BARROWMORE
MODEL RAILWAY GROUP
"Modelling to a high standard amongst friends"

Workshop Notes: Photocopying for innumerate modellers

It is a truism (with some truth behind it, like most truisms) that the population can be divided into two sorts of people: first, those who <u>can</u> add up but <u>can't</u> spell; and second, those who <u>can't</u> add up but <u>can</u> spell. I fall into the second category, and it occurred to me that many modellers must be mystified as I was by such mathematical concepts such as 'ratios' and 'scales'.

So, if you are one of those who can do "2 + 2 = 4" in your head, don't bother to read any further!

Photocopiers Most people these days have access to photocopiers - they are common office equipment and copying facilities are often available at low prices in many High Street shops, filling stations, etc. You can buy a multi-function copier for well under £100, which, when connected to a personal computer will allow you to print from the PC, send fax messages, print photographs from digital cameras and scan documents and pictures as well as photocopying in colour and black-and-white. They will usually work as 'stand-alone' copiers. Bigger machines (as well as costing much more) are obviously more flexible than smaller ones – they will have enlargement and reduction facilities, as well as accepting A3 size (twice the size of this page) originals. Copiers do exist which have an even larger capacity, but these are necessarily quite expensive: architects or drawing office suppliers shops sometimes provide a service; or, you can beg a favour from someone who works in such an office!

Diag.1: a 4mm:lft scale drawing of a coal wagon from the 1930s
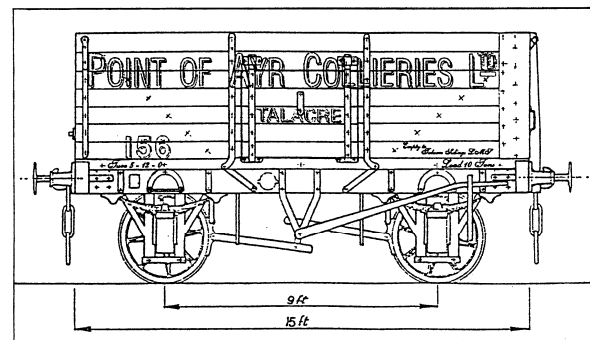
Enlargement and reduction As modellers, a lot of our copying will involve drawings which may be required in a different scale to that of the original. So, how do you calculate the enlargement or reduction required? You must first know (or calculate) the scale of the original drawing; very often this will be quoted on the drawing, e.g. "7mm to 1ft", or "1:43.5" (this is known as a ratio, where 1 unit on the drawing is the equivalent of 43½ of the same units on the real thing); but beware! - don't take a quoted scale as 'Gospel', as the drawing may already have been reduced or enlarged. Check!
The presence of a scale such as:

<div align="center">

" 0   1   2   3   4   5ft
|___|___|___|___|___| "

</div>
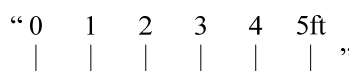
on the original drawing can make things easier - you can use a ruler to measure the distance between "0" and "5ft"; work out what the equivalent of 5ft will measure on your required version, then do a simple calculation: 5ft on your required drawing divided by 5ft on the original drawing.

An example: You have a 7mm scale drawing which you want to convert to 4mm scale. So, 5ft in 4mm to 1ft scale is: 20mm (5 x 4) = the desired scale. On the original 7mm to 1ft drawing, 5ft will measure 35mm (5 x 7). Therefore the conversion factor (from 7mm scale to 4mm scale) will be: 20 divided by 35 = 0.571, or 57.1% (the same as 4 divided by 7). Set this factor on the enlargement/reduction control on the copier (your copier may only accept whole numbers, in which case enter 57%), make a copy and then check the result by measuring the reduced photocopy. It is always a good idea to check, because (a) your calculations may have been wrong (!), or, the machine may need adjustment. In this latter case, there is not a lot you can do about it straight away, other than guess what the error was and make another copy taking this figure into account: trial and error will get the correct scale drawing in the end! You could well be satisfied with a less-than-perfect scale result in any case – particularly if you are a devotee of the 'work-from-dimensions-rather-than-the-drawing' school. Of course there is a more scientific way than 'trial and error' to go about quantifying a machine's 'built-in' error and calculating a corrected conversion factor: if 5ft on the original comes out as 19mm instead of the required 20mm on your copy, you first have to divide the required measurement of 20mm by the test result of 19mm, to get 1.0526;

secondly, multiply your original conversion factor (57.1%) by this correction factor and you get (57.1 x 1.0526) 60.1. Try this as a new conversion factor of 60% and you should get a more acceptable result.
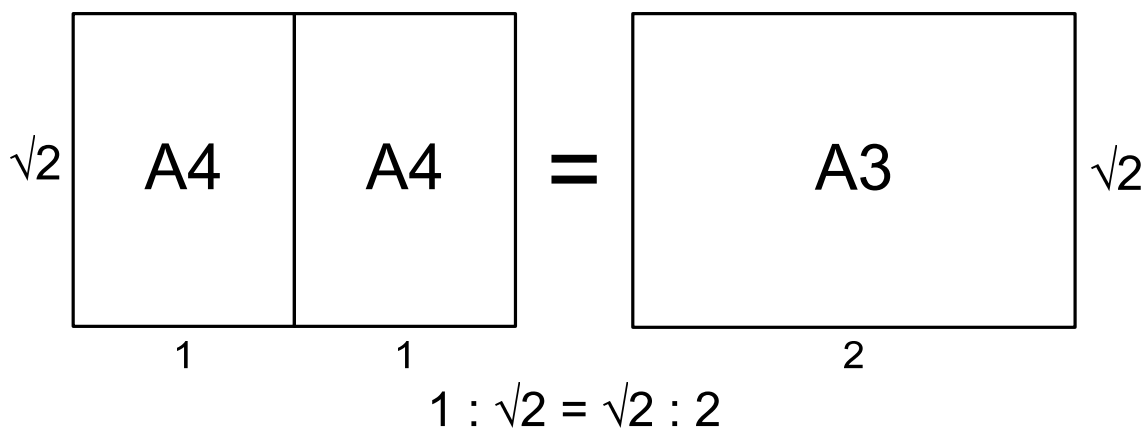
You will find that most copiers have a similar range of enlargement/reduction available. Enlargement is usually up to 2x (i.e. 200%) in several stages, including a 'fine-tuning' (normally 1%) increment; reduction normally goes down to 0.25x (i.e. 25%). These figures are built-in to the machines to cover the common office needs of converting A4 size (210mm x 297mm) originals into A5 (148mm x 210mm) copies, or vice versa.

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(Note on paper sizes: you may have wondered why a piece of A4 paper measures what it does. The use of International ('A') paper sizes dates in the U.K. from British Standard 730 (I.S.O. 216) published in 1937, and is based on a rectangle with an area of one square metre, the sides of which are in the ratio of $1:\sqrt{2}$, i.e. 1:1.4142135. The following brief description by Markus Kuhn explains the system very well:

The ISO paper size concept

In the ISO paper size system, the height-to-width ratio of all pages is the square root of two (1.4142 : 1). In other words, the width and the height of a page relate to each other like the side and the diagonal of a square. This aspect ratio is especially convenient for a paper size. If you put two such pages next to each other, or equivalently cut one parallel to its shorter side into two equal pieces, then the resulting page will have again the same width/height ratio.

$$\sqrt{2} \left| \begin{array}{c|c} A4 & A4 \\ \hline 1 & 1 \end{array} \right| = \begin{array}{c} A3 \\ \hline 2 \end{array} \right| \sqrt{2}$$

$$1 : \sqrt{2} = \sqrt{2} : 2$$

The ISO paper sizes are based on the metric system. The square-root-of-two ratio does not permit both the height and width of the pages to be nicely rounded metric lengths. Therefore, the area of the pages has been

defined to have round metric values. As paper is usually specified in g/m², this simplifies calculation of the mass of a document if the format and number of pages are known.

ISO 216 defines the **A series** of paper sizes based on these simple principles:

- ? The height divided by the width of all formats is the square root of two (1.4142).
- ? Format A0 has an area of one square meter.
- ? Format A1 is A0 cut into two equal pieces. In other words, the height of A1 is the width of A0 and the width of A1 is half the height of A0.
- ? All smaller A series formats are defined in the same way. If you cut format A*n* parallel to its shorter side into two equal pieces of paper, these will have format A(*n*+1).
- ? The standardized height and width of the paper formats is a rounded number of millimeters.

In short, this means that if the short side is doubled, or the longer side halved, then the ratio remains the same. A0 (1 sq.metre) therefore measures 841mm x 1189mm, Al measures half this in area - 594mm x 841mm, this page is A4 size – 210mm x 297mm, and so on down to A10 which is 26mm x 37mm).

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These limits of 2x and 0.5x when enlarging or reducing drawings raise another potential problem: .if you want to convert something using a conversion factor outside these limits, you have to do it in stages.

Things to bear in mind when enlarging or reducing by any significant factor include the fact that any imperfections present are made more obvious by enlargement; luckily, the opposite also applies - reduction makes errors less obvious. But reduction very often has a detrimental effect on any text present:

Diag.2: the same Point of Ayr colliery wagon drawing reduced to 2mm:lft scale
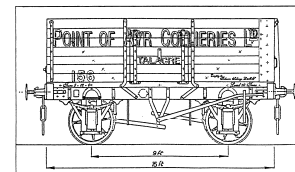

- you may not be able to read it! Added to this 'illegibility factor', faint lines on the original may not appear at all on the reduced copy.

There are lessons to be learned from the above when you are producing drawings yourself: (a) make them to a bigger scale than you eventually want, so that reduction will hide some of your 'pigs ears'; (b) use a scale which will make the overall
area of the drawing less than A4 (210mm x 297mm) size, so that it will be acceptable by most machines;
 (c) any text must be large enough in letter size to stand reduction without becoming illegible. There is an alternative here - don't put any text onto the original drawing, but reduce it to the required size and then add the lettering; (d) incorporate a simple ('0 1 2 3 …ft') scale so that dimensions can be scaled off the drawing whatever reduction (or enlargement) is used - don't just say '4mm to 1ft scale' or whatever.
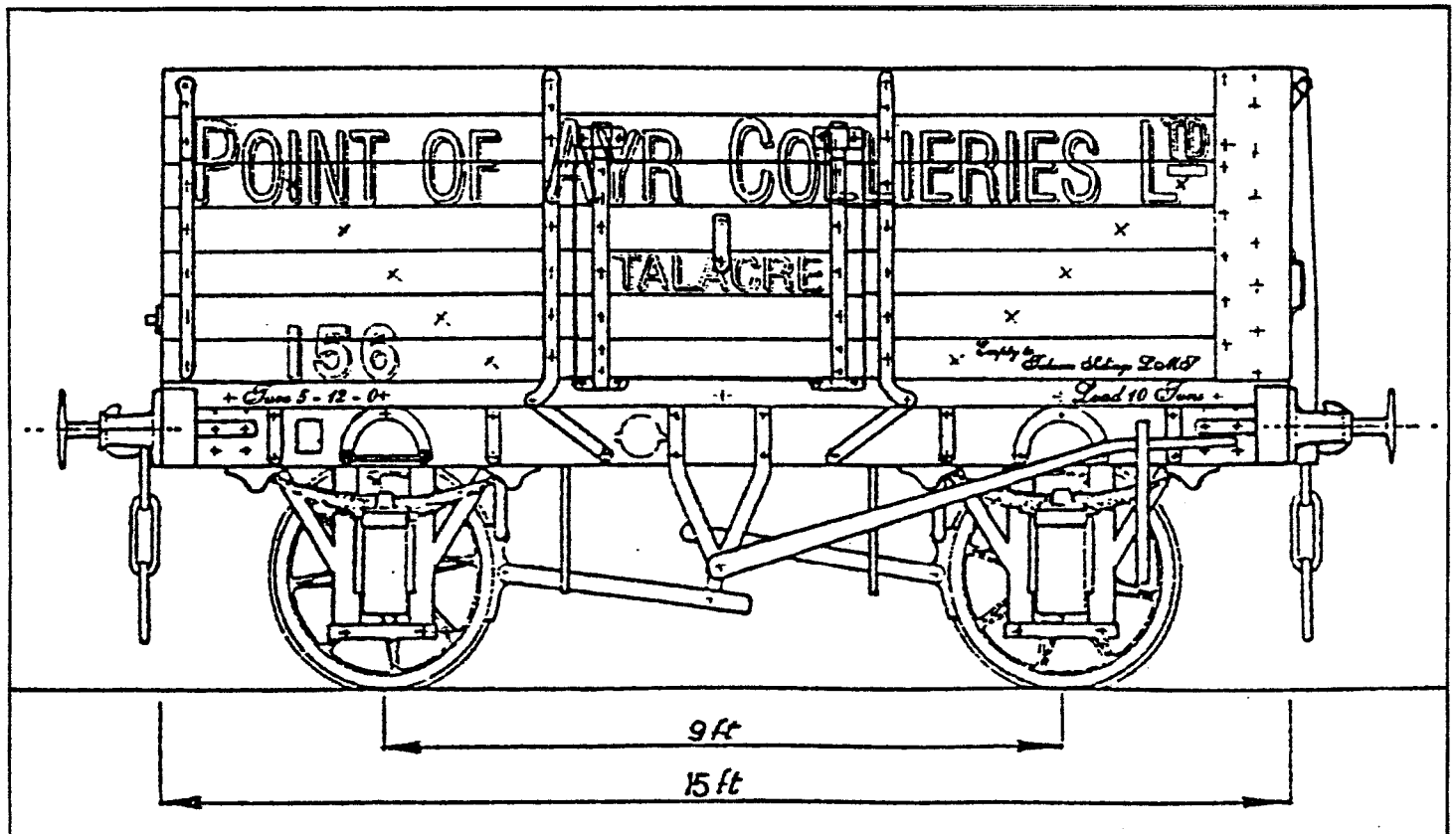
Diag.3: the same drawing, enlarged to 10mm:1ft scale; some horizontal lines are no longer quite straight

Sometimes, distortion creeps in when enlarging: a line which was originally straight turns out very slightly curved, and angles can be slightly distorted. But these are faults inherent in optical systems, where there is no such thing as a 'perfect' lens! Where it can make difficulties is when you have reduced a too-large original onto several smaller sheets and then taped them together: you may find that lines on the original do not meet up on the edges on your Sellotaped version!

Diag.4: Part of a drawing of an LNWR water tank, to show what can happen to joins on photocopied sheets. Usable for modelling, but not very attractive!
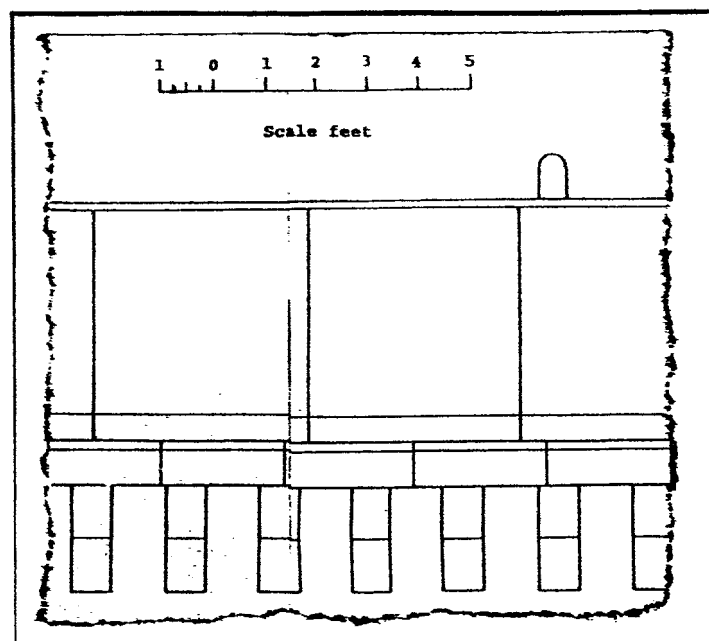
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