PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Improvements in or relating to Gear Systems through which a Shaft is Driven

We, THE COLCHESTER LATHE COMPANY LIMITED, of Colchester, Essex, a British Company, do hereby declare the invention, for which we pray that a patent may be
5 granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to gear wheel or chain gear systems for directly linking one
10 rotatable shaft with another.

In particular the invention concerns means for linking one rotatable shaft with another in a manner such as will ensure that the angular rotational movement of one shaft
15 will bear the relationship 1 to 0.03937, or 1 to a multiple of 0.03937, within a tolerence of one part in 39,370 and without using a gear wheel or chain wheel with 127 teeth.

20 The invention is concerned to meet a problem which arises when machines or mechanisms are required to operate both in the English (Imperial) and the metric systems of linear measurement, a problem
25 which affects such machine tools as screw-cutting lathes with a single lead screw which is called upon to cut, or otherwise form, threads according to either system. Such lathes are commonly provided with gear
30 boxes to drive the lead screw at a desired rotational speed relative to that of the lathe spindle. The problem arises from the relationship between the inch and the millimetre, (one inch=25.4 mms) a relationship which
35 is not readily translated into gear ratios. It has hitherto been proposed to provide lathe gear boxes which comprise change wheels capable of driving the lead screw in a manner suited to either English or metric threads,
40 however such gear boxes have either included one wheel with 127 teeth (and such wheels are to large for convenient incorporation) or included an array of wheels each with less than 127 teeth but in such a construction the conversion error from English to Metric has
45 been considerably larger than 1 part in 39,370.

It is the principle purpose of this invention to provide a screw-cutting lathe lead-screw gearbox in which the change wheels
50 are all of a practical size and which will drive the lead-screw in a manner suited equally to the cutting of English or metric screw threads and will do so within normally acceptable tolerances, namely to within 1
55 part in 39,370 of the theoretical perfection

The present invention is based on the known fact that one inch equals 25.4 millimetres and our discovery is that the fraction 288/7315 differs from 1/25.4 by only about
60 one part in 40,000, and according to the present invention there is provided gear wheel or chain system for linking one rotatable shaft with another in which the shafts are linked so that rotation of one shaft effects
65 in rotation of the other shaft in a step-up or step-down ratio of 288:7315.

The value for the present purpose of the fraction 288/7315 lies in the fact that both numerator and denominator can be factorised
70 into small integers. When setting up a train of gears to drive a lead screw with one inch pitch at a relative speed such that for one turn of the spindle the lead nut will advance one millimetre these gears must, to take ad-
75 vantage of the present invention, bring about a reduction of 288/7315.

Now numerator and denominator factorise thus: —

$$288 = 2 \times 2 \times 2 \times 2 \times 2 \times 3 \times 3$$ 80

$$7315 = 19 \times 11 \times 7 \times 5$$

From this it will be appreciated that pairs of reasonable size gear wheels can be chosen that will bring about the desired reduction in a succession of simple steps.

All standard metric threads are simply related to the millimetre as all English standard threads are related to the inch. Thus with the optional addition of a set of gears according to the invention the normal gear box ratios will permit both English and metric standard threads to be cut from a single lead screw.

A further useful feature of the factorising of 7315 is that this includes the factor 19, which permits a choice of gears to cut the pipe thread 19 to the inch which is used in both English and metric countries.

One example of a gear train to provide a reduction in the ratio 288/7315 is through three pairs of gears with intermediate gears carried on lay shafts, these bring about the following three changes in series

$$16:19 \text{ and } 1:11 \text{ and } 18:35$$

In an alternative, preferred, arrangement to be used when the lead screw has four threads per inch so that the ratio becomes $(4 \times 288)/7315$, we use these three successive changes.

$$4:19 \text{ and } 16:22 \text{ and } 36:35$$

A useful feature of this series is that it uses a 16 tooth gear wheel which is normally employed in a conventional gear box.

Embodiments of the present invention will now be considered, by way of example only, with reference to the accompanying illustrative drawings in which:—

Fig. 1 diagrammatically illustrates a gear box for a screw cutting lathe which incorporates a gear system in accordance with the present invention and which system is shown in a condition to cut metric thread sizes;

Fig. 2 is a similar drawing of the gear box shown in Figure 1 in which the gear system is shown adjusted to a condition to cut English (Imperial) thread sizes;

Fig. 3 illustrates a practical construction for a gear box of a screw cutting lathe which incorporates a gear system of the present invention and can be adjusted to cut either conventional English or metric thread sizes; and

Fig. 4 is a table of conventional metric thread sizes together with the gear wheels which are engaged in the gear box of Fig. 3 to cut the respective metric thread sizes.

Where possible throughout the following description the same parts or members in each of the Figures have been accorded the same references and for convenience of description, and where applicable, the number of

teeth (or relative ratios between the teeth) of gear wheels incorporated in the gear boxes have been denoted and encircled on the gear wheels in each of the Figures.

Referring to Figs. 1 and 2 of the drawings, a lathe spindle 1, in addition to rotatably driving a workpiece (not shown) in 1:1 ratio, carries a gear wheel 2 which engages with an idler gear wheel 3 which in turn drives a shaft 4 through a change gear wheel 5. The shaft 4 carries a gear wheel 6 which is axially slidable thereon but is splined for rotation therewith. Associated with the gear wheel 6 is a clutch member 7 which is engagable with a clutch member 8 to drive a shaft 9. Mounted on and for rotation with the shaft 9 in an array of gear wheels shown generally at 10. The shaft 9 carries a further clutch member 11 which is engagable with a clutch member 12 to drive an output shaft 13 and a lead screw 14 which is directly coupled to the output shaft. Splined for rotation with the output shaft 13 is a gear wheel 15.

The gear box includes a further shaft 16 which carries 3 gear wheels 17 to 19 which are splined for rotation therewith.

The array of gear wheels 10 on shaft 9 includes a gear wheel 20 which directly engages with the gear wheel 18 on shaft 16. The clutch members 7 and 8 are arranged so that when they are engaged to transmit drive, the gear wheels 6 and 17 are out of mesh and vice versa, and the clutch members 11 and 12 are arranged so that when they are engaged to transmit drive, the gear wheels 15 and 19 are out of mesh and vice versa. It is to be realised that axial movement of the clutch members and the gear wheels (where applicable) relative to their respective shafts is achieved by conventional means and is well known in the art.

The lead screw 14 carries a lead nut 21 which is adapted to move a cutting tool (not shown) to effect screw cutting of the work piece in known manner.

Considering the gear box shown in Figures 1 and 2 generally for cutting metric sized threads; by the present invention if the lead screw 14 has 1 T.P.I. (one inch pitch) and the spindle 1 is geared to drive the lead-screw 14 through a step-down ratio of $\dfrac{288}{7315}$, then for each revolution of the spindle 1 the leadnut 21 moves axially $\dfrac{288}{7315}$ inches $\triangleq 1$ millimetre.

However, if the leadscrew 14 has n T.P.I. ($\dfrac{1}{n}$ inch pitch) then for each revolution of the spindle 1 the lead nut 21 moves axially

$$\frac{288}{7315} \times \frac{1}{n} \text{ inches} = \frac{1}{n} \text{ millimetres.}$$

If auxiliary gearing is incorporated in the gear box in addition to the gear system for providing the step-down ratio of $\frac{288}{7315}$

5 from the spindle to the lead screw and the auxiliary gearing provides a step-up or step-down ratio of A, then for each revolution of the spindle 1, the lead nut 21 moves axially

$$\frac{288}{7315} \times \frac{A}{n} \text{ inches} = \frac{A}{n} \text{ millimetres.}$$

10 Consequently for a gear box in which the leadscrew is driven from the spindle through a gear system which provides the ratio of 288A:7315n, the pitch of the cut screw will be $\frac{A}{n}$ millimetres.

15 In general, screw cutting lathes are provided with a leadscrew of 4 T.P.I. and we will now consider the case where n=4.

The Table given in Fig. 4 gives examples of conventional pitch sizes in millimetres on 20 the metric scale of screw threads together with the corresponding ratio A (which is simply calculated from the above: pitch in millimetres $=\frac{A}{n}$) which is necessary to be provided by auxiliary gearing to the gear 25 system of the present invention which has the ratio of $\frac{288}{7315}$ to cut said metric threads when n=4.

Referring now particularly to Fig. 1 in which the leadscrew 1 has 4 T.P.I. (n=4), 30 with the gear wheels engaged in the position illustrated, drive from the spindle 1 is transmitted by way of gear wheels 2, 3, 5, shafts 4 and 9, gear wheels 20, 18, shaft 16, gear wheels 19, 15 and shaft 13 to the lead-35 screw 14.

Consequently drive from the spindle 1 is transmitted to the leadscrew 14 in the ratio

$$\frac{4}{19} \times \frac{16}{22} \times \frac{36}{35} \text{ and for each revolution of the}$$

spindle 1 the leadnut 21 moves

$$\left(\frac{288}{7315}\right) \times \frac{8}{2} \times \frac{1}{4} \text{ inches} = 1 \text{ millimetre so}$$

that a screw thread having a 1 millimetre pitch is cut.

Referring now particularly to Fig. 2, with the gear wheels engaged in the position 45 illustrated, drive from the spindle 1 is transmitted by way of gear wheels 2, 3, 5, shaft 4, gear wheels 6, 17, shaft 16, gear wheels 18, 20 and shafts 9 and 13 to the leadscrew 14. Consequently drive from the spindle 1 is

transmitted to the leadscrew 14 in the ratio 50

$$\frac{4}{19} \times \frac{19}{22} \times \frac{22}{16} \text{ and for each revolution of the}$$

spindle 1 the leadnut 21 moves $\frac{1}{4} \times \frac{1}{n}$

inches $=\frac{1}{16}$ inches so that a screw thread having 16 T.P.I. is cut.

It will also be noted that by disengaging 55 gear wheels 6 and 17 and engaging clutches 7 and 8 the drive from the spindle 1 is transmitted to the leadscrew 14 in the ratio $\frac{4}{19}$ and for revolution of the spindle 1

the leadnut 21 moves $\frac{4}{19} \times \frac{1}{n} = \frac{1}{19}$ inches so 60

that a screw thread having 19 T.P.I. is being cut.

With the gear system in the condition shown in Fig. 1 a screw of 1 millimetre pitch can be cut and it will be apparent that the 65 ratio A of auxiliary gearing to the ratio $\frac{288}{7315}$ is equal to 4 (see Fig. 4) and drive is transmitted from shaft 9 to shaft 16 in the ratio $\frac{16}{22}$ of $\frac{16}{22}$ through gear wheels 20 and 18. To

provide a range of metric screw threads 70 which can be selected for cutting, the array of gear wheels 10 is provided and the gear box is adjustable so that drive from any one of the gear wheels 10 can be selected to drive the shaft 16, say through the gear 75 wheel 18 or any one of an array of gear wheels (not shown) carried on the shaft 16 and adapted for rotation therewith, the wheels in which array have a number of teeth which is a multiple of 11. 80

For example if the gear wheel 18 can be engaged to be driven from any one of the gear wheels of the array 10 in Fig. 1, then the metric screw threads (in millimetre pitch) which can be selected to be cut are: — 85 1.0; 1.25; 1.375; 1.5; 1.625; and 1.75.

Conversely if the gear wheel 18 in Fig. 2 can be engaged to drive any one of the gear wheels in the array 10 (in a manner which is well known in gear boxes for cut- 90 ting conventional English threads), then the English screw threads (in T.P.I.) which can be selected to be cut are: — 16; 18; 20; 22; 24; 26; and 28.

It will therefore be seen that part of the 95 standard range of metric thread sizes has been obtained by the addition of the pair of gear wheels 15 and 19 to a conventional English gear box layout and conveniently the 16:22 ratio gear wheels (20 and 18) in Fig. 100

1 are used in the cutting of metric threads and the reciprocal of the ratio (22:16 gear-wheels 18 and 20) shown in Figure 2 is used in the cutting of English threads.

It is to be realised that the ratio A can be extended to provide a required number of selections for cutting metric threads and in addition to provide a required number of selections of cutting English threads and a practical construction for a lathe gear box will now be considered with reference to Fig. 3.

In Fig. 3 the gear box has an output shaft 22 which is adapted to drive the leadscrew (not shown) having 4 T.P.I. and carrying a leadnut (not shown) and an input shaft 23 which is driven through change gear wheels (not shown) from the lathe headstock (not shown).

The change gear wheels are adapted to be driven in either a 2:1 or 1:2 ratio with respect to the lathe spindle (rotating work-piece) and in addition provided a step-down ratio of $\dfrac{24}{57}$ to drive the input shaft 23.

The gear box includes a ladder system of gear wheels in the form of three rotatably mounted shafts 25 to 27 of which shaft 25 carries gear wheels 28 to 30, shaft 26 carries gear wheels 31 to 40 and shaft 27 carries gear wheels 41 to 44.

The shaft 25 can be driven from the input shaft 23 by engagement of a clutch 45 and splined for rotation with the input shaft 23 are a pair of gear wheels 46, 47. The gear wheels, 46, 47 are integral and capable of alternate and respective engagement with a pair of gear wheels 48, 49 which are integral and are rotatably mounted on the shaft 26. The gear wheels 46, 47 are arranged so that they are both disengaged when the clutch 45 is engaged to drive the shaft 25 and when either gear wheel 46 meshes with gear wheel 48 or gear wheel 47 meshes with gear wheel 49 the clutch 45 is disengaged. The gear wheel 49 engages with a gear wheel 50 which is fixedly mounted for rotation with the shaft 27.

The gear wheel 29 on the shaft 25 is engageable with gear wheel 35 and splined for rotation with, and axially adjustable on, the shaft 25 to engage with either of gear wheels 28 and 30 through clutches 51 and 52 respectively. Gear wheels 28 and 30 are rotatively mounted on the shaft 25 but are coupled to rotate therewith when clutch 51 or 52 respectively is engaged. The gear wheel 29 is arranged to engage with gear wheel 35 when both clutches 51 and 52 are disengaged and to disengage from gear wheel 35 when one or other clutch 51, 52 is engaged.

The gear wheels 28 and 30 respectively engage with gear wheels 32 and 40 on the

shaft 26 and the gear wheels 31 to 40 are splined for rotation with the shaft.

The gear wheels 41 to 44 are splined for rotation with the shaft 27 and are axially adjustable thereon so that gear wheel 41 can engage with either of gear wheels 31 and 33, gear wheel 42 can engage with either of gear wheels 34 and 35, gear wheel 43 can engage with either of gear wheels 36 and 37, and gear wheel 44 can engage with either of gear wheels 38 and 39.

The shaft 27 carries a further gear wheel 53 which is splined for rotation therewith and engage with a gear wheel 54 mounted for rotation with a free running feed shaft 55. Mounted for rotation with the feed shaft 55 is a further gear wheel 56 which is integral with the gear wheel 54.

Carried on the output shaft 22 is a pair of gear wheels 57, 58 which are integrally formed and splined for rotation with the output shaft and also to be capable of axial adjustment on the output shaft. The gear wheels 57, 58 are capable of adjustment to be engaged alternatively and respectively with gear wheels 56, 54 on the feed shaft 55 and have associated therewith a clutch 59 which, when engaged transmits drive between the shafts 25 and 22. The gear wheels 57, 58 are arranged so that, when the clutch 59 is engaged, they are disengaged from gear wheels 56, 54 and when one or other of the gear wheels 57, 58 engages with the gear wheels 56, 54 respectively, the clutch 59 is disengaged.

Axial adjustment of the gear wheels 29, 41 to 44, 46, 47 and 57, 58 to effect engagement between required gear wheels and/ or clutches 45, 51, 52 and 59 to provide a selected gear ratio is conveniently effected by lever mechanisms by a manner well known in the art.

We will now consider operation of the gear box shown in Fig. 3 to effect cutting of screw threads in the metric range. The clutch 45 is engaged and either gear wheel 57 is engaged with gear wheel 56 (as shown) or gear wheel 58 is engaged with gear wheel 54. The selection of gear ratios attainable are provided by driving shaft 26 directly from gear wheel 29 (as shown) or through either of gear wheels 28 and 30 by engagement of either clutch 51 or 52 respectively, and also by driving the shaft 27 through any one of the gear wheels 41 to 44 (each of which can be engaged with either of two gear wheels on the shaft 26). Consequently the gear wheels 28 to 44 can be adjusted to select any one of 24 available gear ratios between the shafts 25 to 27. In addition, by providing the choice of engagement between gear wheels 56 and 57 or 54 and 58 and by providing the choice of an input ratio of 2:1 or 1:2 from the lathe headstock to the

change gear wheels, any one gear ratio can be selected from 96 available gear ratios.

As an example, of gear wheel 29 is engaged with gear wheel 35 (as shown) gear wheel 41 engaged with gear wheel 33, gear wheel 56 engaged with gear wheel 57 (as shown) and the input ratio from the lathe headstock to the change gear wheels is 1:2 then, for each revolution of the spindle, the leadnut moves axially

$$\frac{1}{2}\times\frac{24}{57}\times\frac{23}{23}\times\frac{20}{22}\times\frac{36}{45}\times\frac{18}{35}\times\frac{1}{4} \text{ inches} =$$

0.5 millimetres (i.e. a screw thread of 0.5 millimetre pitch is cut).

If the ratio from the lathe headstock to the change gear wheels is re-adjusted to provide an input ratio of 2:1, then a screw thread of 2.0 millimetre pitch is cut or if the gear wheel 58 is engaged with the gear wheel 54 then a screw thread of 1.25 millimetre pitch is cut.

By suitable selection of the engaging gear wheels the range of gearing ratios shown in the table of Fig. 4 can be obtained and for each Metric screw thread pitch size given, the corresponding engaging gear wheels are shown together with the input ratio from the lathe headstock to the change gear wheels (i.e. either 2:1 or 1:2).

In operation of the gear box shown in Fig. 3 to effect cutting of screw threads in the English (Imperial) range, the clutch 45 is disengaged (as shown) and the clutch 59 is engaged. Drive from the input shaft 23 is now transmitted through either gear wheels 47, 49 and 50 (as shown) or gear wheels 46, 48, 49 and 50 to the shaft 27 from which drive is transmitted by way of any one of gear wheels 41 to 44 and 28 to 30 to the shaft 25 and therefrom to the output shaft 22. It will be apparent that the gear wheels 41 to 44 and 28 to 30 can be adjusted to select any one of 24 available gear ratios between shafts 25 to 27. In addition, by providing the choice of engagement between gear wheels 47 and 49 or 46 and 48 and by providing the choice of an input ratio of 1:2 or 2:1 from the lathe headstock to the change gear wheels, any one gear ratio can be selected from 96 available gear ratios (excluding direct drive from the input shaft 23 to the output shaft 24 when both clutches 45 and 59 are engaged).

As an example, if gear wheel 47 is engaged with gear wheel 49 (as shown), gear wheel 42 is engaged with gear wheel 34, gear wheel 35 is engaged with gear wheel 29 (as shown) and the input ratio from the lathe headstock to the change gear wheels is 1:2, then for each revolution of the spindle the leadnut moves axially

$$\frac{1}{2}\times\frac{24}{57}\times\frac{19}{20}\times\frac{20}{22}\times\frac{22}{24}\times\frac{23}{23}\times\frac{1}{4}$$

$$\text{inches} =\frac{1}{24} \text{ inches (i.e. a screw thread is cut}$$

having 24 T.P.I.).

If the ratio from the lathe headstock to the change gear wheels is re-adjusted to provide an input ratio of 2:1 then a screw thread having 6 T.P.I. is cut, or if the gear wheel 46 is engaged with the gear wheel 48, then a screw thread having 36 T.P.I. is cut.

By suitable selection of the gear wheels in the box a range of English thread sizes can be cut and the engagement of gear wheels to provide such a range will be apparent to persons skilled in the art and who are conversant with conventional gear boxes for screw cutting lathes.

It will be apparent from the foregoing that for a given gear box constructed in accordance with the present invention as applied to a screw cutting lathe, if the lead screw is charge for one having a different pitch it is only necessary to change the ratio provided by the change gear wheels to maintain the correct ranges and selections on both the English and metric screw thread scales; for example, if in Fig. 3 the leadscrew having 4 T.P.I. is changed for one having x T.P.I., then the change gear wheels are altered to provide a

$$\text{ratio of } \frac{24}{57}\times\frac{x}{4}=\frac{6x}{57}=\frac{2x}{19}.$$

Similarly a leadscrew of metric pitch in millimetres may be used by substituting $\frac{7315}{288y}$

for x in the formula $\frac{2x}{19}$. The necessary change

$$\text{wheel ratio becoming:} \frac{2x7315}{19x288y}=\frac{385}{144y}$$

where y is the leadscrew pitch in millimetres. For example, the most common metric leadscrew pitch is 6 millimetres. Change wheels required then become y=6. therefore,

$$\frac{\text{Drivers}}{\text{Driven}} \frac{385}{144\times6}=\frac{11\times7\times5}{16\times9\times6} \text{ which may be}$$

conveniently transposed into usable form thus:

$$\frac{\text{Drivers}}{\text{Driven}} \frac{28}{54}\times\frac{55}{64}.$$

It is to be understood that whereas the invention has an important use in its application to screw cutting lathes it is not limited to this but may be employed in other applications, as for example, where a single screw must make measurements or cause controlled measurements according to either the inch (Imperial) system or metric linear measurements. As one example, a micrometre measuring engine with a single screw could, by interpolation of a gear system according

to the invention, be changed from one measurement system to the other.

It is also to be understood that instead of toothed gear wheels we may use chains and sprockets or toothed belts with matching toothed wheels.

WHAT WE CLAIM IS:—

1. A gear wheel or chain gear system for linking one rotatable shaft with another in which the shafts are linked so that rotation of one shaft effects in rotation of the other shaft in a step-up or step-down ratio of $288:7315$.

2. A system as claimed in claim 1 in which one rotatable shaft is linked with the other rotatable shaft through successively linked gear wheel or chain gear mechanisms to provide two or more stages in effecting a step-up or step-down ratio between rotation of the two shafts, each stage providing a step-up or step-down ratio which constitutes or includes one or more factors of $\dfrac{288}{7315}$ and the combined stages provide a step-up or step-down ratio which consists of $\dfrac{288}{7315}$.

3. A system as claimed in either claim 1 or claim 2 wherein at least one selectable auxiliary gear wheel or chain gear mechanism is incorporated in the system whereby multiplies or fractions of the ratio $\dfrac{288}{7315}$ can be selected within a predetermined range.

4. A gear wheel or chain gear system substantially as herein described with reference to Figs. 1 and 2 or Fig 3 of the accompanying illustrative drawings.

5. A mechanism which includes a system as claimed in any one of claims 1 to 4.

6. A mechanism as claimed in claim 5 which comprises a screw cutting lathe adapted to cut threads on either the English (Imperial) system or metric system in which the leadscrew can be driven from the head stock spindle by way of the gear wheel or chain gear system.

7. A screw cutting lathe substantially as herein described with reference to Figs. 1 and 2 of the accompanying illustrative drawings.

8. A screw cutting lathe substantially as herein described with reference to Fig. 3 of the accompanying illustrative drawings.

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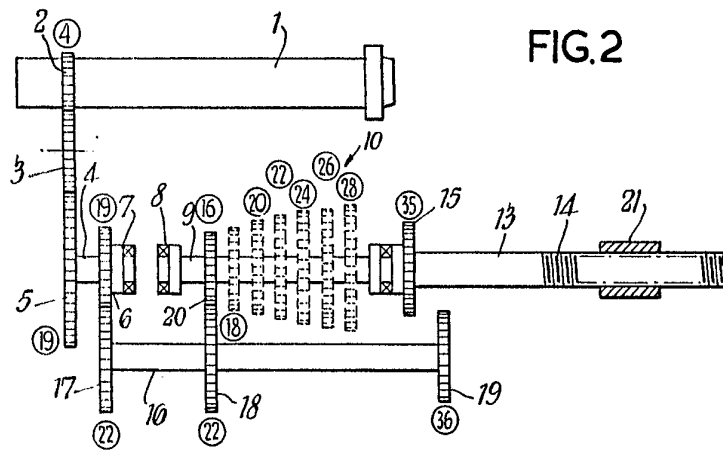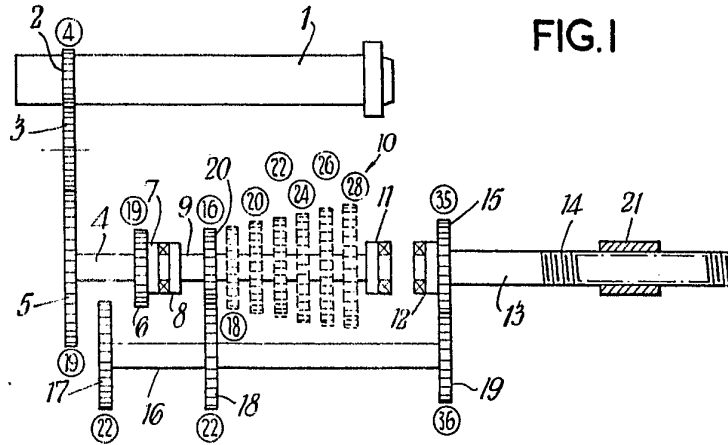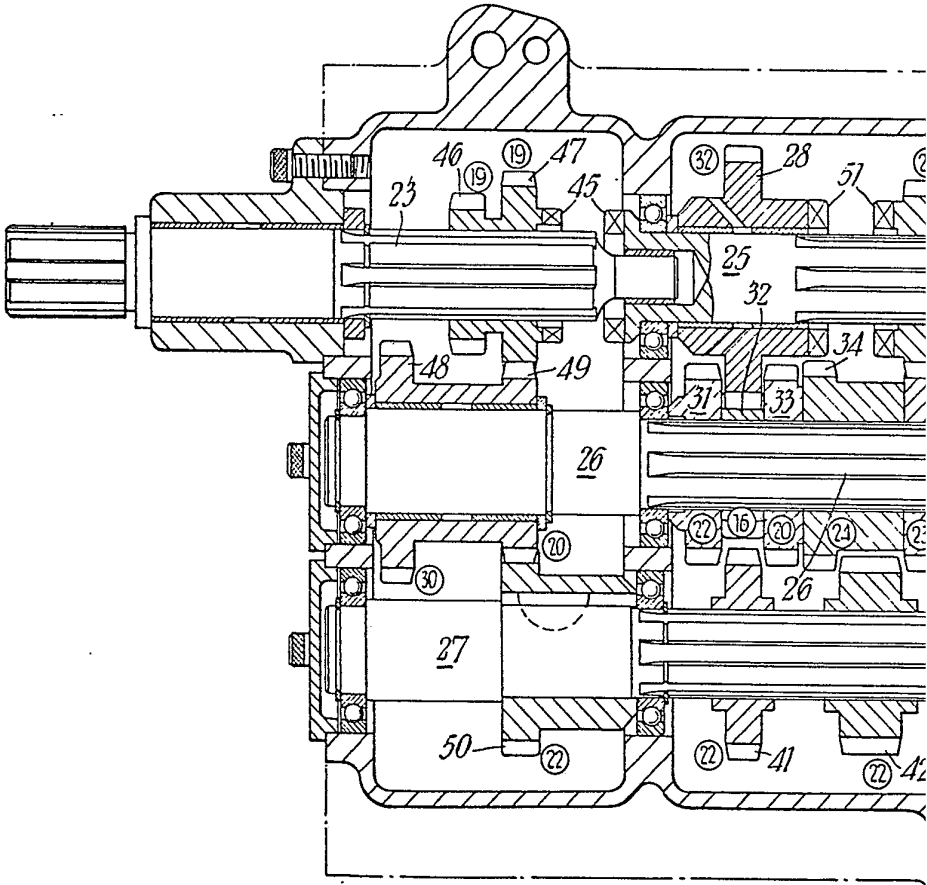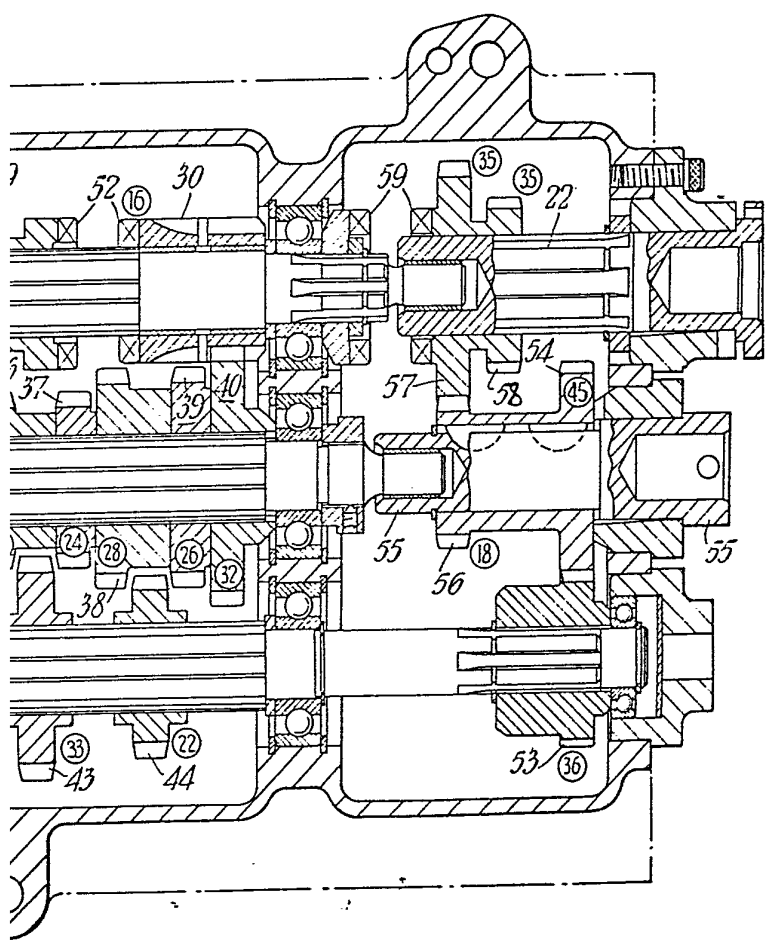12 South Parade, Leeds, 1, Yorks.
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FIG.1

FIG.2

23

46 19 47
19 45
32 28 51

25
32

48 49
34
31 33

26

22 16 20 24

20
26

30

27

50
22 22 41 22 4

1190810   COMPLETE SPECIFICATION
3 SHEETS   *This drawing is a reproduction of*
the Original on a reduced scale
Sheet 2

FIG.3

MILLIMETRE PITCH SIZE	RATIO A PROVIDED BY AUXILIARY GEARING WHEN n=4	GEAR WHEELS IN FIG.3 THROUGH WHICH DRIVE IS TRANSMITTED IN ADDITION TO CHANGE GEAR WHEELS HAVING A RATIO 8:19	INPUT RATIO FROM HEADSTOCK TO CHANGE GEAR WHEELS
0.2	0.8	30;40;37,43,53,54;56;57	1·2
0.225	0.90	30;40;36,43,53;54;56;57	1·2
0.25	1·0	30;40;33;41;53 ;54;56;57	1·2
0.3	1·2	30;40;34;42;53;54;56;57	1·2
0.35	1·4	30;40;38;44;53;54;56;57	1·2
0.4	1·6	29;35;37;43;53;54;56;57	1·2
0.45	1·8	29;35;36;43;53;54;56;57	1·2
0.5	2·0	29;35;33;41 ;53;54;56;57.	1·2
0.6	2·4	29;35;34;42;53;54;56;57	1·2
0.7	2·8	29;35;38;44;53;54;56;57	1·2
0.75	3·0	30;40;34;42;53;54;54;58	1·2
0.8	3·2	28;32;37;43;53;54;56;57	1·2
0.9	3·6	28;32;36;43;53;54;56;57	1·2
1·0	4·0	29;35;37;43;53;54;54;58	1·2
1·1	4·4	28; 32; 31;41; 53; 54;56;57	1·2
1·2	4·8	28;32;34;42;53;54;56;57	1·2
1·25	5·0	29;35;33;41;53;54;58.	1·2
1·3	5·2	28;32;39;44;53;54;56;57	1·2
1·4	5·6	28;32;38;44;53;54;56;57	1·2
1·5	6·0	29;35;34;42;53;54;54;58	1·2
1·75	7·0	29;35;38;44;53;54;54;58	1·2
2·0	8·0	28;32;37;43;53;54;54;58	1·2
2.5	10·0	28;32;33;41;53;54;54;58	1·2
3·0	12·0	28;32;34;42;53;54;54;58	1·2
3.5	14·0	28;32;38;44;53;54;54;58	1·2
4·0	16·0	29;35;37;43;53;54;54;58	2·1
4.5	18·0	29;35;36;43;53;54;54;58	2·1
5·0	20·0	29;35;33;41;53;54;54;58	2·1
5·5	22·0	29;35;31;41;53;54;54;58	2·1
6·0	24·0	29;35;34;42;53;54;54;58	2·1
7·0	28·0	29;35;38;44;53;54;54;58	2·1
8·0	32·0	28;32;37;43;53;54;54;58	2·1
9·0	36·0	28;32;36;43;53;54;54;58	2·1
10·0	40·0	28;32;33;41;53;54;54;58	2·1
12·0	48·0	28;32;34;42;53;54;54;58	2·1
14·0	56·0	28;32;38;44;53;54;54;58	2·1

FIG.4