Feb. 28, 1967 W. W. KOSKIE 3,305,976

LAPPING METHOD AND APPARATUS

Filed May 7, 1964

Fig. 1

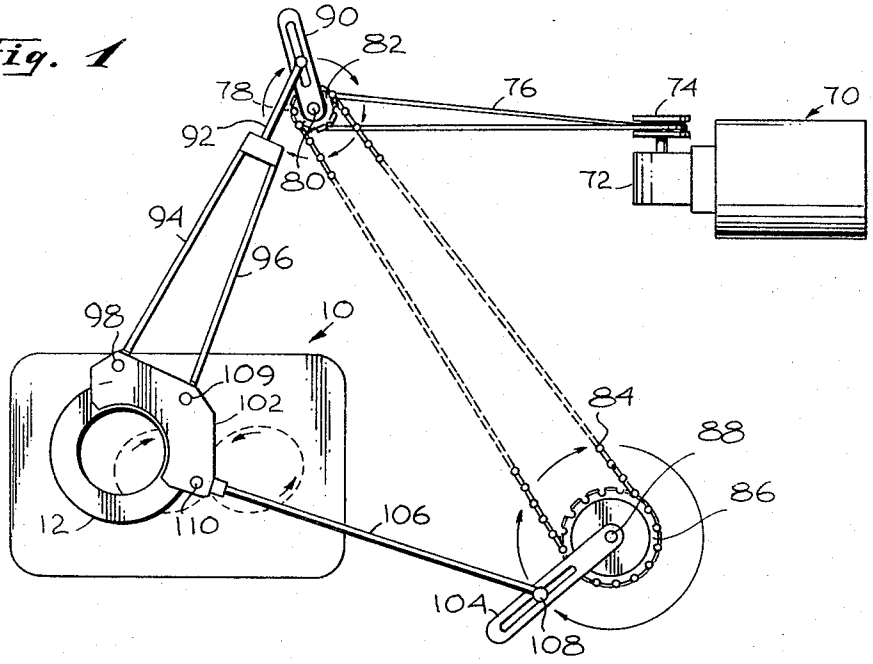
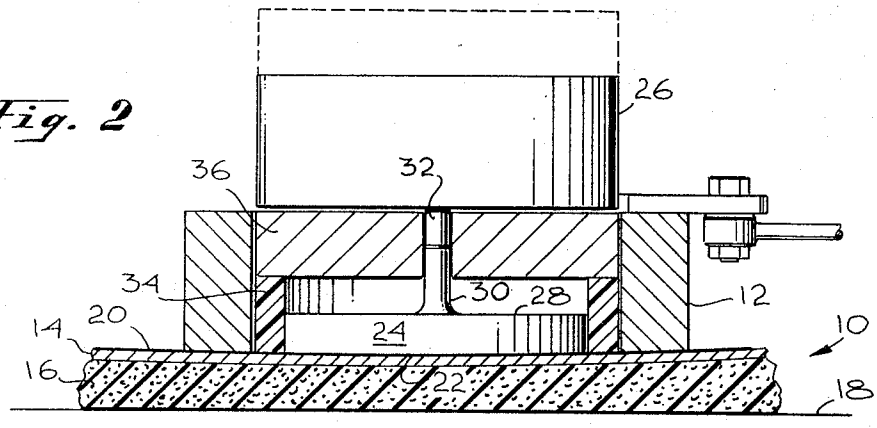


Fig. 2



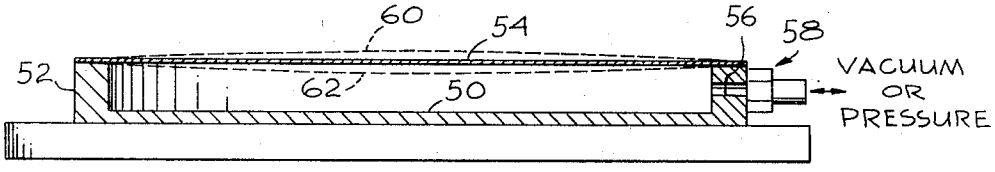


Fig. 3

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United States Patent Office

3,305,976
Patented Feb. 28, 1967

3,305,976

LAPPING METHOD AND APPARATUS

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Filed May 7, 1964, Ser. No. 365,606
8 Claims. (Cl. 51—151)

This invention relates generally to apparatus useful for forming a curved surface on small mechanical members which surface can be given a large and precise radius of curvature.

In many diverse pieces of equipment, small mechanical members having surfaces with a very slight curvature (i.e. large radius of curvature) are required. It is oftentimes very difficult to form desired surfaces on such members inasmuch as conventional grinding techniques are usually not applicable because of the relatively small surface area and the large radius of curvature required. Where machine grinding is not applicable, the surfaces could be formed manually but this would require a great deal of time and effort by very skilled persons. Consequently, it is usually extremely costly to provide a large number of such members each of which has a precisely curved surface formed thereon. However, in certain pieces of equipment, the provision of such members is necessary for the satisfactory operation of the equipment. One such piece of equipment constitutes magnetic disc recording apparatus which often employs magnetic heads of the so-called "flying" type. In operation, the moving air developed by a rotating disc functions as a bearing to support the flying heads a precise distance away from the disc surface. The heads must each be provided with a precisely curved surface in order to establish optimum aerodynamic effects for supporting the heads. In view of this and similar applications, it is an object of the present invention to provide an improved method and apparatus for forming slightly and precisely curved surfaces on relatively small mechanical members.

In accordance with one aspect of the invention, curved surfaces are formed on small mechanical members by randomly moving the member on a lapping plate having an abrasive lapping compound thereon, which plate is curved to the desired radius of curvature.

In accordance with one embodiment of the invention, the lapping plate forms one surface of a closed container and can be flexed to the desired curvature by controlling the vacuum or pressure within the container. In another embodiment of the invention, the flexible plate is merely supported on a variable amount of flexible padding. In both embodiments, the surface of the mechanical member to be formed is in contact with the plate and a weight is supported on the member to maintain the surface in engagement with the plate. In the second lapping plate embodiment, the weight helps flex the plate to the desired curvature.

In accordance with a still further aspect of the invention, apparatus is provided for moving the member over the lapping plate in essentially a figure "8" pattern which pattern simulates random motion.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIGURE 1 is a plan view of apparatus constructed in accordance with the invention for moving a mechanical member on a lapping plate in a substantially random-like fashion;

FIGURE 2 is a vertical sectional view of a preferred embodiment of the invention particularly illustrating the manner in which a magnetic head can be supported on a deformable lapping plate; and

FIGURE 3 is a vertical sectional view of an alternate lapping plate embodiment.

Attention is now called to FIGURE 1 of the drawings which illustrates a lapping plate apparatus **10** upon which a mechanical member, such as a magnetic head useful in magnetic disc storage systems, can be moved by a transport ring **12** for reshaping or conforming the surface of the mechanical member to the shape or curvature of the lapping plate.

FIGURE 2 illustrates a preferred embodiment of lapping plate apparatus **10** which includes a flexible lapping plate **14** formed of aluminum or some other material which can be flexed to a desired radius. The lapping plate **14** is supported on a pad **16** formed of a resilient material. The pad **16** is supported on a rigid surface **18**. An abrasive compound **20** is spread on the upper surface of the lapping plate **14**.

The surface **22** of a mechanical member **24**, herein shown to be a magnetic head, is supported in engagement with the lapping plate **14**. In order to assure proper engagement of the surface **22** with the lapping plate **14**, and in order to deform the lapping plate **14** to the desired curvature, a weight **26** is supported on the head **24**. The head **24** is illustrated as including a disc portion **28** having a center post **30** extending vertically therefrom. In order to assure substantially equal distribution of the weight **26** over the entire surface **22**, the weight **26** is supported on a pin **32** engaged with the center post **30**. The disc portion **28** of the head **24** is enclosed within a toroidal head holder **34** which supports a disc shaped pin housing **36** having a central opening which receives both the center post **30** and the pin **32** and maintains them in alignment. Thus, the weight **26** is transmitted through the pin **32** and the center post **30** and is equally distributed over the surface **22** on the disc portion **26** of the head **24**. In order to conform the surface **22** to the curvature of the lapping plate **14**, the head **24** can be randomly moved over the lapping plate by randomly moving the transport ring **12** which enclosed the pin housing **36**, head holder **34**, and head **24**.

After the head **24** is moved on the lapping plate **14** for a sufficiently long period, the surface **22** thereof will conform to the curvature of the lapping plate **14**. The curvature of the lapping plate **14** depends upon three significant factors; namely, the magnitude of weight **26**, the thickness of lapping plate **14**, and the amount of padding or resilient material sandwiched between the rigid support **18** and the lapping plate **14**. By varying the magnitude of weight **26** and/or the amount of padding **16** employed, the desired plate curvature can be established.

FIGURE 3 illustrates an alternative lapping plate apparatus which includes a base plate **50** having a wall **52** extending vertically therefrom. The lapping plate comprises a flexible diaphragm **54**, which can for example be constructed of aluminum, which is secured to the upper surface of the wall **52** in opposed relationship to the base plate **50**. Thus, a substantially closed volume is defined between the plates **50** and **54** and the wall **52**. A single opening **56** can be provided to communicate the enclosed

volume, through a valve means 58, with means (not shown) for developing either a vacuum or a high pressure within the enclosed volume. If a high pressure is developed, the diaphragm 54 will of course flex upwardly as illustrated by the dotted line 60 so as to develop a concave curvature on the surface of a mechanical member moved thereon. On the other hand, if a vacuum is developed in the enclosed volume, the diaphragm 54 will flex to the position illustrated by dotted line 62 to thereby form a convex surface on the mechanical member moved on the lapping plate 54.

FIGURE 1 illustrates the apparatus for moving the transport ring 12 over the lapping plate 14 (or 54) in a substantially random-like manner while exerting little or no pressure on the lapping plate. Actually, the apparatus of FIGURE 1 operates to move the ring 12 in an essentially FIGURE 8 pattern which serves to simulate random motion. The drive apparatus of FIGURE 1 includes a motor 70 which through gear box 72 drives pulley 74. V-belt 76 engaged with pulley 74 is also frictionally engaged with pulley 78 secured to rotatable shaft 80. Also secured to shaft 80 is a sprocket 82 which is coupled by sprocket chain 84 to a sprocket 86 secured to shaft 88. If the sprockets 82 and 86 have a 1:2 ratio the ring 12, as should be apparent, permits the generation of a FIGURE 8 pattern. In order to minimize lapping plate wear, rather than using an exact 1:2 sprocket ratio, a slightly different ratio can be employed. Thus, a 9:20 sprocket will generate a walking or changing pattern which will prevent rapid plate wear.

Secured to the shaft 80 is a bell crank 90 having an arm 92 pivoted thereto. The arm 92 is coupled to a pair of members 94 and 96 which together comprise an A-frame. Members 94 and 96 are secured by swivel bearings 98 and 100 to a plate 102 fixed to the ring 12.

A bell crank 104 is secured to the shaft 88. An arm 106 is coupled by a swivel bearing 108 to the bell crank 104 and by a swivel bearing 110 to the plate 102 fixed to the ring 12.

Inasmuch as the sprocket 82 has approximately half as many teeth as the sprocket 86, its rotational speed will be approximately twice as great as that of the sprocket 86. Consequently, the ring 12 will be moved in a pattern substantially similar to the FIGURE 8 pattern illustrated in FIGURE 1. As noted however, the sprocket ratio should preferably be chosen so as to minimize plate wear.

Each of the bell cranks 90 and 104 are provided with longitudinally extending slots therein in which the bearings at the terminals of arms 92 and 106 can be slidably adjusted. The effective throw of the cranks can thus be varied by fixing the arm terminals at different points in the slots. Thus, the heights of the ring movement pattern can be adjusted by varying the position in which the bearing at the terminal of arm 108 is fixed in the slot of bell crank 104. On the other hand, the width of the ring movement pattern can be adjusted by adjusting the position of the terminal of arm 92 in the slot of bell crank 90.

In the use of the present apparatus, it is desirable to apply the lapping compound to a plate which is extremely clean. Moreover, the lapping compound should be changed reasonably often to maintain its uniform abrasive characteristics. Movement of the magnetic head 24 in the pattern described, will tend to form circles on the head surface 22 if the weight 26 is distributed evenly on the outer post 30. Any variation of the weight on the post will result in different patterns being formed on different head surfaces utilizing the same lapping apparatus. In order to assure proper distribution of the weight on the post, care should be taken to assure that the pin 32 extends very slightly (e.g. .005 inch) above the pin housing 36.

In the actual operation of the apparatus, the head can be initially subjected to a coarse lapping phase during

which a relatively large amount of padding 16 is used under the lapping plate 14 and the magnitude of the weight 26 is relatively large. The head should be lapped for a certain interval and thereafter should be checked with an optical flat. In a subsequent finer lapping phase, both the magnitude of the weight and the number of pads used beneath the plate can be reduced and the curvature of the head surface can again be checked with an optical flat. After a reasonable amount of experimentation, an operator will be able to judge with a reasonably high degree of accuracy, exactly what weight, how many pads, and how long each head should be lapped in each phase.

From the foregoing, it should be appreciated that a method and apparatus has been provided herein for reshaping a surface of a mechanical member so as to conform the surface of a desired curvature.

What is claimed is:

1. Apparatus for reshaping a surface on a mechanical member so as to give the surface a precise curvature, said apparatus comprising:
   - a substantially flat horizontally oriented plate;
   - said member supported on said plate with said surface in engagement therewith;
   - means for distorting said plate to said precise curvature; and
   - means for moving said member in a substantially random manner over said plate.

2. Apparatus for reshaping a surface on a mechanical member so as to give the surface a precise curvature, said apparatus comprising:
   - a flexible substantially flat horizontally oriented lapping plate having an abrasive surface;
   - said member supported on said lapping plate with said member surface in engagement with said abrasive surface;
   - means for distorting said lapping plate to said precise curvature; and
   - means for moving said member in a substantially random manner over said lapping plate.

3. The apparatus of claim 2 including a base plate having a wall extending upwardly therefrom:
   - means securing said lapping plate to said wall opposed to said base plate thereby defining a closed volume therebetween; and
   - wherein said means for distorting said plate includes means for varying the pressure in said closed volume.

4. The apparatus of claim 2 including a rigid surface and at least one flexible pad supported thereon; and
   - means supporting said lapping plate on said pad.

5. Apparatus for reshaping a surface on a mechanical member so as to give the surface a precise curvature, said apparatus comprising:
   - a flexible lapping plate having an abrasive surface;
   - said member supported on said lapping plate with said member surface in engagement with said abrasive surface;
   - means for distorting said lapping plate to said precise curvature;
   - means for moving said member over said plate including first and second bell cranks each rotated at different speeds;
   - a transport ring supported on said abrasive surface enclosing said member; and
   - first and second arms respectively pivotally secured between said first and second bell cranks and said transport ring.

6. A method of reshaping a surface on a mechanical member so as to give the surface a precise curvature comprising the steps of:
   - distorting a lapping plate to the curvature desired;
   - supporting said member on said plate with said surface engaged with said plate; and
   - moving said member in a substantially random-like fashion on said plate.

7. Apparatus for reshaping a surface on a magnetic

head so as to give the surface a precise curvature, said apparatus comprising:

a flexible lapping plate having an abrasive surface;

said head supported on said lapping plate with said head surface in engagement with said abrasive surface;

means for distorting said plate to said precise curvature; and

means for moving said head in a substantially random manner over said plate.

8. The apparatus of claim 7 wherein said magnetic head includes a vertically extending center post; and

means for supporting a weight on said center post for urging said head surface against said lapping plate.

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