Understanding TURNTABLE SPECIFICATIONS

Part 2—A record player is far from the simple mechanical device it appears to be. If it is not properly designed, you won't get the best from your hi-fi system. A good turntable is essential to top performance.

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LAST MONTH I DISCUSSED SOME OF THE design considerations involved in insuring optimum performance of the pickup arm/cartridge combination. That discussion was based upon information supplied by Thorens, the Swiss turntable manufacturer. Now, I would like to examine some of the design elements involved in the turntable drive and suspension systems of a record player, again based upon information that I obtained during my recent visit to the Thorens engineering and production facilities.

In evaluating turntable performance, most audiophiles look to three published specifications: rumble, wow-and-flutter, and speed accuracy. Indeed, under ideal laboratory conditions, these are the only three specifications that would ordinarily have to be considered. But most of us do not play records under ideal laboratory conditions and, what's worse, the records we play are anything but perfect, especially in recent years. Certainly, susceptibility to acoustic feedback is a fourth quality of any turntable system that the prospective purchaser should consider. We will examine the importance of a turntable's suspension system presently, but for the moment, let's discuss turntable rumble.

It is not uncommon to run across two turntables, one that boasts of a rumble figure in excess of 70 dB, while another claims a much more modest 50 dB or even less. Listening to records on both turntables may show that the turntable having the lesser rumble figure may actually produce less noise than the one having the higher figure.

The National Association of Broadcasters (NAB) formulated a method of rumble measurement in 1964. In the NAB measurement system, only those frequencies between 10 Hz and 250 Hz are included at their full amplitude when making the measurement. Below 10 Hz, a filter rolls off response of the measurement system at a rate of 6 dB-per-octave, while the 3-dB-cutoff at the high end of the range is at 500 Hz with a slope of 12 dB-per-octave above the range. The weighting curve, as it is called, is shown in Fig. 1. An associated test record, having a reference level of 1.4 cm-per-sec peak recorded velocity in lateral modulation at 100 Hz also contains a "silent groove" following the reference signal. The rumble, or signal-to-noise ratio, is expressed as the difference between the reading obtained on a standard VU meter when the modulated groove is playing and the reading observed during playing of the silent groove.

Two additional rumble measurement

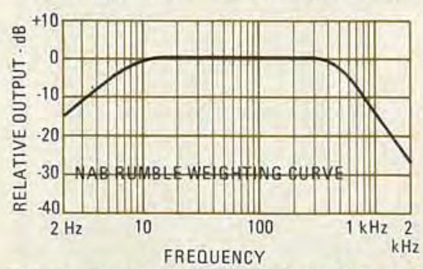


FIG. 1—THE NAB WEIGHTING CURVE used with a test record to measure turntable rumble.

standards were developed by DIN (the German Standards organization). Their standard, DIN 45-539 uses two different weighting networks, as illustrated in Fig. 2. Curve "A", (the unweighted DIN rumble weighting curve) is practically equivalent to the NAB curve. Curve "B" however, used for making a weighted, or DIN "B" measurement, attempts to deliver test results or numbers that correspond as nearly as possible to the subjective impression of rumble. Because human hearing is less sensitive to low frequencies than to mid-frequencies, the filter attenuates the low frequencies at a rate of 12 dB-per-octave on each side of a center frequency, 315 Hz.

The DIN test record, 45-544 used in

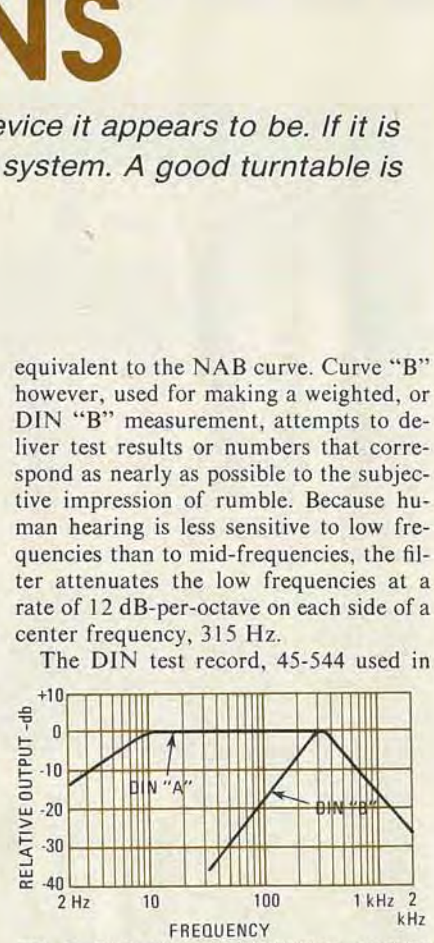


FIG. 2—TWO RUMBLE WEIGHTING CURVES developed by DIN, the German standards organization.

making DIN rumble measurements contains a 315-Hz reference signal recorded at a velocity of 5.42 cm-per-sec (single channel) in addition to the required "silent groove."

In 1966, CBS Laboratories (now known as CBS Technology Center) developed a new weighting curve for measurement of rumble. High-frequency rolloff used in this weighting curve is almost identical to that used in the DIN standard; but at low frequencies, a dropoff of only 6 dB-per-octave is used. The test record developed for this measurement system, known as RRLL (*R*elative *R*umble *L*oudness *L*evel) has a 100-Hz reference tone recorded at 5 cm-per-sec later-

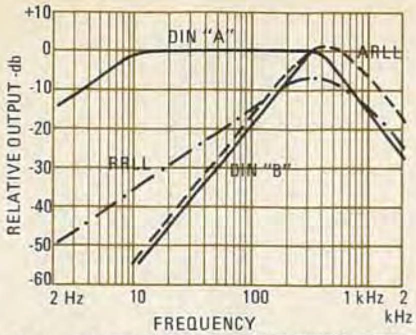


FIG. 3—**FOUR POPULAR RUMBLE WEIGHTING CURVES. Text explains their uses and why they differ.**

ally and readings are made on an RMS responding meter. This new reference frequency at reference level results in a fundmental difference of readings (compared with the 315-Hz reference level used in DIN) of 7 dB, even before you take into account the difference in the weighting curves.

Finally, there is the ARLL (A*udible* Relative *L*oudness *L*evel) used by some laboratories and publications. This one starts out using the basic NAB procedure, but adds a filter that corresponds to the standard "A" weighting network used in sound-level meters and in making IHF signal-to-noise measurements for amplifiers, tuners, etc. The four most popular weighting curves have been superimposed in Fig. 3 to give readers some idea how widely rumble measurement may vary, from system to system, both because of differences in reference levels against which the residual noise is measured and because of the differences in the weighing curves themselves. Clearly, there is no way to meaningfully compare an NAB rumble figure with a DIN "B" specifica-

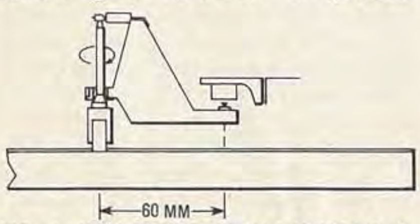


FIG. 4—NEW RUMBLE TEST ADAPTOR, by Thorens, consists of a spindle and a swiveled platform to support the pickup cartridge of the turntable system under test.

tion, or a DIN "A" result against an RRLL result. The important point here is that when you compare rumble figures of competing products you make sure that both figures were arrived at using the same test procedure. The IHF (*I*nstitute of *H*igh *F*idelity) is now trying to arrive at a standard to be used by the high-fidelity industry, but until that standard is adopted and used, it's up to the consumer to beware of specsmanship. Needless to say, most turntable manufacturers in recent years tend to favor the DIN "B" method simply because it yields higher dB numbers. Unfortunately, infrasonic rumble components, though inaudible as such (and therefore not included in the DIN "B" method) can have a serious effect on sound reproduction. This is especially true with the new DC amplifiers that amplify signals down to "0 Hz". Severe rumble components in the 6-Hz to 12-Hz region, as we pointed out last month, can aggravate pickup-arm resonance problems. Also, large woofer cone excrusions at subsonic frequencies, though in themselves inaudible, can push the speaker cone out of its linear operating region, thereby introducing IM distortion at audible frequencies.

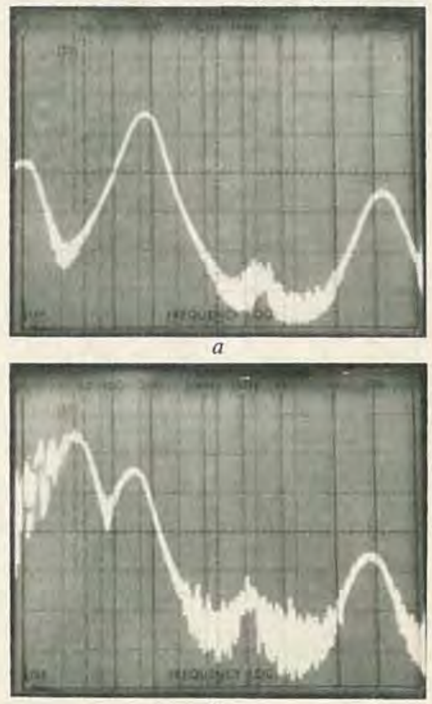
New Rumble Measurement Instrument

Rumble measurements are further complicated by the fact that rumble is also contained in the test records themselves, besides being generated by turntable drive mechanisms. Engineers at Thorens discovered that the average rumble of many of the rumble test records popularly used was approximately the same as that of many high quality turntable systems. The record may therefore contribute as much to the rumble measurement as the turntable itself. For this reason, Thorens developed a new device (Fig. 4) to replace the test record for rumble measurements. Figure 5 shows the Thorens Rumble Test Adaptor being used to check a Thorens TD-126 Mk III turnta-


FIG. 5—ILLUSTRATION shows the Thorens rumble test adaptor in actual use. A special test record is used.

ble. The device consists essentially of two elements: a spindle and a swiveled frame, upon which the stylus of the pickup cartridge is placed. The spindle, which is rigidly connected to the turntable shaft, is carefully polished and plated, first with copper and then with nickel. The bearing contact is equipped with high-polymer parts. The two elements of the Rumble Test Adaptor are rigidly connected, allowing any vibration or noise to be transmitted to the pickup cartridge for subsequent measurement. The test record seen in Fig. 5 is now used only to establish a reference level against which to measure the rumble value. The construction of the bearing of this device enables vibrations in both vertical and lateral directions of each stereo channel to be detected.

Whether rumble is measured this way or with a test record, a great deal of information can be gained with the aid of a spectrum analyzer, since it is important to know the content (frequencies) of the rumble as well is its overall single-number value. Using the Rumble Test Adaptor just described, we tried to analyze the rumble content of a typical high-quality turntable that uses a synchronous 1800-RPM motor and belt drive. Even using a low-noise, hum-free (we thought) setup in the tests we were plagued by hum and some noise pickup which threatened to mask the results. To differentiate between electrically generated hum and noise and low-frequency rumble content, we therefore made two plots on the analyzer. The first, shown in Fig. 6-a is a linear sweep from 0 Hz to 200 Hz (20 Hz per linear horizontal division on the scope face) taken with the arm at rest, but with the turntable rotating (motor on). The peak at the extreme left of the display is the "zero beat" of the analyzer and may be ignored. Approximately three divisions to the right is the expected peak at 60 Hz (line frequency) and to the right we see a second major peak at 180 Hz (third harmonic of the line frequency). A much


a

b

FIG. 6—SPECTRUM ANALYZER RECORDS. The trace at *a* was made with pickup arm at rest while turntable was rotating. Trace at *b* was made with pickup resting on platform of the test adaptor.

lower amplitude peak is also detectable at 120 Hz (second harmonic of 60 Hz).

Compare these results with those obtained when the stylus was positioned on the frame of the Thorens Rumble Test Adaptor while the turntable revolved, as shown in Fig. 6-b. The first thing we notice is a brand new peak at 30 Hz which is actually taller than the "hum" peak at 60. If you divide the rotation of the motor (1800 RPM) by 60 seconds, sure enough you come up with 30 Hz. In other words, a severe rumble component is being contributed by the motor on a once-per-revolution basis. Even more interesting are additional spikes observed at the extreme left of the display, in the region below 20

TABLE 1

Turntable	Test Record	Rumble Adaptor
Average direct-drive model	−46 dB	−60 dB
High-quality direct drive with quartz speed control	−48 dB	−51 dB
Thorens TD 126 Mk III	−50 dB	−72 dB

Hz. These spikes, too, are greater in amplitude than the electrically generated hum noise observed earlier and one or more of them may well lie in the exact frequency region of pickup-arm/cartridge resonance. Clearly, a single meter measurement of rumble, by whatever standard, could not disclose this much information about the nature of the noise itself.

Thorens maintains that their new Rumble Test Adaptor can provide help in explaining the audible differences between various turntables which, using test records to establish rumble figures, come up with rumble figures which at first glance are not significantly different. As proof of this, they offer a summary of measurements made the "old" (test record) way and using their Rumble Test Adaptor. The summary is shown in Table 1 and note that, in all cases, the more severe DIN "A" (unweighted) measurements were used.

Improving Turntable Suspensions

The fourth factor which determines the quality and performance of a turntable system is its suspension system. Unfortunately, few manufacturers of turntables are able to say much about their efforts in this direction, largely because the quality of a suspension system does not lend itself to a measurement. Acoustic feedback, whether it be a continuously howling sound when volume is turned up too loud, or partial feedback which falls short of that extreme but nevertheless causes coloration of reproduced sound, is a problem known to all-too-many audio buffs. Acoustic feedback may be airborne (sound waves from the speaker vibrate against the turntable's structure and are picked up by the stylus riding in a record groove) or it may result from vibration carried through the floor, the surface upon which the turntable is mounted, etc.

The classical floating suspension system, shown in Fig. 7, does offer a number of advantages such as high insensitivity to solid-borne vibrations above 20 Hz and great immunity to mechanical and acoustic feedback. However, there are also disadvantages. It is sensitive to ultra-low frequncy disturbances, such as those transmitted to the turntable from the movement of people on a wood floor or from external jolts. Studies have shown that when this conventional suspension system is used, choosing a low resonant frequency for the system is not sufficient for

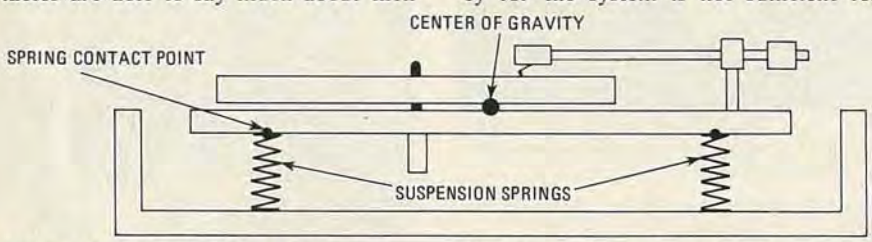


FIG. 7—TYPICAL TURNTABLE SUSPENSION SYSTEM as it appears when at rest.

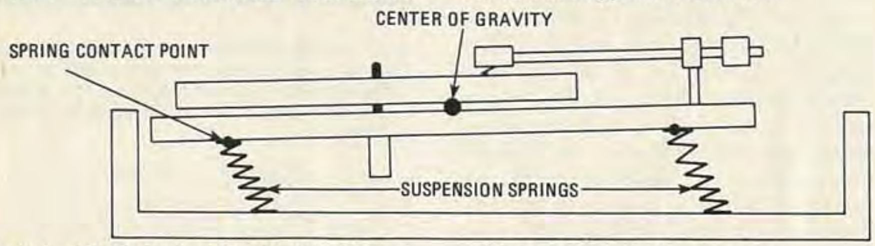


FIG. 8—HORIZONTAL DEFLECTION of the typical turntable mounting board causes complex rotational and vertical movements.

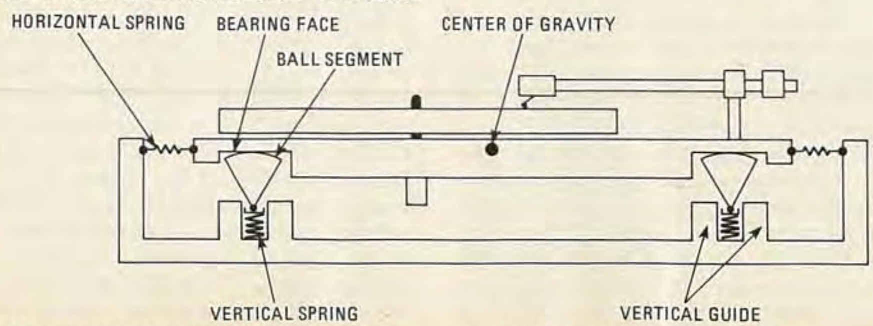


FIG. 9—BASIC DRAWING of the Thorens *Ortho-Inertial* turntable suspension system.

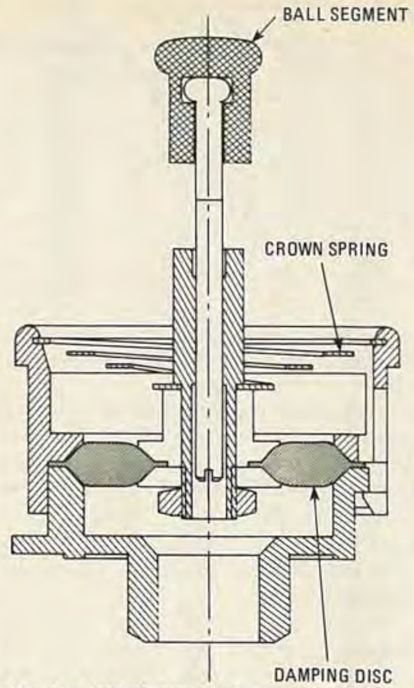


FIG. 10—CROSS-SECTION view of the ball-segment mounting arrangement used by Thorens.

achieving optimum behavior. Difficulties arise when so-called "mode conversion" effects take place. For example, a simple horizontal excitation may produce an intricate combination of translational and rotational displacements. Figure 8 illustrates such an effect in a conventional suspension system.

According to Thorens, their newly developed *Ortho-Inertial* suspension system eliminates many of these problems. The suspension system is illustrated in simplified form in Fig. 9. The chassis of the turntable is supported by ball-segment bearings and by separate spring elements for horizontal and vertical displacments. The bearing faces on the chassis are in the same plane as the center of gravity and each ball segment bearing is supported at its midpoint by a spring possessing freedom only in the vertical direction. A detailed cross-sectional view is shown in Fig. 10.

If this system is set into motion by a horizontal excitation, the chassis rolls over the ball segments. Since the center of gravity and the bearing faces lie in the same plane, no rotational motion occurs. Furthermore, since the height of the chassis does not change when it rolls over the ball segments, the vertical springs retain their fixed length and vertical displacment does not take place. The ball-segment bearings are fabricated of rubber and afford isolation and damping of disturbance frequencies within the audio range. This reduces the turntable's sensitivity to acoustic feedback as well.

It has been repeated in print many times that all a turntable has to do is rotate at a constant speed and so so quietly. As you can see from this and last month's discussion of pickup arm design, that is more easily said than done. **R-E**