiffens the arm.

Reducing Vibrations

Now we have a tonearm tube which reduces the intensity of the vibrations coming from the pickup end of the tonearm, and by the time the pickup vibrations reach the pivot area of the tonearm, they are reduced tremendously.

But wait, didn't we say that the vibrations from the base of the tonearm were still on a collision course? Yes, but we can easily take care of that. You will recall that the vibrations from the turntable drive system were almost totally absorbed by the massive turntable chassis before they reached the tonearm base. You will also recall that a proper tonearm pivot arrangement would help decouple the residual tonearm base vibrations from the tonearm tube. Thirdly, we saw that if the mass of the tonearm at the pivot was light that the pivots would rattle.

A single solution virutally eliminates all three problems. If we put a heavy mass at the hub of the arm (Fig. 11), the mass of the tonearm at the pickup end will remain virtually unchanged. However, this hub mass will absorb the residual mechanical vibrations from the arm tube, it will absorb the residual mechanical vibrations which come from the tonearm base, and it will act as a positive force to assist the tonearm pivot contact. With one design addition, we have greatly reduced or eliminated three large problems.

The next article will discuss tonearm mass, and we'll see that a light mass tonearm can create more problems than it solves. We'll discuss rear weight design, and try to get into antiskating and why it really isn't necessary. This will also lead into a discussion of straight line tracking arms and the inertial effects causing tracking error. A