The name of my design is taken from that given to the first electric toaster developed by Alan McMasters of Scotland in 1893. This follows from the rather unusual proportions of the Eclipse.

This is a compact vented system with a 4-inch driver, Newark 55-1853. With a bass cut-off frequency of 55 Hz, the system is not quite full-range but close enough.

Listening level

As might be expected for a system that uses a 4-inch driver with a volume displacement of 15 cm^3 to reproduce to 55 Hz, the maximum output level of the system is 87 dB at 1 meter. A pair of the speakers produces 90 dB at 1 meter. At 2 meters, the output level of the pair drops to 84 dB, this being within the average home listening range of 75-85 dB. Listening to a pair of these speakers at a distance much greater than 2 meters or about 6 feet could result in an inadequate (distortion-less) level of reproduction.

If full-range, then it must be vented

The 55-1853 driver has an efficiency bandwidth product (EBP) equal to 130 indicating that the driver tends to be more suitably used in a vented as opposed to closed-box system. As I wanted the speaker to have a bass cut-off frequency at least approaching 50 Hz to make the system full-range, and given that Xmax of this driver is only 2.6mm, I chose to make the speaker a vented design.

Flattening frequency response

Looking at the frequency response of the 55-1853 driver in the data sheets (www.farnell.com/datasheets/2329596.pdf), there is a –6 dB maximum dip in response at 4 kHz, and this dip in response spreads from 3 kHz to 10 kHz. To adjust for this, the baffle step frequency of the Eclipse is made equal to 702 Hz corresponding to width of the box of the Eclipse equal to 6-1/2 inches. That is, where John Murphy's formula for finding the baffle step frequency (www.trueaudio.com) is converted for box width in inches,

F = 4560/ 6.5 inch = 702 Hz

where F is the baffle step frequency

Baffle step of the Eclipse system is left uncompensated.

Finding a suitable alignment with a freq. response simulator

Simulating frequency response of the 55-1853 driver in a BB4 vented system with WinISD (www.linearteam.org), the default configuration has a box volume of 3.52 liters and (tubular) vent diameter of 10.2 cm. This results in a required vent length or Lv equal to 185.66 cm or more than 6 feet, which is impractical.

Looking at the equation for vent length, it can be seen that reducing the vent diameter will reduce the required length of the vent. Here is the equation for vent length taken from page 51 of the fifth edition of Vance Dickason's The Loudspeaker Design Cookbook,

$$L_V = \frac{1.43X10^7 R^2}{F_B^2 V_B} - 1.463R$$

where

L_V = length of tubular vent flush mounted on speaker baffle
F_B = tuning frequency, Hz
V_B = box volume, cubic inches
R = radius of vent, inches

There is a minimum of vent diameter less than which results in power compression becoming prohibitive. The vent diameter should be made larger than the minimum where possible. The equation for vent diameter is below.

$$D_V \geq 39.37\sqrt{\frac{411.25V_D}{\sqrt{F_B}}}$$

where

D_V = diameter of vent, inches
F_B = tuning frequency, Hz
V_D =cone displacement volume, cubic meters

The above equation for D_V is taken from the same page 51 as that for L_V. Solving for D_V where V_D and F_B equal respectively 15.44 X 10^{-6} cubic meters and 60 Hz, then D_V minimum equals 1.12 inches.

Based on the above calculation of D_V, I decided to try a vent with a 2-inch diameter. Decreasing the vent diameter of the default alignment of WinISD from 10.2 cm to 5.08 cm (2 inches), the simulator reported a required length of the vent as equal to 44.19 cm or 17.4 inches. This is still too long including the fact that the vent at the end inside the box must be 3 inches distant from the rear panel of the box.

Looking at the above equation for vent length L_V, it is apparent that L_V is inversely proportional to the internal box volume V_B. So the second step to try to further reduce the length of the vent was to increase V_B from the default value of 3.52 Liters to 6.85 Liters. With this increase of volume, the simulator reported a required vent length of 21.06 cm (8.29 inch). This length of vent that is a straight pipe can be fitted into a box of not excessive internal depth equal to 12 inches.

In the simulated frequency response of WinISD, the reduced vent diameter and increased volume resulted in a half-decibel dip extending from 100 Hz to 200 Hz, a half-decibel peak at 70 Hz, and a corner frequency of 55 Hz. This is understandable given that Q_{TS} of the 55-1853 driver equals 0.38, and in the BB4 type of alignment, Q_{TS} corresponding to the increased volume should equal 0.54 where leakage loss equals 7.

Simulating frequency response with WinISD alternately selecting QB3 and C4 alignments with the reduced vent diameter equal to 5.08 cm and increased box volume of 6.85 Liters, frequency response and the corner frequency remained about the same as for the BB4 alignment. The simulator indicated vent lengths longer than that of the BB4 alignment equal to 24.7 cm and 26.6 cm for respectively the QB3 and C4 alignments. The Eclipse has the shorter BB4 vent length equal to 21.06 cm or 8.29 inch.

How to build the Eclipse

Figure 1 shows an exploded view of the enclosure of the Eclipse. The interior of this box measures 5 in. wide by 8 in. high by 11.5 in. deep for an interior volume equal to 460 cubic inches. This interior volume minus volume taken up by the vent-pipe and the driver totaling 37 cubic inches equals 423 cubic inches or slightly more than the altered V_B tried in the simulations equal to 418 cubic inches.

Figure 2 shows a front view of the baffle butting against the top and bottom panels of the inner frame of Fig. 1, and a cross-sectional view of the opening for mounting the driver. The frame of the 55-1853 driver does not make it easy to obtain an air-tight seal when mounted on the baffle. This can be done with some additional effort by making a 45° chamfer on the exterior surface of the baffle as shown at Fig. 2. The lower circular opening for the vent should fit very tightly around the section of PVC pipe serving as the vent.

Figure 3 gives the dimensions of the section of PVC pipe that is the vent of the Eclipse. A support for the vent pipe at its end inside the enclosure is shown at the bottom of Fig. 3.

The inner frame of Fig. 1 is assembled first. To avoid splitting the ends of the MDF top and bottom panels, use a single centered drywall screw for each glued butt joint attaching the top and bottom panels to the front and back panels. Next insert the section of PVC pipe of Fig. 3 into the lower opening of the baffle flush with the outside surface of the baffle. Run the support shown at the bottom of Fig. 3 over the end of the pipe close to the rear panel and use drywall screws to attach the support to the bottom panel. Use latex caulk applied to the pipe where entering the baffle from inside to secure it to the baffle and fill any openings between the baffle and the pipe.

Close up the box by applying wood adhesive along the 4 edges of each side of the inner frame of Fig. 1 and use drywall screws to attach the two side panels of Fig. 1 to the inner frame. No damping material is installed in the interior of the box.

To mount the Newark 55-1853 driver through the upper opening of the baffle of Fig. 2, first apply 1/8 inch thick by 3/8 inch wide driver gasket to the chamfer. This gasket material has an adhesive along one side of the gasket and can be obtained from Parts Express (www.partsexpress.com), part # 260-540. This makes for a tight fit, so the driver must be inserted through the opening being careful not to scrape the gasket off of the chamfer.

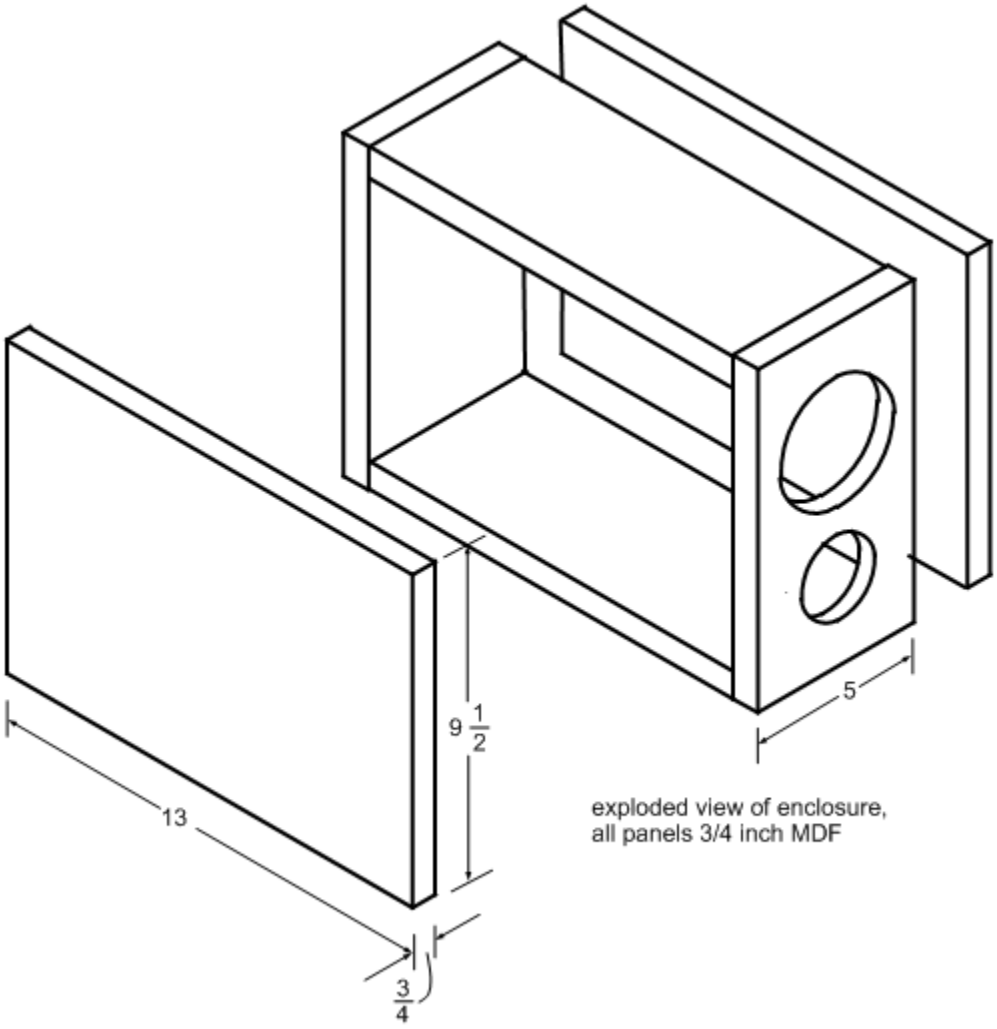

Figure 1: First construct the inner frame and install the vent. Following that, attach the side panels to the inner frame using butt joint –type construction.

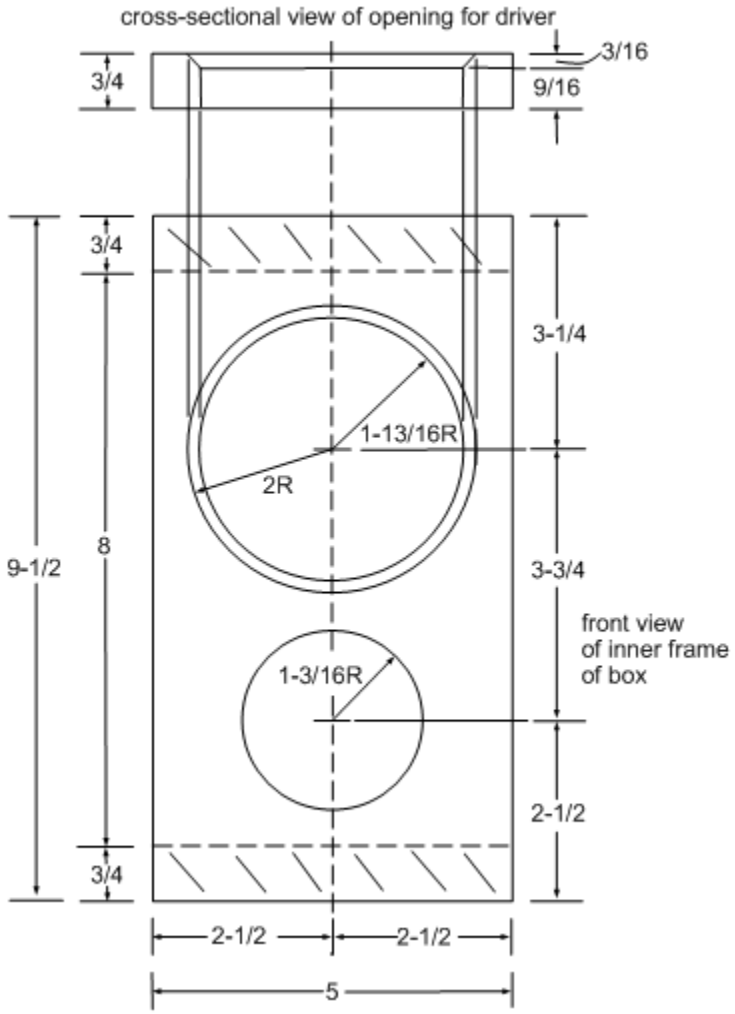

Figure 2: Mounting the 55-1853 driver through the upper opening of the baffle shown above, including the application of a gasket, makes it possible to get an air-tight seal between the driver and baffle.

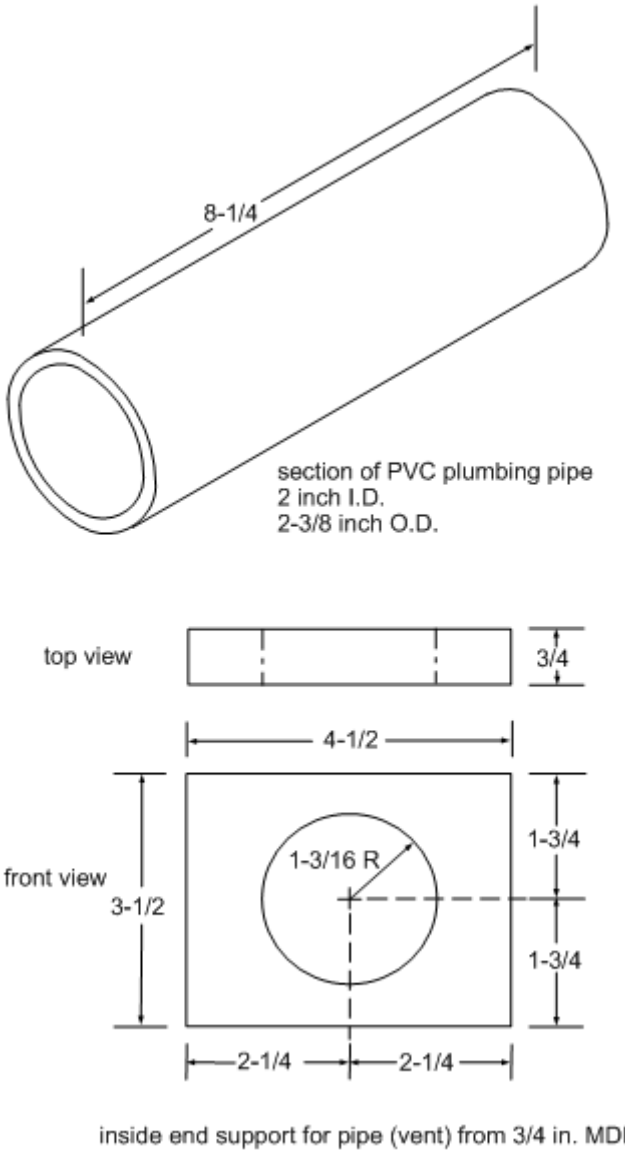

Figure 3: The vent of the Eclipse is a section of PVC plumbing pipe that is supported at the end of the pipe towards the back of the Eclipse's enclosure by the supporting block of MDF shown at the bottom of the figure.