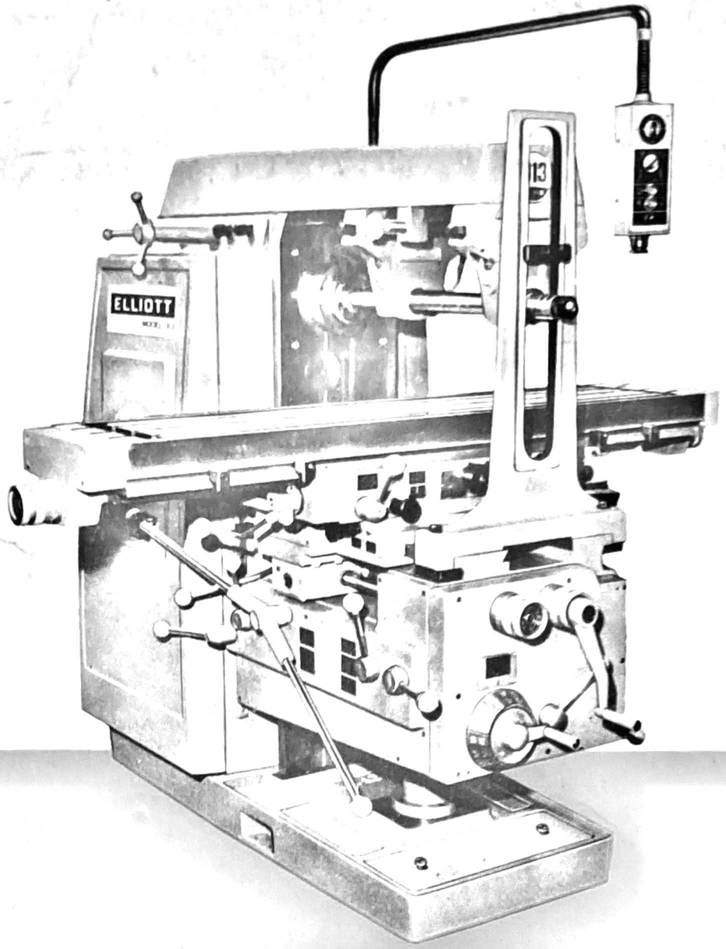
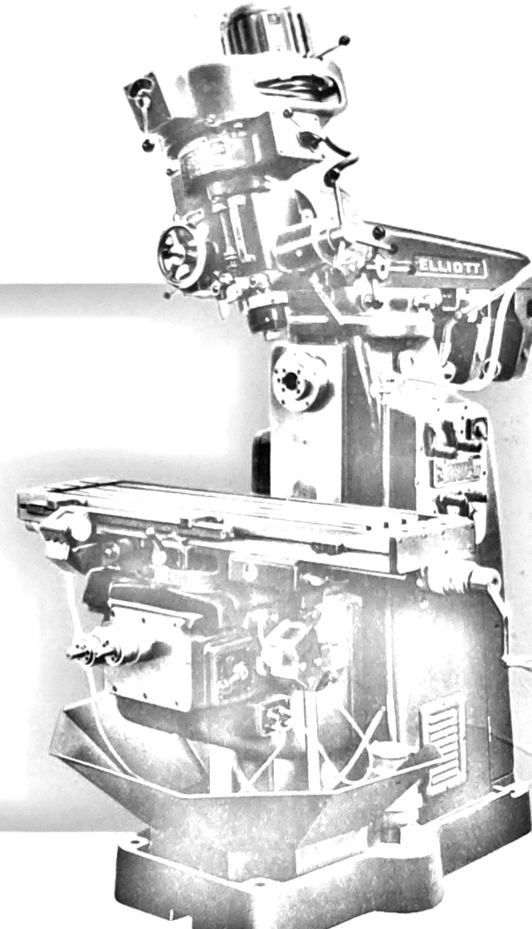
OPERATING MANUAL

ELLIOTT

UNIVERSAL DIVIDING HEADS



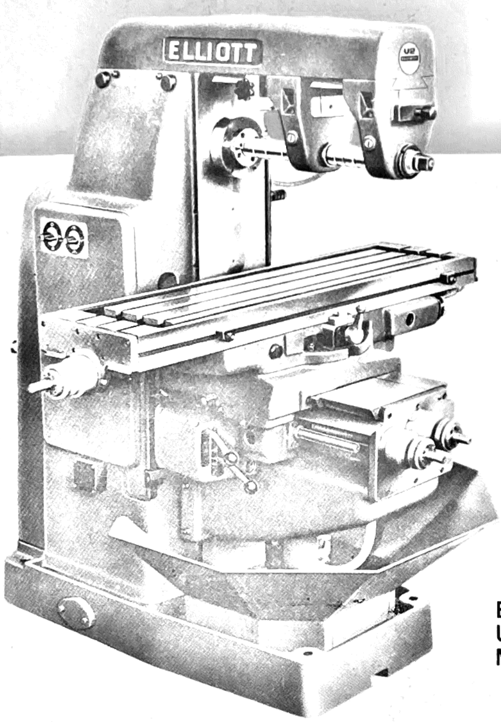
ELLIOTT 70 SERIES
UNIVERSAL MILLING MACHINE
MODEL 313



ELLIOTT

MILLING MACHINES

ELLIOTT OMNIMIL
MODEL 02



ELLIOTT
UNIVERSAL MILLING MACHINE
MODEL U2

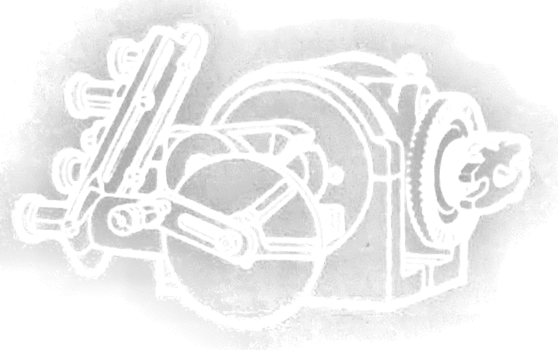
LEAFLETS GIVING FULL DETAILS OF OUR RANGE OF 29 MODELS OF MILLING MACHINES ARE AVAILABLE ON REQUEST

Parkside Steel 020 8801 7199
Units 7-8 Mowlem Trading Estate
Leeside Road
N.17 0QJ

UNIVERSAL DIVIDING HEADS

ELLIOTT OF LONDON GROUP

ELLIOTT



PRECISION UNIVERSAL DIVIDING HEADS

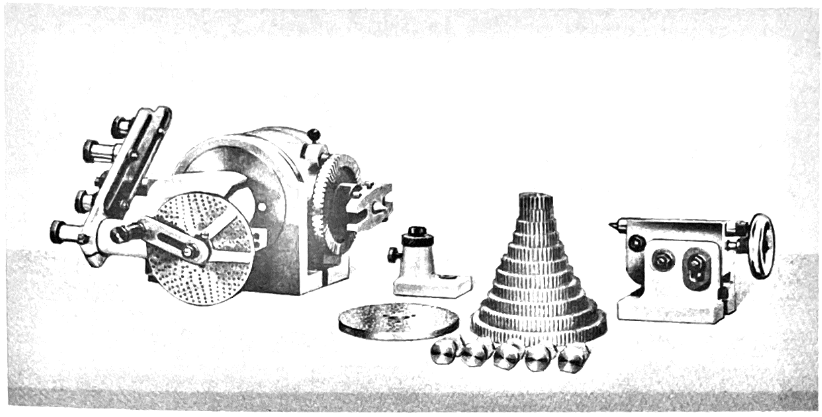
Contents

ELLIOTT OF LONDON GROUP

ELLIOTT

7″, 9″, 10″ AND 12″ SWING

PRECISION UNIVERSAL DIVIDING HEAD



These Dividing Heads together with their standard sets of change gears and hole circle plates provide a complete range of divisions and leads as tabulated in the following pages. They are fully universal so that they can be used for generating cams as well as for helical milling, and any number of divisions capable of simple indexing can be achieved with the work spindle in any position from the horizontal to the vertical.

The master worm wheels are cut on special single purpose hobbing machines provided with a pitch correction mechanism and the threads of the worm are finished on a precision thread grinding machine. Modern machines and carefully maintained tooling are used to produce all the main components to a similar high standard of accuracy and the result is that total accumulated error including cyclical effects is held within 1 min. 30 secs. of arc.

Each unit is subjected to a vigorous final inspection procedure which includes testing for spacing error on an optical equipment capable of registering errors of 5 seconds of arc (0.00007" at 3" radius).

All parts which could with advantage be hardened and ground are made from alloy steels suitably heat treated whilst the main castings are high grade cast iron. The worm wheel is made of hard gear bronze.

ELLIOTT

7", 9", 10" AND 12" SWING

PRECISION UNIVERSAL DIVIDING HEAD

Simple or Indirect Indexing Chart

RATIO OF HEAD 1:40

Standard Plates—Index plate 1	Hole Circles—15, 18, 20, 23, 27, 31, 37, 41, 47
" " 2	" 16, 17, 19, 21, 29, 33, 39, 43, 49

No. of divisions	Hole Circle	Index Arm: complete turns	Index Arm: Fraction of a turn.
2	–	20	–
3	39	13	13/39
	27	13	9/27
4	–	10	–
5	–	8	–
6	39	6	26/39
	27	6	18/27
7	49	5	35/49
	21	5	15/21
8	–	5	–
9	27	4	12/27
	18	4	8/18
10	–	4	–
11	33	3	21/33
12	39	3	13/39
	27	3	9/27
13	39	3	3/39
14	49	2	42/49
	21	2	18/21
15	39	2	26/39
	27	2	18/27
16	20	2	10/20
17	17	2	6/17

No. of divisions	Hole Circle	Index Arm: complete turns	Index Arm: Fraction of a turn.
18	27	2	6/27
18	18	2	4/18
19	19	2	2/19
20	–	2	–
21	21	1	19/21
22	33	1	27/33
23	23	1	17/23
24	39	1	26/39
	27	1	18/27
25	20	1	12/20
26	39	1	21/39
27	27	1	13/27
28	49	1	21/49
	21	1	9/21
29	29	1	11/29
30	39	1	13/39
	27	1	9/27
31	31	1	9/31
32	20	1	5/20
33	33	1	7/33
34	17	1	3/17
35	49	1	7/49
	21	1	3/21

No. of divisions	Hole Circle	Index Arm: complete turns	Index Arm: Fraction of a turn.
36	27	1	3/27
37	37	1	3/37
38	19	1	1/19
39	39	1	1/39
40	–	1	–
41	41	–	40/41
42	21	–	20/21
43	43	–	40/43
44	33	–	30/33
45	27	–	24/27
46	23	–	20/23
47	47	–	40/47
48	18	–	15/18
49	49	–	40/49
50	20	–	16/20
52	39	–	30/39
54	27	–	20/27
55	33	–	24/33
56	49	–	35/49
58	29	–	20/29
60	39	–	26/39
	27	–	18/27

No. of divisions	Hole Circle	Index Arm: Fraction of a turn.
62	31	20/31
64	16	10/16
65	39	24/39
66	33	20/33
68	17	10/17
70	49	28/49
72	27	15/27
74	37	20/37
75	15	8/15
76	19	10/19
78	39	20/39
80	20	10/20
82	41	20/41
84	21	10/21
85	17	8/17
86	43	20/43
88	33	15/33
90	27	12/27
92	23	10/23
94	47	20/47
95	19	8/19
98	49	20/49
100	20	8/20
104	39	15/39
105	21	8/21
108	27	10/27
110	33	12/33

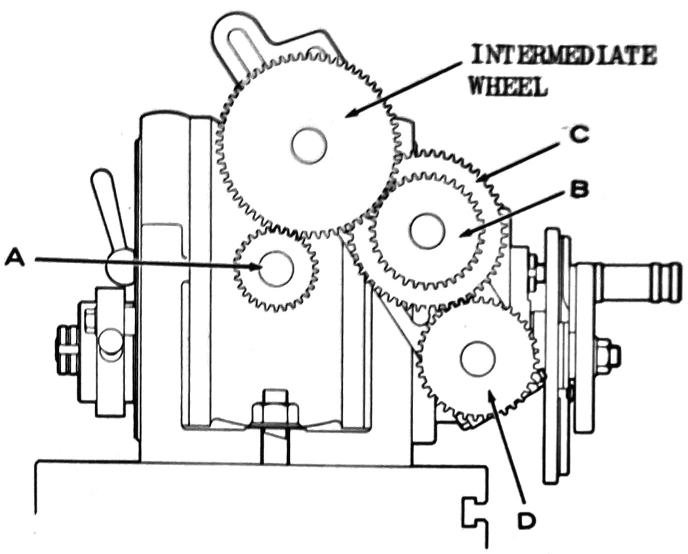
No. of divisions	Hole Circle	Index Arm: Fraction of a turn.
115	23	8/23
116	29	10/29
120	39	13/39
	27	9/27
124	31	10/31
128	16	5/16
130	39	12/39
132	33	10/33
135	27	8/27
136	17	5/17
140	49	14/49
144	18	5/18
145	29	8/29
148	37	10/37
150	15	4/15
152	19	5/19
155	31	8/31
156	39	10/39
160	20	5/20
164	41	10/41
165	33	8/33
168	21	5/21
170	17	4/17
172	43	10/43
180	27	6/27
	18	4/18
184	23	5/23

No. of divisions	Hole Circle	Index Arm: Fraction of a turn.
185	37	8/37
188	47	10/47
190	19	4/19
195	39	8/39
196	49	10/49
200	20	4/20
205	41	8/41
210	21	4/21
215	43	8/43
216	27	5/27
220	33	6/33
230	23	4/23
232	29	5/29
235	47	8/47
240	18	3/18
245	49	8/49
248	31	5/31
260	39	6/39
264	33	5/33
270	27	4/27
280	49	7/49
290	29	4/29
296	37	5/37
300	15	2/15
360	18	2/18
	27	3/27
400	20	2/20

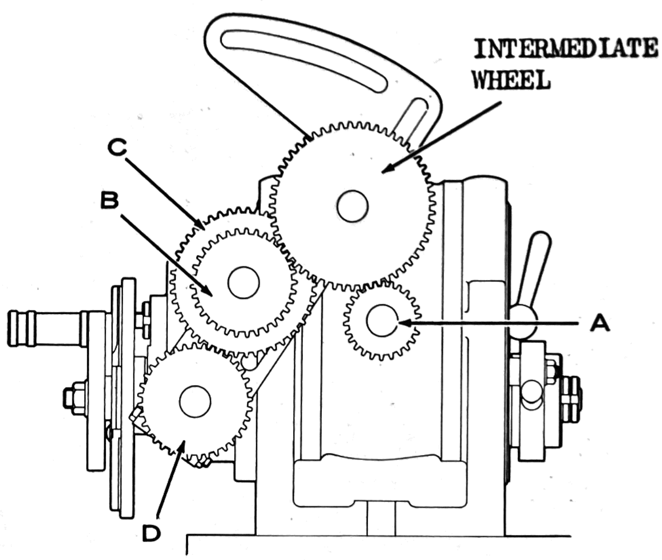
CHANGE GEARS and MOVEMENTS for DIFFERENTIAL INDEXING

Ratio of Head 1 : 40

PITCH CIRCLES PROVIDED: 15, 16, 17, 18, 19, 20, 21, 23, 27, 29, 31, 33, 37, 39, 41, 43, 47, 49 holes.



LEFT HANDED MODEL



RIGHT HANDED MODEL

Dividing number	Pitch circle	Revolution of the Index Arm	Wheel on the spindle of the dividing head A	Wheel on the compound sleeve B	Wheel on the compound sleeve C	Wheel on the shaft of the dividing disc D	Number of intermediate wheels L H HEAD	Number of intermediate wheels R H HEAD
51	17	14/17	48	–	–	24	2	1
53	49	35/49	72	24	40	56	–	1
57	49	35/49	40	–	–	56	2	1
59	33	22/33	32	–	–	48	1	2
61	33	22/33	32	–	–	48	2	1
63	33	22/33	48	–	–	24	2	1
67	49	28/49	48	–	–	28	1	2
69	20	12/20	56	–	–	40	2	1
71	27	15/27	40	–	–	72	1	2
73	49	28/49	48	–	–	28	2	1
77	20	10/20	48	–	–	32	1	2
79	20	10/20	24	–	–	48	1	2
81	20	10/20	24	–	–	48	2	1
83	20	10/20	48	–	–	32	2	1
87	15	7/15	24	–	–	40	2	1
89	27	12/27	32	–	–	72	1	2
91	39	18/39	48	–	–	24	2	1
93	27	12/27	32	–	–	24	2	1
96	49	21/49	32	–	–	28	2	1
97	20	8/20	48	–	–	40	1	2
99	20	8/20	32	40	28	56	–	1
101	20	8/20	48	40	24	72	1	–
102	20	8/20	32	–	–	40	2	1
103	20	8/20	48	–	–	40	2	1
106	43	16/43	48	24	24	86	–	1
107	20	8/20	64	32	56	40	1	–
109	16	6/16	28	–	–	32	2	1
111	39	13/39	72	–	–	24	1	2
112	33	11/33	64	–	–	24	1	2
113	39	13/39	56	–	–	24	1	2
114	39	13/39	48	–	–	24	1	2
117	33	11/33	24	–	–	24	1	2
118	39	13/39	32	–	–	48	1	2
119	39	13/39	24	–	–	72	1	2
121	39	13/39	24	–	–	72	2	1
122	39	13/39	32	–	–	48	2	1
123	39	13/39	24	–	–	24	2	1
125	39	13/39	40	–	–	24	2	1
126	39	13/39	48	–	–	24	2	1
127	39	13/39	56	–	–	24	2	1
129	39	13/39	72	–	–	24	2	1
131	20	6/20	28	–	–	40	1	2
133	49	14/49	48	–	–	24	1	2
134	49	14/49	48	–	–	28	1	2
137	49	14/49	24	–	–	28	1	2
138	49	14/49	32	–	–	56	1	2
139	49	14/49	24	48	32	56	–	1

CHANGE GEARS and MOVEMENTS for DIFFERENTIAL INDEXING—cont.

Dividing number	Pitch circle	Revolution of the Index Arm	Wheel on the spindle of the dividing head A	Wheel on the compound sleeve B	Wheel on the compound sleeve C	Wheel on the shaft of the dividing disc D	Number of Intermediate wheels L.H. HEAD	Number of Intermediate wheels R.H. HEAD
141	18	5/18	40	–	–	48	1	2
142	49	14/49	32	–	–	56	2	1
143	49	14/49	24	–	–	28	2	1
146	49	14/49	48	–	–	28	2	1
147	49	14/49	48	–	–	24	2	1
149	49	14/49	72	–	–	28	2	1
151	20	5/20	72	–	–	32	1	2
153	20	5/20	56	–	–	32	1	2
154	20	5/20	48	–	–	32	1	2
157	20	5/20	24	–	–	32	1	2
158	20	5/20	24	–	–	48	1	2
159	20	5/20	28	56	32	64	–	1
161	20	5/20	28	56	32	64	1	–
162	20	5/20	24	–	–	48	2	1
163	20	5/20	24	–	–	32	2	1
166	20	5/20	48	–	–	32	2	1
167	20	5/20	56	–	–	32	2	1
169	20	5/20	72	–	–	32	2	1
171	21	5/21	40	–	–	56	2	1
173	27	6/27	64	32	56	72	–	1
174	27	6/27	32	–	–	24	1	2
175	27	6/27	64	32	40	72	–	1
176	27	6/27	64	24	24	72	–	1
177	27	6/27	48	–	–	72	1	2
178	27	6/27	32			72	1	2
179	27	6/27	32	48	24	72	–	1
181	27	6/27	32	48	24	72	1	–
182	27	6/27	32	–	–	72	2	1
183	27	6/27	32	–	–	48	2	1
186	27	6/27	64	–	–	48	2	1
187	27	6/27	56	24	48	72	1	–
189	27	6/27	64	–	–	32	2	1
191	20	4/20	72	–	–	40	1	2
192	20	4/20	64	–	–	40	1	2
193	20	4/20	56	–	–	40	1	2
194	20	4/20	48	–	–	40	1	2
197	20	4/20	24	–	–	40	1	2
198	20	4/20	32	40	28	56	–	1
199	20	4/20	32	64	40	100	–	1
201	20	4/20	24	40	24	72	–	1
202	20	4/20	48	40	24	72	1	–
203	20	4/20	24	–	–	40	2	1
204	20	4/20	32	–	–	40	2	1
206	20	4/20	48	–	–	40	2	1
207	20	4/20	56	–	–	40	2	1
208	20	4/20	64	–	–	40	2	1
209	20	4/20	72	–	–	40	2	1
211	16	3/16	28	–	–	64	1	2
212	43	8/43	48	24	24	86	–	1
213	27	5/27	40	–	–	72	1	2
214	20	4/20	64	32	56	40	1	–
217	21	4/21	64	–	–	48	2	1
218	16	3/16	56	–	–	64	2	1
219	21	4/21	48	–	–	28	2	1
221	17	3/17	24	–	–	24	1	2
222	18	3/18	72	–	–	24	1	2
223	43	8/43	64	24	48	86	1	–
224	18	3/18	64	–	–	24	1	2
225	27	5/27	40	–	–	24	2	1
226	18	3/18	56	–	–	24	1	2
227	49	8/49	72	28	64	56	–	1
228	18	3/18	48	–	–	24	1	2
229	18	3/18	44	–	–	24	1	2
231	18	3/18	48	–	–	32	1	2
233	18	3/18	56	–	–	40	1	2
234	18	3/18	24	–	–	24	1	2
236	18	3/18	32	–	–	48	1	2
237	18	3/18	24	–	–	48	1	2
238	18	3/18	24	–	–	72	1	2
239	18	3/18	32	64	24	72	–	1
241	18	3/18	32	64	24	72	1	–
242	18	3/18	24	–	–	72	2	1
243	18	3/18	32	–	–	64	2	1
244	18	3/18	32	–	–	48	2	1
246	18	3/18	24	–	–	24	2	1
247	18	3/18	56	–	–	48	2	1
249	18	3/18	48	–	–	32	2	1
250	18	3/18	40	–	–	24	2	1
251	18	3/18	64	32	44	48	1	1
252	18	3/18	48	–	–	24	2	1
253	33	5/33	40	–	–	24	1	1
254	18	3/18	56	–	–	24	2	1
255	18	3/18	72	24	40	48	1	–
256	18	3/18	64	–	–	24	2	1
257	49	8/49	64	28	48	56	1	–
258	43	7/43	64	–	–	32	2	1
259	49	7/49	72	–	–	24	1	2
261	29	4/29	72	24	64	48	–	1
262	20	3/20	28	–	–	40	1	2
263	49	8/49	72	28	64	56	1	–
265	49	7/49	72	24	40	56	–	1
266	49	7/49	64	–	–	32	1	2
267	27	4/27	32	–	–	72	1	2
268	49	7/49	48	–	–	28	1	2
269	20	3/20	28	40	32	64	1	–
271	49	7/49	72	–	–	56	1	2

CHANGE GEARS and MOVEMENTS for DIFFERENTIAL INDEXING—cont.

Dividing number	Pitch circle	Revolution of the Index Arm	Wheel on the spindle of the dividing head A	Wheel on the compound sleeve B	Wheel on the compound sleeve C	Wheel on the shaft of the dividing disc D	Number of intermediate wheels L.H. HEAD	Number of intermediate wheels R.H. HEAD
272	49	7/49	64	–	–	56	1	2
273	49	7/49	24	–	–	24	1	2
274	49	7/49	48	–	–	56	1	2
275	49	7/49	40	–	–	56	1	2
276	49	7/49	32	–	–	56	1	2
277	49	7/49	24	–	–	56	1	2
278	49	7/49	24	48	32	56	–	1
279	27	4/27	32	–	–	24	2	1
281	49	7/49	24	56	24	72	1	–
282	43	6/43	56	24	24	86	–	1
283	49	7/49	24	–	–	56	2	1
284	49	7/49	32	–	–	56	2	1
285	49	7/49	40	–	–	56	2	1
286	49	7/49	48	–	–	56	2	1
287	49	7/49	24	–	–	24	2	1
288	49	7/49	32	–	–	28	2	1
289	49	7/49	72	–	–	56	2	1
291	15	2/15	48	–	–	40	1	2
292	49	7/49	48	–	–	28	2	1
293	15	2/15	56	40	32	48	–	1
294	49	7/49	48	–	–	24	2	1
295	15	2/15	32	–	–	48	1	2
297	33	4/33	56	24	48	28	–	1
298	49	7/49	72	–	–	28	2	1
299	23	3/23	24	–	–	24	1	2
301	43	6/43	48	–	–	24	2	1
302	16	2/16	72	–	–	32	1	2
303	15	2/15	48	40	24	72	1	–
304	16	2/16	48	–	–	24	1	2
305	15	2/15	32	–	–	48	2	1
306	15	2/15	32	–	–	40	2	1
307	15	2/15	56	40	48	72	1	–
308	16	2/16	48	–	–	32	1	2
309	15	2/15	48	–	–	40	2	1
311	16	2/16	72	24	24	64	–	1
313	16	2/16	28	–	–	32	1	2
314	16	2/16	24	–	–	32	1	2
315	16	2/16	40	–	–	64	1	2
316	16	2/16	32	–	–	64	1	2
317	16	2/16	24	–	–	64	1	2
318	16	2/16	24	48	28	56	–	1
319	29	4/29	72	24	64	48	1	–
321	16	2/16	24	64	24	72	1	–
322	23	3/23	64	–	–	32	2	1
323	16	2/16	24	–	–	64	2	1
324	16	2/16	32	–	–	64	2	1
325	16	2/16	40	–	–	64	2	1
326	16	2/16	24	–	–	32	2	1

Dividing number	Pitch circle	Revolution of the Index Arm	Wheel on the spindle of the dividing head A	Wheel on the compound sleeve B	Wheel on the compound sleeve C	Wheel on the shaft of the dividing disc D	Number of intermediate wheels L.H. HEAD	Number of intermediate wheels R.H. HEAD
327	16	2/16	28	–	–	32	2	1
329	16	2/16	72	24	24	64	1	–
331	16	2/16	48	24	44	64	1	–
332	16	2/16	48	–	–	32	2	1
333	27	3/27	72	–	–	24	1	2
334	16	2/16	56	–	–	32	2	1
335	33	4/33	40	44	48	72	1	–
336	16	2/16	64	–	–	32	2	1
337	43	5/43	56	32	40	86	–	1
338	16	2/16	72	–	–	32	2	1
339	27	3/27	56	–	–	24	1	2
341	43	5/43	40	32	24	86	–	1
342	27	3/27	64	–	–	32	1	2
343	15	2/15	86	24	64	40	1	–
345	27	3/27	40	–	–	24	1	2
346	27	3/27	64	32	56	72	–	1
347	43	5/43	40	32	24	86	1	–
348	27	3/27	32	–	–	24	1	2
349	27	3/27	48	24	44	72	–	1
350	27	3/27	64	32	40	72	–	1
351	27	3/27	24	–	–	24	1	2
352	27	3/27	64	24	24	72	–	1
353	27	3/27	56	–	–	72	1	2
354	27	3/27	48	–	–	72	1	2
355	27	3/27	40	–	–	72	1	2
356	27	3/27	32	–	–	72	1	2
357	27	3/27	24	–	–	72	1	2
358	27	3/27	24	48	32	72	–	1
359	43	5/43	100	32	48	86	1	–
361	19	2/19	64	–	–	32	1	2
362	27	3/27	32	56	28	72	1	–
363	27	3/27	24	–	–	72	2	1
364	27	3/27	32	–	–	72	2	1
365	20	2/20	56	24	48	32	–	1
366	27	3/27	32	–	–	48	2	1
367	27	3/27	56	–	–	72	2	1
368	27	3/27	64	24	24	72	1	–
369	41	4/41	64	28	56	32	–	1
371	21	2/21	64	24	56	32	–	1
372	27	3/27	64	–	–	48	2	1
373	20	2/20	72	32	48	40	–	1
374	27	3/27	56	32	64	72	1	–
375	27	3/27	40	–	–	24	2	1
377	29	3/29	24	–	–	24	1	2
378	27	3/27	64	–	–	32	2	1
379	20	2/20	72	40	56	48	–	1
381	27	3/27	56	–	–	24	2	1
382	20	2/20	72	–	–	40	1	2

TABLE of LEADS

Ratio of Head 1:40

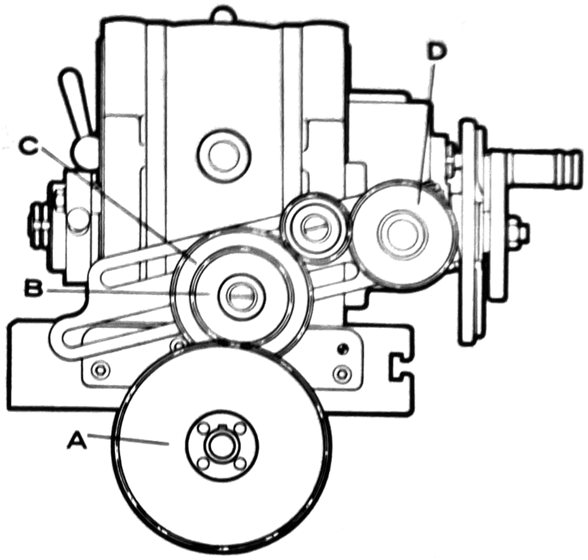
Lead of Table Screw, ¼ inch (English)

Lead obtained = $\frac{10'' \ D \times B}{C \times A}$

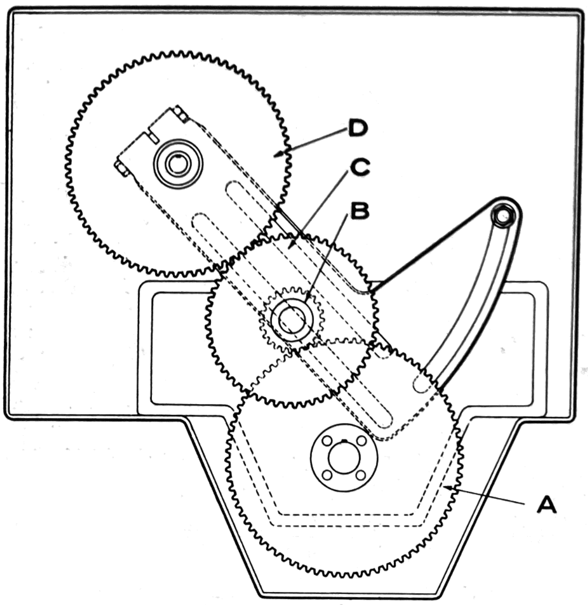
Lead of Table Screw, 5 mm (Metric)

Lead obtained = $\frac{200 \text{ mm} \ D \times B}{C \times A}$

Change gear wheels provided: 24, 24, 28, 32, 40, 48, 56, 64, 72, 86, 100 teeth.
Use any gears as idlers to make up centre distance where necessary.
Two idlers or no idler gives right hand helix. One idler gives left hand helix.
The leads given in this table are obtained by driving through the worm gear reduction in the normal manner. For the cutting of very short leads refer to Page 19.
The Table of Leads is based on the use of a Dividing Head with the standard ratio of 1:40 and either a ¼" pitch table screw for English Leads or a 5 mm pitch screw for Metric leads. The English and Metric leads resulting from the same change gear set-up are therefore not direct conversions.



LEFT HAND DIVIDING HEAD



RIGHT HAND DIVIDING HEAD

Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant: Driven B	Wheels on the Change Gear Quadrant: Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
0.670	100	24	86	24	13.4
0.781	100	28	86	24	15.62
0.800	100	24	72	24	16.00
0.893	100	32	86	24	17.86
0.930	86	24	72	24	18.6
1.029	100	24	56	24	20.58
1.042	100	32	86	28	20.84
1.047	86	24	64	24	20.94
1.050	100	28	64	24	21.0
1.067	100	32	72	24	21.34
1.085	86	28	72	24	21.70
1.116	100	40	86	24	22.32
1.196	86	24	56	24	23.92
1.200	100	24	48	24	24.00
1.221	86	28	64	24	24.42
1.240	86	32	72	24	24.8
1.250	72	24	64	24	25.0
1.302	100	40	86	28	26.04
1.333	100	40	72	24	26.66
1.340	100	48	86	24	26.8
1.371	100	32	56	24	27.42
1.395	86	24	48	24	27.9
1.400	100	28	48	24	28.0
1.429	72	24	56	24	28.58
1.440	100	24	40	24	28.8
1.458	72	28	64	24	29.16
1.488	100	40	86	32	29.76
1.500	100	40	64	24	30.0
1.550	86	40	72	24	31.0
1.563	100	56	86	24	31.26

English leads based on ¼" pitch table screw. Metric leads based on 5 mm pitch table screw

Ratio of lead 1:40

Two idlers or none produce right hand helix. One idler gives left hand helix

Use any gears as idlers to make up centre distance as necessary

CHANGE GEARS SUPPLIED 24, 24, 28, 32, 40, 48, 56, 64, 72, 86 and 100 teeth

Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant: Driven B	Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
1.595	86	32	56	24	31.9
1.600	100	32	48	24	32.0
1.607	64	24	56	24	32.14
1.628	86	28	48	24	32.56
1.667	72	28	56	24	33.34
1.674	86	24	40	24	33.48
1.680	100	28	40	24	33.60
1.714	100	40	56	24	34.28
1.744	86	40	64	24	34.88
1.750	100	40	64	28	35.10
1.778	100	40	72	32	35.56
1.786	100	64	86	24	35.72
1.800	100	48	64	24	36.00
1.809	86	40	72	28	36.18
1.823	100	56	86	28	36.46
1.860	86	32	56	28	37.20
1.861	86	48	72	24	37.22
1.867	100	32	48	28	37.34
1.875	64	24	48	24	37.50
1.905	72	32	56	24	38.10
1.920	100	32	40	24	38.40
1.944	72	28	48	24	38.88
1.954	86	28	40	24	39.08
1.993	86	40	56	24	39.86
2.000	72	24	40	24	40.00
2.009	100	72	86	24	40.18
2.035	86	40	64	28	40.70
2.057	100	24	28	24	41.14
2.067	86	40	72	32	41.34
2.083	72	40	64	24	41.66
2.084	100	64	86	28	41.68
2.093	86	48	64	24	41.86
2.100	100	56	64	24	42.00
2.133	100	64	72	24	42.66
2.143	64	32	56	24	42.86
2.171	86	56	72	24	43.42
2.178	100	56	72	28	43.56
2.188	64	28	48	24	43.76
2.222	72	32	48	24	44.44
2.233	100	48	86	40	44.66
2.240	100	32	40	28	44.80
2.250	64	24	40	24	45.10
2.286	100	40	56	32	45.72
2.326	86	40	64	32	46.52
2.333	100	40	48	28	46.66
2.344	100	72	86	28	46.88
2.381	100	64	86	32	47.62
2.392	86	48	56	24	47.84
2.400	100	48	56	28	48.00
2.431	72	40	64	28	48.62

Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant: Driven B	Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
2.442	86	28	32	24	48.84
2.450	100	56	64	28	49.10
2.481	86	48	72	32	49.62
2.489	100	56	72	32	49.78
2.500	56	28	48	24	50.00
2.532	86	56	72	28	50.64
2.571	56	24	40	24	51.42
2.593	72	32	48	28	51.86
2.605	86	32	40	28	52.10
2.625	64	28	40	24	52.50
2.658	86	40	56	32	53.16
2.667	100	48	72	40	53.34
2.678	64	40	56	24	53.56
2.679	100	72	86	32	53.58
2.700	100	72	64	24	54.00
2.713	86	40	48	28	54.36
2.743	100	64	56	24	54.86
2.778	72	40	64	32	55.56
2.791	86	48	56	28	55.82
2.800	100	28	24	24	56.00
2.812	64	24	32	24	56.24
2.845	100	64	72	32	56.50
2.849	86	56	64	28	56.98
2.857	56	32	48	24	57.14
2.867	100	24	72	86	57.34
2.880	100	48	40	24	57.60
2.894	86	64	72	28	57.88
2.917	72	56	64	24	58.34
2.977	100	64	86	40	59.54
3.000	56	28	40	24	60.00
3.086	100	72	56	24	61.72
3.101	86	48	72	40	62.02
3.111	72	32	40	28	62.22
3.125	64	40	56	28	62.50
3.126	100	56	86	48	62.52
3.140	64	72	86	24	62.80
3.150	64	72	100	28	63.10
3.175	72	40	56	32	63.50
3.189	86	48	56	32	63.78
3.190	56	64	86	24	63.80
3.200	56	64	100	28	64.00
3.214	64	48	56	24	64.28
3.225	64	86	100	24	64.50
3.241	72	40	48	28	64.82
3.256	86	28	24	24	65.12
3.267	100	56	48	28	65.34
3.281	64	28	32	24	65.62
3.308	86	64	72	32	66.16
3.333	72	48	64	32	66.66
3.345	72	86	100	28	66.90

Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant: Driven B	Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
3.349	100	72	86	40	66.98
3.360	100	24	40	56	67.20
3.403	72	56	64	28	68.06
3.428	56	32	40	24	68.56
3.429	100	24	28	40	68.58
3.488	86	48	64	40	69.76
3.500	100	56	64	40	70.00
3.556	100	64	72	40	71.12
3.571	56	40	48	24	71.42
3.572	100	64	86	48	71.44
3.588	86	24	56	72	71.76
3.600	100	24	48	72	72.00
3.618	86	40	72	56	72.36
3.646	64	28	48	40	72.52
3.657	100	32	56	64	73.14
3.663	86	28	64	72	73.26
3.673	56	24	28	24	73.46
3.686	100	24	56	86	73.72
3.704	72	40	48	32	74.08
3.721	86	32	24	24	74.42
3.733	100	56	72	48	74.66
3.750	48	24	32	24	75.00
3.763	100	28	64	86	75.26
3.799	86	28	48	56	75.98
3.809	72	32	28	24	76.18
3.810	72	24	56	64	76.20
3.822	100	32	72	86	76.44
3.840	100	24	40	64	76.80
3.876	86	100	72	24	77.52
3.889	72	56	64	32	77.78
3.907	86	24	40	56	78.14
3.920	100	56	40	28	78.40
3.987	86	40	28	24	79.74
4.000	48	32	40	24	80.00
4.019	100	48	86	72	80.38
4.070	86	40	32	28	81.40
4.114	100	24	28	48	82.28
4.135	86	64	72	40	82.70
4.167	56	40	48	28	83.34
4.186	86	32	64	72	83.72
4.200	100	56	64	48	84.00
4.253	86	32	56	64	85.06
4.267	100	32	48	64	85.34
4.286	48	24	28	24	85.72
4.300	100	28	56	86	86.00
4.320	100	24	40	72	86.40
4.341	86	56	72	48	86.82
4.342	86	28	48	64	86.84
4.361	86	24	64	100	87.22
4.375	64	28	24	24	87.50

English leads based on ¼" pitch table screw. Metric leads based on 5 mm pitch table screw
Ratio of lead 1:40
Two idlers or none produce right hand helix. One idler gives left hand helix
Use any gears as idlers to make up centre distance as necessary
CHANGE GEARS SUPPLIED 24, 24, 28, 32, 40, 48, 56, 64, 72, 86 and 100 teeth

Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant Driven B	Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
4.444	72	28	56	64	88.88
4.465	86	24	40	64	89.30
4.466	86	32	40	48	89.32
4.479	72	24	64	86	89.58
4.480	100	32	40	56	89.60
4.500	100	40	64	72	90.00
4.522	86	28	72	100	90.44
4.537	72	28	48	56	90.74
4.558	86	28	40	56	91.16
4.572	100	64	56	40	91.44
4.651	86	24	24	40	93.02
4.667	48	32	40	28	93.34
4.687	64	24	32	40	93.74
4.688	100	72	86	56	93.76
4.762	72	24	28	40	95.24
4.778	100	40	72	86	95.56
4.784	86	32	56	72	95.68
4.785	86	24	28	48	95.70
4.800	100	24	24	48	96.00
4.821	64	24	56	72	96.42
4.861	72	28	32	40	97.22
4.884	86	56	64	48	97.68
4.898	56	32	28	24	97.96
4.900	100	28	32	56	98.00
4.914	100	32	56	86	98.28
4.961	86	32	48	64	99.22
4.978	100	64	72	56	99.56
4.984	86	24	56	100	99.68
5.000	56	28	24	24	100.00
5.017	100	28	48	86	100.34
5.023	86	24	40	72	100.46
5.040	100	28	40	72	100.80
5.080	72	32	56	64	101.60
5.088	86	28	64	100	101.76
5.105	64	56	48	28	102.10
5.119	72	24	56	86	102.38
5.120	100	32	40	64	102.40
5.142	100	40	56	72	102.84
5.143	40	24	28	24	102.86
5.160	100	24	40	86	103.20
5.168	86	32	72	100	103.36
5.185	72	32	24	28	103.70
5.186	72	28	48	64	103.72
5.209	72	24	64	100	104.18
5.210	86	28	40	64	104.20
5.226	72	28	64	86	104.52
5.233	86	40	64	72	104.66
5.250	40	28	32	24	105.00
5.316	86	32	28	40	106.32
5.333	100	32	24	40	106.66

Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant Driven B	Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
5.357	64	24	28	40	107.14
5.358	100	72	86	64	107.16
5.375	100	40	64	86	107.50
5.400	100	24	32	72	108.0
5.426	86	28	24	40	108.52
5.427	86	56	48	40	108.54
5.444	72	28	40	56	108.88
5.469	64	28	32	40	109.38
5.486	100	24	28	64	109.72
5.556	72	24	24	40	111.12
5.581	86	24	32	64	111.62
5.582	86	24	24	48	111.64
5.600	100	24	24	56	112.0
5.625	64	24	32	48	112.50
5.698	86	28	32	56	113.96
5.714	72	24	28	48	114.28
5.733	100	32	48	86	114.66
5.759	64	24	56	86	115.18
5.760	100	32	40	72	115.20
5.788	86	56	72	64	115.76
5.814	86	32	64	100	116.28
5.833	48	24	24	28	116.66
5.861	86	28	40	72	117.22
5.926	72	32	48	64	118.52
5.952	72	24	56	100	119.04
5.954	86	32	40	64	119.08
5.972	72	24	48	86	119.44
5.980	86	40	56	72	119.60
6.000	56	28	40	48	120.00
6.020	100	28	40	86	120.40
6.077	72	28	64	100	121.54
6.122	56	24	28	40	122.44
6.125	64	28	40	56	122.50
6.143	100	40	56	86	122.86
6.171	100	48	56	72	123.42
6.172	100	24	28	72	123.44
6.202	86	32	24	40	124.04
6.222	72	28	40	64	124.44
6.250	64	40	24	24	125.00
6.279	86	48	64	72	125.58
6.300	100	28	32	72	126.00
6.350	72	32	28	40	127.00
6.379	86	24	28	64	127.58
6.400	100	24	24	64	128.00
6.429	32	24	28	24	128.58
6.450	100	48	64	86	129.00
6.460	86	40	72	100	129.20
6.482	72	40	48	56	129.64
6.512	86	24	24	56	130.24
6.534	100	28	24	56	130.68

Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant Driven B	Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
6.563	64	24	32	56	131.26
6.645	86	32	56	100	132.90
6.667	56	28	48	64	133.34
6.689	100	56	72	86	133.78
6.697	64	24	56	100	133.94
6.698	86	32	40	72	133.96
6.719	64	24	48	86	134.38
6.720	100	48	40	56	134.40
6.750	64	24	40	72	135.00
6.784	86	28	48	100	135.68
6.806	72	28	32	56	136.12
6.825	72	32	56	86	136.50
6.857	40	24	28	32	137.14
6.880	100	32	40	86	137.60
6.944	72	24	48	100	138.88
6.945	72	28	56	100	138.90
6.968	72	28	48	86	139.36
6.977	86	40	32	48	139.54
7.000	40	24	24	28	140.0
7.111	72	32	40	64	142.22
7.143	64	32	28	40	142.86
7.167	72	24	40	86	143.34
7.176	86	24	28	72	143.52
7.200	100	24	24	72	144.00
7.268	86	40	64	100	145.36
7.292	64	40	48	56	145.84
7.314	100	32	28	64	146.28
7.326	86	28	32	72	146.52
7.347	56	24	28	48	146.94
7.371	100	48	56	86	147.42
7.372	100	24	28	86	147.44
7.408	72	32	24	40	148.16
7.442	86	24	24	64	148.84
7.465	72	40	64	86	149.30
7.467	100	28	24	64	149.34
7.500	64	24	24	48	150.0
7.525	100	28	32	86	150.5
7.597	86	28	24	56	151.94
7.619	56	32	48	64	152.38
7.020	72	24	28	64	152.40
7.644	100	64	72	86	152.88
7.657	64	28	32	56	153.14
7.679	56	24	48	86	153.58
7.680	100	48	40	64	153.60
7.714	56	24	40	72	154.28
7.752	86	32	48	100	155.04
7.778	48	28	24	32	155.56
7.813	64	24	48	100	156.26
7.815	86	48	40	56	156.30
7.838	64	28	48	86	156.76

English leads based on $\frac{1}{4}$" pitch table screw. Metric leads based on 5 mm pitch table screw
Ratio of lead 1:40
Two idlers or none produce right hand helix. One idler gives left hand helix.
Use any gears as idlers to make up centre distance as necessary
CHANGE GEARS SUPPLIED 24, 24, 28, 32, 40, 48, 56, 64, 72, 86 and 100 teeth

Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant Driven B	Wheels on the Change Gear Quadrant Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
7.875	64	28	40	72	157.50
7.936	72	32	56	100	158.72
7.963	72	32	48	86	159.26
7.974	86	40	28	48	159.48
8.000	100	40	32	64	160.0
8.035	64	40	56	72	160.70
8.063	64	24	40	86	161.26
8.102	72	28	48	100	162.04
8.140	86	40	32	56	162.80
8.163	56	32	28	40	163.26
8.167	48	28	40	56	163.34
8.229	100	32	28	72	164.58
8.306	86	40	56	100	166.12
8.333	48	24	24	40	166.66
8.334	56	28	24	40	166.68
8.361	72	28	40	86	167.22
8.372	86	24	24	72	167.44
8.400	100	28	24	72	168.00
8.437	64	24	32	72	168.74
8.506	86	32	28	64	170.12
8.532	72	40	56	86	170.64
8.534	100	32	24	64	170.68
8.572	56	24	32	64	171.44
8.572	56	24	24	48	171.44
8.600	100	24	24	86	172.00
8.640	100	48	40	72	172.80
8.681	72	40	64	100	173.62
8.682	86	28	24	64	173.64
8.721	86	24	32	100	174.42
8.750	32	24	24	28	175.0
8.929	56	24	48	100	178.58
8.930	86	48	40	64	178.60
8.959	56	28	48	86	179.18
8.960	100	56	40	64	179.20
9.000	40	24	32	48	180.0
9.044	86	56	72	100	180.88
9.074	72	28	24	56	181.48
9.115	64	28	48	100	182.30
9.143	56	32	40	64	182.86
9.214	56	24	40	86	184.28
9.260	72	32	48	100	185.20
9.302	86	40	24	48	186.04
9.303	86	40	28	56	186.06
9.333	48	28	40	64	186.66
9.334	40	28	24	32	186.68
9.375	64	40	32	48	187.50
9.406	64	28	40	86	188.12
9.524	48	32	28	40	190.48
9.556	72	32	40	86	191.12
9.569	86	32	28	72	191.38
9.598	64	40	56	86	191.96
9.600	100	32	24	72	192.00
9.643	56	24	32	72	192.86
9.675	100	72	64	86	193.50
9.690	86	40	48	100	193.80
9.723	48	28	24	40	194.46
9.768	86	56	48	72	195.36
9.796	56	24	28	64	195.92
9.828	100	32	28	86	196.56
9.844	64	28	32	72	196.88
9.921	72	40	56	100	198.42
9.923	86	32	24	64	198.46
9.954	72	40	48	86	199.08
9.967	86	48	56	100	199.34
9.968	86	24	28	100	199.36
10.000	48	24	28	56	200.0
10.033	100	28	24	86	200.66
10.046	86	48	40	72	200.92
10.078	64	24	32	86	201.56
10.080	100	56	40	72	201.60
10.159	72	32	28	64	203.18
10.175	86	28	32	100	203.50
10.209	64	28	24	56	204.18
10.238	72	24	28	86	204.76
10.286	40	24	28	48	205.72
10.320	100	48	40	86	206.40
10.336	86	64	72	100	206.72
10.370	72	28	24	64	207.40
10.371	72	56	48	64	207.42
10.417	72	24	32	100	208.34
10.419	86	56	40	64	208.38
10.451	72	28	32	86	209.02
10.467	86	40	32	72	209.34
10.500	40	24	32	56	210.00
10.631	86	40	28	64	212.62
10.667	72	48	40	64	213.34
10.713	32	24	28	40	214.26
10.714	56	40	32	48	214.28
10.750	48	24	40	86	215.00
10.800	100	48	32	72	216.00
10.853	86	40	24	56	217.06
10.937	64	40	32	56	218.74
10.972	100	48	28	64	219.44
11.021	56	24	28	72	220.42
11.057	100	72	56	86	221.14
11.111	48	32	24	40	222.22
11.160	64	40	56	100	223.20
11.163	86	32	24	72	223.26
11.198	64	40	48	86	223.96
11.200	100	48	24	56	224.00
11.250	64	24	24	72	225.00
11.429	28	24	24	32	228.58
11.467	100	32	24	86	229.34
11.518	64	24	28	86	230.36
11.520	100	64	40	72	230.40
11.574	72	40	48	100	231.48
11.629	86	24	24	100	232.58
11.667	48	24	24	56	233.34
11.719	64	24	32	100	234.38
11.721	86	56	40	72	234.42
11.757	64	28	32	86	235.14
11.905	72	24	28	100	238.10
11.944	72	24	24	86	238.88
11.960	86	40	28	72	239.20
12.000	40	24	24	48	240.00
12.040	100	56	40	86	240.80
12.153	72	28	32	100	243.06
12.245	56	40	28	48	244.90
12.250	40	28	32	56	245.00
12.286	100	40	28	86	245.72
12.343	100	48	28	72	246.86
12.403	86	40	24	64	248.06
12.444	72	56	40	64	248.88
12.500	32	24	24	40	250.00
12.542	48	28	40	86	250.84
12.558	86	48	32	72	251.16
12.600	100	56	32	72	252.00
12.698	72	40	28	64	253.96
12.758	86	48	28	64	255.16
12.798	56	40	48	86	255.96
12.800	100	56	28	64	256.00
12.857	64	32	28	72	257.14
12.858	32	24	28	48	257.16
12.900	100	48	32	86	258.00
12.963	72	40	24	56	259.26
13.020	64	40	48	100	260.40
13.024	86	48	24	56	260.48
13.062	56	32	28	64	261.24
13.082	86	72	64	100	261.64
13.125	48	28	32	72	262.50
13.163	56	24	28	86	263.26
13.289	86	32	28	100	265.78
13.333	48	24	24	64	266.66
13.393	64	48	56	100	267.86
13.396	86	64	40	72	267.92
13.437	56	28	32	86	268.74
13.438	64	24	24	86	268.76
13.500	40	24	32	72	270.00
13.566	86	28	24	100	271.32
13.611	48	28	24	56	272.22

English leads based on ¼" pitch table screw. Metric leads based on 5 mm pitch table screw
Ratio of lead 1:40
Two idlers or none produce right hand helix. One idler gives left hand helix
Use any gears as idlers to make up centre distance as necessary
CHANGE GEARS SUPPLIED 24, 24, 28, 32, 40, 48, 56, 64, 72, 86 and 100 teeth

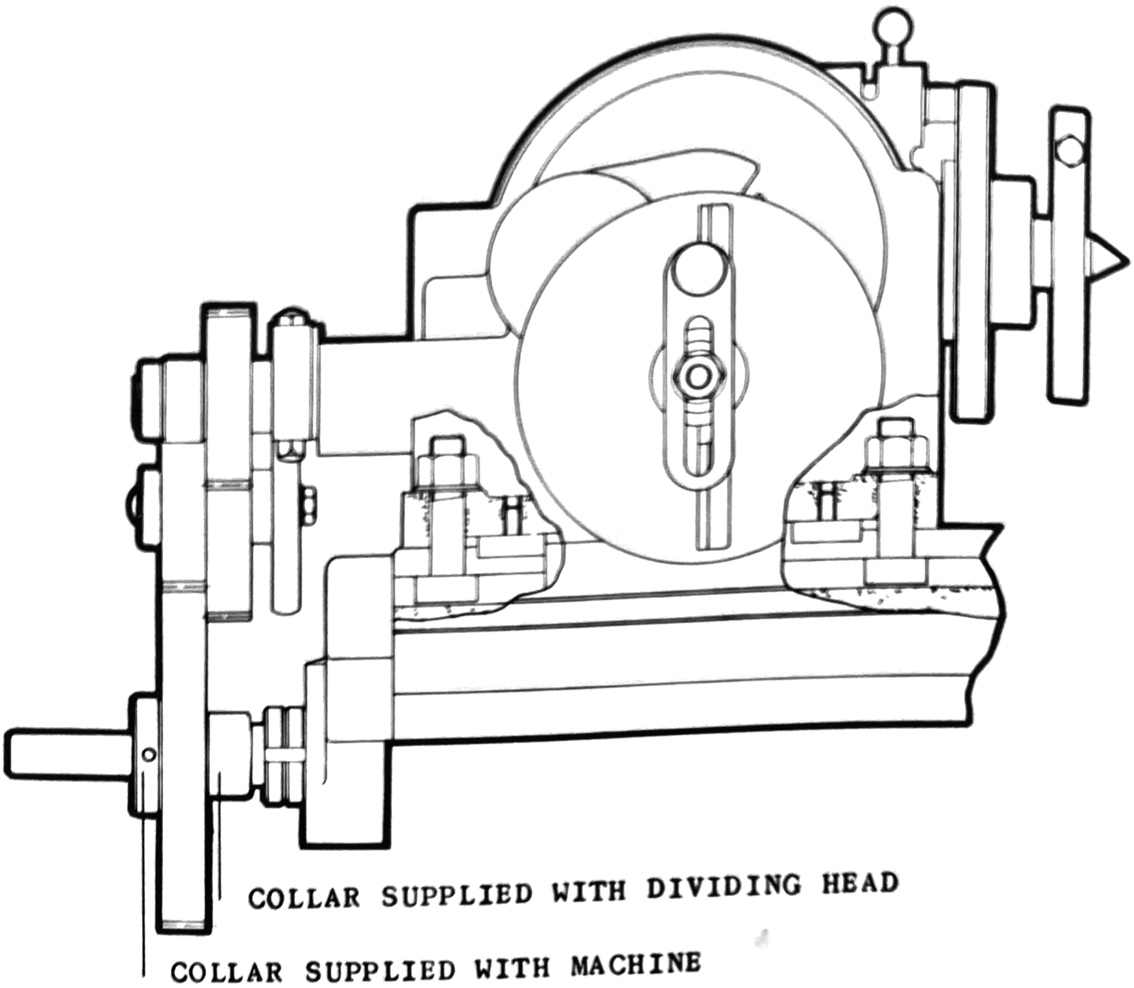
Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant: Driven B	Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
13.650	72	32	28	86	273.00
13.672	64	28	32	100	273.44
13.713	56	48	40	64	274.26
13.715	40	24	28	64	274.30
13.760	100	64	40	86	275.20
13.889	72	24	24	100	277.78
13.933	72	56	48	86	278.66
13.935	72	28	24	86	278.70
13.953	86	40	24	72	279.06
14.000	40	24	24	56	280.00
14.063	64	40	32	72	281.26
14.286	28	24	24	40	285.72
14.333	48	32	40	86	286.66
14.352	86	48	28	72	287.04
14.400	100	48	24	72	288.00
14.536	86	40	32	100	290.72
14.583	48	40	32	56	291.66
14.584	32	28	24	40	291.68
14.651	86	56	32	72	293.02
14.694	56	32	28	72	293.88
14.743	100	48	28	86	294.86
14.815	72	40	24	64	296.30
14.880	56	40	48	100	297.60
14.884	86	56	28	64	297.68
14.931	72	40	32	86	298.62
14.933	100	56	24	64	298.66
14.950	86	72	56	100	299.00
15.000	32	24	24	48	300.00
15.050	100	56	32	86	301.00
15.238	72	48	28	64	304.76
15.239	48	32	28	64	304.78
15.306	56	24	28	100	306.12
15.357	48	24	28	86	307.14
15.429	56	48	40	72	308.58
15.480	100	72	40	86	309.60
15.504	86	64	48	100	310.08
15.556	72	56	32	64	311.12
15.625	64	24	24	100	312.50
15.677	48	28	32	86	313.54
15.750	40	28	32	72	315.00
15.873	72	64	56	100	317.46
15.874	72	32	28	100	317.48
15.925	72	64	48	86	318.50
15.926	72	32	24	86	318.52
16.000	40	24	24	64	320.00
16.071	56	40	32	72	321.42
16.125	40	24	32	86	322.50
16.204	72	28	24	100	324.08
16.280	86	56	40	100	325.60
16.327	56	40	28	64	326.54

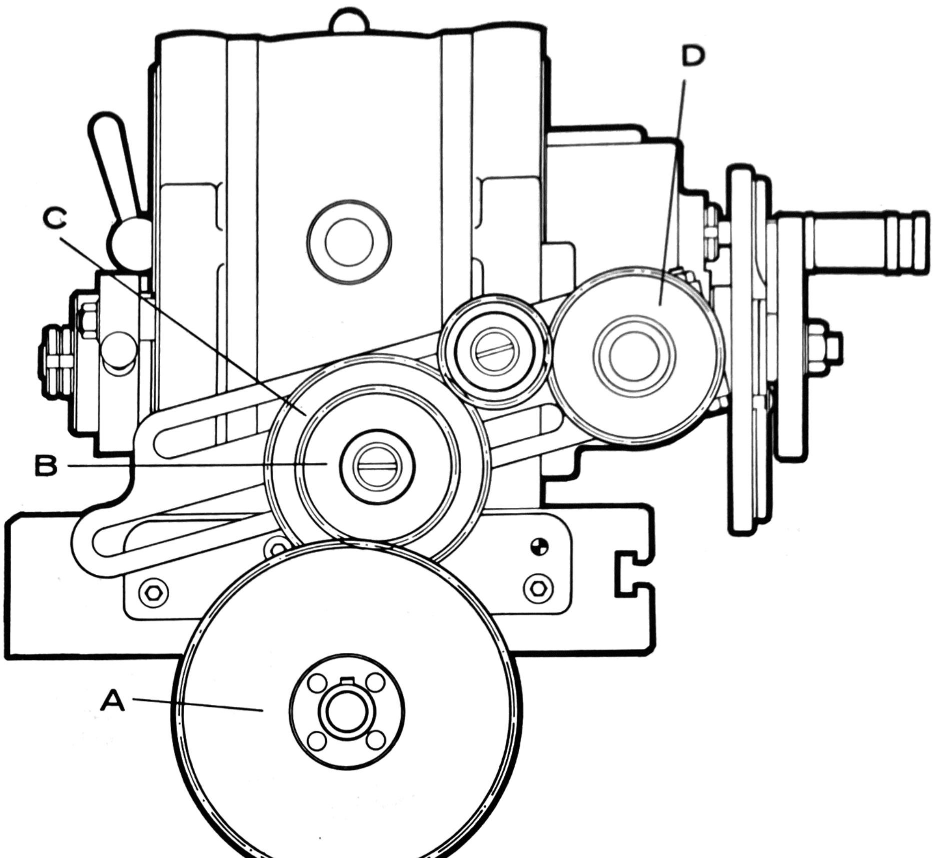
Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant: Driven B	Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
16.333	40	28	24	56	326.66
16.456	100	64	28	72	329.12
16.612	86	40	28	100	332.24
16.667	48	40	28	56	333.34
16.722	72	56	40	86	334.44
16.744	86	48	24	72	334.88
16.797	64	40	32	86	335.94
16.800	100	56	24	72	336.00
16.875	64	48	32	72	337.50
17.062	72	40	28	86	341.24
17.141	56	48	32	64	342.82
17.143	32	24	28	64	342.86
17.144	28	24	24	48	342.88
17.200	100	64	32	86	344.00
17.275	64	72	56	86	345.50
17.361	72	40	32	100	347.22
17.364	86	56	24	64	347.28
17.442	86	48	32	100	348.84
17.500	32	24	24	56	350.00
17.550	56	32	28	86	351.00
17.778	48	32	24	64	355.56
17.858	56	24	24	100	357.16
17.917	64	32	24	86	358.34
17.918	48	24	24	86	358.36
18.000	40	24	24	72	360.00
18.229	48	28	32	100	364.58
18.285	40	32	28	64	365.70
18.367	56	40	28	72	367.34
18.428	40	24	28	86	368.56
18.519	72	32	24	100	370.38
18.605	86	64	40	100	372.10
18.663	72	86	64	100	373.26
18.667	40	28	24	64	373.34
18.750	40	24	32	100	375.00
18.750	48	40	32	72	375.00
18.812	40	28	32	86	376.24
19.048	28	32	24	40	380.96
19.111	72	64	40	86	382.22
19.136	86	64	28	72	382.72
19.197	56	40	32	86	383.94
19.200	100	64	24	72	384.00
19.285	56	48	32	72	385.70
19.286	32	24	28	72	385.72
19.350	100	72	32	86	387.00
19.380	86	40	24	100	387.60
19.444	24	28	24	40	388.88
19.531	64	40	32	100	390.62
19.535	86	56	24	72	390.70
19.590	56	48	28	64	391.80
19.656	100	64	28	86	393.12

Lead per one Revolution expressed in inches	Wheel on the Table Spindle A	Wheels on the Change Gear Quadrant: Driven B	Driving C	Wheel on the Dividing Head D	Lead per one Revolution expressed in mm.
19.687	64	56	32	72	393.74
19.840	72	40	28	100	396.80
19.908	72	40	24	86	398.16
19.934	86	48	28	100	398.68
20.00	48	32	24	72	400.0
20.07	100	56	24	86	401.4
20.09	64	72	56	100	401.8
20.16	64	72	48	86	403.2
20.35	86	56	32	100	407.0
20.41	56	32	28	100	408.2
20.42	32	28	24	56	408.4
20.48	56	64	48	86	409.6
20.57	56	64	40	72	411.4
20.74	72	56	24	64	414.8
20.83	72	48	32	100	416.6
20.90	72	56	32	86	418.0
20.93	86	72	40	100	418.6
21.00	40	48	32	56	420.0
21.33	72	86	56	100	426.6
21.43	56	48	40	100	428.6
21.50	40	24	24	86	430.0
21.88	64	56	40	100	437.6
21.94	56	40	28	86	438.8
22.04	56	48	28	72	440.8
22.11	100	72	28	86	442.2
22.22	72	64	40	100	444.4
22.40	48	40	32	86	448.0
22.50	64	48	24	72	450.0
22.86	28	24	24	64	457.2
22.93	100	64	24	86	458.6
23.04	48	72	56	86	460.8
23.14	72	40	24	100	462.8
23.26	86	64	32	100	465.2
23.33	48	56	32	64	466.6
23.44	64	72	48	100	468.8
23.52	64	56	32	86	470.4
23.81	56	64	48	100	476.2
23.89	72	64	32	86	477.8
24.00	48	72	40	64	480.0
24.19	64	72	40	86	483.8
24.31	72	56	32	100	486.2
24.57	56	64	40	86	491.4
24.88	48	86	72	100	497.6
25.00	48	40	24	72	500.0
25.08	40	28	24	86	501.6
25.09	48	56	40	86	501.8
25.51	56	40	28	100	510.2
25.60	48	40	28	86	512.0
25.71	56	48	24	72	514.2
25.72	28	24	24	72	514.4

English leads based on ¼" pitch table screw. Metric leads based on 5 mm pitch table screw.
Ratio of lead 1:40
Two idlers or none produce right hand helix. One idler gives left hand helix
Use any gears as idlers to make up centre distance as necessary
CHANGE GEARS SUPPLIED 24, 24, 28, 32, 40, 48, 56, 64, 72, 86 and 100 teeth

Lead per one Revolution expressed in inches	Wheel on the Table Spindle	Wheels on the Change Gear Quadrant: Driven	Wheels on the Change Gear Quadrant: Driving	Wheel on the Dividing Head	Lead per one Revolution expressed in mm.
	A	B	C	D	
25.80	100	72	24	86	516.0
26.04	48	40	32	100	520.8
26.16	86	72	32	100	523.2
26.25	48	56	32	72	525.0
26.33	56	48	28	86	526.6
26.58	86	64	28	100	531.6
26.67	48	56	28	64	533.4
26.79	56	72	48	100	535.8
26.88	64	56	28	86	537.6
27.00	40	48	32	72	540.0
27.13	86	56	24	100	542.6
27.22	24	28	24	56	544.4
27.30	72	64	28	86	546.0
27.34	64	56	32	100	546.8
27.43	40	48	28	64	548.6
27.64	56	72	40	86	552.8
27.78	72	64	32	100	555.6
27.87	72	56	24	86	557.4
28.00	48	86	64	100	560.0
28.13	64	72	40	100	562.6
28.57	40	64	56	100	571.4
28.67	48	64	40	86	573.4
29.17	48	56	40	100	583.4
29.39	56	64	28	72	587.8
29.76	48	40	28	100	595.2
29.86	72	86	40	100	597.2
29.90	86	72	28	100	598.0
30.00	32	48	28	56	600.0
30.23	64	72	32	86	604.6
30.48	28	32	24	64	609.6
30.61	56	48	28	100	612.2
30.71	56	48	24	86	614.2
30.72	28	24	24	86	614.4
30.86	40	48	28	72	617.2
31.01	86	64	24	100	620.2
31.11	48	56	24	64	622.2
31.25	64	56	28	100	625.0
31.35	48	56	32	86	627.0
31.36	32	28	24	86	627.2
31.50	40	56	32	72	630.0
31.75	28	64	72	100	635.0
31.85	72	64	24	86	637.0
31.99	48	86	56	100	639.8
32.00	40	56	28	64	640.0
32.14	40	72	56	100	642.8
32.25	40	72	48	86	645.0
32.41	72	56	24	100	648.2
33.33	40	32	24	100	666.6
33.59	40	86	64	100	671.8
34.29	28	64	48	72	685.8
34.55	56	72	32	86	691.0
34.72	48	40	24	100	694.4
34.88	86	72	24	100	697.6
35.00	48	56	24	72	700.0
35.10	56	64	28	86	702.0
35.16	64	72	32	100	703.2
35.56	24	32	24	64	711.2
35.71	56	64	32	100	714.2
35.72	28	24	24	100	714.4
35.83	48	64	32	86	716.6
36.00	40	64	32	72	720.0
36.46	32	56	48	100	729.2
36.86	40	48	28	86	737.2
37.04	72	64	24	100	740.8
37.33	72	86	32	100	746.6
37.50	40	72	48	100	750.0
37.63	40	56	32	86	752.6
38.10	28	40	24	64	762.0
38.39	56	86	40	100	767.8
38.57	32	48	28	72	771.4
38.89	24	40	24	56	777.8
39.49	56	72	28	86	789.8
40.00	48	64	24	72	800.0
40.18	56	72	32	100	803.6
40.31	48	72	32	86	806.2
40.82	56	64	28	100	816.4
40.95	48	64	28	86	819.0
40.96	28	32	24	86	819.2
41.14	40	64	28	72	822.8
41.67	48	64	32	100	833.4
41.81	48	56	24	86	836.2
41.99	64	86	32	100	839.8
42.00	40	56	24	72	840.0
42.66	72	86	28	100	853.2
42.86	40	48	28	100	857.2
43.00	40	64	32	86	860.0
43.75	40	56	32	100	875.0
44.44	24	40	24	64	888.8
44.64	32	40	28	100	892.8
44.79	48	86	40	100	895.8
45.00	32	56	28	72	900.0
45.72	28	48	24	64	914.4
45.92	56	72	28	100	918.4
46.07	48	72	28	86	921.4
46.67	32	56	24	64	933.4
46.88	48	72	32	100	937.6
47.62	48	64	28	100	952.4
47.78	48	64	24	86	955.6
47.99	56	86	32	100	959.8
48.00	40	64	24	72	960.0
48.38	40	72	32	86	967.6
48.61	48	56	24	100	972.2
49.14	40	64	28	86	982.8
49.77	72	86	24	100	995.4
50.00	40	56	28	100	1000.0
50.17	40	56	24	86	1003.4
51.19	28	40	24	86	1023.8
51.43	32	64	28	72	1028.6
52.50	32	56	24	72	1050.0
53.33	28	56	24	64	1066.6
53.57	48	72	28	100	1071.4
53.75	32	48	24	86	1075.0
54.85	56	86	28	100	1097.0
55.28	40	72	28	86	1105.6
55.56	24	32	24	100	1111.2
55.99	64	86	24	100	1119.8
56.25	40	72	32	100	1125.0
57.14	40	64	28	100	1142.8
57.33	40	64	24	86	1146.6
58.33	40	56	24	100	1166.6
59.53	28	40	24	100	1190.6
60.00	32	64	24	72	1200.0
61.43	28	48	24	86	1228.6
62.22	24	56	24	64	1244.4
62.50	32	48	24	100	1250.0
62.71	32	56	24	86	1254.2
63.99	56	86	24	100	1279.8
64.29	40	72	28	100	1285.8
64.50	40	72	24	86	1290.0
66.67	40	64	24	100	1333.4
67.19	40	86	32	100	1343.8
68.57	28	64	24	72	1371.4
69.11	32	72	28	86	1382.2
69.44	24	40	24	100	1388.8
70.00	24	56	24	72	1400.0
71.43	28	48	24	100	1428.6
71.67	24	48	24	86	1433.4
72.92	32	56	24	100	1458.4
74.65	48	86	24	100	1493.0
75.00	40	72	24	100	1500.0
76.39	24	44	24	100	1527.8
76.77	40	86	28	100	1535.4
80.00	24	64	24	72	1600.0
80.36	32	72	28	100	1607.2
80.63	32	72	24	86	1612.6
81.91	28	64	24	86	1638.2
83.33	24	48	24	100	1666.6
83.61	24	56	24	86	1672.2
89.58	40	86	24	100	1791.6
92.14	28	72	24	86	1842.8





METHOD OF MOUNTING LEFT HAND DIVIDING HEAD
ON TO MILLING MACHINE TABLE

As the name implies the first function of a Dividing Head is to be able to re-position the work piece by rotating it through a given angle, or through a definite fraction of a complete circle so that if the operation is repeated a succession of equally spaced slots or holes can be machined in it.

DIRECT INDEXING - Although of limited application this is the simplest of all methods, in that an indexing plunger engages directly a disc mounted on the work spindle itself and having a circle of equally spaced holes or slots. The Elliott 9", 10" and 12" Universal Dividing Heads incorporate this feature, the disc having 24 holes so that this number of spaces, or any factor of 24 can be obtained direct.

Before applying direct indexing, move lever L1 (Fig.2) to the out position, thus disengaging worm W (Fig.2) from worm wheel WW (Fig.2).
It is good practice to remove the direct indexing plate when it is not being used, so that conflicting movements cannot be attempted simultaneously

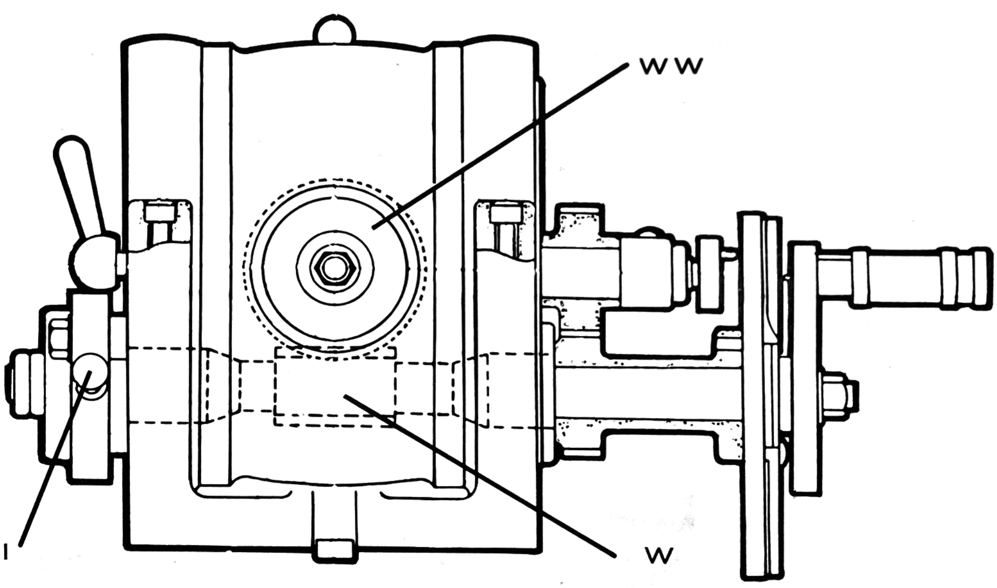


FIGURE 2

INDIRECT INDEXING - If the desired movement of the dividing head can be obtained merely by turning the crank from one position on the hole plate to another whilst the plate is locked stationary this is called plain or simple indexing. The calculations involved are very simple. Suppose it is required to cut a gear having 23 equally spaced slots in a cylindrical component. The standard worm-gear ratio is 40:1, so one complete revolution of the work spindle requires 40 turns of the crank. Therefore, to turn the spindle 1/23rd part of a revolution requires 40/23 or 1.17/23 revolutions of the crank. The usual standard hole-plates have circles containing the following numbers of holes:

15	16	17	18	19	20
21	23	27	29	31	33
37	39	41	43	47	49

By using the second of the plates, adjusting the radius of the crank plunger to the 23 holes circle, and setting the sector arm for 17 holes, one can proceed to simple index the 23 spaces, moving the crank one complete turn plus the 17 holes at each movement. In this as in all indexing, care must be taken to avoid inaccuracy due to backlash. If, when moving the crank, the operator accidentally overshoots the hole which he intends to engage, the crank should be moved back a considerable amount and then brought forward again so as to approach the hole carefully and to engage without overtravel.
Stated arithmetically if the circumference of a workpiece is to be divided into a number of equal divisions "n" and the corresponding movement of the crank arm is "a" then

$$a = \frac{40}{n}$$

Indexing Angles

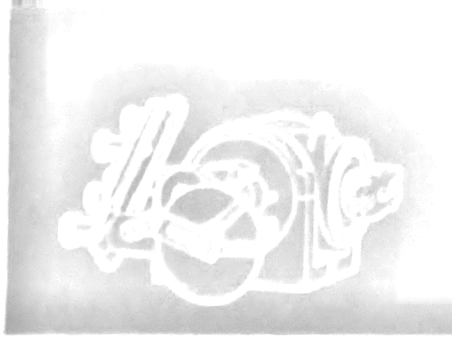
It is obvious that as 40 revolutions of the crank give one complete revolution of the spindle, one turn of the crank will give:

$$\frac{360}{40} = 9^{\circ}$$

and 1/9 of a turn $= 1^{\circ}$

Example: "Index 38°." Turns of the crank $= \frac{38}{9} = 4\frac{2}{9}$ i.e four complete turns of crank and 2° (four holes in an 18 hole circle giving 2°)

To index to minutes. One turn of the crank $= 9 \times 60 = 540$ mins.



Differential Indexing is normally used when a particular number of divisions cannot be obtained by simple indexing. Let us take for example 61 spaces which number does not appear in our simple indexing table on Page 4.
To simple index we require to make 40/61 turns of the crank which cannot be done with standard plates. We choose a number close to that which we wish to index, e.g 60 spaces. This would require 40/60 turns of the crank which can be achieved by taking 10 holes on the 15-hole circle or various obvious alternatives. After 61 movements of the crank the work spindle would have moved 1/60th of a turn beyond the complete circle, therefore gearing must be arranged to transmit from the work spindle a suitable reverse movement to the hole plate so as to counterbalance the overtravel.

To remove 1/60th of a revolution of overtravel will require 1/60 x 40 revs of movement of the hole plate, on account of the worm gear ratio. A gear ratio of 40:60 is thus required between the work spindle and hole plate. The change gears supplied with dividing heads usually have the following numbers of teeth:

24	24	28	32	40	
48	56	64	72	86	100

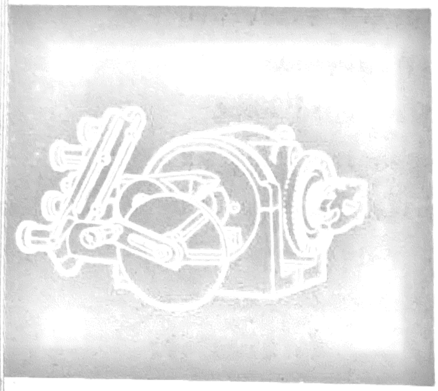
Therefore to obtain the ratio 40:60 the gears 48/72 could be used with suitable idlers.

To take an example in which the approximated number is larger than the actual number of spaces required, let us suppose that it is necessary to index 57 spaces and we decide to index for 60. Then 60 spaces requires 40/60 turns of the crank per movement, which we can do quite well since 40/60 = 2/3, e.g 12 holes on the 18 hole circle. Now after 57 movements the work spindle will need a further 3/60th of a turn to have completed a whole revolution. Therefore, to provide this additional movement the hole plate must be advanced in the same direction as the turns of the crank 3/60 x 40 turns during one revolution of the work spindle, the gears 48:24 or 56:28 being suitable.
In these examples it has been possible to obtain the differential gearing by single train and idlers. To take an example where compound gearing is required, assume 73 spaces are required and it is decided to adopt 75 as the approximation.

Differential Indexing (continued)

Then after 73 indexings a further 2/75th of a revolution would require to be added to the movement of work spindle to complete the cycle. To supply this the differential gearing would be $2/75 \times 40 = 80/75$. This cannot be done by a single train of the standard wheels, so, factorizing, we obtain

$$\frac{80}{75} = \frac{16}{15} = \frac{4}{3} \times \frac{4}{5} \quad \text{for which we can use} \quad \frac{64}{48} \times \frac{32}{40}$$



The required gearing ratio can be evaluated by the formula:

$$\text{Differential gearing ratio} = (A - B) \times \frac{40}{B}$$

where A = The actual number of divisions required.

B = The number chosen for indexing purposes.

If B should be larger than A the formula becomes

$$\text{Differential gearing ratio} = (B - A) \times \frac{40}{B}$$

DETERMINATION OF NUMBER OF IDLERS. If the selected number is greater than the actual number of divisions required, then the gearing must drive the hole plate in the same direction as the crank movements. To do this a simple gear will require one idler and a compound gear no idler.

If the selected number is less than the actual number of divisions required, then the gearing must drive the hole plate in the opposite direction to the crank movements. To do this a simple gear will require two idlers and a compound gear one idler.

BLOCK INDEXING. In the examples which we have used it has been assumed that the spaces would be cut consecutively. With the block system, however, which is occasionally used in gear cutting the work is indexed an amount equal to several spaces between cuts. Thus a 17 tooth gear might be cut by indexing the 1st, 4th, 7th, 10th, 13th and 16th spaces and then continuing the process for a second revolution to cut the 2nd, 5th, 8th etc. until after nearly three revolutions the job is completed. The method is sometimes helpful when cutting cast iron gears in one pass since the heat generated is distributed more evenly along the circumference.

LOW LEAD ATTACHMENT

FOR MILLING LEADS DOWN TO 0.050" or 1 mm

WHERE THE WORK DIAMETER DOES NOT EXCEED 12 TIMES THE PITCH

The conventional set-ups for generating leads below 2" on English Machines or 40 mm with metric screws, demand a 'pick-up' of 5:1 or more in the drive from the machine table to the Dividing Head worm and this can result in heavy binding loads in the change gears, sometimes making it necessary to disengage the power feed and perform the operation by manual rotation of the Dividing Head crank, so that the table movement is actually transmitted back from the head through what is now a reducing gear train.

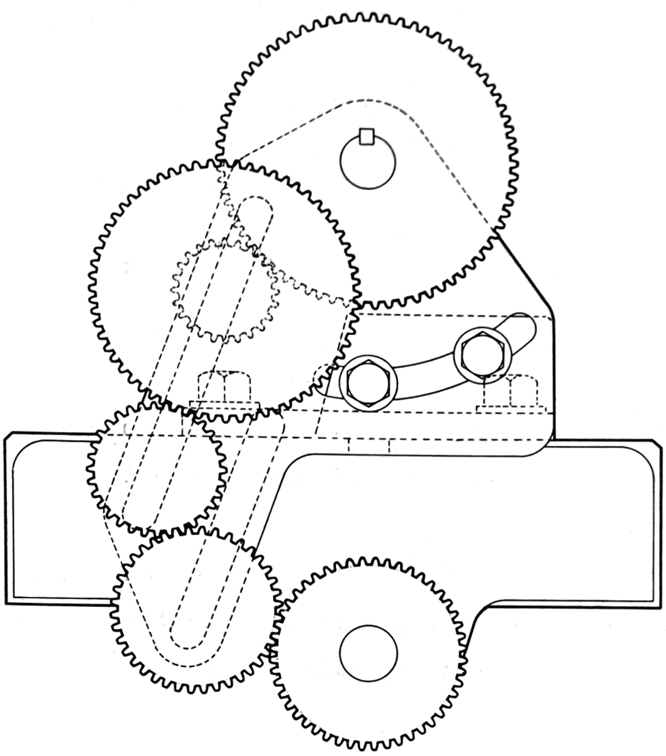


FIGURE 3

There are on the market, some very expensive devices, which have been designed to overcome this problem, but subject to certain limitations as described below, the ELLIOTT low lead attachment shown in Fig.3 increases the scope of the standard equipment for a very modest cost.

With this arrangement the drive from the table screw is transmitted through the standard change gears directly to the work spindle, and not through the worm gear. Therefore, the worm must be disengaged when using this attachment. The result is that a change gear set-up of 5:1 which would normally produce a lead of 2" on English machines, now gives a lead of 0.050", (5 turns of the work spindle for one revolution of the $\frac{1}{4}$" pitch table screw). Conversely, a lead of 2" can be produced with change gears set-up to give a reduction of 1:8 instead of a pick-up of 5:1 this resulting in much better operating conditions.

SHORT LEAD ATTACHMENT (continued)

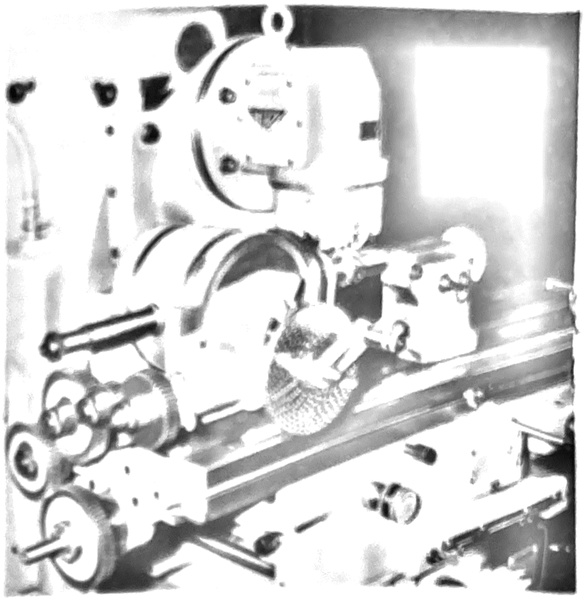


FIGURE 4

The operator should note the following points when setting up for short leads:-

1 If the lead angle of any thread which is to be cut with a gashing cutter is less than 45^{o}, this cannot be accommodated by swivelling the universal saddle of the milling machine. The correct practice is to use a universal milling head because this can be set to any angle from zero to 90^{o} whilst the worktable remains square with the machine knee and column (Fig.4)

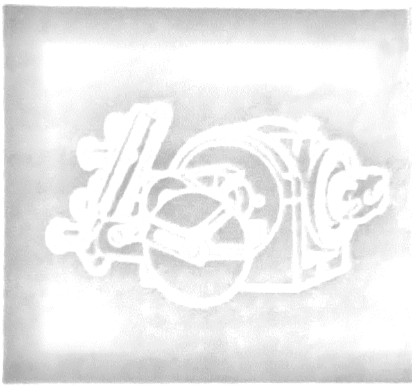
2 When attempting to cut low leads either with a normal dividing head set-up or with the help of the ELLIOTT low lead attachment, it is necessary to consider the resulting feed rate. Even the slowest feed rate available for driving the machine table is likely to give an excessive rate at the cutter if the work involves a short lead on a large diameter. For example - to cut a $\frac{1}{8}$" lead on a $1\frac{1}{2}$" diameter workpiece with a table feed of only 0.4 inches per minute - results in the thread being cut at 15 inches per minute. If the diameter were 3 inches it follows that the cutting rate would be 30 inches per minute, which would be impractical on a ferrous material. As a general rule therefore, the ELLIOTT low lead equipment is intended for cutting pitches down to 0.05 inches or 1 mm on workpieces the diameter of which does not exceed 12 times the pitch.

3 In order to obtain the best conditions the fastest acceptable spindle speed should be used, so reducing the tooth loading on the cutter. If the problem still persists it will be necessary to disengage the table drive, re-engage the dividing head worm and perform the operation by hand turning of the crank, as already described.

CUTTING HELICES. For spiral milling the hole plate is geared to the end of the table screw as already described. Thus with the locating plunger engaging any hole the crank must transmit the motion to the work spindle whilst the table travels. At the end of a cut the table is returned to the starting position, and the machine stopped so that the plunger can be moved as required to index the work.

All standard universal milling machines of British or American manufacture are fitted with a $\frac{1}{4}$ in. lead table guide screw. Since standard dividing heads contain a 40:1 reduction gear, it follows that with equal change gear ratio between head and table screw one revolution of the chuck will require 40 revolutions of the screw, which gives the Standard Lead of 10 in. Metric machines have a 5 mm pitch table screw giving a standard lead of 200 mm.

CALCULATION OF CHANGE GEARS. The determination of change gears for cutting leads, which are in whole numbers and simple fractions of inches, when cutting flutes in drills, etc. is easily accomplished. To cut a lead of $5\frac{1}{4}$ in.



$$\frac{\text{Lead required}}{\text{Standard Lead}} = \frac{5\frac{1}{4}\text{" in.}}{10\ \text{in.}} = \frac{21}{40}$$

$$= \frac{7 \times 3}{2 \times 2 \times 2 \times 5} = \frac{7}{8} \times \frac{3}{5}$$

It is obvious that the standard change gears $\frac{56}{64} \times \frac{24}{40}$ would give the required ratio though this gear train could not be set up for a right-hand helix, which requires no idlers, because the 64 tooth gear mounted with the 24 tooth gear on the stud would foul either the nut, or spacing collar adjacent to the final 40 tooth gear. The same gears are therefore used in the order $\frac{24}{64} \times \frac{56}{40}$ Any idler may be inserted in the train at a convenient point to reverse the rotation of the work spindle for left hand helices.

In practice all the leads obtainable with the change gears supplied are listed in ascending order on pages 8 to 13 and for most purposes it is sufficient to select the lead which is nearest to what is desired. Where a more accurate result is essential, a calculation as per the foregoing example should be made so as to establish whether a mathematically exact solution can be found simply by producing one or more special change gears. If this procedure still does not result in a satisfactory solution, a computation based on continued fractions should be made, this as described on Page 24.

The table slide is swivelled clockwise for left hand helices and counter-clockwise for right hand helices by an amount equal to the spiral angle of the helix. When the spiral angle exceeds 30° the set-up becomes rather unsatisfactory on account of the excessive swivel of the table slide, and it is better to use a universal attachment so that the cutter spindle can be set to the required spiral angle and the table remain in the normal position. When the spiral angle exceeds 45° it is usually impossible to mill except by this method. (Fig.4)

GEAR CUTTING Although the cutting of gears by milling gives only an approximately correct form, and takes longer than hobbing or gear shaping, milled gears can be satisfactory except at very high speeds, and it is more economical to produce a few urgently required replacements on a universal miller than to break down a production run in the gear cutting department.

The shape of the tooth flank is mainly dependent upon the number of teeth in the gear, a pinion having considerable curvature whilst an infinitely large gear, i.e. a rack, has straight flanks. For this reason eight cutters are supplied for each pitch.

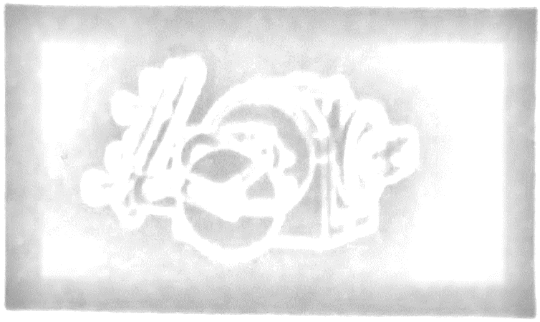
1. To cut 135 teeth to a rack
2. To cut 55 to 134 teeth
3. To cut 35 to 54 teeth
4. To cut 26 to 34 teeth
5. To cut 21 to 25 teeth
6. To cut 17 to 20 teeth
7. To cut 14 to 16 teeth
8. To cut 12 and 13 teeth

If in doubt as to whether milled teeth will meet a particular case it should be remembered that these cutters produce almost perfect teeth when the number corresponds to the lower number of a range. Gears with corrected addenda have non-standard outside diameters and cannot be produced by standard cutters.

STRAIGHT TOOTH SPUR GEARS. A suitable cutter is selected according to the number of teeth to be cut - the pitch and pressure angle engraved thereon being checked with the requirements - and is mounted on the arbor so as to cut towards the dividing head. The blank is mounted between the head and tailstock, preferably on centres, and is positively locked for angular rotation with the driving plate. If the gear is bored it should be mounted on a short keyed mandrel, or it may, when practicable, be located on its own shaft. The jack supplied with the dividing head should be used to support slender work.

The indexing process has already been described.

Steel gears not coarser than 8 D.P and cast iron gears not coarser than 6 D.P are often cut to size in one pass, but, in general, it is better to finish with a second and lighter cut. The gauging should be done with a gear tooth vernier caliper set to the appropriate depth and chordal thickness, but sometimes the vertical feed dial is set to zero with the cutter just contacting the blank, so that the final cut may be taken with the dial indicating the full depth of the teeth.



SINGLE HELICAL GEARS. The curvature of the pitch line taken across a section normal to the teeth of a helical gear is less than that given by the pitch radius, and, therefore, when choosing the cutter the actual numbers of teeth to be cut must be multiplied by secant$^3\theta$ where θ = the spiral angle. Thus to cut 15 teeth at 20° spiral angle, the equivalent number of teeth from the point of view of curvature, 15 x secant^3 20° = 18.078. One would therefore require not a No.7 cutter but a No.6 as used for straight spur gears having 17 to 20 teeth.

Assuming now that the above gear is to have teeth of 5 diametral pitch,

$$\text{Pitch diameter of gear} = \frac{15}{5} \times \text{Sec.}20^\circ$$

$$= 3.1926 \text{ in.}$$

$$\text{Lead} = \frac{\text{Pitch Circumference}}{\text{Tangent of Spiral Angle}}$$

$$= \frac{3.1926 \times \pi}{0.36397}$$

$$= 27.557 \text{ in.}$$

The nearest lead given by the tables is 27.500 in. obtained by using the standard change gears $\frac{56}{32} \times \frac{44}{28}$ This discrepancy, amounting to approximately 0.002 in. per inch of face width, would be unacceptable in single helical gears of considerable width unless the mating gears had an equal number of teeth, in which case the same lead would apply to both members, one being right hand and one left hand. The approximation would, however, be satisfactory for relatively narrow gears or for skew gears which engage each other with axes at right angles.

Non standard Leads. In the event of a close approximation being essential this can be done by resorting to continued fractions.

Ratio required in example = 27.557 : 10,000

```
10,000)27,557(2
       20,000
        7,557)10,000(1
               7,557
               2,443)7557(3
                     7329
                      228)2443(10
                          2280
                           163)228(1
                               163
                                65)163(2
                                   130
                                    33, etc.
```

	2	1	3	10	1	2	
$\frac{1}{0}$	$\frac{2}{1}$	$\frac{3}{1}$	$\frac{11}{4}$	$\frac{113}{41}$	$\frac{124}{45}$	$\frac{361}{131}$	, etc.

Taking the ratio $\frac{124}{45}$ we get $\frac{124}{45} \times 10$ in. = 27.5555 in. lead

representing an error of only 0.0015 in. in 27.557 in. which is entirely negligible, but to do this special change gears would be required.

$$\frac{124}{45} = \frac{31 \times 2 \times 2}{5 \times 3 \times 3} = \frac{31}{5} \times \frac{4}{9} = \frac{62}{40} \times \frac{64}{36}$$

The 40 tooth and 64 tooth gears are standard, but those containing 62 and 36 teeth would have to be made for the purpose.

To perform the above calculation, first express the lead required divided by standard lead as a vulgar fraction, viz. 27,557/10,000. Then divide the denominator into the numerator, the quotient being 2 and the remainder 7557. Now divide the remainder into the divisor of the previous division and continue the process ad lib.

Arrange the quotients as shown and beneath the first one write down that quotient divided by one. In front of this fraction write $\frac{1}{0}$ and develop the succeeding fractions in the following manner.

To determine the numerator of the fraction beneath the second quotient multiply the latter by the numerator of the preceding fraction and add to the product the next preceding numerator. To determine the denominator of the fraction beneath the second quotient multiply the latter by the denominator of the preceding fraction and add to the product the next preceding denominator (which in the first stage is zero). For instance, to find the fraction beneath the fourth quotient:

Quotient x previous numerator = 10 x 11

Add the next previous numerator

and (10 x 11) + 3 = 113

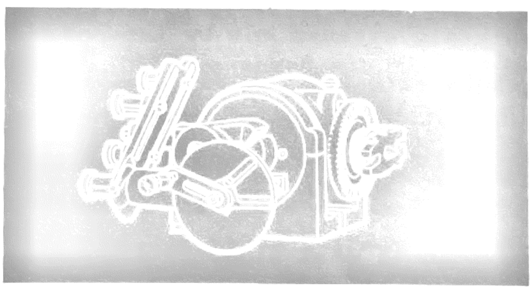
Quotient x previous denominator = 10 x 4

Add the next previous denominator

and (10 x 4) + 1 = 41

The fraction is $\frac{113}{41}$

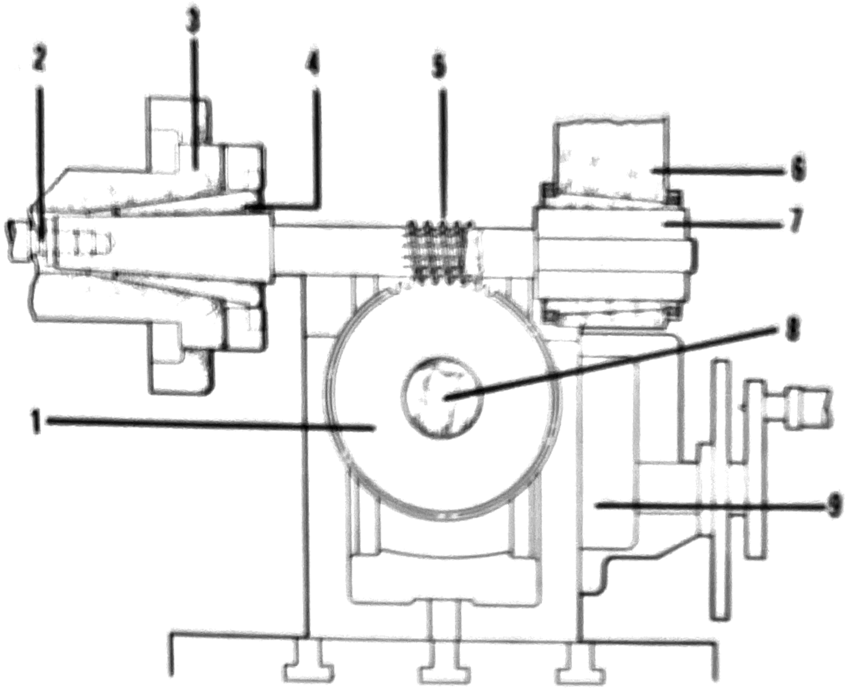
The process is continued in the same manner to obtain further fractions. It will be seen that each succeeding fraction represents a closer approximation to the required lead than the previous one, and it only remains to choose a sufficiently accurate fraction which will factorize suitably.



WORM GEARS. Worm wheels may be milled with great accuracy (Fig.5), and the method used is now being adopted for finishing worm gears which have been hobbed in the usual manner. To produce them on the miller a hob should be made which, before gashing, has a form identical with that of the worm, except that the outside diameter is increased to cut the clearance at the root of the wheel teeth. The gashes should be of a pitch fine enough to ensure that the hob can drive the worm wheel. It may fit on the arbor in the usual way, may be made solid to suit the spindle nose (or morse adaptor in case of International Standard spindle noses) and arbor steady, or may be overhung from the spindle nose, according to the diameter of the worm.

The wheel blank is set up between the dividing head and tailstock, and positively located with the former for indexing. The machine table is swivelled and set at an angle equal to the lead angle of the mating worm, the direction of swivel being determined by the hand of the latter. A roughing cutter, which may be a standard involute cutter but should preferably be smaller than the hob diameter and which represents a pitch not exceeding that to be cut, is mounted on the machine arbor, the wheel blank being centred beneath it. A number of gashes, corresponding to the number of teeth required in the worm wheel, are now cut to a depth which must be left to the discretion of the operator. The gashes should be deep enough to enable the hob to drive the wheel but no deeper, since they must subsequently be completely cleaned out by the hob. The best way is to try the hob by hand in engagement with the gashes.

Where the worm is very small it may be necessary to make a small gashing cutter similar to a woodruff or tee slotting cutter, the sides being tapered according to the pressure angle of the gears.



1	Workpiece	6	Machine Arbor Steady
2	Drawbar	7	Bearing pressed on to Hob
3	Machine Spindle	8	Mandrel
4	Morse Adaptor	9	Dividing Head
5	Hob		

FIGURE 5

When the gashes are completed the hob should be mounted on the spindle, the swivel slide brought back to the zero position, and the carrier removed so that the blank and its mandrel can rotate freely between the centres, which must now be suitably lubricated. The position of the hob relative to the boss face of the blank should be carefully checked and the table locked, or, failing that, the operator should ascertain that any backlash in the screw is taken up relative to the direction of thrust from the hob. The hob is engaged by raising the table and guiding the blank by hand into engagement, after which the spindle is started up and vertical feed is applied. A refinement which is worth adopting consists of moving the cross slide slightly towards and away from the column whilst the final sizing is done, thus overcoming the condition whereby a particular hob tooth always engages a particular wheel tooth at the same point in the cycle.

CAM MILLING. This operation requires either a vertical machine or a horizontal model complete with vertical or universal attachment together with an extended drive (Fig.6 Page 29) which allows the Dividing Head to be positioned at a reasonably central point on the work table. Figure 7 (Page 29) shows the set-up for milling a cam, in which the rise is directly proportional to the angle through which it is turned, but in which the lead or total rise for one complete revolution does not coincide with any table lead obtainable by using standard change wheels. The procedure is to select a standard table lead somewhat greater than the lead of the cam, and to set over both the dividing head spindle and the axis of the cutter to such an angle that the radial component of the table lead, or, in other words, the increment in the centre distance between the cutter and the work for a complete revolution of the latter, corresponds to the required cam lead. The diagram (Fig. 8 Page 29) shows that

this angle is determined by $\text{Cos. } \alpha = \dfrac{\text{Lead of Cam}}{\text{Lead of Table}}$

If the contour of the cam is to change its lead at certain points the table lead selected should be great enough to exceed the maximum cam lead, so that the various leads can be correctly generated by changing the angle of inclination but without changing the gears.

The cutter should, in general, be the same diameter as the roller which is to engage the cam. It should preferably have left hand helical flutes for right hand cutting and vice versa so as to thrust towards the spindle nose, and the length of the flutes must be sufficient to allow for the relative endwise movement of the work as indicated by X in the diagram.

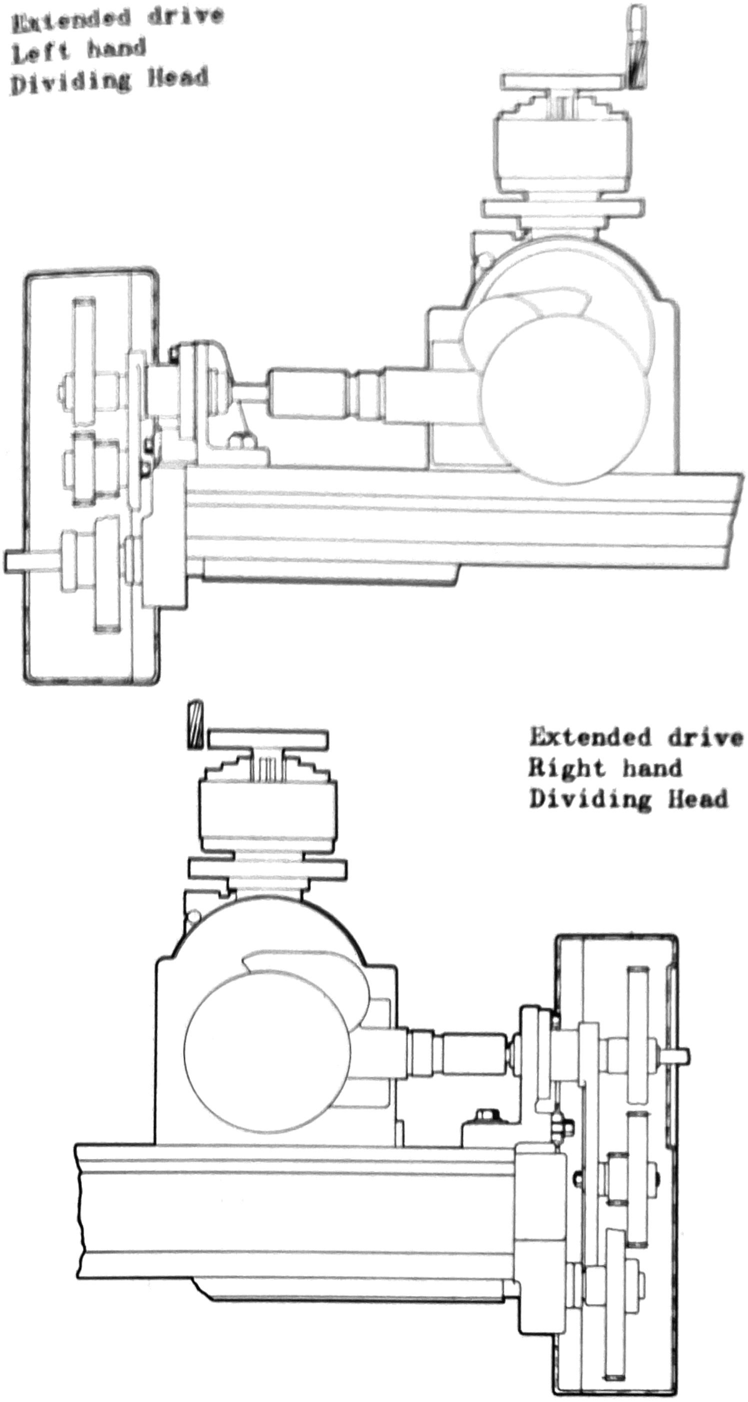


FIGURE 6

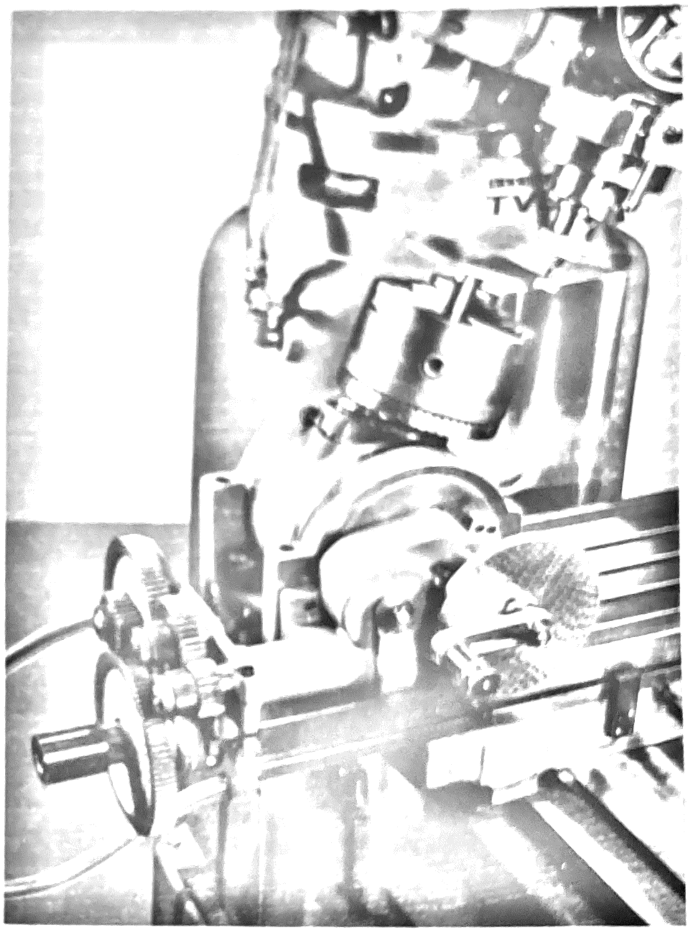
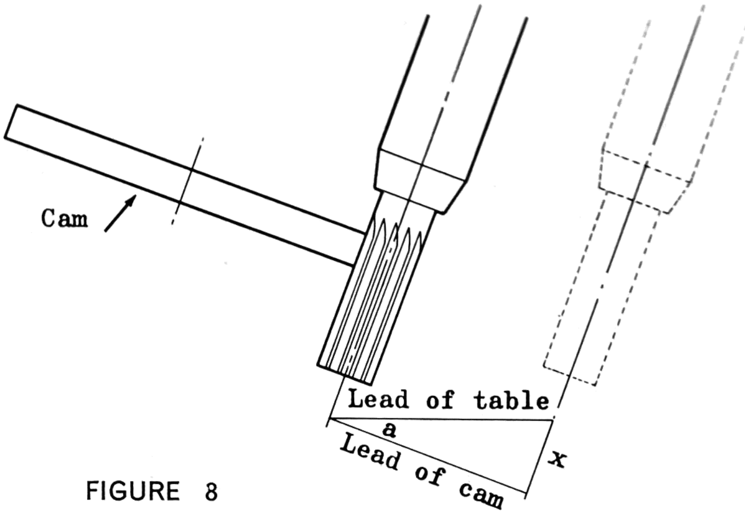


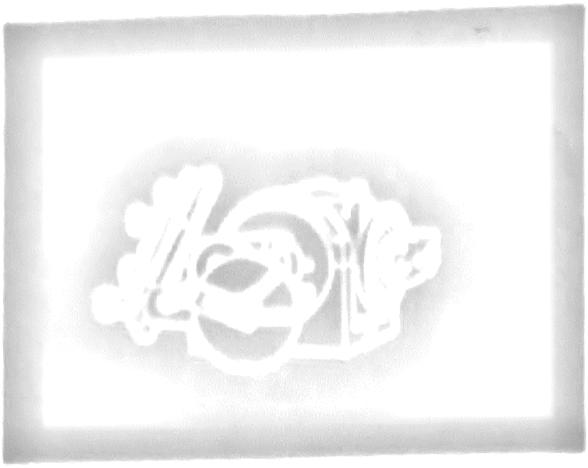
FIGURE 7



$$\cos.a = \frac{\text{Lead of cam}}{\text{Lead of table}}$$

$$x = \text{lead of table} \times \sin a$$

FIGURE 8



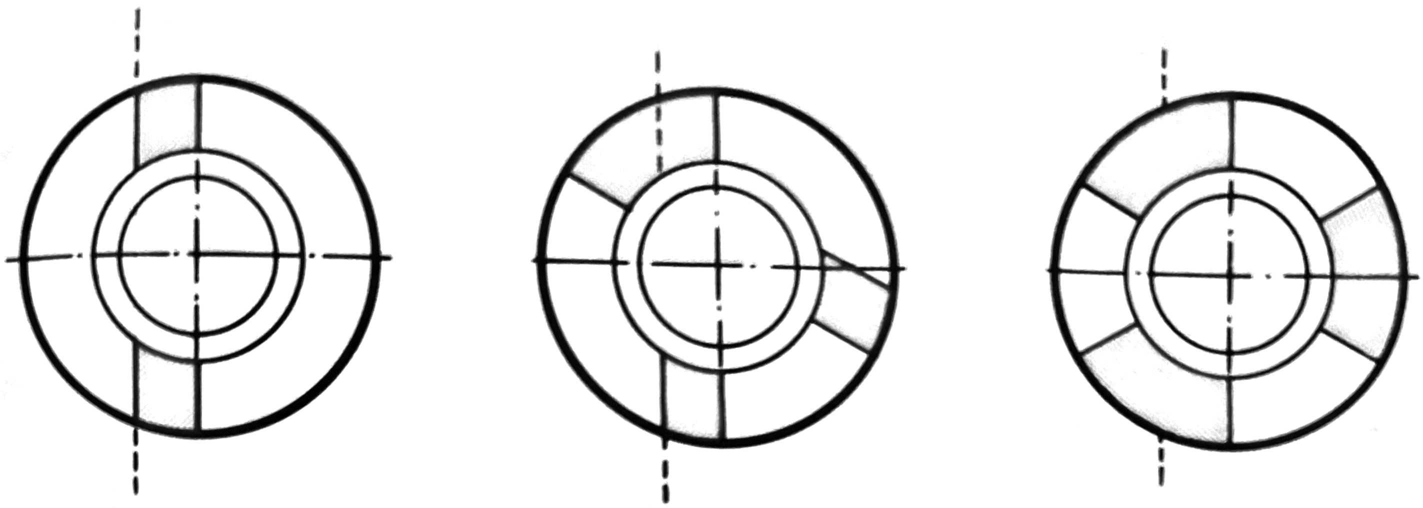
MILLING CLUTCH TEETH. Dog clutches with either square or inclined driving faces can be milled on a Universal Dividing Head or alternatively, if the root area of the spaces is to be square with the bore, on a Rotary Table provided with means of indexing. Most clutches of these types are designed with an odd number of teeth, so proportioned that the milling cutter can pass right across the face of the work to produce the leading flank on one tooth and the trailing flank of another at one pass. When setting up to mill inclined faces it is important to ensure that one side of the cutter intersects the axis of the clutch at a point halfway down the depth of the clutch tooth. All clutches with inclined teeth will have a better disengaging action if they are designed to be cut with the roots of the teeth inclined to the axis so that when pairs are fully engaged the lines of the roots could be projected to meet at a common apex point on the clutch axis. This is almost essential in the case of vee tooth clutches and the set-up is illustrated in Fig. 11 (Page 31) This technique however, increases machining time because the practice of taking the pass right across the clutch diameter is no longer applicable.

The angle θ is determined from the formula:

$$\cos\theta = \tan\frac{180^\circ}{N} \times \cot \text{cutter angle (included angle)}$$

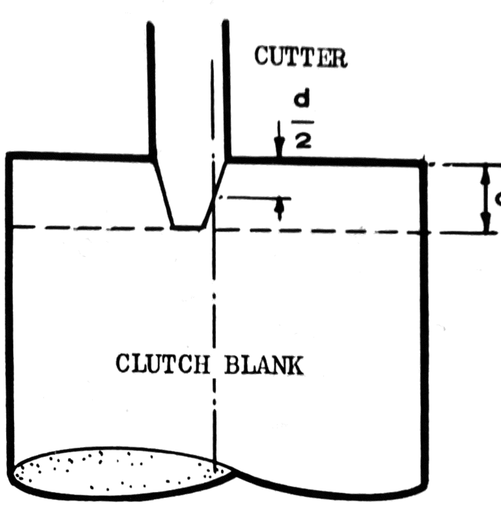
where

N = No. of teeth.



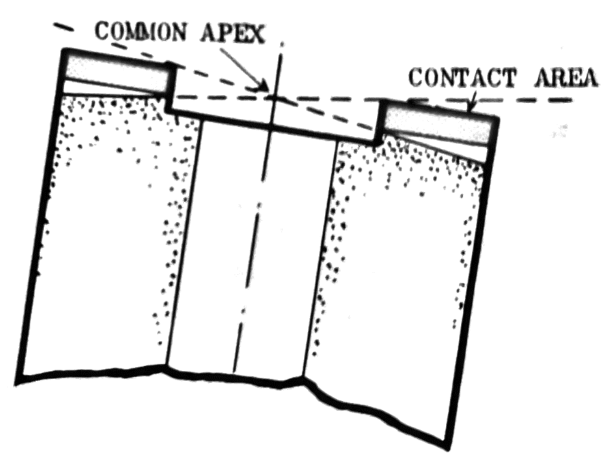
METHOD OF CUTTING CLUTCH TEETH

FIGURE 9



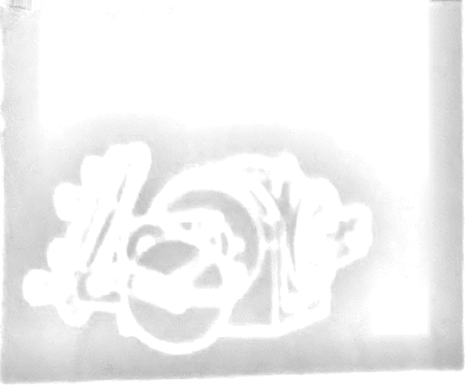
SETTING CUTTER FOR
TEETH WITH INCLINED FACES

FIGURE 10



INCLINED ROOTS FOR
BETTER DISENGAGING ACTION

FIGURE 11



ADJUSTMENTS AND MAINTENANCE

1. Angular adjustment of the head is effected by slackening the two screws (m) and then swinging the main body on its trunnions to the desired position, subsequently securely tightening the two screws.

2. Angular settings may be obtained from the graduations on the main body.

3. When the head has been used with the spindle axis inclined it should be reset in the horizontal position by clocking a test bar held in the spindle taper.

4. Chuck adaptors and other work holders should be located on the outside diameter of the spindle nose which is threaded to enable these to be screwed to the spindle.

5. For differential indexing it is necessary to fit the differential shaft (i) by inserting the expanding spigot into the rear of the spindle and securing by tightening the nut (o).

6. The clamp lever (p) at the back of the dividing head, remote from the operator, serves to lock the main spindle after indexing and should be used whenever cutting is performed with the spindle stationary.

The worm wheel is made of a special bronze with excellent wearing qualities and adjustment for the elimination of backlash will not be required until the head has given very considerable service.

When adjustment is necessary, lever (a) which is connected to the eccentric bush and normally used for disengaging the worm and worm wheel, can be utilised to eliminate any backlash by adjusting the stop screw in the semi-circular slot.

End play of the spindle is unlikely to arise as the generously proportioned thrust faces are all hardened and ground. If it should become necessary, adjustment can be made by means of the slotted nut immediately behind the worm wheel. This nut is revealed after removing the name plate on the head, and can be tightened after releasing the grub screw securing it to the spindle. After adjustment the grub screw should be re-tightened and the safety clip replaced.

Internal lubrication is provided by an oil bath. The oil should be changed annually, draining and re-filling through the access hole covered by the name plate.

A lubricating nipple is provided for the main spindle bearing and oil holes for the rear spindle bearing, for the spiral gear drive and for replenishing the reservoir. These should receive attention at least once per day when the head is in continuous use.

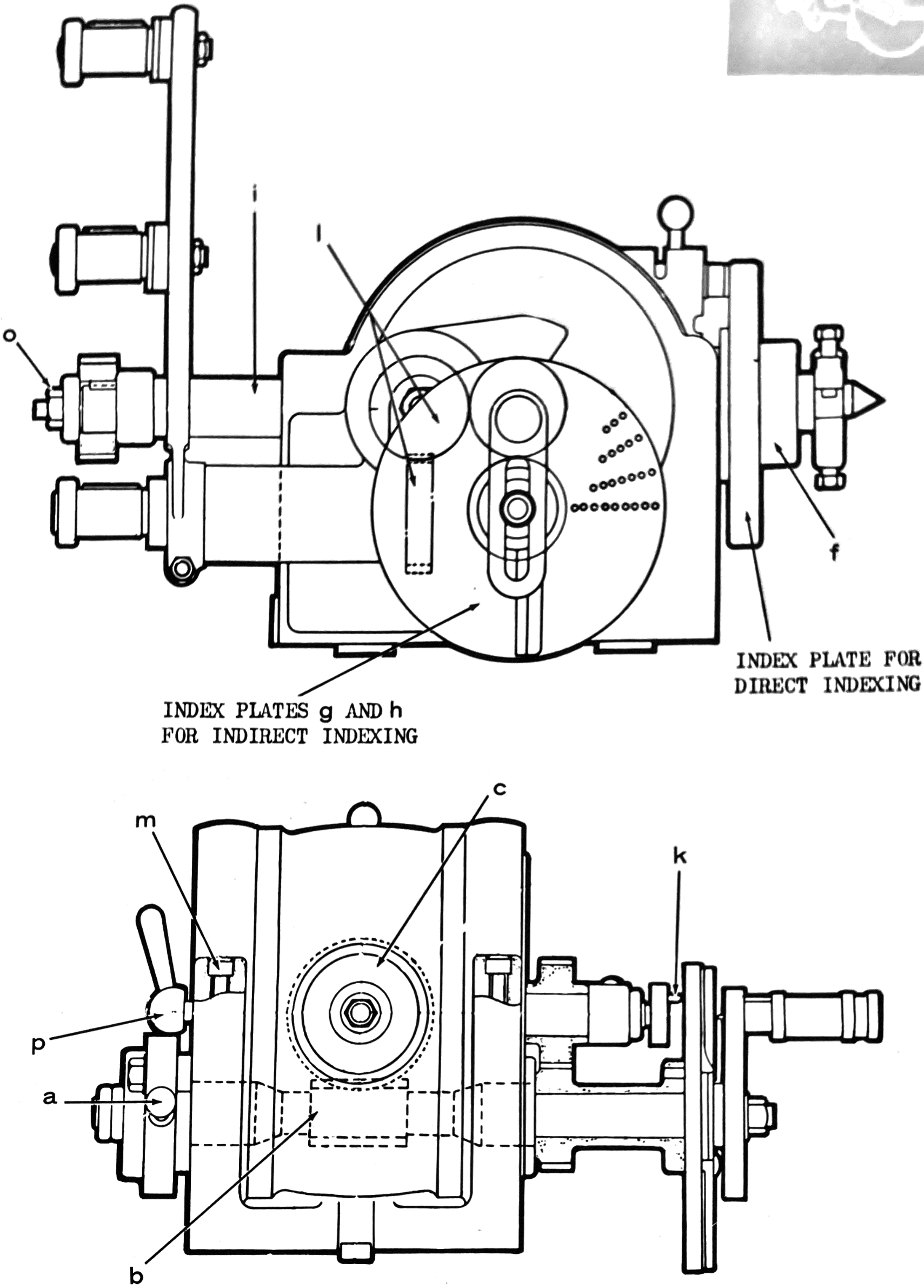
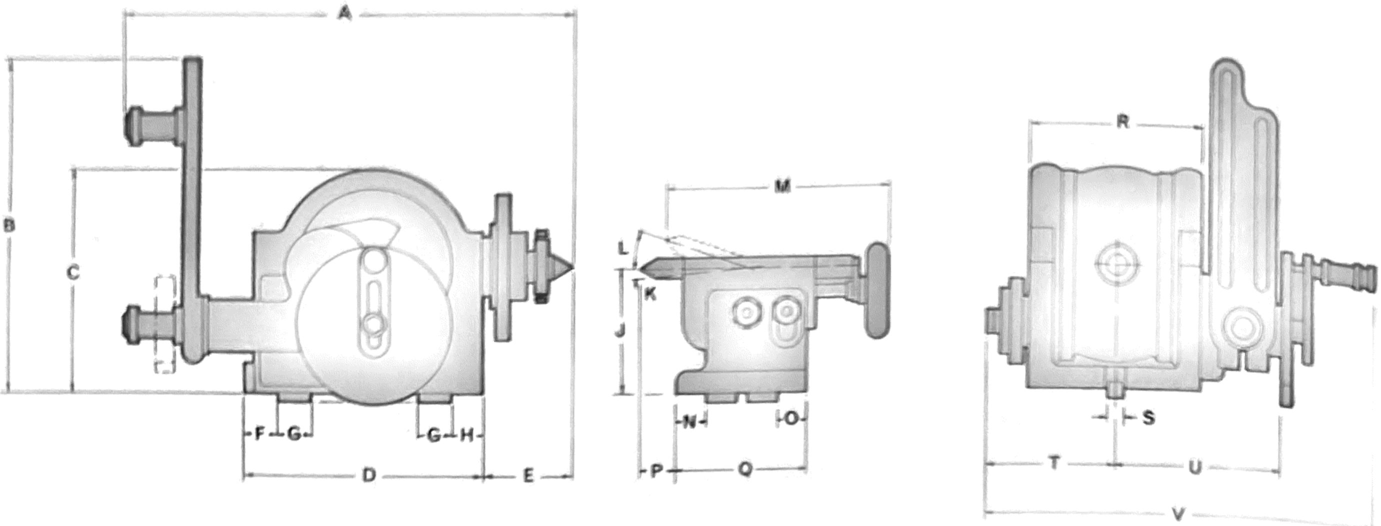
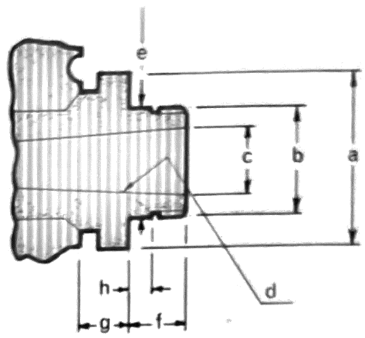

i
l
o
f
INDEX PLATE FOR DIRECT INDEXING
INDEX PLATES g AND h FOR INDIRECT INDEXING
c
m
k
p
a
b

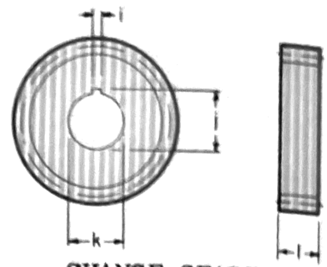
FIGURE 12



specification



SPINDLE NOSE



CHANGE GEARS

	7" SWING MODEL		9" SWING MODEL		10" SWING MODEL		12" SWING MODEL	
A	12⅛"	308 mm	17.15/16"	456 mm	17.15/16"	456 mm	17.15/16"	456 mm
B	8¾"	222 mm	13"	330 mm	13½"	343 mm	14½"	368 mm
C	6.5/16"	160 mm	8.7/16"	214 mm	8.15/16"	227 mm	9.15/16"	252 mm
D	7¼"	184 mm	9.11/16"	246 mm	9.11/16"	246 mm	9.11/16"	246 mm
E	1¼"	31.7 mm	3½"	89 mm	3½"	89 mm	3½"	89 mm
F	1⅜"	35 mm	1⅜"	35 mm	1⅜"	35 mm	1⅜"	35 mm
G	1⅛"	28.5 mm	1¼"	31.7 mm	1¼"	31.7 mm	1¼"	31.7 mm
H	1.5/16"	33.3 mm	1⅜"	35 mm	1⅜"	35 mm	1⅜"	35 mm
J	3½"	89 mm	4½"	114 mm	5"	127 mm	6"	152 mm
K	14°	14°	4°	4°	4°	4°	4°	4°
L	14°	14°	20°	20°	20°	20°	20°	20°
M	6⅛"	155.5 mm	9"	228.6 mm	9"	228.6 mm	9"	228.6 mm
N	⅝"	15.8 mm	1¼"	31.7 mm	1¼"	31.7 mm	1¼"	31.7 mm
O	11/16"	17.4 mm	1¼"	31.7 mm	1¼"	31.7 mm	1¼"	31.7 mm
P max	¾"	19 mm	1.13/16"	46 mm	1.13/16"	46 mm	1.13/16"	46 mm
Q	4¼"	108 mm	5¼"	133.3 mm	5¼"	133.3 mm	5¼"	133.3 mm
R	4⅞"	123.8 mm	7⅛"	180.9 mm	7⅛"	180.9 mm	7⅛"	180.9 mm
S	9/16"	14.2875 mm	9/16"	14.2875 mm	11/16"	17.4625 mm	11/16"	17.4625 mm *
T	3¾"	95.2 mm	5⅜"	136.5 mm	5⅜"	136.5 mm	5⅜"	136.5 mm
U	5⅛"	130 mm	6.15/16"	176 mm	6.15/16"	176 mm	6.15/16"	176 mm
V	12¾"	324 mm	16½"	419 mm	16½"	419 mm	16½"	419 mm
a dia	2"	50.8 mm	3¼"	82.5 mm	3¼"	82.5 mm	3¼"	82.5 mm
b	1½"-10 UNS	1½"-10 UNS	2"-10 UNS	2"-10 UNS	2"-10 UNS	2"-10 UNS	2"-10 UNS	2"-10 UNS
c dia	.938"	23.8251 mm	1.231"	31.2673 mm	1.231"	31.2673 mm	1.231"	31.2673 mm.
d taper	No.3 Morse	Cone Morse 3	No.4 Morse	Cone Morse 4	No.4 Morse	Cone Morse 4	No.4 Morse	Cone Morse 4
e dia	1.9/16"	39.688 mm	2.1/16"	52.388 mm	2.1/16"	52.388 mm	2.1/16"	52.388 mm
f	21/32"	16.668 mm	1.3/16"	30.163 mm	1.3/16"	30.163 mm	1.3/16"	30.163 mm
g	¼"	6.35 mm	25/32"	19.843 mm	25/32"	19.843 mm	25/32"	19.843 mm
h	5/32"	3.968 mm	½"	12.7 mm	½"	12.7 mm	½"	12.7 mm
i	3/16"	4.762 mm	¼"	6.35 mm	¼"	6.35 mm	¼"	6.35 mm
j	.815"	20.7009 mm	1⅛"	28.575 mm	1⅛"	28.575 mm	1⅛"	28.575 mm
k dia	¾"	19.05 mm	1"	25.4 mm	1"	25.4 mm	1"	25.4 mm
l	9/16"	14.287 mm	13/16"	20.637 mm	13/16"	20.637 mm	13/16"	20.637 mm

* NOTE: FOR 12" SWING DIVIDING HEADS SUPPLIED WITH ELLIOTT 70 SERIES MILLS DIMENSION S = $\frac{11}{16}$" (18 mm)

SPECIFICATION	7" SWING MODEL		9" SWING MODEL		10" SWING MODEL		12" SWING MODEL	
Height of centres	3½"	89 mm	4½"	114 mm	5"	127 mm	6"	152 mm
Worm gear ratio	1:40	1:40	1:40	1:40	1:40	1:40	1:40	1:40
Spindle bore	17/32"	13.5 mm	⅞"	22 mm	⅞"	22 mm	⅞"	22 mm
Taper of dividing head spindle	No.3 Morse	Cone Morse 3	No.4 Morse	Cone Morse 4	No.4 Morse	Cone Morse 4	No.4 Morse	Cone Morse 4
Code word	VICME	VICME	VININ	VININ	VITEN	VITEN	VIDOZ	VIDOZ

COMPONENT PARTS LIST

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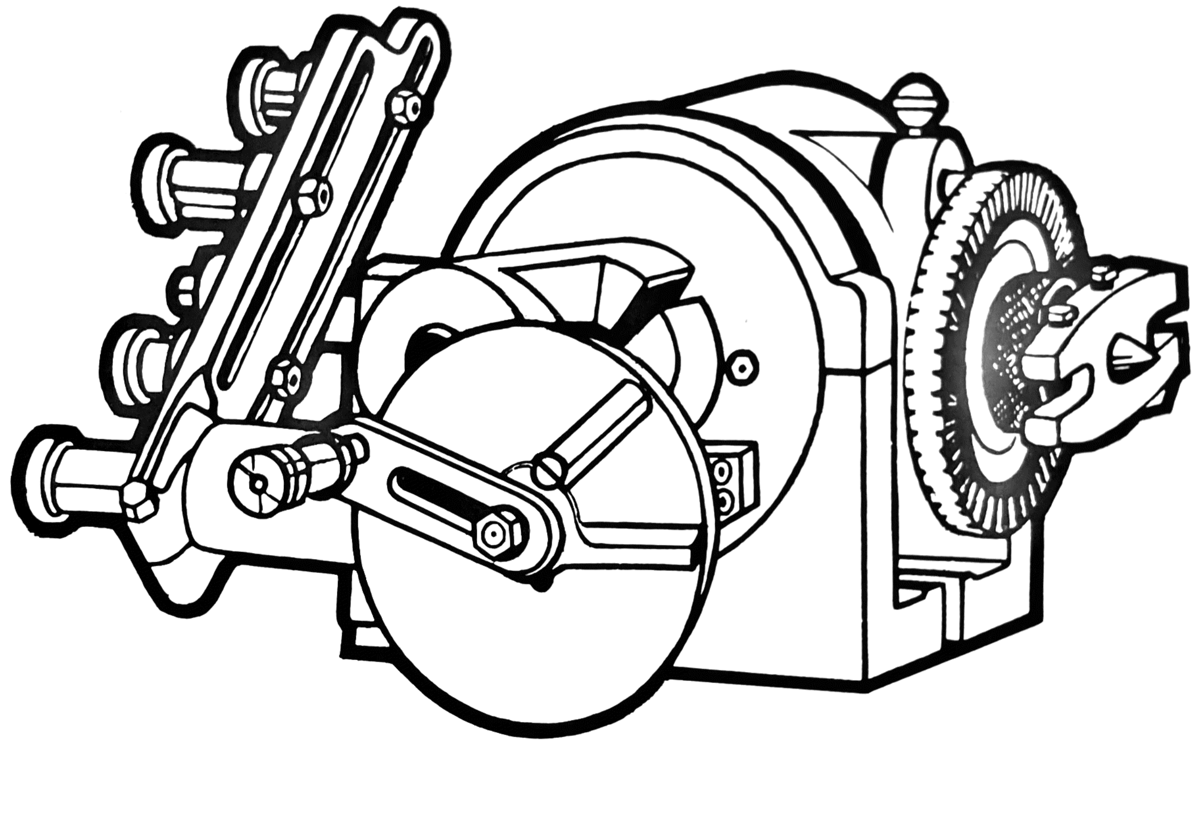


PRECISION UNIVERSAL DIVIDING HEADS

ELLIOTT

PRECISION UNIVERSAL DIVIDING HEAD

7" swing

Illus. No.	Part No.	DESCRIPTION
1	5-27-A	Knurled nut
2	5-55-A	Change gear 24T
	5-56-A	Change gear 28T
	5-57-A	Change gear 32T
	5-58-B	Change gear 40T
	5-59-B	Change gear 48T
	5-60-B	Change gear 56T
	5-61-B	Change gear 64T
	5-62-B	Change gear 72T
	5-63-C	Change gear 86T
	5-64-C	Change gear 100T
4	5-75-A	Retaining nut
5	5-26-B	Differential arbor
6	5-77-B	Long drawbar
7	5-78-B	Short drawbar
8	-	Socket cap screw
9	5-5-C	L.H Segment
10	5-4-C	R.H Segment
11	USN 1⅛	Slotted nut
11A	BOP.12219	Spring ring
12	5-39-A	Wormscrew
13	5-18-B	½ Wormwheel
14	5-17-B	½ Wormwheel with boss
15	5-25-B	Spacing washer
16	5-31-A	Thrust washer
17	5-68-A	Oil washer
18	BOP.17920-B	Cover
19	1-33-A	Slot nut
20	5-8-A	Bush
21	5-9-B	Driver
22	8-12-A	No.3 Morse taper centre
23	5-84-B	Protecting nut
24	5-83-C	Main spindle
25	K2066-B	Key
26	5-30-B	Wormshaft
27	5-21-A	Clamping pad
28	5-53-A	Screw
29	5-46-A	Eccentric screw
30	5-1-D	Body
31	24-32-A	Handle
32	5-22-A	Locking bolt
33	-	Oiler

Illus. No.	Part No.	DESCRIPTION
34	5-10-B	Gear change bracket
35	5-42-A	Gear change spindle
36	5-43-A	Gear change sleeve
37	k00-07	Key
38	5-51-A	Washer
39	5-40-A	Gear change screw
40	1-40-A	Pin
41	5-37-A	Dividing plate lock
42	BOP.269-A	Spring
43	5-49-A	Screw
44	5-38-B	Idler arbor
45	5-15-A	Idler 26T
46	5-48-A	Bush
47	5-50-A	Table bolt
48	1-44-A	Tenon
49	5-47-A	Clamping bolt
50	5-2-C	Base
51	5-44-A	Spiral pin
52	5-14-A	Bush
53	5-12-A	Spur gear 26T
54	5-11-A	Spiral gear with boss 19T
55	5-54-A	Screw
56	5-13-A	Spiral gear 19T
57	5-3-C	Gear bracket
58	5-45-A	Clamp block
59	5-16-B	Plate gear 26T
60	5-6-A	Eccentric sleeve
61	K12-03	Key
62	5-41-B	Spiral arbor
63	5-20-A	Bottom index arm
64	5-19-A	Top index arm
65	5-34-A	Index pin
66	BOP.100-A	Spring
67	5-72-A	Handle
68	5-73-A	Knurled collar
69	5-71-A	Indexing barrel
70	5-74-A	Indexing arm
71	BOP.99-A	Index and spring
72	5-32-A	Screw
73	5-52-A	Countersunk screw
74	5-33-B	Index plate 'A'
	5-67-B	Index plate 'B'

WORK SUPPORT JACK

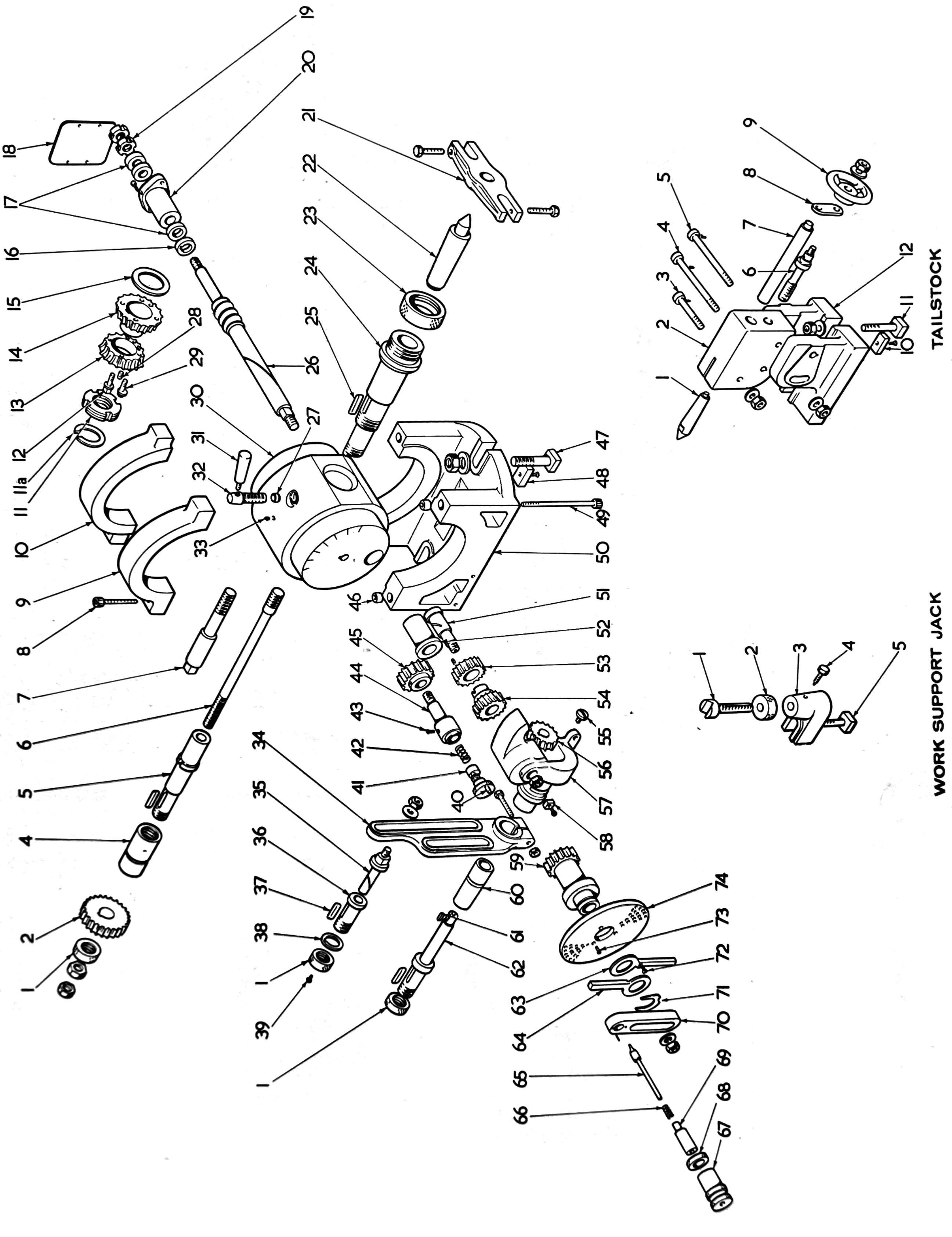
Illus. No.	Part No.	DESCRIPTION
1	7-3-A	Adjusting screw
2	7-2-A	Adjusting nut
3	7-1-A	Body
4	7-4-A	Thump screw
5	5-50-A	Table bolt

TAILSTOCK

Illus. No.	Part No.	DESCRIPTION
1	2-7-A	Centre
2	6-2-B	Footstock body
3	6-6-A	Short clamping bolt
4	6-7-A	Long clamping bolt
5	6-9-A	Link bolt
6	6-8-A	Feed screw
7	6-4-A	Centre sleeve
8	6-5-A	link
9	6-3-A	Handwheel
10	1-44	Tenon
11	5-50-A	Table bolt
12	6-1-C	Footstock base

Items 27, 31 and 32 only fitted when specially ordered.

7" swing



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PRECISION UNIVERSAL DIVIDING HEADS

9", 10" & 12" swing

Illus. No.	Part No.	DESCRIPTION
1	291-26-B	Locknut for change gears
2	291-44-C	Backgear stub shaft
3	291-17-D	Change gear bracket
4	291-54-B	Washer
5	291-57-B	Change gear spindle
6	291-58-B	Change gear sleeve
7	291-59-B	Change gear screw
8	5-72-A	Handle
9	5-73-A	Knurled collar
10	5-71-A	Indexing barrel
11	BOP.100	Compression spring
12	5-34-A	Index pin
13	291-36-C	Indexing arm
14	BOP.190-B	Index arm spring
15	1-34-B	Screw for index arm
16	1-21-A	Top index arm
17	1-22-A	Bottom index arm
18	291-37	Screw for index plate
19	291-9-C	Index plate 'A'
	291-10-C	Index plate 'B'
20	291-40	Dividing plate lock
20A	1-40	Pin for dividing plate lock
21	BOP.269-A	Compression spring
22	291-39-C	Idler arbor
23	291-14-B	Idler gear 31T
24	291-13-B	Plate gear 29T
25	-	Locknut
26	-	Bennett oiler
27	291-5-D	Bracket
28	291-45-B	Washer
29	291-41-B	Spiral gear 19T
30	291-15-B	Bossed spiral gear 19T
31	291-12-B	Spur gear 29T
32	291-43-C	Spiral pin
33	291-8-D	Eccentric bush
34	291-6-C	Gear cover
35	291-2-D	Base (10" and 12" models)
	297-1-D	Base (9" model)
36	-	Socket cap screw
37	291-56-B	Tenon (10" and 12" models)
	1-44-B	Tenon (9" model)
38	-	Socket cap screw
39	291-60-B	Tee bolt (10" and 12" models)
	297-2-B	Tee bolt (9" model)
40	1-53-A	Bush for base
41	-	L2 Lubricator
42	291-1-E	Body

Illus. No.	Part No.	DESCRIPTION
43	291-28-B	Drawbar
44	291-25-C	Differential arbor
45	K20-68-B	Key
46	1-77-A	Spacing collar
	297-4-B	Spacer (9" model)
47	1-60-B	Change gear 24T
	1-61-B	Change gear 28T
	1-62-B	Change gear 32T
	1-63-B	Change gear 40T
	1-64-B	Change gear 48T
	1-65-B	Change gear 56T
	1-66-B	Change gear 64T
	1-67-B	Change gear 72T
	1-68-C	Change gear 86T
	1-69-C	Change gear 100T
48	K14-10	Key
49	-	Socket cap screw
50	291-4-C	L.H. segment
51	291-3-C	R.H. segment
52	BOP.18103	Bakelite ball handle
52A	291-30-B	Lever
53	291-52-B	Clamp bar
54	291-51-B	Screwed piece
55	291-50-B	Handle
56	291-31-C	Wormshaft
57	USN 1¼"	Slotted nut
57A	BOP.12228-B	Spring ring
58	291-18-B	Wormwheel 40T
59	BOP.17872-C	Nameplate (10" and 12" models)
	BOP.17900-C	Nameplate (9" model)
60	BOP.18103	Bakelite ball
61	291-53-B	Quadrant lever
62	187-36-A	Clamping ring
63	291-34-B	Spacer
64	291-19-B	Thrust washer
65	291-7-C	Quadrant
66	BOP.2198	Thrust bearings
67	291-16-B	End cap
68	ULN ⅞"	Locknut
69	BOP.191-A	Compression spring
70	291-29-B	Simple index plunger
71	2092-B	Key
72	291-21-D	Main spindle
73	291-11-C	Index plate
74	291-27-B	Protecting nut
75	1-25-B	No.4 Morse taper centre
76	291-55-B	Driver

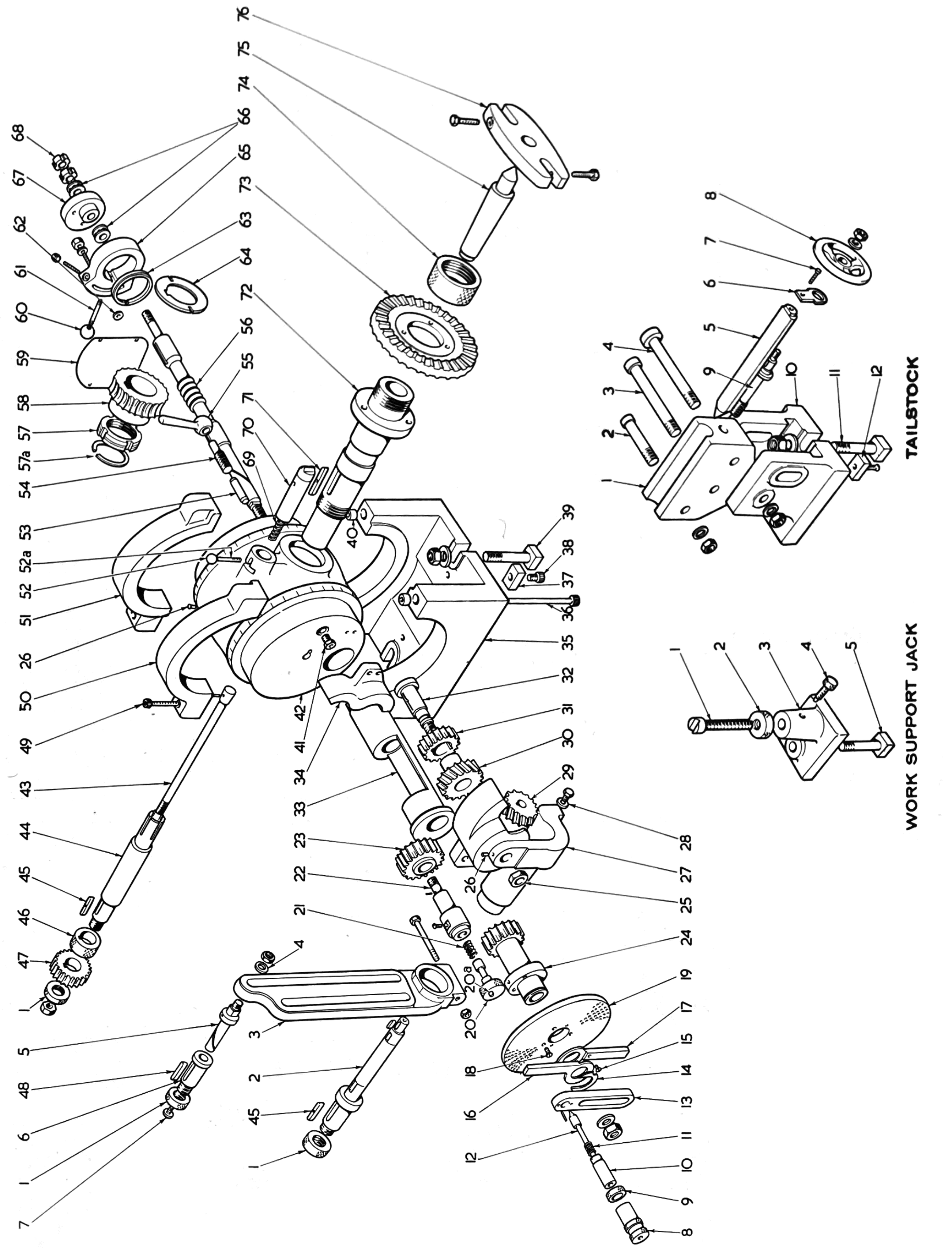
WORK SUPPORT JACK

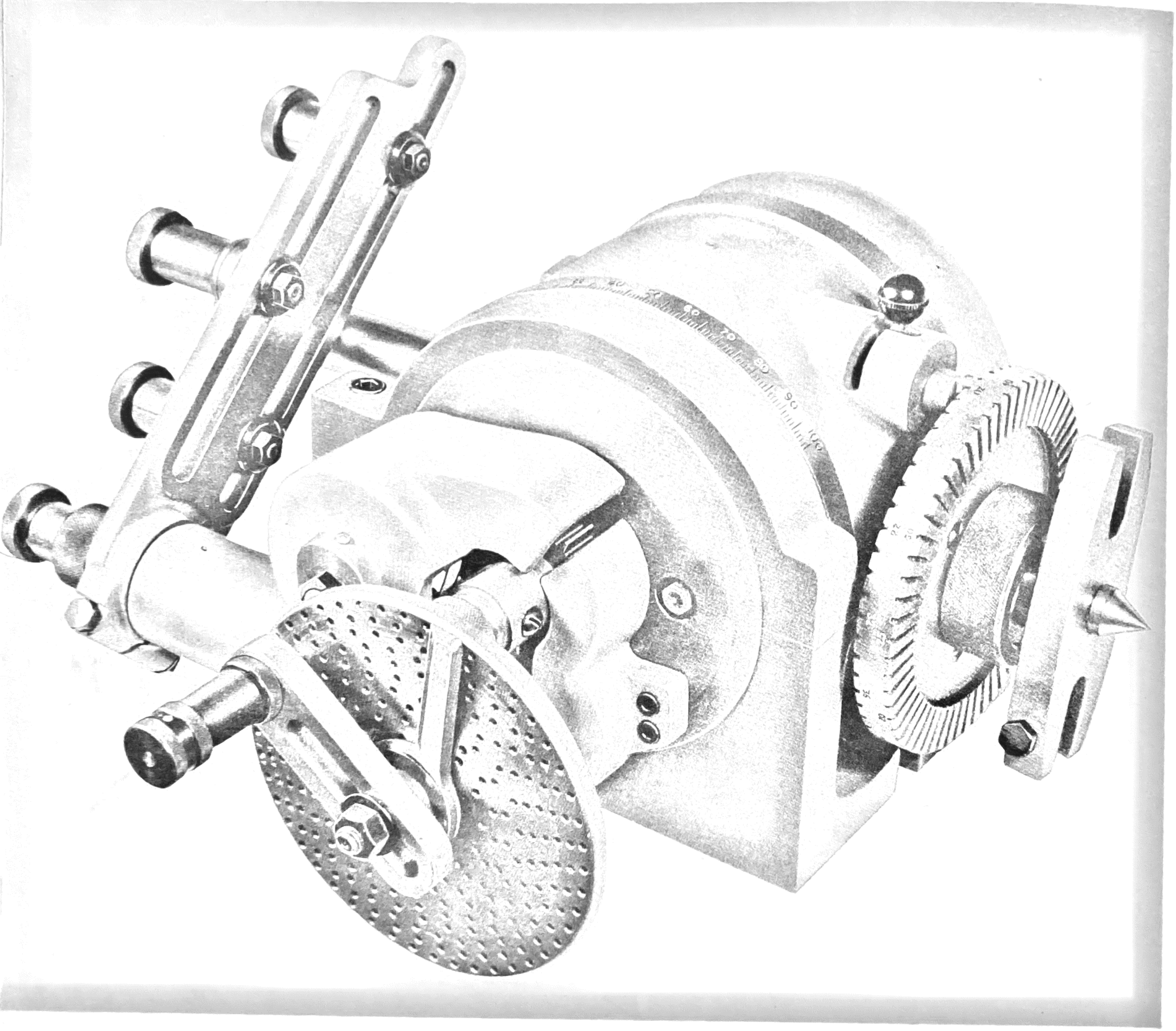
Illus. No.	Part No.	DESCRIPTION
1	293-2-B	Adjusting screw
2	293-3-B	Adjusting nut
3	293-1-B	Body
4	293-4-B	Thumb screw
5	291-60-B	Tee bolt

TAILSTOCK

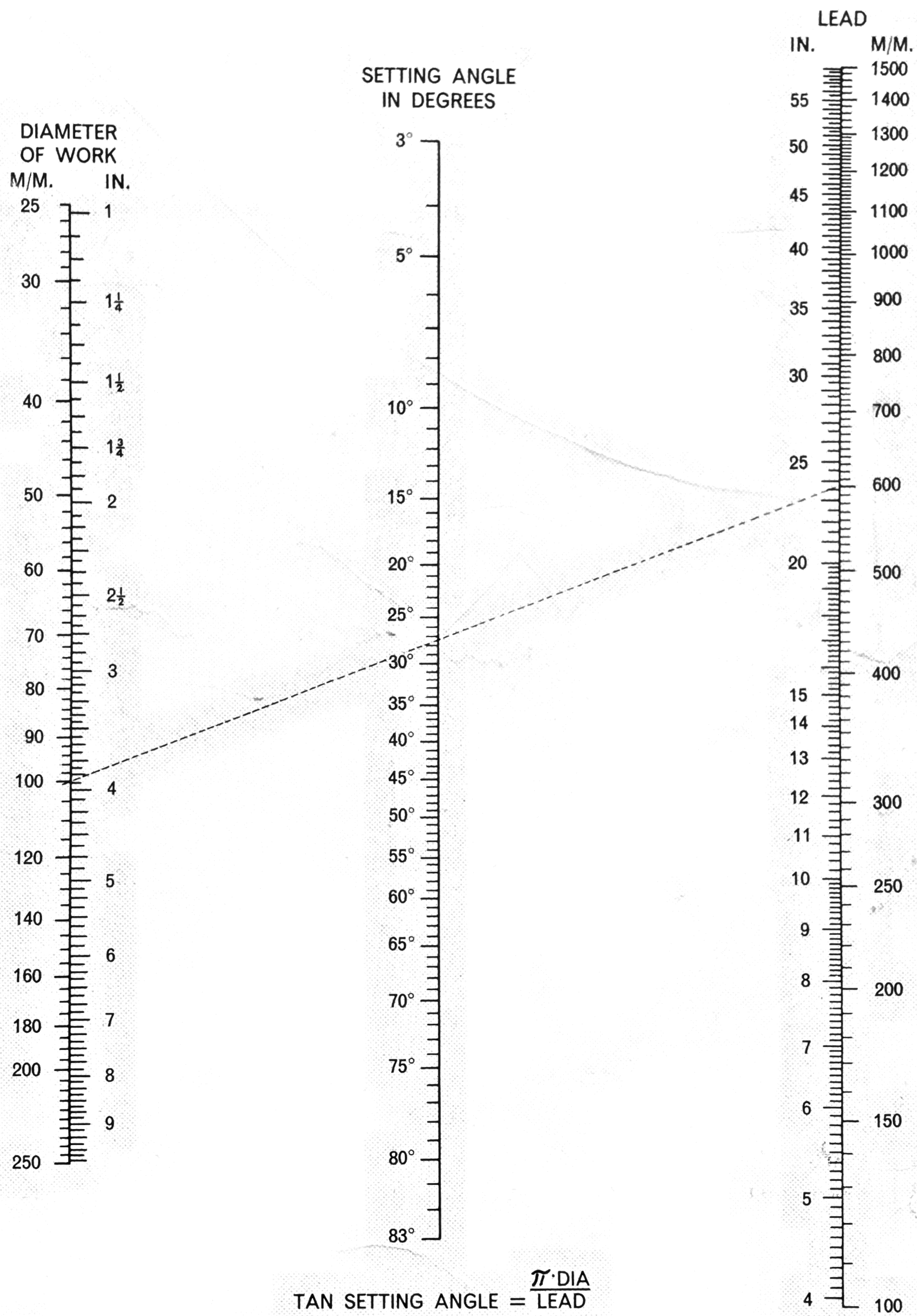
Illus. No.	Part No.	DESCRIPTION
1	292-2-C	Tailstock body
2	292-5-B	Short clamp bolt
3	292-4-B	Swivel bolt
4	292-6-B	Long clamp
5	292-3-B	Sliding centre
6	292-7-B	Link for sliding centre
7	-	Socket cap screw
8	2-3-B	Handwheel
9	292-8-B	Feed screw
10	292-1-D	Tailstock base
11	292-10-B	Tee bolts
12	291-56-B	Tenon

9", 10" & 12" swing





NOMOGRAPH TO GIVE ANGULAR SETTINGS FOR SPIRAL MILLING



$$\text{TAN SETTING ANGLE} = \frac{\pi \cdot \text{DIA}}{\text{LEAD}}$$

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