AN ANALYSIS OF FRET SAW BLADE ANGLES

by Frank Harris

Since joining the Marquetry Society of Canada a couple of years ago I have been puzzled by many things, and one of those "puzzlements" has been the proper angle to set the fret saw to obtain a good fit between mating parts. This puzzlement came about because I was unable to find any consensus among other members, or in books, as to the proper fret saw angle for certain conditions (different saw blade and veneer thicknesses). The few members I have asked about this say they set their fret saws to angles between 10 and 15 degrees. *The Modern Marquetry Handbook* by the Marquetry Society of America (page 73) says, "12 degrees will form a perfectly tight fit that requires little or no filler", without mention of either blade size or veneer thickness. *The Marquetry Manual* by W. A. Lincoln makes two or three references to angles, and sets out one table of angles which vary from 8 to 20 degrees and are related only to veneer thickness, not to blade thickness, (although he says in a previous paragraph that you have to experiment with practice cuts to establish angles).

It is obvious from the high quality of work done by many marquetarians that the saw settings being used are working very well, even though they may not be calculated mathematically or even well understood. It may also be, of course, that those skilled at the craft know that approximations are all that are needed, and that perfect geometrical accuracy is a waste of time. Nonetheless I have set out to do a little trigonometry to determine the theoretically-correct angles for certain conditions, if only to satisfy my own curiosity.

In order to understand why only one fret saw blade angle is correct for a perfect fit for any one combination of veneer thickness and blade size, please refer to **Fig 1**. In this diagram, a "plug" (shown in sawing position) is to be sawn with a fret saw blade of a certain thickness (kerf) set at an angle a, such that the resultant fit of the plug to the "body" of veneer will be exactly flush at the top face of the body. In other words, the dimension of the top face of the plug must exactly equal the dimension of the top face of the "window" cut out of the body in order for the resultant top face to be flush. If this is to be the case, it can be seen that the points shown as A on the top face of the body veneer must be directly over the matching points B on the top face of the plug after sawing. It is obvious from the diagram that, for any given thickness of "body" veneer, and a specific blade thickness, this condition can be met at only one blade angle. (If the blade angle is increased using the same blade thickness, point B on the left side of the diagram will end up to the left of its present position and will no longer

be directly under point A. Similarly, too small a blade angle will move point B to the right, away from its position directly under point A.

So for any given thickness of body veneer and of saw kerf, (I am using "blade thickness" to represent the resultant kerf after sawing) how do we find the correct blade angle? From the diagram, note that the blade angle a is also one internal angle of a right triangle (ABC), of which the hypotenuse (AB) is the body veneer thickness, and the side (BC) opposite the angle a is the blade thickness. From trigonometry we know that the opposite side of a right triangle divided by the hypotenuse is the sine of the angle, so the sine of angle a is the blade thickness divided by the thickness of the body veneer. We can find the blade angle a from a set of trigonometric tables.

If all veneer were the same thickness, or very near the same thickness, only one calculation would be necessary and all marquetarians would be using the same saw angle for any given thickness of blade. Unfortunately such is not the case. In a measurement survey of 52 pieces of veneer (from the two or three hundred that I have accumulated) I found thicknesses from .019" up to .041", and a size for every .001 increment in between. This means a lot of thickness measurements and calculations to get the correct blade angle for each cut in a piece of marquetry if you want to have perfect fits. To make this easier, I have provided a table (Table 1) of blade angles for 26 veneer thicknesses (in increments of .001") and 9 different blade sizes. To use this table it is necessary only to look down the column for the blade number or blade size that you are using, to the row corresponding to the veneer thickness, and pick out the correct blade angle in degrees and tenths. For example, for a 4/0 saw blade and a veneer thickness of .032", the correct blade angle for a geometrically perfect fit would be 15.6 degrees (or 15 degrees, 36 minutes).

For the type of fit shown in **Fig. 1**, flush at the top face, the computation of blade angle depends on the thickness of the body veneer, not on the thickness of the plug. Any variation in the thickness of the plug will show up as irregularities on the bottom face of the assembly. This is not always desirable. For many if not most types of marquetry work, it would be preferable to have the bottom face of the assembly flush, so as to form a solid base, and the irregularities in the upper or "picture face" can be removed by sanding or scraping prior to the finishing process.

This is the situation shown in **Fig. 2**. In this diagram, it can be seen that, in order for the bottom face of the assembly to be flush, it is necessary for the points A on the bottom face of the body veneer to be directly over the points B on the bottom face of the plug. Once again it can be seen that for any given veneer thickness and blade size, this condition will exist for only one blade angle. However, now the computation of blade angle depends not on the thickness of "body" veneer (as in **Fig. 1**), but on the thickness of the veneer in the plug. Once again, the blade angle forms an internal

angle of a right triangle (ABC), and the side BC opposite the angle divided by the hypotenuse (AB, or the thickness of the plug veneer) gives us the sine of the blade angle. Again, the angle can be found from a set of trigonometric tables, or you can use **Table 1** . This calculation is completely independent of the body veneer thickness, and all variations in veneer thickness will appear as irregularities in the upper face of the assembly.

Finally we come to **Figure 3**, where I have included the cellotape that is used in the bevel-cutting technique. Note now that points A and B are separated by the plug thickness, plus a double thickness of cellotape. For a fit similar to the case of **Fig. 2**, where the bottom face of the assembly is flush, all that needs to be done to compensate for the cellotape thickness is to add one double thickness of tape (.004") to the thickness of the plug, and use this sum in the calculation of the sine of the blade angle (or as the veneer thickness in **Table 1**).

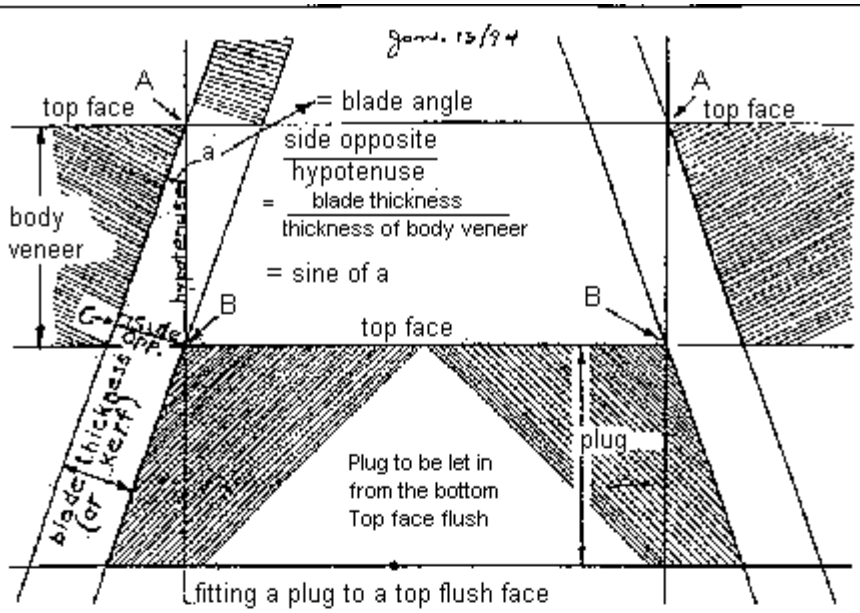


FIG. 1

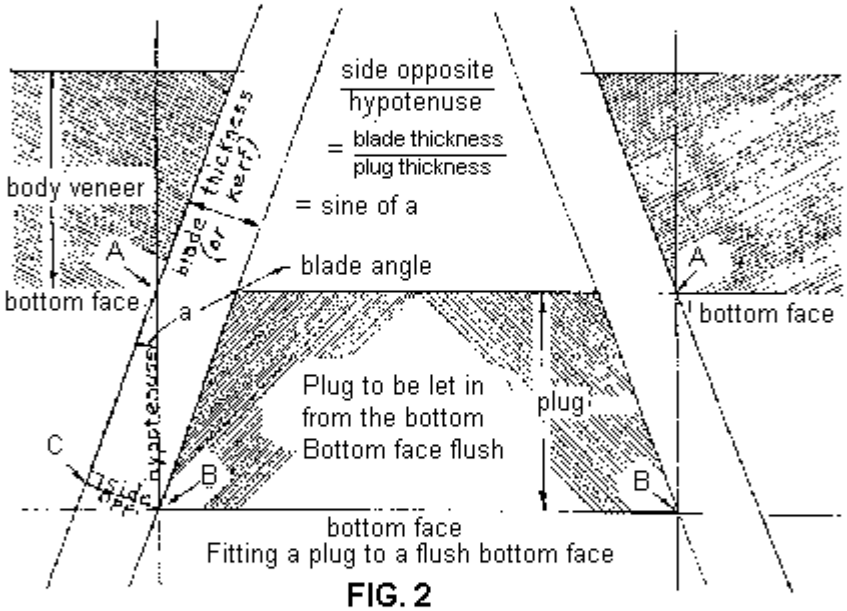
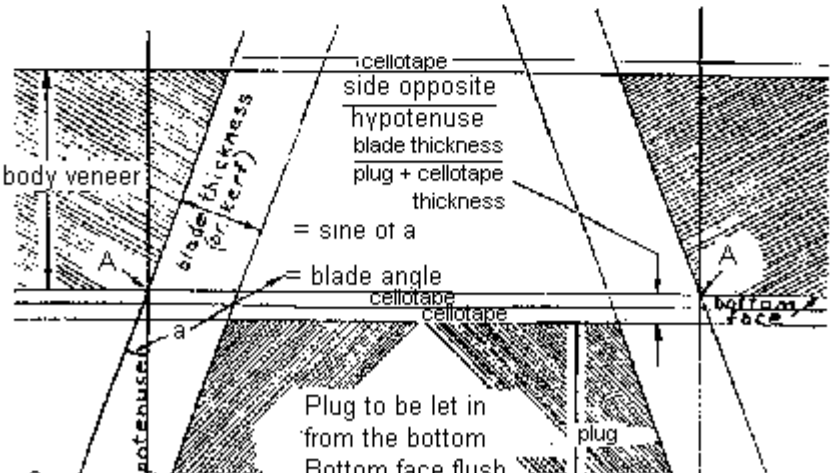


FIG. 2



All that remains is to decide whether all this has any real practical value, and if so, how to use it. I believe it has, if only to give some marquetarians a clearer understanding of what is required to get those tight "invisible" joints that are so desirable. The mathematics and geometry involved inexorably lead us to a "theoretically-perfect method", and this is what every perfectionist wants, isn't it? Of course everyone knows perfection is impossible, so it is your choice as to how far you wish to go along this road. Perhaps you will find among these numbers only a slightly better angle than the one you have been using all along.

A Theoretically-Perfect Method

1. Measure with a micrometer each piece to be inset (i.e., each "plug");
2. If you are using cellotape, add .004" to this thickness;
3. Look up the correct angle in the Table for the saw size you are using;
4. Set the fret saw to this angle for that particular inset piece.

This method will give a theoretically-perfect fit, with a flat back face for easy and solid gluing to a substrate, and all variations in veneer thickness will show up as irregularities on the top face which makes for easy removal by scraping and sanding. When edge gluing by this method, it is important to lay the piece to be inset (the plug) face up on a flat surface, and place the window (the body) over it. If you try to place the plug into the "window" when the body is lying with its upper or picture face against a flat surface, and if the plug is thicker than the body, it will not fit properly.

The equipment required would be a micrometer or caliper capable of measuring to .001", and a means of setting a blade angle accurately on your saw. The latter can be as simple as a protractor fastened to a block of wood with double-sided tape, and stood on your saw table behind the blade while you adjust it. It might also be as complex as a built-in protractor complete with vernier graduated in increments of five minutes of angle.

To conclude, this article could not have been written (and some may wish it hadn't been!) without the able assistance of an engineer friend and former work associate, Mr. Roy Bourke, who with his knowledge of mathematics set me straight on basic trigonometry (which I had forgotten), and who provided valuable expertise and computer time in preparing the table.

Well, there you have it, for better or for worse!!