Skating force and antiskating

Friction between stylus tip and the groove wall produces a force F_f tangential to the groove (see fig. 1) . This frictional force depends on tracking force F_v and friction coefficient μ [3].

$F_f = F_v \cdot \mu$

With 45° stereo groove walls the load on each wall is 0.7 (= sin 45º) of the vertical or tracking force so that the actual friction force is 1.4 $F_v \cdot \mu$ [5].

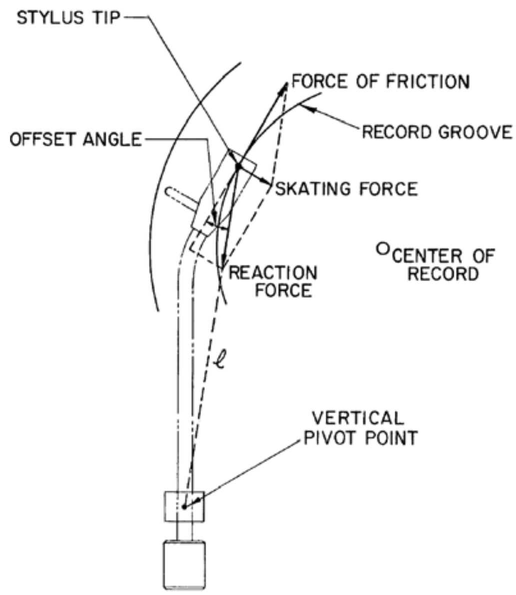


Fig. 1- Position of the arm on the record (from [11])

Figs. 2 and 3 show the amount of friction measured on unmodulated and modulated grooves, respectively. Rotation speed does not affect the friction force [11].

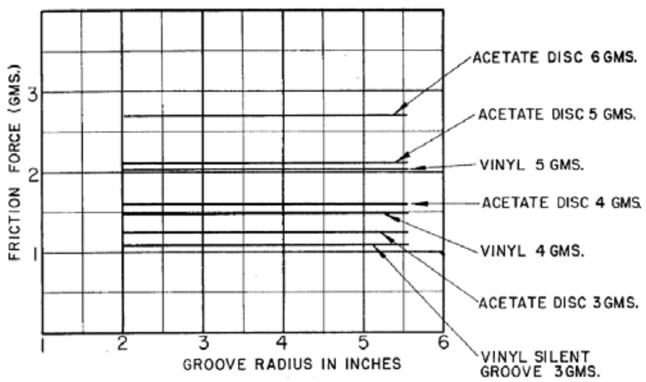


Fig.2 - Friction in silent groove (from [11])

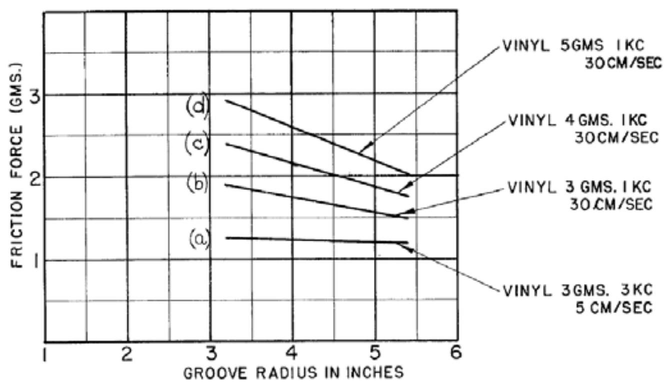


Fig.3 – Friction in modulated groove (from [11])

The friction coefficient μ depends on record material, condition of the record (clean or dirty, groove damage, groove wear), amount of groove modulation, surface roughness, shape and condition (new, worn) of the playback diamond. Values were found to be between 0.22 and 0.64 for Shibata at 1.5 g tracking force [10].

The reaction force (to the friction force) of the tone arm passes through the arm pivot. These two forces combine as vectors and, because of the angle Φ between groove tangent and effective length L, leave an unbalanced force, the skating force F_s. This force is at right angles to the groove tangent and tends to pull the arm towards the record's centre (see fig. 1). In fig. 1 the stylus tip is on a null point, therefore the skating force is directed exactly towards the record centre.

The skating force is determined by the magnitude of Φ, which varies across the record surface (Φ = angle between groove tangent and effective arm length = offset angle Θ + tracking error α, with α varying across the record surface, (see fig. 10)), the cartridge’s mechanical resistance (cantilever damping). In fig.1 the angle Φ is equal to the offset angle Θ.

When there is no skating force, as it is the case with radial tracking tone arms, the vertical tracking force is equally divided between both groove walls: the vectors R (right channel = outer groove wall) and L (left channel – inner groove wall) are of identical length and are at right angles (see fig.4).

If a skating force is generated a different vector diagram is formed, with $F_v + F_s$ as resulting vector. This resulting vector can be resolved into vectors R* and L*, with R* being shorter than L*.

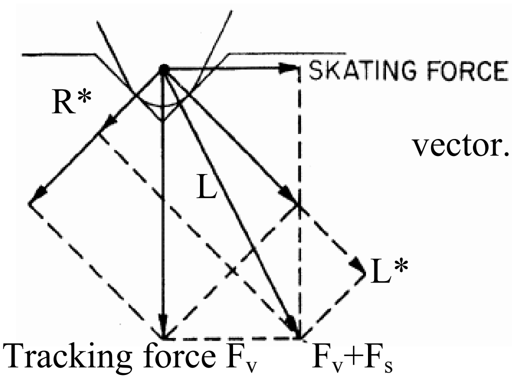


Fig. 4 – Distribution of the tracking force (from [11])

As long as there is no compensation for the skating force, the distribution on the vertical tracking force on the groove walls is such that the component R* on the right channel is smaller than the component on the left channel. Therefore, tracking force is increased on the left channel (inner groove wall), and decreased on the right channel (outer groove wall) [2]. Uncompensated skating force results actually in the stylus mistracking the outer groove wall which results in distortion in the right channel.

Skating force compensation enhances trackability by about 20-25 %. For obtaining equivalent trackability by increasing tracking force alone (without any compensation) an increase of 50 % would be required [2]. This, however, would result in increased contact pressure and hence increased record wear.

The following findings presented by Kogen [2] are based on experiments and measurements.

When playing unmodulated grooves, the elliptical stylus produces a greater skating force than a spherical stylus (see fig. 5).

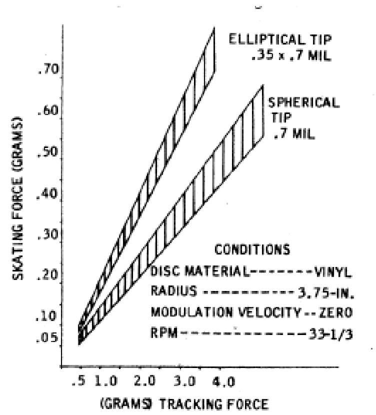


Fig. 5 – Skating force vs tracking force (from [2])

Figs. 6 and 7 show the effect of groove modulation on skating force for spherical and elliptical stylus, respectively.

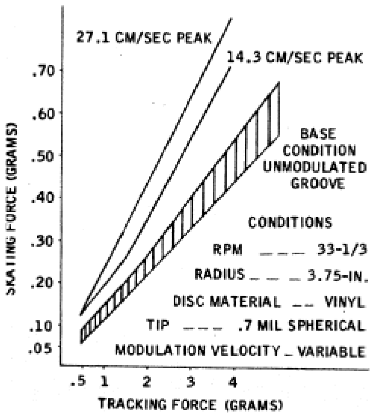


Fig. 6 – Typical effect of skating force vs tracking force, modulated groove, spherical stylus tip (from [2]]

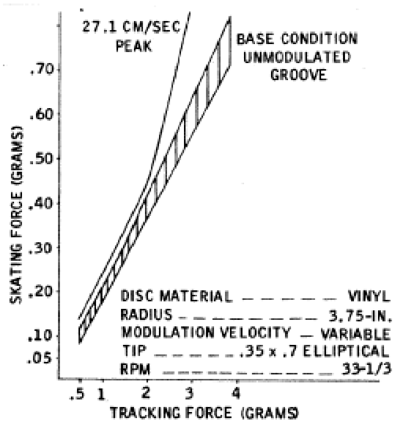


Fig. 7 - Typical effect of skating force vs tracking force, modulated groove, elliptical stylus tip (from [2])

A groove modulation of 27.1 cm/sec peak is about the maximum velocity one would find in a good-quality record.

Higher modulation velocities result in increased skating force [1, 2]. Wright [6] could show experimentally that the friction force increased for higher modulation velocities (for sinewaves).
Snell and Rangabe [7] showed that the dependence of the friction force of modulation velocity was different for different cartridges (see fig.8).

FIG. 2.

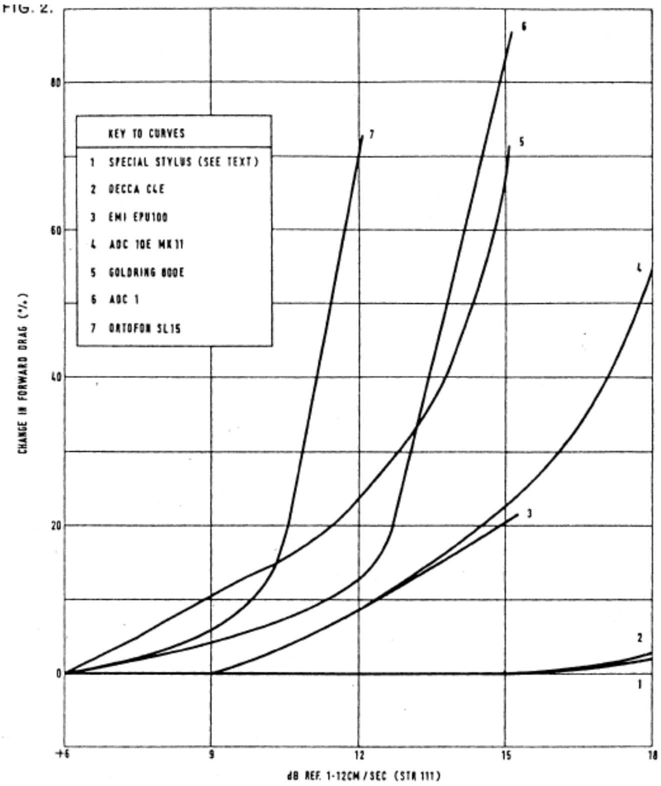


Fig.8 – Change in drag vs modulation velocity (from [7])

In 1968 RCA determined the effect of modulation velocity on stylus drag [9]. It was found that for a tracking force of 1.5 grams the modulation velocity had little effect on measured groove speed as measured by means of a stroboscope. The same velocities had however a significant effect (factor 4) when a tracking force of 5 grams was applied. The measurements were performed on a lacquer test record. On a vinyl pressing the decrease in groove speed would be 0.7 of the one measured on the lacquer. The equipment used was not specified apart from weight and moment of inertia of the turntable.

According to Gilson [5] the effect of groove modulation (modulation drag) is composed of three related elements, inertial drag, compliance drag, transducer drag.

Inertial drag: energy absorbed in accelerating the stylus assembly (accelerations up to 1400 g have been observed). Since the deceleration force is lost in frictional loss and not fed back into the system, a constant torque is imposed on the turntable motor, such that the inertial drag is increasing towards the records centre.

Compliance drag: energy absorbed in overcoming stiffness and damping of the cantilever suspension. Greatest at low frequencies where lateral stylus excursion is at maximum. Compliance drag increases towards the record's centre. Damping (and hence mechanical resistance) can vary considerably among different cartridges and even between samples of the same cartridge [7].

Transducer drag: energy absorbed in converting mechanical energy into electrical output from the generator system. It increases towards the record's centre.

According to Gilson the tangential friction force further pulls the cantilever into line with the arm pivot. This cantilever displacement force is substantially the same as the frictional force F_f.
He concludes that by applying skating force compensation at the arm pivot both the skating and the cantilever displacement force are compensated. Since on certain parts of the record there will be overcompensation and on the remaining parts undercompensation (see below), the cantilever will be displaced the record's centre and towards the outer rim respectively. "The amount by which the cantilever/armature system is displaced will depend on the static compliance of the cartridge, and any ill-effects on sound quality will depend on the sensitivity of the transducer system to non-linearity due to displacement from the true dead-centre position."

Groove velocity (for unmodulated grooves) appears not to change skating force. [2]. This finding was later confirmed by Wright [6] with an experimental setup (for measuring skating force) similar to the one used by Kogen [2], namely a cartridge that could swivel on a micro-bearing attached to the headshell. Wright used a Decca International tonearm because of the very low friction of its unipivot whereas Kogen used a Shure-SME 3009 tonearm.

Groove radius has an effect on skating force in that there is a minimum at about 3.5 inch with maxima at outer an inner grooves, the value at the outer groove being higher than at the inner groove [2], the curve being hence of somewhat parabolic shape. The skating force varies between 90 and 100 % of its maximum value (see fig. 9).

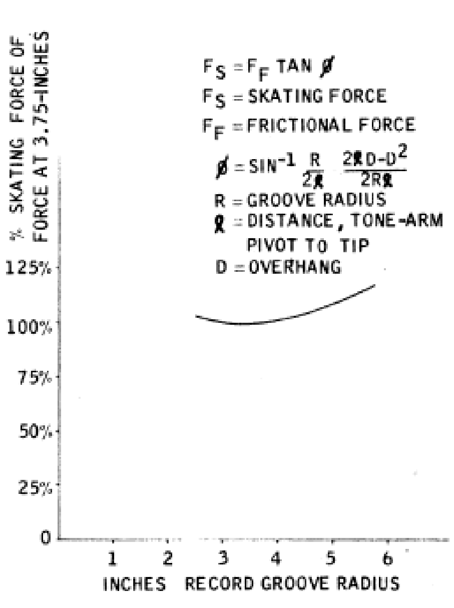


Fig.9 – Skating force vs record-groove radius (from [2])

Groove velocity varies with radius, the skating force however was found to be constant with velocity. According to fig. 9, however, skating force changes with groove radius, which appears to be in contradiction with the previous finding, but according to Kogen [2] there are factors not completely understood (such as material hardness, surface roughness, possibly as a function of additives, groove shape, warpage, dishing of the record) which resulted in significant differences being noted from record to record and for various radii.

The skating force F_s is a function of groove radius R, overhang D and effective arm length L [2, 3].

$F_s = F_f \bullet \tan \Phi$ [2, 3, 4]

with

F_f = frictional force = $F_v \bullet \mu$

with

$$\sin \phi = \frac{R}{2L} + \frac{2LD - D^2}{2LR}$$

Φ (angle between groove tangent and effective length,) varies across the record surface. Fig. 10 shows Φ for different overhang values, with curve EE (19.05 mm overhang) being representative of commonly used overhangs.

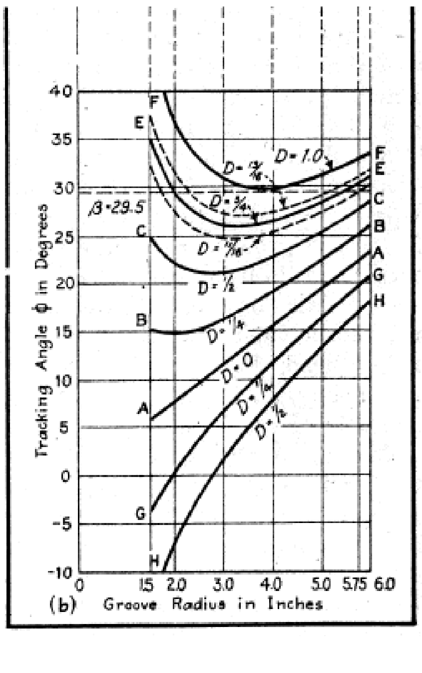


Fig. 10 – Tracking error vs groove radius (from [3])

Skating force compensation is provided at the arm pivot. This means that a torque is applied at the pivot which results in a compensating force that is at right angles to the effective length.

This compensation force is determined by

$F_A = F_f \bullet \sin \Phi$

which is different from the skating force

$F_s = F_f \bullet \tan \Phi$;

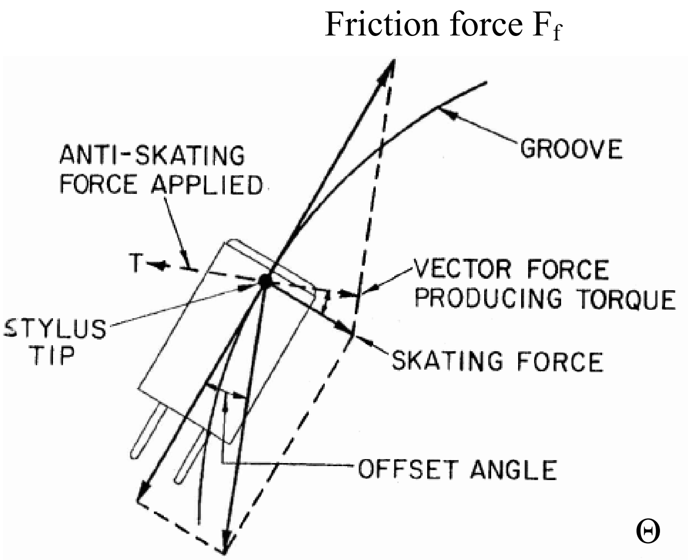


Fig. 11 – vector diagram of forces at the headshell (from [11])

the tan Φ vector (vector force producing torque) is directed towards the record's centre whereas the sin Φ vector (skating force) is at right angles to the effective length. (see fig. 11). Note that in fig. 11 the stylus tip is on a null point such that $\Phi = \Theta$.

A different way of calculating skating force is to use offset angle Θ and tracking error α [8]. For groove radii greater than outer null and smaller than inner null, the skating force is

$$F_s = F_f \bullet \sin(\Theta + \alpha)$$

Between the two null points, the skating force is

$$F_s = F_f \bullet \sin(\Theta - \alpha)$$

The horizontal tracking error α is

$$\alpha = \pi/2 - (\Phi + \Theta) \quad \text{with} \quad \cos \Phi = \frac{1}{2 \cdot L \cdot R} \cdot (L^2 - Lm^2 + R^2)$$

where

L = effective arm length R = groove radius Lm = mounting distance

Final remarks:

Since skating force is not constant across the record surface but describes a somewhat parabolic curve exact compensation is not possible: whatever the precision of setting the antiskating , the curve of the skating force will be intersected in two points at best.

From discussions on web forums it becomes evident that some people think that skating force is zero when the tracking error is equal to zero, as it is the case in the null points. This is true only for linear tracking arms, for pivoted arms this simply not correct. As long as the line connecting the stylus tip to the arm pivot is not tangential to the groove at the contact point, which is always the case for pivoted arms, a skating force is generated. For that very reason tangential pivoted arms like the Garrard Zero and the Thales still have anti-skating mechanisms.

[1] Alexandrovitch, “A stereo groove problem”, J. of the Audio Engineering Society 1961, p.166

[2] Kogen, “The skating force phenomenon”, Audio, Oct.1967, p.53; Nov. 1967, p.38

[3] Bauer, “Tracking angle in phonograph pickups”, Electronics, March 1945, p.110

[4] Oakley, “Skating force, mountain or molehill”, Audio, March 1967, p.40

[5] Gilson, “The cartridge alignment problem”, Wireless World, Oct.1981, p.59

[6] Wright, “Bias correction and dynamic conditions”, Hi-Fi News, Oct.1969, p.1187

[7] Snell et al., “Frictional drag and bias compensation, Hi-Fi News, Feb. 1970, p.221

[8]Randhawa, “Pickup arm design techniques”, Wireless World, March 1978, p.73; April 1978, p.63

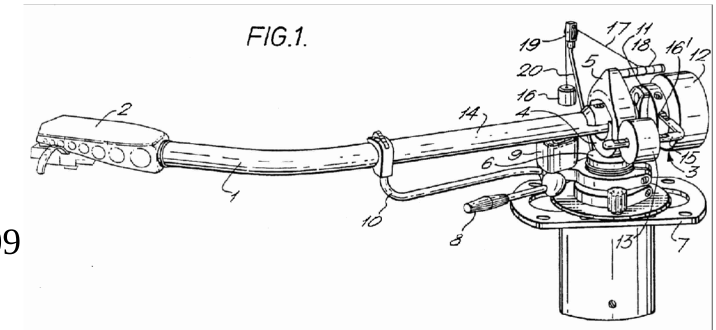
[9] Halter, Letters to the editor, J. of the Audio Engineering Society 1968, p.354

[10] Pardee, “Determination of sliding friction between stylus and record groove”, J. of the Audio Engineering Society 1981, p.890

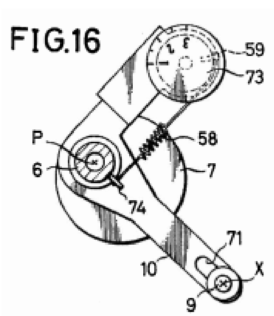
[11] Alexandrovich, “New approach to tone arm design”, Audio Engineering Society preprint 149 (1960)

Annex

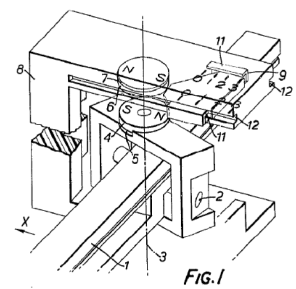
In this section a few historical details of the skating force saga are presented as well as some patents relating to anti-skating mechanisms. Thanks to the help of members of the Vinyl Engine and German Analog Forum some of the arms and the two skating force measuring devices could be identified.



Most anti-skating mechanisms probably still use the well known weight on a thread, such as shown here on a SME 3009



Some arms like the SME V use a spring mechanism, probably looking like the one depicted on the left, some like the Garrard Zero 100 use magnets.

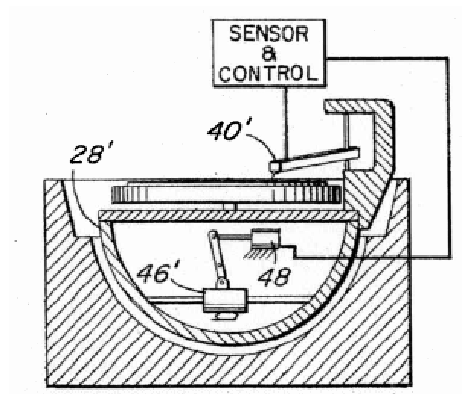


The first time skating force was mentioned in print was probably in a letter to the editor of The Gramophone. That letter by G. Raymond, in the December 1924 issue, was in response to Percy Wilson’s paper entitled “Needle track alignment”, published in September 1924. Raymond clearly links this force, or side thrust, as he calls it, to the offset angle, or divergence, as called by Wilson. According to Raymond, the record, while revolving, moves the needle in the direction of the tangent. “This force can be resolved into two, one of which is in line with the [axis of the tone arm] and one at right angles to the tangent; the former is neutralised by the tone-arm, but the latter is the one to which I want to draw attention. It can only be met by the resistance of the groove, so we have a force pushing against one side of the groove and away from the other.”

In his reply to that letter and in his later publication “Two notes on gramophone adjustment” in The Gramophone, March 1925, Wilson suggested that side pressure was most easily created, and therefore cured, by altering the balance of the tone arm, an equivalent of which would be an unlevel gramophone, a solution which became known as “dynamic levelling”. That method consisted of lowering the needle on to a blank surface (outer rim or back of single-sided record) of a rotating record and to look whether the sound-box swung inwards or outwards. A little packing was then put under the feet such that the stylus had to move “uphill”.

This particular anti-skating mechanism has been subject of US Patent 3,674,278 to William S. Bowerman (1972).

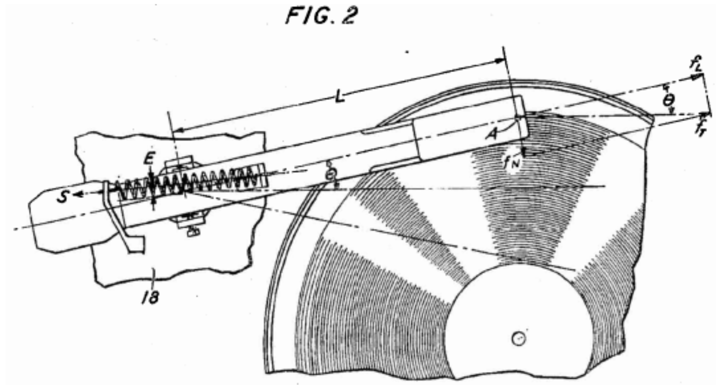
Hemispherical hub (28’) floats on an air bearing.
An adjustable weight (46’) is attached to solenoid (48) which receives controlling instructions that are generated at the interface between the base and the arm assembly. The weight is moved along a line which is perpendicular to the groove tangent at the point where the needle makes contact, thereby shifting the centre of gravity which results in tilting the hub together with table, platter and arm.



US Patent 1,866,403 to Bell Telephone Laboratories (1931) was probably the first patent ever to discuss skating force and to propose an anti-skating mechanism.

In particular, the patent says:
“Referring to fig. 2, let A represent an extreme position of the stylus. The needle friction for this position will be some force f_T acting tangentially to the groove. This force may be resolved into to components f_L acting along the center line of the arm and f_N acting normal to the center line”.

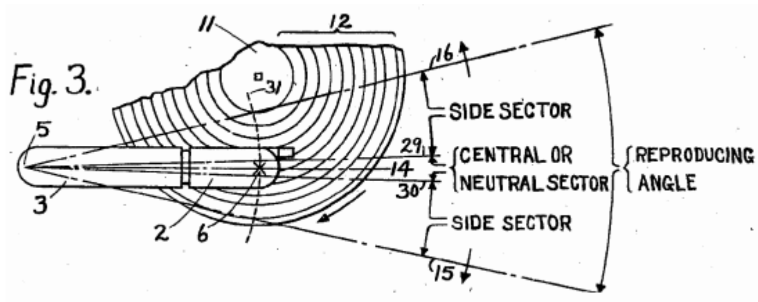
FIG. 2



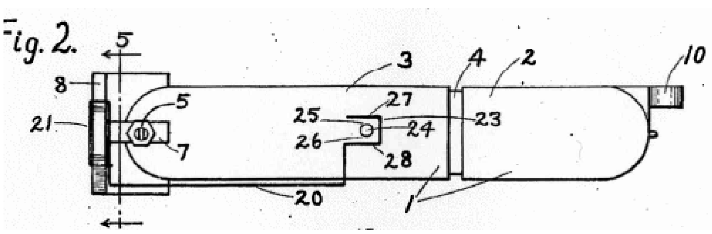
A spring is mounted such that its center line intersects the arm pivot and generates a rotational torque.

Straight tone arms were rather common in the old days and they seem to present some particularities with respect to skating force, in the sense that they generate both inside and outside forces.

US Patent 2,316,637 to The Soundscriber Corporation (1943) discusses these particularities.



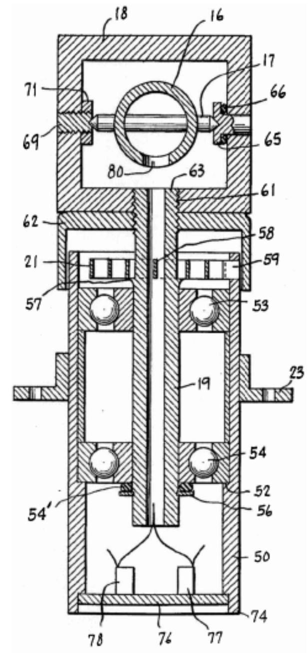
At one point on the record (line 5-14) the arm’s axis and the vertical plane are tangent to the groove.
When the arm is on either side of that line, the lateral component of stylus friction acts away from the line, as indicated by arrows 15, 16.
Depending on the position of the stylus relative to the line the skating force is hence acting towards the record center or towards the record’s outer edge.



To counteract these two forces a device (20) made from spring wire is fixed to the arm support (8). The device has a longitudinal arm, extending parallel to the tone arm (3), and having at its end a U-shaped projection (27, 28) embracing a vertical pin (24) on the arm tube. In the arm’s tangential (or neutral) position the parts (27, 28) of the projection are not in contact with the pin. When the arm is moving on either side of the neutral position, the pin (24) is in contact with one of legs (27, 28) so that the spring wire exerts a force opposing the respective skating force.

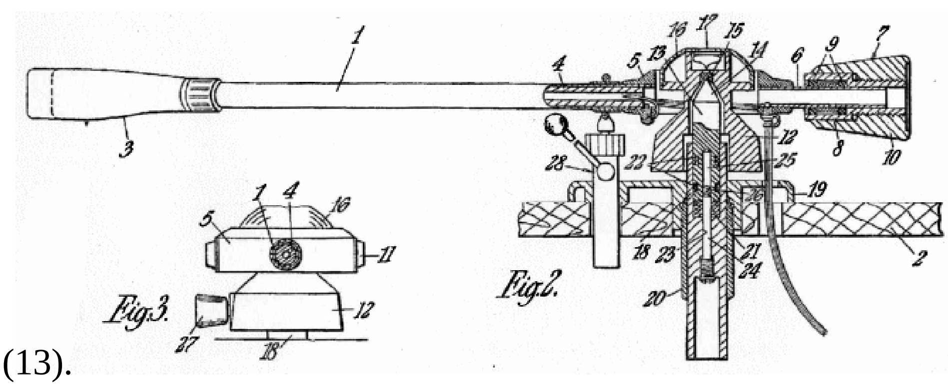
US Patent 3,088,742 to Fairchild Recording Equipment (1963) uses a coiled spring (21) resting on a shoulder (57) of vertical pivot shaft (19) which is supported in bearings (53, 54) within bearing tube (50). The arm tube (16) is mounted by the horizontal pivot (27) on yoke (18).
The inner end of spring (21) is hooked into slot (58) on the shaft (19), while the other end hooks into slot (59) on bearing tube (50).

This anti-skating mechanism was included in the Fairchild 500 tone arm.



British Patent 968,833 to Percy Wilson (1964) proposes a somewhat unusual anti-skating mechanism in that it is not the skating force itself which is compensated but the longitudinal push/pull along the arm which is produced by the friction between the groove and the stylus.

Arm tube (1) is secured to ring (5), which in turn is supported in horizontal bearings (11) mounted on a balance member (12). Balance member (12) is supported on vertical bearing (15) on top of plunger (13).



The centre of gravity of balance member (12) is situated below the plane of the horizontal bearings. Since the vertical pivot (15) is above the horizontal pivot plane (11), any pull or push along the arm will tilt the balance member about pivot (15). The mass of the balance member will then be displaced from a position exactly beneath the vertical pivot and gravity will exert a torque on the balance member which will balance the displacing force.

British Patent 1,005,810 to Decca Ltd. (1966) shows a ring magnet (9) mounted in the cup (19) carrying the pivot blade (18). Magnet (9) reacts against the field of a pair of magnets (10) which are mounted in element (21) made from plastic material. Element (21) is arranged to be in a smooth sliding fit over the exterior of pivot base (13) and can be moved vertically to vary the field between magnets (9) and (10).

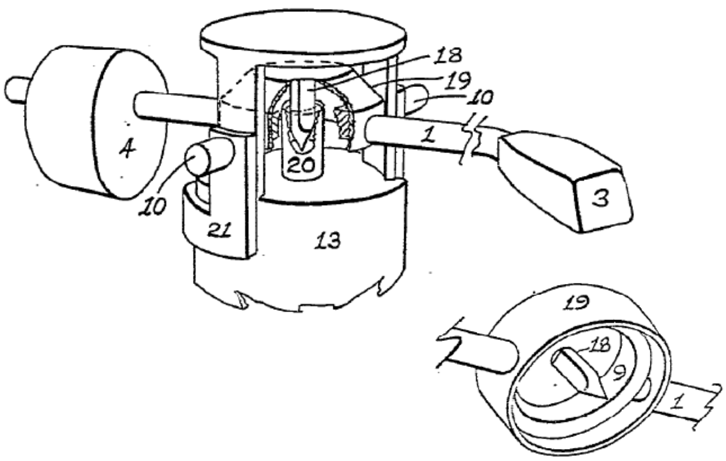
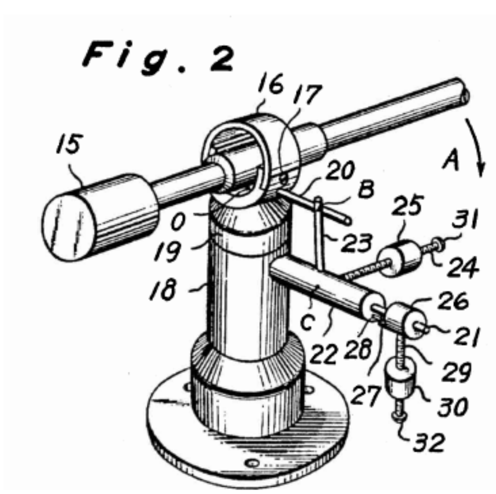
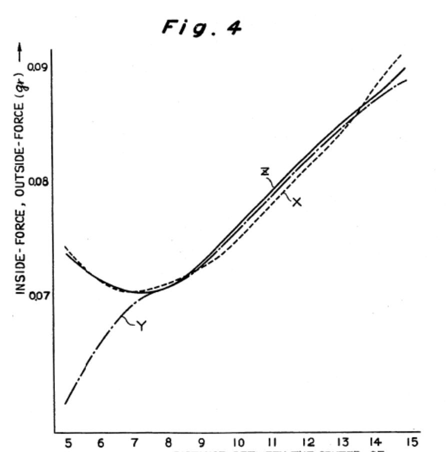


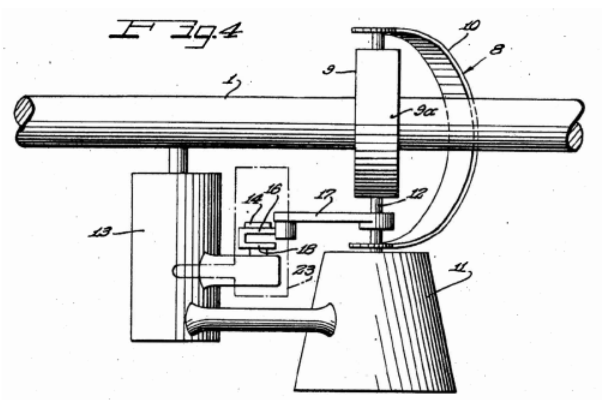
Figure 1 Decca International tonearm
(*Courtesy www.vinylengine.com)*

US Patent 3,380,744 to Victor Company of Japan (1968) shows a first collar (22) which is driven rotated by the arm via pins (20, 23) so that a first weight (25) is rotated about axis (21). When the cartridge comes to the inner portion of the record at about 70 mm radius, stopper (28) on collar (22) engages step (27) on a second collar (26) such that a second weight (30) is rotated about axis (21). As both weights are rotated, the total value of anti-skating force is increased progressively (curve Z in fig.4, curve X being the skating force).





US Patent 3,492,006 to Sony (1970) shows an arm member (17) connected to vertical arm bearing shaft (12), with shaft and arm member rotating with the tone arm when the arm moves across the record. A cam mechanism (14, 16, 18) is rotatably mounted on axis (19). A tensioned thread (15) is fixed to the outermost end of cam (14), the tension can be adjusted by the user. Arm member (17) contacts the cam mechanism by means of roller (21). When the arm moves across the record the arm member (17) pushes the cam mechanism so that the mechanism rotates about its axis (19), against the tension of thread (15).



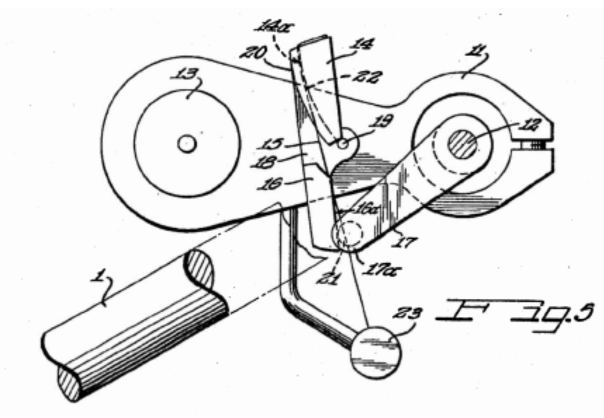


Figure 2 Sony Pua286 (*Courtesy www.vinylengine.com)*

British Patent 1,273,981 to SME (1972) shows a tone arm which allows to set anti-skating simultaneously with setting vertical tracking force. A bearing sleeve (21) is fixed to the rear of pillar head (20). In this sleeve a hollow shaft (22) is mounted in ball bearings (23), which are in fact the arm's vertical bearings. The right end of the shaft (22) carries a yoke (26) which in turn supports the arm (30) itself in horizontal bearings (32). The cross-section of the arm in the bearing area is hexagonal so that pillar screws (33) can be threaded into that section. To the left end of shaft (22) is secured a cap (24) which is fashioned to provide a sliding fit for rod (60) carrying weights (61, 62).

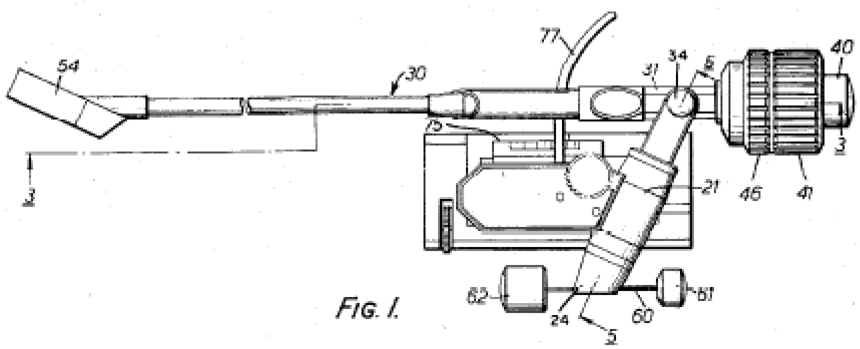


FIG. 1.

The arm (30) has an extension on which is arranged a counterbalancing assembly (40, 41, 46). In use, rod (60) is moved to its initial or zero tracking force marking, and the arm is balanced horizontally using the counterbalancing assembly. To set vertical tracking force, the rod (60) is moved forwardly. The axis of the shaft (22) is at an angle to the horizontal, and the axis of horizontal bearings (32) will be correspondingly inclined. As a result, the imposition of vertical tracking force on the stylus will be accompanied by a lateral force, proportional to the vertical force, and related to the vertical force by the tangent of the angle, which angle is adjustable by the user.

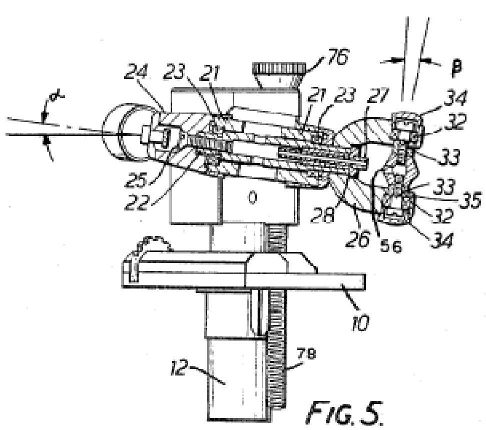
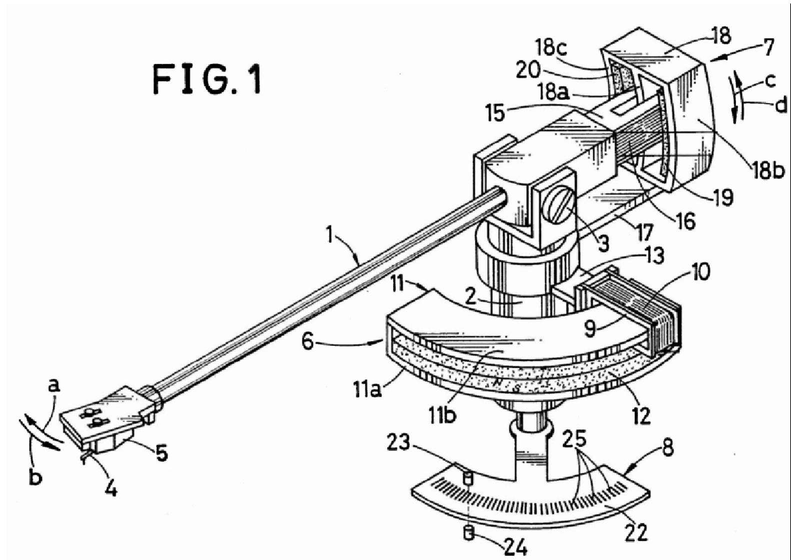


FIG. 5.

US Patent 4,214,756 to Sony (1980) uses a servo control system comprising a rotor (bobbin 9, coil 10) fixed to the arm and a stator (yoke 11, magnet 12) fixed to the chassis of the record player. A horizontal position detector comprises a slit plate (22), a lamp (23) and a light sensitive element (24).



When the arm is rotated, the light from the lamp is intermittently intercepted by the slit plate, thereby generating pulses the number of which corresponds to the rotational angle of the arm. The pulses are counted by a microprocessor and a voltage is applied to the coil (10), generating a current which intersects with the magnetic flux from the magnet (12) and imparts an outside horizontal torque to the arm to cancel the skating force which depends on the position of the stylus.

Vertical tracking force VTF is generated by a similar servo system (coil 16, magnets 19, 20). The output of the tracking force adjusting circuit is taken into account for the determination of the voltage applied to the anti-skating force servo system.

Figure 3 Sony Biotracer (*Courtesy www.thevintageknob.org)*

US Patent 4,257,615 to Hans Mørch (1981) uses a device (24) pulling a string (7) attached to housing (2). Housing (2) is supported on pivot (1) which is excentrically positioned with respect to the element's centre of gravity. When the arm is moving toward the record centre the string is reeled around the outer surface of housing (2) over a range where the horizontal distance from the outer surface to the pivot point is decreasing. With the pull in the string being constant, a proportionally decreasing anti-skating torque is the result.

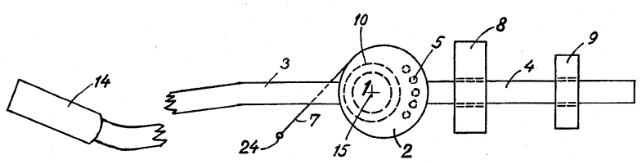


Figure 4 Mørch DP-6 (*Courtesy www.moerch.dk)*

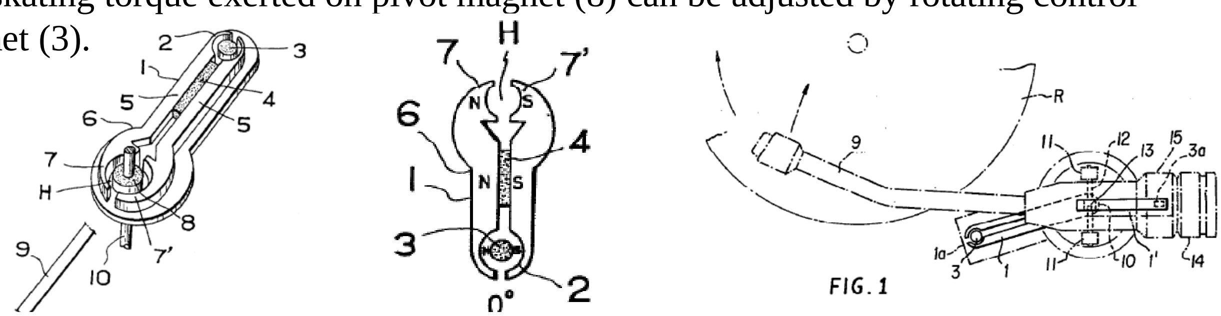
US Patent 4,264,078 to Koshin Denki Seisakusho (1981) shows the Acos Lustre GST 801.

Figure 5 Acos Lustre GST 801

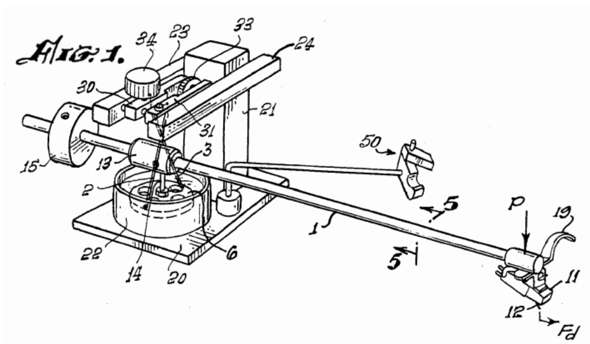
(*Courtesy www.vinylengine.com*)

A support member (1) consisting of a pair of spoon Shaped frames made of ferromagnetic material is fixed on the base plate of the record player.
A radially magnetized, rotatable control magnet (3) is fitted at one end, a laterally magnetized bar magnet (4) is fitted at the middle section.

The combined magnetic flux of magnets (3, 4) produces a magnetic field H at the opposite end with north and south poles (7, 7').
A radially magnetized magnet (8) is fixed at the vertical arm pivot such that it is within magnetic field H of the support member (1). The flux density of the field, and hence the anti-skating torque exerted on pivot magnet (8) can be adjusted by rotating control magnet (3).



US Patent 4,570,253 (1986) to William Firebaugh.



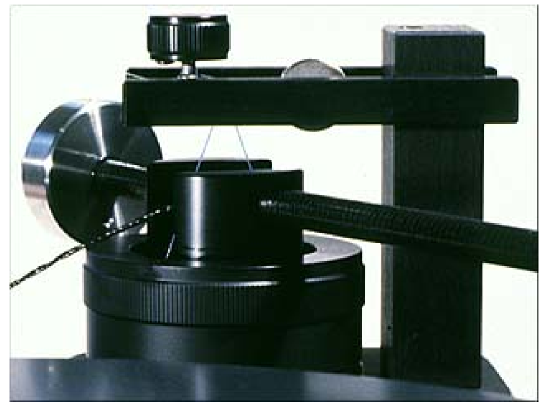
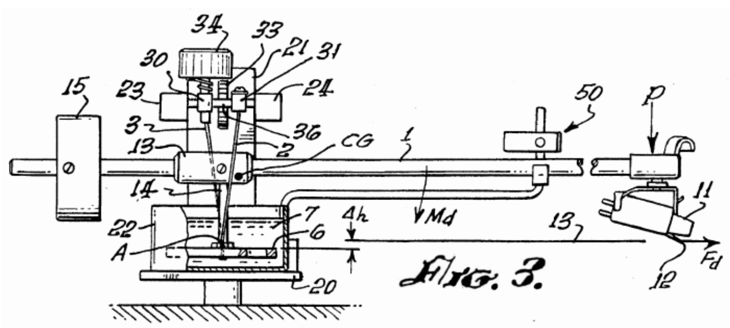
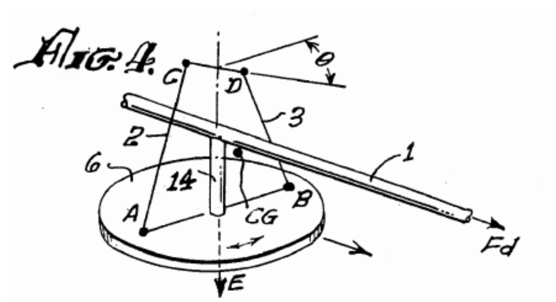


Figure 6 Well Tempered tonearm
(*Courtesy www welltemperedlab.com)*





A disc (6) carrying the arm assembly is immersed in a cup (22) of damping fluid (7). The disc and arm tube are suspended from supports arms (30, 31) by a bifilar suspension (2, 3). The distance between the top ends of the ligaments on the supports C-D the distance between their lower ends on the disc is A-B. From Fig. 4 it can be seen that these distances A-B and C-D are unequal. It is further apparent that the line connecting the top ends of the ligaments is not parallel to the line connecting their lower ends, which results in an initial torsional displacement of the suspension which creates a torque M_{as}. If the arm is free to swing in a horizontal plane, it will swing toward the outside rim of the record. The magnitude of torque M_{as} is adjustable by the user by means of thumbwheel (33) which adjusts the spacing between support arms (30, 31).

The stylus drag force F_d increases the tension in rear ligament (3) and reduces the tension in front ligament (2). This difference in tension produces an outward torque. Thus, the anti-skating torque is automatically increased during louder passages. Further, the plane of the attachment point of the ligaments on disc (6) is below the record (• h) so that during loud passages the stylus drag force creates a torque M_d which adds to the tracking force.

Swiss Patent 694,567 (2005) shows the Thales arm.

Also on this arm it is the longitudinal push/pull along horizontal lever (30) produced by the friction between the groove and the stylus that is compensated rather than the skating force itself. A weight is attached to the lower end of vertical lever (32). In order to compensate for the friction force the weight has to be moved away from the vertical axis (49).

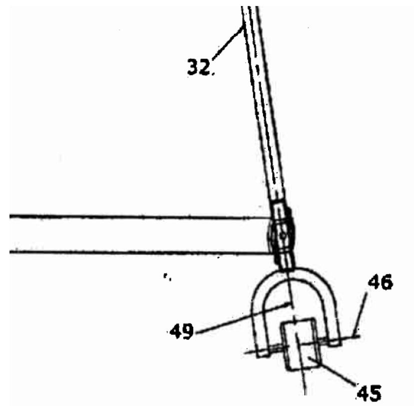


Figure 7 Thales tonearm *(Courtesy www.6moons.com)*

US Patent 7,382,713 (2008) to Robert Graham shows the Phantom II.

The upper end of belt (72) is attached to fixed tone arm gantry (66) at attachment point (74). The lower end is fixed to support member (48) at attachment point (76). The belt runs over a pulley (60) mounted on pivot arm which rotates around pivot point (64) on tone arm gantry (66). Extending from pivot point (64) is a calibrated rod (68) carrying a counterweight (70). Support member (48) rotates with the main arm through magnetic coupling at first and second magnets (44, 46). When the arm moves toward the record centre, the calibrated rod and counter- weight move upward producing a variable anti-skating force that is proportional to the position of the tone arm on the record.

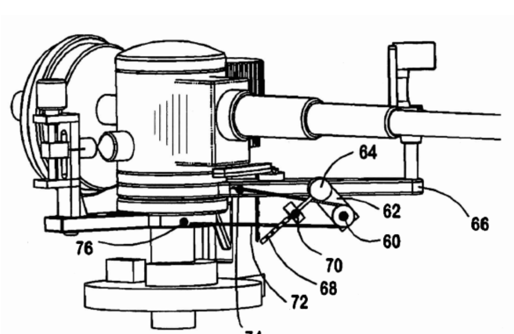
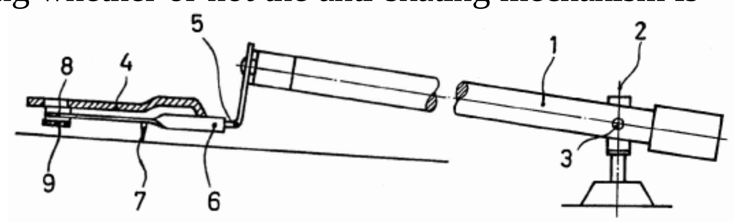


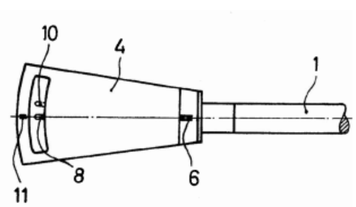
FIG. 5

Figure 8 Graham Phantom II
(*Courtesy www stereophile.com)*

The two following patents are of particular interest since they are relating to devices for measuring skating force which in turn allows to set the anti-skating mechanism of the tone arm correctly.

German Published Application 1,262,631 (1968) to Dual shows a device (4) which is mounted instead of the cartridge. The device carries a leaf spring (6) on which a stylus (7) is mounted. The front end of the spring forms an indicator (9) the position of which relative to a mark (11) is indicating whether or not the anti-skating mechanism is set correctly.





This device was initially designed to be used with the Dual 1019 and was sold under the name Skate-o-meter.
It used a 16 micron spherical sapphire stylus and was to be used on unmodulated grooves or grooves with low modulation velocities, in the latter case the record player speed had to be set to 16 rpm.

Figure 9 Dual skate-o-meter
(*Courtesy http://freenet-homepage.de)*

US Patent 4,183,537 to Namiki Precision Jewel Co. (1980) shows a base (15) which is fixed to the headshell instead of the cartridge. A cantilever (9), fitted with a needle that should be similar to the one used in the real phono cartridge, is supported in circular revolving pivot (10) by damper (12). The revolving pivot is mounted to the base by means of a pivot (13) which is fixed by a screw (14). When a skating force is present, revolving pivot (10) and cantilever (9) revolve counterclockwise in a horizontal direction about vertical axis Y-Y’ going through upper and lower pivot bearings (16), and pivot (13) as well as the tone arm (17) shift toward the record centre. A tube (22), carrying an indicator (23) and a magnet (24), is attached to spindle (21) for easy revolution. A moving rod (25) of magnetic material is supported on the revolving pivot (10). Since rod (25) moves in a horizontal direction, magnet (24) revolves in a pendulum fashion which motion is amplified by indicator (23). Position 6-B indicates non-compensated skating force, when the indicator is on position 6-A, skating force and anti-skating force are mutually offsetting, the anti-skating mechanism is hence set to the correct value.

FIG. 5

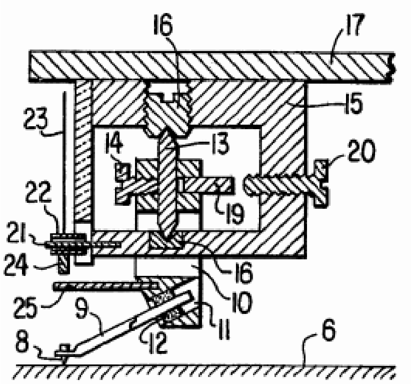
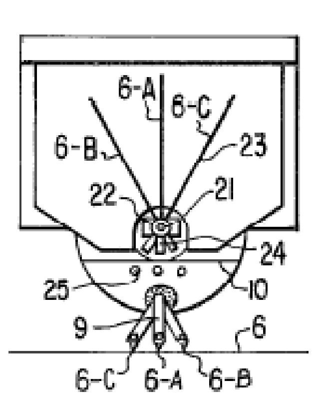


FIG. 6



This device was manufactured by Orsonic and sold as side pressure gauge SG-1 and 2G-2E. The SG-1 came in three versions, with 15 micron spherical tip (SG-1R), 7x18 micron elliptical tip (SG-1E), 6x35 micron line contact tip (SG-1L). The SG-2 had a replacable stylus.

Figure 10 Orsonic SG-1

Figure 11 Orsonic 2G-2E
(*Courtesy www.imageshack.us)*

Klaus Rampelmann, The Hague (Netherlands), October 2009