Phase Diagram

for hand-held contact microphones, phonograph turntable,
mixing board and equalizer

Robert Wannamaker
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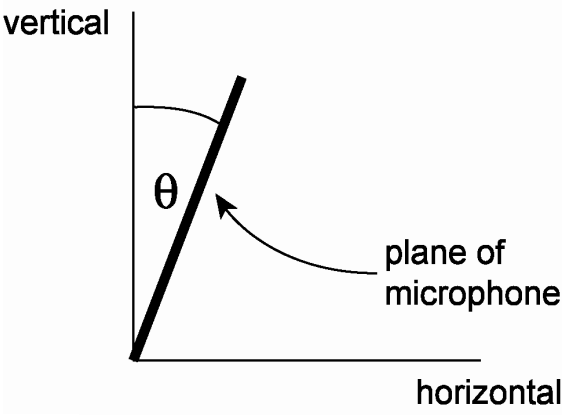
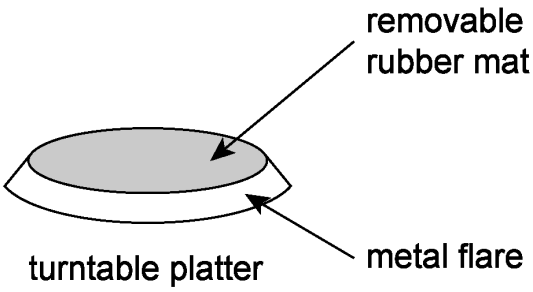
Construct two handheld contact microphones (see the appendix “Inexpensive Contact Microphone Contruction”) with special leads roughly 15 cm long consisting of straight lengths of 18 gauge insulated hook-up wire. These are to be held in either hand by gripping their phono jacks such that the leads reside in a horizontal plane and point away from the gripping hand towards the axis of revolution of the turntable platter (i.e., the leads are oriented radially).

The orientation of each piezo unit is specified below by the angle θ between its planar metal face and the vertical, as shown at right. (Sighting perpendicularly into the page corresponds to sighting down the leads away from the performer’s hand and towards the centre of the platter).





The turntable should be of the sort that possesses a metal platter with a integral metal flare at its edge. On top of the platter should reside a standard removable rubber vibration-damping mat.

The EQ may be as simple as an inexpensive guitar effect pedal with 6-7 bands and affording at least ±15 dB gain in each band. The loudnesses of the two piezo outputs should be made equal using the mixer. The respective signals should be panned hard left and hard right and fed to speakers that are spatially separated by about 3 metres. The lower the low-frequency cutoff of the speaker system, the better.

Phase I

Set the EQ such that a 300-600 Hz band is amplified by 15 dB with respect to some nominal zero while all other bands are attenuated by 15 dB. Bring the edge of the RH piezo disk in light contact with the metal flare at and angle θ between -2 to-5 degrees. The leads will flex allowing the piezo unit to bounce up and down at a steady rate that will increase with the downward pressure manually exerted by the performer. Find the least pressure that results in steady repeated bouncing (the repetition rate should be 10-15 Hz) before entering with the LH at a similar pressure. The initial volume is *mp* and will increase without intervention to *f* over the course of the section.

At all times the rates of bouncing should be the same for each handheld unit to within ±50%, but the performer is free to improvise by gradually and continuously varying the rates with respect to each other within these bounds. The average pressure exerted is steadily increased over the course of around 7 minutes. As the rates of bouncing increase they become irregular, losing a sense of steady pitch above 80 Hz, at which point θ should be slowly increased to zero, and then allowed to become slightly positive until only the slipping of the metal platter against the metal piezo is heard.

transition

Lift the piezos, adjust the EQ so that a 0-300 Hz is amplified by 15 dB while all other bands are attenuated by 15 dB, and bring the piezos firmly in contact with the edge of the rubber mat at and angle θ between -2 and -5 degrees so that steady bouncing with a repetition rate of about 60 Hz is obtained. This transition should be executed as rapidly as possible.

Phase II

As before, the rates of bouncing should be the same for each handheld unit to within ±50%, but the performer is free to improvise by gradually and continuously varying the rates with respect to one another within these bounds. After 2 minutes, the average pressure exerted is decreased gradually until the lowest steadily sustainable repetition rate is attained (it may be necessary to decrease θ to -10 degrees to attain this). The LH piezo is then allowed to stop bouncing. The EQ is gradually adjusted so that all bands are at 0 dB attenuation, beginning with the lowest frequency bands.

transition

Gripping the metal disk of the LH piezo unit firmly between thumb and index finger with θ =0 degrees, bring it in contact with the inclined surface of the metal flare so that it first scrapes and then squeals loudly. While this is happening, slip the edge of the RH piezo unit between the rubber mat and the metal platter (i.e., at θ =90 degrees) with the crystal face upwards. This should all take place within roughly 2 sec. Use the mixer to null the output of the LH piezo, then remove the rubber mat while keeping the RH piezo flat on the surface of the metal platter at its rim. Pan the output of the RH piezo to stereo centre.

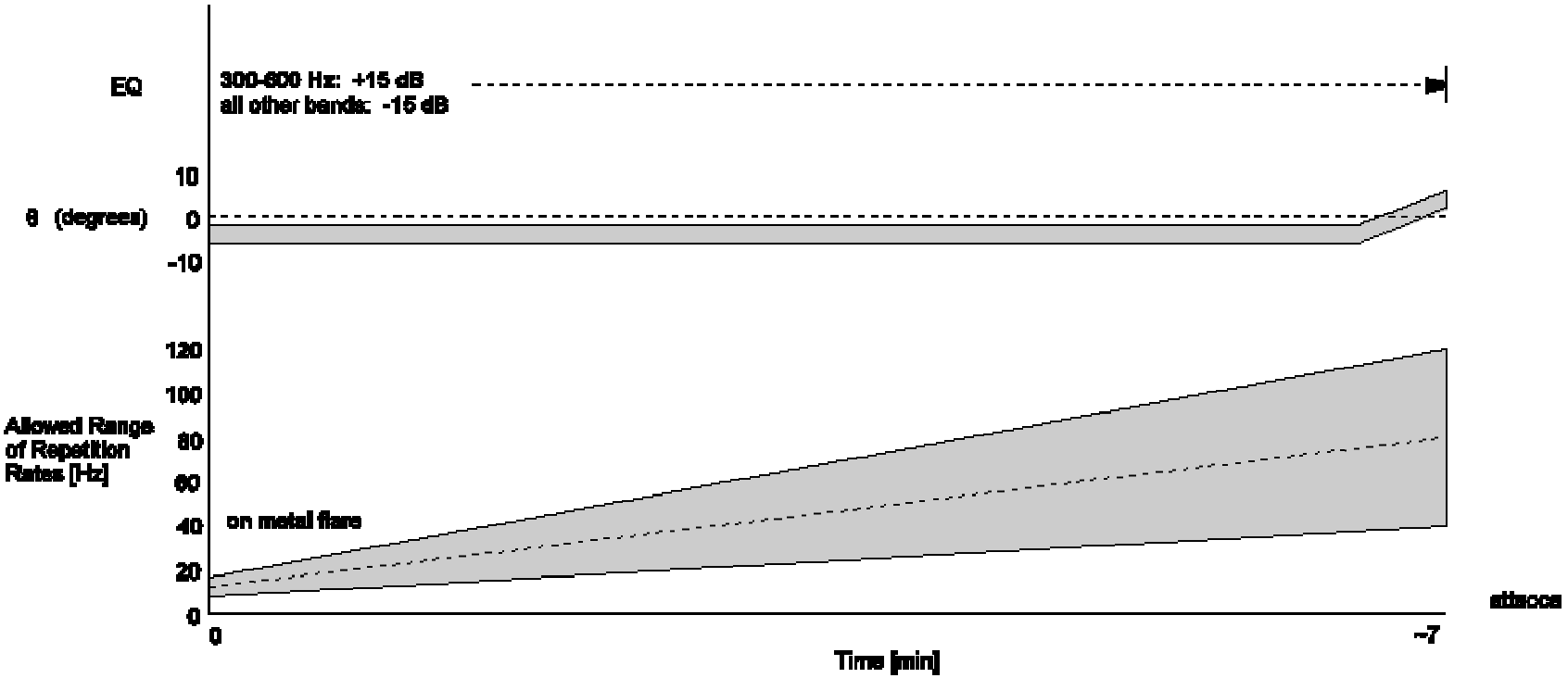
Phase III

The RH piezo unit rests flat against the metal platter near its rim until the end of the section. Very lightly place the (silenced) LH piezo unit flat against the platter just like the RH one. Slowly decrease its θ value from 90 to 0 degrees so that it begins to bounce against the platter. Make fine adjustments to the contact of the RH unit with the platter so that it optimally picks up the ringing of the metal and the bouncing of the LH unit. Over the course of roughly 4 minutes, increase the pressure on the LH unit so that its repetition rate increases, ultimately becoming an irregular warble, increasing the pressure on the RH unit concomitantly. Then increase θ for the LH unit so that it begins to slip smoothly against the platter, finally removing it entirely from contact. Over the course of a few seconds, decrease θ for the RH unit to less than 90 degrees while decreasing the pressure on it, and finally remove it from contact with the platter.

The sequence of operations is represented in the following graphic-score pages.

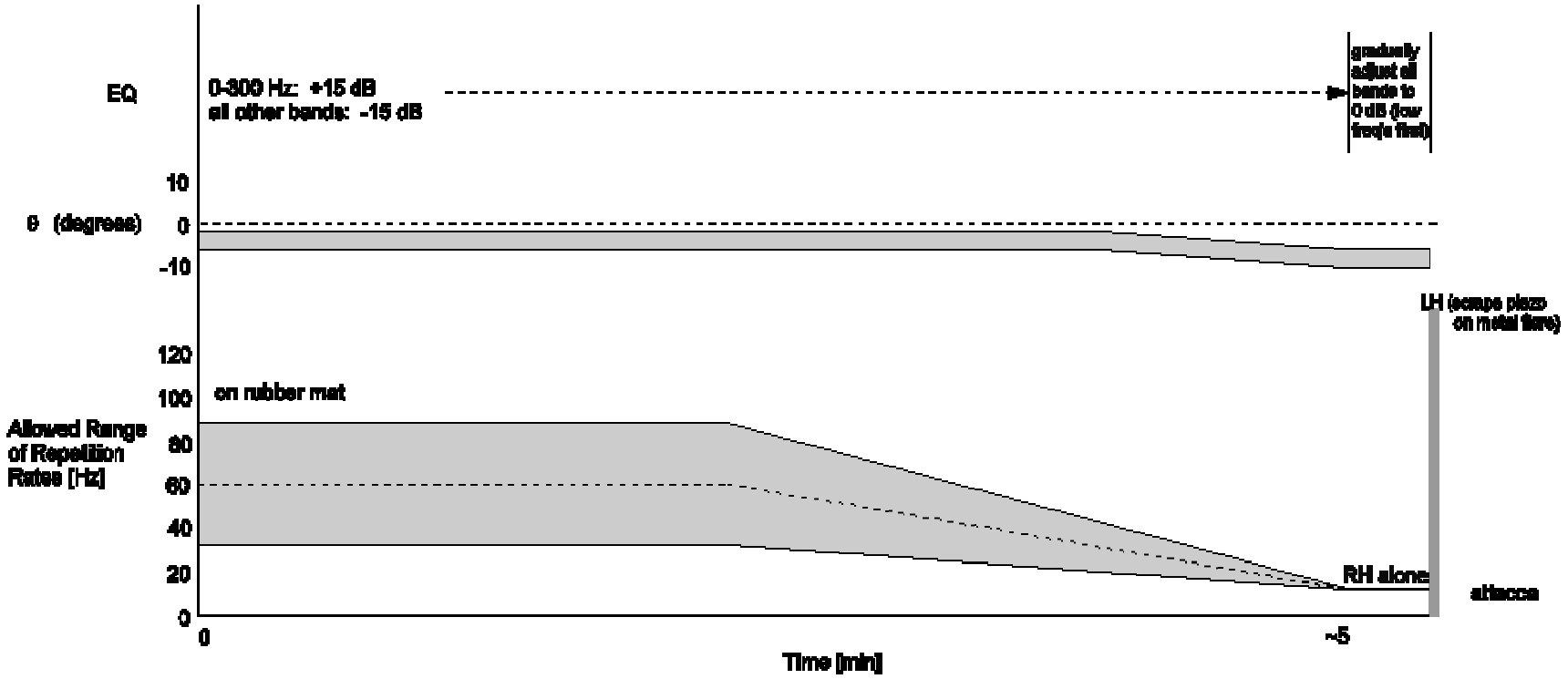
Rob Wannamaker
June 2000

Phase Diagram: Phase I



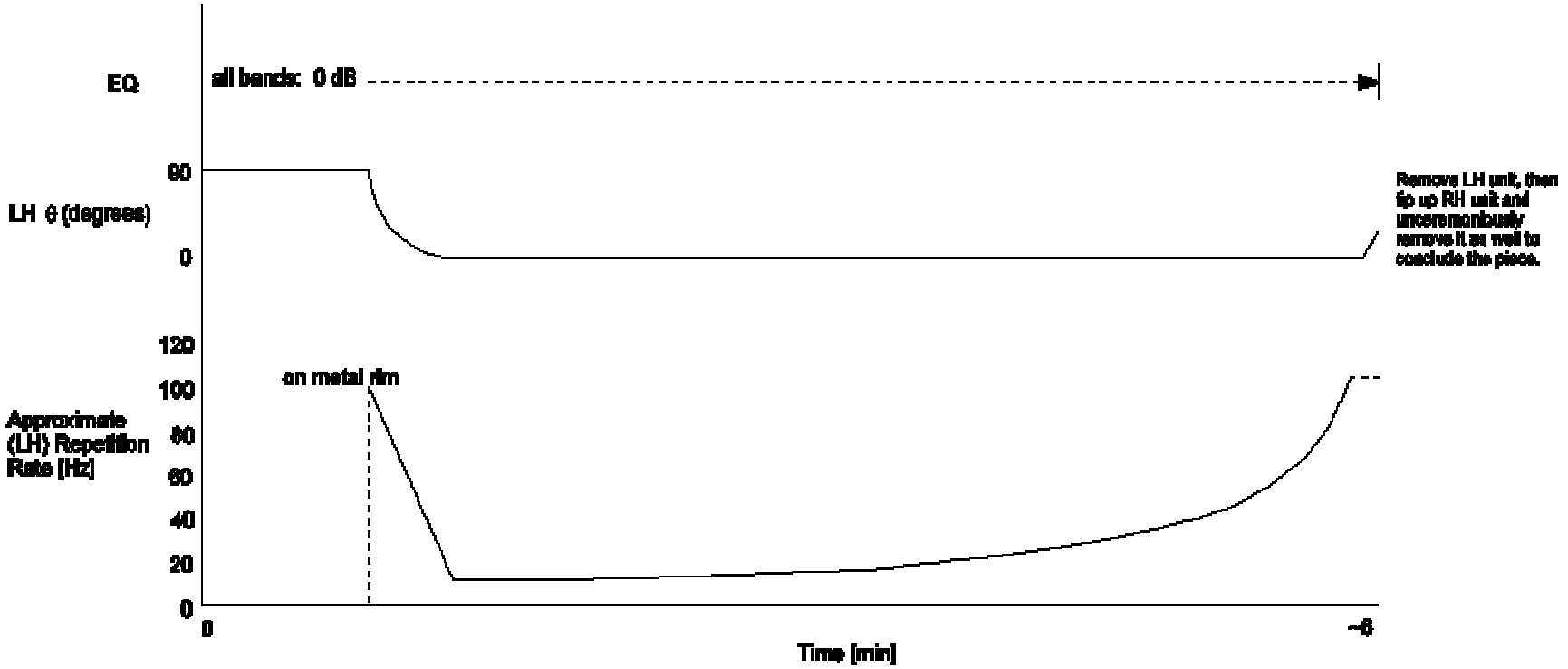
The specifications are identical for each hand, but the right hand starts several seconds before the left. Initially, the outputs of the two piezo units are panned hard left and right.

Phase Diagram: Phase II



The specifications are identical for each hand, but the left hand stops several seconds before the right, then violently scrapes the edge of the piezo against the metal flare of the platter marking the transition to Phase III.

Phase Diagram: Phase III



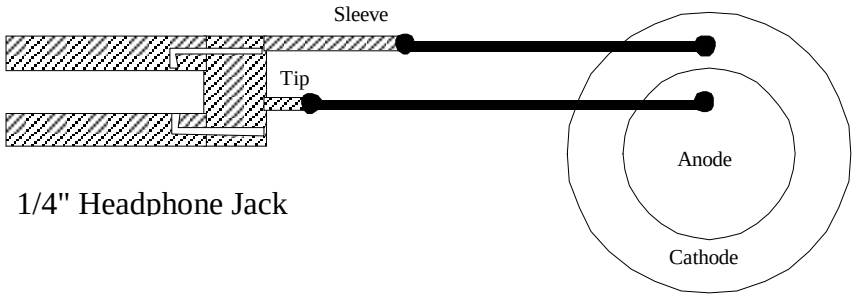
Begin by quickly nulling the output of the LH piezo, removing the rubber mat and gradually panning the RH to stereo centre. The RH piezo lies flat against the moving metal rim of the platter throughout, until it is tipped up and removed at the end of the piece. The pressure applied to the RH unit is mildly increased over the course of the piece so that it increasingly picks up the ringing of the metal and the bouncing of the LH piezo unit.

APPENDIX: Inexpensive Contact Microphone Construction

From a surplus or electronics supply store obtain piezoelectric units. They come in various sizes, the larger ones having greater response at low frequencies. (A diameter of 2.5-3.0cm is suitable for *phase diagram*.) The units may be sold separately or you may have to tear apart electric doorbell buzzers to obtain them. They resemble a pair of thin, concentric metal discs laminated together. The smaller disc is actually a thin conductive layer (which, for our purposes, we will designate as the positive electrode or *anode*) bonded to an underlying piezoelectric crystal or ceramic. The other side of the crystal is bonded to the larger conductive disc (the negative electrode or *cathode*).

Piezoelectric substances develop a voltage across them when mechanically deformed, and thus transduce mechanical signals into electrical ones. Leads must be soldered to the electrodes in order transmit the small voltage differences between them (~1 V peak) to an amplifier. These leads can be soldered directly to the terminals of a female 1/4" headphone jack, which can then be patched directly into a guitar or keyboard amp (see the schematic below). The anode should be connected to the tip terminal of the headphone jack, to minimize occurrences of hum resulting from simultaneously touching the metal sleeve of the jack and the electrode to which it is connected.

Rough handling will eventually cause the anode connection to break, so it is good to keep some spare units handy. When the break occurs, a portion of the metal anode is usually torn from the underlying crystal. The connection can be re-soldered a few times, but after repeated breaks the anode will be depleted, and the piezo will have to be replaced. The units can be made more sturdy by embedding the connections in epoxy, the added weight will also change the frequency response of the microphone.



1/4" Headphone Jack

Piezoelectric Unit

ASSEMBLY SCHEMATIC