(No Model.)

G. B. GRANT.

MACHINE FOR PLANING GEAR TEETH.

No. 407,437. Patented July 23, 1889.

Fig. 2.

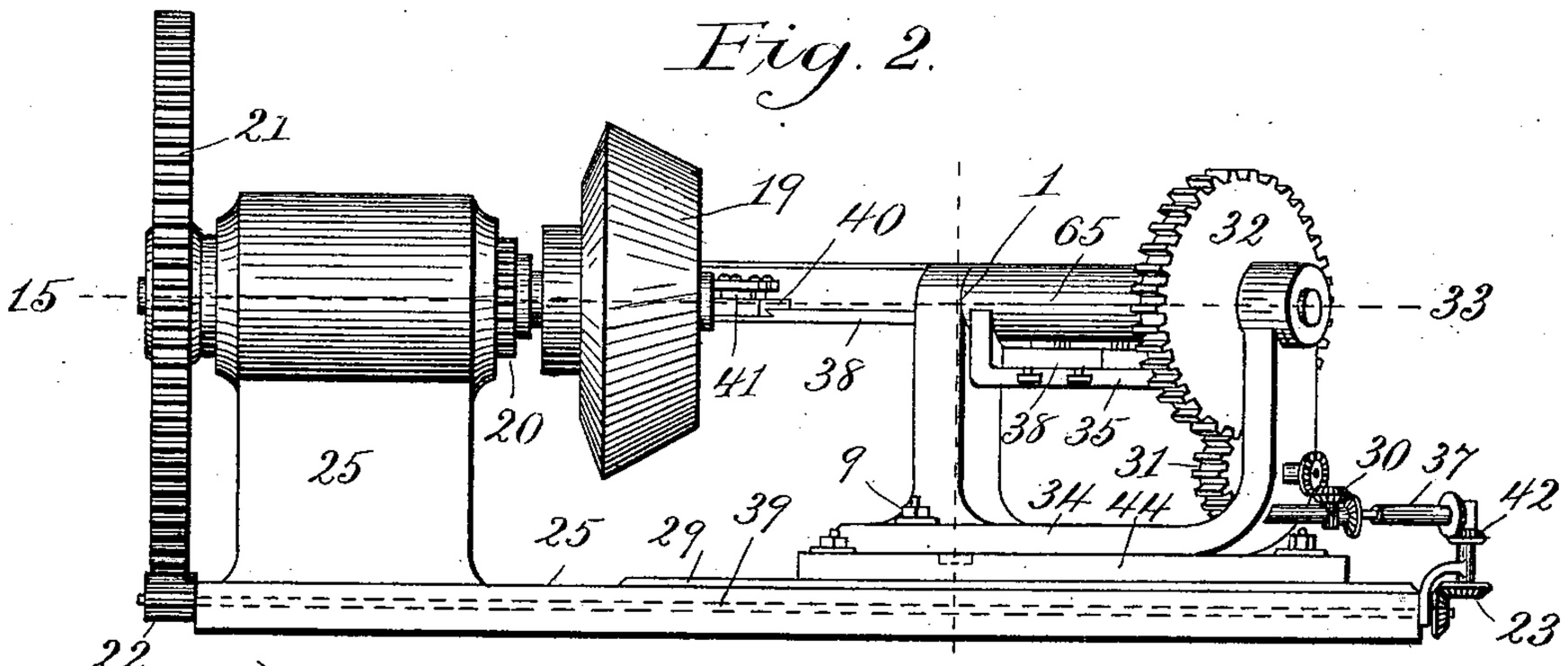


Fig. 1.

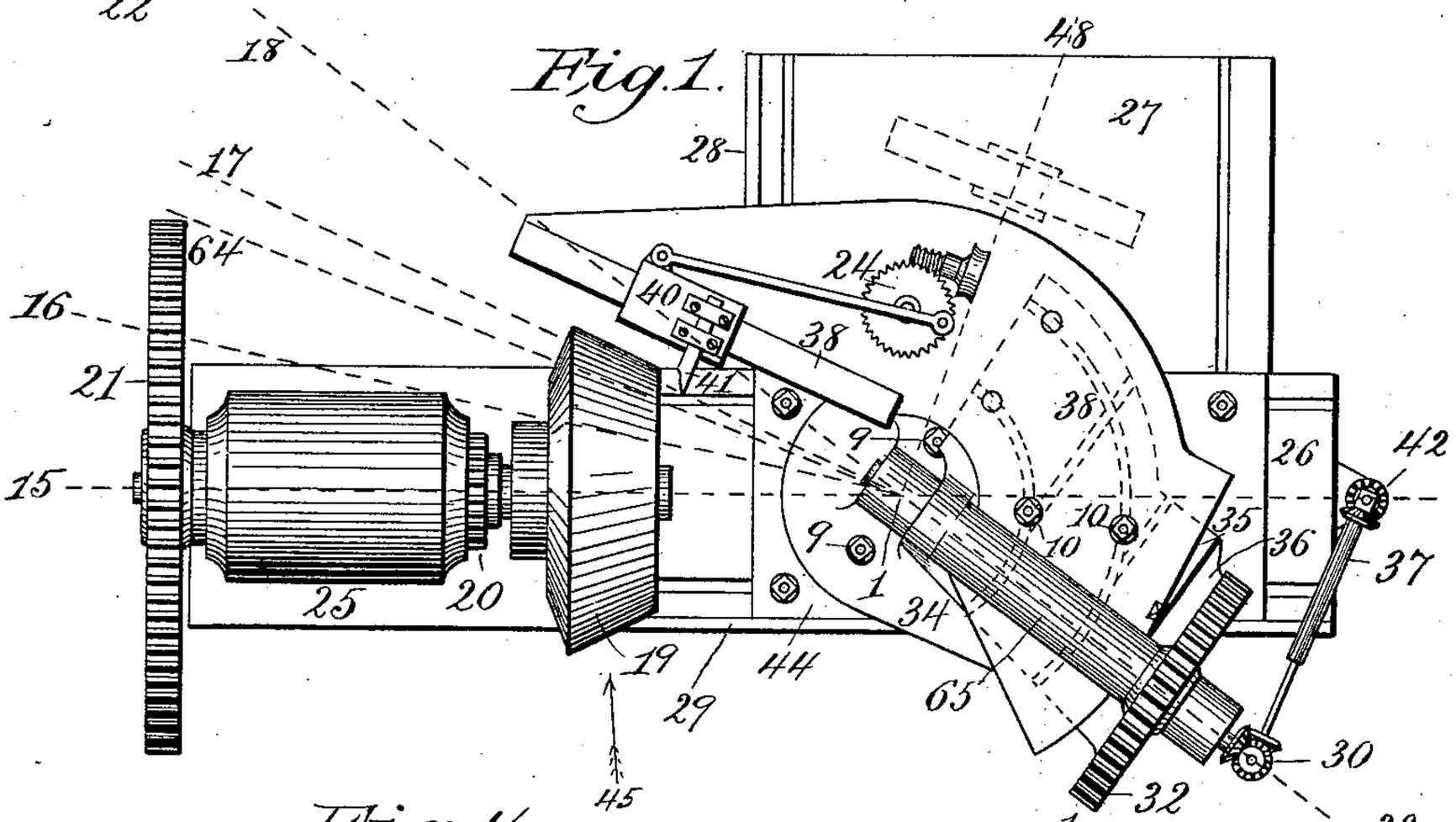


Fig. 4.

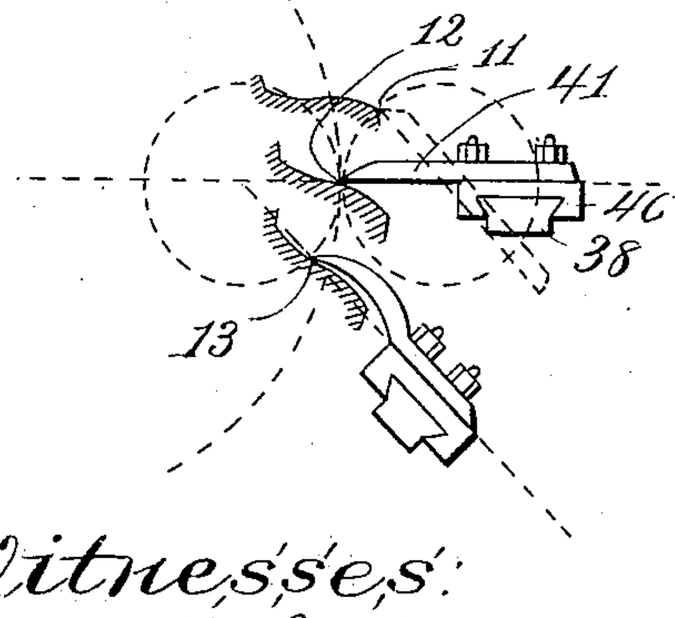
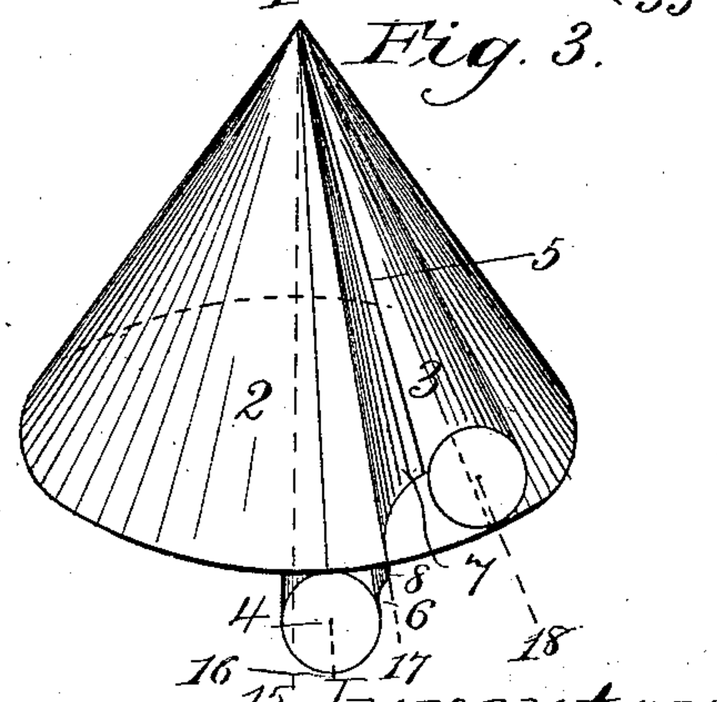


Fig. 3.



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UNITED STATES PATENT OFFICE.

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MACHINE FOR PLANING GEAR-TEETH.

SPECIFICATION forming part of Letters Patent No. 407,437, dated July 23, 1889.

Application filed January 14, 1887. Serial No. 224,382. (No model.)

To all whom it may concern:

Be it known that I, GEORGE B. GRANT, of Lexington, in the county of Middlesex and State of Massachusetts, have invented certain new and useful Improvements in Machines for Planing the Teeth of Gear-Wheels, of which the following is a specification.

This machine is designed to plane the working-surfaces of the teeth of bevel or spur gears to the theoretically correct form of either the epicycloidal or involute shape. It does not plane the teeth to a copy of a templet which has previously been brought as nearly as may be to the correct form, as usual with machines for the same purpose, but it originates the tooth curve according to its mathematical theory, and will plane it as nearly true as the perfection of the parts of the machine will permit.

Figure 1 is a plan of the whole machine. Fig. 2 is a side elevation from the position 45 of Fig. 1. Fig. 3 illustrates the mathematical principle upon which the operation of the machine is based. Fig. 4 shows the operation of the cutting-tool in several positions.

The principle of the operation of the machine is shown in outline by the diagram Fig. 3, in which the pitch cone of the gear to be planed is represented by 2. If a small cone 3 is rolled on the pitch cone, their apices coinciding at the point 1, any element 5 of the rolling cone will sweep up an epicycloidal surface 7 on the pitch cone, which is suitable for the working-face of a gear-tooth. Similarly, if a small cone 4 be rolled on the inside of the pitch cone, any element 6 will sweep up a hypocycloidal surface 8, which is suitable for the flank of a gear-tooth. The machine is designed to carry this principle into practical operation, and its method is to reciprocate a planing-tool in an element of a cone that is rolled on the pitch cone of the gear being cut. It is most convenient to use a rolling cone with a circular base; but there are many curves that would act as its base without altering the principle of its operation. When the rolling cone is increased in size until its center angle is ninety degrees, it becomes a plane circle. Its element will form an epicycloidal surface as before; but it is now called an "involute" surface. The involute surface is a special case of the epicycloidal surface, differing from it principally in the valuable feature that it will allow a variation in the center distance of the shafts of spur-gears, or in the angle between the shafts of bevel-gears, without affecting the uniformity of the motion transmitted.

In the figures, the gear-blank 19 is held by a gear-spindle 20, that is supported by the frame 25 and oscillated by the index-wheel 21. The index-wheel receives a slow feeding motion by means of the pinion 22.

The carriage 44 is adjustable on the frame 25 in two different directions at right angles, or nearly so, to each other. It can be moved against the guide 29 in a direction parallel with the center line 15 1 of the gear-spindle, and it can also be moved against the guide 28 at right angles to that center line. The carriage can be fastened in any position on the part 26 or the part 27 of the frame.

The stand 34 is carried by the carriage 44, and can be angularly adjusted by turning it on that carriage about a vertical axis through the point 1 in the center line 15 1, and be fastened in any angular position by means of bolts 9, which hold in circular T-slots in the carriage 44.

The tool-shaft 65, which represents the axis of the rolling cone, is held by the stand 34 with its axis perpendicular to the axis of the stand and passing through the center point 1. This tool-shaft axis 33 1 can thus be placed in line with the axis 15 1 of the gear-spindle, or set at any angle with it on either side of it and there fastened.

The tool-guide 38 represents the element of the rolling cone. It is adjustably fixed on the plate 35, which is attached to the tool-shaft 65 and turns with that shaft. It is angularly adjustable on the plate 35, so that it can be set at any desired angle with the axis 33 1 of the tool-shaft about the point 1 as a center. It is also laterally adjustable upon the plate 35, so that it can be set parallel to the axis of the tool-shaft at any desired distance from it by means of the scale 36. The tool-guide 38 rests upon the plate 35, and is fastened upon it by bolts 10, which hold in T-slots in it. When the tool-guide is to be either angularly or laterally adjusted on the

plate, the bolts are loosened and the guide moved by hand to the desired position. The tool-carriage 40 is reciprocated upon the tool-guide 38 by means of the crank-wheel 24, operated by the worm-gear driven by the worm and pulley shown. The pulley is driven by a belt from a balanced counter-shaft, so that the crank-wheel is slowly revolved when it is in any position.

The planing-tool 41 is attached to the tool-carriage 40, and its cutting-point is set to travel in a line passing through the center point 1. The tool-shaft 65 is oscillated by the wheel 32 and the pinion 31, and the two pinions 22 and 31 are connected by any positive gearing—such as the shaft 39, the gears 23, 42, and 30, and the shaft 37—that will permit a definite velocity ratio to be transmitted from one to the other.

To plane the teeth of an epicycloidal gear, the machine is adjusted and operated as follows: The gear-blank 19, having teeth roughly shaped or cast to the desired form, is fastened upon the gear-spindle 20. The angle 15 1 17 is the known center angle of the gear, being the center angle of its pitch cone. The angle 17 1 18 is the chosen center angle of the rolling cone. The axis 33 1 of the tool-shaft is set in the line 18 1, and the tool-guide 33 is set parallel with the line 17 1. The tool 41 is set with its cutting-point in the line 17 1. If now the wheel 32 is oscillated while the tool is reciprocated, the tool will always travel in the surface of a cone which is externally tangent to the pitch cone of the gear-blank. The gear-spindle and the tool-shaft are then connected by gears in such proportion that they oscillate together in opposite directions with angular velocities in the inverse ratio of the sines of the center angles of the pitch cone and the rolling cone. The action of the tool is more clearly shown by Fig. 4. The tool is set to just cut on the point of the tooth, as at 11, and as both gear-blank and tool are fed through a small angle at each reciprocation of the tool the face of the tooth will be slowly trimmed until the tool reaches the pitch line at 12. The gear-spindle and the tool-shaft are then returned, the next tooth is brought into position, and the operation is repeated.

To trim the flank of the tooth, the axis 33 1 of the tool-shaft is set to the axis 16 1 of the internal rolling cone, the tool-guide is set parallel to the line 17 1, the tool is set to the line 17 1, and the tool is slowly fed from the pitch cone at 12 toward the center as far as required. The action is shown by Fig. 4 at 13. The operation for gears with involute teeth is very similar. The angle 64 1 15 is the known center angle of the base-cone of the gear. In involute gears the base-cone is the smallest pitch cone, any larger cone being chosen at will for the working pitch cone. The tool-guide 38 is set parallel to the line 64 1, and the tool is adjusted to that line. The tool-shaft 65 is swung around so that its axis takes the position 48 1 at right angles to the line 64 1. The tool will then always travel in a radial line in the vertical plane circle through 64 1, and the operation is precisely the same as described for the faces of epicycloidal teeth.

The operation for planing the teeth of epicycloidal spur-gears is the same as for bevel-gears, except that the tool-shaft and the tool-guide are set parallel to the axis of the gear-spindle, and the tool-shaft is set by moving the carriage 44 on the part 27 of the frame 25, so that the tool-shaft axis 33 1 is in the pitch line of the gear being planed.

I claim—

1. In a gear-planing machine, the combination of a frame, a gear-spindle, a tool-shaft, the axes of the gear-spindle and the tool-shaft intersecting and being angularly adjustable with respect to each other, a positive connecting mechanism, whereby the gear-spindle and the tool-shaft are simultaneously oscillated, a tool-guide attached to the tool-shaft, and a tool-carriage, with means for reciprocating it upon the tool-guide, substantially as described.

2. In a gear-planing machine, the combination of a frame, a gear-spindle, a tool-shaft, the axes of the gear-spindle and the tool-shaft intersecting and being angularly adjustable with respect to each other, a positive connecting mechanism, whereby the gear-spindle and the tool-shaft are simultaneously oscillated, a tool-guide attached to the tool-shaft and adjustable upon it in a plane parallel to its axis, whereby the tool-guide is attached to the tool-shaft at an angle with its axis and on either side of it in a plane parallel to it, and a tool-carriage, with means for reciprocating it upon the tool-guide, substantially as described.

3. In a gear-planing machine, the combination of the frame 25, the gear-spindle 20, for holding the gear-wheel to be planed, the tool-shaft 65, for holding the planing-tool, the axes of the gear-spindle and the tool-shaft intersecting at the point 1 and being angularly adjustable with respect to each other, the train of gearing whereby the gear-spindle and the tool-shaft are simultaneously oscillated, the tool-guide 38, attached to the tool-shaft in a plane parallel with its axis, and the tool-carriage 40, with means for reciprocating it upon the tool-guide, substantially as described.

4. In a gear-planing machine, the combination of the gear-spindle 20, the frame 25, the tool-shaft 65, the axes of the gear-spindle and the tool-shaft intersecting and being angularly adjustable with respect to each other, the train of gearing whereby the gear-spindle and the tool-shaft are simultaneously oscillated, the tool-guide 38, attached to the tool-shaft and angularly adjustable upon it in a plane parallel with its axis, and the tool-carriage 40, with means for reciprocating it upon the tool-guide, substantially as described.

5. In a gear-planing machine, the combination of the frame 25, the gear-spindle 20, the tool-shaft 65, the axes of the gear-spindle and

the tool-shaft intersecting and being angularly adjustable with respect to each other, the train of gearing whereby the gear-spindle and the tool-shaft are simultaneously oscillated, the tool-guide 38, attached to the tool-shaft at right angles with its axis, and the tool-carriage 40, with means for reciprocating it upon the tool-guide, substantially as described.

6. In a gear-planing machine, the combination of the gear-spindle 20, the frame 25, supporting the gear-spindle, the stand 34, supported upon the frame and adjustable upon it in a direction parallel with the axis of the gear-spindle, the tool-shaft 65, supported on the stand 34, with its axis intersecting the axis of the gear-spindle, the tool-guide 38, attached to the tool-shaft, and the tool-carriage 40, with means for reciprocating it upon the tool-guide, substantially as described.

7. In a gear-planing machine, the combination of the gear-spindle 20, the frame 25, supporting the gear-spindle, the stand 34, supported on the frame and adjustable upon it in a direction parallel to the axis of the gear-spindle, the tool-shaft 65, supported by the stand, with its axis intersecting the axis of the gear-spindle, the train of gearing whereby the gear-spindle and the tool-shaft are simultaneously oscillated, the tool-guide 38, attached to the tool-shaft and angularly adjustable upon it in a plane parallel to its axis, and the tool-carriage 40, with means for reciprocating it upon the tool-guide, substantially as described.

8. In a gear planing machine, the combination of the frame, the gear-spindle, the tool-shaft, the axes of the gear-spindle and the tool-shaft being laterally adjustable with respect to each other, the positive connecting mechanism whereby the gear-spindle and the tool-shaft are simultaneously oscillated, the tool-guide attached to the tool-shaft, and the tool-carriage, with means for reciprocating it upon the tool-guide, substantially as described.

9. In a gear-planing machine, the combination of a frame, a gear-spindle, a tool-shaft, the axes of the gear-spindle and the tool-shaft intersecting and being laterally and angularly adjustable with respect to each other, a positive connecting mechanism, whereby the gear-spindle and the tool-shaft are simultaneously oscillated, a tool-guide attached to the tool-shaft in a plane parallel with its axis, and a tool-carriage, with means for reciprocating it upon the tool-guide, substantially as described.

10. In a gear-planing machine, the combination of the frame 25, the gear-spindle 20, the tool-shaft 65, laterally adjustable with respect to the gear-spindle, the train of gearing connecting the gear-spindle with the tool-shaft, the tool-guide 38, attached to the tool-shaft, and the tool-carriage 40, with means for reciprocating it upon the tool-guide, substantially as described.

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