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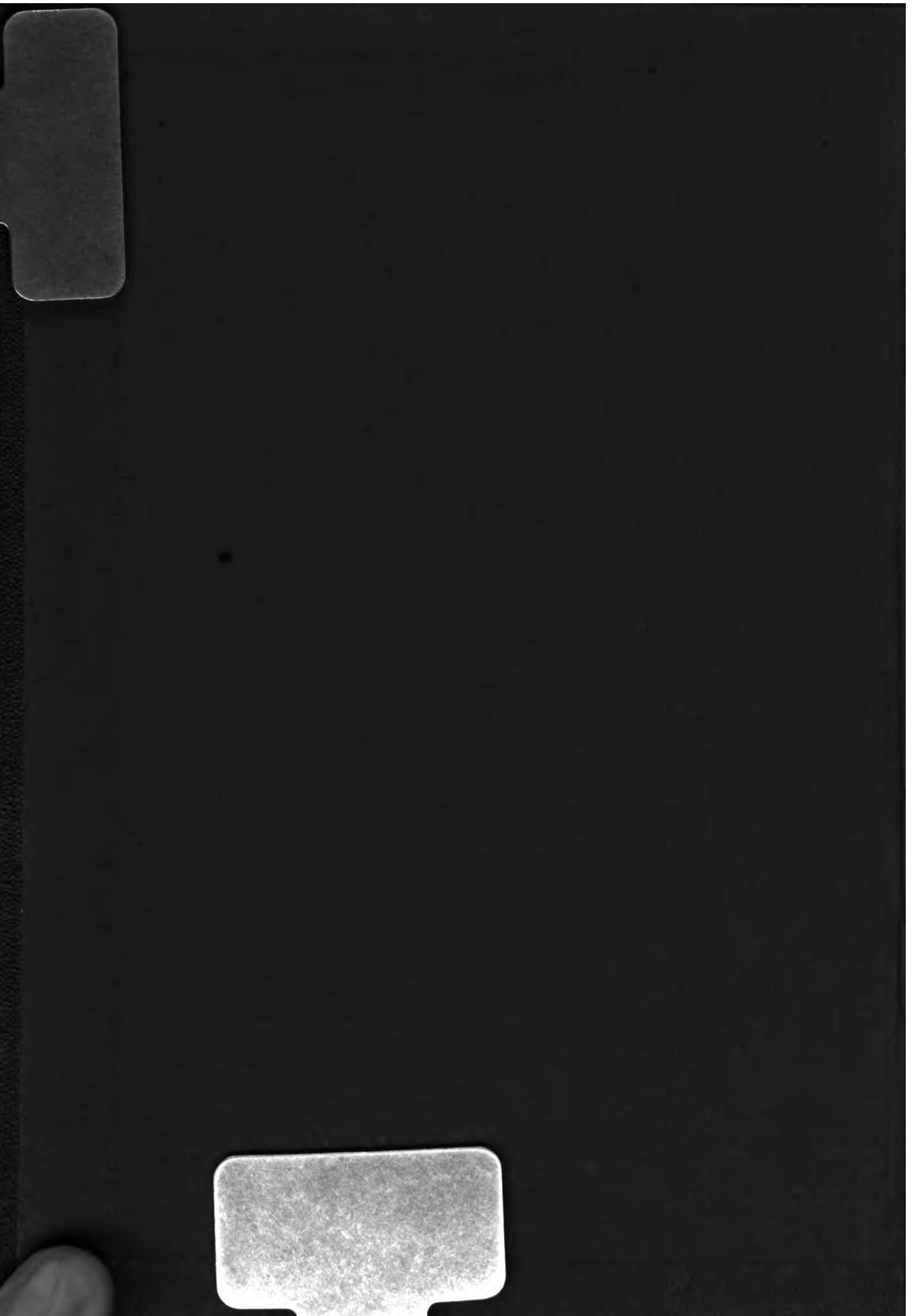
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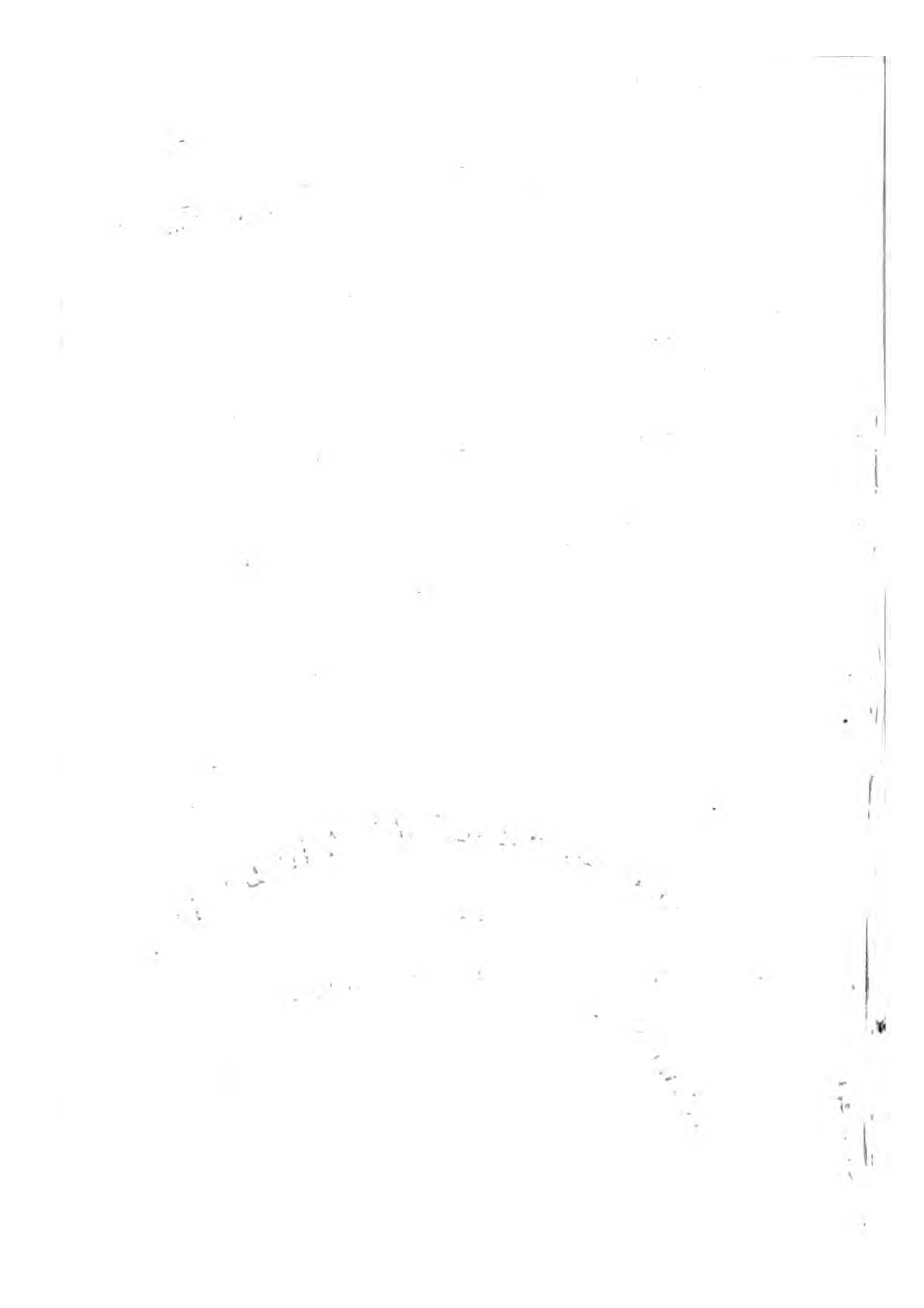
TREATISE ON THE COMBINED
CIRCULAR, MULTI-CIRCULAR,
SLIDE RULE.











ENTERED AT STATIONERS' HALL.

T R E A T I S E

ON THE COMBINED

CIRCULAR, MULTI-CIRCULAR

AND

FIVE-FIGURES LOGARITHMIC DECIMALS

S L I D E R U L E ;

with copious Tables of Natural Sines, Rumbs, Area of Circular Segments, &c., &c., and numerous practical examples and illustrations on Instrument equivalent to Gunter's Scale upwards of 50 feet long.

BY

T H O M A S D I X O N , E N G I N E E R ,

B U T T E R S H A W , N E A R B R A D F O R D , Y O R K S .

(*Author of " The Millwright and Engineer's Ready Reckoner,"*

" Triple Radius Double Slide Rule," &c.

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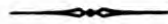
JAMES BROWN, PRINTER, ETC., 14, MANCHESTER ROAD.

1883.

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P R E F A C E .



The combined Circular, Multi-Circular, and Logarithmic Decimals Slide Rule to which the following remarks and illustrations apply, having been carefully set out on a machine specially designed and made for the purpose, and also been provided with distinguishing figured arms, &c., it is well adapted for obtaining results to four and estimate fifth place of figures with ease and facility.

DESCRIPTION OF INSTRUMENT.

The Circular Rule Dial, viz. that representing Numbers and Common Logarithms near the out edge of instrument contains only two sets of circles, divisions and figures, but the dial of Multi-Circular Rule contains ten, numbered in regular succession, to show the relative position of each set to the first marked 0 nearest the centre — and

Calling each set of circles on both dials a round, the starting and finishing place of which is at the left hand radius line A, A; inasmuch as the numbers represented at the finish of any round is same as starts the next to the left on the starting line; and in all calculations the figures on numbers lines are used to represent integers, decimals or mixed as may be required; and lastly the axle of instrument is prepared to carry any convenient No. of figured Index Arms, as B, C, D, to indicate the respective rounds which contain the numbers represented therein, — then for the Application of Instrument.

—First, dealing with the Circular Rule, and commencing with calculations of simple

MULTIPLICATION.

The sum of the angles of any Multiplicand and Multiplier giving the angle of Product, and the product containing one less integer than, or an equal number to, what the multiplicand and multiplier contain together, accordingly as the Product and Multiplicand are, or are not in the same round,

Ex. 1.—For the Product of 73 multiplied 19.

—In all instances using the Index Arms so as not to block or hide the numbers to be dealt with, and in this instance applying the Arm B to starting line and Arm C to the multiplier—

Having fastened the Index Arm B at the starting line A, A to the Arm C set to the multiplier 19 on Numbers round.

Then simply by moving Arm B to the multiplicand 73 on Numbers round, the

Answer will be shown at Arm C in four figures = 1387.

Ex. 2.—Required the Products of 42×23 and 42×27 .

Having fastened Arm B at the starting line A, A to Arm C at 23, and to Arm D at 27, then by moving B to 42, the 1st product is shown at C = 966 in three figures, and the 2nd product at D = 1134 in four, all at one setting.

Or Ex. 3.—For the Product of say $43 \times 37 \times 19$.

Supposing Arm B at the starting line A, A fastened to Arm C at 37, and then Arm C at the starting line A, A fastened to Arm D at 19.

—By moving Arm B to 43 on number round the

1st Product of 43×37 will be shown at C = 1591, and

2nd Product of $43 \times 37 \times 19$ at D = nearly 30230.

Or for

DIVISION.

Reversing the operations for multiplication. The difference of the angles of Dividend and Divisor giving the angle of quotient, and the No. of Integers in quotient being 1 more than, or equal to the difference between the no. contained in the dividend and divisor, accordingly as the quotient and dividend are, or are not in the same round.—thus for

Ex. 4.—To find the quotient of 396 divided by 18.

Having fastened arm (say) B at the starting line, to Arm C at the divisor 18; then by moving C to 396 the quotient is shown at B in two figures = 22, because the difference between the three integers in dividend and the two in divisor is 1 and the dividend and quotient are in one, or same round.

Or for

SINGLE RULE OF THREE.

Inasmuch as one multiplication and one division are required conjointly, for

Ex. 5.— As 18 : 39 : : 96 : Answer.

Having fastened Arm (say) B at starting line A, A to C at 39,
and also Arm (say) D do. C at 18 div.

Then by moving Arm B to 96, C being moved to the

Product of $39 \times 96 = 3744$ in four figures, and D
or the Quotient $39 \times 95 \div 18 = 208$ in three, all at one setting.

Or Ex. 6 Evolution — For the Square and Cube of 19.

Having fastened (say Arm B) at starting line to Arm C at 19.
 and Arm C do, Arm D at 19.
 Then by moving B to 19 the
 Square is shown in three figures at C = 361, and the
 Cube - in four do. at D = 6859
 and so on

Or applying the Multi-circular Rule to calculations of
 Multiplication.

To obtain the No. of round which contains the product,
 and the No. of Integers in that product.

1st.—Add the round which contains the multiplier to that
 which contains the multiplicand and the sum (if less than 10)
 or the right hand figure of sum (when 10 or above) will
 indicate the required round, or 1 less, accordingly as the
 product and multiplicand are in one and the same round,
 or not.

And 2nd.—In all instances the no. of integers in product
 being 1 less than, or equal to, what the multiplicand and
 multiplier contain together, accordingly as the sum of the
 turns (obtained as above) is less, or not less than 10.

Thus—Ex. 7.—To find the Products of 41×23 .

41 being on round 6 and 23 on round 3.

6 plus 3 giving the round for product 9.

Having fastened Arm B at starting line to Arm C at 23.

By moving B to 41 the Product is shown on round 9 at
 Arm C = 943 in three integers. Or

Ex. 8.—For the Product of 77×49 .

77 being on round 8, and 49 on round 6

8 plus 6 giving 14 — then

Having fastened Arm B at starting line to C at 49.

By moving B to 77 as we find the product will not be
 in the same round as the multiplicand, and under such cir-
 cumstances 1 has to be added to the 14 obtained above to
 make 15, the right hand figure 5 of which gives the round
 for Answer.

So by looking at Arm C on round 5 we find the product
 3773 in four figures because the sum of the turns, &c. as
 above is more than 10.

Or Ex. 9.—For the approximate Product of 937.8×883.5 .

Round 9 for 937.8 plus round 9 for 883.5 giving 18.

Having fastened Arm B at starting line to C at 883.5.

By moving B to 937.8 as we find the product will not be in the same round as the multiplicand, so according to rule adding 1 to the 18 obtained above we obtain 9 for the right hand figure, and consequently for the no. of round which contains the product at C slightly in excess of 828500 in six integers, while the product accurately obtained arithmetically = 828546.3.

Or for

DIVISION.

The No. of Round for divisor deducted from that for dividend ; the difference, or 1 less than the difference giving the No. of round for quotient, as the quotient is, or is not in the same round as the divisor ; the no. of Integers in Quotient being obtainable in the ordinary way Thus for

Ex. 10.—To find the quotient of 125 divided by 105.

Round 0 for 125 less round 0 for 105 giving 0.

Having fastened Arm (say C) at starting line to B at 105.

By moving B to 125 we find the quotient on round 0 at Arm C in one integer = 1.1905.

Or Ex. 11.—For the quotient of 105 divided by 125.

Having fastened Arm C at starting line to B at 125, as by moving B to 105 we find the quotient and dividend are not in the same round ; then according to instructions as under these circumstances the round for quotient is obtained by deducting round 0 from 0 (whose difference 0 we call 10) and from 10 the 1 which makes 9,—so the quotient is given on round 9 at Arm C = .84 in decimals.

It being here worth noticing, that for calculations of Division, the Divisor and Quotients are to be read behind the dividend, or the contrary way to what the figures or numbers on dial advance ; while multipliers and products require to be read contrary way, or in advance of the multiplicand.

Or for calculations of Multiplication and Division conjointly—as in

SINGLE RULE OF THREE.

Ex. 12.—As 183 : 917 : : 711 : Answer.

Here having fastened Arm B at starting line to C at 711 ;
and Arm D do. C at 183.

By moving B to 917 the Ans. is shown at D = 3562 in round 5.

Or for

INVOLUTION AND EVOLUTION.

Ex. 13.—To find the Square and Cube of 117.

Having fastened Arm B at starting line to C at 117 ;
and Arm C at do. D at 117.

then by moving Arm B to 117 the

Square is shown at Arm C very nearly 13690 on round 1, and the

Cube is shown at Arm D very nearly 1601600 on round 2,
Or by reversing operations the Square Root of 13690 and
the Cube Root of 1601600 are shown = 117 nearly.

Or next applying the circular and multi-circular portions of
instrument conjointly to calculations of Logarithms.

As the distinguishing figure on any round of the dial or
multi-circular rule represents the first decimal figure of loga-
rithms of all the numbers on that round, while the four fol-
lowing decimals can be read on the round of circular rule
marked common logarithms, at any arm placed to the number
on multi-circular rule dial whose logarithm is required—
then for

Ex. 14.—To find the Common Logarithm of say 8974.

Here 8974 being on round 9, as by placing any arm,
say B at 8974 on round 9, we obtain 9 for the first loga-
rithmic decimal of 8974, and at the same arm B read very
nearly 5295, so the approximate logarithmic decimals of
8974 to five places of figures = .95295 and affixing the cha-
racteristic or Integer 3 we obtain logarithm 3.95295 from
the conjoint application of the dials of both rules, whereas
according to Hutton's Tables, &c., the correct answer is
3.9529861.

Or Ex. 15.—For the Cube Root and 3.5 Root of 8974 in last example taking its logarithm as 3,953.


Having fastened Arm say C at starting line to B at 3,
 and do. D do. B at 3.5.
 then merely by moving B to 3.953 we obtain at the
 Arm C the log. 1.3176 representing Cube Root of 8974, and
 at D do. 1.1294 do. 3.5 Root the former
 corresponding to 20.782 and the latter to 13.472, very nearly
 the respective answers.

Or again—


As by making additional circles on the instrument contain figures and divisions to represent degrees, &c. in the quadrant of a circle, the conjoint application of circular and multi-circular rules may be made to give natural sines, tangents, secants, &c. with the same facility as logarithms, merely by using a small table of the degrees which begin each round at the starting line, so attention is directed thereto, although the natural sines, &c. for every ten minutes to five places of decimals are given at the end of this pamphlet.

And lastly—Although the combined circular and multi-circular slide rule is not so handy for many calculations as the Triple Radius Double Slide straight instrument yet much greater accuracy being secured by the former than latter, so the application of former will often be found advantageous.





SUNDRY TABLES.



**TABLE
OF SINES AND COSINES FOR RADIUS 1.**

Sines.	0'	10'	20'	30'	40'	50'	
0 Degs.	.00000	.00291	.00582	.00873	.01164	.01454	89 Degs.
1	.01745	.02036	.02327	.02618	.02908	.03199	88
2	.03490	.03781	.04071	.04362	.04653	.04943	87
3	.05234	.05524	.05814	.06105	.06395	.06685	86
4	.06976	.07266	.07556	.07846	.08136	.08426	85 Degs.
5 Degs.	.08716	.09005	.09295	.09585	.09874	.10164	84
6	.10453	.10742	.11031	.11320	.11609	.11898	83
7	.12187	.12476	.12764	.13053	.13341	.13629	82
8	.13917	.14205	.14493	.14781	.15069	.15356	81
9	.15643	.15931	.16218	.16505	.16792	.17078	80 Degs.
10 Degs.	.17365	.17651	.17937	.18224	.18509	.18795	79
11	.19081	.19366	.19652	.19937	.20222	.20507	78
12	.20791	.21076	.21360	.21644	.21928	.22212	77
13	.22495	.22778	.23062	.23345	.23627	.23910	76
14	.24192	.24474	.24756	.25038	.25320	.25601	75 Degs.
15 Degs.	.25882	.26163	.26443	.26724	.27004	.27284	74
16	.27564	.27843	.28123	.28402	.28680	.28959	73
17	.29237	.29515	.29793	.30071	.30348	.30625	72
18	.30902	.31178	.31454	.31730	.32006	.32282	71
19	.32557	.32832	.33106	.33381	.33655	.33929	70 Degs.
20 Degs.	.34202	.34475	.34748	.35021	.35293	.35565	69
21	.35837	.36108	.36379	.36650	.36921	.37191	68
22	.37461	.37730	.37999	.38268	.38537	.38805	67
23	.39073	.39341	.39608	.39875	.40142	.40408	66
24	.40674	.40939	.41204	.41469	.41734	.41998	65 Degs.
25 Degs.	.42262	.42525	.42788	.43051	.43313	.43575	64
26	.43837	.44098	.44359	.44620	.44880	.45140	63
27	.45399	.45658	.45917	.46175	.46433	.46690	62
28	.46947	.47204	.47460	.47716	.47971	.48226	61
29	.48481	.48735	.48989	.49242	.49495	.49748	60 Degs.
30 Degs.	.50000	.50252	.50503	.50754	.51004	.51254	59
31	.51504	.51753	.52002	.52250	.52498	.52745	58
32	.52992	.53238	.53484	.53730	.53975	.54220	57
33	.54464	.54708	.54951	.55194	.55436	.55678	56
34	.55919	.56160	.56401	.56641	.56880	.57119	55 Degs.
35 Degs.	.57358	.57596	.57833	.58070	.58307	.58543	54
36	.58779	.59014	.59248	.59482	.59716	.59949	53
37	.60182	.60414	.60645	.60876	.61107	.61337	52
38	.61566	.61795	.62024	.62251	.62479	.62706	51
39	.62932	.63158	.63383	.63608	.63832	.64056	50 Degs.
40 Degs.	.64279	.64501	.64723	.64945	.65166	.65386	49
41	.65606	.65825	.66044	.66262	.66480	.66697	48
42	.66913	.67129	.67344	.67559	.67773	.67987	47
43	.68200	.68412	.68624	.68835	.69046	.69256	46
44	.69466	.69675	.69883	.70091	.70298	.70505	45 Degs.
45	.70711	.70916	.71121	.71325	.71529	.71732	
	60'	50'	40'	30'	20'	10'	Cosines.

**TABLE
OF SINES AND COSINES FOR RADIUS 1.**

Sines.	0'	10'	20'	30'	40'	50'	
45 Degs.	.70711	.70916	.71121	.71325	.71529	.71732	44 Degs.
46	.71934	.72136	.72337	.72537	.72737	.72937	43
47	.73135	.73333	.73531	.73728	.73924	.74120	42
48	.74314	.74509	.74703	.74896	.75089	.75280	41
49	.75471	.75661	.75851	.76041	.76229	.76417	40 Degs.
50 Degs.	.76604	.76791	.76977	.77162	.77347	.77531	39
51	.77715	.77897	.78079	.78261	.78442	.78622	38
52	.78801	.78980	.79158	.79335	.79512	.79688	37
53	.79864	.80038	.80212	.80386	.80558	.80730	36
54	.80902	.81072	.81242	.81412	.81580	.81748	35 Degs.
55 Degs.	.81915	.82082	.82248	.82413	.82577	.82741	34
56	.82904	.83066	.83228	.83389	.83549	.83708	33
57	.83867	.84025	.84182	.84339	.84495	.84650	32
58	.84805	.84959	.85112	.85264	.85416	.85567	31
59	.85717	.85866	.86015	.86163	.86310	.86457	30 Degs.
60 Degs	.86603	.86748	.86892	.87036	.87178	.87321	29
61	.87462	.87603	.87743	.87882	.88020	.88158	28
62	.88295	.88431	.88567	.88701	.88835	.88968	27
63	.89101	.89232	.89363	.89493	.89623	.89752	26
64	.89879	.90007	.90133	.90259	.90383	.90507	25 Degs.
65 Degs.	.90631	.90753	.90875	.90996	.91116	.91236	24
66	.91355	.91472	.91590	.91706	.91822	.91936	23
67	.92050	.92164	.92276	.92388	.92499	.92609	22
68	.92718	.92827	.92935	.93042	.93148	.93253	21
69	.93358	.93462	.93565	.93667	.93769	.93869	20 Degs.
70 Degs	.93969	.94068	.94167	.94264	.94361	.94457	19
71	.94552	.94646	.94740	.94832	.94924	.95015	18
72	.95106	.95195	.95284	.95372	.95459	.95545	17
73	.95630	.95715	.95799	.95882	.95964	.96046	16
74	.96126	.96206	.96285	.96363	.96440	.96517	15 Degs.
75 Degs.	.96593	.96667	.96742	.96815	.96887	.96959	14
76	.97030	.97100	.97169	.97237	.97304	.97371	13
77	.97437	.97502	.97566	.97630	.97692	.97754	12
78	.97815	.97875	.97934	.97992	.98050	.98107	11
79	.98163	.98218	.98272	.98325	.98378	.98430	10 Degs.
80 Degs.	.98481	.98531	.98580	.98629	.98676	.98723	9
81	.98769	.98814	.98858	.98902	.98944	.98986	8
82	.99027	.99067	.99106	.99144	.99182	.99219	7
83	.99255	.99290	.99324	.99357	.99390	.99421	6
84	.99452	.99482	.99511	.99540	.99567	.99594	5 Degs.
85 Degs.	.99619	.99644	.99668	.99692	.99714	.99736	4
86	.99756	.99776	.99795	.99813	.99831	.99847	3
87	.99863	.99878	.99892	.99905	.99917	.99929	2
88	.99939	.99949	.99958	.99966	.99973	.99979	1
89	.99985	.99989	.99993	.99996	.99998	.99999	0 Degs.
90	1.						
	60'	50'	40'	30'	20'	10'	Cosines.

**TABLE
OF TANGENTS AND COTANGENTS FOR RADIUS 1.**

Tangents.	0'	10'	20'	30'	40'	50'	
0 Degs.	.00000	.00291	.00582	.00873	.01164	.01455	89 Degs.
1	.01746	.02037	.02328	.02619	.02910	.03201	88
2	.03492	.03783	.04075	.04366	.04658	.04949	87
3	.05241	.05533	.05824	.06116	.06408	.06700	86
4	.06993	.07285	.07578	.07870	.08163	.08456	85 Degs.
5 Degs.	.08749	.09042	.09335	.09629	.09923	.10216	84
6	.10510	.10805	.11099	.11394	.11688	.11983	83
7	.12278	.12574	.12869	.13165	.13461	.13758	82
8	.14054	.14351	.14648	.14945	.15243	.15540	81
9	.15838	.16137	.16435	.16734	.17033	.17333	80 Degs.
10 Degs.	.17633	.17933	.18233	.18534	.18835	.19136	79
11	.19438	.19740	.20042	.20345	.20648	.20952	78
12	.21256	.21560	.21864	.22169	.22475	.22781	77
13	.23087	.23393	.23700	.24008	.24316	.24624	76
14	.24933	.25242	.25552	.25862	.26172	.26483	75 Degs.
15 Degs.	.26795	.27107	.27419	.27732	.28046	.28360	74
16	.28675	.28990	.29305	.29621	.29938	.30255	73
17	.30573	.30891	.31210	.31530	.31850	.32171	72
18	.32492	.32814	.33136	.33460	.33783	.34108	71
19	.34433	.34758	.35085	.35412	.35740	.36068	70 Degs.
20 Degs.	.36397	.36727	.37057	.37388	.37720	.38053	69
21	.38386	.38721	.39055	.39391	.39727	.40065	68
22	.40403	.40741	.41081	.41421	.41763	.42105	67
23	.42447	.42791	.43136	.43481	.43828	.44175	66
24	.44523	.44872	.45222	.45573	.45924	.46277	65 Degs.
25 Degs.	.46631	.46985	.47341	.47698	.48055	.48414	64
26	.48773	.49134	.49495	.49858	.50222	.50587	63
27	.50953	.51320	.51688	.52057	.52427	.52798	62
28	.53171	.53545	.53920	.54296	.54673	.55051	61
29	.55431	.55812	.56194	.56577	.56962	.57348	60 Degs.
30 Degs.	.57735	.58124	.58513	.58905	.59297	.59691	59
31	.60086	.60483	.60881	.61280	.61681	.62083	58
32	.62487	.62892	.63299	.63707	.64117	.64528	57
33	.64941	.65355	.65771	.66189	.66608	.67028	56
34	.67451	.67875	.68301	.68728	.69157	.69588	55 Degs.
35 Degs.	.70021	.70455	.70891	.71329	.71769	.72211	54
36	.72654	.73100	.73547	.73996	.74447	.74900	53
37	.75355	.75812	.76272	.76733	.77196	.77661	52
38	.78129	.78598	.79070	.79544	.80020	.80498	51
39	.80978	.81461	.81946	.82434	.82923	.83415	50 Degs.
40 Degs.	.83910	.84407	.84906	.85408	.85912	.86419	49
41	.86929	.87441	.87955	.88473	.88992	.89515	48
42	.90040	.90569	.91099	.91633	.92170	.92709	47
43	.93252	.93797	.94345	.94896	.95451	.96008	46
44	.96569	.97133	.97700	.98270	.98843	.99420	45 Degs.
45	1.00000	1.00583	1.01170	1.01761	1.02355	1.02952	
	60'	50'	40'	30'	20'	10'	Cotan- gents.

TABLE
OF TANGENTS AND COTANGENTS FOR RADIUS 1.

Tangents.	0'	10'	20'	30'	40'	50'	
45 Degr.	1.00000	1.00583	1.01170	1.01761	1.02355	1.02952	44 Degr.
46	1.03553	1.04158	1.04766	1.05378	1.05994	1.06613	43
47	1.07237	1.07864	1.08496	1.09131	1.09770	1.10414	42
48	1.11061	1.11713	1.12369	1.13029	1.13694	1.14363	41
49	1.15037	1.15715	1.16398	1.17085	1.17777	1.18474	40 Degr.
50 Degr.	1.19175	1.19882	1.20593	1.21310	1.22031	1.22758	39
51	1.23490	1.24227	1.24969	1.25717	1.26471	1.27230	38
52	1.27994	1.28764	1.29541	1.30323	1.31110	1.31904	37
53	1.32704	1.33511	1.34323	1.35142	1.35968	1.36800	36
54	1.37638	1.38484	1.39336	1.40195	1.41061	1.41934	35 Degr.
55 Degr.	1.42815	1.43703	1.44598	1.45501	1.46411	1.47330	34
56	1.48256	1.49190	1.50133	1.51084	1.52043	1.53010	33
57	1.53987	1.54972	1.55966	1.56969	1.57981	1.59002	32
58	1.60033	1.61074	1.62125	1.63185	1.64256	1.65337	31
59	1.66428	1.67530	1.68643	1.69766	1.70901	1.72047	30 Degr.
60 Degr.	1.73205	1.74375	1.75556	1.76749	1.77955	1.79174	29
61	1.80405	1.81649	1.82906	1.84177	1.85462	1.86760	28
62	1.88073	1.89400	1.90741	1.92098	1.93470	1.94858	27
63	1.96261	1.97681	1.99116	2.00569	2.02039	2.03526	26
64	2.05030	2.06553	2.08094	2.09654	2.11233	2.12832	25 Degr.
65 Degr.	2.14451	2.16090	2.17749	2.19430	2.21132	2.22857	24
66	2.24604	2.26374	2.28167	2.29984	2.31826	2.33693	23
67	2.35585	2.37504	2.39449	2.41421	2.43422	2.45451	22
68	2.47509	2.49597	2.51715	2.53865	2.56046	2.58261	21
69	2.60509	2.62791	2.65109	2.67462	2.69853	2.72281	20 Degr.
70 Degr.	2.74748	2.77254	2.79802	2.82391	2.85023	2.87700	19
71	2.90421	2.93189	2.96004	2.98869	3.01783	3.04749	18
72	3.07768	3.10842	3.13972	3.17159	3.20406	3.23714	17
73	3.27085	3.30521	3.34023	3.37594	3.41236	3.44951	16
74	3.48741	3.52609	3.56557	3.60588	3.64705	3.68909	15 Degr.
75 Degr.	3.73205	3.77595	3.82083	3.86671	3.91364	3.96165	14
76	4.01078	4.06107	4.11256	4.16530	4.21933	4.27471	13
77	4.33148	4.38969	4.44942	4.51071	4.57363	4.63825	12
78	4.70463	4.77286	4.84300	4.91516	4.98940	5.06584	11
79	5.14455	5.22566	5.30928	5.39552	5.48451	5.57638	10 Degr.
80 Degr.	5.67128	5.76937	5.87080	5.97576	6.08444	6.19703	9
81	6.31375	6.43484	6.56055	6.69116	6.82694	6.96823	8
82	7.11537	7.26873	7.42871	7.59575	7.77035	7.95302	7
83	8.14435	8.34496	8.55555	8.77689	9.00983	9.25530	6
84	9.51436	9.78817	10.0780	10.3854	10.7119	11.0594	5 Degr.
85 Degr.	11.4301	11.8262	12.2505	12.7062	13.1969	13.7267	4
86	14.3007	14.9244	15.6048	16.3499	17.1693	18.0750	3
87	19.0811	20.2056	21.4704	22.9038	24.5418	26.4316	2
88	28.6363	31.2416	34.3678	38.1885	42.9641	49.1039	1
89	57.2900	68.7501	85.9398	114.589	171.885	343.774	0 Degr.
90	Infinite.						
	60'	50'	40'	30'	20'	10'	Cotan- gents.

**TABLE
OF SECANTS AND COSECANTS FOR RADIUS 1.**

Secants.	0'	10'	20'	30'	40'	50'	
0 Degr.	1.00000	1.000004	1.000017	1.00004	1.00007	1.00011	89 Degr.
1	1.00015	1.00021	1.00027	1.00034	1.00042	1.00051	38
2	1.00061	1.00072	1.00083	1.00095	1.00108	1.00122	87
3	1.00137	1.00153	1.00169	1.00187	1.00205	1.00224	86
4	1.00244	1.00265	1.00287	1.00309	1.00333	1.00357	85 Degr.
5 Degr.	1.00382	1.00408	1.00435	1.00463	1.00491	1.00521	84
6	1.00551	1.00582	1.00614	1.00647	1.00681	1.00715	83
7	1.00751	1.00787	1.00825	1.00863	1.00902	1.00942	82
8	1.00983	1.01024	1.01067	1.01111	1.01155	1.01200	81
9	1.01247	1.01294	1.01342	1.01391	1.01440	1.01491	80 Degr.
10 Degr.	1.01543	1.01595	1.01649	1.01703	1.01758	1.01815	79
11	1.01872	1.01930	1.01989	1.02049	1.02110	1.02171	78
12	1.02234	1.02298	1.02362	1.02428	1.02494	1.02562	77
13	1.02630	1.02700	1.02770	1.02842	1.02914	1.02987	76
14	1.03061	1.03137	1.03213	1.03290	1.03368	1.03447	75 Degr.
15 Degr.	1.03528	1.03609	1.03691	1.03774	1.03858	1.03944	74
16	1.04030	1.04117	1.04206	1.04295	1.04385	1.04477	73
17	1.04569	1.04663	1.04757	1.04853	1.04950	1.05047	72
18	1.05146	1.05246	1.05347	1.05449	1.05552	1.05657	71
19	1.05762	1.05869	1.05976	1.06085	1.06195	1.06306	70 Degr.
20 Degr.	1.06418	1.06531	1.06645	1.06761	1.06878	1.06995	69
21	1.07115	1.07235	1.07356	1.07479	1.07602	1.07727	68
22	1.07853	1.07981	1.08109	1.08239	1.08370	1.08503	67
23	1.08636	1.08771	1.08907	1.09044	1.09183	1.09323	66
24	1.09464	1.09606	1.09750	1.09895	1.10041	1.10189	65 Degr.
25 Degr.	1.10338	1.10488	1.10640	1.10793	1.10947	1.11103	64
26	1.11260	1.11419	1.11579	1.11740	1.11903	1.12067	63
27	1.12233	1.12400	1.12568	1.12738	1.12910	1.13083	62
28	1.13257	1.13433	1.13610	1.13789	1.13970	1.14152	61
29	1.14335	1.14521	1.14707	1.14896	1.15085	1.15277	60 Degr.
30 Degr.	1.15470	1.15665	1.15861	1.16059	1.16259	1.16460	59
31	1.16663	1.16868	1.17075	1.17283	1.17493	1.17704	58
32	1.17918	1.18133	1.18350	1.18569	1.18790	1.19012	57
33	1.19236	1.19463	1.19691	1.19920	1.20152	1.20386	56
34	1.20622	1.20859	1.21099	1.21341	1.21584	1.21830	55 Degr.
35 Degr.	1.22077	1.22327	1.22579	1.22833	1.23089	1.23347	54
36	1.23607	1.23869	1.24134	1.24400	1.24669	1.24940	53
37	1.25214	1.25489	1.25767	1.26047	1.26330	1.26615	52
38	1.26902	1.27191	1.27483	1.27778	1.28075	1.28374	51
39	1.28676	1.28980	1.29287	1.29597	1.29909	1.30223	50 Degr.
40 Degr.	1.30541	1.30861	1.31183	1.31509	1.31837	1.32168	49
41	1.32501	1.32838	1.33177	1.33519	1.33864	1.34212	48
42	1.34563	1.34917	1.35274	1.35634	1.35997	1.36363	47
43	1.36733	1.37105	1.37481	1.37860	1.38242	1.38628	46
44	1.39016	1.39409	1.39804	1.40203	1.40606	1.41012	45 Degr.
45	1.41421	1.41835	1.42251	1.42672	1.43096	1.43524	
	60'	50'	40'	30'	20'	10'	Cosecants.

**TABLE
OF SECANTS AND COSECANTS FOR RADIUS 1.**

Secants.	0'	10'	20'	30'	40'	50'	
45 Degr.	1.41421	1.41835	1.42251	1.42672	1.43096	1.43524	44 Degr.
46	1.43956	1.44391	1.44831	1.45274	1.45721	1.46173	43
47	1.46628	1.47087	1.47551	1.48019	1.48491	1.48967	42
48	1.49448	1.49933	1.50422	1.50916	1.51415	1.51918	41
49	1.52425	1.52938	1.53455	1.53977	1.54504	1.55036	40 Degr.
50 Degr.	1.55572	1.56114	1.56661	1.57213	1.57771	1.58333	39
51	1.58902	1.59475	1.60054	1.60639	1.61229	1.61825	38
52	1.62427	1.63035	1.63648	1.64268	1.64894	1.65526	37
53	1.66164	1.66809	1.67460	1.68117	1.68782	1.69452	36
54	1.70130	1.70815	1.71506	1.72205	1.72911	1.73624	35 Degr.
55 Degr.	1.74345	1.75072	1.75808	1.76552	1.77303	1.78062	34
56	1.78829	1.79604	1.80388	1.81180	1.81981	1.82790	33
57	1.83608	1.84435	1.85271	1.86116	1.86990	1.87834	32
58	1.88708	1.89591	1.90485	1.91388	1.92302	1.93226	31
59	1.94160	1.95106	1.96062	1.97029	1.98008	1.98998	30 Degr.
60 Degr.	2.00000	2.01014	2.02039	2.03077	2.04128	2.05191	29
61	2.06267	2.07356	2.08458	2.09574	2.10704	2.11847	28
62	2.13005	2.14178	2.15366	2.16568	2.17786	2.19019	27
63	2.20269	2.21535	2.22817	2.24116	2.25432	2.26766	26
64	2.28117	2.29487	2.30875	2.32282	2.33708	2.35154	25 Degr.
65 Degr.	2.36620	2.38107	2.39614	2.41142	2.42692	2.44264	24
66	2.45859	2.47477	2.49119	2.50784	2.52474	2.54190	23
67	2.55930	2.57698	2.59491	2.61313	2.63162	2.65040	22
68	2.66947	2.68884	2.70851	2.72850	2.74881	2.76945	21
69	2.79042	2.81175	2.83342	2.85545	2.87785	2.90063	20 Degr.
70 Degr.	2.92380	2.94737	2.97135	2.99574	3.02057	3.04584	19
71	3.07155	3.09774	3.12440	3.15155	3.17920	3.20737	18
72	3.23607	3.26531	3.29512	3.32551	3.35649	3.38808	17
73	3.42030	3.45317	3.48671	3.52094	3.55587	3.59154	16
74	3.62796	3.66515	3.70315	3.74198	3.78166	3.82223	15 Degr.
75 Degr.	3.86370	3.90613	3.94952	3.99393	4.03938	4.08591	14
76	4.13357	4.18238	4.23239	4.28366	4.33622	4.39012	13
77	4.44541	4.50216	4.56041	4.62023	4.68167	4.74482	12
78	4.80973	4.87649	4.94517	5.01585	5.08863	5.16359	11
79	5.24084	5.32049	5.40263	5.48740	5.57493	5.66533	10 Degr.
80 Degr.	5.75877	5.85539	5.95536	6.05886	6.16607	6.27719	9
81	6.39245	6.51208	6.63633	6.76547	6.89979	7.03962	8
82	7.18530	7.33719	7.49571	7.66130	7.83443	8.01565	7
83	8.20551	8.40466	8.61379	8.83367	9.06515	9.30917	6
84	9.56677	9.83912	10.1275	10.4334	10.7585	11.1045	5 Degr.
85 Degr.	11.4737	11.8684	12.2913	12.7455	13.2347	13.7631	4
86	14.3356	14.9579	15.6368	16.3804	17.1984	18.1026	3
87	19.1073	20.2303	21.4937	22.9256	24.5621	26.4505	2
88	28.6537	31.2576	34.3823	38.2016	42.9757	49.1141	1
89	57.2987	68.7574	85.9456	114.593	171.888	343.775	0 Degr.
90	Infinite.						
	60'	50'	40'	30'	20'	10'	Cosecants.

TABLE OF RUMBS

And Natural Sines which every Point and Quarter Point of the Compass
makes with the Meridian.

NORTH.	SOUTH.	Points.	Angles.	Sines.	Tangents	Secants.	Angles.
		0 Pts.	0°	.0	.0	1.	90°- 0'- 0"
		$\frac{1}{4}$	2°-48'-45"	.04907	.04913	1.00121	87-11-15
		$\frac{1}{2}$	5 -37 -30	.09802	.09849	1.00484	84-22-30
		$\frac{3}{4}$	8 -26 -15	.14673	.14833	1.01094	81-33-45
N. BY E. N. BY W.	S. BY E. S. BY W. }	1 Pts.	11-15- 0	.19509	.19891	1.01959	78-45- 0
		$1\frac{1}{4}$	14- 3-45	.24298	.25049	1.03089	75-56-15
		$1\frac{1}{2}$	16-52-30	.29028	.30334	1.04500	73- 7-30
		$1\frac{3}{4}$	19-41-15	.33689	.35781	1.06209	70-18-45
N.N.E. N.N.W.	S.S.E. S.S.W. }	2 Pts.	22-30- 0	.38268	.41421	1.08239	67-30- 0
		$2\frac{1}{4}$	25-18-45	.42756	.47296	1.10621	64-41-15
		$2\frac{1}{2}$	28- 7-30	.47140	.53451	1.13389	61-52-30
		$2\frac{3}{4}$	30-56-15	.51410	.59938	1.16587	59- 3-45
N.E. BY N. N.W. BY N.	S.E. BY S. S.W. BY S. }	3 Pts.	33-45- 0	.55557	.66818	1.20269	56-15- 0
		$3\frac{1}{4}$	36-33-45	.59570	.74165	1.24501	53-26-15
		$3\frac{1}{2}$	39-22-30	.63439	.82068	1.29364	50-37-30
		$3\frac{3}{4}$	42-11-15	.67156	.90635	1.34962	47-48-45
N. E. N.W.	S. F. S. W. }	4 Pts.	45- 0- 0	.70711	1.00000	1.41421	45- 0- 0
		$4\frac{1}{4}$	47-48-45	.74095	1.10333	1.48907	42-11-15
		$4\frac{1}{2}$	50-37-30	.77301	1.21850	1.57631	39-22-30
		$4\frac{3}{4}$	53-26-15	.80321	1.34834	1.67870	36-33-45
N. E. BY E. N.W. BY W.	S. E. BY E. S. W. BY W. }	5 Pts.	56-15- 0	.83147	1.49661	1.79995	33-45- 0
		$5\frac{1}{4}$	59- 3-45	.85773	1.66840	1.94514	30-56-15
		$5\frac{1}{2}$	61-52-30	.88192	1.87087	2.12136	28- 7-30
		$5\frac{3}{4}$	64-41-15	.90399	2.11432	2.33888	25-18-45
E. N. E. W. N. W.	E. S. E. W. S. W. }	6 Pts.	67-30- 0	.92388	2.41421	2.61313	22-30- 0
		$6\frac{1}{4}$	70-18-45	.94154	2.79481	2.96833	19-41-15
		$6\frac{1}{2}$	73- 7-30	.95694	3.29656	3.44490	16-52-30
		$6\frac{3}{4}$	75-56-15	.97003	3.99222	4.11556	14- 3-45
E. BY N. W. BY N.	E. BY S. W. BY S. }	7 Pts.	78-45- 0	.98079	5.02734	5.12583	11-15- 0
		$7\frac{1}{4}$	81-33-45	.98918	6.74146	6.81522	8-26-15
		$7\frac{1}{2}$	84-22-30	.99518	10.1532	10.2023	5-37-30
		$7\frac{3}{4}$	87-11-15	.99880	20.3556	20.3802	2-48-45
WEST.	EAST.	8 Pts.	90- 0- 0	1.	Infinite.	Infinite.	0- 0- 0
				Cosines.	Cotngnts.	Coscts.	Angles.

N.B.—The Sines, Tangents, and Secants of Angles in 4th column represent
,, Cosines, Cotangents, and Cosecants of Angles in last column.

USEFUL GAUGE POINTS.

1 Inch	= 1/12 Foot ;	or	100 Inches	= 2.54 Metres
1 Foot	= 1/3 Yard ;	or	105 Feet	= 32. do.
1 Yard	= 1/22 Chain ;	or	35 Yards	= 32. do.
1 Centimetre	= 10 Millimetres	= 1/10 Decimetre	= .3937 Inches	
1 Decimetre	= 1/10 Metre	= 10 Centimetres	= 3.937 do.	
1 Metre	= 1/10 Decametre	= 100 do.	= 39.37 do.	
1 Diameter	= 1 Crclr. Area	= .7854 or nrly. 11/14 Sq. Area		
11 do.	= 121 do.	= 95. Sq. Area		
1 Ft. do.	= 1 do. ft. do.	= 7.29 Sq. Decimetres		
1 Ft. Square	= 1 Sq. ft. do.	= 9.29 do. do.		
1 Sq. Yard	= 9 do. do.	= .836 Sq. Metres		
1 Sq. Centimetre	= 1/100 Sq. Decimetre	= .155 Sq. Ins.		
1 Sq. Decimetre	= 1/100 Sq. Metre	= 15.5 do.		
1 Sq. Metre	= 1/100 Sq. Hecto. or	8 Sq. Metres	= 86.11 Sq. Ft.	
1 In.dia. × 1ft.lng	= 9.424 Cu. Ins.	= .034 Gallons	= .1544 Litres	
10 ,, dia. × 1ft.do.	= 942.4 do.	= 3.4 do.	= 15.44 do.	
1 Ft. do. × 1ft.do.	= 1 Cylind Ft.	= 4.89 do.	= 22.2 do.	
*1 Ft.Sq. × 1ft.do.	= 1 Cube Ft.	= 6.235 do.	= 28.32 do.	
1 Decilitre	= 1/10 Litre	= 6.1027 Cu. Ins.	= .1762 Pints.	
1 Litre	= 1/10 Decalitre	= 61.027 do.	= .2202 Gals.	
42 Litres	= 4.2 do.	=	= 9.25 do.	
2.309 Ft. height of Water Column = 1 lb per sq. inch = 7.03 Kilo-				
grammes per sq. Decimetre				
1. Metre do.	= 9.98 Kilogs. per Decimetre	= 1.4207 lbs. per Sq. Inch		
1 Pound per circular Inch	- - - - -	= 8.95 Kilos. per Sq. Decim.		
1 Kilogramme per Square Centimetre	- - - - -	= 14.23 lbs. per Sq. Inch		
4.99 do.	- - - - -	= 11 lbs. Av. Weight		
£1 sterling	= 20 Shillings = 240 Pence = 960 Farthings	= 25 Francs.		
1 Franc	= 100 Centimes, - - - - - or 5 Francs	= 4 Shillings		
12 Pence or 1 Shilling per lb Av.	= 2.76 Francs per Kilogramme			
4 Francs 60 Cents. per Kilogramme	= 20 pence per lb. Av.			
3 Shillings per yard	- - - - -	= 4.1 Francs per Metre.		

Twice the Sine of 1/2 Arc of any circle = Length of Chord of whole Arc.

Length of 1° Arc of Circle of Radius 1 = .01745

No. of Degrees in Sector of any Circle × Diameter² of Circle of which the Sector is part, the product ÷ 459 = Area of Sector.— And Area of Sector less product of Sine × Cosine of 1/2 Arc = Area of Segment.

*17 Cub. Ft. = 106 Gallons.

AREA OF SEGMENTS OF A CIRCLE.

AREAS OF SEGMENTS OF A CIRCLE WHOSE DIAMETER IS UNITY.

Heights.	.000	.001	.002	.003	.004	.005	.006	.007	.008	.009
.01	.0013	.0015	.0017	.0020	.0022	.0024	.0027	.0029	.0032	.0035
.02	.0037	.0040	.0043	.0046	.0049	.0052	.0055	.0059	.0062	.0065
.03	.0069	.0072	.0076	.0079	.0082	.0086	.0090	.0094	.0098	.0101
.04	.0105	.0109	.0113	.0117	.0121	.0126	.0130	.0134	.0138	.0142
.05	.0147	.0151	.0156	.0160	.0165	.0169	.0174	.0178	.0183	.0188
.06	.0192	.0197	.0202	.0207	.0212	.0217	.0222	.0227	.0232	.0237
.07	.0242	.0247	.0252	.0257	.0262	.0268	.0273	.0278	.0284	.0289
.08	.0294	.0300	.0305	.0311	.0316	.0322	.0327	.0333	.0339	.0344
.09	.0350	.0356	.0362	.0367	.0373	.0379	.0385	.0391	.0397	.0403
.10	.0409	.0415	.0421	.0427	.0433	.0439	.0445	.0451	.0458	.0464
.11	.0470	.0476	.0483	.0489	.0495	.0502	.0508	.0514	.0521	.0527
.12	.0534	.0540	.0547	.0553	.0560	.0567	.0573	.0580	.0587	.0593
.13	.0600	.0607	.0613	.0620	.0627	.0634	.0641	.0648	.0654	.0661
.14	.0668	.0675	.0682	.0689	.0696	.0703	.0710	.0717	.0724	.0732
.15	.0739	.0746	.0753	.0760	.0767	.0775	.0782	.0789	.0796	.0804
.16	.0811	.0818	.0826	.0833	.0841	.0848	.0855	.0863	.0870	.0878
.17	.0885	.0893	.0900	.0908	.0916	.0923	.0931	.0938	.0946	.0954
.18	.0961	.0969	.0977	.0984	.0992	.1000	.1008	.1016	.1023	.1031
.19	.1039	.1047	.1055	.1063	.1071	.1078	.1086	.1094	.1102	.1110
.20	.1118	.1126	.1134	.1142	.1150	.1158	.1167	.1175	.1183	.1191
.21	.1199	.1207	.1215	.1223	.1232	.1240	.1248	.1256	.1265	.1273
.22	.1281	.1289	.1298	.1306	.1314	.1323	.1331	.1339	.1348	.1356
.23	.1365	.1373	.1382	.1390	.1398	.1407	.1415	.1424	.1432	.1441
.24	.1449	.1458	.1467	.1475	.1484	.1492	.1501	.1510	.1518	.1527
.25	.1535	.1544	.1553	.1561	.1570	.1579	.1588	.1596	.1605	.1614

INCHES OR PENCE IN DECIMALS OF FOOT OR SHILLING.

Inches.	0 Inch.	$\frac{1}{4}$ Inch.	$\frac{1}{2}$ Inch.	$\frac{3}{4}$ Inch.
0 inch.	.0 feet	.02083 ft.	.0416 ft.	.0625 ft.
1	.0833	.10416	.125	.14583
2	.1666	.1875	.2083	.22916
3	.25	.27083	.2916	.3125
4	.3333	.35416	.375	.39583
5	.4166	.4375	.4583	.47916
6	.5	.52083	.5416	.5625
7	.5833	.60416	.625	.64583
8	.6666	.6875	.7083	.72916
9	.75	.77083	.7916	.8125
10	.8333	.85416	.875	.89583
11	.9166	.9375	.9583	.97916

POUNDS, &c.. IN DECIMALS OF A CWT.

7 lbs.=1-16Cwt.	14 lb.= $\frac{1}{8}$ Cwt.	$\frac{1}{4}$ Cwt.	$\frac{1}{2}$ Cwt.	$\frac{3}{4}$ Cwt.
7 lbs.=0625	.125	.25	.5	.75
1 lb. =.00893	.13393	.25893	.50893	.75893
2 =.01786	.14286	.26786	.51786	.76786
3 =.02679	.15179	.27679	.52679	.77679
4 =.03571	.16071	.28571	.53571	.78571
5 =.04464	.16964	.29464	.54464	.79464
6 =.05357	.17857	.30357	.55357	.80357

PENCE IN DECIMALS OF A POUND.

Pence.	0	$\frac{1}{4}$	$\frac{1}{2}$	$\frac{3}{4}$
0	.0	.00104	.00208	.00312
1	.00417	.00521	.00625	.00729
2	.00833	.00938	.01042	.01146
3	.0125	.01354	.01458	.01562
4	.01667	.01771	.01875	.01979
5	.02083	.02187	.02291	.02396
6	.025	.02604	.02708	.02812
7	.02917	.03021	.03125	.03229
8	.03333	.03437	.03542	.03646
9	.0375	.03854	.03958	.04062
10	.04167	.04271	.04375	.04479
11	.04583	.04687	.04792	.04896





