The operation of the circuit can be quite easily understood if one remembers that inductors pass lower frequencies and not higher ones and capacitors pass higher frequencies and not lower ones. Parallel combinations of L & C give open circuit at one particular frequency and series combinations of L & C give a short circuit at one particular frequency. i.e. the L's & C's are opposite in action and the parallel and series combinations are also opposite in action :

At low frequencies L1 and L1$'$ pass the signal which passes from right to left across the output terminals. At middle frequencies L1 C1 and L1$'$ C1$'$ become open circuit and L2 C2 L2$'$ C2$'$ become short circuit, so the signal passes from left to right across the output terminals (180° phase change). At still higher frequencies C1 and C1$'$ pass the signal and the signal direction reverts to right to left. However during the beginning the inductors L1, L1$'$ give a 90° phase shift and at the end of the sequence C1 C1$'$ give another 90° shift. The sum total amounts to 360° at the output terminals with respect to the input terminal voltage.

The amplitude can be seen to remain constant by looking at Figure 9. The bandpass and bandstop effects add up to zero attenuation, provided the Q Values of the parallel and series combinations are carefully controlled.

The Benefits of Source Alignment.

With conventional crossover networks (i.e. those not containing delay elements) the axis on which the energy adds at one crossover point is perpendicular to a line through the acoustic sources. Figure 10 shows this. A certain amount of improvement to this condition can be effected by putting the treble unit out of phase with respect to the mathematical phase or messing about with the crossover points of HF and LF units to "gap" the crossover point. Another solution is to design the crossover with very high cut off rates outside the pass bands. These solutions work tolerably well but are all something of a compromise.

Another problem which occurs with non aligned sources is in the off axis response. Consider figure 11 which is a top or plan view of the speaker in figure 10. Even assuming the designer has made a good compromise and the''on axis' response is good (Axis 'A' in fig 11) when the off axis positions are inspected then a varying path difference occurs between LF and HF source. Clearly the response in the crossover region is not going to be the same at 'B' or 'C' as it is at 'A'. This means that the total energy response of the loudspeaker in a live room will show problems at all angles except the on axis or zero angle. Whilst such problems exist in the amplitude response of the loudspeaker and we cope with them in a normal listening environment the stereo information and time delay effects confuse the ears and do not allow a precise stereo image to be constructed.

Figures 12 and 13 show similar diagrams for a speaker with sources aligned to a plane. The axis of best performance is now horizontal in fig 12 and even off axis in the horizontal plane the energy at the crossover point is not subject to path differences. The total energy into the room is therefore more complete in terms of stereo information.