July 17, 1951 F. LOHUTKO 2,560,967

APPARATUS FOR GRINDING GEARS AND GEAR CUTTERS

Filed Dec. 14, 1948

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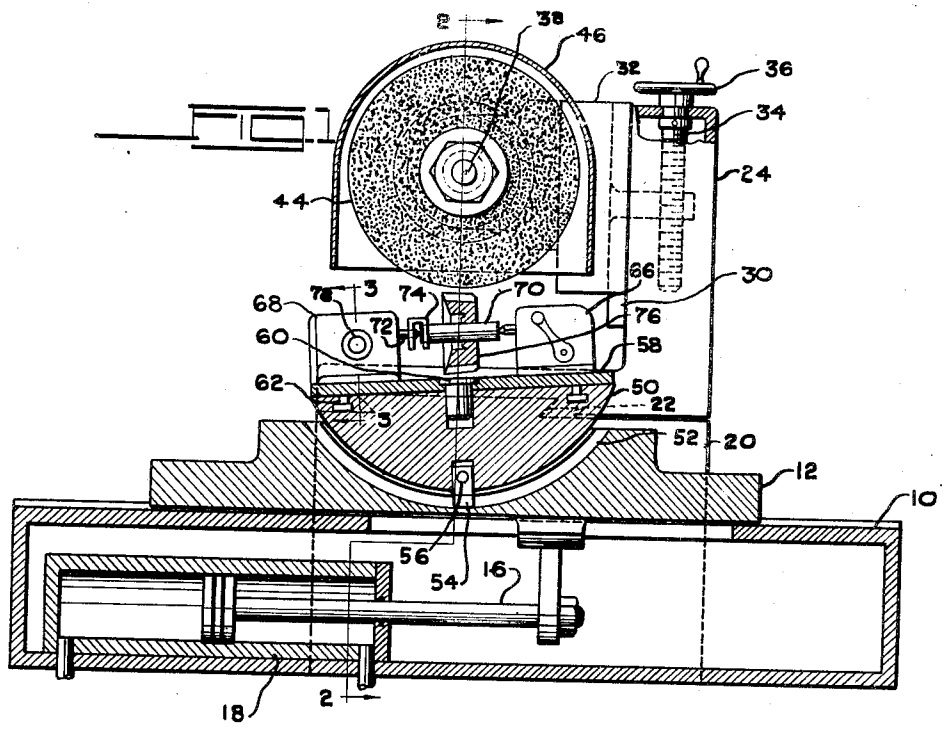


FIG. 3

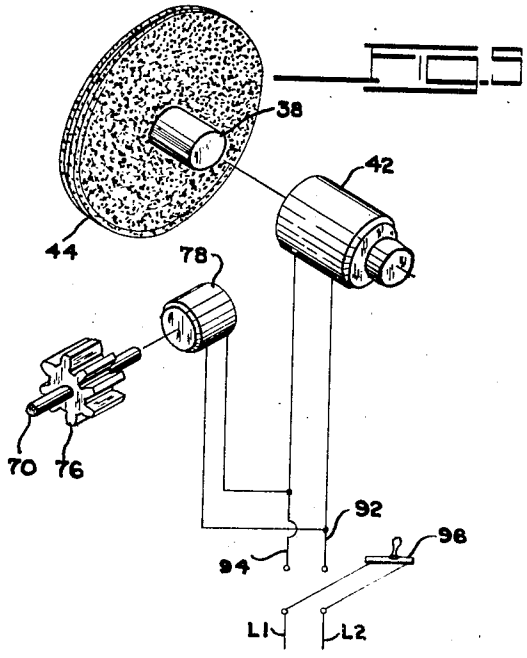
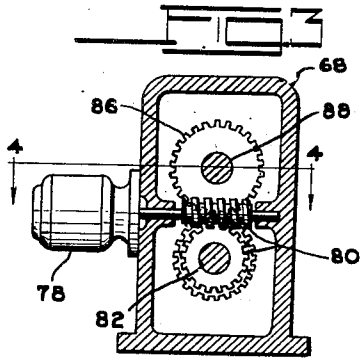


FIG. 4



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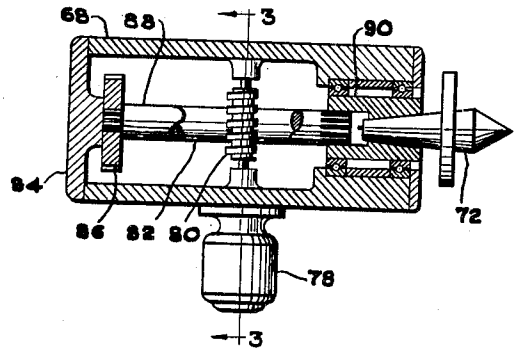
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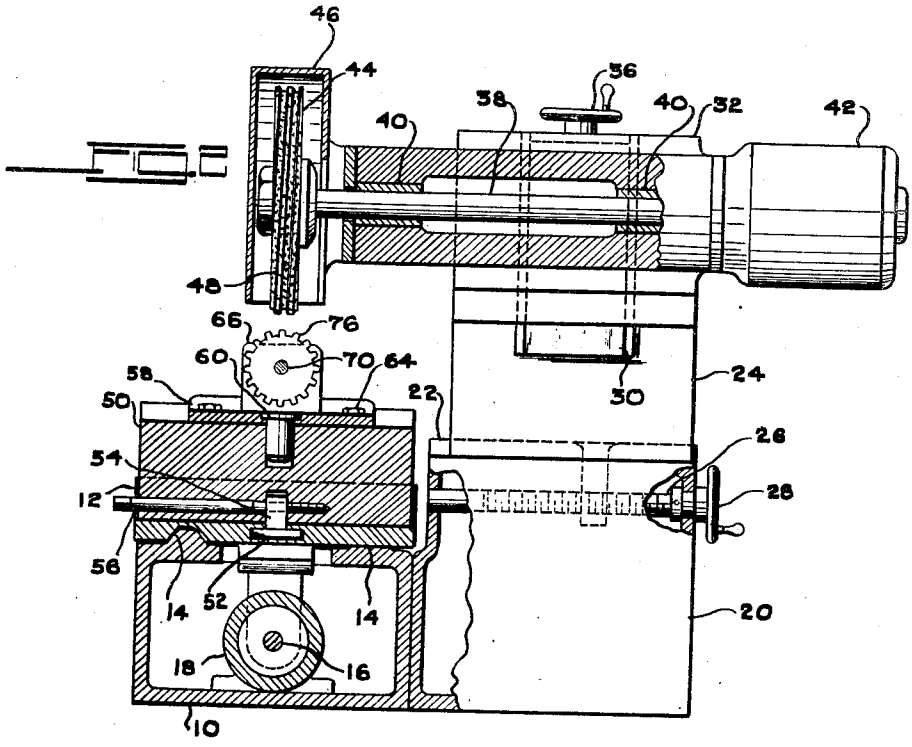
APPARATUS FOR GRINDING GEARS AND GEAR CUTTERS

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FIG. 4





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FIG. 6

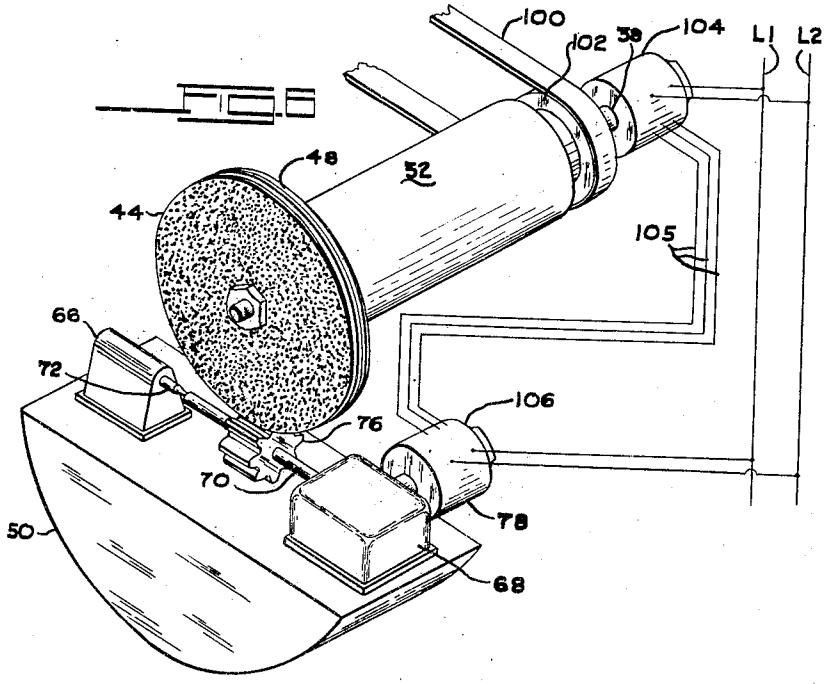
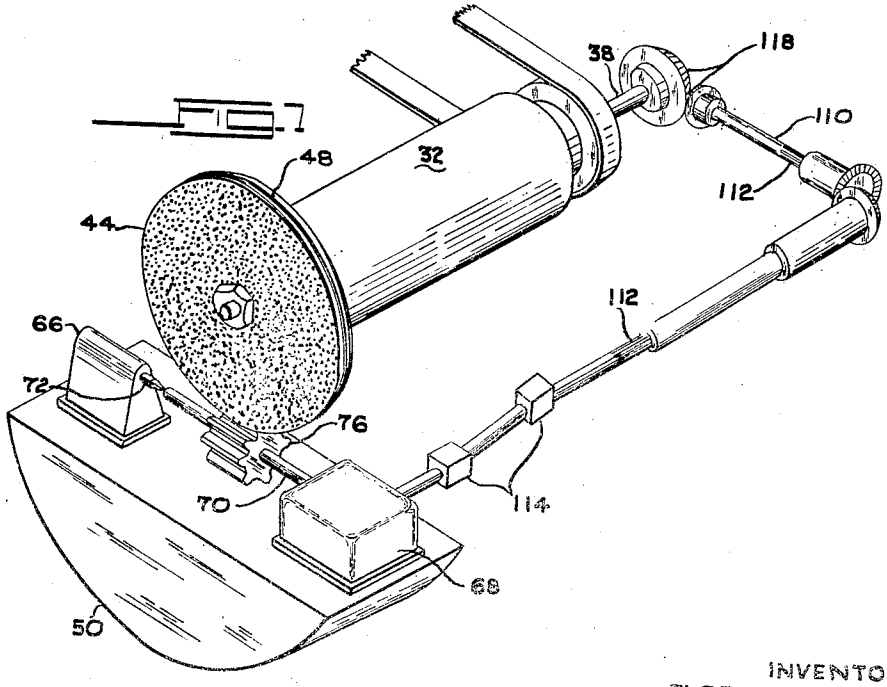


FIG. 7



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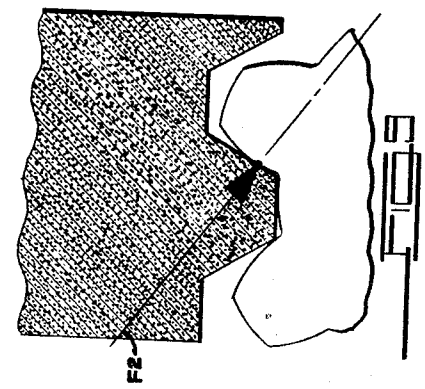


FIG. 9

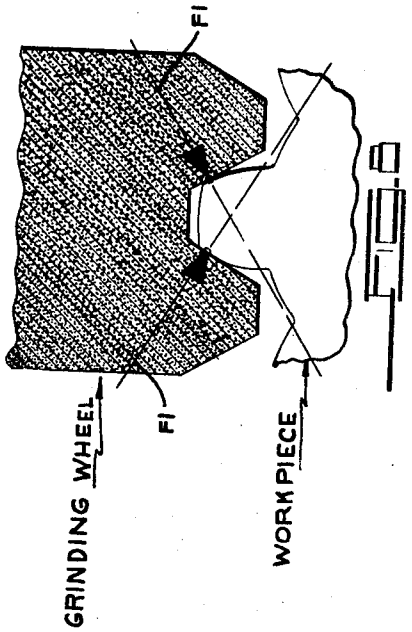


FIG. 8

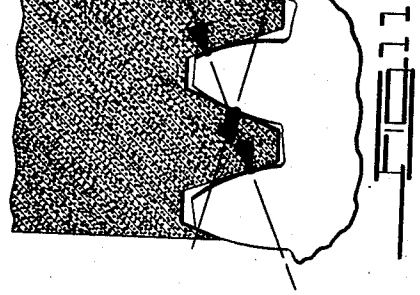


FIG. 11

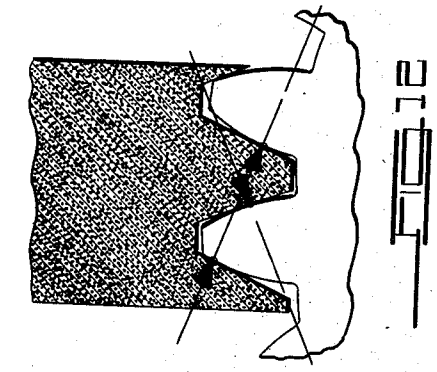


FIG. 12

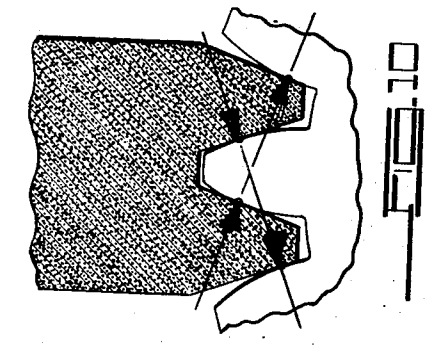


FIG. 10

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APPARATUS FOR GRINDING GEARS AND GEAR CUTTERS

Floryan Lohutko, Detroit, Mich., assignor to The Thompson Grinder Company, Springfield, Ohio, a corporation of Ohio

Application December 14, 1948, Serial No. 65,255

11 Claims. (Cl. 51—95)

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This invention relates to grinding machines, and particularly to grinding machines especially adapted for grinding gears and gear cutters and the like.

The art of grinding gears and gear cutters is highly complex and requires accurate fixtures and machines and the like, and heretofore has been an operation requiring a high degree of skill and consuming considerable length of time.

This is due to the fact that the tooth forms on the gears and gear cutters are finally finished by a grinding operation and therefore receive their ultimate accuracy therefrom.

Also in the case of gear cutters it is necessary to provide clearance angles along the sides of the cutting teeth in order to provide for the proper cutting action when it is utilized for forming a gear blank into a gear.

Prior art arrangements for grinding gears and gear cutters generally took the form of a grinding wheel so shaped and arranged that it would form only one side of a tooth at a time. Thus, to grind completely around the periphery of a gear or gear cutter it was necessary to grind one side of the teeth going around the workpiece in one direction and then to reverse the workpiece and grind the other side of the teeth. It will be apparent that this procedure, involving as it does two setups, was inherently inaccurate and troublesome.

Certain other arrangements have been proposed wherein the grinding wheel carried a helical thread form thereon so that as it rotated the gear or gear cutter being ground also rotated. This arrangement was more satisfactory than the one described above, but all machines heretofore which have utilized this principle have been exceedingly complex and expensive and difficult to operate.

The primary object of the present invention is to provide an improved arrangement for grinding workpieces such as gears and gear cutters which is much simpler to operate than machines which have been constructed according to the prior art.

A still further object is the provision of a fixture in combination with a grinding machine in which workpieces such as gears and gear cutters can be mounted and ground to precise forms by simple grinding practices.

A still further object is the provision of an improved method of grinding gears and gear cutters which results in a highly accurate product and which is much more easy to carry out than any of the methods according to present day practices.

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These and other objects and advantages will become more apparent upon reference to the following description taken in connection with the accompanying drawings in which:

Figure 1 is a vertical longitudinal section through one form of the machine adapted for practicing this invention;

Figure 2 is a transverse section through the machine and is indicated by the line 2—2 on Figure 1;

Figure 3 is a vertical section through the headstock end of the workpiece supporting fixture and is indicated by the line 3—3 on Figure 1;

Figure 4 is a plan section through the headstock and is indicated by the line 4—4 on Figure 3;

Figure 5 is a diagrammatic perspective view showing the electrical interlock between the wheel driving motor and the headstock motor whereby synchronous operation of the wheel and workpiece arbor are obtained;

Figure 6 is a view similar to Figure 5 but showing a modified manner of interlocking the wheel and workpiece arbor;

Figure 7 shows still another view of effecting synchronous operation of the wheel and workpiece arbor;

Figures 8 and 9 are views showing a typical tooth forming operation on a small gear or gear cutter; and

Figures 10, 11, and 12 show a similar operation in connection with a larger gear.

Referring to the drawings more in detail, the machine shown in Figures 1 through 4 comprises a bed 10 and reciprocably mounted thereon is a table 12. The table 12 may be supported in the usual manner on the V and flat ways, best seen at 14 in Figure 2, and has connected therewith the fluid actuating plunger 16 which is reciprocably mounted in the hydraulic cylinder 18 in the bed 10.

Adjacent to the bed 10, and preferably rigidly connected therewith, is a frame part 20 and the upper surface thereof is formed with a guideway 22 which reciprocably supports the upper frame part 24. The frame part 24 is adjustable along the guideway 22 by means of the screw 26 and hand wheel 28 according to usual practices. The upper frame part 24 has on one vertical face thereof a slide 30 which reciprocably supports a wheel head structure 32. As in the case of the frame part 24 the wheel head structure 32 is adjustable vertically on its supporting slide by means of the screw 34 and hand wheel 36.

It will be apparent that the right angle slide arrangement of the slides 22 and 30 permit the

positioning of the wheel head 32 in any position of adjustment in its plane.

In combination with the adjustability of the table 12 on the bed 10, this combination provides for complete three dimensional relative positioning of the table 12 and the wheel head 32 in order to bring the workpiece on the table and the grinding wheel into proper operative engagement.

The wheel head has a wheel shaft 38 extending therethrough which may be supported in any suitable manner as by the bearings 40 in opposite ends of the wheel head. A motor 42 is connected to one end of the shaft for driving it and a wheel 44 is mounted on the other end in a suitable and well known manner. A wheel guard 46 is preferably provided which surrounds the said wheel. As will be noted, especially in Figure 2, the wheel 44 has a helical groove therein as at 48 and the cross sectional configuration of this groove is exactly that of the thread form which it is desired to grind on the workpiece. This wheel may be formed by any dressing operation suitable for that purpose, but is preferably shaped by a dressing device and process, as shown and claimed in my co-pending application, Serial No. 65,258 and filed on the 14th day of December, 1948.

Returning to the table 12, this member pivotally mounts a sub-table or platform 50. The sub-table 50 is adapted for pivoting in a vertical plane on the table 12 by means of its arcuate lower surface which mounts in an arcuate recess in the upper part of the table 12. This construction is best seen in Figure 1.

For clamping the sub-table 50 in any particular position of adjustment, there is preferably a T-slot 52 extending around the arcuate recess in the table 12 and into which the T-bolt 54 extends. The T-bolt may be drawn up to clamp the sub-table 50 into position by means of the tapered locking member 56, as will best be seen in Figure 2.

Mounted on top of the sub-table 50 is still another table or platen 58 which is pivotal in a horizontal plane about the pivot or dowel pin 60. Similarly, as with the table 50 the platen 58 is adapted to be clamped in any position of adjustment by means of the T-slot 62 in the table 50 and the clamping bolts 64 extending therein and through the platen 58.

The platen 58 has mounted at one end thereof a tailstock unit 66 and at the other end thereof a headstock unit 68. Between these units there is mounted a workpiece arbor 70 and which is drivingly connected with the output shaft 72 of the headstock unit by means of a dog member 74. The workpiece 76 is mounted on the arbor 70 in any suitable manner so as to be rigid therewith during the grinding operation.

For driving the output shaft 72 of the headstock unit the arrangement shown in Figures 3 and 4 may be employed. In these figures it will be noted that there is a headstock drive motor 78 which drives through a worm and wheel arrangement at 80 into a shaft 82 which traverses the headstock unit from end to end. At the rear end, that is the left end as viewed in Figure 1, of the headstock unit there is a removable cover plate 84 and beneath which there are the change gears 86 which interconnect the shaft 82 with the drive shaft 88. The drive shaft 88 is splined, at its right end, to the rotatable member 90 which receives the headstock center or output shaft 72.

As mentioned previously, it is necessary for the grinding wheel and for the workpiece being ground to rotate at synchronous speeds. This is due to the fact that the groove formed on the grinding wheel is helical, and therefore as it rotates the workpiece also rotates in order to maintain the teeth being formed thereon in exact register with the said groove.

One arrangement for maintaining the workpiece and the wheel in synchronous operation is shown in Figure 5, wherein the wheel head motor 42 and the workpiece driving motor 78 are synchronous motors and are interconnected by the wires 92 and 94 with the alternating current power lines L1 and L2.

It will be apparent that closure of the switch 95 will result in synchronous operation of the grinding wheel and the workpiece arbor. It will be apparent that if the workpiece arbor were not driven by the motor 78 it would still rotate due to the threaded form of the grinding wheel. This is not desirable, however, because accurate thread forms cannot be generated in this manner. This is due to the fact that the grinding load shifts in magnitude and direction as the relative positions of the tooth being ground and the groove forming the said tooth change. If no compensation were to be made for this shifting load, then the workpiece being ground would have the greatest amount of material removed therefrom over the area where the greatest grinding load occurred, and this would produce an improper tooth form.

This is illustrated in Figures 8 and 9 wherein a relatively severe tooth grinding operation is being carried out. The gear or gear cutter being formed in Figures 8 and 9 is relatively small and due to this fact the pressure between the workpiece and the grinding wheel varies rapidly and from one side to the other.

As shown in Figure 8, wherein the tooth being formed is in the center position relative to the grinding wheel, it will be noted that the vectors F1 representing the force of the grinding wheel on the sides of the tooth are equal in size and are symmetrically arranged. In this particular position then the gear tooth will normally be properly ground. However, in Figure 9 the gear has rotated through a small angle while the wheel has turned through a relatively large angle and the tooth has shifted to one side of center. At this time, it will be noted that the line of force between the wheel and tooth, and represented by the vector F2, has shifted so that substantially the entire thrust of the wheel on the gear is toward one side. Under these conditions it would not be possible properly to grind the tooth form unless the position of the workpiece being ground were fixed by some instrumentality other than its grinding engagement with the wheel. It will be seen, therefore, that by driving the wheel and workpiece synchronously the shifting thrust between the wheel and workpiece is compensated for and an accurately formed tooth results.

In the grinding of gears the teeth thereof normally extend in a direction parallel with the axis of the gear. For grinding workpieces of this type the table 50 would thus normally be moved to a position where the axis of the mandrel 70 extended in a direction parallel with the direction of reciprocation of the table 12. In gear cutters, however, it is necessary for there to be a clearance angle extending backwardly from the cutting face of the cutter and to form a workpiece of this type

the workpiece 50 is tilted as shown in Figures 1 and 2.

It will be apparent that the workpiece will be ground with the proper clearance angle extending rearwardly from the cutting edge thereof. Once the cutter has been formed on the grinding wheel the face thereof, that is the left hand face as viewed in Figure 1, may be successively ground back in order to resharpen the cutter during use thereof.

Normally, for relatively thin cutters, a large wheel may be used and the entire tooth form on the cutter ground without axially reciprocating the table 12. However, if the gear cutter or gear to be ground has a substantial axial length, such that it cannot be completely formed except by axial reciprocation of the table 12, this operation can be performed without in any way effecting the formation of the tooth. It will merely be necessary to go around the workpiece more than one time, either reciprocating the table 12 at the same time or adjusting it to two or more positions and grinding around the workpiece one or more times for each of the said positions.

In order to indicate the severity of the grinding operation shown in Figures 8 and 9 and also to indicate that similar conditions obtain in workpieces of other sizes, Figures 10, 11 and 12 show a larger type gear being ground and with the thrusts between the grinding wheel and gear tooth being indicated. It will be apparent that while these thrusts do not change as rapidly or as much as do the thrusts in Figures 8 and 9, there is, nevertheless, sufficient shifting thereof to require that the workpiece be synchronously driven in order properly to form the gear tooth thereon.

Figures 6 and 7 show modified arrangements for obtaining synchronous operation of the wheel and workpiece. In Figure 6 the wheel shaft is driven by a belt 100 which passes over a pulley 102 mounted on the wheel shaft. Also carried on the wheel shaft is a Selsyn type transmitter 104 connected with the power lines L1 and L2. The Selsyn transmitter is interlocked by the wires 105 in the usual manner with the Selsyn receiver 106 which forms the headstock driving motor. The Selsyn receiver is also connected with the power lines L1 and L2 and as well known in connection with this type of driving arrangement remains in absolute synchronism with the Selsyn transmitter 104 at all times.

In Figure 7 a similar arrangement is shown wherein the wheel shaft is selectively connected with the headstock by means of the gearing 108 and shafting 110. As is well known this provides for a positive mechanical interconnection of the headstock and wheel shaft and thereby positively insures synchronization thereof.

In order to permit the wheel head and the table supporting the workpiece to be adjusted relatively to each other the shafting 110 preferably includes the splined connections at 112 and the differential units at 114. By this arrangement the full flexibility of adjustment of the wheel and workpiece is maintained without in any way interfering with the synchronous driving thereof.

If it is desired to grind helical gears or gear cutters, the platen 58 is set to the proper angle about its pin 60 and then clamped in position. Thereafter the grinding of the helical work member can proceed as outlined above.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and, accordingly, it is desired to comprehend such modifications

within this invention as may fall within the scope of the appended claims.

I claim:

1. In combination in a grinding machine for grinding gears and gear cutters; a grinding wheel having a spiral groove on the periphery thereof, a bed, a table movable on said bed, a fixture mounted on said table comprising a sub-table directly supported by said bed and a platen supported on said table, headstock and tailstock means on said platen defining a work axis, and means for pivotally adjusting said sub-table on said table and said platen on said sub-table thereby to vary the angularity between the axis of said wheel and said work axis, and means for driving said wheel and a workpiece mounted on said axis at synchronous speed.

2. In a grinding machine; a bed, a table reciprocable on said bed, a sub-table mounted on said bed for pivotal movement on a horizontal axis, a platen mounted on said sub-table for pivotal movements on an axis perpendicular to the said horizontal axis, a headstock and a tailstock on said platen defining a work axis, a column adjacent said bed, a wheel head carried on said column and movable vertically and horizontally thereon, a grinding wheel rotatably mounted on said wheel head and having a spiral groove on the outer periphery thereof, and drive means operable for driving said wheel head and said headstock in synchronism.

3. In a grinding machine; a bed, a table reciprocable on said bed, a sub-table mounted on said bed for pivotal movement on a horizontal axis, a platen mounted on said sub-table for pivotal movements on an axis perpendicular to the said horizontal axis, a headstock and a tailstock on said platen defining a work axis, a column adjacent said bed, a wheel head carried on said column and movable vertically and horizontally thereon, a grinding wheel rotatably mounted on said wheel head and having a spiral groove on the outer periphery thereof, and drive means operable for driving said wheel head and said headstock in synchronism, said headstock including change gears for changing the ratio of its speed to that of said wheel.

4. In a grinding machine; a bed, a table reciprocable on said bed, a sub-table mounted on said bed for pivotal movement on a horizontal axis, a platen mounted on said sub-table for pivotal movements on an axis perpendicular to the said horizontal axis, a headstock and a tailstock on said platen defining a work axis, a column adjacent said bed, a wheel head carried on said column and movable vertically and horizontally thereon, a grinding wheel rotatably mounted on said wheel head and having a spiral groove on the outer periphery thereof, and drive means operable for driving said wheel head and said headstock in synchronism, the said drive means comprising individual synchronous motors drivingly connected with each of said headstock and said wheel.

5. In a grinding machine; a bed, a table reciprocable on said bed, a sub-table mounted on said bed for pivotal movement on a horizontal axis, a platen mounted on said sub-table for pivotal movements on an axis perpendicular to the said horizontal axis, a headstock and a tailstock on said platen defining a work axis, a column adjacent said bed, a wheel head carried on said column and movable vertically and horizontally thereon, a grinding wheel rotatably mounted on said wheel head and having a spiral

groove on the outer periphery thereof, and drive means operable for driving said wheel head and said headstock in synchronism, said drive means comprising means for driving said wheel and means connecting said headstock with said wheel whereby said wheel and headstock are driven in synchronism.

6. In a grinding machine; a bed, a table reciprocable on said bed, a sub-table mounted on said bed for pivotal movement on a horizontal axis, a platen mounted on said sub-table for pivotal movements on an axis perpendicular to the said horizontal axis, a headstock and a tailstock on said platen defining a work axis, a column adjacent said bed, a wheel head carried on said column and movable vertically and horizontally thereon, a grinding wheel rotatably mounted on said wheel head and having a spiral groove on the outer periphery thereof, and drive means operable for driving said wheel head and said headstock in synchronism, said drive means comprising a Selsyn transmitter driven synchronously with said wheel and a Selsyn receiver connected with said transmitter and driving said headstock.

7. In a grinding machine; a bed, a table reciprocable on said bed, a sub-table mounted on said bed for pivotal movement on a horizontal axis, a platen mounted on said sub-table for pivotal movements on an axis perpendicular to the said horizontal axis, a headstock and a tailstock on said platen defining a work axis, a column adjacent said bed, a wheel head carried on said column and movable vertically and horizontally thereon, a grinding wheel rotatably mounted on said wheel head and having a spiral groove on the outer periphery thereof, and drive means operable for driving said wheel head and said headstock in synchronism, said drive means comprising gears and shafting connecting said wheel with said headstock.

8. In a grinding machine; a bed, a fixture on said bed having a headstock and tailstock defining a work axis, means for pivoting said headstock and tailstock as a unit to move said work axis about a horizontal axis extending transversely therethrough or about another axis at right angles to said horizontal axis, a frame on said bed adjacent said fixture and adjustable toward and from said work axis in the direction of said horizontal axis, a wheel head carried on said frame and adjustable vertically thereon, a shaft in said wheel head extending in the same direction as said horizontal axis, a grinding wheel on one end of said shaft overhanging said work axis and having a spiral groove therearound, a drive means at the other end of said shaft for driving said wheel through said shaft, and means interlocking said shaft and said headstock whereby a workpiece on said work axis is driven in synchronism with said wheel.

9. A fixture for supporting gears and gear cutters to be ground comprising a reciprocable table member having an arcuate slot therein, a sub-table mounted on said table and having a portion thereof engaging said arcuate slot for pivoting movement about a first axis, a platen mounted on said sub-table for pivoting movement about an axis thereon perpendicular to said first axis, and headstock and tailstock means on said platen defining a work axis.

10. A fixture for supporting gears and gear cutters to be ground and comprising a reciprocable table, a sub-table having an arcuate slot therein mounted on said table and having a portion thereof engaging said arcuate slot for pivoting movements about a first axis, a platen mounted on said sub-table for movement about an axis perpendicular to said first axis, means for clamping said platen to said sub-table and said sub-table to said table in any of their positions of adjustment, and headstock and tailstock means on said platen defining a work axis on which the workpiece to be ground is supported.

11. In a grinding machine; a bed, a table reciprocable on said bed, a sub-table mounted on said bed for pivotal movement on a horizontal axis, a platen mounted on said sub-table for pivotal movements on an axis perpendicular to the said horizontal axis, a headstock and a tailstock on said platen defining a work axis, a column adjacent said bed, a wheel head carried on said column and movable vertically and horizontally thereon, a grinding wheel rotatably mounted on said wheel head and having a spiral groove on the outer periphery thereof, and drive means operable for driving said wheel head and said headstock whereby the rotation of the workpiece by said headstock is synchronized to the rotation of said spiral threaded wheel for center positioning of the tooth being formed relative to the spiral groove of the grinding wheel.

FLORYAN LOHUTKO.

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