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METHOD AND A MACHINE FOR THE PROGRESSIVE CUTTING BY GENERATION OF INVOLUTE TEETH

Filed Nov. 14, 1938

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3 Sheets-Sheet 1

FIG. 1

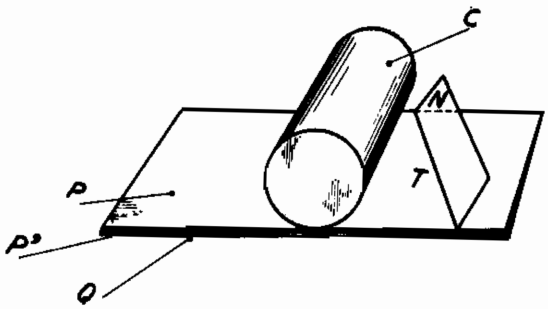


FIG. 2

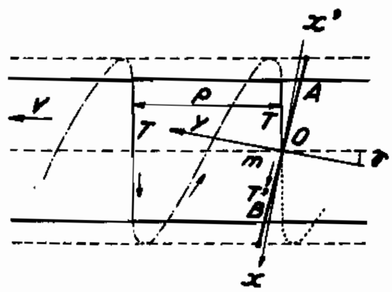
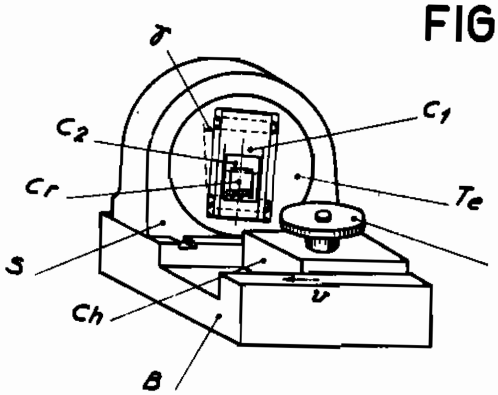


FIG. 3



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3 Sheets-Sheet 2

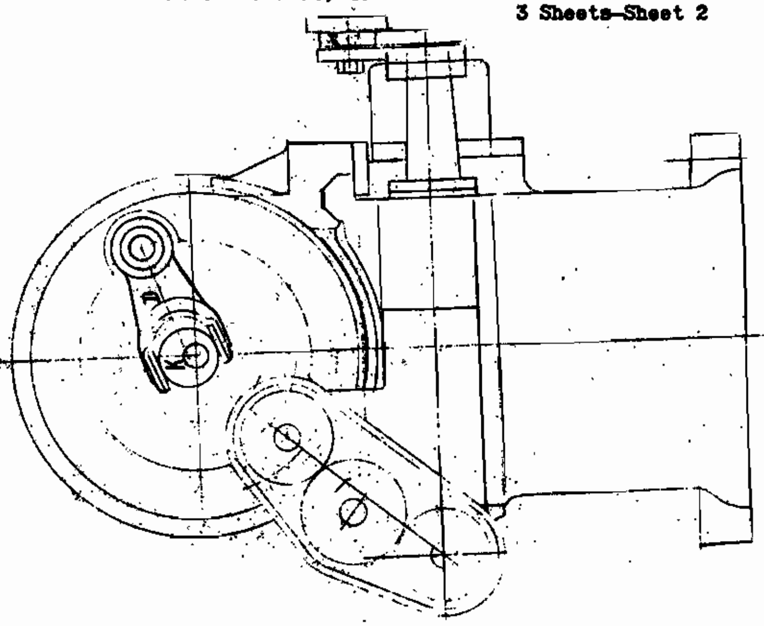

Fig. 7.

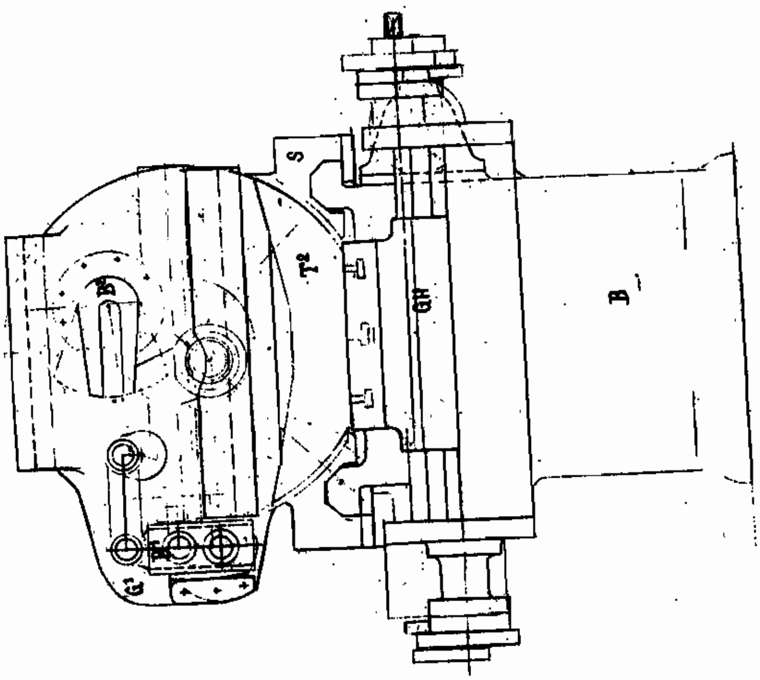

Fig. 4.

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Fig. 6.

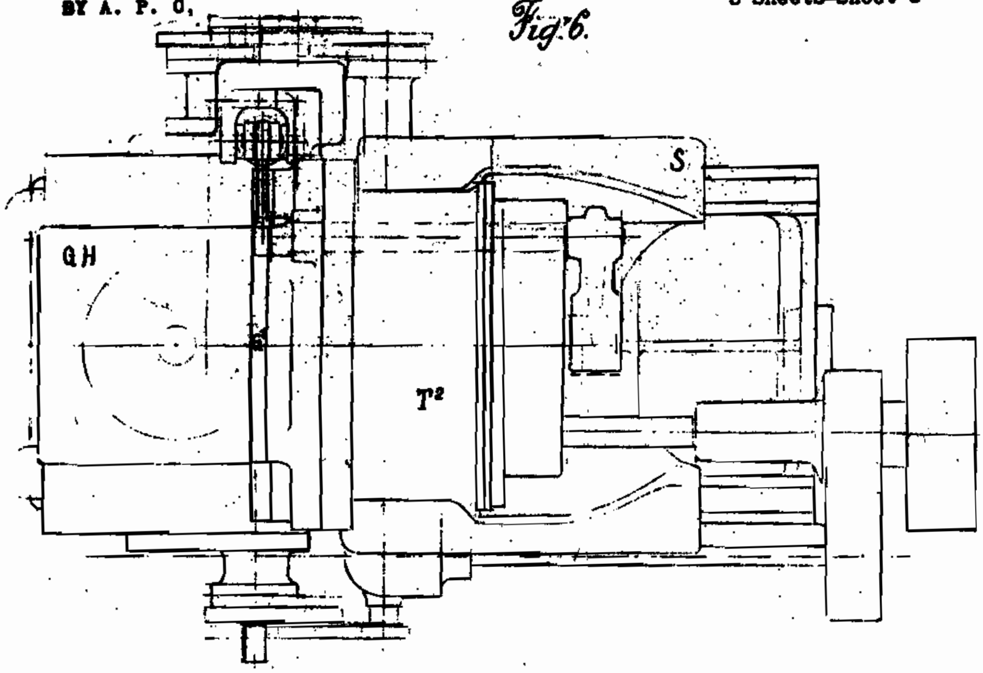
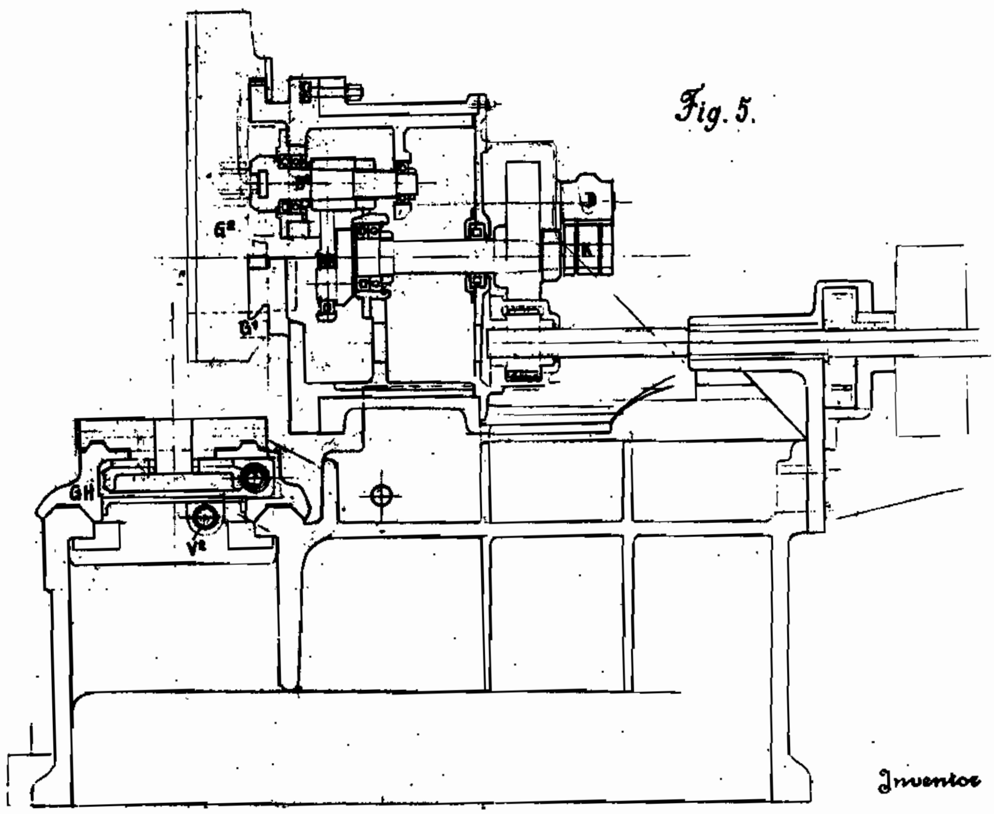


Fig. 5.



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ALIEN PROPERTY CUSTODIAN

METHOD AND A MACHINE FOR THE PROGRESSIVE CUTTING BY GENERATION OF INVOLUTE TEETH

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Application filed November 14, 1938

This invention has for its object a method and a machine for the progressive cutting by generation of involute teeth of the rectilinear and helical gear systems for cylindrical spur wheels.

A certain number of gear cutting machines are provided in which the gear cutting method by generation of an involute is applied and in which the gear cutting tool which is used is a rack with projecting teeth of a prismatical form, the edges of the prism being parallel to the axes of the gear.

This cutting method essentially consists in mounting the cutting tool on a support member to which a predetermined rectilinear movement is imparted; on this support the tool moves according to a time law which, moreover, may be any law, and perpendicularly to the blank to be cut and its cutting edge has as the geometrical place the surface of its rack tooth.

Supposing that the cutting operation has been performed, a gear is obtained which is formed of a spur wheel correctly engaging the above described rack and it is quite convenient to define the said gear by the pitch surfaces of the blank of the cut gear and of the cutting rack which are a cylinder and a plane respectively.

It can be proved that if the blank is so rotated that its pitch surface rolls without sliding on the pitch plane of the rack, the surface which is described by the cutting tool will generate in the blank a complementary surface which will be the envelope of the first surface, both surfaces thus insuring correct conditions of engagement.

From what is disclosed above it may be seen that in every cutting machine operating by generation there are two kinds of movements to be considered:

1. The cutting movement or movement of the tool on its support, in the course of which the cutting edge of the tool describes the surface of the rack tooth, this movement being effected with a velocity which is a quite arbitrary one.

2. The generating movement proper or the movement of the blank with respect to the tool support. This movement generally results from two composing movements which, this time, depend one of the other and are effected with such velocities that the pitch surface which is bound to the tool support rolls on the pitch surface which is bound to the blank.

This cutting method can be called a rolling cutting method, since it may be readily seen that when the pitch surface of the tool rolls on the pitch surface of the blank with a linear velocity which is equal to the circumferential velocity of the said blank, the rack moves with the moving blank and engages, so to say, the wheel being cut so that each of the cutting teeth performs the complete cutting of a predetermined cut tooth; the same result would be obtained by causing the rack to roll on a blank of a plastic material, each tooth of the rack cutting in the said blank an indentation which would be complementary to this tooth.

It results therefrom that the number of teeth which are effectively cut is always equal to the number of cutting teeth; practically, the number of teeth of the gear to be cut is always higher than the number of the teeth of the rack; it necessarily results therefrom in all the machines in which the tool is a rack, and more particularly in the machines of Sunderland and Maag, a periodical return movement of the rack which is restored to its initial position, thus forming a certain number of dead cycles which are essentially disadvantageous to the efficiency of the machine.

It has been tried to do away with this inconvenience by insuring the continuous and progressive cutting of the teeth, thus permitting to eliminate these dead cycles, but one was led to give up the use of the rack tool, which is a rectilinear tool the construction and the operation of which are simple and practical ones, and to resort to tools which are much more complicated, such as milling-cutters, guide-screw ou cutters which offer certain inconveniences; more particularly they require complicated and expensive machines.

The cutting method according to the invention consists in using a tool-rack for the continuous and progressive cutting of rectilinear and helical tooth formations in cylindrical wheels.

The cutting movement is an alternating or reciprocal movement with predetermined trajectory and period of the rack on its support. This displacement is such that the trace of a tooth of this tool on the pitch plane is a straight line of a given length, the said plane being not, this time, bound to the rack, but having with respect to the latter a certain uniform velocity which is bound to the module to be obtained and to the period of the cutting movement.

The generating movement results from two movements which are in some way independent of each other, i. e. a slow horizontal movement of the carriage which supports the blank and which moves with a uniform and arbitrary velocity, and the rotating movement of the blank, the angular velocity of which is bound to the choice of the velocity of the carriage.

This generating movement permits to effect the continuous and progressive cutting of the totality of the circumference of the blank without it being necessary to periodically restore the rack to its initial position.

The method according to the invention is justified by the following considerations.

C being the pitch cylinder of the blank,
Q a marking plane which will be called the fixed plane,
P the pitch plane of the theoretical rack,
N a plane bound to P, and
T its trace on P (see Figure 1),

C rotates with a constant velocity, the fictitious rack (P, N) being such that its pitch plane P slides on Q while rolling without sliding on C in the manner of a belt, without there being in the course of the cutting operation any interruption in the movement of C and P. Finally, the tool is mounted on a support to which a plane P′ is bound which slides on Q′ with a uniform horizontal movement which is uninterrupted in the course of the cutting operation and with a velocity which is very small with respect to the velocity of P.

The performance of the cutting movement and of the generating movement will be successively justified:

1. Cutting movement

It will be supposed, first, that rectilinear tooth formations are to be executed (see Figure 2).

The tool-rack receives on its support a reciprocating horizontal movement in the course of which the trace m of a cutting edge describes with respect to P′ an arc of curve T′, this arc and its description law being such that when m passes from A to B its trajectory with respect to P is rectilinear and orthogonal to the velocity of the horizotnal movement of P on P′.

The arc T′ is obtained in the following manner. The point m describes on an arc $x'\ x$ a reciprocating movement $x=f(t)$ and the axis $x'\ x$ itself receives in the perpendicular direction Oy a reciprocating movement of very small amplitude and of the same period. The slope of the axis $x'x$ and the reciprocating movement of the same are so chosen that when m passes from A to B its trajectory T on P is a rectilinear one.

2. Generating movement

If P′ was fixed on Q, the relation between the rotation of the blank and the rotation of the shaft which causes the reciprocating movement of the tool-supporting slide would be the same as in the usual machines having a tool-rack, but, since the plane P′ slides on Q with a very small velocity v, the rotation velocity of the blank must be corrected by means of a differential gear.

In the appended drawings there are shown by way of example a form of execution of a gear cutting machine for carrying out the method according to the invention.

Figures 1 and 2 are geometrical views showing the method which has been described and which have been referred to in the course of the disclosure of the said method.

Figure 3 is a diagrammatical perspective view of the machine.

Figure 4 is an elevational view of the said machine.

Figure 5 is a longitudinal sectional view of the same.

Figure 6 is a plane view of the same.

Figure 7 is a side elevational view of the same.

The blank F, the plane of which is vertically arranged, is mounted on a carriage *Ch* moving with a uniform velocity v on the frame B. The plane Q of Figure 1 is bound to this carriage. Two worms V_1 and V_2 effect the rotation of the blank and the advancing movement of the carriage respectively.

On the other hand, on the frame is fixed a support S the position of which can be adjusted according to the pitch diameter of the blank. A head T*e* mounted on the said support has on the same a direction which can be adjusted about a horizontal axis which is perpendicular to Q, but which remains fixed in the course of the cutting operation. This head carries a slide C_1 which receives a reciprocating movement the amplitude of which is very small and controllable. This movement, which is obtained by means of a rocking shaft B_1 is controlled by means of a pivotal system and of a fork D by a cam K of a suitable profile.

The slide C_2 which carries the tool is mounted on the above mentioned slide; its reciprocating movement of variable amplitude is controlled by a finger D*g* the position of which can be adjusted on a rocking shaft B_2; this rocking shaft is driven by a pitman and crank system.

The slope of the head T*e* is such that the guides of C_2 make the angle gamma with the vertical line.

Finally, the rack C*r*, which works when moving downwardly, has on C_2 a position which can be adjusted about an axis which parallel to the axis of T*e* so that the active face of the tool is in a horizontal position. The removing of the tool at the end of its stroke is obtained by means of a roll and of a stop and a spring insures the restoring of the same.

Modification of the adjustment for cutting helical teeth.

The machine being adjusted in the above mentioned manner, it is sufficient to rotate the head T*e* by an angle α in either direction without changing the tool; with a new adjustment of the rotation of the blank a helical gear is thus cut wth right or left-handed teeth, the spiral angle of which being equal to α.

The machine according to the invention offers the following advantages.

The carriage receives a uniform movement which is very slow and without any interruption in the course of the cutting operation; it can be made very heavy and very stable; furthermore, the members for the cutting movement can have a small inertia and, accordingly, move with velocities which are rather high.

Owing to this fact and to the elimination of the above mentioned dead cycle which corresponds to the return movement of the carriage, a distinctly higher efficiency can be obtained with the machine as described.

Furthermore, in spite of the velocity of the cutting operation, which regularly takes place on the whole surface of the blank, the heating of the latter is a uniform one.

Furthermore, as shown in the disclosure of the method according to the invention, a simple modification of the adjustment permits of cutting helical gears; on the other hand, without changing the adjustment, wheels with a plurality of modules can be cut by means of tools of different modules.

Finally, the said machine, which performs the uninterrupted and progressive cutting by means of a rack is clearly found to be more economical and simpler than the machines which presently perform the same cutting operation but by means of complicated and expensive tools.

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