3) To specify completely any phase response we need to know what happens during the history of the observation. The person observing, going away and re-observing has a different concept of what happened during the event to the person observing the event continuously. The observer during the event could have noted the number of revolutions of the front wheel and the transient observer should have asked the question, either "how many wheel revolutions have taken place since I last saw the bike"; or "what speed has the bike travelled over what distance? Answers to these questions would give the phase response of the back wheel reference the front in terms of

(i) phase vs revolutions
(ii) phase vs distance travelled
(iii) phase vs time

Combining (i) and (iii) would give us the phase with respect to number of revolutions in a certain time. This is the concept of phase vs frequency used in loudspeaker measurements.

4) The bearing on the back wheel will need less oiling than the front bearing since it goes round fewer times. Chopper owners take note.

Phase Response in Loudspeakers

The amplitude response plot for a drive unit is well known but just to recap this is what it means. A perfect drive unit should reproduce sound pressure at a constant level independent of the driving voltage frequency but at a level dependent on the on-axis conversion efficiency. A practical drive unit can do this very well through its "pass band" and the designer of the loudspeaker system arranges for the passbands of drive units to add together to cover the whole audio band. Because of the laws of physics the extreme low frequencies are governed by factors such as cabinet volume, lowest frequency reproduced Q factor and acoustic conversion efficiency. Drive units therefore behave as band pass devices operating over a specific portion of the audio band. This means that they will reproduce a specific range of frequencies with constant amplitude and outside this range they will attenuate or offer much reduced output. Badly designed drive units will emphasise certain frequencies outside the pass band sometimes to an intolerable level. The band pass characteristics of the drive units in a typical two way system are shown in figure 1.

In just the same way the phase response can be plotted. This is the phase of the acoustic radiation generated by the drive unit, on axis with respect to the oscillating input voltage. A constant level horizontal line shows that the acoustic radiation is in phase with the driving voltage and all is well. (The back wheel is in step with the front wheel).

Because of the nature of electrical filters, transducers and the associated laws of physics where there are changes in the amplitude response there are corresponding and quite predictable changes in the phase response. A typical phase response for the bass unit in figure 1 is shown in figure 2. Over the operating band the acoustic phase is following the input voltage phase.