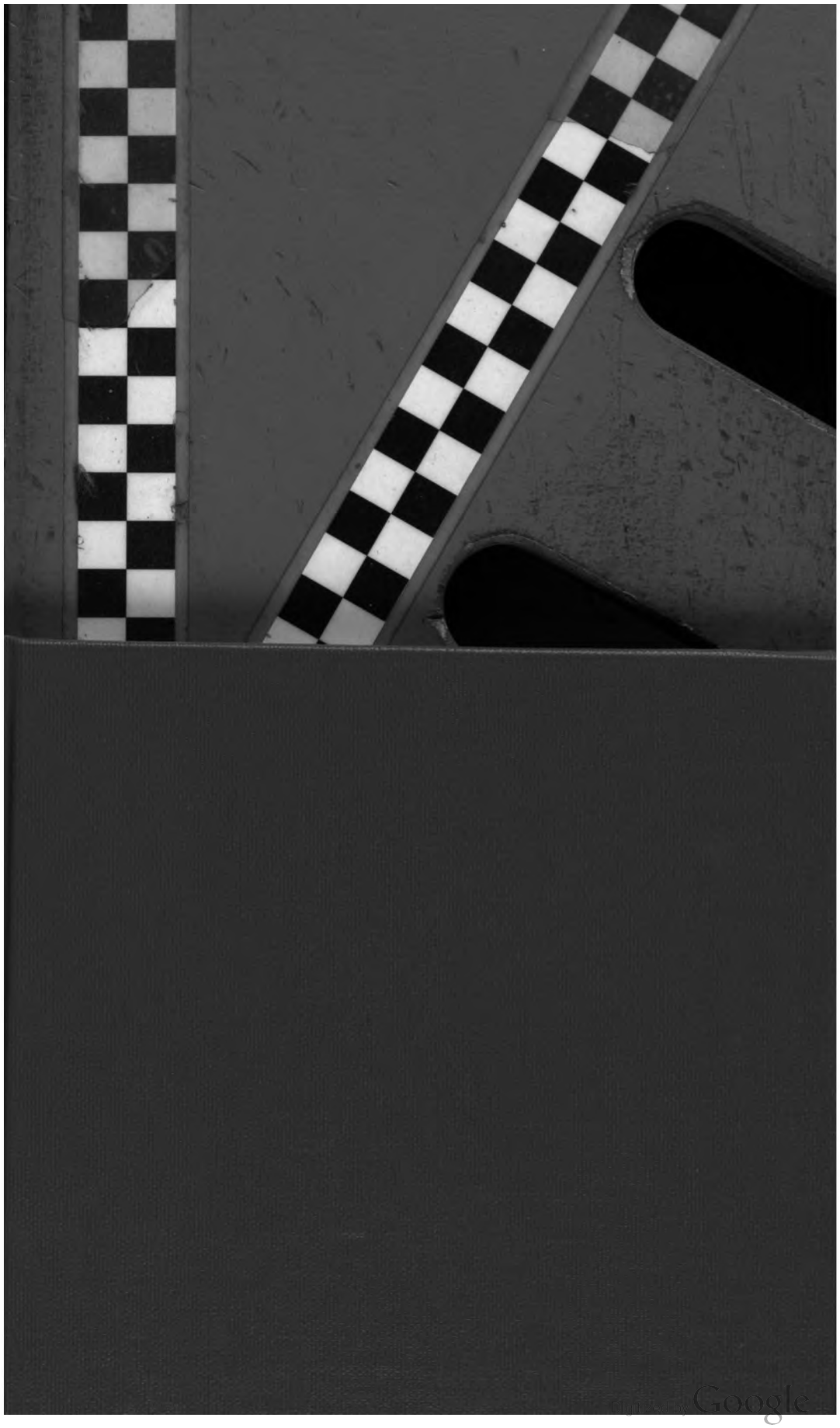

WHEELS AND PINIONS

AND

HOW TO DETERMINE THEIR EXACT SIZE

WITH

NINE TABLES AND ONE PLATE

BY

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TRANSLATED AND EDITED WITH ADDITIONS

BY

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PREFACE.

Exact knowledge of the true relative total diameters of wheels and pinions to be established in watches is of comparatively recent date. It is not more than twenty-five years ago that anything like scientific data touching the solution of this problem was given to the world. The original of the present treatise, a translation of which now appears for the first time in the English language, was published in French, in the *Journal Suisse d'horlogerie* in 1879. Before that, approximations, more or less exact, were all that we possessed. It was, of course, at all times easy to determine the relative diameters of the primitive circles of wheel and pinion gearing into each other, from their center distance, etc., but the quantity to be added to these diameters in order to obtain the best possible transmission of power, even while the correct form of the addenda was known, was a more difficult task, in watches at least, owing to the low numbered pinions that have to be employed in them and the consequent utilization, in many places, of the entire driving capacity of the tooth out to the very apex of its addendum, in order to avoid as much as possible the driving before the line of centers.

This task is now accomplished, and in the present treatise the watchmaker has a convenient manual, in the form of tables by means of which he can find immediately and without any figuring the exact size of wheel or pinion to be replaced. There is no more "cutting and trying," and no more rounding up necessary after a wheel has been put in. The workman, having measured the center distance, finds in the tables the correct size of the missing wheel or pinion for that center distance, and either proceeds to cut one just right, or selects one from a stock already cut. It is, however, necessary that the chapter on "observations concerning the use of the tables" be carefully read and understood. To this I would add that in tables III to X the integrals of the quantities between two successive whole numbers have been omitted, the fractions only being given, and the last preceding integral has to be taken with each fraction as the whole quantity sought.

Although for the every day practical use of the watchmaker the tables are all that is necessary, I have nevertheless thought it well to add the formulæ, and their mathematical development, by which the tables are calculated and constructed, in case a wheel or pinion of a combination of numbers other than those found in the tables should have to be replaced. In such a case the workman familiar with trigonometry can readily find the required total diameter by the use of the formulæ, or if not conversant with mathematics can request some one who is, to solve them for him. But the tables contain all the combinations of numbers usually occurring in watches.

I have taken the liberty to amplify an expression here and there for the sake of greater clearness, as well as to make additions where I thought the needs of the repairer required it.

THE TRANSLATOR.

August 19, 1896.

OBSERVATIONS CONCERNING THE USE OF THE TABLES.

These tables have been calculated for wheels and pinions that are made according to principles generally adopted, viz:

Pinions of ten leaves and below, have a thickness of leaves equal to one-half the space between, i. e., one third of their pitch. Pinions of 12 and 14 have the thickness of their leaves equal to $\frac{2}{5}$ of their pitch. The sides of the leaves are radii and the exedants semi-circles.

The wheels have teeth of a width equal to the space between them. The exedant is epicycloidal, generated by a circle equal to one half the diameter of the primitive circle of the pinion. The teeth of wheels that have been rounded with the Ingold fraise have a form nearest approaching the epicycloid.

For the dial wheels, whose depth should have very little play, the proportion of the width of the teeth to the spaces between them is given in each table. The teeth of these wheels are as wide as the spaces, and the addenda of the pinions as well as those of the wheels are epicycloidal, generated by a circle whose diameter is equal to half that of the primitive circle of the wheel or pinion into which they gear. The sides of the teeth of wheels and leaves of pinions should be radii.

The more nearly wheels and pinions are made according to the principles here enunciated, the nearer will they approach the sizes given in the tables, and the more perfectly will they transmit the force communicated to them. With a little practice and attention it will be easy to make changes according as the case may require. Thus, a pinion whose leaves are too thick must be taken a trifle larger than the measure indicated, and will require a wheel with the spaces a little wider than the teeth and the addenda a little shorter. The contrary must be followed for a pinion whose spaces are too open, etc.

Some watchmakers, basing their opinion on an observation made by Camus, and reproduced by M. Saunier[1] want their pinions a little smaller than the measure indicated. I am of the opinion that it is better to select pinions as near the right size as possible. These pinions will, nevertheless, be generally a little smaller in their primitive diameters than the ideal size would be, and for the following reasons:

1st. Pinions, such as we more often find them, are ordinarily too full, i. e., their leaves are thicker than they ought to be, which increases the height of the addenda.

2nd. These addenda have generally a form too oval, approaching the form of a semi-ellipse rather than that of a semi-circle.

1. Treatise on Modern Horology, p. 1099, and *Revue Chron.*, 1875, p. 215.

3rd. The teeth of wheels, such as the rounding up cutters leave them, have almost always too short addenda, which, relatively to its total diameter, implies a larger primitive circle, corresponding to a pinion smaller in proportion than it ought to be.

Table I, which is the basis of this whole work, has been calculated with the utmost care. Still, having from the start assumed sufficient to calculate the driving angle of wheel and pinion to one second approximately, more or less, it follows that the fourth figure of the decimals in this table is not always absolutely exact; as, however, the errors arising from this cannot exceed one or two ten thousandths, I found it better to let them stand as they are, rather than drop them and increase the preceding figure by one, which necessarily would have brought in some errors greater than four ten thousandths.

As to the tables II to IX, their utility will be made apparent by the following example:

Suppose that both dial wheels, but not the cannon pinion, are missing in a watch. The cannon pinion has 12 leaves and its diameter is 2.48 millimeters. Looking in table VIII for column headed cannon pinion and the number 2.48, we will find on the same horizontal line the diameters of the three other pieces, hour wheel, intermediate, and intermediate pinion, as well as the center distance of the latter, at which the tenon should be placed, which is 4 millimeters.

In like manner, having to replace, say an escape wheel pinion of six leaves, gearing into a wheel of sixty teeth and appropriate to a center distance of 8 militers, we look in table VII, and in the column of center distances for the latter number and on the same horizontal line of the columns relating to it, we find the diameters of both wheel and pinions necessary, viz: 1.71 for the pinion and 15.22 for the diameter of wheel. In this connection it is important to observe that it is wise never to depend on the size of the remaining wheel or pinion to which the other is to be replaced and matched, but to measure the center distance and go by it, because the depth may originally have been badly pitched, or the wheel may have been of defective proportions from the start. By measuring the center distance and taking it as a guide, it will be shown by the figures in the columns corresponding to it whether such is the case, and if so, and the error is important enough, both wheel and pinion should be changed.

Tables II to IX have been made up by multiplying every center distance by the figures in table I, columns T and K (see bottom of table). In the same way the diameters of wheel and pinion may be found for any other center distance than those found in the tables.

It will be observed that it is immaterial what system of measurement is employed in the use of the tables, whether that of the English inch or the metric, provided the unit adopted is decimally divided. Nor is the use of the system by douziemes precluded, for, in the example quoted above for the selection of dial wheels, we may take the numbers 2.48 as 24.8 douziemes, or for 248 douziemes, and the center distance will be 40 douziemes in the first and 400 douziemes in the second case. But the use of the tables is certainly more convenient in the employment of a decimal system.

How to Determine the Diameters of Wheels and Pinions in Watch Work.

To Mr. Isely, professor of mathematics at Neuchatel (Switzerland) is due the credit of having opened the way to works of the nature of the present one, in publishing[1] the first mathematically calculated tables giving the value of the exedants (addenda) of wheels and their total diameter relative to that of pinions into which they gear. Before him there existed only the tables of Mr. Dauphin[2] and those of Mr. Ch. Ed. Jacot[3] obtained by the graphic method, and insufficiently accurate.

Besides that of Mr. Isely, several methods have been proposed for the calculation of the addenda of wheels; thus, that of Mr. Resal[4] and that of Mr. Saunier[5] which scarcely differs from that taught by Mr. J. Grossman, for some time past, at the Horological school of Locle.

The calculations, according to all these methods, are somewhat laborious, and the work of approximation by the following method is much more rapid. Unfortunately, the latter did not occur to me till too late, when all my calculations were already made by the method practiced in Locle. However, it served me the purpose of verifying and checking them.

Method Practiced at Chaux-de-Fonds for Determining the Height of the Epicycloidal Addenda.

See Plate I.

Let r = G P = Primitive radius of wheel.

Let g = A P = A S = radius of generating circle.

Let s = G A = $r + g$ = the distance from the center of the generating circle to center of wheel.

Let a = G S = the total radius of the wheel.

Let A = the angle which the generating circle has moved over from the moment when the tooth of the wheel and leaf of the pinion were first in contact on the line of centers, till the tooth lets go of the pinion leaf.

(1.) Bulletin of the Society of Natural Sciences of Neuchatel, 1873, vol. IX., p. 381.

(2.) *Revue Chronometrique*, July, 1851, vol. III., Suppl't, p. 8. These tables are remarkably exact, and were not sufficiently appreciated at the epoch of their publication.

(3.) Practical studies of depthings, Chaux-de-Fonds, 1867.

(4.) See *Journal Suisse d'horlogerie*, 1st year, p. 72.

(5.) *Revue Chronometrique*, 1875.

Let $M = G + T$ = the angle over which the wheel has turned in the same time.

Let T = the angle corresponding to half the width of the wheel tooth and equal to one-fourth of the pitch.

If we assign to g the value of unity, r will express the relative angular velocities of the two, wheel and generating circle, and consequently the relation between the two angles A and M.

Thus, $A = r\,M = r\,G + r\,T$.

Considering the triangle G A S we find that the value of the angle

$$S = 180° - A - G$$

or

$$S = 180° - r\,(G + T) - G \qquad (a)$$

Moreover, trigonometry teaches that

$$\frac{\text{Sin. } G}{g} = \frac{\text{Sin. } S}{s} \qquad (b)$$

The quantities r, T, g and s figuring in equations (a) and (b) are known. It is therefore only necessary to find, by the method of approximations, a value of G such that, substituted in the two equations the values of S become identical, and we shall possess all the elements for the solution of the problem. It is to be observed that the angle S, being always an obtuse one, it is its supplement and not the angle S itself that we obtain in reducing to figures the equation (b).

For example, let us take a wheel of 48 teeth, driving a pinion of 6, we have:

$$r = 16$$

$$g = 1$$

$$s = 17$$

$$T = \frac{360}{4 \times 48} = 1°\ 52'\ 30''$$

and equation (a) becomes:

$$S = 180° - 16\ (G + 1°, 52', 30'') - G,$$

and equation (b):

$$\text{Sin. Suppl. } S = 17 \text{ sin. } G.$$

If now we suppose[1] the value of $G = 3°, 22', 20''$, equation (a) gives:

$$\text{Suppl. } S = 87°, 19', 40''.$$

and equation (b):

$$\text{Suppl. Sin. } S = 89°, 38', 35''$$

The value given to G is therefore too great.

(1.) We know in a general way that when a pinion, which is driven, has 12 leaves, the angle M is a little greater than the pitch of the wheel teeth; that it is less when the pinion has 10 leaves and becomes smaller by degrees as the pinion leaves are less in number.

After a few trials we give to G the value of $3°, 22', 6.373''$ and we obtain:

(a) Suppl. S $= 87°, 15', 48.341''$, or, S $= 92°, 44', 11.659''$.

(b) Suppl. S $= 87°, 15'\ 48.3''$, or, S $= 92°, 44', 11.7''$.

The difference is insignificant and, except in particular cases, it is not necessary to pursue the approximation as closely.

There remains to be determined the angle A, and the sine (a) which latter is the total radius of the wheel. The angle A $= r$ M, as already found by the equation (a), it is in this case:

$$83°, 53', 41.968''.$$

And as $$\frac{\text{Sin. G}}{g} = \frac{\text{Sin. A}}{a}$$

we have $$\frac{\text{Sin. } 3°, 22', 6.373''}{1} = \frac{\text{Sin. } 83°, 53', 41.968''.}{a}$$

whence

$$a = 16.9228,$$

and the height of the addendum

$$= a - r = 0.9228.$$

If we take the primitive radius of the pinion for unity, instead of that of the generating circle, we have for the total radius of the wheel:

$$\frac{a}{2} = 8.4614.$$

and for the height of the addendum $= 0.4614$.

General Table of the Sizes and Relations of Wheels and Pinions Most Used in Watches.—Table I.

Relation of Primitive Circles.	Number of Teeth in the Wheel.	Number of Leaves in the Pinion.	THE PRIMITIVE RADIUS OF PINION = 1.			PRIMITIVE DIAMETER OF WHEEL = 1.		WHEN CENTER DISTANCE = 1.		Relation of Wheel to Pinion.	Driving Angle before the Line of Centers.	Driving Angle after the Line of Centers.	Thickness of Pinion Leaves.	Pitch of the Pinion.
			Height of Adenda.	Total Diameter of Wheel.	Total Diameter of Pinion.	Total Diameter of Wheel.	Total Diameter of Pinion.	Total Diameter of Wheel.	Total Diameter of Pinion.					
			The Pinions, Etc.								° ′ ″	° ′ ″	° ′	° ′
3	42	XIV	0.2583	6.5167	2.1795	1.0861	0.3633	1.6292	0.5449	2.9900		28 43 26	10 17	25 43
10	120	XII	0.3042	20.6085	2.2094	1.0304	0.1105	1.8735	0.2009	9.3276		32 50 43	12	30
9	108	"	0.3032	18.6064	2.2094	1.0337	0.1227	1.8606	0.2209	8.4215		32 42 53	12	30
8	96	"	0.3019	16.6039	2.2094	1.0377	0.1381	1.8449	0.2455	7.5151		32 33 14	12	30
7.50	90	"	0.3012	15.6025	2.2094	1.0402	0.1473	1.8356	0.2599	7.0619		32 27 30	12	30
7	84	"	0.3003	14.6006	2.2094	1.0429	0.1578	1.8251	0.2762	6.6084		32 21 3	12	30
6.66	80	"	0.2997	13.9327	2.2094	1.0450	0.1657	1.8173	0.2882	6.3061		32 16 15	12	30
6	72	"	0.2983	12.5966	2.2094	1.0497	0.1841	1.7795	0·3156	5.7014		32 5 9	12	30
5	60	"	0.2955	10.5909	2.2094	1.0591	0.2209	1.7652	0.3682	4.7936		31 43 35	12	30
4	48	"	0.2915	8.5829	2.2094	1.0729	0.2762	1.7165	0.4419	3.8847		31 12 37	12	30
3	36	"	0.2853	6.5706	2.2094	1.0951	0.3682	1.6426	0.5524	2.9739		30 24 23	12	30
											° ′ ″			
10	100	X	0.3407	20.6815	2.2094	1.0341	0.1105	1.8801	0.2009	9.3607	0 56 14	35 3 46	12	36
9	90	"	0.3396	18.6792	2.2094	1.0377	0.1227	1.8679	0.2209	8.4545	1 4 17	34 35 43	12	36
8	80	"	0.3383	16.6765	2.2094	1.0423	0.1381	1.8530	0.2455	7.5480	1 14 13	34 45 47	12	36
7.60	76	"	0.3377	15.8754	2.2094	1.0444	0.1454	1.8460	0.2569	7.1854	1 18 53	34 41 7	12	36
7.50	75	"	0.3374	15.6749	2.2094	1.0450	0.1473	1.8441	0.2599	7.0947	1 20 6	34 39 54	12	36
7	70	"	0.3366	14.6731	2.2094	1.0481	0.1578	1.8341	0.2762	6.6412	1 26 46	34 33 14	12	36
6.40	64	"	0.3353	13.4707	2.2094	1.0524	0.1726	1.8204	0.2986	6.0970	1 36 2	34 23 58	12	36
6	60	"	0.3344	12.6689	2.2094	1.0557	0.1841	1.8098	0.3156	5.7341	1 43 9	34 16 51	12	36
5	50	"	9.3314	10.6627	2.2094	1.0663	0.2209	1.7771	0.3682	4.8261	2 5 21	33 54 39	12	36
4	40	"	0.3271	8.6543	2.2094	1.0818	0.2762	1.7309	0.4419	3.9170	2 37 16	33 22 44	12	36
3	30	"	0.3206	6.6412	2.2094	1.1069	0.3682	1.6603	0.5524	3.0059	3 27 2	32 32 58	12	36
10	80	VIII	0.3906	20.7812	2.2618	1.0391	0.1139	1.8892	0.2056	9.1879	6 59 5	38 0 55	15	45
9	72	"	0.3894	18.7789	2.2618	1.0433	0.1257	1.8779	0.2262	8.3027	7 7 23	37 52 37	15	45
8	64	"	0.3880	16.7761	2.2618	1.0485	0.1414	1.8640	0.2513	7.4172	7 17 36	37 42 24	15	45
7.50	60	"	0.3872	15.7744	2.2618	1.0516	0.1508	1.8558	0.2661	6.9743	7 23 40	37 36 20	15	45
7	56	"	0.3864	14.7727	2.2618	1.0552	0.1616	1.8466	0.2827	6.5314	7 30 32	37 29 28	15	45
6	48	"	0.3839	12.7679	2.2618	1.0640	0.1885	1.8240	0.3231	5.6450	7 47 22	37 12 38	15	45
5	40	"	0.3809	10.7618	2.2618	1.0762	0.2262	1.7936	0.3762	4.7581	8 10 15	36 49 45	15	45
4	32	"	0.3762	8.7525	2.2618	1.0941	0.2827	1.7505	0.4524	3.8697	8 48 7	36 11 53	15	45

10	70	VII	0.4234	20.8468	2.2992	1.0423	0.1150	1.8952	0.2090	9.0670	11 30 29	39 55 14	17 8	51 26
9	63	"	0.4222	18.8445	2.2992	1.0469	0.1277	1.8844	0.2299	8.1961	11 38 53	39 46 50	17 8	51 26
8	56	"	0.4208	16.8416	2.2992	1.0526	0.1437	1.8713	0.2555	7.3250	11 49 14	39 36 29	17 8	51 26
7	49	"	0.4190	14.8379	2.2992	1.0599	0.1642	1.8547	0.2874	6.4535	12 1 19	39 23 24	17 8	51 26
11	66	VI	0.4652	22.9304	2.3491	1.0423	0.1068	1.9109	0.1958	9.7615	17 37 15	42 22 45	20	60
10	60	"	0.4641	20.9283	2.3491	1.0464	0.1175	1.9026	0.2136	8.9092	17 44 15	42 15 45	20	60
9	54	"	0.4629	18.9258	2.3491	1.0514	0.1305	1.8926	0.2349	8.0567	17 52 42	42 7 18	20	60
8	48	"	0.4614	16.9229	2.3491	1.0577	0.1468	1.8803	0.2610	7.2041	18 3 9	41 56 51	20	60
7.50	45	"	0.4605	15.9211	2.3401	1.0614	0.1566	1.8731	0.2764	6.7776	18 9 20	41 50 40	20	60
7	42	"	0.4596	14.9192	2.3491	1.0657	0.1678	1.8649	0.2936	6.3512	18 16 21	41 43 39	20	60
6	36	"	0.4573	12.9145	2.3491	1.0762	0.1958	1.8449	0.3356	5.4977	18 33 34	41 26 26	20	60
5	30	"	0.4538	10.9077	2.3491	1.0908	0.2349	1.8179	0.3915	4.6434	18 56 57	41 3 3	20	60

FOR DIAL TRAINS.

The Pinions Alternately Drive and are being Driven.

The Thickness of the Leaves of Pinions are equal to the Spaces.

													WHEEL.
													Width of the Tooth.
4	48	XII	0.2838	8.5829	2.5677	1.0729	0.3210	1.7165	0.5135	3.3437		9 27 33	15	3 45
4	40	X	0.3232	8.6543	2.6465	1.0818	0.3308	1.7309	0.5293	3.2701		10 11 20	18	4 30
4	32	VIII	0.3795	8.7525	2.7589	1.0941	0.3449	1.7505	0.5518	3.1724	0 3 56	11 11 4	22 30	5 38
3	42	XIV	0.2516	6.5167	2.5032	1.0861	0.4172	1.6292	0.6258	2.6033		11 12 21	12 51	4 17
3	36	XII	0.2805	6.5706	2.5610	1.0951	0.4268	1.6426	0.6403	2.5656		11 55 6	15	5
3	30	X	0.3193	6.6412	2.6386	1.1069	0.4398	1.6603	0.6596	2.5170		12 50 15	18	6
			The Thickness of the Leaves of Pinions equal ⅔ their Pitch.										Pitch.
4	48	XII	0.2424	8.5829	2.4847	1.0729	0.3106	1.7165	0.4969	3.4543		8 39 17	12	7 30
4	40	X	0.2757	8.6543	2.5514	1.0818	0.3189	1.7309	0.5103	3.3919		9 18 19	14 24	9
4	32	VIII	0.3228	8.7525	2.6456	1.0941	0.3307	1.7505	0.5291	3.3083	1 3 40	10 11 20	18	11 15
3	42	XIV	0.2051	6.5167	2.4102	1.0861	0.4017	1.6292	0.6026	2.7038		10 16 1	10 17	8 34
3	36	XII	0.2397	6.5706	2.4794	1.0951	0.4132	1.6426	0.6198	2.6501		10 54 16	12	10
3	30	X	0.2725	6.6412	2.5451	1.0069	0.4242	1.6603	0.6363	2.6094	0 16 33	11 43 27	14 24	12
A	B	C	D	E	F	G	H	I	K	L	M	N	O	P

Table II.

Wheels of 80 Teeth.—Pinions of X Leaves.

Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.	
	Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.
0.			4.	0.96	7.41	8.	1.96	14.82	12.	2.95	22.24
.1	0.02	0.19	.1	1.01	.60	.1	.99	15.01	.1	.97	.42
.2	.05	.37	.2	.03	.78	.2	2.01	.19	.2	3.00	.61
.3	.07	.56	.3	.06	.97	.3	.04	.38	.3	.02	.79
.4	.10	.74	.4	.08	8.15	.4	.06	.56	.4	.04	.98
.5	.12	.93	.5	.10	.34	.5	.09	.75	.5	.07	23.16
.6	.15	1.11	.6	.13	.52	.6	.11	.94	.6	.09	.35
.7	.17	.30	.7	.15	.71	.7	.14	16.12	.7	.12	.53
.8	.20	.48	.8	.18	.89	.8	.16	.31	.8	.14	.72
.9	.22	.67	.9	.20	9.08	.9	.18	.49	.9	.17	.90
1.	0.25	.85	5.	1.23	.26	9.	2.21	.68	13.	3.19	24.09
.1	.27	2.04	.1	.25	.45	.1	.23	.86	.1	.22	.27
.2	.29	.22	.2	.28	.64	.2	.26	17.05	.2	.24	.46
.3	.32	.41	.3	.30	.82	.3	.28	.23	.3	.27	.64
.4	.34	.59	.4	.33	10.01	.4	.31	.42	.4	.29	.83
.5	.37	.78	.5	.35	.19	.5	.33	.60	.5	.31	25.01
.6	.39	.96	.6	.37	.38	.6	.36	.79	.6	.34	.20
.7	.42	3.15	.7	.40	.56	.7	.38	.97	.7	.36	.39
.8	.44	.34	.8	.42	.75	.8	.41	18.16	.8	.39	.57
.9	.47	.52	.9	.45	.93	.9	.43	.34	.9	.41	.76
2.	0.49	.71	6.	1.47	11.12	10.	2.45	.53	14.	3.44	.94
.1	.52	.89	.1	.50	.30	.1	.48	.71	.1	.46	26.13
.2	.54	4.08	.2	.52	.49	.2	.50	.90	.2	.49	.31
.3	.56	.26	.3	.55	.67	.3	.53	19.09	.3	.51	.50
.4	.59	.45	.4	.57	.86	.4	.55	.27	.4	.54	.68
.5	.61	.63	.5	.60	12.04	.5	.58	.46	.5	.56	.87
.6	.64	.82	.6	.62	.23	.6	.60	.64	.6	.58	27.05
.7	.66	5.00	.7	.64	.41	.7	.63	.83	.7	.61	.24
.8	.69	.19	.8	.67	.60	.8	.65	20.01	.8	.63	.42
.9	.71	.37	.9	.69	.79	.9	.68	.20	.9	.66	.61
3.	0.74	.56	7.	1.72	.97	11.	2.70	.38	15.	3.68	.79
.1	.76	.74	.1	.74	13.16	.1	.72	.57	.1	.71	.98
.2	.79	.93	.2	.77	.34	.2	.75	.75	.2	.73	28.16
.3	.81	6.11	.3	.79	.53	.3	.77	.94	.3	.76	.35
.4	.83	.30	.4	.82	.71	.4	.80	21.12	.4	.78	.54
.5	.86	.49	.5	.84	.90	.5	.82	.31	.5	.81	.72
.6	.88	.67	.6	.87	14.08	.6	.85	.49	.6	.83	.91
.7	.91	.86	.7	.89	.27	.7	.87	.68	.7	.85	29.09
.8	.93	7.04	.8	.91	.45	.8	.90	.86	.8	.88	.28
.9	.96	.23	.9	.94	.64	.9	.92	22.05	.9	.90	.46

The Leaves of Pinions take up One-third of the Pitch.

Table III.

Wheels of 75 Teeth.—Pinions of X Leaves.

Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.	
	Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.
0.			4.	1.04	7.38	8.	2.08	14.75	12.	3.12	22.13
.1	0.03	0.18	.1	.07	.56	.1	.11	.94	.1	.15	.31
.2	.05	.37	.2	.09	.75	.2	.13	15.12	.2	.17	.50
.3	.08	.55	.3	.12	.93	.3	.16	.31	.3	.20	.68
.4	.10	.74	.4	.14	8.11	.4	.18	.49	.4	.22	.87
.5	.13	.92	.5	.17	.30	.5	.21	.67	.5	.25	23.05
.6	.16	1.11	.6	.20	.48	.6	.24	.86	.6	.28	.24
.7	.18	.29	.7	.22	.67	.7	.26	16.04	.7	.30	.42
.8	.21	.48	.8	.25	.85	.8	.29	.23	.8	.33	.60
.9	.23	.66	.9	.27	9.04	.9	.31	.41	.9	.35	.79
1.	0.26	.84	5.	1.30	.22	9.	2.34	.60	13.	3.38	.97
.1	.29	2.03	.1	.33	.40	.1	.37	.78	.1	.41	24.16
.2	.31	.21	.2	.35	.59	.2	.39	.97	.2	.43	.34
.3	.34	.40	.3	.38	.77	.3	.42	17.15	.3	.46	.53
.4	.36	.58	.4	.40	.96	.4	.44	.33	.4	.48	.71
.5	.39	.77	.5	.43	10.14	.5	.47	.52	.5	.51	.90
.6	.42	.95	.6	.46	.33	.6	.50	.70	.6	.54	25.08
.7	.44	3.13	.7	.48	.51	.7	.52	.89	.7	.56	.26
.8	.47	.32	.8	.51	.70	.8	.55	18.07	.8	.59	.45
.9	.49	.50	.9	.53	.88	.9	.57	.26	.9	.61	.63
2.	0.52	.69	6.	1.56	11.06	10.	2.60	.44	14.	3.64	.82
.1	.55	.87	.1	.59	.25	.1	.63	.63	.1	.67	26.00
.2	.57	4.06	.2	.61	.43	.2	.65	.81	.2	.69	.19
.3	.60	.24	.3	.64	.62	.3	.68	.99	.3	.72	.37
.4	.62	.43	.4	.66	.80	.4	.70	19.18	.4	.74	.56
.5	.65	.61	.5	.69	.99	.5	.73	.36	.5	.77	.74
.6	.68	.79	.6	.72	12.17	.6	.76	.55	.6	.80	.92
.7	.70	.98	.7	.74	.36	.7	.78	.73	.7	.82	27.11
.8	.73	5.16	.8	.77	.54	.8	.81	.92	.8	.85	.29
.9	.75	.35	.9	.79	.72	.9	.83	20.10	.9	.87	.48
3.	0.78	.53	7.	1.82	.91	11.	2.86	.29	15.	3.90	.66
.1	.81	.72	.1	.85	13.09	.1	.89	.47	.1	.93	.85
.2	.83	.90	.2	.87	.28	.2	.91	.65	.2	.95	28.03
.3	.86	6.09	.3	.90	.46	.3	.94	.84	.3	.98	.21
.4	.88	.27	.4	.92	.65	.4	.96	21.02	.4	4.00	.40
.5	.91	.45	.5	.95	.83	.5	.99	.21	.5	.03	.58
.6	.94	.64	.6	.98	14.02	.6	3.02	.39	.6	.05	.77
.7	.96	.82	.7	2.00	.20	.7	.04	.58	.7	.08	.95
.8	.99	7.01	.8	.03	.38	.8	.07	.76	.8	.11	29.14
.9	1.01	.19	.9	.05	.57	.9	.09	.94	.9	.13	.32

The Leaves of Pinions take up One-third of the Pitch.

Table IV.

Wheels of 70 Teeth.—Pinions of VII Leaves.

Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.	
	Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.
0.			4.	0.84	7.58	8.	1.67	15.16	12.	2.51	22.74
.1	0.02	0.19	.1	.86	.77	.1	.69	.35	.1	.53	.93
.2	.04	.38	.2	.88	.96	.2	.71	.54	.2	.55	23.12
.3	.06	.57	.3	.90	8.15	.3	.73	.73	.3	.57	.31
.4	.08	.76	.4	.92	.34	.4	.76	.92	.4	.59	.50
.5	.10	.95	.5	.94	.53	.5	.78	16.11	.5	.61	.69
.6	.13	1.14	.6	.96	.72	.6	.80	.30	.6	.63	.88
.7	.15	.33	.7	.98	.91	.7	.82	.49	.7	.65	24.07
.8	.17	.52	.8	1.00	9.10	.8	.84	.68	.8	.68	.26
.9	.19	.71	.9	.02	.29	.9	.86	.87	.9	.70	.45
1.	0.21	.90	5.	1.05	.48	9.	1.88	17.06	13.	2.72	.64
.1	.23	2.08	.1	.07	.67	.1	.90	.25	.1	.74	.83
.2	.25	.27	.2	.09	.85	.2	.92	.44	.2	.76	25.02
.3	.27	.46	.3	.11	10.04	.3	.94	.63	.3	.78	.21
.4	.29	.65	.4	.13	.23	.4	.96	.81	.4	.86	.40
.5	.31	.84	.5	.15	.42	.5	.99	18.00	.5	.82	.58
.6	.33	3.03	.6	.17	.61	.6	2.01	.19	.6	.84	.77
.7	.36	.22	.7	.19	.80	.7	.03	.38	.7	.86	.96
.8	.38	.41	.8	.21	.99	.8	.05	.57	.8	.88	26.15
.9	.40	.60	.9	.23	11.18	.9	.07	.76	.9	.91	.34
2.	0.42	.79	6.	1.25	.37	10.	2.09	.95	14.	2.93	.53
.1	.44	.98	.1	.28	.56	.1	.11	19.14	.1	.95	.72
.2	.46	4.17	.2	.30	.75	.2	.13	.33	.2	.97	.91
.3	.48	.36	.3	.32	.94	.3	.15	.52	.3	.99	27.10
.4	.50	.55	.4	.34	12.13	.4	.17	.71	.4	3.01	.29
.5	.52	.74	.5	.36	.32	.5	.19	.90	.5	.03	.48
.6	.54	.93	.6	.38	.51	.6	.22	20.09	.6	.05	.67
.7	.56	5.12	.7	.40	.70	.7	.24	.28	.7	.07	.86
.8	.59	.31	.8	.42	.89	.8	.26	.47	.8	.09	28.05
.9	.61	.50	.9	.44	13.08	.9	.28	.66	.9	.11	.24
3.	0.63	.69	7.	1.46	.27	11.	2.30	.85	15.	3.14	.43
.1	.65	.88	.1	.48	.46	.1	.32	21.04	.1	.16	.62
.2	.67	6.06	.2	.50	.65	.2	.34	.23	.2	.18	.81
.3	.69	.25	.3	.53	.83	.3	.36	.42	.3	.20	29.00
.4	.71	.44	.4	.55	14.02	.4	.38	.60	.4	.22	.19
.5	.73	.63	.5	.57	.21	.5	.40	.79	.5	.24	.38
.6	.75	.82	.6	.59	.40	.6	.42	.98	.6	.26	.56
.7	.77	7.01	.7	.61	.59	.7	.45	22.17	.7	.28	.75
.8	.79	.20	.8	.63	.78	.8	.47	.36	.8	.30	.94
.9	.82	.39	.9	.65	.97	.9	.49	.55	.9	.32	30.13

The Leaves of Pinion take up One-third of the Pitch.

Wheels of 64 Teeth.—Pinions of VIII Leaves.

Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.	
	Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.
0.			4.	1.01	7.46	8.	2.01	14.91	12.	3.02	22.37
.1	0.03	0.19	.1	.03	.64	.1	.04	15.10	.1	.04	.55
.2	.05	.37	.2	.06	.83	.2	.06	.28	.2	.07	.74
.3	.08	.56	.3	.08	8.02	.3	.09	.47	.3	.09	.93
.4	.10	.75	.4	.11	.20	.4	.11	.66	.4	.12	23.11
.5	.13	.93	.5	.13	.39	.5	.14	.84	.5	.14	.30
.6	.15	1.12	.6	.16	.57	.6	.16	16.03	.6	.17	.49
.7	.18	.30	.7	.18	.76	.7	.19	.22	.7	.19	.67
.8	.20	.49	.8	.21	.95	.8	.21	.40	.8	.22	.86
.9	.23	.68	.9	.23	9.13	.9	.24	.59	.9	.24	24.05
1.	0.25	.86	5.	1.26	.32	9.	2.26	.78	13.	3.27	.23
.1	.28	2.05	.1	.28	.51	.1	.29	.96	.1	.29	.42
.2	.30	.24	.2	.31	.69	.2	.31	17.15	.2	.32	.60
.3	.33	.42	.3	.33	.88	.3	.34	.34	.3	.34	.79
.4	.35	.61	.4	.36	10.07	.4	.36	.52	.4	.37	.98
.5	.38	.80	.5	.38	.25	.5	.39	.71	.5	.39	25.16
.6	.40	.98	.6	.41	.44	.6	.41	.89	.6	.42	.35
.7	.43	3.17	.7	.43	.62	.7	.44	18.08	.7	.44	.54
.8	.45	.36	.8	.46	.81	.8	.46	.27	.8	.47	.72
.9	.48	.54	.9	.48	11.00	.9	.49	.45	.9	.49	.91
2.	0.50	.73	6.	1.51	.18	10.	2.51	.64	14.	3.52	26.10
.1	.53	.91	.1	.53	.37	.1	.54	.83	.1	.54	.28
.2	.55	4.10	.2	.56	.56	.2	.56	19.01	.2	.57	.47
.3	.58	.29	.3	.58	.74	.3	.59	.20	.3	.59	.66
.4	.60	.47	.4	.61	.93	.4	.61	.39	.4	.62	.84
.5	.63	.66	.5	.63	12.12	.5	.64	.57	.5	.64	27.03
.6	.65	.85	.6	.66	.30	.6	.66	.76	.6	.67	.21
.7	.68	5.03	.7	.68	.49	.7	.69	.94	.7	.69	.40
.8	.70	.22	.8	.71	.68	.8	.71	20.13	.8	.72	.59
.9	.73	.41	.9	.73	.86	.9	.74	.32	.9	.74	.77
3.	0.75	.59	7.	1.76	13.05	11.	2.76	.50	15.	3.77	.96
.1	.78	.78	.1	.78	.23	.1	.79	.69	.1	.79	28.15
.2	.80	.96	.2	.81	.42	.2	.81	.88	.2	.82	.33
.3	.83	6.15	.3	.83	.61	.3	.84	21.06	.3	.85	.52
.4	.85	.34	.4	.86	.79	.4	.86	.25	.4	.87	.71
.5	.88	.52	.5	.88	.98	.5	.89	.44	.5	.90	.89
.6	.90	.71	.6	.91	14.17	.6	.92	.62	.6	.92	29.08
.7	.93	.90	.7	.94	.35	.7	.94	.81	.7	.95	.26
.8	.95	7.08	.8	.96	.54	.8	.97	22.00	.8	.97	.45
.9	.98	.27	.9	.99	.73	.9	.99	.18	.9	4.00	.64

The Leaves of Pinion take up One-third of the Pitch.

Wheels of 60 Teeth.—Pinions of VIII Leaves.

Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.	
	Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.
0.			4.	1.06	7.42	8.	2.13	14.85	12.	3.19	22.27
.1	0.03	0.19	.1	.09	.61	.1	.16	15.03	.1	.22	.46
.2	.05	.37	.2	.12	.79	.2	.18	.22	.2	.25	.64
.3	.08	.56	.3	.14	.98	.3	.21	.40	.3	.27	.83
.4	.11	.74	.4	.17	8.17	.4	.24	.59	.4	.30	23.01
.5	.13	.93	.5	.20	.35	.5	.26	.77	.5	.33	.20
.6	.16	1.11	.6	.22	.54	.6	.29	.96	.6	.35	.38
.7	.19	.30	.7	.25	.72	.7	.32	16.15	.7	.38	.57
.8	.21	.48	.8	.28	.91	.8	.34	.33	.8	.41	.75
.9	.24	.67	.9	.30	9.09	.9	.37	.52	.9	.43	.94
1.	0.27	.86	5.	1.33	.28	9.	2.39	.70	13.	3.46	24.13
.1	.29	2.04	.1	.36	.46	.1	.42	.89	.1	.49	.31
.2	.32	.23	.2	.38	.65	.2	.45	17.07	.2	.51	.50
.3	.35	.41	.3	.41	.84	.3	.47	.26	.3	.54	.68
.4	.37	.60	.4	.44	10.02	.4	.50	.44	.4	.57	.87
.5	.40	.78	.5	.46	.21	.5	.53	.63	.5	.59	25.05
.6	.43	.97	.6	.49	.39	.6	.55	.82	.6	.62	.24
.7	.45	3.15	.7	.52	.58	.7	.58	18.00	.7	.65	.42
.8	.48	.34	.8	.54	.76	.8	.61	.19	.8	.67	.61
.9	.51	.53	.9	.57	.95	.9	.63	.37	.9	.70	.80
2.	0.53	.71	6.	1.60	11.13	10.	2.66	.56	14.	3.73	.98
.1	.56	.90	.1	.62	.32	.1	.69	.74	.1	.75	26.17
.2	.59	4.08	.2	.65	.51	.2	.71	.93	.2	.79	.35
.3	.61	.27	.3	.68	.69	.3	.74	19.11	.3	.81	.54
.4	.64	.45	.4	.70	.88	.4	.77	.30	.4	.83	.72
.5	.67	.64	.5	.73	12.06	.5	.79	.49	.5	.86	.91
.6	.69	.83	.6	.76	.25	.6	.82	.67	.6	.88	27.09
.7	.72	5.01	.7	.78	.43	.7	.85	.86	.7	.91	.28
.8	.75	.20	.8	.81	.62	.8	.87	20.04	.8	.94	.47
.9	.77	.38	.9	.84	.81	.9	.90	.23	.9	.96	.65
3.	0.80	.57	7.	1.86	.99	11.	2.93	.41	15.	3.99	.84
.1	.82	.75	.1	.89	13.18	.1	.95	.60	.1	4.02	28.02
.2	.85	.94	.2	.92	.36	.2	.98	.79	.2	.04	.21
.3	.88	6.12	.3	.94	.55	.3	3.01	.97	.3	.07	.39
.4	.90	.31	.4	.97	.73	.4	.03	21.16	.4	.10	.58
.5	.93	.50	.5	2.00	.92	.5	.06	.34	.5	.12	.77
.6	.96	.68	.6	.02	14.10	.6	.09	.53	.6	.15	.95
.7	.98	.87	.7	.05	.29	.7	.11	.71	.7	.18	29.14
.8	1.01	7.05	.8	.08	.48	.8	.14	.90	.8	.20	.32
.9	.04	.24	.9	.10	.66	.9	.17	22.08	.9	.23	.51

The Leaves of Pinions take up One-third of the Pitch.

Wheels of 60 Teeth.—Pinions of VI Leaves.

Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.		Center Distance.	TOTAL DIAMETERS.	
	Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.		Pinion.	Wheel.
0.			4.	0.85	7.61	8.	1.71	15.22	12.	2.56	22.83
.1	0.02	0.19	.1	.88	.80	.1	.73	.41	.1	.58	23.02
.2	.04	.38	.2	.90	.99	.2	.75	.60	.2	.61	.21
.3	.06	.57	.3	.92	8.18	.3	.77	.79	.3	.63	.40
.4	.09	.76	.4	.94	.37	.4	.79	.98	.4	.65	.59
.5	.11	.95	.5	.96	.56	.5	.82	16.17	.5	.67	.78
.6	.13	1.14	.6	.98	.75	.6	.84	.36	.6	.69	.97
.7	.15	.33	.7	1.00	.94	.7	.86	.55	.7	.71	24.16
.8	.17	.52	.8	.03	9.13	.8	.88	.74	.8	.73	.35
.9	.19	.71	.9	.05	.32	.9	.90	.93	.9	.75	.54
1.	0.21	.90	5.	1.07	.51	9.	1.92	17.12	13.	2.78	.73
.1	.23	2.09	.1	.09	.70	.1	.94	.31	.1	.80	.92
.2	.26	.28	.2	.11	.89	.2	.96	.50	.2	.82	25.11
.3	.28	.47	.3	.13	10.08	.3	.99	.69	.3	.84	.30
.4	.30	.66	.4	.15	.27	.4	2.01	.88	.4	.86	.49
.5	.32	.85	.5	.17	.46	.5	.03	18.07	.5	.88	.68
.6	.34	3.04	.6	.20	.65	.6	.05	.26	.6	.90	.87
.7	.36	.23	.7	.22	.84	.7	.07	.45	.7	.93	26.07
.8	.38	.42	.8	.24	11.03	.8	.09	.65	.8	.95	.26
.9	.41	.61	.9	.26	.23	.9	.11	.84	.9	.97	.45
2.	0.43	.81	6.	1.28	.42	10.	2.14	19.03	14.	2.99	.64
.1	.45	4.00	.1	.30	.61	.1	.16	.22	.1	3.01	.83
.2	.47	.19	.2	.32	.80	.2	.18	.41	.2	.03	27.02
.3	.49	.38	.3	.35	.99	.3	.20	.60	.3	.05	.21
.4	.51	.57	.4	.37	12.18	.4	.22	.79	.4	.08	.40
.5	.53	.76	.5	.39	.37	.5	.24	.98	.5	.10	.59
.6	.56	.95	.6	.41	.56	.6	.26	20.17	.6	.12	.78
.7	.58	5.14	.7	.43	.75	.7	.29	.36	.7	.14	.97
.8	.60	.33	.8	.45	.94	.8	.31	.55	.8	.16	28.16
.9	.62	.52	.9	.47	13.13	.9	.33	.74	.9	.18	.35
3.	0.64	.71	7.	1.49	.32	11.	2.35	.93	15.	3.20	.54
.1	.66	.90	.1	.52	.51	.1	.37	21.12	.1	.22	.73
.2	.68	6.09	.2	.54	.70	.2	.39	.31	.2	.25	.92
.3	.70	.28	.3	.56	.89	.3	.41	.50	.3	.27	29.11
.4	.73	.47	.4	.58	14.08	.4	.43	.69	.4	.29	.30
.5	.75	.66	.5	.60	.27	.5	.46	.88	.5	.31	.49
.6	.77	.85	.6	.62	.46	.6	.48	22.07	.6	.33	.68
.7	.79	7.04	.7	.64	.65	.7	.50	.26	.7	.35	.87
.8	.81	.23	.8	.67	.64	.8	.52	.45	.8	.37	30.06
.9	.83	.42	.9	.69	15.03	.9	.54	.64	.9	.40	.25

The Leaves of Pinions take up One-third of the Pitch.

Dial Wheels.—Pinions of X and XII Leaves.

WHEELS OF 40 AND 36 TEETH.

Center Distance.	TOTAL DIAMETERS.			
	Intermediate Wheel.	Canon Pinion.	Hour Wheel.	Intermediate Pinion.
2.	3.29	1.24	3.46	1.02
.1	.45	.30	.63	.07
.2	.61	.36	.81	.12
.3	.78	.43	.98	.17
.4	.94	.49	4.15	.22
.5	4.11	.55	.33	.28
.6	.27	.61	.50	.33
.7	.44	.67	.67	.38
.8	.60	.74	.85	.43
.9	.76	.80	5.02	.48
3.	.93	1.86	.19	1.53
.1	5.09	.92	.37	.58
.2	.26	.98	.54	.63
.3	.42	2.05	.71	.68
.4	.58	.11	.88	.73
.5	.75	.17	6.06	.79
.6	.91	.23	.23	.84
.7	6.08	.29	.40	.89
.8	.24	.36	.58	.94
.9	.41	.42	.75	.99
4.	.57	2.48	.92	2.04
.1	.73	.54	7.10	.09
.2	.90	.60	.27	.14
.3	7.06	.67	.44	.19
.4	.23	.73	.62	.25
.5	.39	.79	.79	.30
.6	.56	.85	.96	.35
.7	.72	.91	8.14	.40
.8	.88	.98	.31	.45
.9	8.05	3.04	.48	.50
5.	.21	3.10	.65	2.55
.1	.38	.16	.83	.60
.2	.54	.22	9.00	.65
.3	.71	.29	.17	.70
.4	.87	.35	.35	.76
.5	9.03	.41	.52	.81
.6	.20	.47	.69	.86
.7	.36	.53	.87	.91
.8	.53	.60	10.04	.96
.9	.69	.66	.21	3.01

Center Distance.	TOTAL DIAMETERS.			
	Intermediate Wheel.	Canon Pinion.	Hour Wheel.	Intermediate Pinion.
6.	9.86	3.72	10.39	3.06
.1	10.02	.78	.56	.11
.2	.18	.84	.73	.16
.3	.35	.90	.90	.21
.4	.51	.97	11.08	.27
.5	.68	4.03	.25	.32
.6	.84	.09	.42	.37
.7	11.01	.15	.60	.42
.8	.17	.21	.77	.47
.9	.33	.28	.94	.52
7.	.50	4.34	12.12	3.57
.1	.66	.40	.29	.62
.2	.83	.46	.46	.67
.3	.99	.52	.64	.73
.4	12.16	.59	.81	.78
.5	.32	.65	.98	.83
.6	.48	.71	13.15	.88
.7	.64	.77	.33	.93
.8	.81	.83	.50	.98
.9	.98	.90	.67	4.03
8.	13.14	4.96	.85	4.08
.1	.31	5.02	14.02	.13
.2	.47	.08	.19	.18
.3	.63	.14	.37	.24
.4	.80	.21	.54	.29
.5	.96	.27	.71	.34
.6	14.13	.33	.89	.39
.7	.29	.39	15.06	.44
.8	.46	.45	.23	.49
.9	.62	.52	.40	.54
9.	.78	5.58	.58	4.59
.1	.95	.64	.75	.64
.2	15.11	.70	.92	.69
.3	.28	.76	16.10	.75
.4	.44	.83	.27	.80
.5	.61	.89	.44	.85
.6	.77	.95	.62	.90
.7	.93	6.01	.79	.95
.8	16.10	.07	.96	5.00
.9	.26	.14	17.14	.05

The Leaves of Pinions take up Two-fifths of the Pitch.

Dial Wheels.—Pinions with VIII and X Leaves.

WHEELS OF 32 AND 30 TEETH.

Center Distance.	TOTAL DIAMETERS.			
	Intermediate Wheel.	Canon Pinion.	Hour Wheel.	Intermediate Pinion.
2.	3.32	1.27	3.50	1.06
.1	.49	.34	.68	.11
.2	.65	.40	.85	.16
.3	.82	.46	4.03	.22
.4	.98	.53	.20	.27
.5	4.15	.59	.38	.32
.6	.32	.65	.55	.38
.7	.48	.72	.73	.43
.8	.65	.78	.90	.48
.9	.81	.85	5.08	.53
3.	.98	1.91	.25	1.59
.1	5.15	.97	.43	.64
.2	.31	2.04	.60	.69
.3	.48	.10	.78	.75
.4	.65	.16	.95	.80
.5	.81	.23	6.13	.85
.6	.98	.29	.30	.90
.7	6.14	.35	.48	.96
.8	.31	.42	.65	2.01
.9	.48	.48	.83	.06
4.	.64	2.55	7.00	2.12
.1	.81	.61	.18	.17
.2	.97	.67	.35	.22
.3	7.14	.74	.53	.28
.4	.31	.80	.70	.33
.5	.47	.86	.88	.38
.6	.64	.93	8.05	.43
.7	.80	.99	.23	.49
.8	.97	3.05	.40	.54
.9	8.14	.12	.58	.59
5.	.30	3.18	.75	2.65
.1	.47	.24	.93	.70
.2	.63	.31	9.10	.75
.3	.80	.37	.28	.80
.4	.97	.44	.45	.86
.5	9.13	.50	.63	.91
.6	.30	.56	.80	.96
.7	.46	.63	.98	3.02
.8	.63	.69	10.15	.07
.9	.80	.75	.33	.12

Center Distance.	TOTAL DIAMETERS.			
	Intermediate Wheel.	Canon Pinion.	Hour Wheel.	Intermediate Pinion.
6.	9.96	3.82	10.50	3.17
.1	10.13	.88	.68	.23
.2	.29	.94	.85	.28
.3	.46	4.01	11.03	.33
.4	.63	.07	.20	.39
.5	.79	.14	.38	.44
.6	.96	.20	.55	.49
.7	11.12	.26	.73	.55
.8	.29	.33	.90	.60
.9	.46	.39	12.08	.65
7.	.62	4.45	.25	3.70
.1	.79	.52	.43	.76
.2	.95	.58	.60	.81
.3	12.12	.64	.78	.86
.4	.29	.71	.95	.92
.5	.45	.77	13.13	.97
.6	.62	.84	.30	4.02
.7	.78	.90	.48	.07
.8	.95	.96	.65	.13
.9	13.12	5.03	.83	.18
8.	.28	5.09	14.00	4.23
.1	.45	.15	.18	.29
.2	.61	.22	.35	.34
.3	.78	.28	.53	.39
.4	.95	.34	.70	.44
.5	14.11	.41	.88	.50
.6	.28	.47	15.05	.55
.7	.44	.54	.23	.60
.8	.61	.60	.40	.66
.9	.78	.66	.58	.71
9.	.94	5.73	.75	4.76
.1	15.11	.79	.93	.82
.2	.27	.85	16.10	.87
.3	.44	.92	.28	.92
.4	.61	.98	.45	.97
.5	.77	6.04	.63	5.03
.6	.94	.11	.80	.08
.7	16.10	.17	.98	.13
.8	.27	.24	17.15	.19
.9	.44	.30	.33	.24

The Leaves of Pinions take up Two-fifths of the Pitch.