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Orlov et al.

[11] **3,925,936**

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[54] **LAPPING MACHINE**

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[21] Appl. No.: **542,266**

Related U.S. Application Data

[63] Continuation of Ser. No. 435,998, Jan. 23, 1974, abandoned.

[52] **U.S. Cl.** **51/118;** 51/120

[51] **Int. Cl.**[2] ... **B24B 5/00;** B24B 29/00; B24B 9/00

[58] **Field of Search** ..... 51/111 R, 117, 118, 120

[56] **References Cited**

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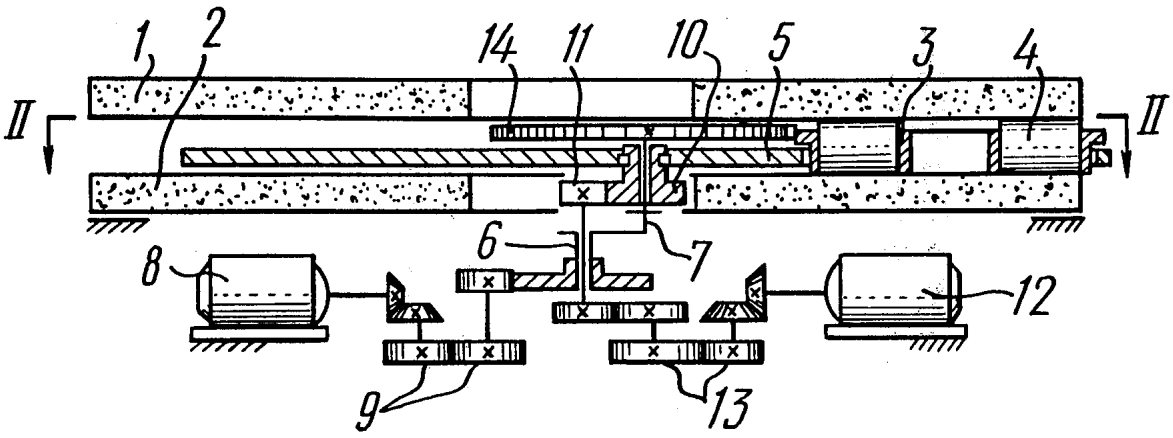
Primary Examiner—Othell M. Simpson
Attorney, Agent, or Firm—Holman & Stern

[57] **ABSTRACT**

A lapping machine in which there is provided a tool or lapping tools, cages accommodating workpieces being lapped, and a central shaft drive rotating a sun wheel which is operatively connected to the cages.

The sum wheel is in permanent force transmitting connection with the cages independently of their relative position. Apart from the main motion transmitted from the sun wheel, there is imparted to the cages an additional variable and cyclic motion independent of the sun wheel, whereby the lapping tool and the workpieces or cages will receive at least dual-component compound relative motion so that an imaginary pattern defined by the intersection points between the workpiece surfaces being lapped and the lapping tool become more dense and uniform.

4 Claims, 5 Drawing Figures



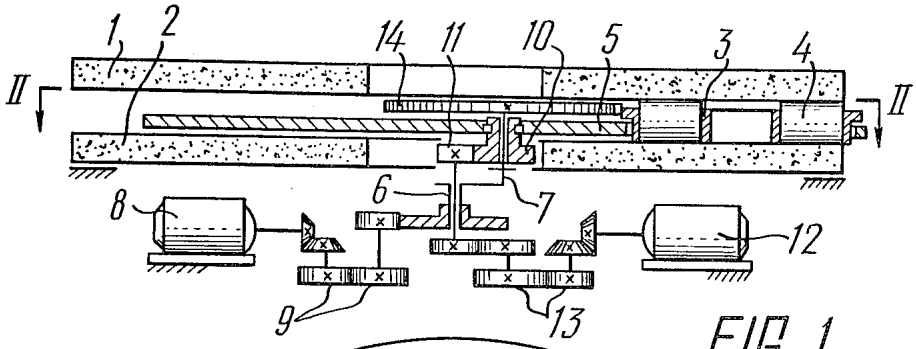


FIG. 1

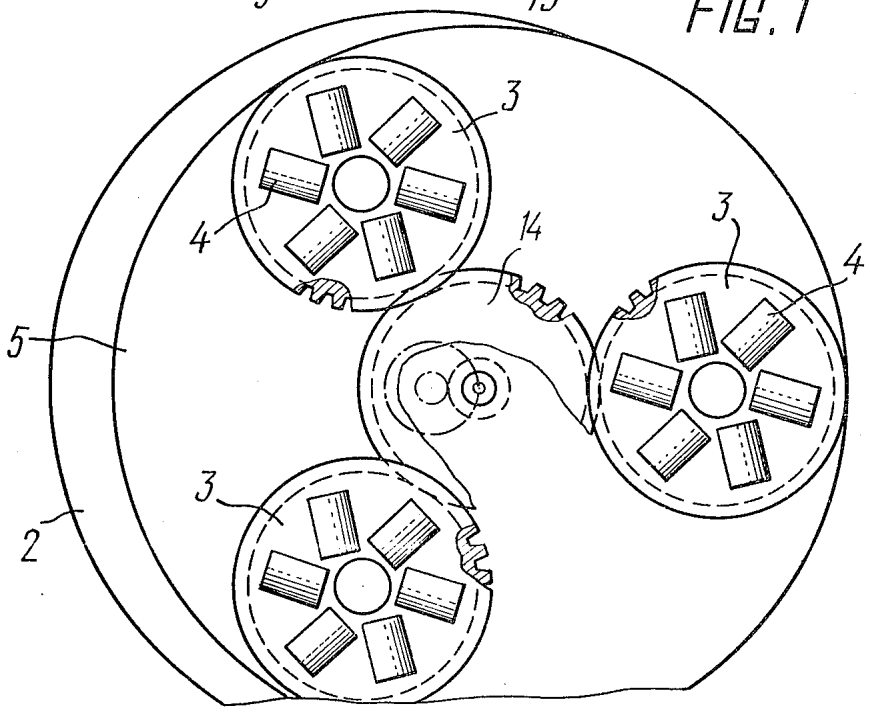


FIG. 2

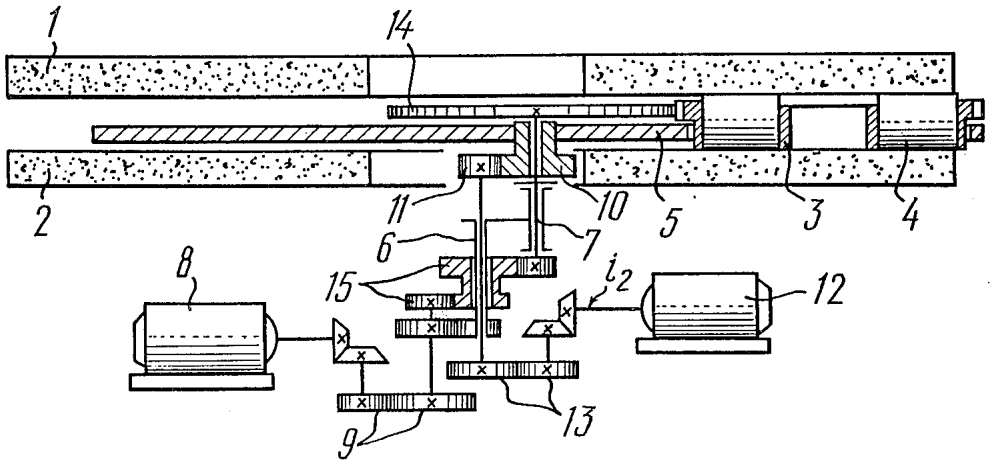


FIG. 3

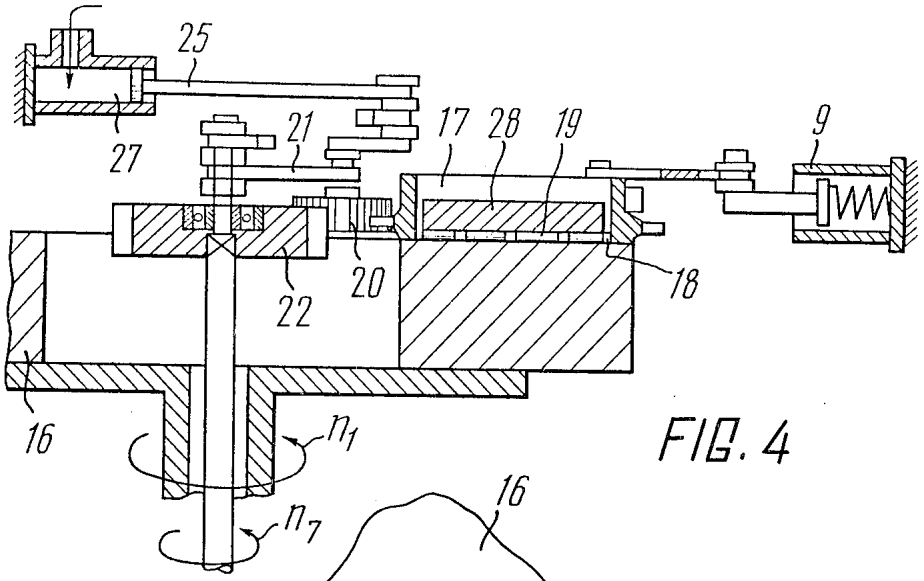
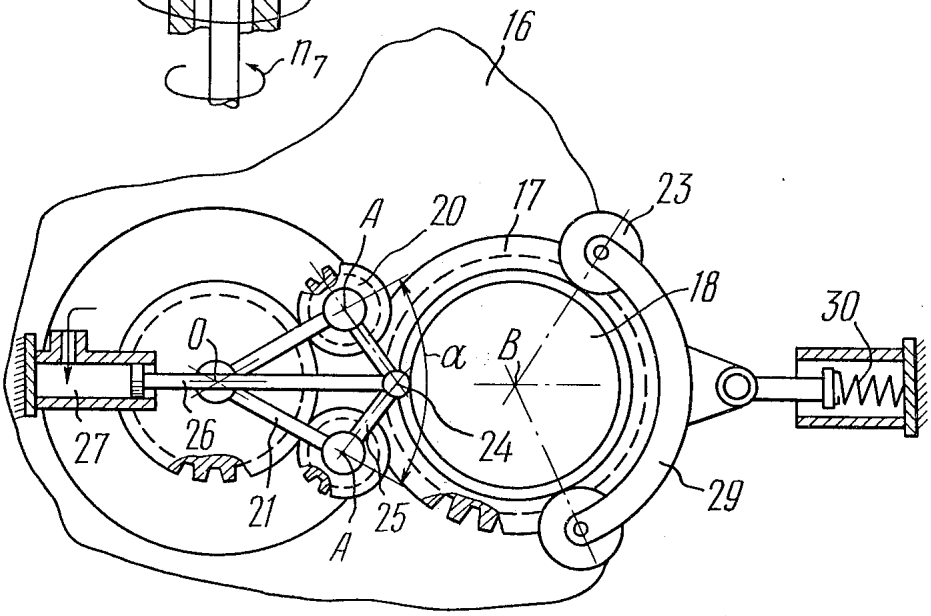

25
27
21
17
28
19
9
22
20
18
16
n_1
n_7

FIG. 4


16
A
20
17
23
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30
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α
B
27
26
24
21
25
A
29

FIG. 5

LAPPING MACHINE

BACKGROUND OF THE INVENTION

This is a continuation of application Ser. No. 435,998 filed Jan. 23, 1974, now abandoned.

The invention relates to production methods of the mechanical and instrumentation engineering, and to the machining of precision surfaces of critical machine and instrument parts using free abrasive. More specifically, the invention is concerned with the force transmission systems of actuating mechanisms for the working members of lapping machines.

PRIOR ART

Known lapping machines have a complicated and largely variable kinematic system for their working motion. A complicated working motion contributes to improved quality and productivity of the lapping operation since it creates favorable conditions for operation of the abrasive grains. In known surface lapping machines, the working motion is normally obtained by different combinations of two-three rotary motion components of the workpieces and lapping tools, or by combining rotary and reciprocatory motions.

Known in the art are lapping tools having an eccentric cage drive made by Hofman (USA), model PR-3 and others, such as disclosed in U.S. Pat. Nos. 2,709,876, and 2,944,375. In these lapping machines, the workpieces are accommodated in the sockets of a cage which is eccentrically mounted relative to the central shaft axis.

Also known in the art is a single-disc surface lapping machine of the Lapmaster type disclosed in F.R.G. Pat. No. 1,114,107 of Mar. 29, 1962. In this lapping machine, the workpieces are accommodated in a cage on the base inside a dressing ring which rotates about its own axis due to the tooth gearing with the sun wheel.

The lapping machines having two working laps are the most versatile ones. The lower lap may be used to lap one of the workpiece planes, while the parallel sides of the workpiece are lapped between the two disc laps.

The lapping machines having the stationary working laps ensure higher accuracy of lapping as compared to those having the movable laps, but they are less productive.

During operation, the laps of the lapping machines wear out and lose the initial shape of the working surface, whereby the accuracy of lapping becomes lower.

OBJECTS AND SUMMARY OF THE INVENTION

Therefore, it is an object of the invention to provide a lapping tool having an improved productivity of lapping, while ensuring high lapping accuracy.

It is also an object of the invention to provide a lapping machine incorporating the lap dressing feature so as to ensure a long-term maintenance of its flatness and to increase the service life thereof.

Furthermore, it is an object of the invention to provide a lapping machine of the above-described type, in which all the above-mentioned advantages are achieved by making an inexpensive and simple modification of the lapping machine, without adversely effecting its reliability in operation and convenience of its repair and maintenance.

These and other objects are accomplished in a lapping machine comprising a lapping tool, cages accommodating workpieces, a central shaft drive rotating a sun wheel which is operatively connected to said cages, in which according to the invention, said sun wheel is in permanent force transmitting connection with the cages independently of their relative position, and there is provided an adjustable mechanism imparting an additional cyclic motion to the cages, which is variable in speed and amplitude, with said motion being independent of the main motion imparted by the sun wheel and being permanently maintained concurrently therewith, whereby the lapping tool and the workpieces or cages will receive at least a dual-component compound relative orbital motion so that an imaginary pattern defined by the intersection points between the lapping tool and the surface of the workpieces being lapped becomes more dense and uniform.

This structural embodiment generally stated above improves the efficiency and uniformity of the working contact between the lapping surface of the working tool (lap) and the surface of the workpiece being lapped, with the compound cyclic motion making it possible to control the redistribution of the working friction load over the lap surface.

In accordance with one embodiment of the invention, in an eccentric lapping machine, the sun wheel is rigidly fitted on an eccentric shaft, the cages comprise planet gears in an external mesh with said sun wheel, a gear loosely mounted on the eccentric shaft and rigidly connected to a plate coaxial therewith, with the plate having sockets in which said cages are loosely received, and an additional drive for rotating said gear and plate about their common central axis.

In this embodiment, the workpieces will cyclically come in contact with the central and peripheral zones of the lapping tools due to the rotation of the cages with the workpieces, whereby, on the one hand, the taper of the workpieces is prevented, and on the other hand, the laps can be positively dressed in the course of operation of the machine tool using the material of the workpieces. Uniform wear of the laps over the entire working surfaces is thereby ensured.

In order to ensure the positive dressing, the machine tool according to the invention offers an opportunity of a speed adjustment for both the main and auxiliary rotational drives.

In addition, the invention contemplates the provision of a drive system for a positive rotation of said eccentric shaft and sun wheel about their own axis.

This auxiliary drive system, provided in addition to the system for imparting the conventional compound orbital motion to the cages accommodating the workpieces relative to the lap, will add an additional rotation of the cages, while meshing with the sun wheel so as to more uniformly redistribute the working loads over the lap and to offer larger possibilities of the positive dressing thereof.

In accordance with another embodiment of the invention, a lapping machine for one-side lapping having support rollers for cages or dressing rings provided with outer teeth is characterized in that it is provided with two idle gears mounted on axles which are connected by means of two movable pull rods to the central axis of the lap, to the sun wheel axis and to pull rods forming a parallelogram linkage, with said linkage providing the adjustment of the relative spacing of the gears meshing with the central teeth of the cage dressing ring, and drive means for separating or bringing the gears together, with said means acting upon the pull rods.

This embodiment permits, by varying the angular position of the idle gears relative to the axis of symmetry of the lap and dressing ring, the radial displacement of the latter so as to perform the positive dressing of the working lap directly in the course of lapping.

One modification of the second embodiment of the invention provides that said support rollers are permanently spring-loaded along the common axis of symmetry of the lap and dressing ring.

This guarantees the reliable tooth meshing between the dressing ring, idle gears and the sun wheel during any possible adjustment displacements of the members of the force transmitting system of the lapping machine as hereinabove described.

The features and advantages of the invention will be better understood from the following detailed description of specific embodiments thereof, which are given as examples only, with reference to the accompanying drawings, in which: ,

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a diagrammatical cross section of an eccentric lapping machine according to the invention and a force transmitting system thereof;

FIG. **2** is a sectional view taken along the line II—II in FIG. **1** showing cages comprising planet gears in external mesh with the sun wheel which is rigidly fitted on the eccentric;

FIG. **3** is a diagrammatical cross section of an eccentric lapping machine according to the invention which is provided with a drive system for rotating the eccentric shaft and sun wheel about the axis of the eccentric shaft;

FIG. **4** is a diagrammatical cross section of a lapping machine with dressing rings according to the invention and the force transmitting system thereof; and

FIG. **5** is a diagrammatical plan view of a lapping machine with dressing rings according to the invention provided with two idle gears meshing with the sun wheel and with the teeth of the dressing ring.

DETAILED DESCRIPTION OF THE EMBODIMENTS

Mounted between upper and lower laps **1** and **2** (FIGS. **1** and **2**) are cages **3** accommodating workpieces **4.** The cages **3** are loosely placed in sockets of a flat support disc **5.** The flat support disc **5** is driven by a central shaft **6** and is loosely mounted on an eccentric shaft **7** thereof. The central shaft **6** is driven by a reversible electric motor **8** via a change gear set **9.** Loosely mounted on the same eccentric shaft **7** is a toothed wheel **10** which is a planet gear in of a planetary gear which the eccentric shaft **7** is a carrier. The planet gear **10** meshes with a toothed wheel **11** which is independently driven by a reversible electric motor **12** via a change gear set **13.**

A sun wheel **14** is rigidly mounted on the planet gear **10** and meshes with outer teeth of the cages **3.** The laps **1** and **2** may be stationary or rotatable.

The lapping machine operates as follows:

After placing the workpieces **4** in the sockets of the cage **3,** the upper lap **1** is freely mounted on the surface of the workpieces **4** to be lapped. Then, the electric motors **8** and **12** are activated to rotate the central shaft **6** and the toothed wheel **11** so as to drive the flat support disc **5,** which is loosely mounted on the eccentric shaft **7** and is rotatable thereabout, and the sun wheel **14** rigidly mounted on the planet gear, namely toothed wheel **10.** Thus, the cages **3** accommodating the workpieces **4** being will be concurrently rotated by the flat disc **5** and sun wheel **14** to perform a compound plane-parallel orbital motion.

Due to the rotation of the cages **3** with the workpieces **4** being relative to the flat support disc **5,** the workpieces **4** will cyclically come in contact with the central peripheral portions of the laps **1** and **2.** This constitutes an important advantage of the machine tool according to the invention as compared to the known eccentric lapping machines, in which the workpieces occupy a predetermined position relative to the flat disc (plane) and cannot rotate in the sockets (unless the latter are of round shape) about their own vertical axis, so that the workpieces being lapped are tapered. This disadvantage is eliminated in the present lapping machine. The variation of the rotational speed of the central shaft **6** and toothed wheel **11** by means of the change gear sets **9** and **13** permits to largely vary the path and speed of movement of the workpieces **4** and to effect the positive dressing of the laps as it will be generally described hereinbelow.

In the machine tools having stationary laps, the correction of the shape of their working surface to eliminate the defects appearing during the wear in the course of lapping is effected by the positive dressing of the laps.

In accordance with the present invention, the smoothly variable redistribution of the mechanical work of the wear of the abrasive material over the working surface of the laps **1** and **2** is accomplished by changing the ratio between the angular speeds of rotation of the eccentric shaft **7** and the toothed wheel **10** loosely mounted thereon (or of the toothed wheel **11**). The radial shape of the working surface of the laps **1** and **2** is preliminarily measured, and the abovementioned ratio between the angular speeds is then selected by adjusting the sets **9** and **13** in such a manner that the wear shape of the working surface of the lap, which will be obtained in accordance with the selected new operating conditions of the machine tool, should represent something like a mirror reflection of the measured wear shape of the working surface of the laps **1** and **2.** The superposition of the old wear shape and that newly selected, which represent the mirror reflection of each other, enables the desired correction of the flatness of the lap working surfaces without interrupting the productive operation of the lapping machine due to the self-dressing of the laps by the workpieces.

FIG. **3** shows an embodiment of the invention similar to that shown in FIGS. **1** and **2,** in which similar parts are indicated with the same reference numerals.

In this embodiment, there is provided a driving system for positive rotation of the eccentric shaft **7** and sun wheel **14** about their own axis. This system comprises a gear set **15** driven by the motor **8.** The relative orbital motion of the workpieces **4** and laps **1** and **2** becomes thereby more complicated, and additional opportunities are provided for a predetermined positive dressing.

Mounted on a lap **16** (FIGS. **4** and **5**) there are dressing rings **17,** with each dressing ring **17** accommodating a cage **18** with workpieces **19.**

The outer teeth of the dressing ring **17** meshes with two idle gears **20,** with their axles being connected by means of two movable pull rods **21** to the axle of a sun wheel **22** meshing with the idle gears **20.** The dressing ring **17,** on the one hand, meshes with the idle gears **20,**

with their axles being connected by means of the pull rods **21** to the axle of the sun wheel **22** meshing with the idle gears, and on the other hand, this ring is supported by movable support rollers **23.** A movable joint **24** interconnects, by means of pull rods **25,** the axles of the idle gears and a pull rod **26** of a setting means **27** comprising an actuating pneumatic cylinder.

The lapping machine operates as follows:

Prior to the lapping, the workpieces **19** are glued to the cage **18.** The cage **18,** with the workpieces **19,** is mounted inside the dressing ring **17** on the working surface of the lap **16.** A weight **28** may be placed on the cage **18** from above, if the weight of the cage **18** is insufficient to exert a required load. After the cage **18** with the workpieces **19** has been so installed, the drive of the lap **16** and sun wheel **22** is activated to rotate them at a predetermined speed via reversible drive means (not shown). The rotational speed of the sun wheel **22** can be varied both by value and direction during the operation. In addition, by feeding compressed air into the chamber of the setting means **27,** the radial displacement of the dressing ring **17** is effected relative to the lap **16** due to a change in the angular position of the idle gears **20** relative to the axis of symmetry of the lap **16** and dressing ring **17** (by separating or bringing together the gears **20**). This enables the positive dressing of the working surface of the lap **16** during the lapping.

The support rollers **23** mounted on an arcuate member **29** are permanently spring-loaded by means of a spring **30** so as to press the dressing ring **17** against the idle gears **20** along the common axis of symmetry of the dressing ring **17** and lap **16.**

The use of the positive operative connection between the dressing ring **17** and the drive of the sun wheel **22,** which is effected via the movable idle gears **20,** makes it possible to smoothly vary the redistribution of the mechanical work of wear of the abrasive material of the lap **16** over the working surface thereof by varying the ratio between the angular speeds of rotation of the sun wheel **22,** and the lap **16,** as well as angle α between the pull rods **25,** whereby the defects of the lap shape resulting from wear are corrected.

Thus, in using the disc-type lap **16,** the lap will have the most intensive wear in the zone located adjacent to the peripheral portion thereof, and, in this case, the ratio between the angular speeds of the sun wheel **22** and lap **16,** as well as the value of the angle α will be set in such a manner that the zones of the working surface of the lap located adjacent to its central portion should be in frictional contact with the surface of the workpieces for a longer time as compared to the peripheral zones of the lap working surface. The speed settings of the lapping machine are determined on the basis of measured wear of the lap **16** by caluculations based on the compensation of wear due to the redistribution of the working loads.

Therefore, the lapping machines according to the invention can effect the lapping of the surfaces of workpieces to a predetermined surface finish in the course of continuous operation without interrupting the operation of the machine tool for measurements and dressing of the laps under the idle running conditions as it has been made heretofore.

The arrangement of the measuring device for obtaining the data on the shape of the worn surface of the lap directly during the operation of the lapping machine is disclosed in our co-pending application.

It will be apparent to those skilled in the art that the lapping machines according to the invention are applicable for lapping workpieces of largely variable shape with the use of an appropriate shape of the lapping tools having concave, convex and tapered working surfaces.

While the invention has been described herein in terms of preferred embodiments, numerous variations may be made in the machine tool and parts thereof without departing from the spirit of our invention or the scope of the claims below.

What is claimed is:

1. A lapping machine for a two-side lapping of flat surfaces of workpieces, comprising a fixed disk lapping tool having a central axis, cages in which the workpieces are placed and brought into contact with the working surface of the lapping tool, the cages having axes, a first drive for simultaneously rotating the cages with the workpieces around the central axis of the lapping tool and the axes of the cages, said drive including a shaft eccentric with respect to the central axis of the lapping tool, a sun wheel rigidly mounted on said shaft, said cages having planet gears meshing externally with said sun wheel, and operably connected by a gear train with a main drive rotating the cages and eccentric shaft around the axis of the lapping tool and around the axes of the cages, a flat disk parallel to the lapping tool, sockets in said disk, said cages being placed in said sockets coaxially to the eccentric shaft, a second drive, a central gear located on the axis of the lapping tool operably connected to said flat disk and a train of replacable gears with said second drive for imparting rotation to the flat disk together with the cages around the axis of the eccentric shaft.

2. The lapping machine as claimed in claim **1,** in which an auxiliary gear train is provided between the eccentric shaft and the main drive rotating the eccentric shaft around its own axis in addition to said rotation of the eccentric shaft around the axis of the lapping tool.

3. A lapping machine for two-side lapping of workpieces comprising a lapping tool, cages in which the workpieces are placed and brought into contact with the working surface of the lapping tool, a dressing ring, a first drive for rotating the lapping tool around its axis and a second drive for rotating a cage and a dressing ring around a common axis, said dressing ring having outer teeth, support rollers retaining said cage and said dressing ring at one side, said second drive including a sun wheel coaxial to the lapping tool, the sun wheel having an axle, two idle gears, axles on which said idle gears are mounted, two movable pull rods connecting the axles of the two idle gears with the central axle of the lapping tool to the axle of the sun wheel and to pull rods forming a parallelogram linkage for adjusting the relative spacing of said gears meshing simultaneously with the sun wheel and the teeth of the dressing ring, said gears being brought to the dressing ring on the side opposite to the support rollers, and a drive having a pull rod for drawing apart or together said gears connected with the parallolegram linkage.

4. The lapping machine as claimed in claim **3** including a common arcuate number spring loaded along the axis of symmetry of the dressing ring and the support rollers on which said rollers are mounted, and said pull rods for drawing apart and together said gears being adapted for movement along the same axis of symmetry.

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