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SHURE V15 TYPE IV PHONO CARTRIDGE and SME 3009 III TONEARM

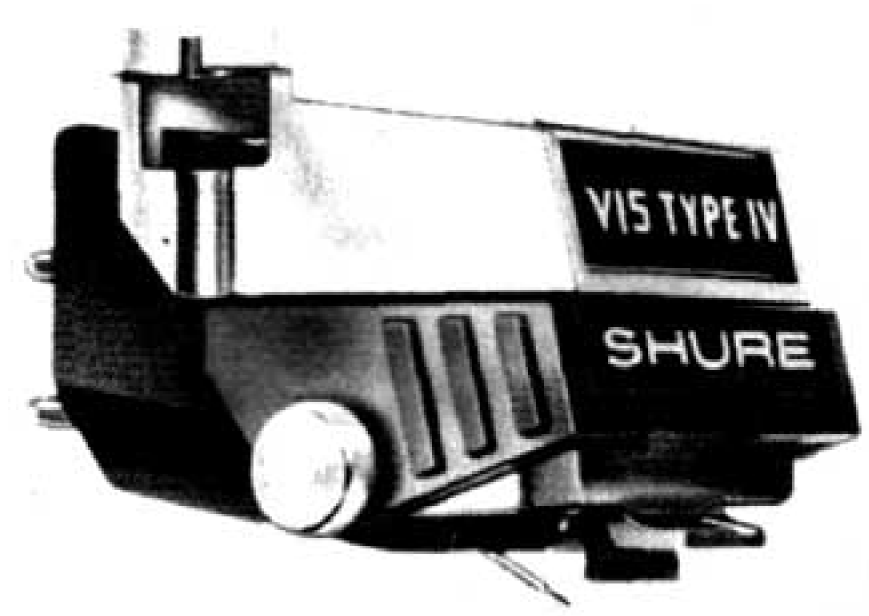
Manufacturer's Specifications

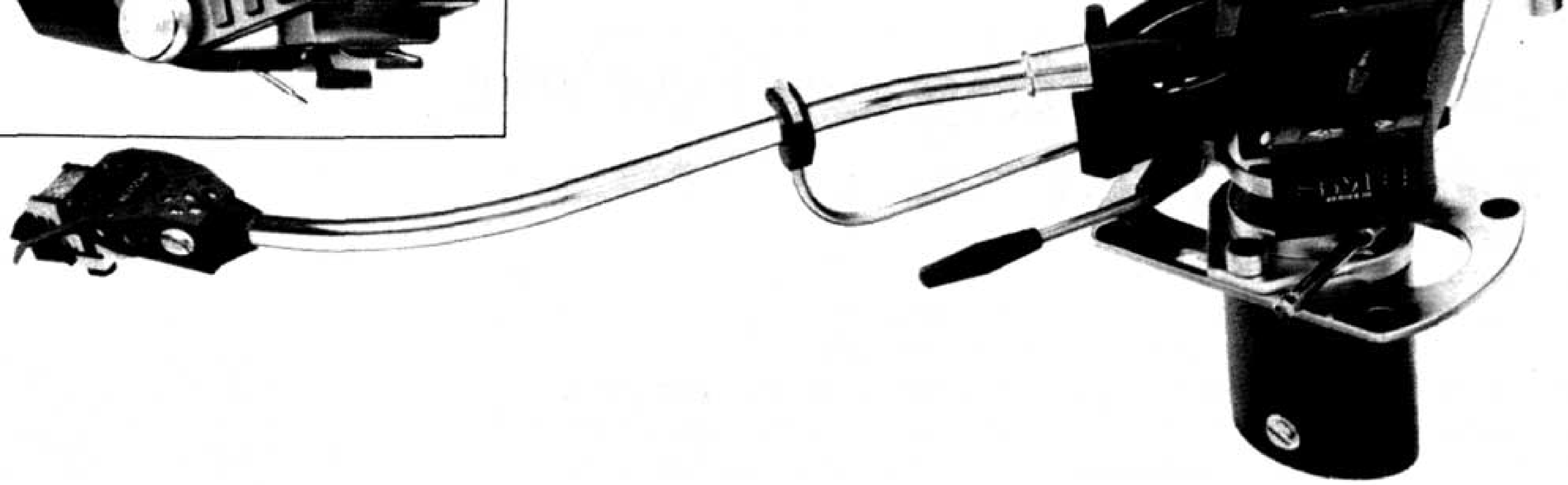
V15 Type IV Phono Cartridge

Generating System: Moving magnet.
Output Voltage: 4 mV (1 kHz, 5 cm/S, horizontal).
Channel Separation: 25 dB at 1 kHz.
Recommended Load Resistance: 47 kilohms.
Recommended Load Capacitance: 250 pF.
Recommended Tracking Force: ¾ to 1 ¼ grams.
Playback Frequency Response: 10 Hz to 25 kHz.
Weight: 6.4 grams.
Price: $191.00; replacement stylus, $66.00.

3009 III Tonearm

Type: Static balance with multiple counterweights.
Effective Length: 22.86 cm
Overhang: Adjustable.
Height Adjustment Range: 2.22 cm
Acceptable Cartridge Weight: 0.1 to 13 grams.
Tracking Force Range: 0 to 2½ grams.
Maximum Tracking Error: 1½ degrees/inch.
Price: $294.00.





SME are the initials of Scale Model Engineering, a British company which has dedicated its efforts to producing what it says is "the best pick-up arm in the world." The 3009 III is their latest effort. SME has been making precision tonearms, to the exclusion of any other audio products, for more than 20 years. Their desire for perfection can be seen in the firm's listening room which was designed and built under the guidance of SME's Managing Director, Alastair Robertson-Aikman. This room, which is shown in Figs. 1 and 2, is 36 feet by 21 feet, 6 inches and has a 10-foot high ceiling. The walls are of brick, while the roof is a single span of reinforced concrete, weighing about 30 tons! Over two tons of wool are used in the rugs and drapes. The music system is very elaborate and includes the usual two front channels plus two rear channels which are fed by a 55-millisecond delay. The loudspeakers include two 18-inch servo-controlled woofers and electrostatic elements for mid-ranges and tweeters. Two turntables are mounted on sand-filled platforms, and their platters are filled with clay to damp out any internal resonances. Other details of the system similarly indicate that SME tonearm designs are auditioned with great care during their development.

The rationale behind the development of the SME 3009 III tonearm is described succinctly by SME in their brochure and other informational sheets. One goal was to achieve a low effective mass at the stylus tip. Since effective mass is different than tracking force, a tonearm/cartridge combination can be set for zero tracking force and still have a high effective mass. At equilibrium, the effective mass means nothing, but as soon as the stylus of the phono cartridge sees any change, as it surely does when it is tracing a record groove, then effective mass becomes important. In the case of record surface variations, due to warp or even high modulation levels, a high effective mass can cause changes in the tracking force and even the vertical tracking angle of the stylus. The SME 3009 III has achieved a very low effective mass, and so problems of this kind should be reduced considerably.

The "S" shaped, nitrogen-hardened titanium carrying arm has a wall thickness about the same as two human hairs. The

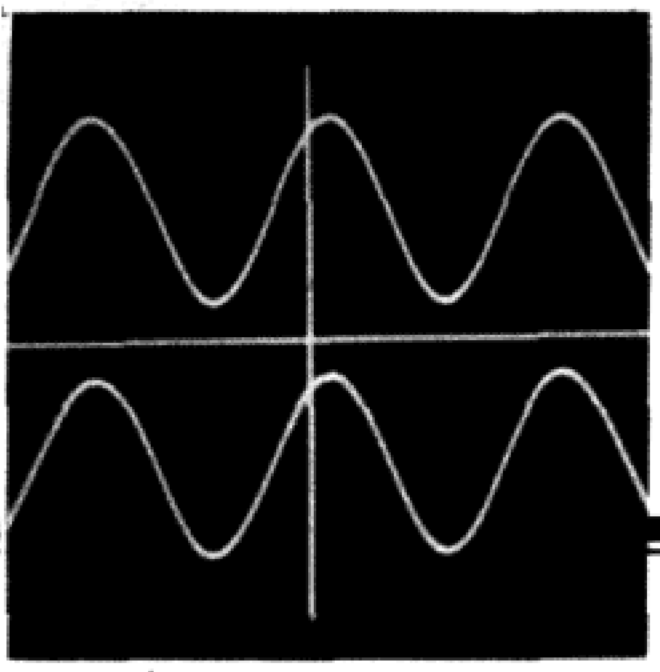


Fig. 3A — Response of Shure V15 Type IV cartridge to 300-Hz signal in band 9 of CBS STR-112, +18 dB re: 11.2 μM; 0.9 g vertical tracking force and 0.7 g sidethrust force. Upper trace represents left channel and lower trace the right channel (as in all photos).

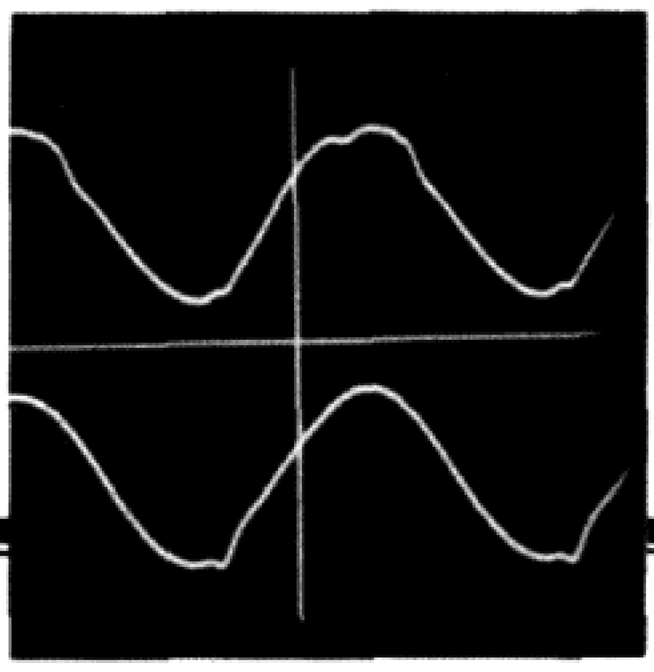
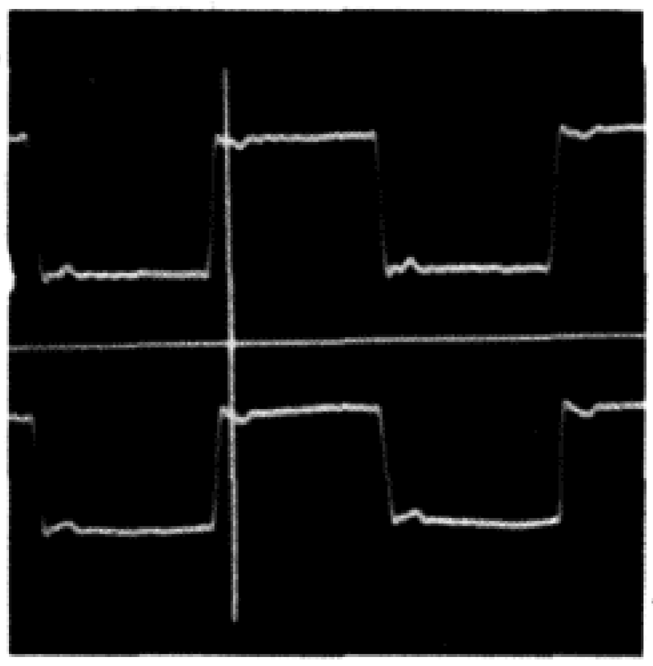


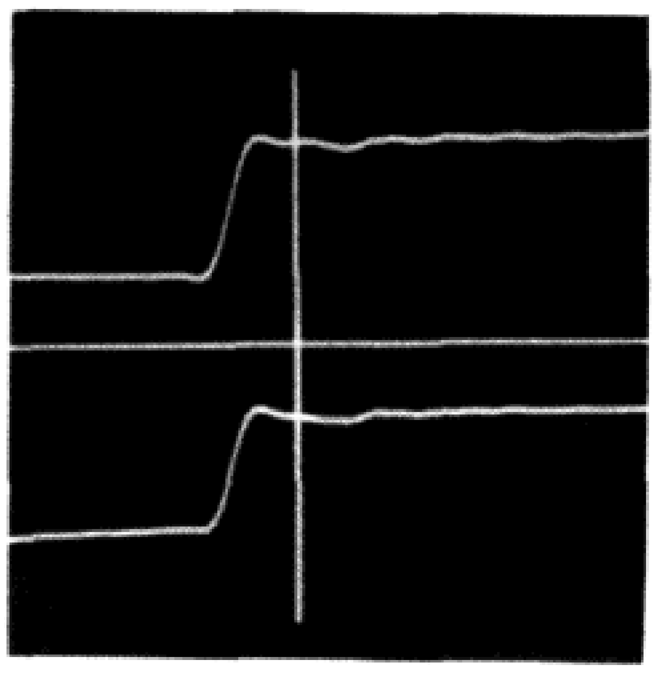
Fig. 3B — Response to a 1-kHz signal in band 3 of B&K 2010, +8 dB (17.76 cm/S at 45 degrees); 1.1 g vertical tracking force and 1.2 g sidethrust force.

low-mass carbon-fiber headshell is fixed securely to the carrying arm. Instead of changing headshells, as with most other designs, the arm tube itself, which SME calls the carrying arm, is slipped in and out of a socket close to the main pivot. The mass of the connector plug and socket, which carry the signal from the cartridge to the arm leads, is kept close to the main pivot which reduces its contribution to the effective mass considerably. Since the effective mass is a function of the square of the distance from the fulcrum or pivot, a mass of 81 grams one inch from the pivot will increase the effective mass, as seen by the phono stylus, by only one gram. Conversely, small increases in mass at the position of the cartridge will increase the effective mass dramatically. For this reason, SME has kept the more massive parts of the 3009 III tonearm as close to the pivot as possible. This has resulted in an effective mass, for the tonearm alone, of about 5 grams. When a cartridge weighing about 6.5 grams is mounted in the tonearm, nearly all of its mass is seen by the stylus, so the effective mass would be about 11.5 grams. This is still an extremely low total effective mass.

Another contribution to maintaining a low effective mass is the use of multiple counterweights, made of lead, which can be loaded into a molded plastic container close to the main pivots. The manual shows the proper combination of weights needed to balance cartridges of different weights. This scheme allows the tracking force to be adjusted from 0 to 1.5 grams, while keeping the mass close to the pivots.

When the stylus is modulated by the signal in the record groove, some of the energy is transmitted through the body of the cartridge into the tonearm. If not sufficiently attenuated, this delayed reflected energy can remodulate the stylus and, in turn, be seen in the output. Such delayed energy can sometimes





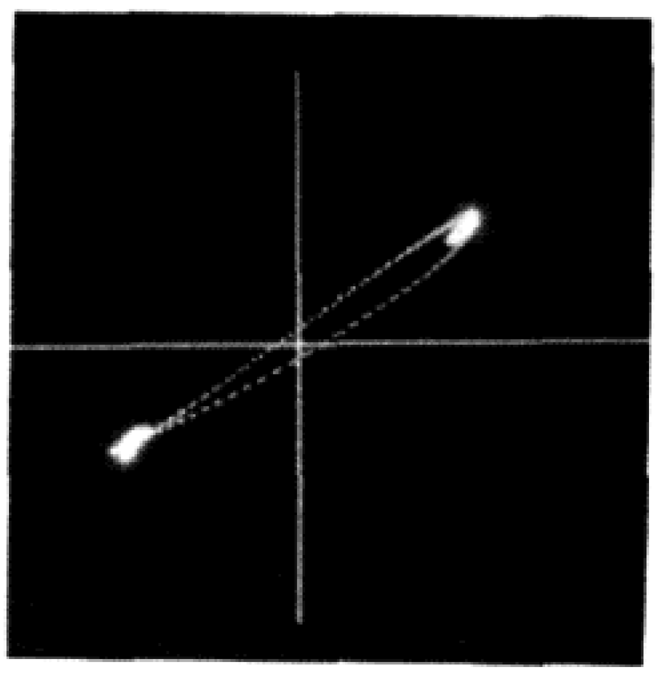


Fig. 4A—Response to a 1-kHz square wave in band 1 of CBS STR-112; 3.54 cm/S modulation in each channel. Combination of SME 3009 III tonearm and Shure V15 Type IV with loadings of R = 27 kilohms and C = 500 pF.

Fig. 4B—Expanded view of Fig. 4A. Note the excellent damping.

Fig. 4C—Same as Fig. 4A except left vs. right channel showing interchannel phase relationship.

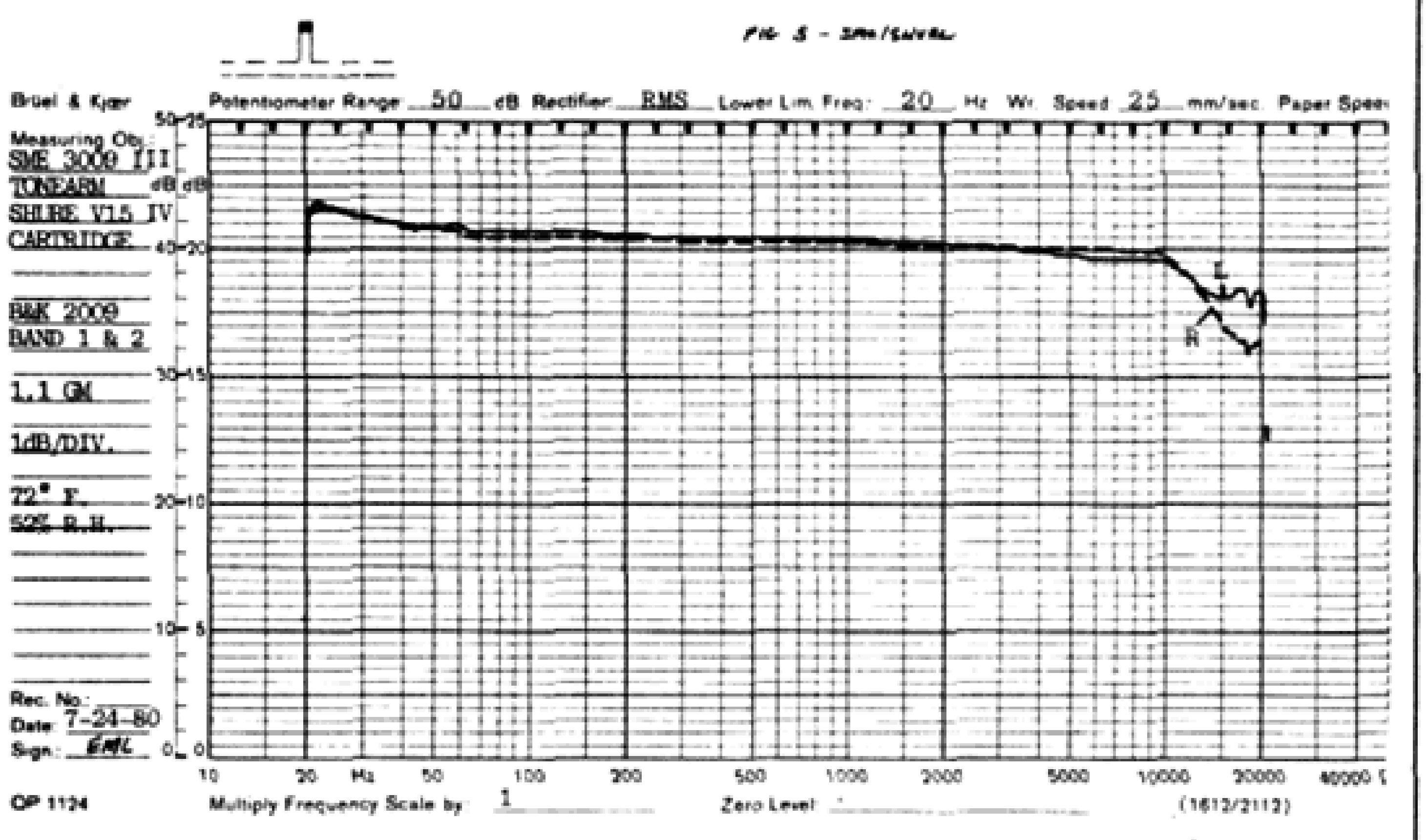
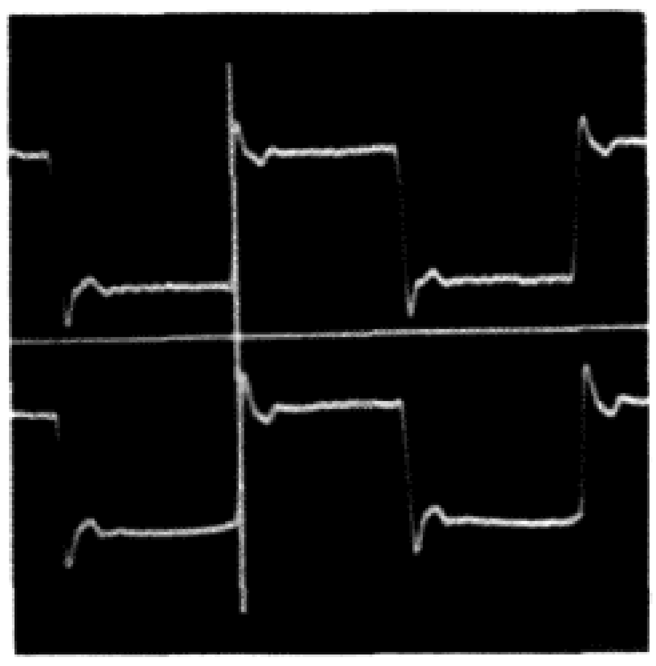
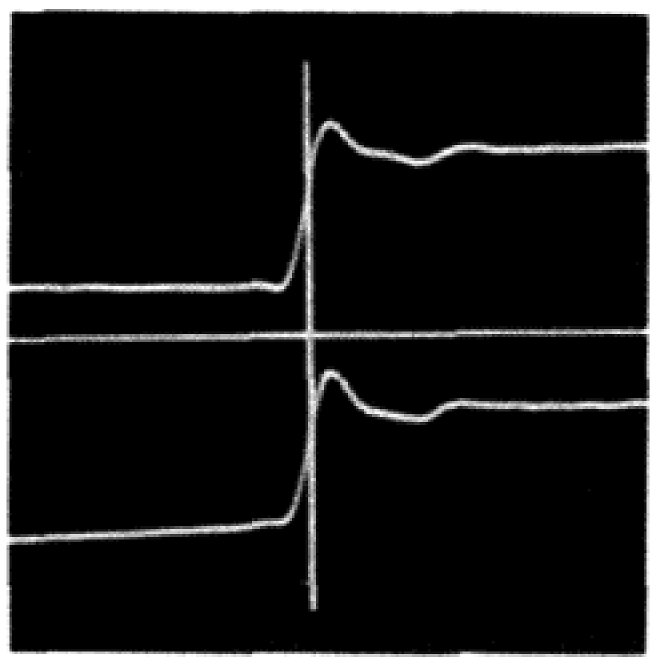


Fig. 5—Amplitude vs. frequency response with input loading as shown in Fig. 4.





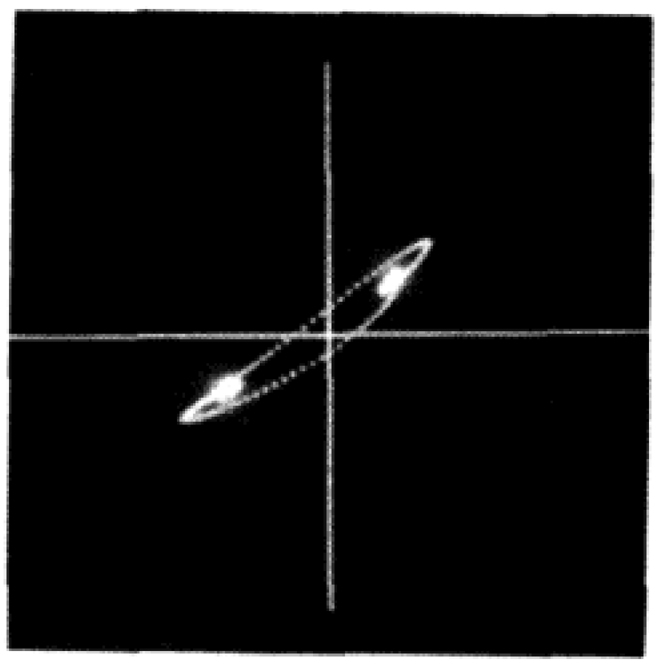


Fig. 6A — Same as Fig. 4A except input loading set to R = 47 kilohms and C = 250 pF.

Fig. 6B—Expanded view of Fig. 6A.

Fig. 6C—Same as Fig. 6A except left vs. right channel showing interchannel phase relationship.

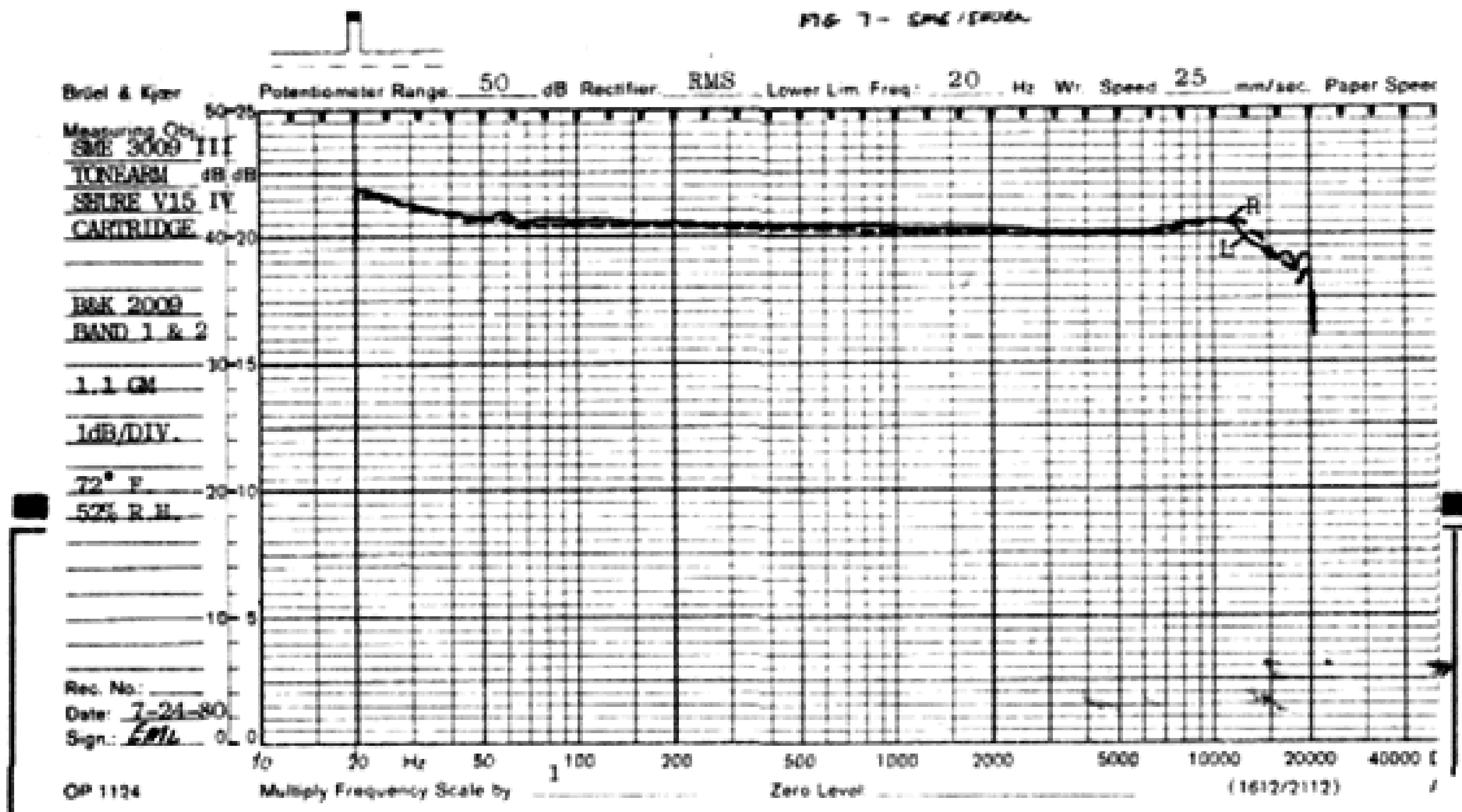
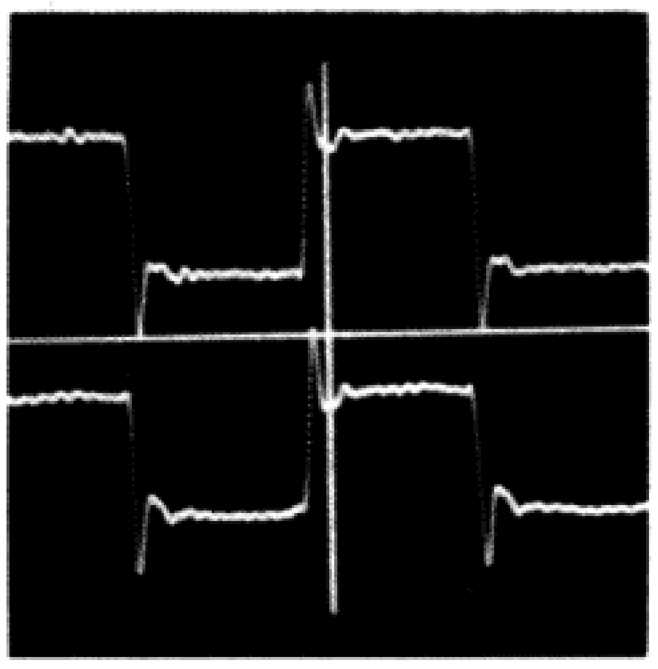
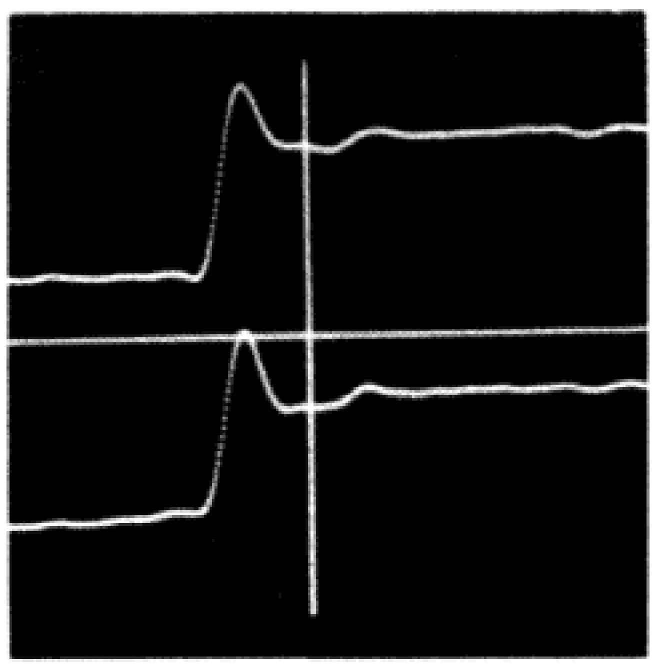


Fig. 7—Amplitude vs. frequency response with input loading as in Fig. 6.

"enhance" the sound by adding "warmth" and "body" in the middle register. It can also add "brightness" and "smear" in the top register. SME has chosen to attenuate these effects and by so doing eliminate such "enhancement."





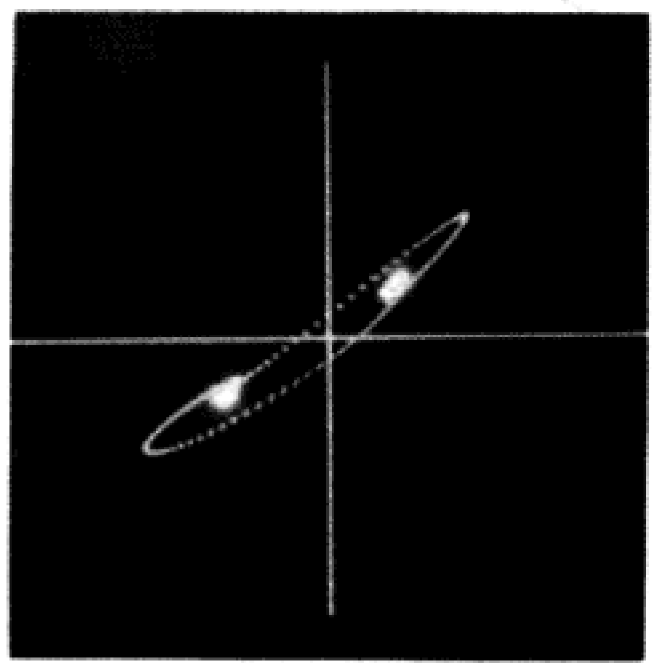


Fig. 8A—Same as Fig. 4A except input loading is R = 100 kilohms and C = 250 pF.

Fig. 8B — Expanded view of Fig. 8A.

Fig. 8C — Same as Fig. 8A except left vs. right channel showing interchannel phase relationship.

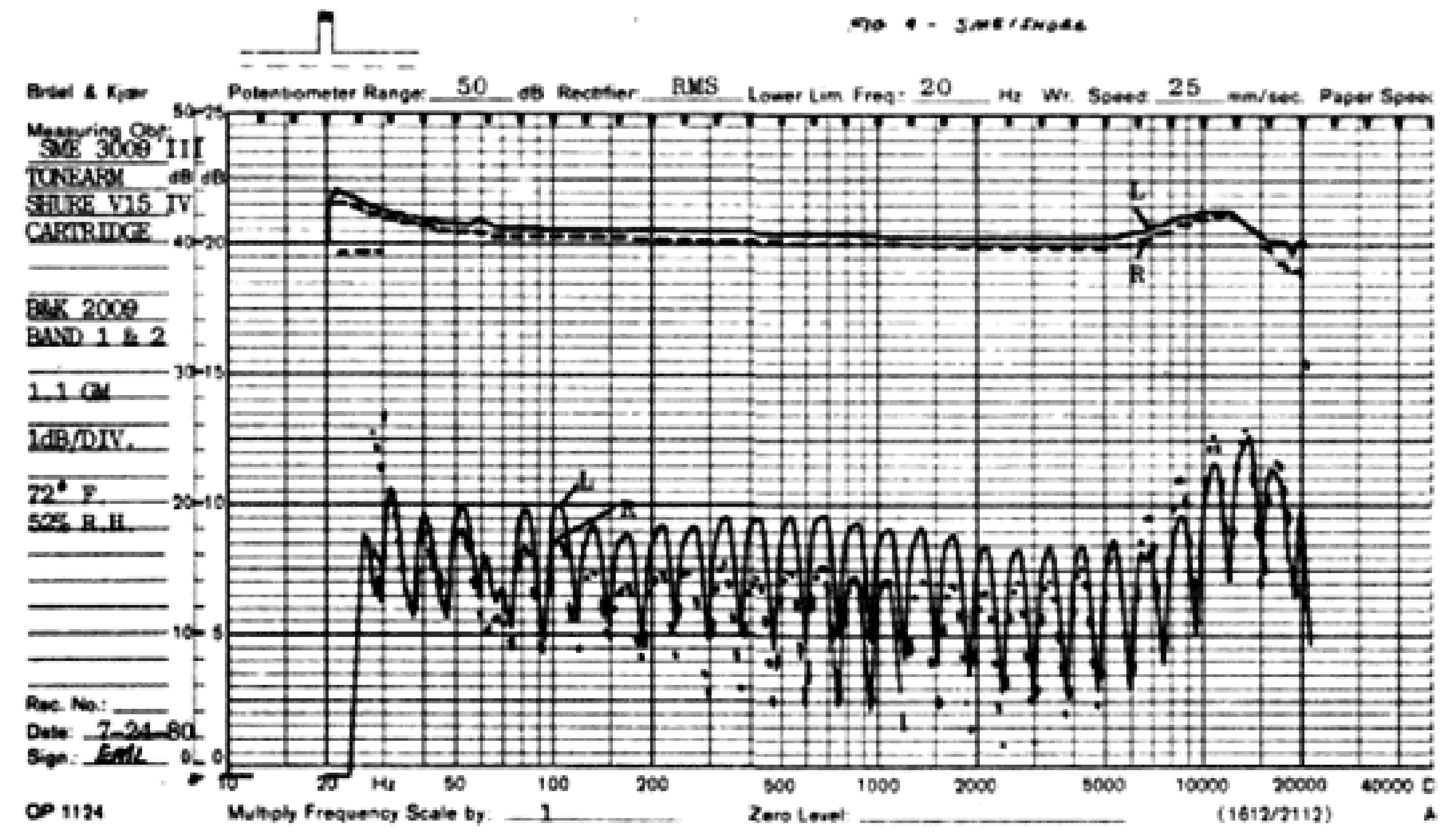


Fig. 9 — Amplitude vs. frequency response with input loading as in Fig. 8. This R-C combination was used during the listening panel evaluations. Interchannel crosstalk is also shown.

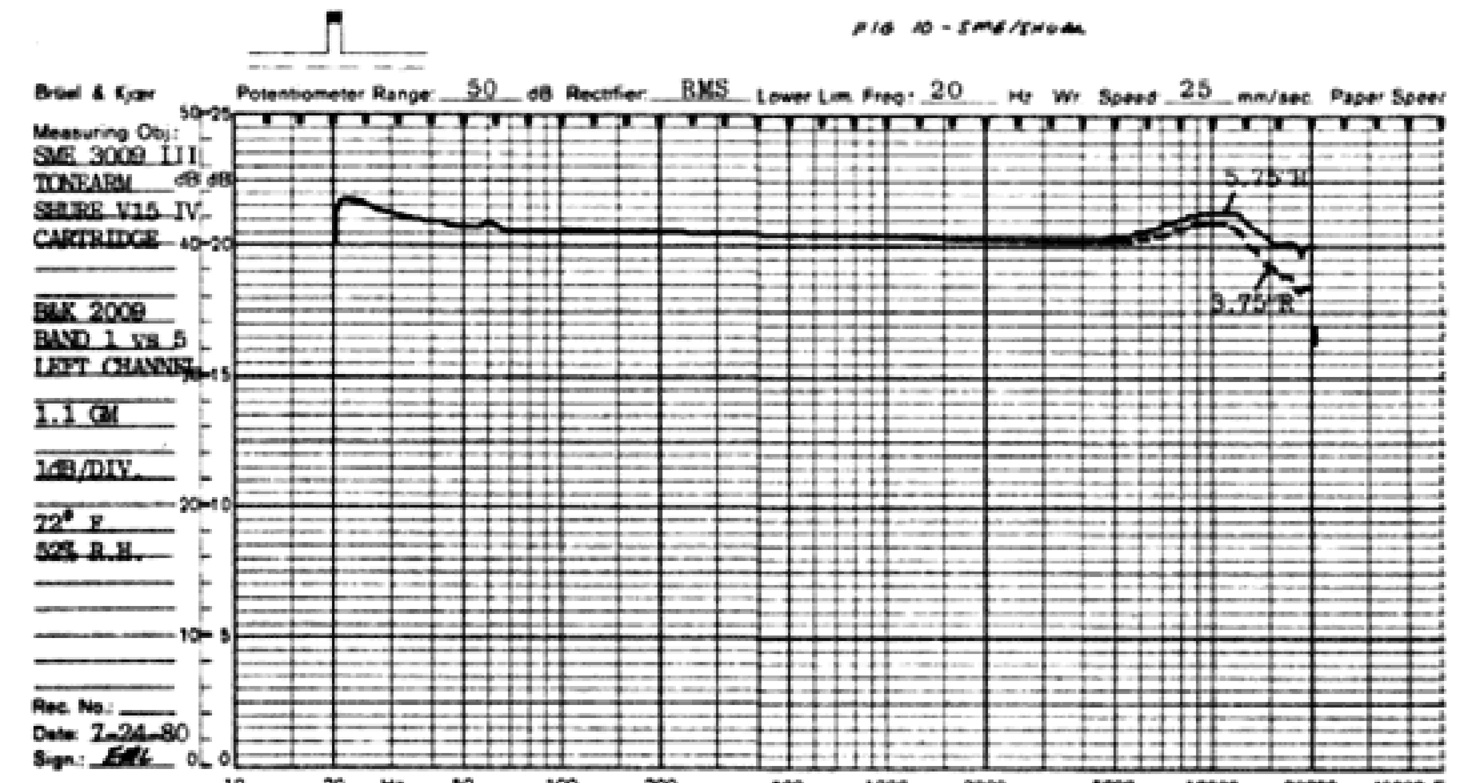


Fig. 10 — Scanning loss vs. record diameter (5.75-inch and 3.75-inch radius); R = 100 kilohms and C = 250 pF.

The vertical pivots, which allow the lateral tonearm movement, are twin stainless-steel ball races, while the horizontal pivots, which allow the vertical movement, are knife-edge bearings. There is a small amount of play in the knife-edge bearings, unavoidable in this type of design, but the large amount of force, which is between 500 to 600 lbs. per square inch, keeps them from causing any problems. The axes of both bearings are located in line with the plane of the stylus when it is playing a record, which means that the ill effects of record warp are greatly reduced. The bearing friction is claimed to be about 20 milligrams. Measuring such tiny forces is extremely difficult, and anything less than 50 milligrams, which is what we measured, is considered excellent.

The location of the pivots, with respect to the turntable platter, is adjustable by a rack and pinion system which moves the main arm post along a track. The total adjustment is one inch, more than sufficient to allow the exact positioning of the stylus of any phono cartridge for minimum distortion due to tracking angle error. The arm height may also be moved up and down by releasing a locking screw. Besides these two arm-positioning adjustments, there are seven other adjustments, including four that are made by simply turning a knob. These include the vertical balance, the lateral balance, the vertical tracking force, and the lateral sidethrust force, all knob adjustable, and the 1.5- to 2.5-gram additional weight, the viscous damping system with its three different paddles, and the patented counterweight system with its six lead weights.

The four-foot phono cable supplied with the SME 3009 III tonearm has gold-plated phono plugs at each end. These cables include internal 220-pF capacitors, which may be removed easily since the phono plugs have threaded covers. There are two gold-plated phono sockets at the bottom of the arm pillar.

The SME 3009 III tonearm is distributed in the U.S.A. by Shure Brothers, an American company with a worldwide reputation for manufacturing phono cartridges and microphones which are the result of dedicated research and engineering. It therefore seemed natural to perform the technical measurements and listening panel evaluations using the top-of-the-line Shure V15 Type IV phono cartridge mounted in the SME 3009 III tonearm.

The Shure V15 Type IV cartridge, reported on previously in

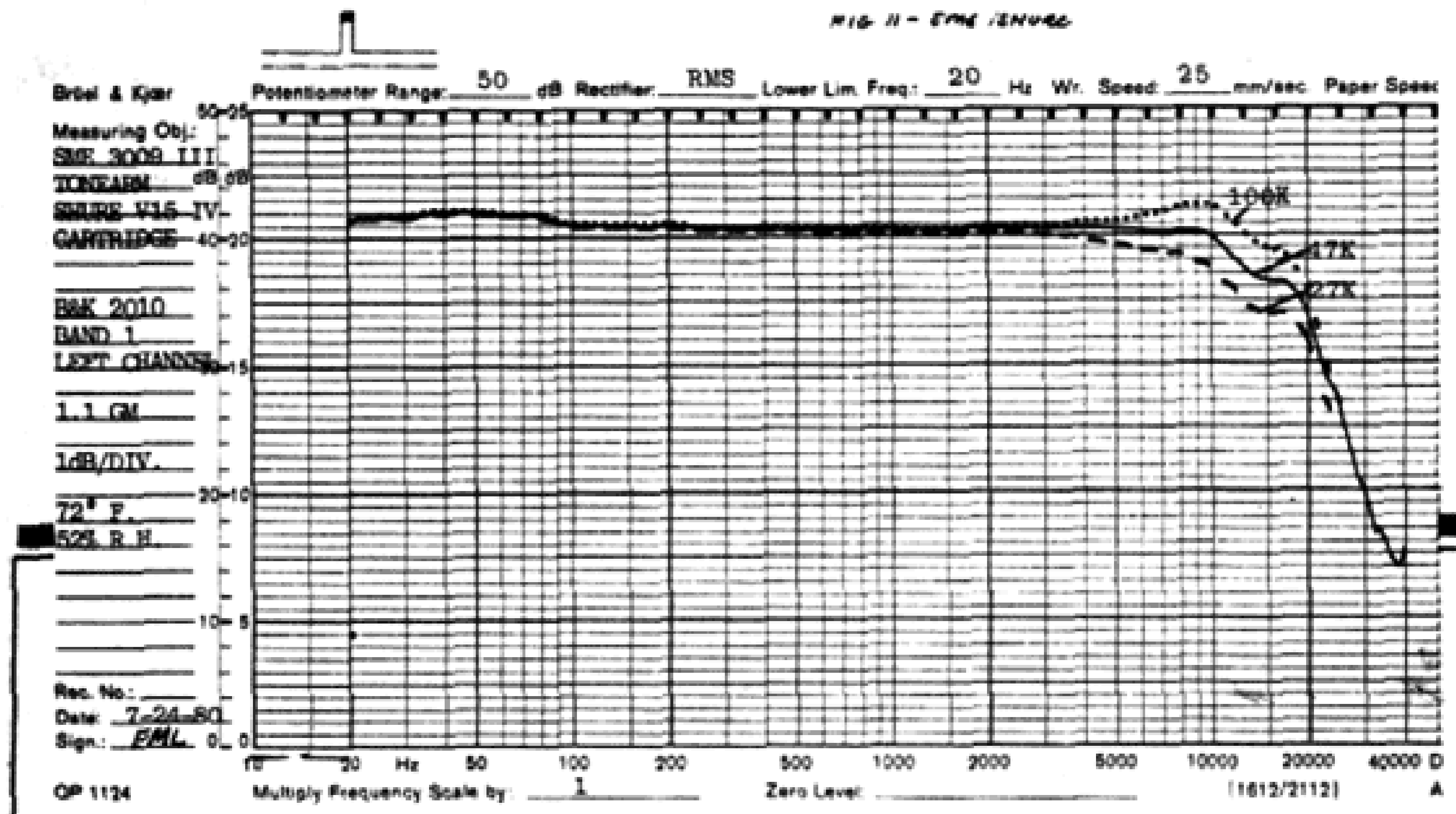


Fig. 11 — Effect of various resistive loadings on output; R = 100, 47 and 27 kilohms and C = 250 pF. Note roll-off above 20 kHz.

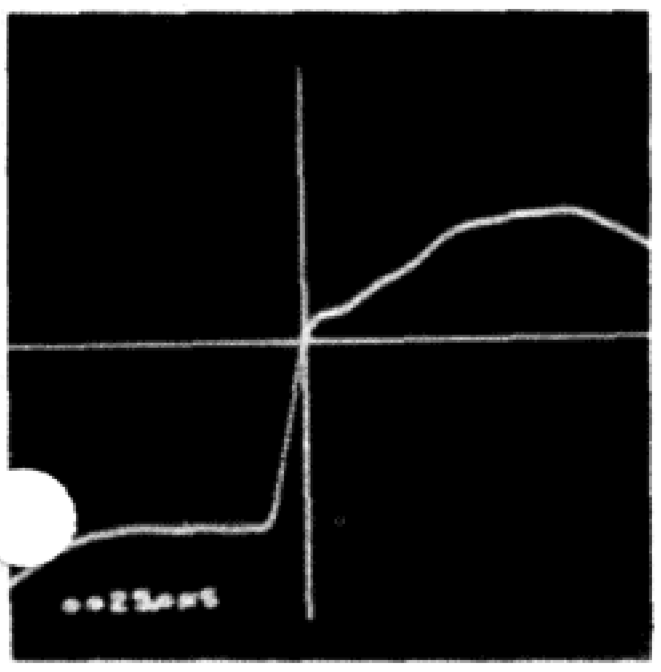


Fig. 12A — Rise time is 25 µS with load of R = 100 kilohms and C = 250 pF.

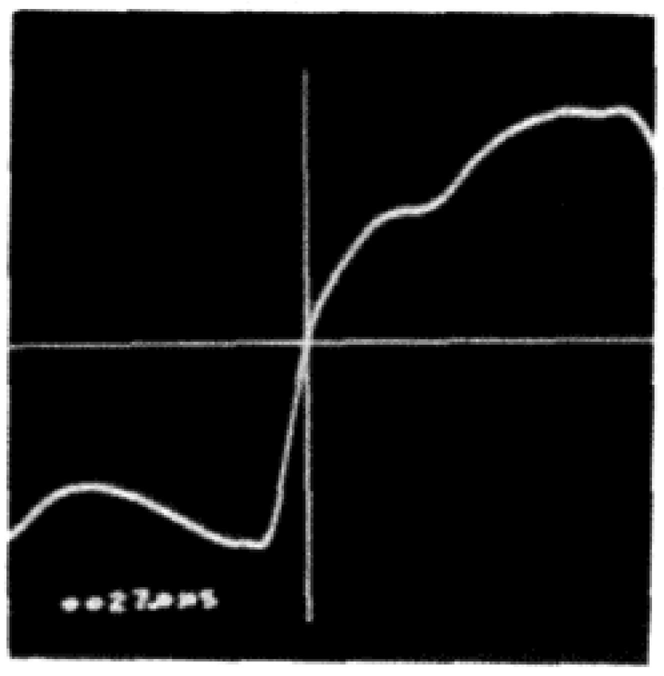
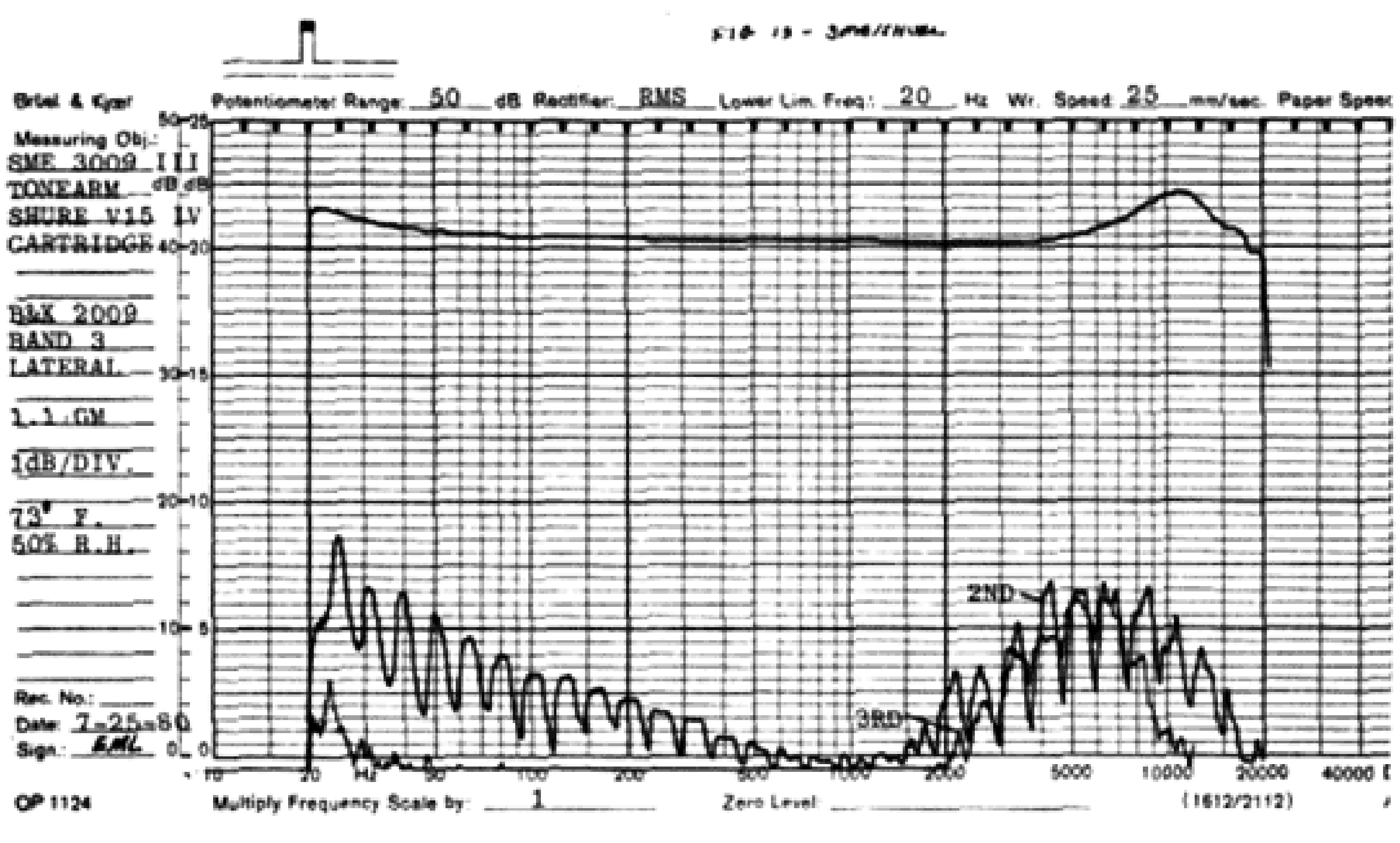


Fig. 12B — Rise time is 27 µS with load of R = 27 kilohms and C = 500 pF.



. 13 — Response and harmonic distortion (2nd and 3rd), lateral modulation; R = 100 kilohms and C = 250 pF.

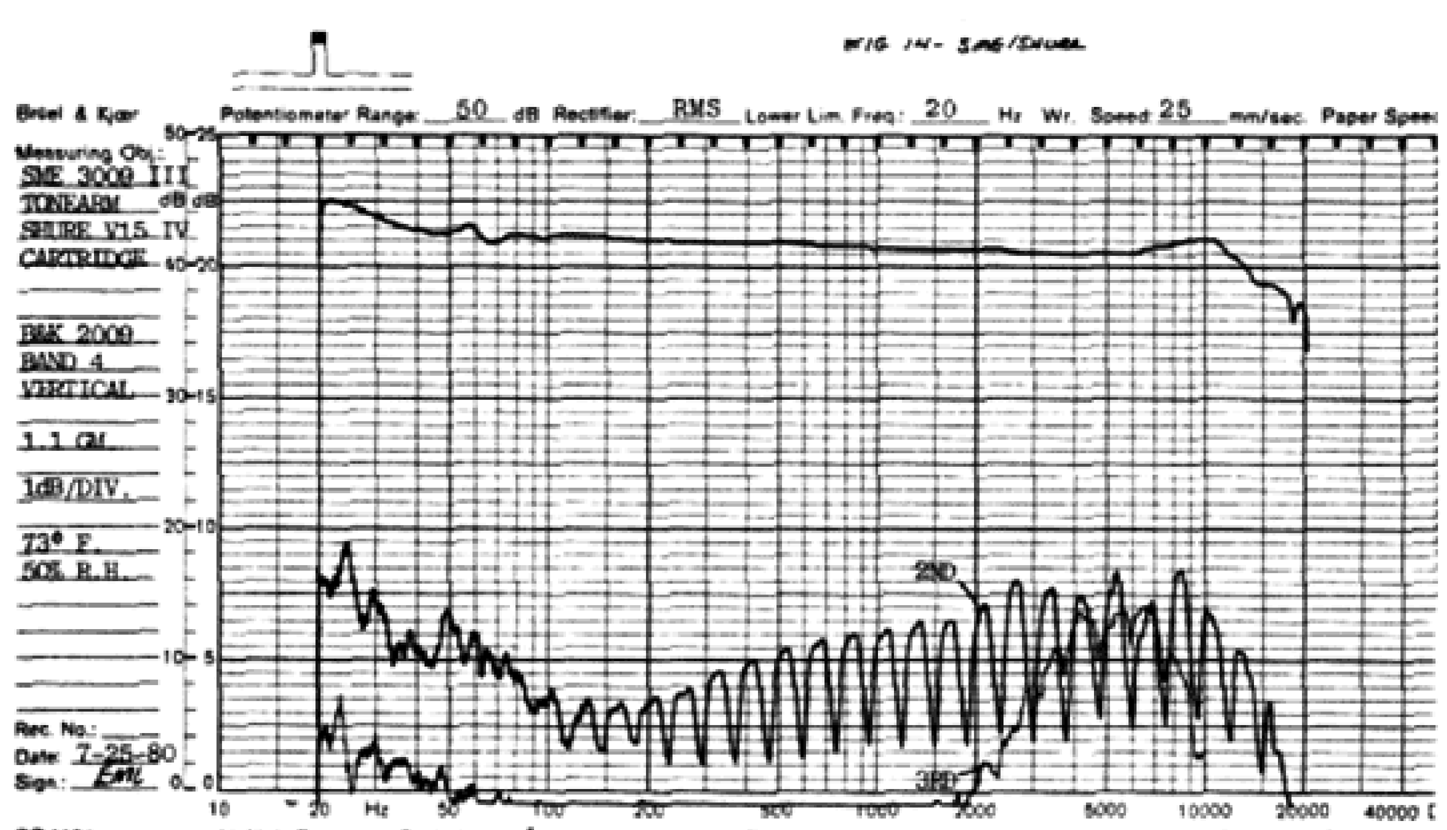


Fig. 14 — Same as Fig. 13 except vertical modulation. Note the increase in 2nd harmonic distortion in the middle register.

the February 1979 issue of *Audio* by B.V. Pisha, incorporates some technical features about which the Shure engineering team has written a number of interesting papers. The dynamic stabilizer system is one such feature. After the initial set-up procedures were completed, the dynamic stabilizer was used throughout the technical measurements and listening tests. Consisting of a tiny, viscous damped brush composed of electrically conductive fibers, this multipurpose device removes dust particles from the grooves of the record, neutralizes the electrostatic attraction between the record and the cartridge, and reduces the amplitude and the Q of the low-frequency resonance due to the compliance of the stylus assembly and the effective mass of the tonearm/cartridge. The dynamic stabilizer is very effective in reducing mistracking due to record warps, since it acts in much the same way as an advance ball system of a disc cutter head by reducing variations in vertical force caused by lack of uniformity in the disc surface.

As in the past, subjective evaluations regarding the performance were made by a listening panel. The panel auditioned two systems for comparison purposes: The reference cartridge/tonearm/turntable system and the SME/Shure combination mounted upon the Pioneer PLC-590 turntable we have used in the past. The two systems were designated "A" and "B" during each selection played. Between the selections, the designations were changed randomly, and the panel was told that this would be done. No comments or discussions were allowed during the playing of each selection; comments about the relative qualities were made and discussed after each selection was finished. Some selections were evaluated using a rapid "A" vs. "B" comparison by synchronizing the two turntables and playing copies of the same record, with a 4- to 6-second delay. The order of the delayed turntable arrangement was also varied during the tests. In other tests, the same record was used on each turntable, and selections ranging from about 1 to 5 minutes in duration were auditioned.

After carefully mounting and adjusting a tonearm, we usually proceed to a brief listening test, without the listening panel present, before making initial measurements to determine the optimum resistance and capacitance loading and tracking force. During this preliminary listening test, the manufacturer's recommendations are followed to set the values of electrical loading and tracking force. The first order of business was then to check the force required by the SME/Shure combination to track the high-level bands of CBS STR-112 and B&K 2010 test records.

Figure 3A shows the left (upper trace) and right (lower trace) channel outputs to the 300-Hz tone on band 5 of CBS test record STR-112. For all photos in this report, as in past reports, the left channel is the upper trace unless otherwise noted. Band 5 is the highest level band of STR-112 and represents +18 dB referenced to a modulation level of 11.2 µM. As can be seen, the SME/Shure combination tracks this band beautifully at 1.1 grams with no sign of distress, which is amazing. In tests of other tonearm/cartridge combinations, we have shown both band 4 (+15 dB) and band 5 (+18 dB) of the STR-112, with the band 5 output usually showing the results of mistracking. Not so with the SME/Shure combination. Instead, Fig. 3B shows the output of band 3 of the B&K 2010 test record, containing a 1-kHz tone cut at +8 dB relative to a 0-dB level of 7.07 cm/S at 45 degrees which is 17.76 cm/S. No jittering was observed while tracking these high-level bands, which is

The SME/Shure combination tracked band 5 of the STR-112 test record beautifully at 1.1 g with no sign of distress, which is amazing.

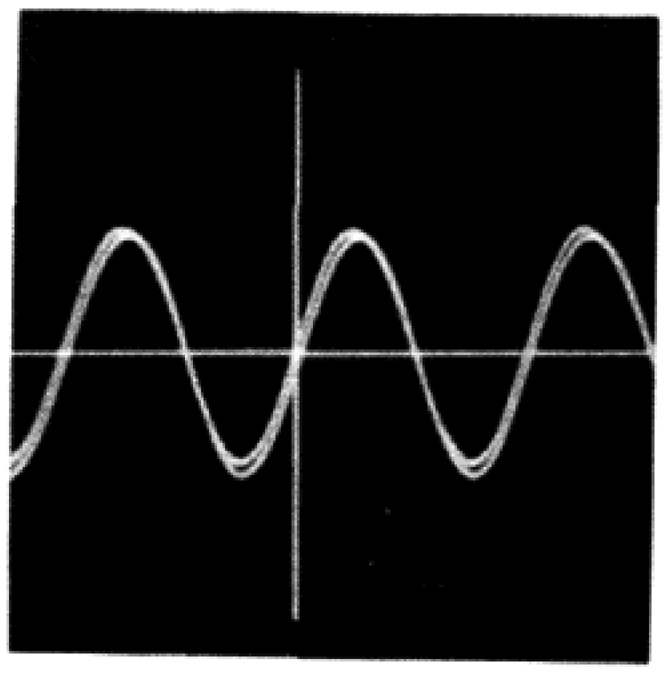


Fig. 15A — 3-kHz left and right channels. Note the slight time offset.

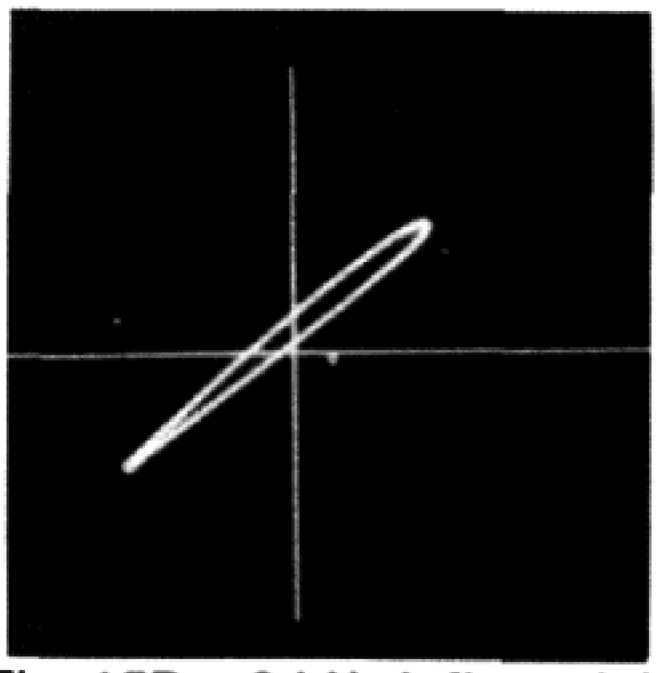


Fig. 15B—3-kHz left vs. right channels. The small amount of "bowing" indicates some nonlinear distortion.

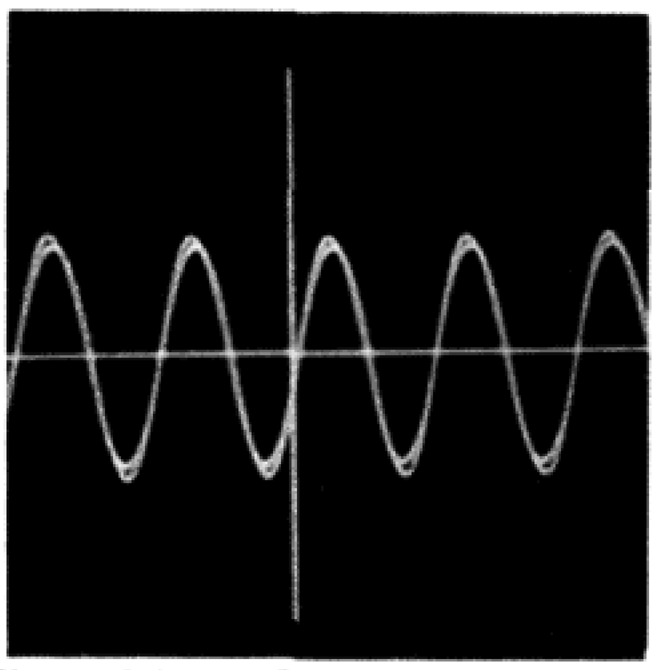


Fig. 16A — Same as Fig. 15A except 5 kHz.

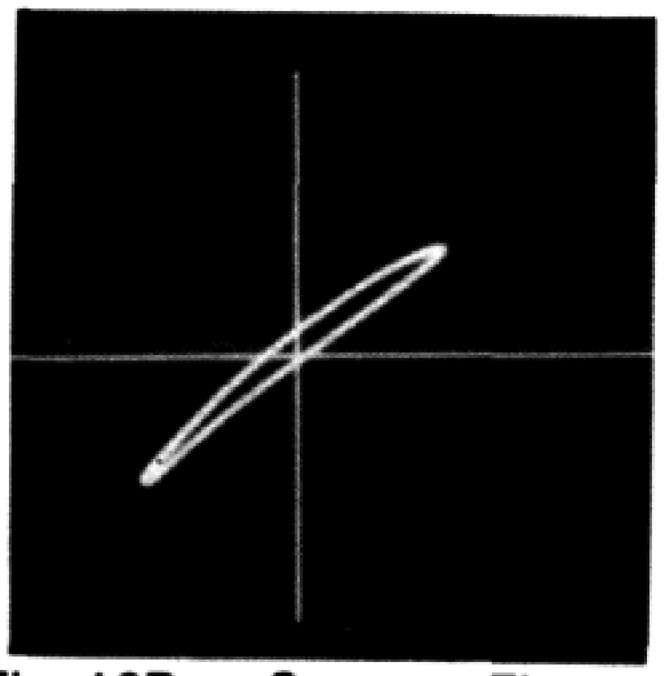


Fig. 16B — Same as Fig. 15B except 5 kHz.

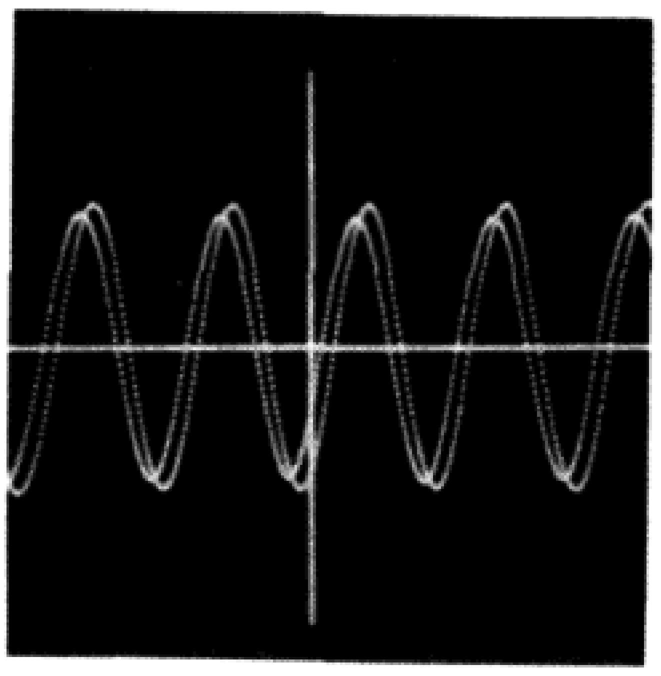


Fig. 17A — Same as Fig. 15A except 10 kHz.

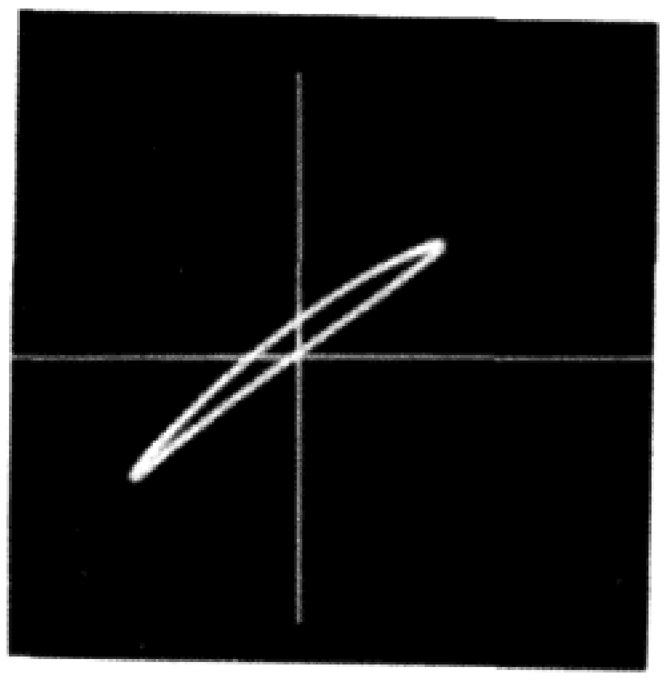


Fig. 17B — Same as Fig. 15B except 10 kHz.

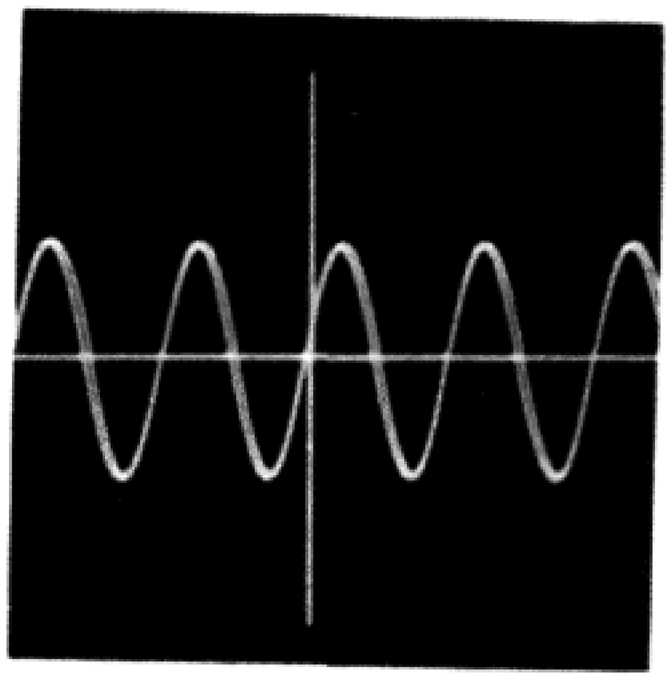


Fig. 18A — Same as Fig. 15A except 20 kHz.

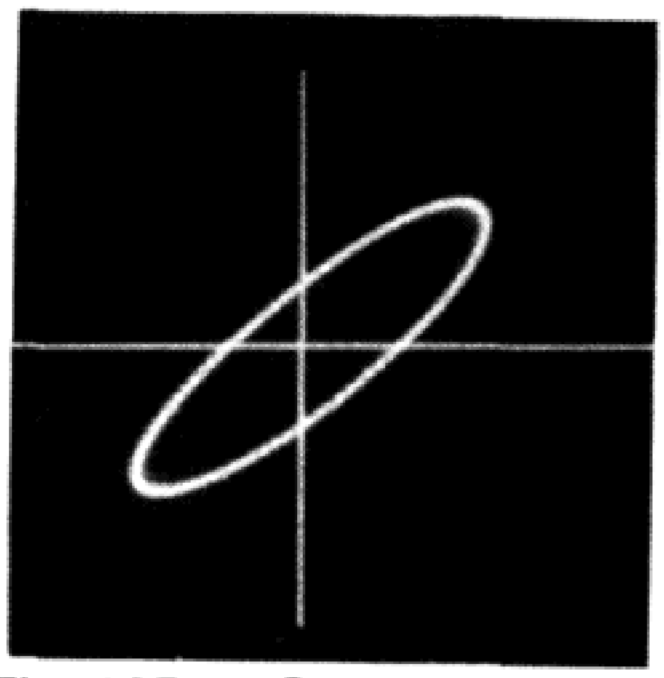


Fig. 18B — Same as Fig. 15B except 20 kHz.

quite remarkable when compared to other tonearm/cartridge combinations. We did find, however, that the sidethrust compensation force had to be set at 1.2 for a tracking force of 1.1 grams. At lower tracking forces, the sidethrust had to be set at a lower value than indicated for the tracking force employed. During the listening evaluations, panel members made no comments which could be attributed to mistracking. It would appear that the quest for "trackability" by Shure and the quest for low dynamic mass by SME have succeeded in this respect.

After finishing the series of measurements which detail the tracking capabilities of the SME/Shure combination, the rest of the measurements were made at 1.1 grams vertical tracking force and a setting of 1.2 for the lateral sidethrust compensation. The calibration for the sidethrust compensation is meant only as a guide to allow it to be set at a value predetermined SME, which corresponds with the vertical tracking force chosen. The actual lateral sidethrust force is much less than the vertical tracking force. It was also determined that there was no high-frequency scanning error introduced when the tracking force was varied form 0.8 to 1.3 grams when using the B&K 2010 record, so the usual graph which would show scanning error due to changes in tracking force is not shown in this report.

A certain lack of brightness had been perceived during the preliminary listening test and it was thought that a change in the resistive (R) and capacitive (C) values of the electrical loading might bring an improvement in the sound of the upper register. As it turned out, the effects upon the output of the Shure V15 Type IV cartridge due to changes in the values of R and C were quite interesting. The results of three different combinations of R and C are shown in Figs. 4 through 9 and Fig. 11.

Figure 4A shows an almost perfect square wave, though the frequency response of Fig. 5, with the same loading, shows a relatively steep roll-off above 10 kHz. Figures 6 and 7 show the results with R = 47 kilohms and C = 250 pF, values found in many phono systems, while in Figs. 8 and 9, the R has been changed to 100 kilohms. This last R-C combination produced the best subjective reaction and was used during the listening panel evaluations. The interchannel crosstalk, also shown in 9, was adequate if not exceptional but did not correlate well with listening panel comments about a lack of perceived spaciousness when compared with the reference system.

Figure 10 shows the scanning loss of the SME/Shure combination when tracing band 1 (5.75-inch radius) and band 5 (3.75-inch radius) of the B&K 2009 test record. It should be pointed out that commercial discs are recorded with compensation for scanning loss by a diameter equalizer which attempts to correct for normal diameter-related scanning loss.

Over the years, various people have written, discussed and debated whether there exists a correlation between the perceived spaciousness of sound reproduction and the bandwidth of the total sound reproduction chain involved. Those who contend that wide bandwidth, extending beyond 20 kHz, improves the spatial quality would find it easy to correlate the listening panel comments about the lack of spaciousness in the sound of the SME/Shure combination with the data presented in Fig. 11. Even with the 100-kilohm loading, the response above 20 kHz is shown to fall steeply when the B&K 2010 record, which has response to 45 kHz, is used as a source. The roll-off is at a rate of about 30 dB/octave.

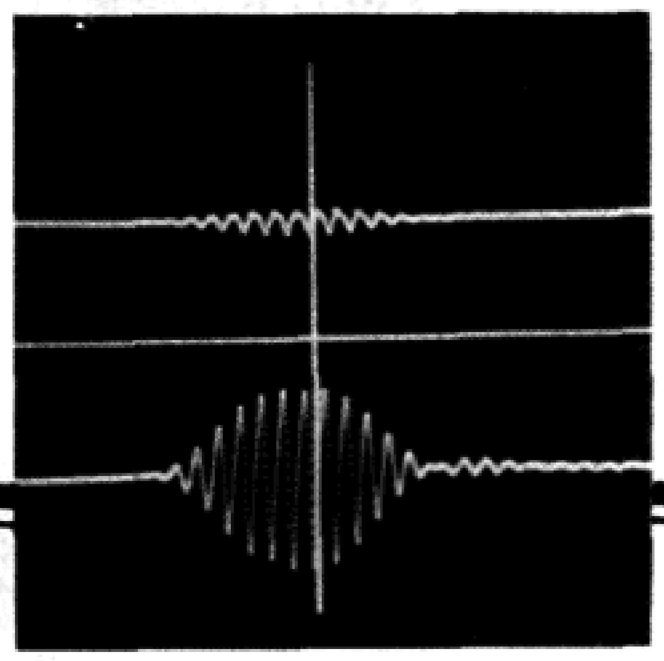


Fig. 19 — Response to 10.8-kHz tone burst from Shure TTR-103 test record, band 4, 30 cm/S peak at 45 degrees. The echo appears to be an artifact of the record.

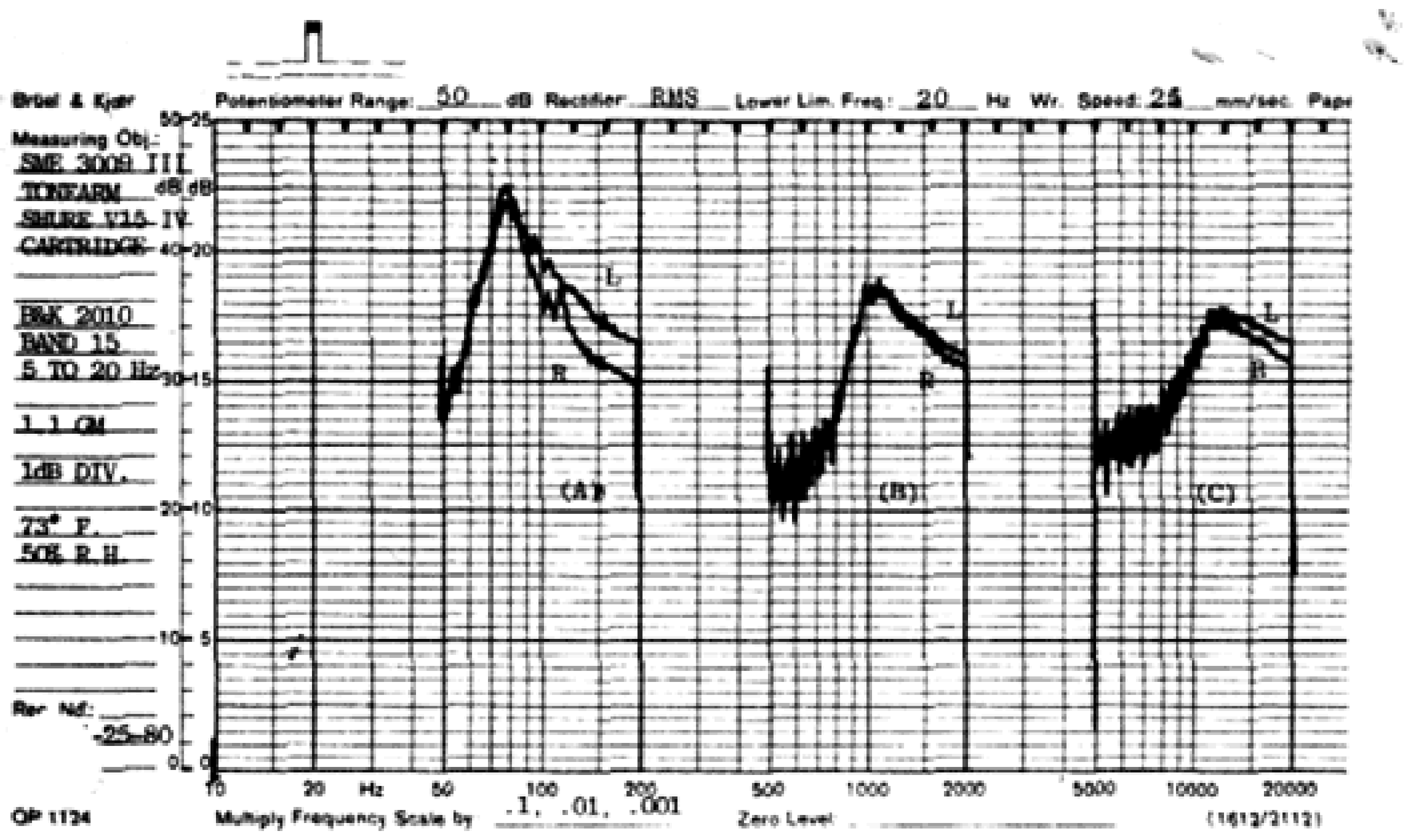


Fig. 20 — Low-frequency resonance. A, undamped resonance occurs at 7.8 Hz and has a Q of 6; in B, damped by the Shure V15 Type IV stabilizer, the resonance shifts to 11 Hz with a Q of 2.75, and in C, damped by both the Shure V15 Type IV stabilizer and the SME 3009 III small paddle damper, the resonance shifts to 12 Hz with a Q of 1.2.

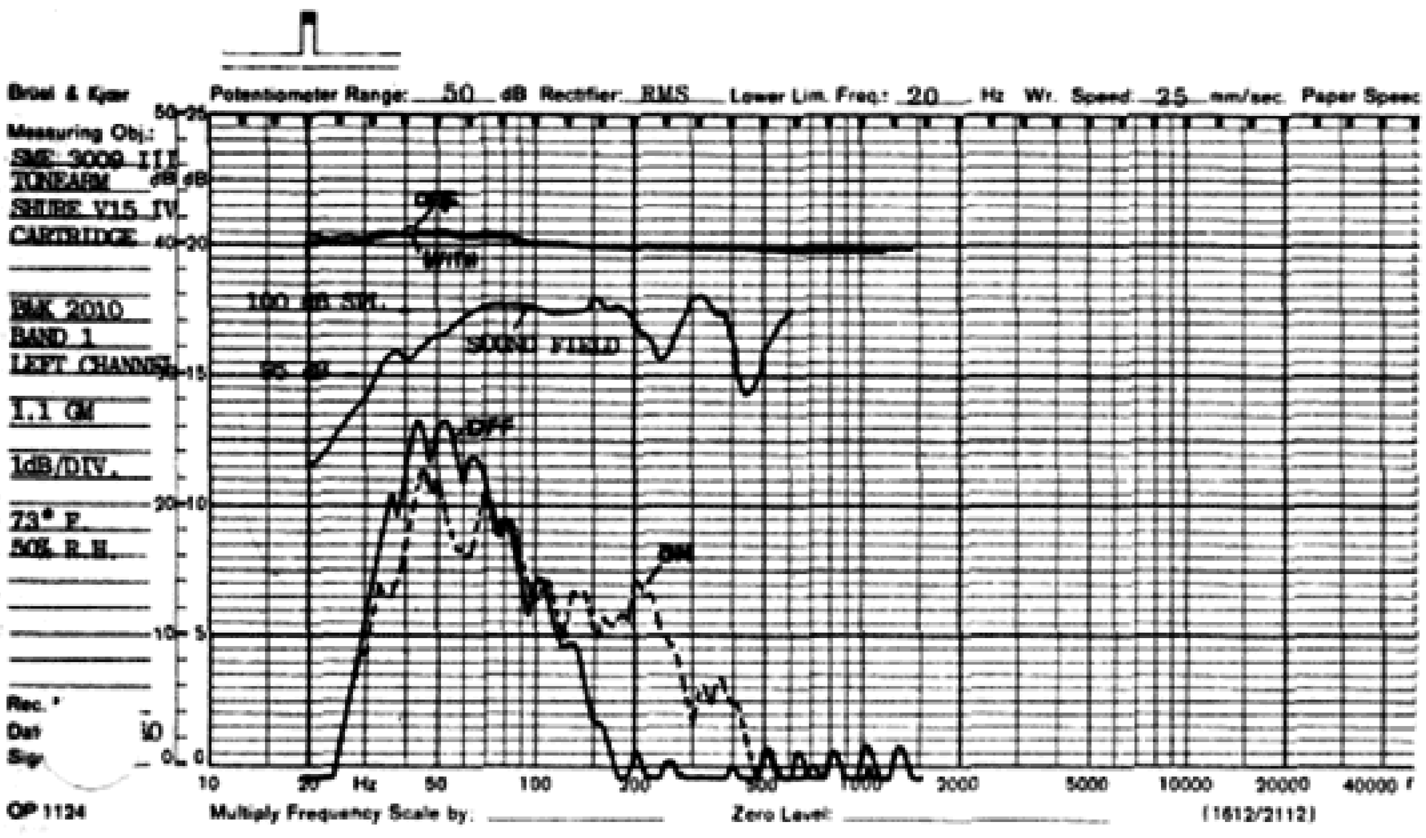


Fig. 21 — Effect of a sound field at the cartridge position. The curve of the sound field spectrum is shown for reference and was synchronized with frequency sweep from test record. SPL reference is for sound field only. Solid line is with sound field off; dashed line is with sound field on. Note the difference in crosstalk.

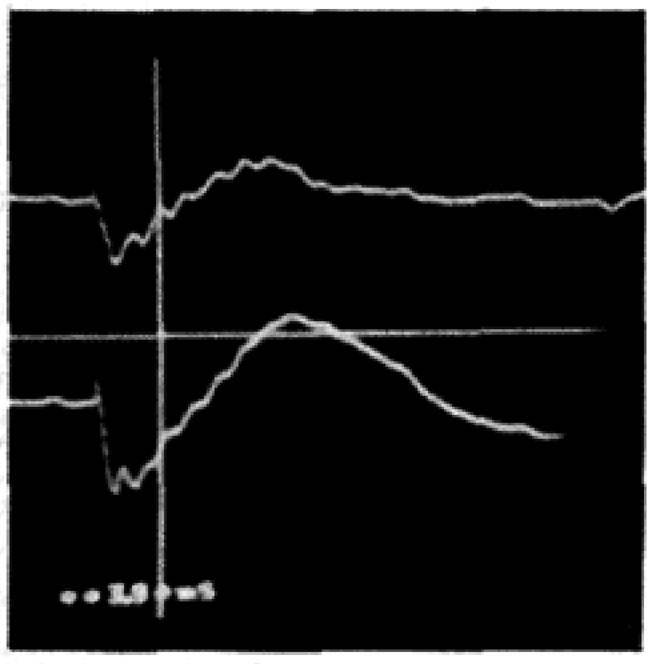


Fig. 22 — Polarity test, both channels. Output is negative going with modulation of groove toward center of record. Tonearm/cartridge resonance is 10.9 Hz. Note the second resonance, which is of lower amplitude and occurs at 256 Hz.

The rise-time information of Figs. 12A and 12B indicate that changing the R-C loading didn't greatly affect the results. The rise time of 25 µS is respectable for a magnetic cartridge with an inductance of 500 mH. Later tests showed the Shure V15 Type IV to be capable of 15-µS rise time into a high-impedance, low-capacitance load. Changes in capacitance had less effect than changes in resistance values of loading.

The inability to completely resolve some comments by the listening panel about the perceived dullness and lack of spaciousness, even with the 100-kilohm load, and some comments about apparent distortion which didn't seem to correlate well with the original distortion measurement data, caused us to rerun the tests for frequency response and distortion. Originally, the second and third harmonic distortion in each channel had appeared reasonably low. Figure 13 shows the distortion for the left channel when the lateral modulation of band 3 of the B&K 2009 record is used as the source. It looks about the same as the results of previously run tests using the 45-degree left- and right-channel bands, 1 and 2, of the same record. But then we used band 4 of this record which provided vertical modulation. Figure 14 shows an increase in the second harmonic distortion, especially in the middle register. Also of interest is the difference in high-frequency response due to the lateral (Fig. 13) and vertical (Fig. 14) components of modulation in the left channel. The lateral modulation produces more high-frequency output than the vertical output. This would tend to give the direct instrumental sounds, which are produced to a great extent by the lateral modulation component, a bright, forward character. It would also cause the stereo information, contained primarily in the vertical modulation component, to be reduced. The presence of a greater amount of second harmonic distortion in the vertical mode, which tends to cause a mellowness, plus the reduced high-frequency energy could very well be the technical answer to the subjective comments. When listening to small ensembles, playing non-complex material, or a large ensemble, playing complex music, there seemed to be little change in the perceived dullness and lack of spaciousness. The ability of the SME/Shure combination to produce a relatively good square wave from CBS STR-112, as shown in Fig. 8, indicates that the ability to reproduce either simple or complex program material should be about the same. This is born out by the results of the listening panel tests, and there were no adverse comments made about wandering or smearing of images.

Part of the perceived lack of brightness is also most probably due to a very positive aspect of the SME 3009 III tonearm. The stiffness of the arm tube, its "S" shape, and the internal damping of the arm tube tend to inhibit the higher frequency mechanical energy inevitably present in all tonearms due to mechanical coupling of energy from the record grooves. This high-frequency energy tends to reflect back to the stylus and be added to the desired signal as a slightly delayed signal which can add an artificial brightness to the perceived sound.

Figures 15 through 18 show the "stop action" digital storage displays for 3, 5, 10, and 20 kHz tones contained in the 20 Hz to 20 kHz sweep of the B&K 2009 record used to obtain the data shown in Fig. 13. The bending in the display of left vs. right channel signals shown in the B part of each figure is due to nonlinear distortion.

Figure 19 shows the response of the SME/Shure combina-

If a truly comprehensive competition were held to determine "the best pick-up arm in the world," the SME 3009 III would be a major contender.

tion to the 10.8-kHz tone burst of band 4 of Shure test record TTR-103. The modulation level is 30 cm/S peak for each of the left and right channels. There is some compression in the highest part of the positive excursion which would account for the second harmonic distortion, but this is an extremely high level of modulation. The echo in the display seems to be an artifact of the record itself.

Comments from the listening panel about the quality of the bass reproduction of the SME/Shure combination were generally favorable. The deep bass was perceived as being tighter and better defined than that from the reference system. The reference system had a slight edge in the upper bass such as is produced by guitar, for instance, but the SME/Shure combination was still considered quite good.

Figure 20 shows the results of the tests for the low-frequency resonance due to the effective mass of the tonearm/cartridge in combination with the compliance of the cartridge stylus assembly. The listening panel tests were conducted with both the SME damping system and the Shure dynamic stabilizer operative, as shown in Fig. 20C. The damping of the low-frequency resonance by this combination is excellent and certainly contributes greatly to the perceived tightness in the bass reproduction.

Figure 21 shows the results of measuring the amplitude vs. frequency response of the left channel with and without the presence of an airborne sound field at the cartridge position. The main left-channel output is about the same with or without the presence of the sound field. The effect upon the crosstalk is a different matter and shows an interesting effect. Without the sound field, the crosstalk appears as it did previously. With the sound field present, the crosstalk output from the right channel is reduced below about 70 Hz, while above about 100 Hz it is greater, being up in level principally at 200 Hz. This might be a clue to the perceived tightness in the lower bass and a slightly forward sound in the upper bass from the guitar. The sound level at the turntable during the listening panel evaluations was considerably lower than that shown in Fig. 21. The actual frequency spectrum and level are also shown in Fig. 21 as a reference. The frequency of the sound field and the frequency of the test record were synchronized during the test.

As mentioned in previous reports, the absolute polarity of the acoustical signal presented to the listening panel is scrupulously maintained for both the reference system and the system under test. A polarity switch is used to determine the correct polarity for each recorded selection used during the evaluation. Figure 22 shows the results of a polarity test which we have devised to check the polarity of phono cartridges; the results of such tests will be included in future reports. To our knowledge, there are two proposed standards, but unfortunately they call for opposite results from phono cartridges. The first is by David S. Stodolsky who proposed standards for phono, tape, radio, etc. in his paper, "The Standardization of Monaural Phases," which appeared in *I.E.E.E. Transactions on Audio and Electroacoustics*, Vol. AU-18, No. 3, pp. 288-299 (Sept. 1970). Using this standard, the Shure V15 Type IV would have a reverse polarity, since it gives a negative electrical output for a modulation of the left channel in the direction toward the center of the record or in the ultimate direction of the stylus as it plays a record. The second proposal is "Standards for Quadraphonic Disc Records" published by the R.I.A.A. as Bulletin E-7 (Sept. 12, 1973). This applies to discrete four-channel records made for a while by RCA. By this proposed standard, the Shure V15 Type IV would have the correct polarity since it would produce a negative output.

Another artifact which shows up in the polarity signal test is the ringing at about 250 Hz which can be seen easily on the loscope. This correlates well with the slightly forward guitar quality and with the tiny glitch in the response seen at that frequency in Figs. 13 and 14. It may be due to a small standing wave phenomenon in the SME 3009 III tonearm.

The mounting and adjusting of the SME 3009 III tonearm is time consuming but not difficult. Many turntables are supplied with mounting boards which provide the elongated hole necessary to mount the tonearm; this cuts the time needed considerably. The manual supplied by SME is very detailed, with 61 clearly written steps and 63 photos and diagrams.

There are very many more good points than bad in the design of the 3009 III tonearm, but a few minor points should be mentioned. One is the relative lack of space in the headshell. The connector pins must be bent at right angles and carefully dressed to mount some cartridges. There is no mention of how the armlift is adjusted. This can be done by moving the curved lift itself to whatever height is necessary. Although there is a set screw in the main collar of the lift assembly, it cannot be moved up or down, although you might be misled into thinking that it can. No mention is made of the fact that the little plastic armlocking device can be used as a means of allowing the tonearm to drop gently to the lead-in groove of a record if the tonearm is positioned correctly. Lastly, it seems a shame that with all the refinements and adjustments on the 3009 III tonearm, there is no sophisticated method of adjusting the vertical tracking angle as there is for adjusting the lateral tracking angle. The lateral tracking angle error adjustment need only be set once for a given cartridge, but the optimum vertical angle can vary from record to record. Of course, no other tonearm, to our knowledge, provides this feature so this is a quibbling matter when considering the overall quality of the SME 3009 III tonearm. It must be said that if a truly comprehensive and fair competition were held to determine "the best pick-up arm in the world," the SME 3009 III would be a major contender. *Edward M. Long*

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