TONEARM DESCRIPTION

Caution
Tonearm (P26～28) and pick-up lead wire (P32) are explained.
Their description is omitted as they are not applicable to KD-750.

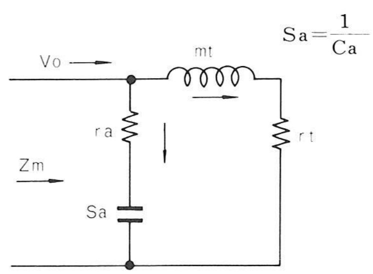
TONEARM

Two big problems on tonearm are tonearm resonance curve and partial resonance caused by lack of stiffness of components.

Tonearm Resonance

A basic equivalent circuit of tonearm for a low frequency range is as shown in Fig. 3-1. This equivalent circuit resonates at fo:

$$f_o = \frac{1}{2\pi} \times \sqrt{\frac{Sa}{mt}} = \frac{1}{2\pi\sqrt{mt \cdot Ca}} \quad \cdots\cdots\cdots 1)$$



Vo:	Velocity amplitude of record groove.
Zm:	Mechanical impedance in view of stylus.
Sa, ra:	Equivalent stiffness and resistance of support of vibration system.
mt:	Equivalent mass of tonearm included cartridge.
rt:	Equivalent resistance of tonearm fulcrum.

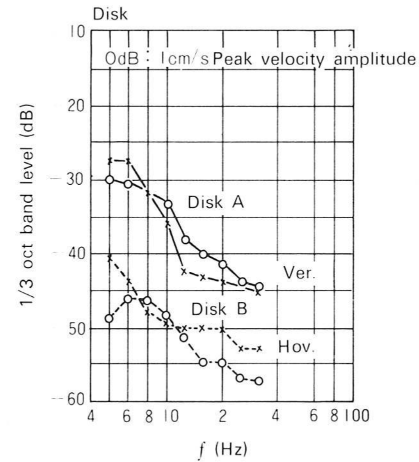
Equivalent circuit of pickup in low freq.

Fig. 3-1

This resonance is the tonearm resonance. Q indicating sharpness of resonance peak is given as;

$$Q = \frac{2\pi \cdot f_o \cdot mt}{ra + rt} \quad \cdots\cdots\cdots (2)$$

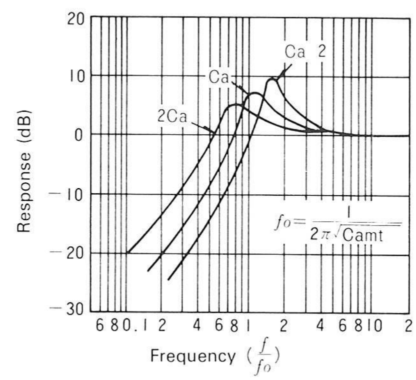
Generally, it is said that fo should be in 7 ～ 12 Hz, so that noise caused by bend of disk and the turn of the motor is eliminated. Frequency characteristics and mechanical impedance characteristics in the case where Ca, mt and Q are changed are shown in Fig. 3-3 to 3-5.



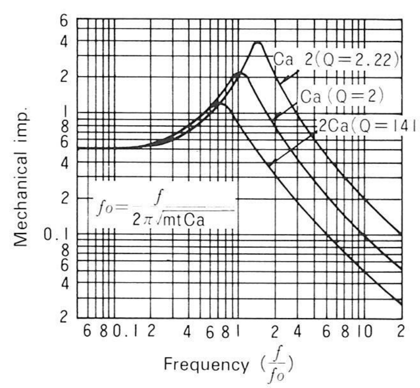
Frequency vs bent disk

Fig. 3-2

In Fig. 3-3, variation of Ca corresponds to replace cartridge. When value of Ca is large, the cartridge is a high compliance one. When value of Ca is small, a low compliance one. As known from eq. (1), tonearm resonance fo decreases as the value of Ca increases.



Frequency characteristic when changing the value of Ca.

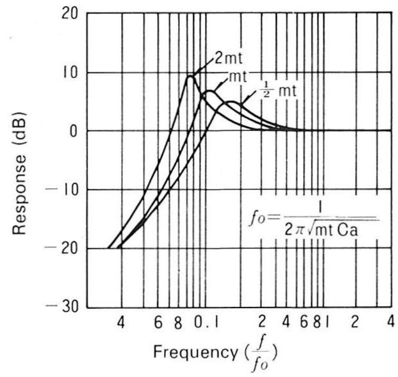


Mechanical impedance when changing the value of Ca.

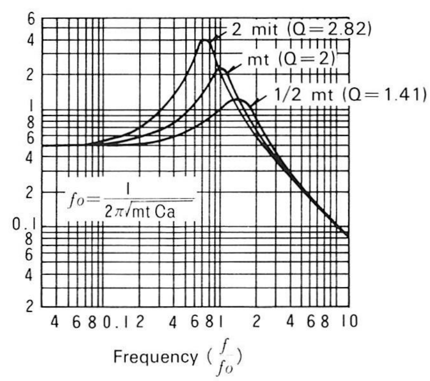
Fig. 3-3

TONEARM DESCRIPTION

In Fig. 3-4, variation of mt corresponds to change of equivalent mass of tonearm. For tonearm such as an universal tonearm which uses uncertain cartridge, if the value of both mt and Ca are large, *fo* decreases too much and intermodulation distortion caused by bent and eccentricity disk may occur. The value of mt must be selected so that *fo* is 7 ~ 12 Hz for all cartridges to be used.



Resonance frequency vs peak when changing the value of mt.

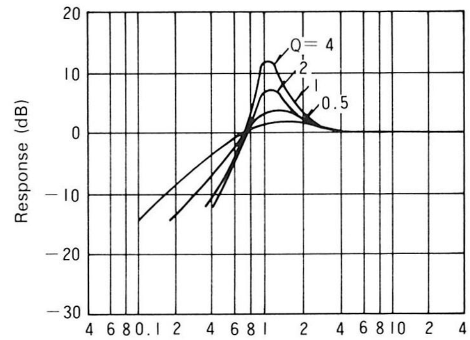


Mechanical when changing the value of mt.

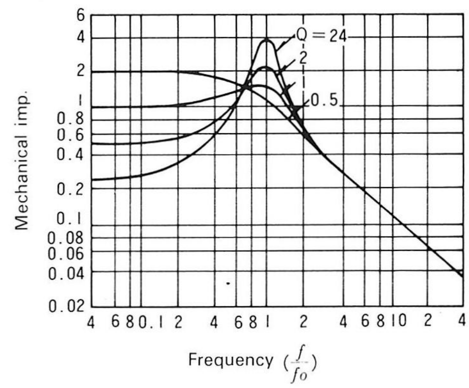
Fig. 3-4

Characteristics in the case where Q is changed are shown in Fig. 3-5. If a cartridge and a tonearm to be used are determined, change of Q corresponds to variation of rt (equivalent resistance of fulcrum of the tonearm. The value of mt, Ca, and ra in eq. (1) and eq. (2) are determined. A large increase of rt result in decrease of Q of resonance peak but frequency characteristic at *fo* or less falls down gradually and mechanical impedance increases. This is undesirable because bent and eccentric disk will be reproduced.

Tonearm, TA-71 which is used in KD-750, was designed to have an equivalent mass of 22g when a cartridge having 6g weight is attached, so that tonearm resonance, *fo*, will be within 7 ~ 12 Hz even if any cartridge is attached. And, Q of resonance peak can be decreased by means of the flexible stand-off decoupling system described in the following, so that the stylus traces a groove on a record without affects of bend or eccentricity.



Q vs resonance

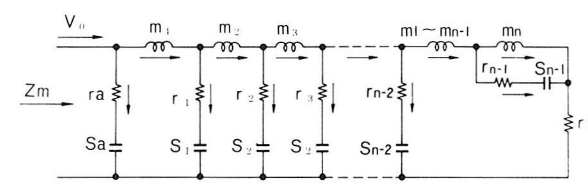


Q vs mechanical impedance

Fig. 3-5

Partial Resonance

There may be a play between a shell and the Tonearm or between a shell and a cartridge, and stiffness of such component as shell and pipe may be lacked since a shell of an universal tonearm such as TA-71 is removable. These plays or lack of stiffness result in a dip of frequency characteristic curve. This dip is called "partial resonance". An equivalent circuit is shown in Fig. 3-6. If no "partial resonance" occurs, the curve will agree with Fig. 3-1.



Vo:	Velocity amplitude of record groove.
Zm:	Mechanical impedance in view of stylus.
Sa, ra:	Equivalent stiffness and resistance of support of vibration system.
rt:	Equivalent resistance of tonearm fulcrum.
m1~mn-1:	Equivalent mass in view of stylus until stylus bar occurs partial resonance.
S1~Sn-2•r1~rn-2:	Equivalent resistance and stiffness of partial resonance section.
mn:	Equivalent mass of back of tonearm fulcrum.
Sn-1•rn-1:	Equivalent stiffness and resistance for partial resonance of back of tonearm fulcrum.

Fig. 3-6

TONEARM DESCRIPTION

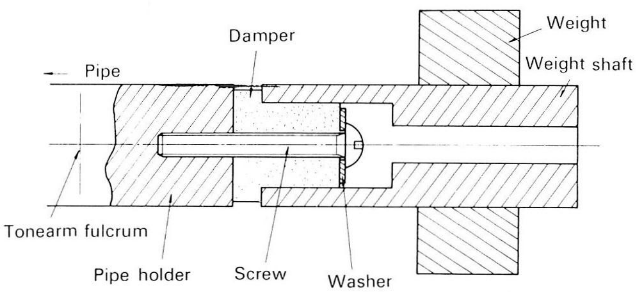
Flexible Stand-off Decoupling Tonearm

A conventional weight attaching method is shown in Fig. 3-7. The weight shaft and weight correspond to mt2 in Fig. 3-8 and the dumper corresponds to rc•Sc. Since Sc cannot be decreased by this method, a partial resonance, is around 50 ~ 150 Hz. No large dip of frequency characteristic curve appears since rc is large, however dips affect cross-talk characteristic and etc. If dips appear, transient characteristic becomes worse, so that tone quality becomes worse and enough effect for howling can not be obtained.

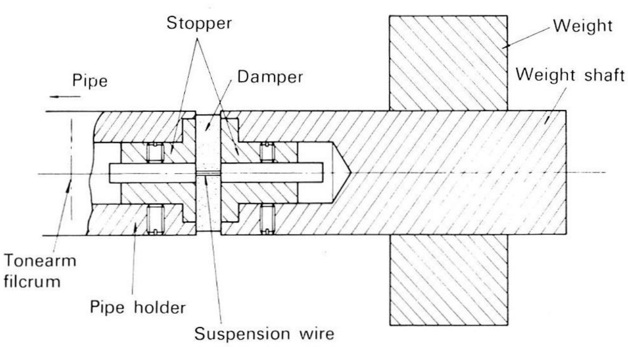
The coupling system is employed to decrease Sc extremely, lower a partial resonance, beyond audible frequency range so that it agrees with the tonearm resonance, and decrease Q of resonance peak utilizing phase difference.

In TA-71, a piano wire of a high elasticity is used for suspension wire, which acts as Sc in Fig. 3-8. And, butyl rubber of a high equivalent resistance is used for dumper, which acts as rc.

Data by observation on TA-71 are shown in Fig. 3-9 where peaks of resonance are suppressed. These curves well represent features of the flexible coupling tonearm.

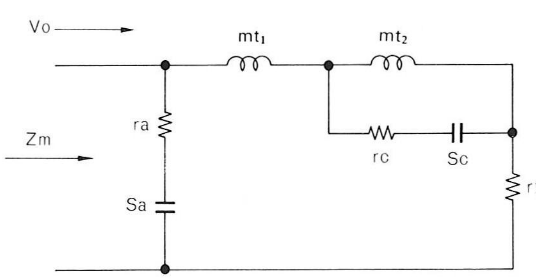


Conventional tonearm



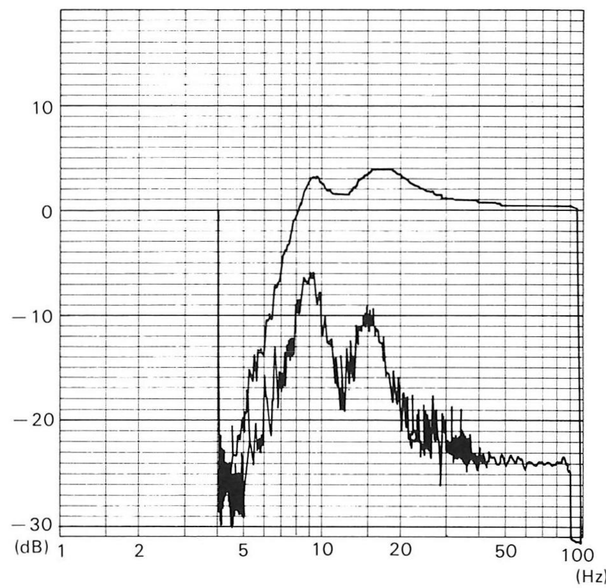
TA-71

Fig. 3-7

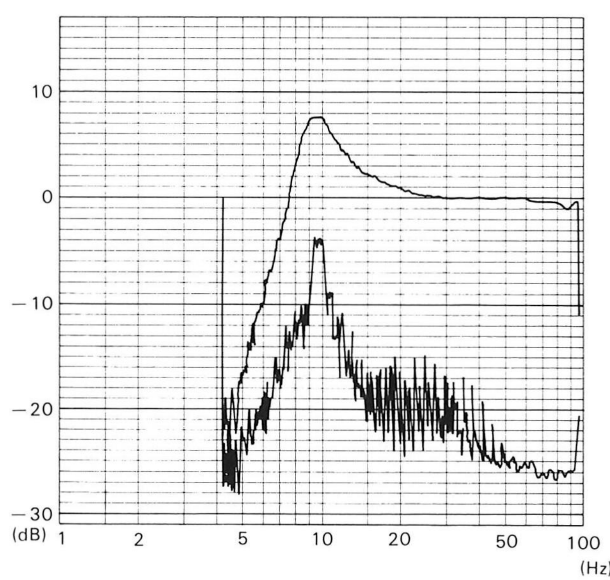


Vo: Velocity amplitude of record groove.
Zm: Mechanical impedance in view of stylus.
Sa, ra: Equivalent stiffness and resistance of support of vibration system.
rt: Equivalent resistance of tonearm fulcrum.
mt1: Equivalent mass of tonearm except weight.
mt2: Equivalent mass of weight.
Sc,rc: Equivalent stiffness and resistance of weight coupling.

Fig. 3-8



TA-71 Characteristic at low frequency region



Conventional tonearm characteristic at low frequency region

Fig. 3-9

TONEARM DESCRIPTION

Bearing

TA-71 uses an angular contact bearing for vertical support and a radial bearing for horizontal support.

Compared data between TA-71 and the conventional our products are shown in Table 3-1 and 3-2. Circularness and race roughness of radial bearing are shown in Fig. 3-10 ~ 3-12.

RADIAL BEARING

	Sample No.	Circularness (μ)				Race roughness	
		Inner-diameter	Outer diameter	Race		Inside	Outside
				Inside	Outside		
Conventional	1	2.0	1.0	1.5	0.9	1.15μ Rmax	0.6μ Rmax
	2	2.2	1.0	0.9	0.8	1.4	0.85
	3	1.2	1.0	1.0	0.5	0.8	1.4
TA-71	1	0.5	0.3	0.4	0.4	0.17	0.15
	2	0.7	0.6	0.5	0.4	0.12	0.12
	3	0.8	0.3	0.5	0.4	0.15	0.20

<Table 3-1>

Angular contact bearing (μ)

Sample	Conventional	TA-71
1	0.16~0.18	0.11~0.12
2	0.2~0.21	0.08~0.09
3	0.14~0.15	0.12~0.13
4	0.18~0.19	0.12~0.13

<Table 3-2>

As known from these tables and figures, bearings are super precision types, so that operation is smoothed, the supporting point does not shift, traceability is improved and partial resonance is suppressed.

TONEARM DESCRIPTION

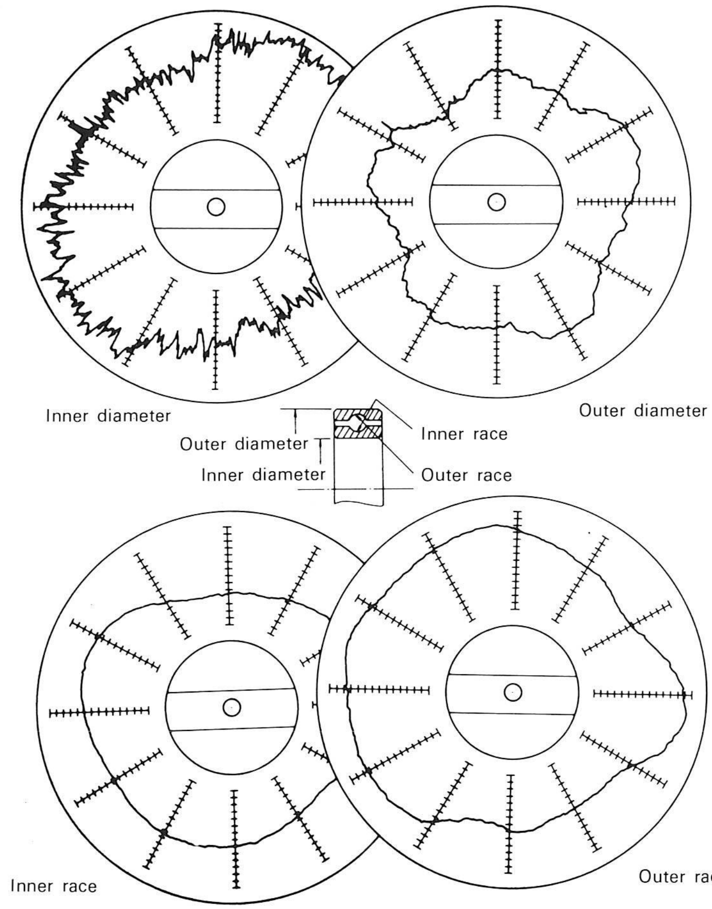


Fig. 3-10 Circularness for conventional radial bearing

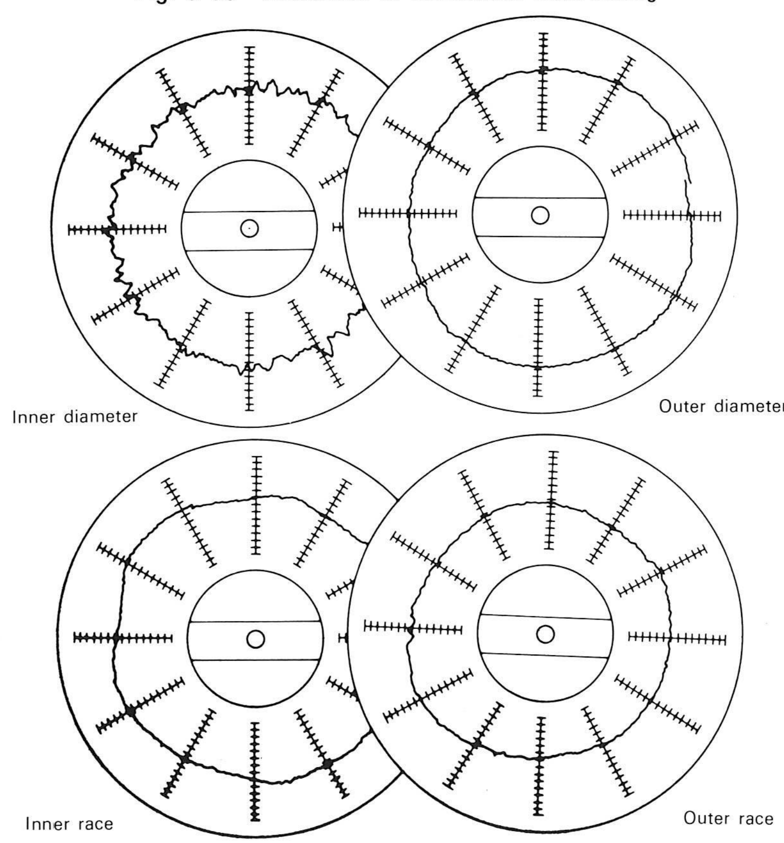


Fig. 3-11 Circularness for TA-71 radial bearing

TONEARM DESCRIPTION

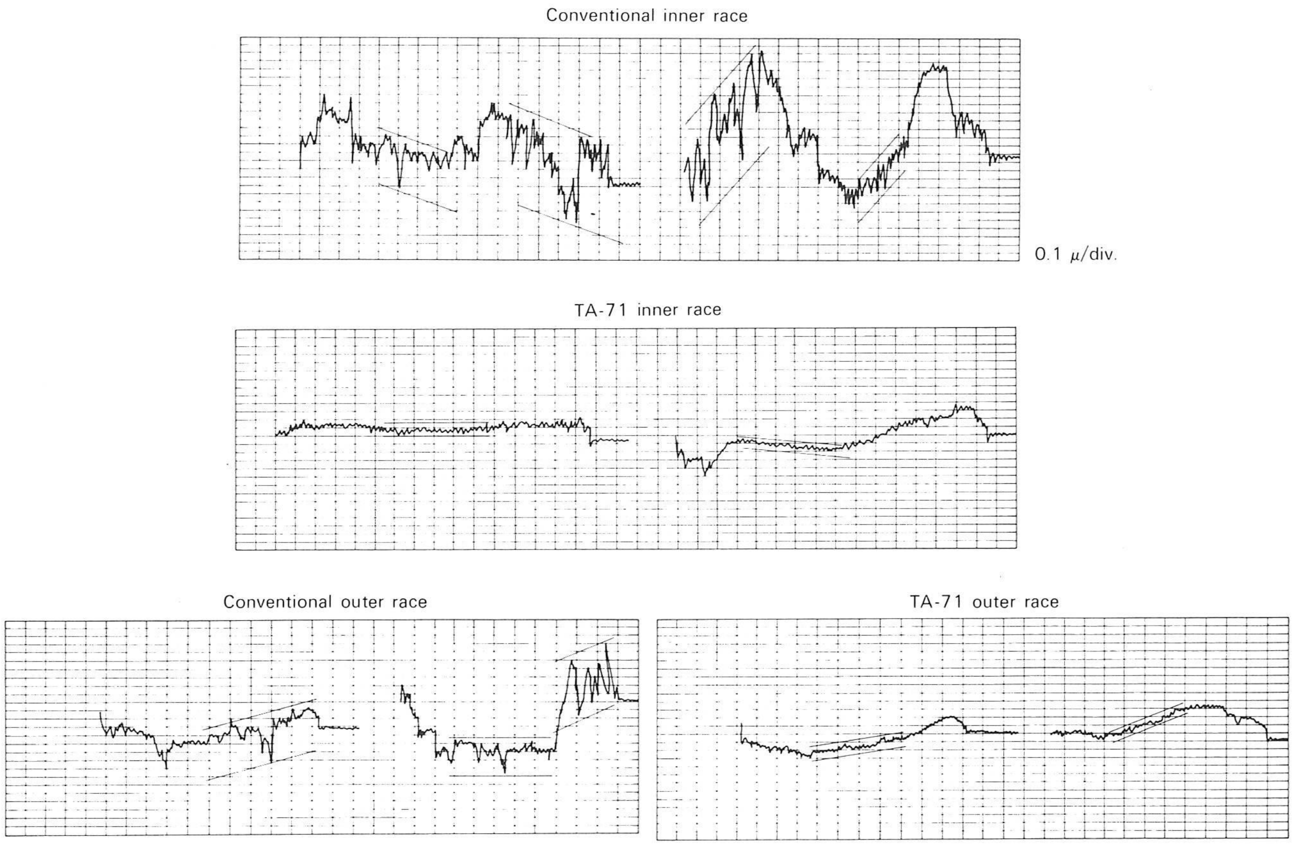


Fig. 3-12 **Surface roughness of race for conventional and TA-71**

Tonearm base

The conventional tonearm bases lack mechanical strength and fixing strength for tonearm. Therefore, if mechanical impedance of tonearm base seen from the tonearm supporting point is small, supporting point shift is liable to occur. As a result, partial resonance generated worsens transient characteristic.

KD-750 uses a collet chuck type tonearm base to ncrease mechanical impedance. Thus, the fonearm is securely fixed and supporting point shift is prevented.

Frequency characteristic of a conventional tonearm base is shown in Fig. 3-13. That of the collet chuck type tonearm base of KD-750 is shown in Fig. 3-14, where a partial resonance at 300 Hz is well suppressed.

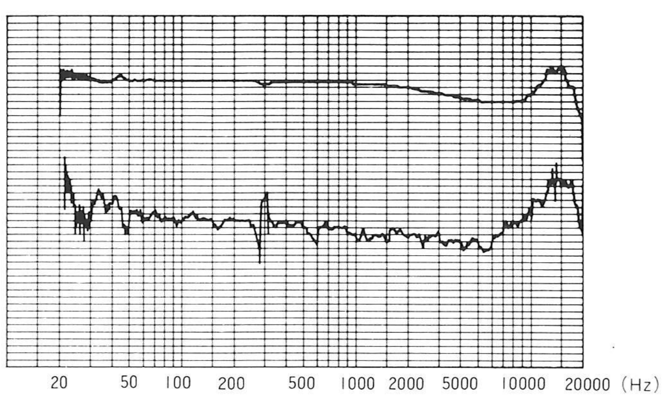


Fig. 3-13 **Conventional tonearm base**

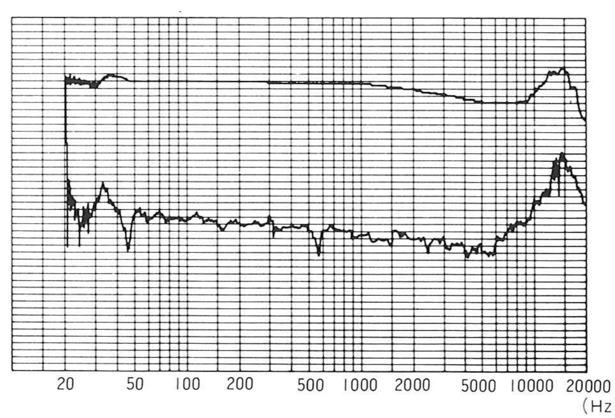


Fig. 3-14 **KD-750 tonearm base**

TONEARM DESCRIPTION/HEAD SHELL

PICK-UP LEAD WIRE

The internal lead wires used in TA-71 are a low resistance, a low capacitance, and a low cross-talk wires as shown in Fig. 3-15. Comparison between this wire and a conventional vinyl wire is shown in Table 3-3.

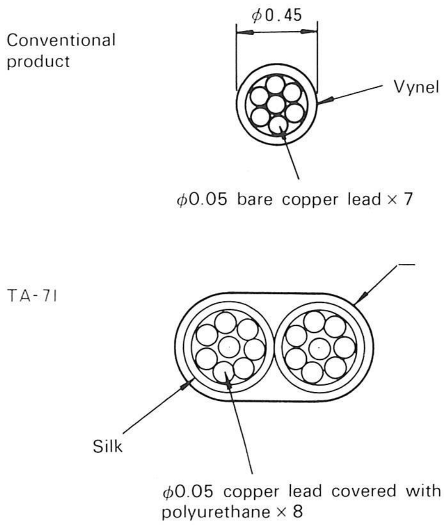


Fig. 3-15

	Conventional	TA-71
Resistance	0.36Ω/282 mm	0.173Ω/282 mm
Capacitance between wires in the air.	14.75 pF/282 mm	7.17 pF/282 mm
Capacitance between wires in pipe.	18.7 pF/282 mm	13.49 pF/282 mm

<Table 3-3>

HEAD SHELL

It has been said that the head shell affects tone quality. Because, the motor and the tonearm was improved and affect of head shell on tone quality has been closed up. The head shell of KD-750 was designed to meet these requirements.

Quality of Material for Head Shell

Materials for head shell is roundly divided into the following 6:

1) Plastics
2) Die Casting Aluminum
3) Molten Metal Forged Aluminum
4) Aluminum
5) Carbon Fiber
6) Magnesium

Among these, magnesium has a low specific gravity of 0.6 and a large mechanical strength compared to aluminum and has a better molding characteristic than carbon fiber.

The most fundamental requirement for head shell is mechanical strength. If mechanical strength is small, partial resonance will occur as shown in Fig. 3-16. It is also required to shift natural vibration frequency beyond audible frequency range.

A bar shown in Fig. 3-17 is assumed. Resonance frequency of the rod is given as follows.

$$f=\frac{\lambda^2}{2\pi \ell^2}\cdot\sqrt{\frac{EIg}{rA}} \quad \cdots\cdots\cdots\cdots (4)$$

ℓ : Bar length
f: Natural vibration of bar
π: Dimensionless coefficient decided by vibration system and a/b
E: Young's modulus
g: 981 cm/S
δ: Poisson's ratio
r: Weight of unit volume

f is increased by making EI, which represents mechanical strength, larger. To increase mechanical strength of head shell whose weight is limited, the conventional of head shell must be considered.

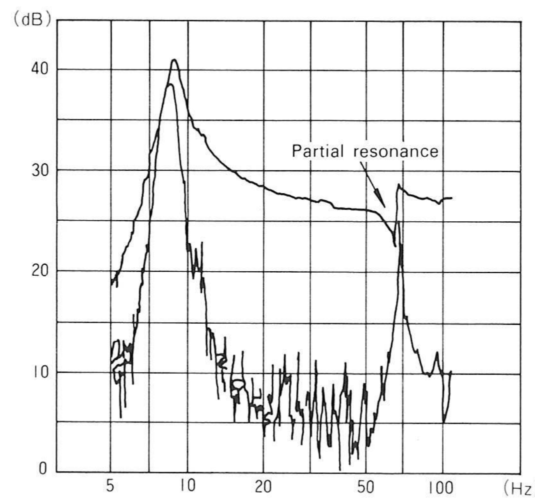


Fig. 3-16

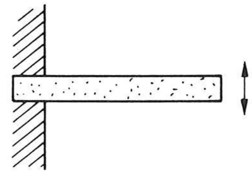


Fig. 3-17

HEAD SHELL

The conventional head shell used in KD-750 is shown in Fig. 3-18. Mass distribution is shown in Fig. 3-19. As shown in the figures, the base part is thick, and the top is lightened and formed as T shape to increase mechanical strength. (See Fig. 3-20.)

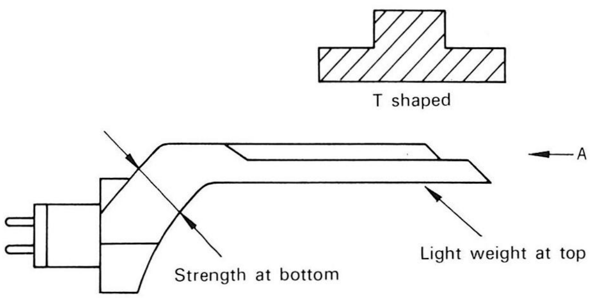


Fig. 3-18

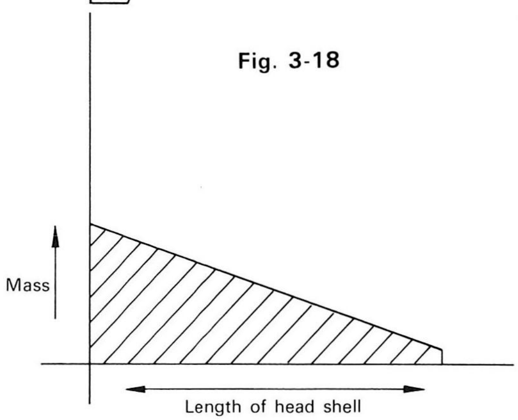


Fig. 3-19 Ideal mass distribution

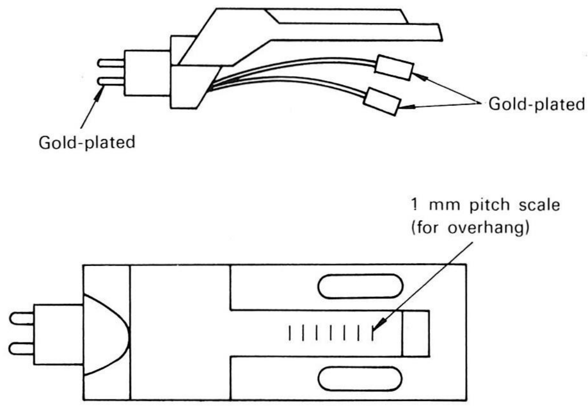


Fig. 3-20

One of factors determining mechanical strength is flexural rigidity. Equation is given as follows.

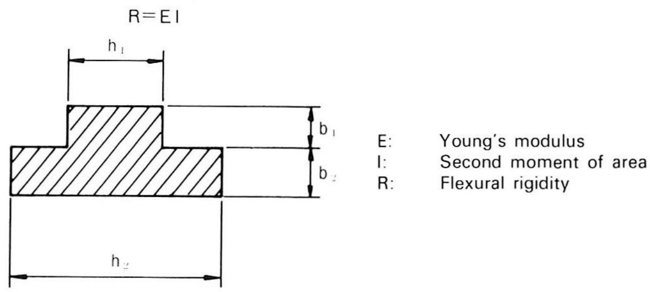


Fig. 3-21a

At this time,

$$I = \frac{1}{R}(b_1h_1^3 + b_2h_2^3)$$

To increase "flexural rigidity" R, second moment of area must be increased.

That is, for the below forms of a and b, when $\ell_1 = \ell_2$, and sectional areas and materials are same, b is stronger than a.

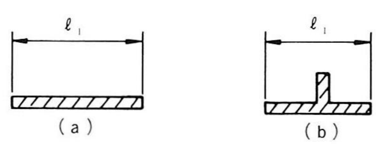
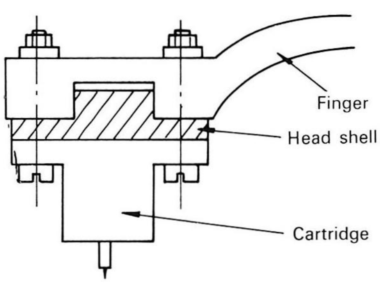


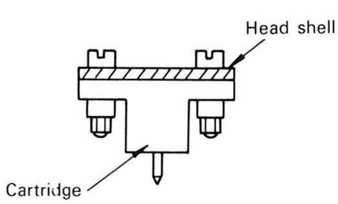
Fig. 3-21b

The headshell of KD-750 keeps fitting strength of cartridge as shown above.

Cartridge fixing strength also must be considered. For the shell of KD-750, the fixing strength is increased by making the finger thick.



(KD-750)



(Conventional)

AUDIO CORD / TURNTABLE SHEET

AUDIO CABLE (OUTPUT CABLE)

Specifications of the output cable are shown in Table 3-4.

Conductor Resistance:	0.23 Ω/m max (20°C)
Shielding Wire Resistance:	0.035 Ω/m max
Capacitance between Conductor and Shielding Wire:	50 pF/m or less
Insulation Resistance between Conductor and Shielding Wire:	40 MΩ/m min
Dielectric Strength Test:	AC500V for 1 min
Earth Lead Resistance:	0.073 Ω/m max

<Table 3-4>

Pin form of a former 5P connector is shown in Fig. 3-22. Such a pin is liable to slip out and contact resistance is ready to increase.

Our newly developed connector is improved in slipping-out and contact resistance, which is shown in Fig. 3-23.

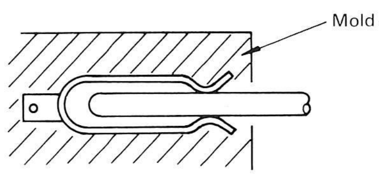


Fig. 3-22

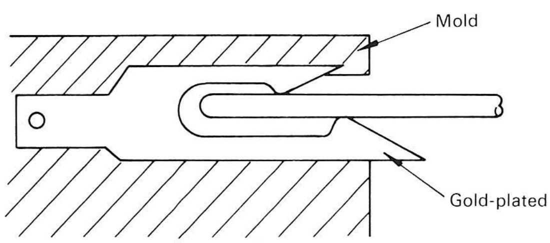


Fig. 3-23

TURNTABLE SHEET

A table sheet is used for the following purposes.
1) to protect a record
2) to prevent a record slipping
3) to prevent vibration

Quality of material and structure greatly affect 2) and 3) above. For KD-750, 2) slip is prevented by flatting the surface of table sheet and 3) vibration is prevented by selecting material and by means of Helmholtz's theory.

Quality of Material for Turntable Sheet

Most of commercially available turntable sheet are made of,
1) natural rubber,
2) SBR
3) butyl rubber.

Requirements for quality of material are as follows.
1) shock absorption
2) vibration absorption
3) noise absorption
4) slip resistance
5) air permeability
6) weather proofing
7) thermal stability

For KD-750, materials and blending ratio were determined to be optimum.

Among these requirements, vibration absorption and slip resistance especially affect tone quality. If slip resistance is low, sound will be faded. Vibration absorption for each material is shown in Fig. 3-24. Difference of materials is cleared at resonance point of each material (natural vibration frequency of rubber is Low) but there is little difference among materials at a high frequency. Thus, no special effect is expected even if material is selected. To improve vibration absorption at high frequency range, KD-750 utilizes a Helmholtz's resonator for the table sheet.

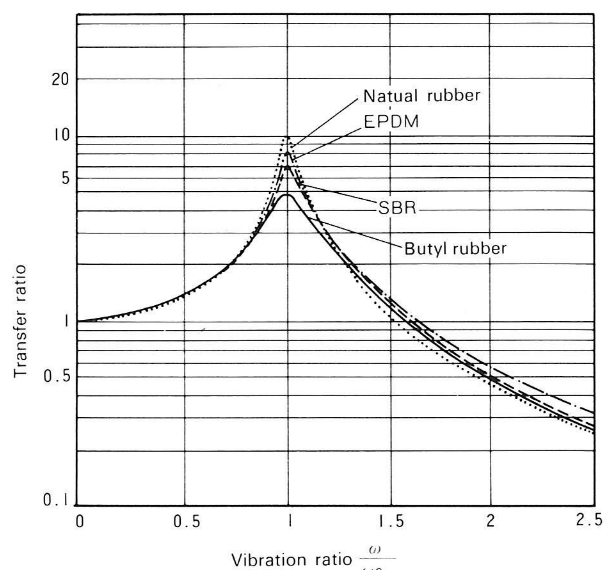


Fig. 3-24 Absorbability for vibration

TURNTABLE SHEET

Requirements of Vibration Absorption at High Frequency Range

A record is in complicated motion on a turntable sheet. Partial resonance occurs at high frequency range and deflection resonance occurs at low frequency range. These resonances are very complexed and affected by setting conditions of record.

When a record is set on a turntable, states shown in Fig. 3-25 ~ 3-27 may occur. Resonance frequency (deflection vibration frequency) of record on each setting condition is given as follows.

$$f_0 = \lambda^2 \frac{h}{4\pi a^2} \sqrt{\frac{E\,g}{3(1-\delta^2)r}} \quad \cdots\cdots(5)$$

- λ : non-dimensional coefficient determined by setting condition and vibration mode
- h : thickness
- a : radiua of record
- E : elastic coefficient of record (3×10^{10} dyne/cm^2)
- δ : Poisson's ratio (0.45)
- r : weight of unit volume (1.3 g/cm^3)

For Fig. 3-25, $fo \fallingdotseq 10$ Hz. For Fig. 3-26, $fo \fallingdotseq 30$ Hz. From these, it is known that the lowest resonance frequency of record is from very low. And, resonance characteristic is very broad compared to the metal. In a condition of Fig. 3-27, little deflection resonance occurs but partial resonance due to acoustic pressure occurs. This resonance can not be indicated by a lot of equation because there are many unspecific setting conditions of table sheet, air layer and record. It is considered that partial resonance occurs at a frequency higher than 3 kHz. A record on a turntable is considered to be on an air layer at high frequency range. Vibration of this air layer caused by partial resonance must be absorbed. Thus, Helmholtz's theory is applied.

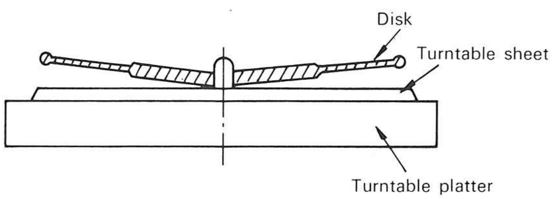


Fig. 3-25 Shaft section settled

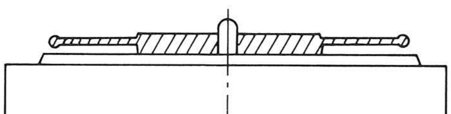


Fig. 3-26 Label section settled

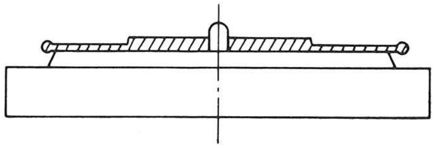


Fig. 3-27 Whole settled

HELMHOLTZ'S RESONATOR

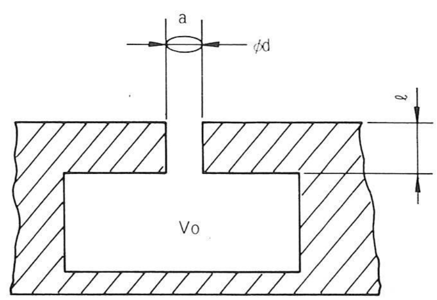
Helmholtz's resonator is also called whisky bottle resonator, and angular frequency is represented by eq. (6) and eq. (7).

$$\omega o^2 = V^2 \frac{a}{Vo\,\ell} \quad \cdots\cdots(6)$$

- V: acoustic velocity
- Vo: volume of cavity
- a: area of neck
- ℓ: length of neck
- ωo: angular frequency of resonator

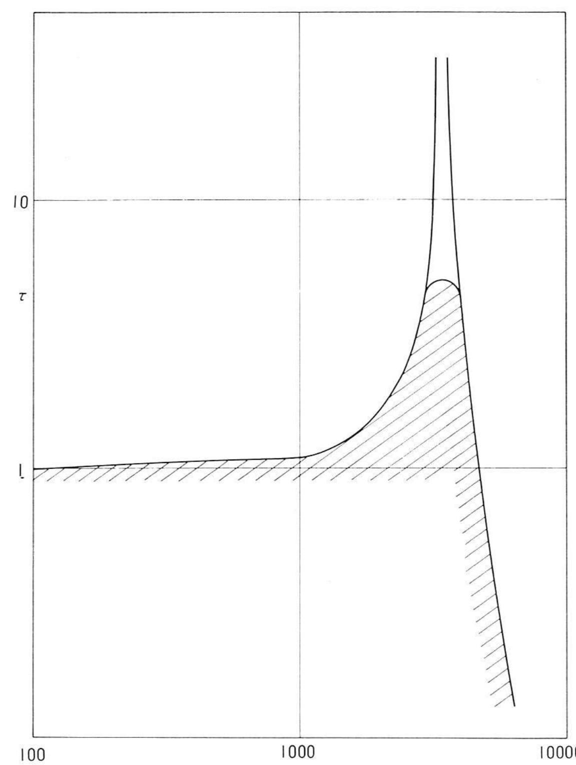
From eq. (6), an experimental equation is given as

$$f = \frac{V}{2\pi} \sqrt{\frac{a}{V_0(\ell + 0.8d)}} \quad \cdots\cdots(7)$$



Resonator

Fig. 3-28



Frequency vs amplitude

Fig. 3-29

TURNTABLE SHEET

(Refer to Fig. 3-29, Resonance Characteristic)

A condition where a record is on a Hel-sheet (a sheet to which Helmholtz's theorem is applied) is shown in Fig. 3-30. Vibration of air caused by partial resonance of record is absorbed most effectively with a cavity including a big hole and a small hole when its resonance frequency agrees with the vibration frequency.

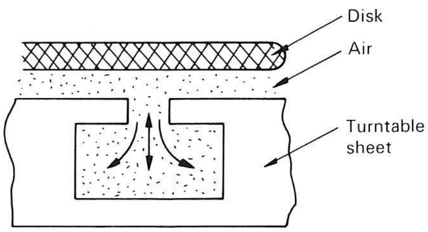


Fig. 3-30

Resonance frequency of the Hel-sheet was determined to 3.5 KHz. Actual effective range of partical resonance of record is considered to be over 1000 ~ 10 kHz. Increase of number of holes results in widening range of resonance. This is because partial resonance characteristic is broad.

The reason why resonance frequency was determined to 3.5 kHz is that the most of partial resonances of record were observed above 3 kHz by experiments.

Distribution of Resonance Points by Equation

The Hel-sheet cants up by 30' toward center. Therefore, lengths of neck are different according to the distance from the center. Let lengths of neck be $\ell 1$, $\ell 2$, $\ell 3$, $\ell 4$ and $\ell 5$, respectively.

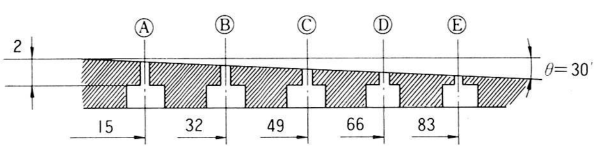


Fig. 3-31

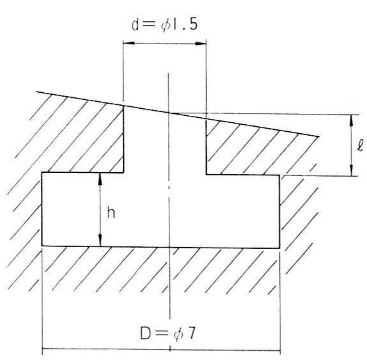


Fig. 3-32

ℓ_1 is,

$\ell_1 = 0.2 - 1.5 \times \tan\theta \qquad \tan\theta = 30' = 0.00872686$

The length is given as
Then,

$\ell_1 = 0.2 - 1.5 \times 0.00873 \fallingdotseq 0.1869$
$\ell_2 = 0.2 - 3.2 \times 0.00873 \fallingdotseq 0.1721$
$\ell_3 = 0.2 - 4.9 \times 0.00873 \fallingdotseq 0.1572$
$\ell_4 = 0.2 - 6.6 \times 0.00873 \fallingdotseq 0.1424$
$\ell_5 = 0.2 - 8.3 \times 0.00873 \fallingdotseq 0.1267$

From eq. (7), resonance frequency, fn, is given as

$$f_n = \frac{34000}{2\pi}\sqrt{\frac{a}{V(\ell + 0.8d)}}\ \text{Hz} \qquad \text{(8)}$$

where

$$a = \frac{\pi}{4}d^2 = \frac{\pi}{4} \times 0.15^2 = 0.01767\text{cm}^2$$

$$V = \frac{\pi}{4}D^2h = \frac{\pi}{4} \times 0.7^2 \times 0.4 = 0.15386\text{cm}^3$$

No.	ℓn (cm)	ℓn+0.8d	V(ℓn+0.8d)	$\frac{a}{V(\ell n+0.8d)}$	$\sqrt{\frac{a}{V(\ell n+0.8d)}}$	fn
Ⓐ	0.1869	0.3069	0.0472	0.3744	0.6119	3311.25
Ⓑ	0.1721	0.2921	0.0449	0.3935	0.6273	3394.59
Ⓒ	0.1572	0.2772	0.0426	0.4148	0.6440	3484.96
Ⓓ	0.1424	0.2624	0.0404	0.4374	0.6614	3579.12
Ⓔ	0.1276	0.2476	0.0381	0.4638	0.6816	3685.18

Ease of resonating is indicated by amplitude ratio, τ.

$$\tau = \frac{1}{1 - \left(\frac{f}{f_n}\right)^2} = \frac{a}{a_0} \qquad \cdots\cdots(9)$$

τ of No. 1 hole is calculated and shown in the following table.

TURNTABLE SHEET

f	$\frac{f}{fn\ A}$	$\left(\frac{f}{fn\ A}\right)^2$	$1-\left(\frac{f}{fn\ A}\right)^2$	$\tau=\frac{a}{a_0}$	a^2
100	0.0302	0.000912	0.99909	1.0009	1.0018
500	0.1510	0.02280	0.97720	1.0233	1.0471
1000	0.3020	0.091204	0.90800	1.10036	1.2108
1500	0.4530	0.20521	0.79479	1.2582	1.5831
2000	0.6040	0.36482	0.63518	1.5744	2.4787
2200	0.6644	0.44143	0.55857	1.7903	3.2052
2400	0.7248	0.52533	0.47467	2.1067	4.4382
2600	0.7852	0.61654	0.38346	2.6078	6.8006
2800	0.8456	0.71504	0.28496	3.4569	11.9501
3000	0.9060	0.82084	0.19716	5.0720	25.7252
3200	0.9664	0.93393	0.06607	15.1355	229.0834
3250	0.9815	0.96335	0.03665	27.2851	
3311.25	1.0000	1.00000	0.0 0	∞	
3350	1.01770	1.02354	0.02354	42.4801	
3400	1.0268	1.05432	0.05432	18.4094	338.9060
3600	1.0872	1.18200	0.18200	5.4945	30.1895
3800	1.1476	1.31699	0.31699	3.1546	9.9515
4000	1.2080	1.45926	0.45926	2.1774	4.7410
4200	1.2684	1.60883	0.60883	1.6425	2.6978
4400	1.3288	1.76571	0.76571	1.3059	1.7053
4600	1.3892	1.92988	0.92988	1.0754	1.1565
4800	1.4496	2.10134	1.10134	0.9079	0.8243
5000	1.5100	2.28010	1.12801	0.8865	0.7885
5200	1.5704	2.46616	1.46616	0.6821	0.4653
5400	1.6308	2.65951	1.65951	0.6026	0.36313
5600	1.6912	2.86016	1.86016	0.5375	0.28991
5800	1.7516	3.06810	2.06810	0.4835	0.2338
6000	1.8120	3.28334	2.28334	0.4379	0.1918
8000	2.4160	5.8371	4.8371	0.2061	0.04772
10000	3.0200	9.1204	8.1204	0.1234	0.01515

f	a^2	ΔW
100	1.0018	100.18
500	1.0471	523.55
1000	1.2108	1,210.80
1500	1.5831	2,374.65
2000	2.4787	4,957.40
2200	3.2052	7,051.44
2400	4.4382	10,651.68
2600	6.8006	17,681.56
2800	11.9501	33,460.28
3000	25.7252	77,175.60
3200	229.0834	733,066.80
3250	744.4770	2,419,550.25
3300	21753.89	
3311.25	—	
3350	1804.559	
3400	338.9060	1,152,280.40
3600	30.1895	108,662.20
3800	9.9515	37,815.70
4000	4.7410	18,964.00
4200	2.6978	11,330.76
4400	1.7053	7,503.32
4600	1.1565	5,319.90
4800	0.8243	3,956.64
5000	0.7885	3,942.50
5200	0.4653	2,419.56
5400	0.3631	1,960.74
5600	0.2889	1,617.84
5800	0.2338	1,356.04
6000	0.1918	1,150.80
8000	0.0427	341.60
10.000	0.01515	151.50

As shown in the above table, resonance frequency distributes over 3300 ~ 3700 Hz, but it is considered that resonance frequency will distribute over 1000 ~ 1000 Hz if a little effect around $\tau=1$ is obtained.

a_0 is the amplitude at resonance. If it is "1", the energy conversion ratio for 1 cycle at $a=\tau\times 1$ is in proportion to a^2.

$$\Delta W=\pi\varepsilon Ka^2 f$$

$$=Qa^2 f \quad \cdots\cdots (10)$$

where

ε : loss coefficient

K : spring constant

Where $Q=\pi\varepsilon K$ Let $Q\fallingdotseq 1$, then the following table is obtained.

Effective Use of Helmholtz's Theory

Figure 3-29 shows resonance characteristic for one hole. By changing dimensions of cabity, an ideal characteristic is obtained.

The resonance frequency of n-1 curve is as follows.

for V1.........Vn

$$f_1=\frac{v}{2\pi}\sqrt{\frac{a}{V_1(\ell+0.8d)}}$$

$$\downarrow$$

$$fn=\frac{v}{2\pi}\sqrt{\frac{a}{Vn(\ell+0.8d)}}$$

fn of 500 Hz ~ 15000 Hz is desirable in this case.

SPECIFICATIONS

MOTOR & TURNTABLE

Drive System	Quartz PLL direct drive system
Motor	20 pole, 30 slot brushless D.C. servo motor (Starting torque 1.5 kg.cm)
Turntable Platter	33 cm (13 inch) diameter, aluminum alloy die-cast Weight: 2.6 kg (5.7 lbs.) Moment of inertia: 550 kg.cm²
Speeds	2 speeds, 33-1/3 and 45 rpm.
Wow & Flutter	Less than 0.022% (WRMS)
Rumble	DIN weighted better than −74 dB DIN unweighted better than−55 dB
Load Fluctuation	0% (within 120 g of tracking force)
Transient Load Fluctuation	Less than 0.0003% (at 33-1/3 rpm., 400 Hz, 20 g.cm load) Less than 0.00015% (at 33-1/3 rpm., 1,000 kHz, 20 g.cm load)
Starting Time	Within 1.8 sec.
Platter Speed Deviation	Less than 0.002%
Time Drift	Less than 0.0002%/h
Temperature Drift	Less than 0.00002%/C°

TONEARM

Type	Static-balanced type, S-shaped pipe arm, EIA plug-in connector
Effective Tonearm Length	245 mm (9-5/8 inch)
Overhang	15 mm (9/16 inch)
Tracking Error	+1.5 to −1.0 degree
Tracking Force Variable Range	0 to 3 grams (0.1 g step)
Usable Cartridge Weight	4 to 14 grams
Adjustable Height Range	Within 6 mm (1/4 inch)
Arm Base	Collet chuck type
Headshell	Magnesium alloy die-cast type Weight: 11 g

CARTRIDGE

(U.S.A., Canada, Europe and U.K. model are not equipped with the DM-11 cartridge)

Furnished Cartridge	DM-11
Stylus	N-11
Frequency Response	20 Hz to 20,000 Hz
Output Voltage	3.5 mV (1,000 Hz, 5 cm/sec.)
Optimum Tracking Force	2.0 ±0.3 grams
Load Impedance	50 kohms
Channel Separation	Better than 27 dB (1,000 Hz)
Replacement Stylus	N-11

MISCELLANEOUS

Power Requirement	AC 120V, 60 Hz: U.S.A., Canada model AC 240V, 50 Hz: U.K. Australia model AC 120V/220V (switchable) 50/60 Hz: Others
Power Consumption	35.0 watts
Dimensions	W 490 mm (19-5/16") H 165 mm (6-1/2") D 423 mm (16-5/8")
Weight	17.5 kg (38.6 lbs.)

SUPPLIED ACCESSORIES:

Low capacitance phono cables with gold plated terminal, EP adaptor with overhang gauge, screw driver, silicon cloth, ground wire

CABINET

Material	Particle board laminated with piano-finished kingrose veneer and a anti-resonance compression base (ARCB) are combined in the construction of cabinet.
Cabinet Ass'y Weight	7.5 kg (16.5 lbs.)
ARCB Weight	3.5 kg (7.7 lbs.)

ADDITIONAL FEATURES:

- Illuminated quartz lock and power indicator
- Electric-controlled brake
- Arm-height adjuster
- Collet chuck arm base
- Anti-skating device
- Viscous-damped cueing device
- LED speed indicator
- Dual suspension and adjustable insulator
- Free-stop action acrylic dust cover (Weight 1.2 kg)
- Tracking force direct readout counter
- Headshell stand

Note: *Kenwood follows a policy of continuous advancements in development. For this reason specifications may be changed without notice.