GEAR CUTTERS

By D D BODLEY-SCOTT FBHI

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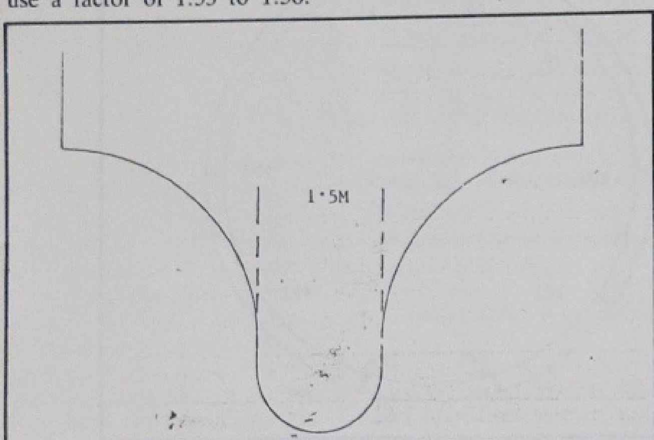
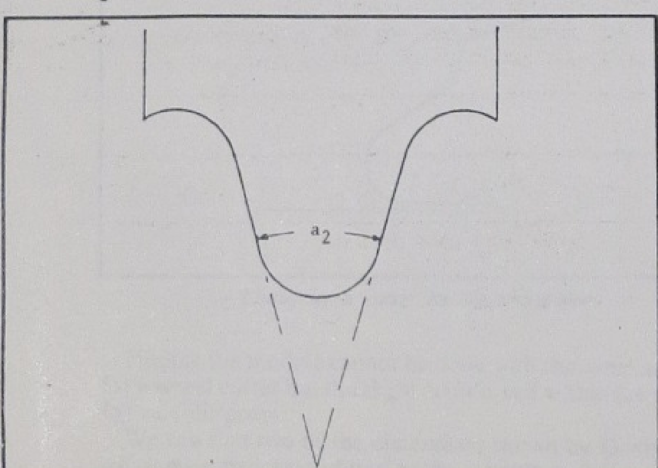
Many readers like myself have been faced with the problem of having assorted gear cutters which carry no identification. There must be some way of finding out the module for which each cutter was designed and, in the case of pinion cutters, for which tooth count. Fortunately, all the necessary information is in "Gears for small Mechanisms," by W O Davis, on data sheet 10. Using this data I shall describe a way of finding these unknowns for constant profile cutters though not involute cutters.

The first question to be answered is whether the cutter is for wheels or pinions. A simple practical answer is to see if the part of the cutter which forms the space between the dedenda has parallel sides or sides at an angle to each other. For the tooth numbers we use, a wheel cutter forms a dedendum with parallel sides. Davis shows in the data sheet that the width of the cutter is 1.5 times the module. It is a simple matter to measure the width of the cutter in millimetres and divide by 1.5 to give the module for that particular cutter. I have measured the wheel cutters made by P P Thornton from 0.2 to 0.8 module and find that they use a factor of 1.53 to 1.56.

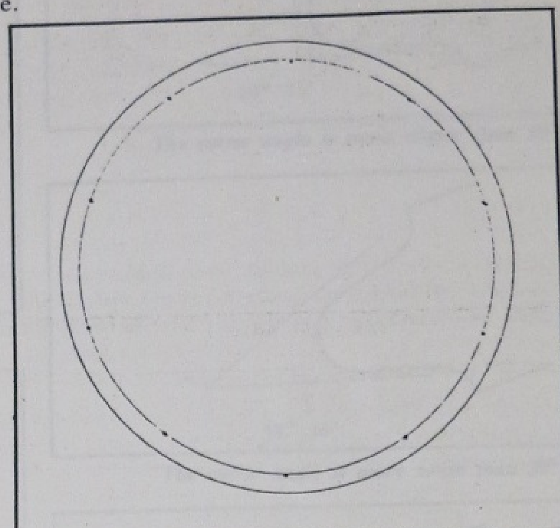


Profile of wheel cutter to show that a factor of 1.5 multiplied by the width gives the module.



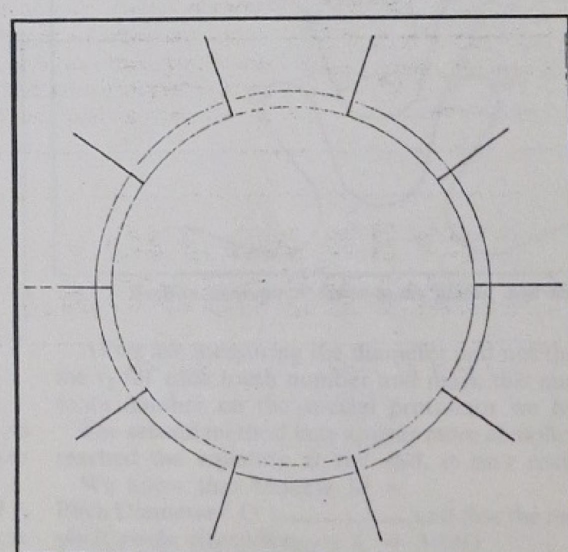
Profile of a six-tooth pinion cutter with an included angle of 38° 36′.

Pinion cutters are not so easy. First of all we have to find the angle between the two sides of the cutter. Davis calls this a_2 a_2 which varies from 30° 36' for a 6-tooth pinion to 10° 46' for a 20-tooth pinion. A special protractor to find this angle is easy to make.



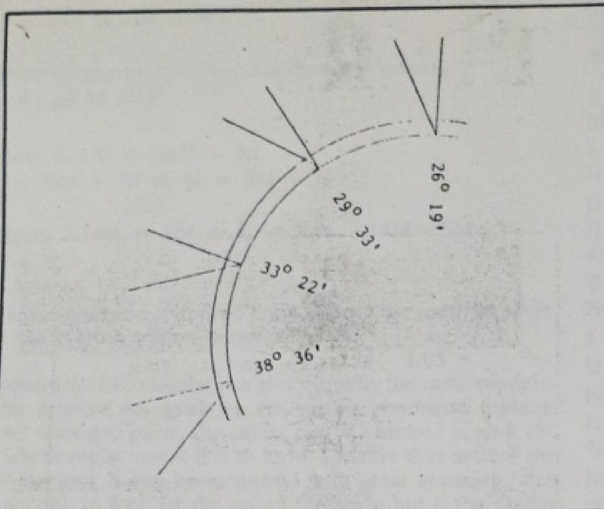
Marking out 10 points for the special protractor.

On a piece of firm, thin, transparent plastic draw with a sharp point two circles about 50 and 54mm diameter from the same centre. Mark 10 approximately equally spaced points around the circumference of the 50mm circle. With a ruler located from the centre, extend a radius for a fair distance from each of these points. Using a protractor with its centre placed on each of these 10 points in turn mark the following angles to the radii.
38° 36', 33° 22', 29° 33', 26° 19', 23° 43', 17° 51', 15° 20', 13° 26', 11° 57', 10° 46'.
Complete the angles as shown in the drawing and mark each with its tooth number, cut along the 54mm circle.

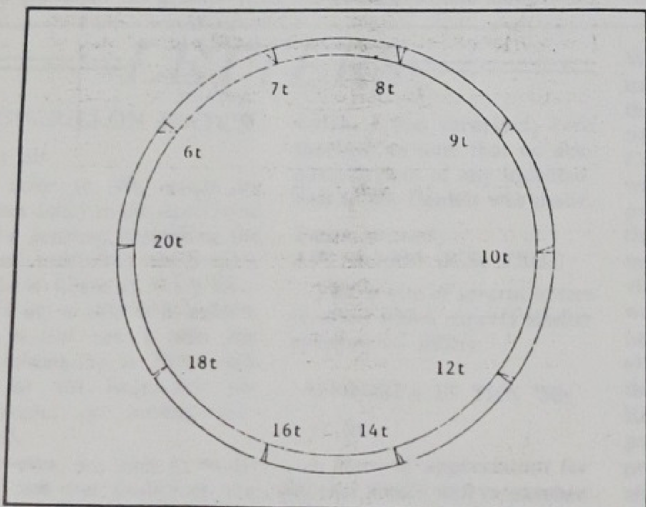


The radial lines.

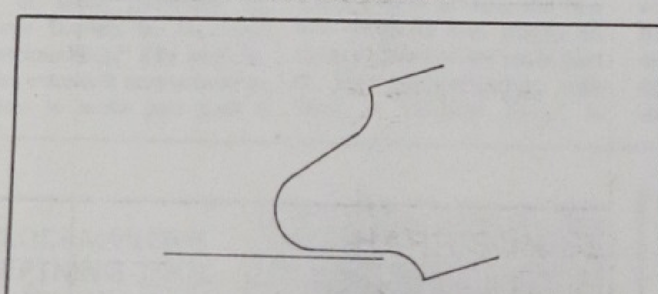
Using a magnifying glass hold one side of the dedendum part of the cutter against a radial line and see if the other side coincides with the angled line; if not, turn it to another position on the disc until the correct angle is found. This will give the pinion tooth number for the cutter.



The angles marked.



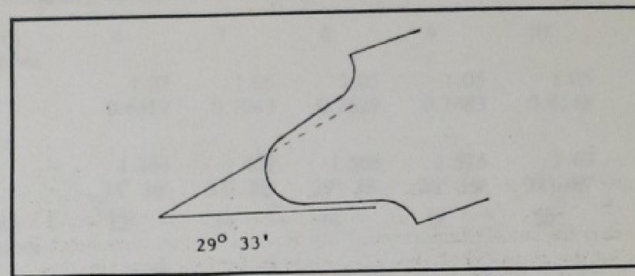
The finished protractor.



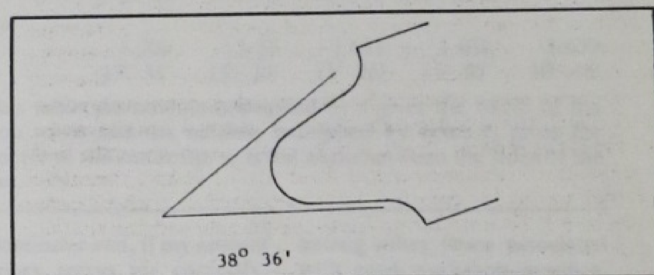
Lining up a cutter on the radial line.

Finding the module cannot be done with the same accuracy as for a wheel cutter but the slight error is still within the tolerances for our purposes.

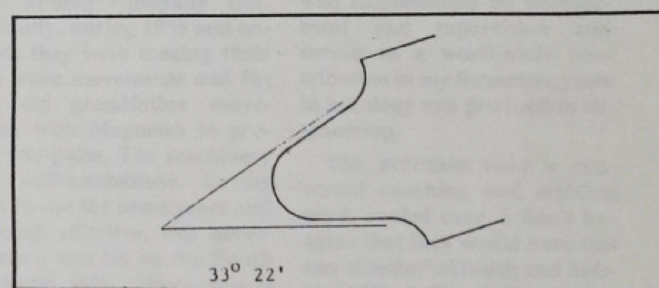
We can find two of the dimensions shown by Davis. S and r_2 which gives two ways of finding the module so that a cross check can be made on the accuracy of this method. The module multiplied by r_2 is the radius of the tip of the cutter. Under the eyeglass the diameter of the tip can be measured with reasonable accuracy with a micrometer. This is, of course, twice the size of r_2. If our special protractor had shown that our unknown cutter was for a 6-tooth pinion we now look at r_2 on the data sheet. The data sheet shows that r_2 of a 6-tooth pinion is 0.64 times the module so the diameter of the tip is twice this or 1.28 times the module. In other words, divide the measured diameter by 1.28 and the answer is the module for the 6-tooth pinion cutter.



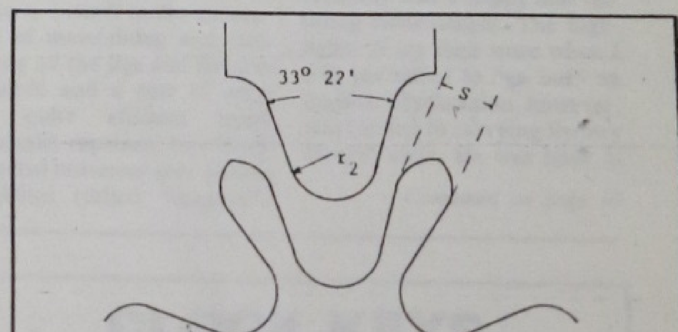
The cutter angle is more obtuse than 29° 33'.



The cutter angle is more acute than 38° 36'.



The cutter coinciding with 33° 22' is a seven-tooth cutter.



Section through a seven-tooth pinion and its cutter.

As we are measuring the diameter and not the radius, double the r_2 for each tooth number and mark this number next to its tooth number on the special protractor we have made.

The second method may appear more complicated but, having reached the equation at the end, it isn't really so difficult.

We know that Module M = Pitch Diameter (D)________ and that the tooth number (t) pitch circle circumference C = 3.14D

The pitch circumference is made up of an equal number of spaces and teeth. The width of a tooth S has a fixed relationship to the module; for example with 6-teeth S = 1.05M. We shall call this relationship SM. The space taken by the cutter at the pitch circle can be measured with reasonable accuracy, this will be X.

So the pitch circle circumference C of a pinion with t teeth is SMt + Xt.

As $C = 3.14\,D$ and $D = \frac{C}{3.14}$

substitute in our formula for the module, namely

$M = D$ and $M = \frac{C}{3.14t}$

we know that $C = SmT + Xt$

so $M = \frac{Smt + Xt}{3.14t}$ or $M = \frac{SM + X}{3.14}$

simplify to $3.14M = SM + X$ or $X = 3.14M - SM$

so $M = \frac{X}{3.14 - S}$

We have measured X and we know S from the tooth number so for our 6-tooth pinion cutter $M = \frac{X}{3.14 - 1.05}$

Hopefully the two calculations give virtually the same module. Since for most of our work we are cutting pinions as replacements for damaged parts, the cutter can be checked against the pinion whose replacement it is to form. I realise that neither the tip diameter nor X can be measured with great accuracy, also that X should, in fact, be the arc of the circle but if the reader would like to experiment with some known cutters I think he will find the error no greater than 5%, which would identify an unknown .35 module cutter as being between .333 and .367.

I have identified a hundred assorted watch wheel and pinion cutters by this method, some as small as a 0.09 module for a 7-tooth pinion. Each is kept in a round plastic box labelled with the necessary details.

Tooth Number	6	7	8	9	10
s	1.05	1.05	1.05	1.05	1.05
r_2	0.6419	0.7045	0.7529	0.7883	0.8148
twice r_2	1.284	1.409	1.506	1.576	1.63
a_2	38° 36'	33° 22'	29° 33'	26° 19'	23° 43'
Tooth Number	12	14	16	18	20
s	1.25	1.25	1.25	1.25	1.25
r_2	0.7528	0.7850	0.8083	0.8255	0.8394
twice r_2	1.506	1.57	1.617	1.651	1.679
a_2	17° 51'	15° 20'	13° 26'	11° 57'	10° 46'

In this table the module multiplied by s gives the width of the pinion tooth and the module multiplied by twice r_2 gives the diameter of the cutter tip. a_2 is the angle between the sides of the cutter.

LETTERS

TOURBILLON WATCH

Dear Sir

I refer to the article by Peyton Autry in the April issue of the Journal, describing the seventh tourbillon watch made by Gene Clark in the USA.

It is not al all easy to achieve such a feat and I offer my congratulations to Mr Clark and to his engraver, Mr McKenzie, on having succeeded.

However, no man is an island, and the design of the movement is clearly based on one of those published by George Daniels in his book "Watchmaking." The book includes extensive instructions as to how to make just such a watch. I was surprised, even shocked, to note that no acknowledgment of any indebtedness to Mr Daniels was made.

Yours sincerely
A G Randall (B.Sc FBHI)

This is one of several letters received which express similar opinions — Editor.

MAGNETA IN THE '30s

Dear Sir,

A word of appreciation for Derek J Bird's well researched letter in the June edition. I feel it is wrong to advance the view that Magneta was simply an agency. I served the early part of my apprenticeship with them at Carteret Street in Westminster and, if my ancient memory serves me correctly, they were known as the Magneta Timing Company Ltd. Certainly, during 1935 and onward, they were making their own slave movements and fitting old grandfather movements with Magnetos to provide the pulse. The machinery was well-established, having been in use for some years and although effective, was nevertheless a wee bit on the Heath Robinson side. There was a power press shop and some fly presses, a small toolroom capable of maintaining and producing all the jigs and fixtures required and a pair of early but quite efficient semi-automatic capstans, two hand-operated universal gear cutting machines (called "engines"), among other items associated with good workshop practice. What was lacking in plant was well compensated by management and supervision and served as a worthwhile contribution in my formative years in horology and production engineering.

The premises were a converted coaching and stabling yard, roofed over. I don't imagine that they would have met any of today's Health and Safety at Work Regulations but it certainly was a happy and fulfilling environment. The highlights of my days were when I was permitted to "go out" on repairs. My function, however, was limited to carrying Sydney Danks' tools. He was later to

Continued on page 18

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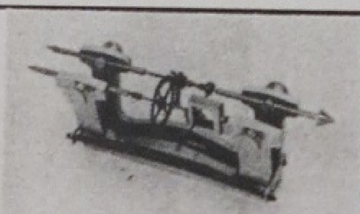

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