# Vibration in Gramophone Turntables

## Correct Distribution of Mass to Minimize Pickup Disturbance

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THE stereo disc has brought with it many problems, some new, some old, showing up once more. In the latter category is groove jumping due to external vibrations reaching the pickup, particularly from the floor.

High-quality equipment incorporating the various well-known motors that were perfectly satisfactory with single-channel pickups tracking at 5-10 grams are now giving trouble when fitted with stereo pickups tracking at somewhat smaller pressures. The writer is amongst those afflicted with a well-sprung floor to the listening room. Normal walking has been impossible anywhere near the playing desk.

Most motor boards are suspended at 4 points, a few at 3 points. The springs are generally spaced at roughly equal intervals, and more often than not are

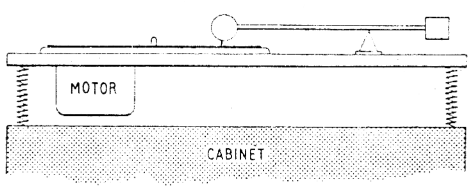



*Fig. 1. Typical playing desk arrangement shown in front elevation.*

identical. Fig. 1 shows the front elevation of a typical playing desk arrangement. The heavy transcription turntable is well to the left side of the motor board and the driving motor is usually further still to the left. The centre of gravity is then much nearer to the left-hand springs than the right-hand springs. The left-hand springs will in consequence be compressed more than the right-hand, but the usual screw adjustment will have been set to put the turntable level. Though differently loaded, the springs are still of equal compliance. The system can be simplified to two dissimilar masses connected by a rigid bar and suspended on two identical springs (Fig. 2).

Now consider the effect of a vertical disturbance on this system, say a single vertical displacement of short duration. It is quite obvious that the lighter side will oscillate with a larger amplitude than the heavier side (Fig. 2a). The system is subjected to two disturbing motions in the vertical plane, a linear one (Fig. 2b) and a rotational one (Fig. 2c). Both will affect the pickup.

As J. Walton has already shown (*Wireless World*, June 1959), the gravity-balanced type of arm is but little affected by vertical *linear* accelerations (Fig. 2b). In fact, the only change of stylus force for a vertical linear acceleration is equal to the force produced by similarly accelerating a mass equivalent to the stylus force.

Fig. 3(a) shows a perfectly balanced pickup arm. The stylus will not be pressing on the disc though it may be touching it. A vertical acceleration applied to the whole system—in this case solely via the pivot—will not alter the attitude of the pickup arm since head and counterweight moments balance. There is thus no change in stylus pressure, it remains at zero all the time, even if it is touching. Fig. 3(b) shows the same arm loaded for simplicity with *m* grams on its head. Again the pivot "looks after" the arm and the stylus only has to accelerate the *m* grams.

As a further check on the validity of this argument, consider the stylus detached from the head and carrying the *m* grams. Apply the vertical acceleration to the system and note the result. The stylus has accelerated the *m* grams: the distance between arm and the head is unaltered as the perfectly balanced arm is unaffected: therefore the loaded stylus may as well have been left attached to the head! Moving the counterbalance weight slightly to produce the *m* grams tracking weight would give the same result.

To get some idea of the forces involved, assume a disturbance producing $\pm 2$mm of sinusoidal vertical (linear) motion at 5c/s. For tracking weights of 1, 3, and 5 gm the forces will be 0.2gm, 0.6gm, and 1.0gm respectively. They are, of course, proportional to the tracking weight for gravity-balanced arms.

These forces are not negligible, but they are not likely to promote groove jumping unless they happen to coincide with some very heavy modulation and then only if relative phases are just so.

Of interest rather than usefulness is the following point. If a pickup arm is gravity balanced to give

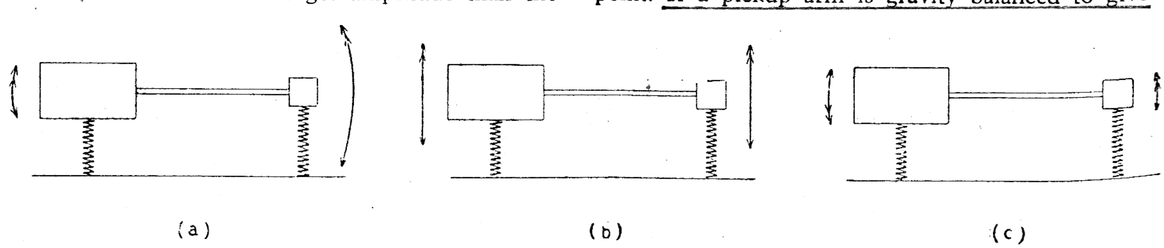



*Fig. 2. Simplification of Fig. 1. The actual motions in Fig. 2(a) are equivalent to the combination of the linear motion in Fig. 2(b) with the rotational motion in Fig. 2(c).*

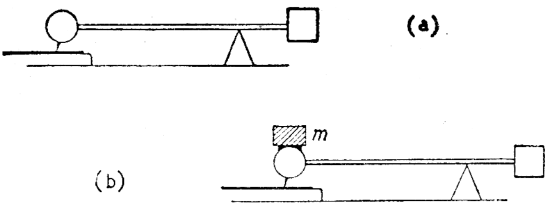



*Fig. 3(a). Perfectly balanced pickup arm. (b) To obtain the required stylus force, the arm of Fig. 3(a) is loaded with m gm on its head.*

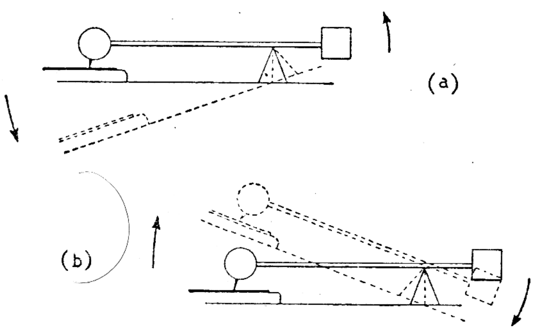



*Fig. 4. Perfectly balanced arm acted on by anti-clockwise (Fig. 4(a)) or clockwise (Fig. 4(b)) rotations of the playing desk.*

zero stylus pressure, and the stylus pressure is then applied by a massless spring, the arm is completely immune to all straight-line vertical motion!

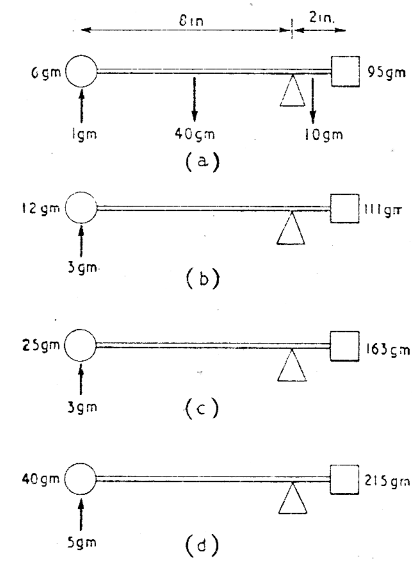
Now consider the rotational component in the vertical plane (Fig 2c). Here the *direction in space* of the *whole* arm is being altered. Therefore it resists with its *whole* inertia. The stylus tip takes almost the whole brunt of this type of disturbance. To clarify this argument, consider a perfectly balanced arm (Fig. 4) with the stylus touching the disc, but, of course, with zero pressure. Now rotate the pivot pedestal-cum-disc system about the pivot point. This is the centre of gravity and is chosen as we are considering the rotational component only. An acceleration as shown in Fig. 4(a) will clearly leave the pick-up behind, i.e., it will jump clear of the disc—relatively.

In the opposite direction, Fig. 4(b), the disc-stylus contact will obviously cause the arm to rotate with the system (unless it lifts it off the pedestal!) To produce this rotation, the stylus has been opposed by the inertia of the whole arm—measured about an axis through its pivot and perpendicular to its length. This same force would be required to keep the stylus in contact with the disc in Fig. 4(a). Adding in the stylus pressure does not alter the situation very much. If weight is added to the head, the total inertia rises a little. If the counterbalance weight is slid toward the pivot the inertia is reduced by an almost imperceptible amount. If by spring, then the inertia is unchanged.

Incidentally a *spring counterbalanced* arm scores in this case as there is no counterbalance weight and arm overhang to add to the inertia. It is, however, a very doubtful gain, as the extra complexity and its accompanying friction may well be even more serious.

For comparison purposes consider the motor board stationary on one side and still moving ± 2mm vertically on the other side, still at the same frequency. For a 15-in wide motor board this is an angular rotation of ±0.0052 radians (about $\frac{1}{3}$ degree), and an angular acceleration of 5.2 radian/sec$^2$.

Fig. 5 shows dimensions and weights of typical pickups based on J. Walton's figures on page 269 of the June issue of *Wireless World.* Below are given moments of inertia about the pivot, calculated on the basis of concentrated head and counter-balance weights and distributed arm mass. In all cases the disturbing force is well in excess of the tracking weight and must cause jumping.




| | Moment of inertia gm-cm$^2$ | Disturbance to stylus force gm |
|---|---|---|
| (*a*) | 10500 | 2.7 |
| (*b*) | 13400 | 3.5 |
| (*c*) | 20100 | 5.2 |
| (*d*) | 27600 | 7.1 |

*Fig. 5. Dimensions and weights of typical pickups with corresponding moments of inertia about the pivot and disturbances to stylus force for an angular acceleration of 5.2 radians/sec$^2$.*

Lest anyone feels these figures are unduly large, consider the motor board motion to be ± $1\frac{1}{2}$mm on the left, and ± $2\frac{1}{2}$mm on the right, in phase. This will produce a just visible rocking motion and involves accelerations and disturbing forces exactly half of those quoted above. Even bringing in the fact that the pickup is most of its time at say 45° to the plane of maximum rotation, the figures are only reduced by a further factor of 0.707.

Observation of motor board movements when the floor or the cabinet is disturbed often reveal quite alarming gyrations, some of them much faster than 5 c/s. Anyway, the initial acceleration is usually larger than any of the following observable movements. It can thus be seen how important it is to minimize all rotational components.

The simplest way of dealing with existing equipment is to add a mass W to the other side of the motor board (Fig. 6), so that the centre of gravity