June 11, 1946. A. AEPPLI 2,401,810

ROLLING MOTION GENERATING GEARING FOR GRINDING MACHINES AND TESTING APPARATUS FOR BEVEL WHEELS

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FIG. 1

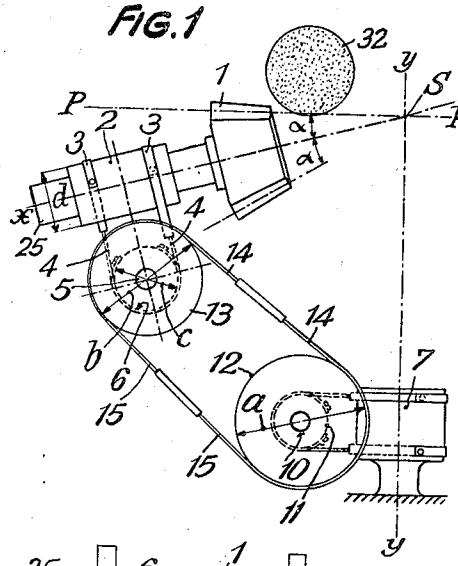
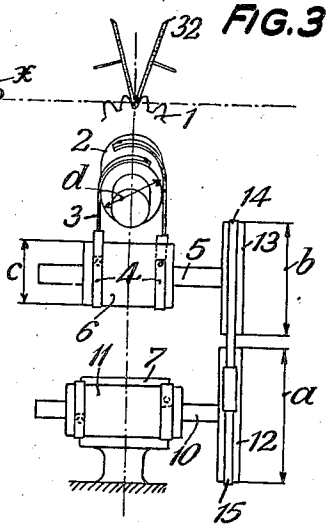


FIG. 3



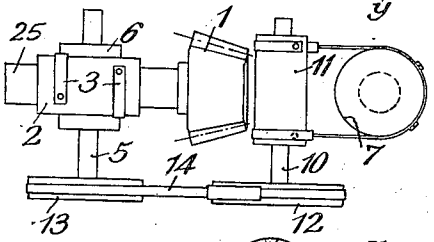


FIG. 2

FIG. 4

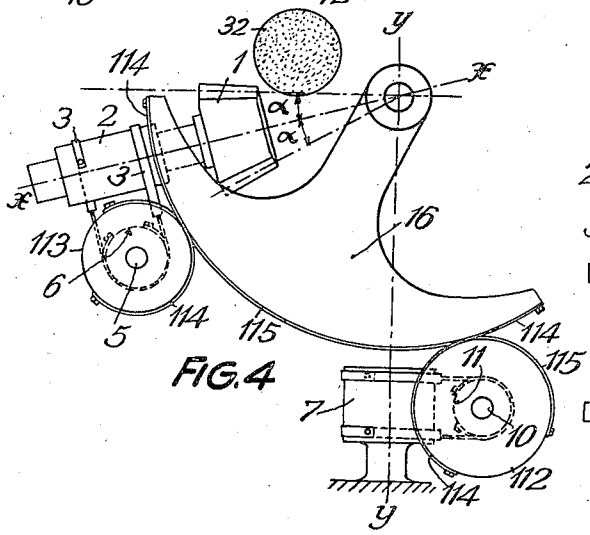
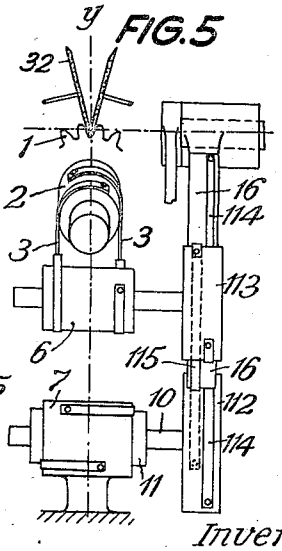


FIG. 5



Inventor:

Albert Aeppli

by Sommers & Young

Attorneys

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FIG.6

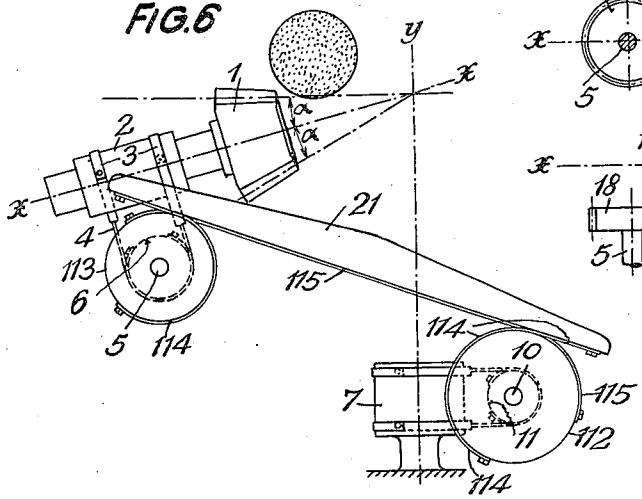
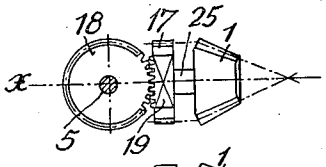


FIG.7



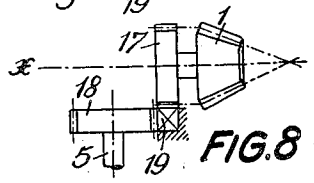
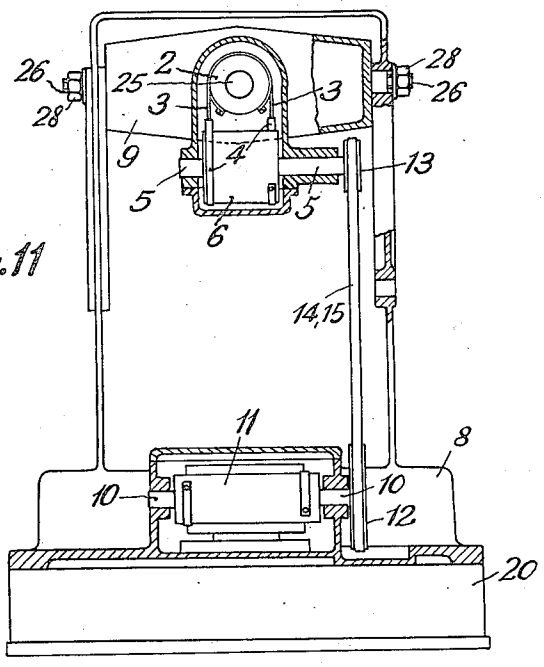


FIG.8

FIG.11



Inventor:
Albert Aeppli
by Sommers & Young
Attorneys

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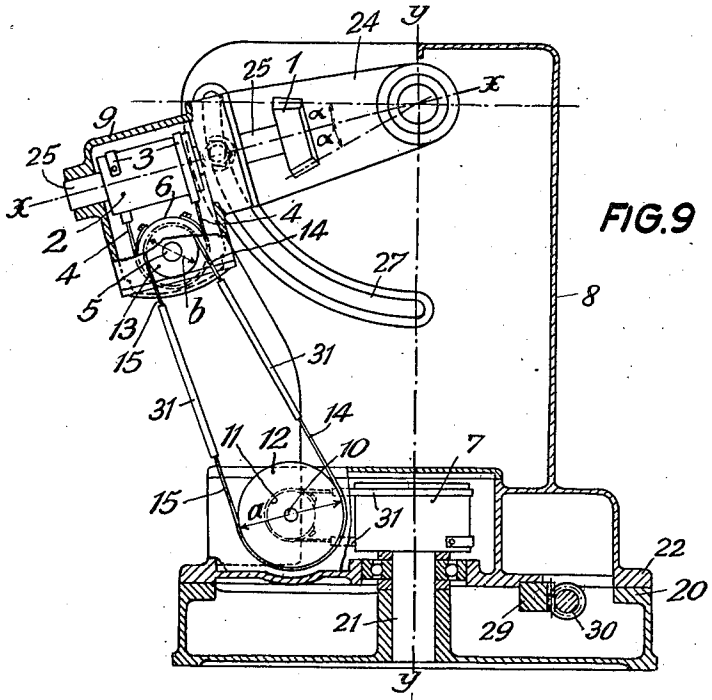


FIG. 9

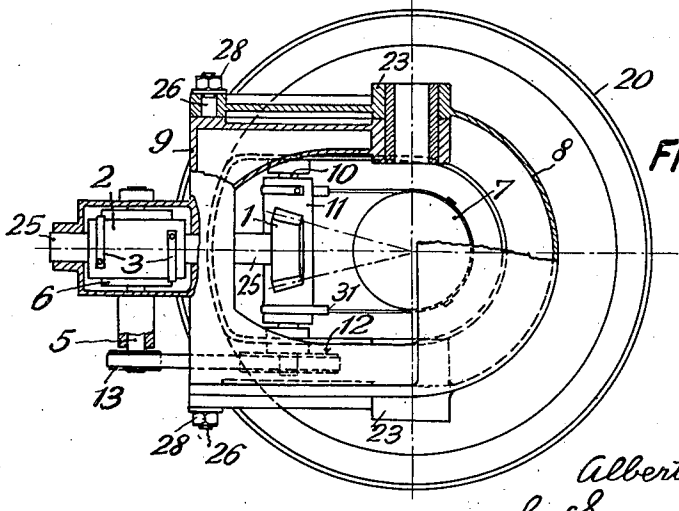


FIG. 10

Inventor:
Albert Aeppli
by Sommers-Young
Attorneys

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2,401,810

UNITED STATES PATENT OFFICE

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ROLLING MOTION GENERATING GEARING FOR GRINDING MACHINES AND TESTING APPARATUS FOR BEVEL WHEELS

Albert Aeppli, Zurich, Switzerland, assignor to Maag-Zahnrader und-Maschinen Aktiengesellschaft, Zurich, Switzerland

Application December 6, 1943, Serial No. 513,105
In Germany July 4, 1942

4 Claims. (Cl. 51—124)

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This invention relates to rolling motion generating gearings for grinding machines and testing apparatus for bevel wheels.

For rolling motion generating gearings for machine tools for machining gear wheels, more particularly gearings of this kind intended for use in connection with testing apparatus, extremely high precision of operation is required.

This can be expected only if the working parts thereof are manufactured with utmost accuracy, said parts are few in number and the connections between them are of high grade efficacy.

The rolling motion generating gearing according to the present invention is characterized in that in it the two rotational movements of which the rolling motion of a cone can be composed, that is, the rotational movement about the axis passing through the apex of the cone of the imaginary plane wheel and that about the axis of the cone are converted in such manner that said rotational movements are no longer performed about intersecting but about parallel axes by which means said movements can be combined with each other in simplest manner at shortest axle spacings with the aid of known means so as to realise the obtainment of a relation between both rotational movements resulting in the form of a ratio of diameters of cylindrical transmission members.

Several embodiments of the present invention are illustrated, by way of example only, in the accompanying drawings in which

Fig. 1 shows a schematic elevation of the working parts of the rolling motion generating gearing according to the invention;

Fig. 2 is a corresponding top plan view;

Fig. 3 shows a side elevation;

Fig. 4 shows an elevation of a modified embodiment of the gearing;

Fig. 5 is a side elevation of Fig. 4;

Fig. 6 shows an elevation of a third embodiment of the invention;

Fig. 7 is a view of a modified detail of Fig. 1;

Fig. 8 is a top plan view corresponding to Fig. 7;

Fig. 9 shows an elevation of the gearing schematically illustrated in Fig. 1;

Fig. 10 is a top plan view corresponding to Fig. 9, and

Fig. 11 is a side elevation corresponding to Fig. 9.

In the drawings numeral 1 indicates the work piece of which a bevel gear is to be formed shown in working position in the machine.

Referring to Fig. 9, a bed 20 carries a vertical

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pin 21 and serves as a mounting for a turntable 22 which is guided by said pin and an intervening ball bearing, the table 22 being integral with a standard 8. In two vertical relatively opposed walls of this standard eye bearings 23 are arranged the common axis of which intersects the extended axis of pin 21 at right angles thereto. In these eye bearings are mounted the arms 24 of a swing 9 in which a work spindle 25 is mounted. The extended axis of this spindle intersects that of the eye bearings 23 perpendicularly as well as the extended axis of the pin 21. The swing 9 can be inclinedly adjusted to the axis of the pin 21. To this end the swing is provided with laterally extending studs 26 which project through arcuate slots 27 in the walls of the standard 8 and carry clamping nuts 28.

On the turntable 22 a worm wheel segment 29 is fastened into which meshes a worm 30 mounted in the bed 20. This worm is rotated in opposite directions by means of a gearing not shown in detail so that the standard has imparted thereto a turning movement about the pin 21. From this swinging movement such rotation of the spindle 25 is derived by means forming the object of the present invention that the work rolls on an imaginary plane wheel coaxial with the pin 21.

In Fig. 1 P—P represents the plane of the imaginary wheel. On this plane the rolling cone of the bevel wheel 1 having an axis x must supposably roll if it is to be ground on the rolling motion principle. The two axes x and y intersect each other at the cone apex S (Fig. 1). With the spindle 25 a rolling cylinder 2 is firmly connected which in turn is coupled through tapes 3, 4 with a cylinder 6 mounted on a countershaft 5 (Fig. 2). The shaft 5 is mounted in the swing 9 so as to extend horizontally underneath the spindle 25 and crossing it at an angle of 90°. The tapes 3 and 4 function in the manner of a crossed belt drive.

Said tapes extend between the two cylinders 2 and 6 at right angles to their axes and parallel with each other so as to couple these cylinders for common rotation devoid of play. A rolling cylinder 7 is sustained by the pin 21 with its axis y remaining stationary. On the standard 8 (Fig. 9) is further rotatably arranged a horizontal counterdrive shaft 10 (see also Fig. 1) on which a cylinder 11 is mounted. This cylinder is connected with a rolling cylinder 7 through tapes 31 in the fashion of a crossed belt drive. The tapes 31, therefore, extend between the two

cylinders 7 and 11 at right angles to the axes thereof and in parallelism with each other.

The shafts 5 and 10 carry on their outer ends belt pulleys 13 and 12, respectively, about which a steel tape 14, 15 is passed. In order to prevent expansion of this steel tape as much as possible in the rectilinear sections thereof strips 31 of greater strength are included.

During the swinging movement of the turntable 22 the tapes 14, 15 being alternately wound on and off the cylinder 7 impart rotative movement to the cylinder 11 which movement is transmitted by the tapes 14, 15 to the shaft 5 which in turn rotates the work spindle 25. The ratio of the two rotational movements, that is, the one about the axis y to that about the axis x, which ratio should be equal to sin α (Fig. 1), must be equal to the relation between the cylinder diameters

$$\frac{b}{a}:\frac{d}{c}$$

For practical reasons it is however most convenient that in constructing the gearing as shown in Fig. 1 the ratio of rotational movements is multiplied with the factor

$$\frac{b}{a}$$

In Figs. 4 and 5 a modified form of the gearing is shown. In this arrangement the shafts 5 and 10 are mounted in the same manner as precedingly described. They are, however, not coupled by steel tapes such as 14 and 15 but by an arcuate sector 16 which is swingably mounted coaxially with the eye bearings 23 and is coupled to cylindrical discs 112, 113 that are secured to the shafts 5 and 10 respectively by rolling tapes 114, 115.

In Fig. 6 a further embodiment of the invention is shown in which the swingable sector 16 shown in Fig. 4 is replaced by a bar 21 which is displaceable in its longitudinal direction and to which rolling bands 114, 115 are fastened.

In Figs. 7 and 8 parts of another modification are shown. In this arrangement the spindle 25 carrying the work 1 and the shaft 5 are so mounted in the swing 9 as to lie in a common plane passing through the axis of rotation of the swing. They are coupled to each other for common rotation by a rack 19 which slides in the swing 9 perpendicularly to this plane and meshes in spur gears 17, 18 which are secured to the spindle 25 and the shaft 5 respectively. This arrangement presents, in distinction from a possible mode of coupling the two shafts 5 and 25 by means of bevel wheels, the advantage that the spur gear tooth systems used can be manufactured more precisely to true form. A similar operative connection for the gearing being composed of a rack and associated spur gears may also be provided between the pin 21 and the shaft 10.

In a bevel wheel grinding machine the grinding disc performs cutting movements longitudinally of a cone generatrix commensurate with the rolling movement. At the end of the stretch along which rolling movement has taken place the grinding disc is retracted from the tooth gap having been machined in a known manner, the relative rolling motion is reversed and the rolling motion generating gearing restored into initial position. During the restoring movement the work is revolubly advanced for one tooth division, whereupon the rolling movement is reversed into the working direction again and the working tool is further applied to the work in which way a fresh working operation is initiated. The machine may also be constructed so as to be able to further machine the same tooth flanks also during the backward rolling motion and divides only at the end of the cycle of rolling operations or divides on the completion of the traverse performed by rolling forwardly and grinds the tooth flank of another tooth gap while rolling backwardly.

Bevel wheel grinding machines for which, above all, extreme accuracy of the product is required are to be equipped with a rolling motion generating device as shown in Figs. 1–6 and 9–11. Those machines, however, can be equipped with a rolling motion generating device as shown in Figs. 7 and 8 for which maximum possible precision is not required but instead an amount of production as great as possible such as conventional in what may be termed single use or special working tools which serve only one purpose and in which only a few sizes of wheels are machined by quantity production and the gear teeth of the gearing are required to be ground into accurately true form.

Bevel wheels of accurate configuration produced in the manner hereinbefore described may be used for making bevel wheel drives for substitution with connections between the axis x and the counterdrive shaft 5 on one hand and between the axis y and the shaft 10 on the other. Theoretically an appropriate connection serving this purpose may also consist in a screw wheel drive having crossed axles. However, such drives scarcely enter into the question due to premature wear on the gear teeth owing to point bearing engagement between cooperating teeth.

For testing apparatus only the tape connection between cylinders as described enters into the question. For such apparatus a testing feeler member is substituted for the grinding disc.

The grinding disc 32 indicated in Fig. 1 describes with its grinding edge a plane surface which coincides with the flank of an imaginary plane wheel extending coaxially with the axis y—y. On this flank the work 1 is supposed to perform a rolling movement.

I claim:

1. In a rolling motion generating mechanism for grinding and testing bevel gears, a first member mounted to rotate about an axis, a second member supported on the first member and mounted to rotate about another axis, which serves for holding the work, a pair of counterdrive shafts parallel to each other respectively mounted perpendicularly relatively to the respective axes, rotary motion transmitting means connecting said countershafts, and rotary motion transmitting means connecting the respective shafts with the respective members to whose axes they are mounted perpendicularly.

2. A rolling motion generating mechanism for grinding and testing bevel gears according to claim 1, and a pair of cylinders respectively mounted on said countershafts, the transmitting means between said shafts comprising a steel band operatively interconnecting said cylinders, and a pair of crossed bands operatively interconnecting said cylinders and their respective rotary members.

3. A rolling motion generating mechanism for grinding and testing bevel gears according to claim 1, and in which the transmitting means connecting the shafts with the respective mem-

bers comprise cylinders mounted on said countershafts, and crossed bands interconnecting the cylinders with their respective rotatable members, the rotary motion transmitting means between the countershafts including a removable and replaceable ratio gearing.

4. A rolling motion generating mechanism for grinding and testing bevel gears according to claim 1, and in which the countershafts are provided with cylinders mounted thereon, and crossed bands interconnecting the cylinders with the respective members to whose axes they are mounted perpendicularly, the rotary motion transmitting means connecting the countershafts including speed ratio producing means for providing a speed ratio equal to that existing between the said two rotatable members.

ALBERT AEPPLI.