

- (1) ● My company is Valve Research.
I also work in solid state design and use digital tool; delay, computers.
 - This paper is work relating to have headphones sound more like loudspeakers.
 - Other researchers may be trying to achieve this using software. I wanted to understand the concept using hardware that could be used by others.
- (2) ● Stereo is listening with both ears to hear all incoming sound.
 - Binaural is left ear hearing left channel only etc.
- (3) ● Blumlein binaural patent in 1931
 - Note baffles at b and between loudspeakers.
 - Microphones a_1 and a_2
 - Shuffle circuit C
 - Blumlein known as inventor of stereo.

- (4) ● Both ears hear both speakers
 - Different amplitude of sound from each speaker to both ears.
 - Different delay of sound from each speaker to both ears
 - Frequency response changes to each ear due to head shape. i.e. nose etc.
 - Position B and D (i.e. 1/2 left, 1/2 right) is also different for speakers & headphones.
- (5) ● Processor has crossfeed i.e. Bauer, Ref 2 or Linkwitz, Ref 3 to approach stereo in headphones and headphone amp.
 - Also my processor using time delays to remove the between ears dominance i.e. due to mid solo etc.

- (6) ● My triple delay system having matched left and right channels and a centre channel of 2 to 3 times different.
 - There are 6 paths total.
- (7) ● Photo shows 3 digital delay units
Left and right of 5mS and centre of 15mS.
 - Also mic preamp on LHS and switch boxes and crossfeed box on RHS.
- (8) ● Reference mics near dummy head (green)
 - In ear mics in dummy head (red)
- (9) ● After calibrating dummy head mics.
 - Processor now has crossfeed, 3 delay units, switching and headphone amp.
- (10) ● Dummy head with small electret mics.
- (11) ● Dummy head with open headphones.
- (12) ● Dummy head with closed headphones.

- (13) • Calibrating mics shown.
- (14) • Dummy head listening to loud speakers.
 - Human using closed headphones (so as to not hear loudspeakers) listening to dummy head's mics only.
 - Human can also remove headphones quickly to hear speakers for comparison.
 - See slide number 9.
- (15) • My microphone amplifiers as required.

4 used.
- (16) • Questions?