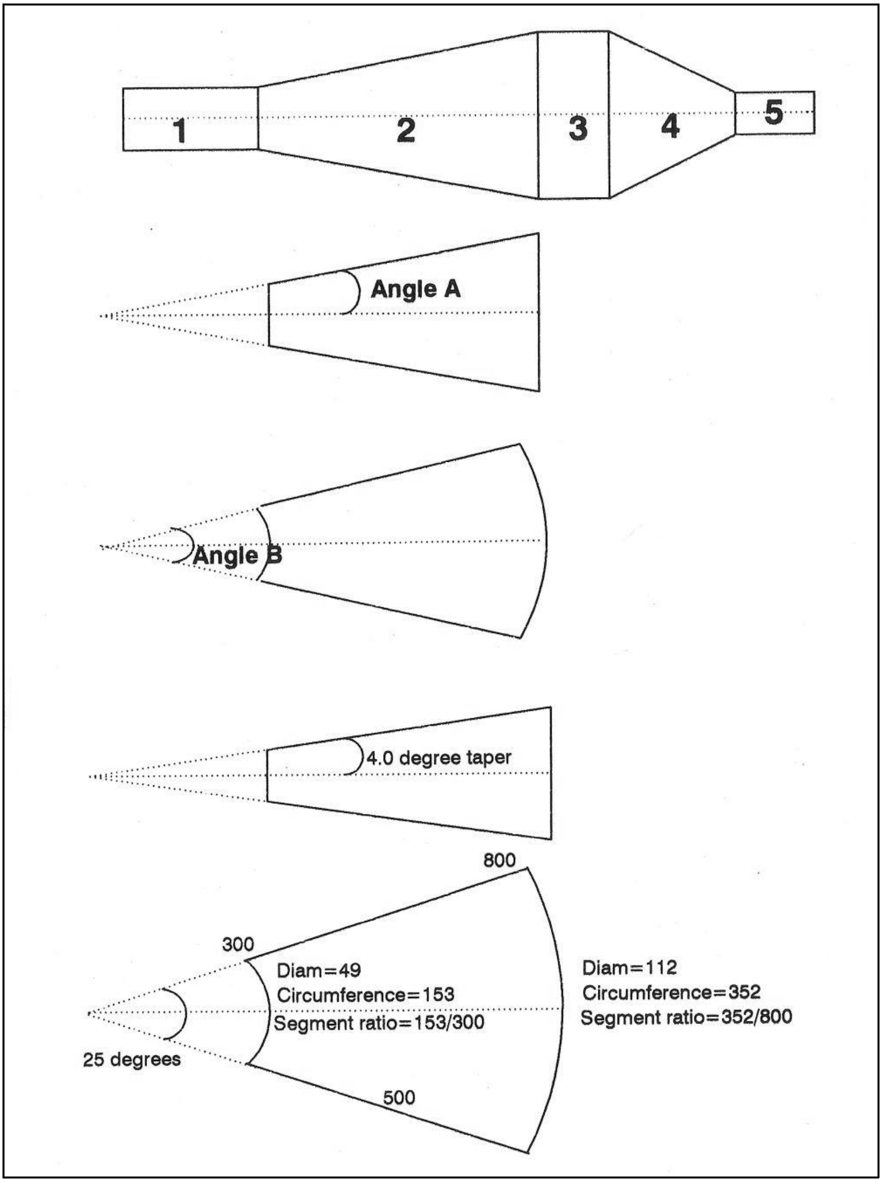

Figure 66 Exhaust cone development

Stage 3: Belly section

The belly section is rolled from a rectangle, whose length is the circumference of the diameter. From the work above, we know the circumference is 352. The length of the belly section is 121 mm. The paper cutout is a rectangle 352 mm x 121 mm

Stage 4: Baffle cone

The large diameter is set at 112 mm, the small diameter is set at 25 mm, and the length is set at 249 mm

249 = cotangent(angle) x (112 - 25)/2

cotangent = 5.742

The cone angle is slightly under 10°

The full cone height is 5.742 x 112/2 = 320 mm

The large diameter has circumference of 352 at a distance of 320

The small diameter has circumference of 78 at a distance of (320 - 249) = 71

Large segment ratio is 352/320 = 1.1

Small segment ratio is 78/71 = 1.1

Fan angle is 57.3 x 1.1 = 63°

Draw the paper cutout as for the diffuser cone

To be effective, the ports should be in harmony with each other and the exhaust, and they should all be tuned for maximum performance at a chosen rpm. Most literature on 2-stroke port timing makes a serious error in concentrating on timing to the exclusion of all else. At the very least, the port shape should come into the picture, and the amount of time that the port is open. Therefore there is an optimum time-area combination to permit the complete passage of the exhaust gases. Since the piston movement is related to conrod length, a simple measurement of the whole port area will not be sufficient.

Early work sponsored by Yamaha, which built on previous pioneering work, gave the key when it was eventually published in the engineering journals by Nagao, and later expanded upon for the tuner by Jennings. The ports of any engine may be reduced to a common base for measurement and comparison. The measurement which makes this possible is the measurement of a specific port time-area, and the units are sec-cm^2/cm^3, or in English: a port time area per unit of swept volume. It is derived by measuring the "mean port area" which is the port area open when the piston is half way down the port as measured by crankshaft degrees, divided by the displacement of the cylinder, multiplied by the total time that the port is open at your chosen rpm. So, here we go.

Using a degree disc on the crank, and carefully synchronising the disc with TDC, measure the drop from the top of the barrel to the piston at TDC. Turn the engine over until the exhaust port opens, and now back until you just cannot get a 20 thou feeler gauge into the port with the gauge held at 45° . Record when the exhaust opens in degrees BBDC off the disc. Measure the drop to the top of the piston as before. Turn the engine over until the crank is half way down the exhaust port, that is, if the exhaust opened at 94° BBDC then turn the crank so that it is now 47° BBDC. Now measure the piston drop again. Subtract the TDC drop to piston from the two other readings to get net piston movements.

You should have collected the following data for the port:
Crank degree BBDC when exhaust opens
Movement of piston in mm from TDC to exhaust opens
Crank degree BBDC when exhaust is half open
Movement of piston in mm from TDC to exhaust half open

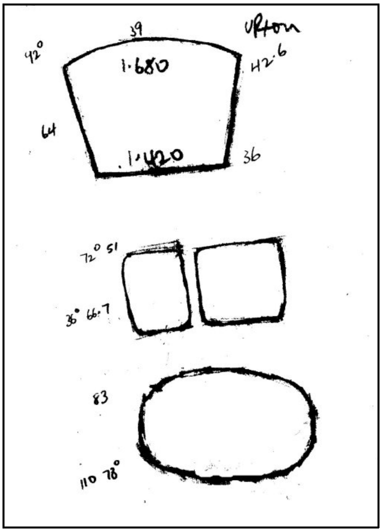

Figure 67 Trace the ports

Now repeat for the transfer port using an identical procedure. The inlet port is very similar but the period of opening is measured as degrees BTDC. Pull the barrel off. Measure the width of the ports from edge to edge. Use tracing paper to take a rubbing image of the port shapes. Take care and time over this as errors in the shape transferred to the paper will invalidate the whole process, paper and grubby finger usually work, Fig 67 is an image scan of an actual tracing by the author which is why it looks a little tatty, but this is definitely a case of care triumphant over technique. Transfer the images to mm graph paper and draw lightly. Because the port was mapped from a cylindrical wall and the tracing paper has been opened out, the image has been distorted by having its width extended. Draw the port using the (correct) height as mapped but with the measured width. This width distortion may be calculated for any given bore size. Now draw a line across where the half open port open position is, and count all the little squares above it, and divide by 100 to get cm^2. Now you know why you needed mm graph paper and not inch graph paper.

The Figures 67 and 68 relate to an Upton kart racing barrel.
Exhaust port opens at 92° which relates to a piston position of +41
The mean position is at 46° which is +64, or 28 down from the top of the port

Count all the squares up, 849
Cylinder swept volume is 207 cc
Formula: time = open$^{\circ}$ / 6n
Maximum power at 8000 rpm
Port open time = (2 x 92) / 6 x 8000 = 0.00383
Port factor = 8.49 x 0.00383 / 207 = 0.000157

The values for the ports should be within the following narrow guidelines

Exhaust	0.00014 to 0.00015
Transfer	0.00008 to 0.00010
Inlet	0.00014 to 0.00016

The exhaust value is slightly high, showing that the port is well able to produce some power at 8000 but is in fact tuned to a higher rpm, about 8800 to 9000. If the value had been say 0.000131 then this low value would show that the exhaust port did not have enough time/area to support power at 8000 rpm. Working back through the formula starting with the median factor value of 0.000145 we would find that the port was tuned for 7270 rpm. We could get more time/area by increasing either the port width which increases area without increasing time, or by raising the port which increases both time and area. The maximum safe limit for the width of an exhaust port is 62% of bore unless the port is very elliptical and you have thin rings in which case you may go to a maximum of 70%. If you need more time/area and you have run out of width then you will have to take more height. Redraw the port shape just (say) 1 mm taller, determine the new open° and the new median position of the piston, and count the squares again. Recalculate all the calculations with the increased area and time values to get a new port factor. It might be tedious but at least you have not ruined your best barrel, yet. In Figures 67 and 68 the transfer port areas are

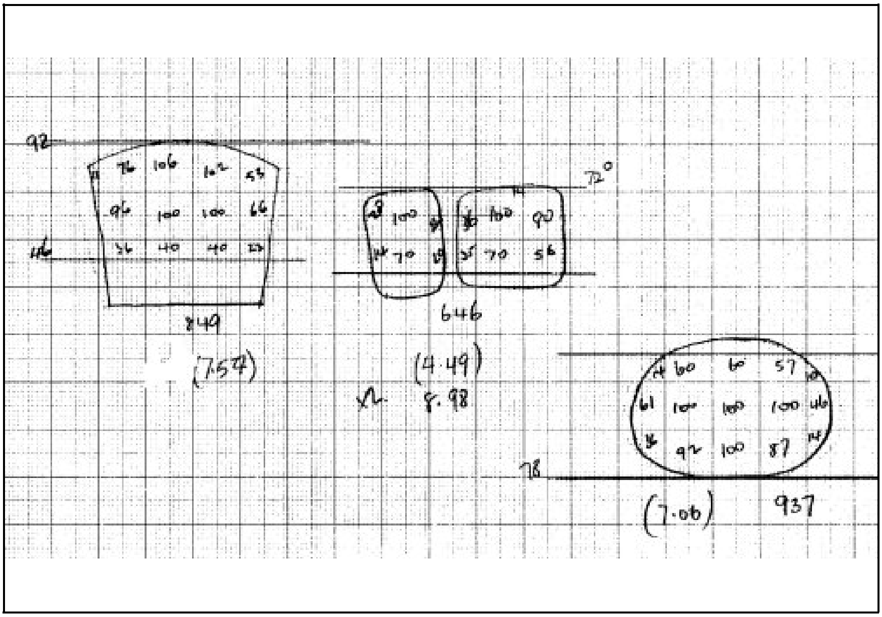

Figure 68 Port area diagram

misleading as the passages leading to the supplementary ports are simply too small to pass enough gas, and we would be better off treating the barrel as having just two transfer ports. This illustrates the problems of taking things at their face value.

The above procedure is OK for individual ports but it is difficult to see the