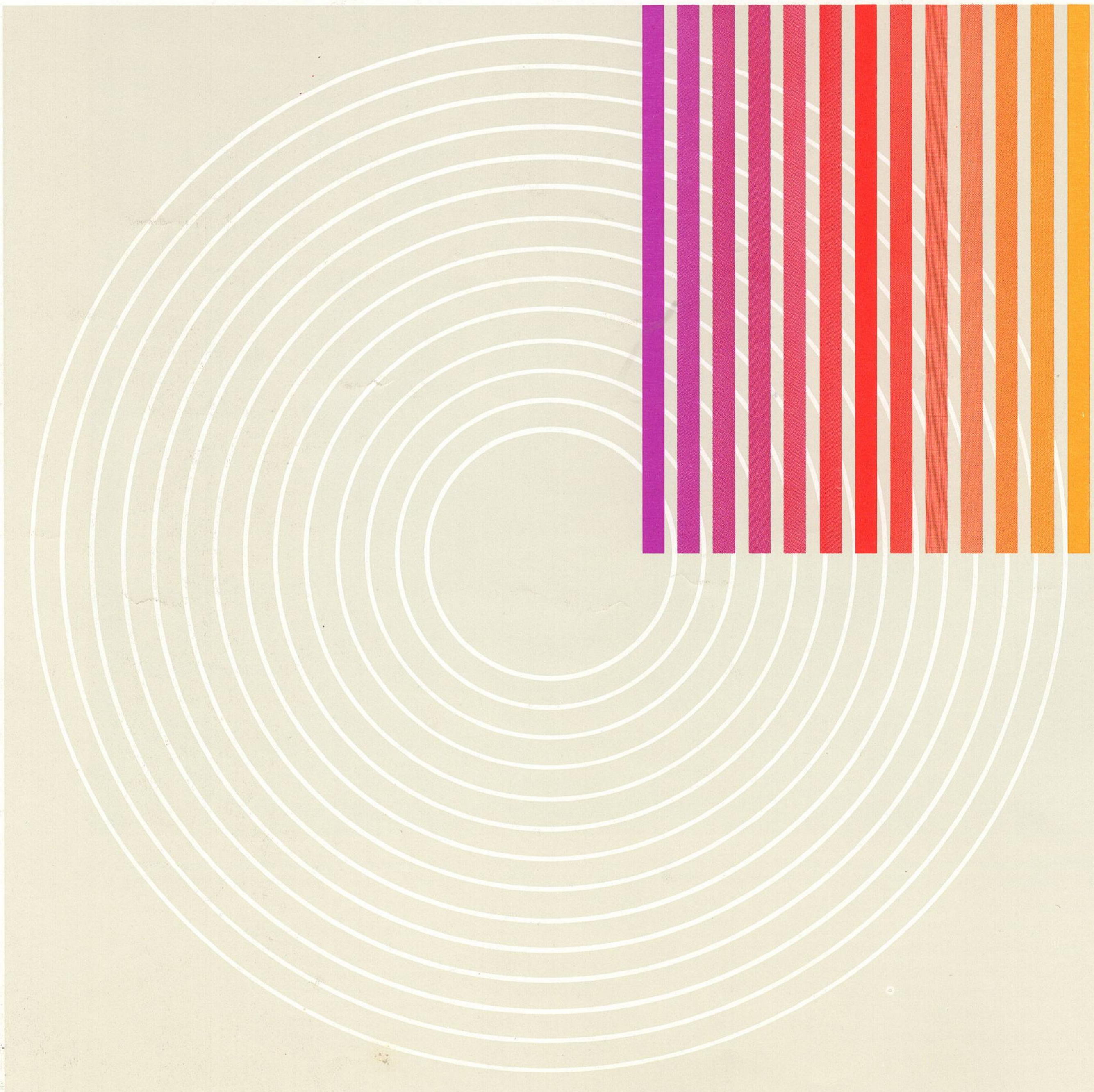
harman/kardon

Rabco ST-7

straight line tracking system



Turntables and playback arms have undergone little fundamental change since Emile Berliner's invention of the flat disc recording format. Even "new" designs have essentially been variations of the conventional approach.

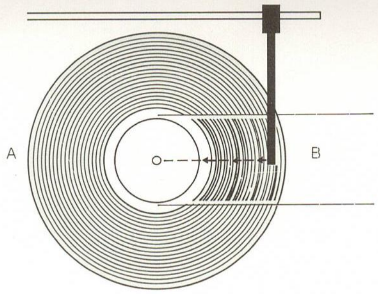
The new Harman/Kardon Rabco ST-7 is creative design in the best sense. It makes use of some conventional methods where they offer the best solutions to practical problems, and of new technology (never before present in a turntable) where the end results are of substantial meaning.

Of course the ST-7 grows out of what came before. But it is not a variation on a conventional theme. It takes the turntable in a totally new direction.

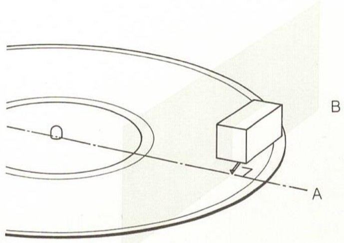
No longer does the music enthusiast have to compromise with make-shift contrivances such as anti-skating controls, "S"-shaped arms, tracking error mechanisms, and all the other devices that are simply attempts to deal with the inherent problems of the pivoted arm. No longer does the record investor have to suffer the sometimes rapid deterioration of costly discs.

Harman/Kardon designed the Rabco ST-7 with one goal: To be the best record playing instrument ever. We believe it achieves that goal.

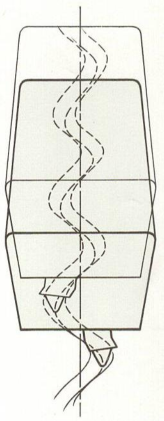
If the groove is cut into the disc at constant pitch (A), the arm can be driven from the rear at constant speed and accuracy will be assured. Variable pitch cutting techniques allow for more economical discs but make constant speed arm drive impossible.



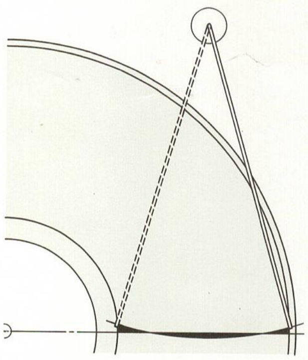
The stylus tip must follow the path originally taken by the cutting stylus for accurate reproduction. This is accomplished if the cartridge is held so the stylus tip always contacts the disc surface at the point of intersection of a radius of the disc (A) and the plane defining the cartridge axis (B), where (B) and (A) are perpendicular to each other. The requirement for perpendicularity results from the desire to precisely repeat the action of the cutting head. It is this perpendicularity that *no* pivotal arm can achieve.



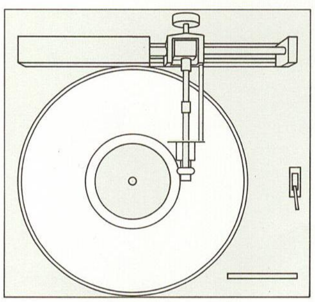
When tracing a modulated groove, the stylus must be able to move equal distances to either side of a center "reference" line. This line is the same as the path the stylus would take if it traced an unmodulated groove. Reference line shifts, caused by external forces like skating, shift the stereo image and can cause poor frequency response by forcing the stylus to vibrate in a non linear part of the cartridge's electro-magnetic field.



A pivotal arm cannot trace the ideal straight path of the cutting head. To achieve the best approximation, the arm requires overhang. While this design is better than one without overhang, it produces tracking error on both sides of the ideal path. Error will exist over the entire disc and is greatest at the beginning, middle and end of the disc.



A straight line arm produces no tracking error. And, because it is free of the effects of skating force, the straight line arm fully satisfies each of the conditions essential for accurate reproduction. The ST-7 also drives the arm at a speed proportional to groove pitch, so its accuracy is maintained across the entire disc.



Any comprehensive discussion of turntable design and performance must begin with a clear understanding of the way disc recordings are made.

The template (master disc) is *cut* on a special lathe where the cutting head and stylus move in a *straight line* from the edge to the center. A carefully mixed, equalized and amplified signal from the master tape creates movement of the cutting head and stylus, inscribing the disc's surface with a groove. The disc rotates at an absolutely constant speed to assure frequency accuracy.

The Ideal Arm

Accurate disc playback depends directly on the ability of the stylus to meticulously follow the "path" made by the cutting head. The *ideal arm* would move over the surface of the disc at precisely the same rate and direction as the cutting head during the original cut.

This would be a relatively easy task if the groove *pitch* (linear spacing between grooves) was kept constant during cutting. It would then be possible to use a "driven" arm, where the drive speed is the same as that of the original cutting head.

However, the advantages in the use of variable pitch are of such benefit that constant pitch recordings are rarely made. Clearly, a playback arm cannot be driven at a constant rate under variable pitch conditions.

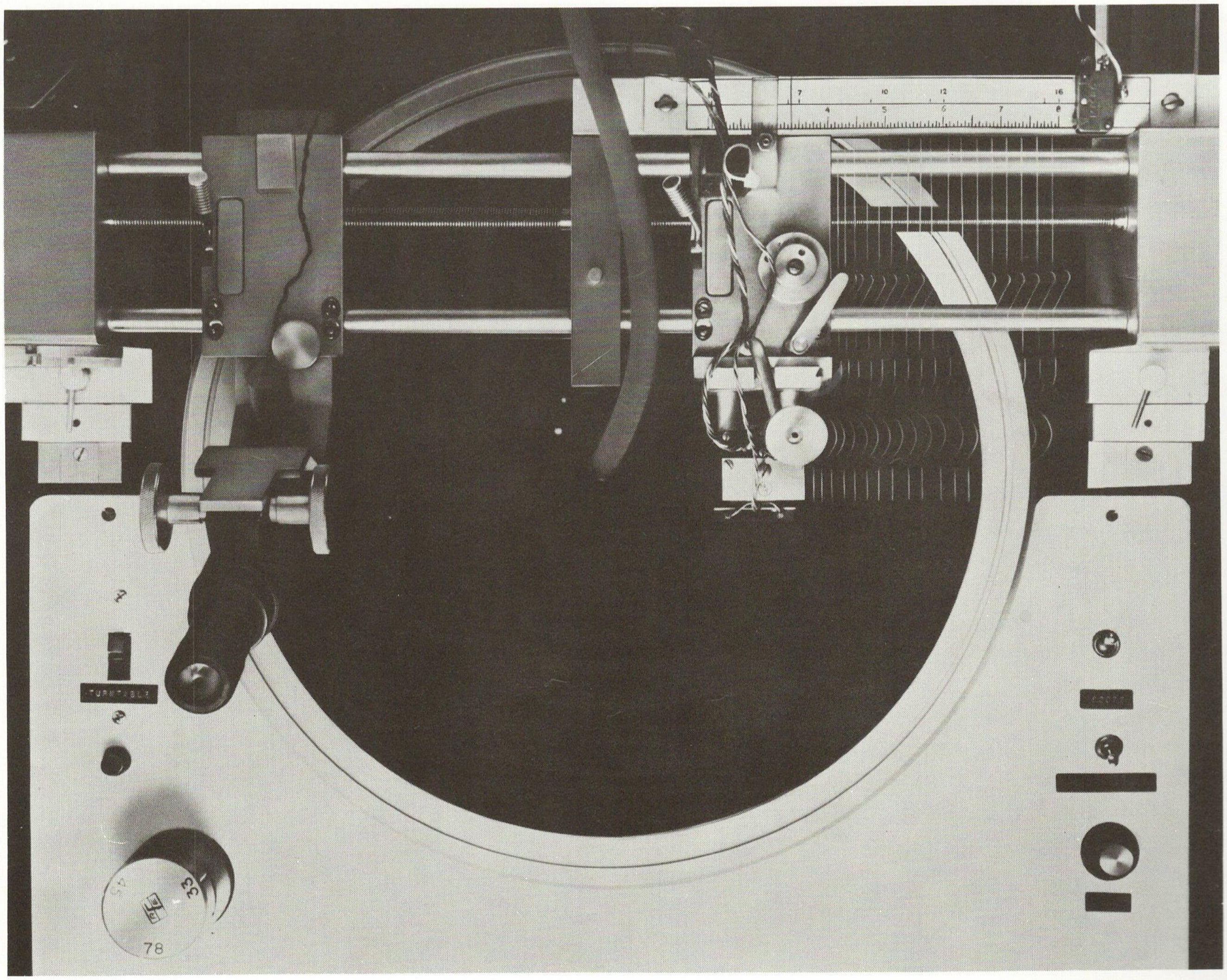
In addition, variable pitch places severe burdens on the design of a real arm since there is no way to anticipate the movement of the spiral groove on the disc. The arm must be designed to follow the groove; i.e., the movement of the arm is dependent on and controlled by the groove pitch. The combined mass of the arm, cartridge and stylus then becomes an important consideration. A "perfect," independently driven arm not only could be quite massive, but would be designed to be massive if perfectly flat discs using constant pitch were available! This is in contradiction to the almost universal belief that playback arms must possess the least possible mass. That belief, held that in the "ideal" arm/cartridge/stylus system: the arm should have infinitely low mass; the stylus compliance (the mechanism that suspends the stylus cantilever and allows it free movement) should have infinitely low mechanical resistance (the term compliance applies both to the mechanical device and the measurable property); and, the stylus cantilever and tip should also have infinitely low mass. Such an ideal system would track the grooves of discs beautifully, but would produce no sound. *To produce sound, the stylus must move relative to the cartridge body.*

The arm, therefore, must satisfy two conflicting conditions: it must appear immovable in relation to the stylus, yet be free to follow the movement of the groove as it spirals inward. This is done by making the arm massive and requiring mechanical resistance in the stylus assembly. The arm mass must be enough to permit the *least* compliant stylus assembly to accurately follow the modulation of the lowest frequency signal recorded at the highest level found on discs.

While mass is needed to obtain a useful signal, it bears a severe penalty: record wear. Mass means inertia (the tendency for objects at rest to remain at rest, and objects in motion to remain in motion), thus abrupt and irregular motion caused by warps and eccentricity on discs are resisted by the inertia of the arm often causing permanent damage to the modulations on the groove walls. Reducing mass reduces inertia and record wear.

Arm Geometry

The arm has the additional task of precisely positioning the stylus to accurately trace the modulations on the groove walls. The longitudinal axis of the cartridge must be kept tangent to the median line of the groove at the point the stylus contacts it to eliminate tracking distortion. Also, the stylus should move equally about the median line of the groove for accurate frequency response and full separation with correct imaging. Since the cutting stylus and head move in a straight line along the radius of the disc when it is cut, the stylus and cartridge should follow precisely the same path during playback to assure freedom from distortion.



This photograph shows the essential elements of a typical cutting lathe. The cutting head (at right) traverses the original lacquer disc in a straight line, moving freely along the two smooth horizontal bars. The third bar drives the cutting head according to the desired pitch. A microscope, (at left) permits visual inspection of the cutting process. (Photographed at Ultrasonic Recording Studios, Hempstead, N.Y.)


RABCO

Pivotal Arms

Every conventional arm shares a common element: a pivot (around which the arm can move) that has a fixed position in relation to the disc.

While such arms can be designed to successfully satisfy the mass requirements demanded of all arms, they do so with difficulty because of a series of problems inherent in the pivotal format.

A stylus positioned at the end of a pivotal arm can only move in an arc, not a straight line. By increasing the distance between the pivot point and stylus, it is possible to minimize the discrepancy between the desired path and the actual one, but increasing the arm length automatically involves increasing its mass. This of course is undesirable, particularly since even a "good" approximation would require the arm to be several meters long.

A pivotal arm permits the point of the stylus to be tangent to the groove at only two positions on the record. At all positions away from these points the error from tangency increases enormously, creating totally unacceptable tracking error. If the arm is offset, either by placing the end of the arm at an angle or creating an S-bend, tracking error is almost tolerable. However, an offset reduces the effective length of the arm for which some compensation, called overhang, must be made. The combination of an offset head with overhang causes the forces acting on the stylus to be unbalanced and creates the most notorious of all pivotal arm problems—skating force, which causes the stylus to exert uneven pressure on the walls of the groove.

Curiously, skating force is a far more serious problem in well-designed pivotal arms than it is in inexpensive ones. More expensive arms generally have lower friction and lower mass, which make the effect of skating force more obvious. What's more, these better arms are designed to handle high quality cartridges on which skating force has its worst effect.

The introduction of the articulated pivotal arm, while it did reduce tracking error, did not end the problems of skating force in pivotal arms. The fact remains that a pivotal arm with an offset head *must* have the problem of skating force and therefore an anti-skating device to combat it. Since skating force varies constantly with the frequency and level of the groove modulations because of friction they impose on the stylus, an anti-skating device which remains constant cannot fully compensate for all of these *varying* forces.

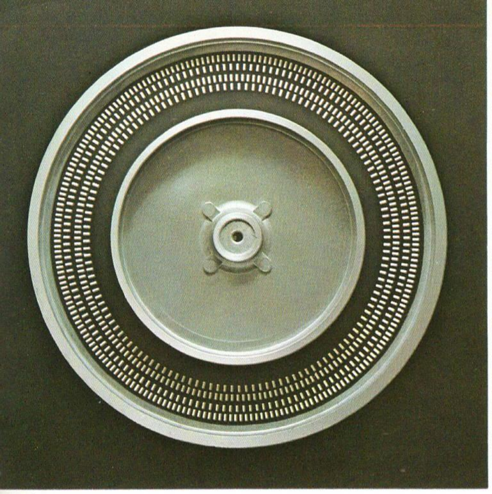
1. The cast aluminum platter of the ST-7 reduces weight, yet provides sufficient mass for good flywheel action. It also carries the strobe patter for speed control.

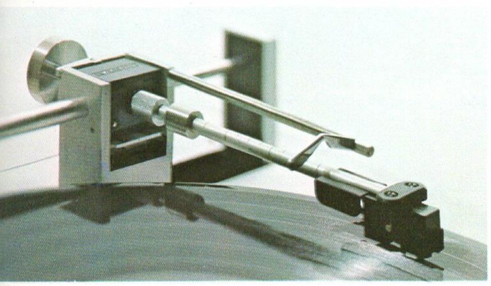
2. An outrigger serves as a finger grip for the ST-7 arm and permits positioning of the arm at any point desired. The specially shaped restrictor protects the arm and serves as an index.

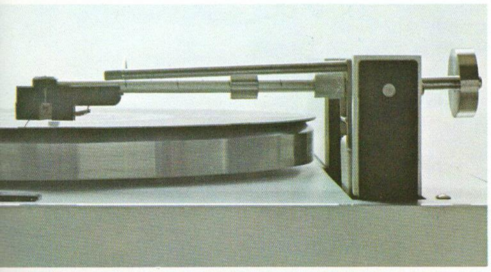
3. The ST-7 arm is designed to achieve optimum performance with extremely low mass. A sliding collar provides correct stylus pressure and mass resistance for both high and low compliance cartridges.

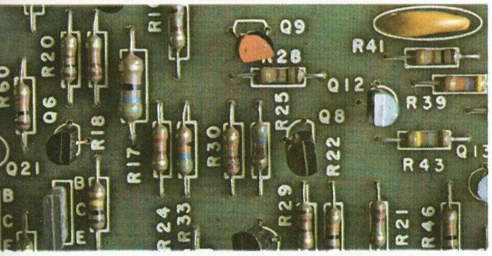
4. Motor operation in the ST-7 is completely electronic. Lockouts governed by logic IC's permit alternate choice of 33-1/3 rpm or 45 rpm. Other sections of the same circuitry turn the motor off at the end of play and actuate the illumination under the control bar.

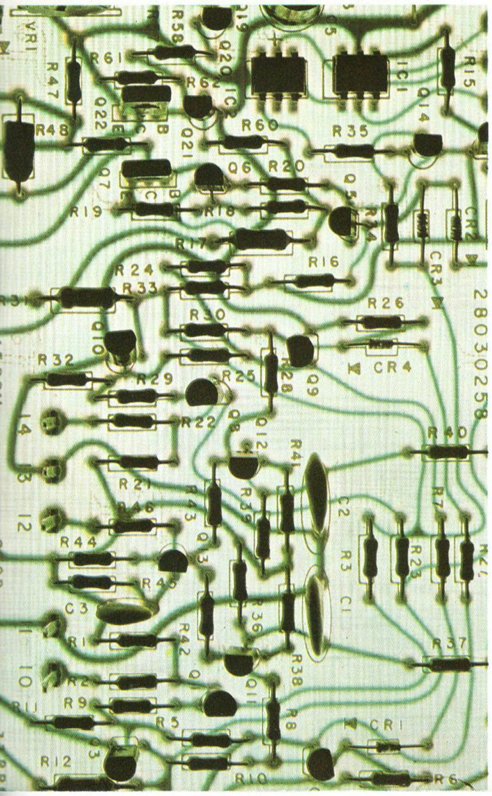
5. The ST-7 platter mat (shown on the left) carries a specially designed rib pattern that damps microphonic oscillation of the disc as well as standing wave propagation along its surface. The disc is supported in the groove area, not at the edges and label. This design prevents the subtle effect of low level acoustic feedback often present in turntables with traditionally designed mats.











Rabco ST-7

Straight Line Tracking Arms

Designers involved with playback arms understood that there was need for an arm that would permit its "pivot" to move parallel to the cartridge and stylus. Such an arm would move, or "track", in a straight line, and therefore exactly follow the path of the cutting head.

It would have other advantages as well. A straight line tracking arm with its moving pivot would need to be only slightly longer than half the diameter of the disc. The length is needed only to allow the moving pivot to fall outside the area of the disc. Since a straight line arm can be short, its mass can be far less. And the shorter length permits the use of lighter materials without loss of rigidity.

In a straight line tracking arm it is not only possible, but *easy* to orient the cartridge and stylus in their best positions. The cartridge axis can ride above the median line of the groove, tangent to it at the point of stylus contact, for all positions of the arm's travel. Tracking error is reduced to zero. External forces acting on the stylus are in complete balance—there is *no* skating force and thus no need for any anti-skating device whatever.

None of the problems that beset pivotal arms arise in the straight line tracking concept. Straight line tracking allows the designer to move directly toward the goal of perfect disc playback.

The Rabco ST-7

Straight line tracking as a concept has been highly valued for some time. Practical implementation of the concept required new technology. Throughout the development of the ST-7 we made every effort to implement fundamentals in a way which assured realization of its potential. In addition, it seemed to us that it should be possible to deal more effectively with other areas of performance—those *within* the arm that straight line tracking does not influence; those that are concerned with the action of the turntable and its drive; and those that allow the most facile control of the entire instrument.

The Rabco Arm

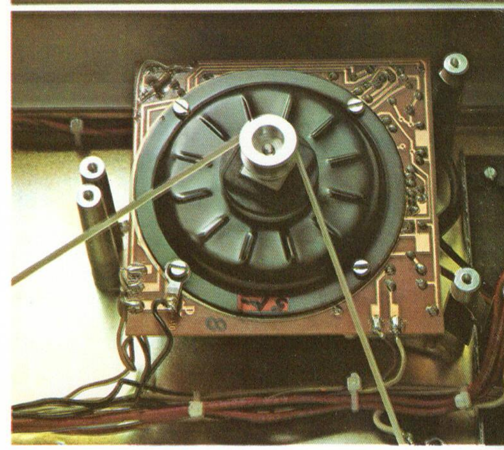
Like the "ideal" arm, the arm of the ST-7 is driven, not with the servo-type gear screw drive of the cutting lathe, but with a patented mechanical servo-drive system.

A precision honed rubber "tire" rides flat on a smooth cylindrical shaft, machined to close tolerances. The shaft, rotating by action of the turntable and its motor drive, causes the rubber tire to rotate. As the arm follows the groove, the rubber tire follows it along the rotating shaft. When the flat surfaces of the tire and shaft are in perfect parallel contact, the drive action stops. The drive action is continuous because the groove constantly moves inward, and the drive speed is directly proportional to the groove spacing. Thus, virtually perfect straight line tracking is accomplished in a way that accommodates the variable pitch technique. But there is an additional advantage. There is no resistance to the movement of the arm—there is no horizontal friction whatever!

Nor is there any vertical friction. The ST-7 does not use standard needlepoint, ball or roller bearings for its vertical pivot. Instead, it uses an ingenious device called a *rolamite* bearing. This bearing allows the arm to move up and down without any friction. And yet another advantage: the elimination of the effects of disc warpage.

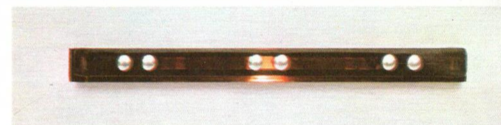
Two problems arise in playing warped discs: First, the problem of keeping the stylus in constant contact with the groove. The answer lies in *reducing* the mass of the arm and placing the arm's pivot in the same plane as the surface of the disc. This minimizes the inertial effects of the warpage. Better contact can be accomplished by increasing tracking force, but this increases record wear.

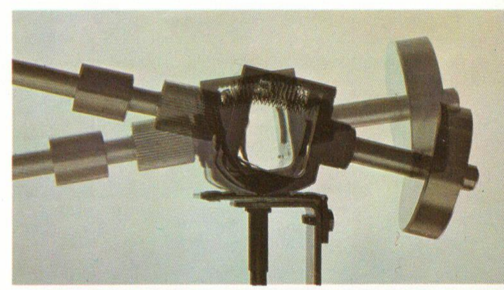
Second, is the effect of warp wow. With an arm that possesses an absolutely stationary vertical pivot, the vertical movement of the arm caused by warpage results in small changes in the effective length of the arm. The effect is the same as if the stylus periodically moved a very small distance away from the arm's pivot

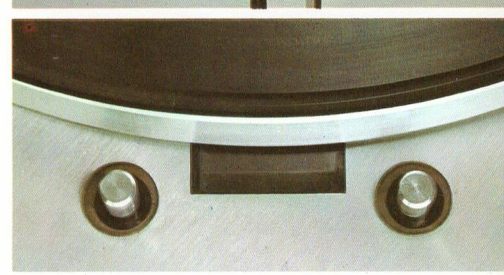


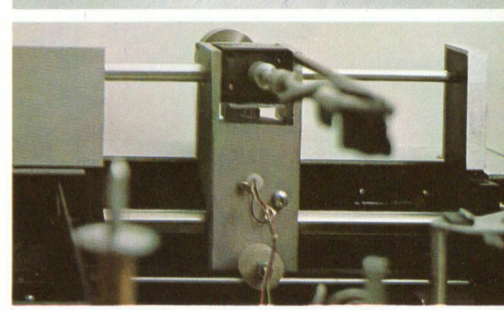
point, away from the ideal point of contact in the groove. These movements result in small changes in the velocity of the stylus relative to the disc's surface, producing noticeable frequency changes in the reproduced sound called warp wow. By carefully choosing the insertion points of the elements of the rolamite bearing, the vertical pivot point of the arm can be made to change position with the vertical movements of the arm. When disc warps cause the ST-7 arm to move up, its vertical pivot also moves up and slightly backward, compensating for warp wow. The upward movement allows the arm to remain level and parallel to its normal position, so the correct stylus tracking angle (nominally 15° from vertical) can be maintained. In addition, the stylus does not need to bear the burden of moving all the arm's mass when a warp is encountered as it does in a fixed pivot arm—the rolamite bearing design helps it do this. Taken together, the benefits of the rolamite bearing are obvious. As a result, the ST-7 arm does a better job of tracking discs than any other arm design.

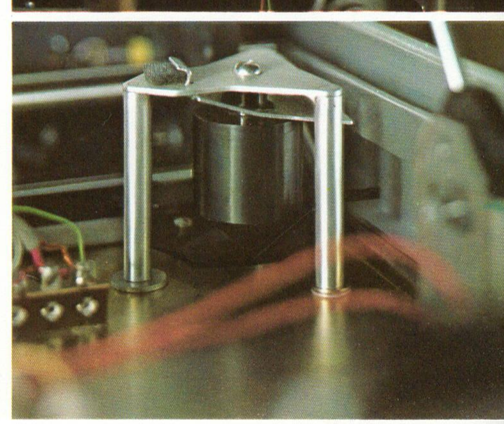
Control of mass in a straight line tracking arm is made easy because of the shorter length. The ST-7 arm takes this basic advantage several steps further. All the non-functional elements that contribute mass have been moved toward the pivot area to reduce their effects (moment of inertia). Some have been eliminated completely. First, the arm has no finger lift for locating it at a specific position on the disc's surface. Instead an outrigger arm with an indexing cross-member is used. Second, the arm has no detachable, decorative head shell; the cartridge is mounted to a small oblong headpiece that is no larger or thicker than the stress of solid mounting or need for rigidity require it to be. Instead, the entire forward element of the arm is detachable, allowing for quick and easy substitution of cartridges. This allows the connector and its mass to be placed very close to the pivot point. (In most arms the finger lift and headshell lock are placed so their contribution to the moment of inertia is not only greater, but also unevenly distributed over the stylus). Finally, the counterweight at the rear of the arm is positioned more closely to the pivot position than in other arms, reducing its moment of inertia.











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6. A "Hall effect" DC motor drives the ST-7 turntable. It is fully servo controlled by circuitry built into the motor itself. Energy developed by the motor brings the platter from stop to either speed in less than one revolution.

10 7. Two speeds and stop are available at a touch through sensitive resistance type switch contacts. No moving parts are involved.

8. A modified "rollamite" type bearing functions as the vertical pivot. The "rollamite" design is essentially friction free and is designed in the ST-7 to overcome the effects of warp wow.

9. Variable controls for 45 rpm (left) and 33 1/3 rpm (right) adjust the turntable speed by ± 5.5%. Accurate speed is obtained with the aid of a stroboscope device visible through the window (center).

10. Arm drive is derived from the continuous rotation of a rubber tire (invisible inside arm housing) in contact with a rotating shaft. The system acts as a servo drive producing arm movement proportional to the groove
11 pitch the stylus encounters.

11. The cueing mechanism includes a massive dash pot containing a high viscosity, silicone based fluid for smooth action in both directions. The cueing linkage allows intermediate settings for precise placement of the stylus on the disc.

Rabco ST-7 Specifications

Tracking Error:	0°
Skating Force:	0
Vertical Friction:*	0
Lateral Friction:**	0
Tone Arm Mass (effective):	6 gms.
Stylus Overhang:	0
Turntable Rumble DIN B.:	−68 dB.
Wow and Flutter NAB weighted:	.04%
DIN B.:	.09%
Hum (Tone Arm In) DIN 45544:	−76 dB.
Speeds:	33⅓ 45 RPM. Adjustable ± 5.5%
Speed Constancy:	± 0.3%
Motor/Drive:	Brushless D.C. (Hall effect) with precision ground belt
Turntable Weight:	2.4 lbs./1.1 Kg.
Dimensions (incl dust cover):	6¾"H x 16½"W x 16¼"D 15.7 cm. H x 41.9 cm W x 41.3 cm. D
Weight Total:	22.2 lbs./10.1 Kg.

*Zero vertical friction is achieved by a rolamite bearing utilizing counter-rotating metal bands which generate self-canceling forces and permit no sliding contact between moving elements.

**No relative rotation exists between stylus and driven end of tone arm.

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Printed in U.S.A. All specifications and features are subject to change without notice.

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