BRITISH STANDARD FOR GEARS FOR INSTRUMENTS AND CLOCKWORK MECHANISMS PART 2. CYCLOIDAL TYPE GEARS

FOREWORD

This British Standard supersedes B.S. 978, 'Gears for clockwork mechanisms', which was published in 1941 as a war emergency measure to assist in the reduction of types and sizes of both gears and cutters.

As a result of experience gained in its use it became evident that a revision was necessary and it was considered desirable to divide the standard into four separate parts as follows:-

Part 1. Involute spur, helical and crossed helical gears.
Part 2. Cycloidal type spur gears.
Part 3. Bevel gears.
Part 4. Worm gears.

Each part will be published as it becomes available.

Suitable hobs and cutters will be dealt with in a later British Standard.

The provisions of this part differ substantially from those of the original B.S. 978, as a cycloidal type of gear has been substituted for the circular arc form. The standards of the Swiss and Black Forest watch and clock industries, particularly the former, have been used as a basis; this was considered desirable because of the prevalent use of those standards of horological work and other applications where a cycloidal form is preferred.

An explanation of this type of gearing, as applied to wheels driving pinions, is included in Appendix A.

Arising out of discussions which have taken place in connection with the work undertaken by the International Organization for Standardization on gears, there are indications that it may be possible to simplify the provisions of the standard in regard to tooth form and proportions. It is intended to give further attention to this subject when more evidence is available.

SECTION ONE : GENERAL

Scope

1. This part applies to cycloidal type spur gears for spring or weight-driven mechanisms in which:

a. the pinion is the driven member, or
b. the pinion is required to act sometimes as the driver and sometimes as the driven member.

For integrating electricity meters the particular form of gear specified herein is not necessary and it is recognised that other existing forms of gear will continue to be used.

Terminology and notation

2. The terms and notation shall be as defined in B.S. 2519, 'Glossary of terms and notation for gearing.' For the convenience of users of the standard, an abbreviated list of symbols is given in Appendix B.

Range of standard modules

3. The standard modules shall be as set out in Table 1, preferred sizes being shown in bold type.

* In course of preparation.

TABLE 1. RANGE OF MODULES
(dimensions in millimetres)

Modules		
0.079	**0.150**	0.320
0.0725		0.340
0.075	0.155	0.360
0.0775	0.160	0.380
0.080	0.165	**0.400**
	0.170	
0.0825	0.175	0.420
0.085	0.180	0.440
0.0875	0.185	0.460
0.090	0.190	0.480
0.0925	0.195	**0.500**
0.095	**0.200**	
0.0975		0.550
0.100	0.210	**0.600**
	0.220	
0.105	0.230	0.650
0.110	0.240	**0.700**
0.115	**0.250**	
0.120		0.750
0.125	0.260	**0.800**
0.130	0.270	
0.135	0.280	0.850
0.140	0.290	0.900
0.145	**0.300**	0.950
		1.000

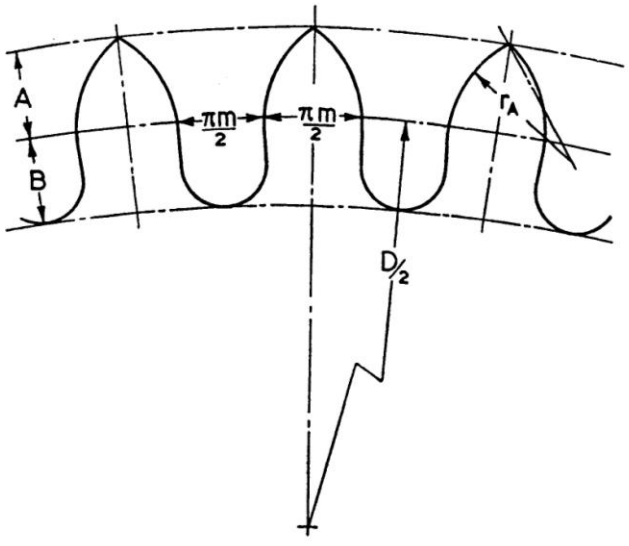

Fig. 1. Tooth proportions for wheels driving pinions in accordance with Clause 4

TABLE 2. PROPORTIONS OF DRIVING WHEELS

Tooth thickness along pitch circle		1.57 *m*
Addendum A		*fm*
Dedendum B		1.57 *m*
Radius of curvature of addendum r_A		mf_r
Pitch diameter	D	T*m*
Outside diameter	D_a	D + 2*fm*
Root diameter	D_r	D – 3.14*m*

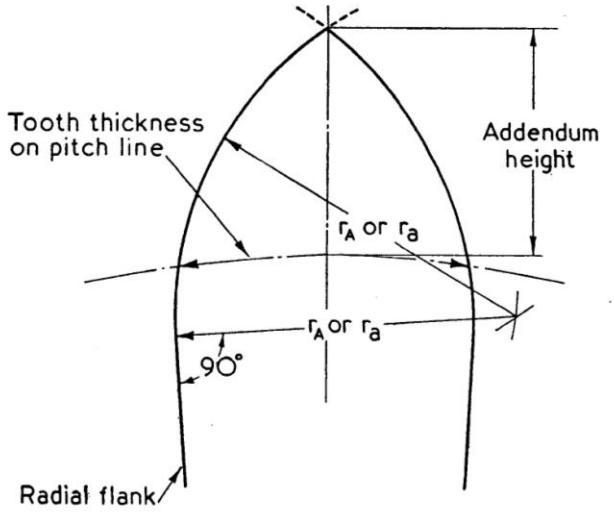

Fig. 2. Construction for position of centre of curvature of addendum

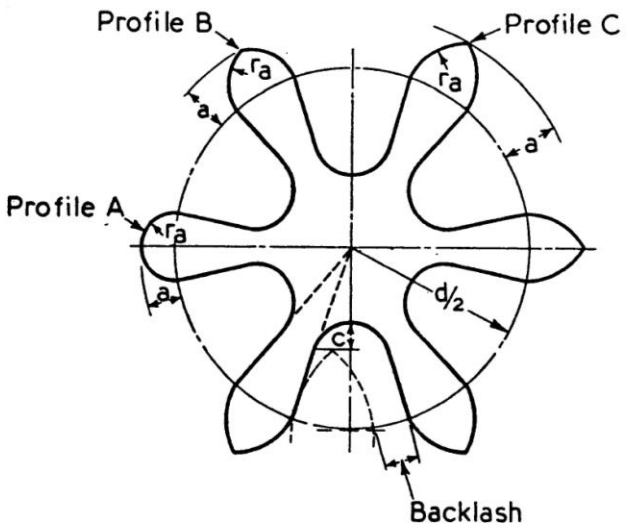

Fig. 3. Proportions for driven pinions with alternative addendum profiles

SECTION TWO : TOOTH FORM AND PROPORTIONS

Wheels driving pinions

4. *a. General.* The teeth of wheels driving pinions designed in accordance with Clause 5 shall have the proportions given in Table 2 and Fig. 1.

Values for f and f_r, appropriate to the gear ratio and the number of teeth in the pinion, shall be obtained from Table 3 (overleaf), or Charts 1 and 2.

The addendum height and the radius of curvature of the addendum shall be in accordance with Table 2. The centre of curvature for the addendum curve shall be chosen so that the curve and the centre line of the tooth intersect on the addendum circle; the radial flank is tangential to this curve (see Fig. 2). The bottom of the tooth spaces shall be approximately semi-circular (see Fig. 1).

Wheels designed in accordance with the provisions of this clause are only suitable to drive pinions designed in accordance with Clause 5.

The two addendum curves intersect at the addendum circle

TABLE 4. PROPORTIONS OF DRIVEN PINIONS (see Fig. 3)

			Number of teeth (t)	
			6–10	11 and over
Tooth thickness along pitch circle			1.05 m.	1.25 m.
Pitch diameter		d	tm	tm
Outside diameter		d_a	$d + 2a$	$d + 2a$
Root diameter		d_r	$d - 2b$	$d - 2b$
Dedendum		b	$(f + 0.4)m$	$(f + 0.4)m$
Bottom clearance		c	0.4 m.	0.4 m.
Minimum backlash			0.52 m.	0.32 m.
*Addendum	Profile A		0.525 m.	0.625 m.
	Profile B	a	0.67 m.	0.805 m.
	Profile C		0.855 m.	1.05 m.
*Radius of curvature of addendum	Profile A		0.525 m.	0.625 m.
	Profile B	r_a	0.70 m.	0.84 m.
	Profile C		1.05 m.	1.25 m.

* See Clause 5, 3rd and 4th paragraphs.

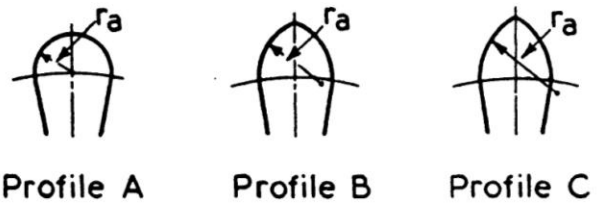

Fig. 4. Pinion addendum profiles

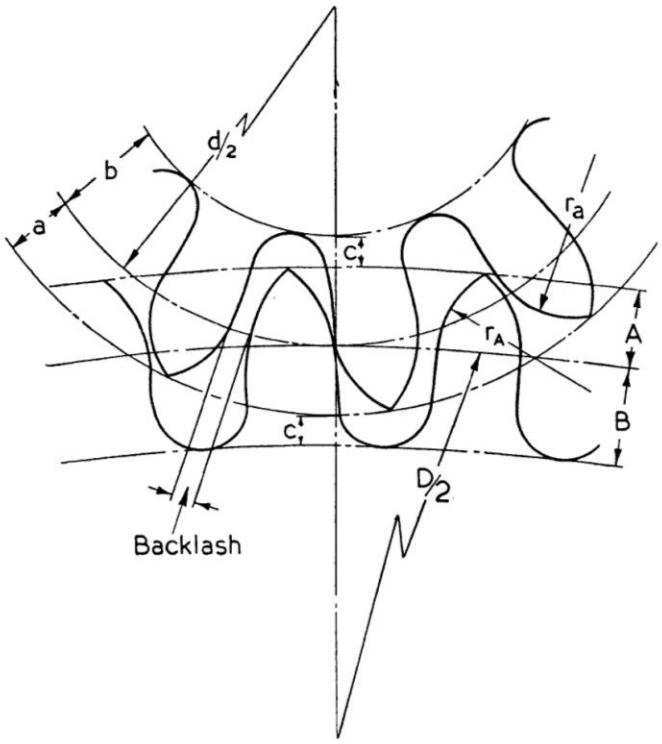

Fig. 5. Tooth proportions for gears in accordance with Clause 5

Driven pinions

5. The teeth of pinions to be driven by wheels designed in accordance with Clause 4 shall have the proportions given in Table 4, appropriate to the number of teeth.

The centres of curvature for the addendum curves shall be chosen so that the curves and the centre line of the tooth intersect in the addendum circle; the radial flank is tangential to this curve (see Fig. 2). The bottom of the tooth spaces shall be approximately semi-circular (see Fig. 3).

Three different addendum profiles are given, with different values for the addendum and the radius of curvature (see Fig. 4). In general these profiles are used under the following conditions:

Profile A	10 teeth and over
Profile B	8 and 9 teeth
Profile C	6 and 7 teeth

TABLE 3. VALUES OF ADDENDUM FACTOR (f) AND ADDENDUM RADIUS FACTOR (f_r)

Ratio	6 Teeth		7 Teeth		8 Teeth		9 Teeth		10 Teeth	
T/t	f	f_r	f	f_r	f	f_r	f	f_r	f	f_r
3	1.259	1.855	1.335	1.968	1.403	2.068	1.465	2.160	1.523	2.244
4	1.280	1.886	1.359	2.003	1.430	2.107	1.494	2.202	1.554	2.290
5	1.293	1.906	1.374	2.025	1.447	2.132	1.513	2.230	1.574	2.320
6	1.303	1.920	1.385	2.041	1.459	2.150	1.526	2.249	1.588	2.341
6½	1.307	1.926	1.389	2.048	1.464	2.157	1.531	2.257	1.594	2.349
7	1.310	1.930	1.393	2.053	1.468	2.163	1.536	2.263	1.599	2.356
7½	1.313	1.934	1.396	2.058	1.471	2.169	1.540	2.269	1.603	2.363
8	1.315	1.938	1.399	2.062	1.475	2.173	1.543	2.274	1.607	2.368
8½	1.318	1.942	1.402	2.066	1.478	2.177	1.547	2.279	1.610	2.373
9	1.320	1.944	1.404	2.069	1.480	2.181	1.549	2.283	1.613	2.377
9½	1.321	1.947	1.406	2.072	1.482	2.184	1.552	2.287	1.616	2.381
10	1.322	1.949	1.408	2.075	1.484	2.187	1.554	2.290	1.618	2.385
11	1.326	1.954	1.411	2.080	1.488	2.193	1.558	2.296	1.623	2.391
12	1.328	1.957	1.414	2.084	1.491	2.197	1.561	2.301	1.626	2.397

Ratio	12 Teeth		14 Teeth		15 Teeth		16 Teeth	
T/t	f	f_r	f	f_r	f	f_r	f	f_r
3	1.626	2.396	1.718	2.532	1.760	2.594	1.801	2.654
4	1.661	2.448	1.756	2.589	1.801	2.654	1.843	2.715
5	1.684	2.482	1.782	2.626	1.827	2.692	1.870	2.756
6	1.700	2.505	1.799	2.652	1.845	2.719	1.889	2.784
6½	1.707	2.516	1.807	2.662	1.853	2.730	1.897	2.795
7	1.712	2.523	1.812	2.671	1.859	2.739	1.903	2.804
7½	1.717	2.530	1.818	2.679	1.864	2.748	1.909	2.813
8	1.721	2.536	1.822	2.686	1.869	2.755	1.914	2.820
8½	1.725	2.542	1.827	2.692	1.874	2.761	1.919	2.827
9	1.728	2.547	1.830	2.697	1.878	2.767	1.923	2.833
9½	1.731	2.552	1.834	2.703	1.881	2.773	1.926	2.839
10	1.734	2.556	1.837	2.707	1.884	2.777	1.929	2.844
11	1.739	2.563	1.842	2.715	1.890	2.785	1.935	2.852
12	1.743	2.569	1.847	2.722	1.895	2.792	1.940	2.859

It should be noted, however, that profiles A and B may, in certain circumstances, be used with advantage for pinions with smaller numbers of teeth than those given above.

Wheels and Pinions for Trains in Which the Pinion may act Sometimes as the Driver and Sometimes as the Driven Member

6. The proportions for wheels and pinions for trains in which the pinion may act sometimes as the driver and sometimes as the driven member shall be in accordance with Table 5 and Fig. 5.

The centres of curvature for the addendum curves shall be chosen so that the curves and the centre line of the tooth intersect on the addendum circle; the radial flank is tangential to this curve (see Fig. 2).

The roots of the teeth shall be approximately semi-circular.

For minute to hour reduction trains, winding trains and hand setting trains, involute teeth in accordance with Part 1 of this standard, 'Involute spur, helical and crossed helical gears,' should be used.

The values of f and f_r appropriate to the number of teeth in the gear shall be obtained from Table 6.

TABLE 5. PROPORTIONS OF WHEELS AND PINIONS FOR TRAINS IN WHICH THE PINION MAY ACT SOMETIMES AS THE DRIVER AND SOMETIMES AS THE DRIVEN MEMBER

Tooth thickness along pitch circle		1.41 m.
Pitch diameter	D or d	Tm or tm
Addendum	A or a	fm
Dedendum	B or b	1.75 m.
Radius of curvature of addendum	r_A or r_a	$f_r m$
Bottom clearance	c	B – a or b – A
Minimum backlash		0.32 m.

TABLE 6. VALUES OF ADDENDUM FACTOR (f) AND ADDENDUM RADIUS FACTOR (f_r) FOR NORMAL DRIVES

Number of teeth in gear (T or t)	Addendum factor (f)	Addendum radius factor (f_r)
8	1.16	1.85
9	1.17	1.87
10, 11	1.19	1.90
12, 13	1.20	1.92
14 to 16	1.22	1.95
17 to 20	1.24	1.98
21 to 25	1.26	2.01
26 to 34	1.27	2.03
35 to 54	1.29	2.06
55 to 134	1.31	2.09
135	1.32	2.11