Jan. 10, 1961 L. G. DAMGAARD 2,967,380

GRINDING OR POLISHING APPARATUSES

Filed April 16, 1959 5 Sheets-Sheet 1

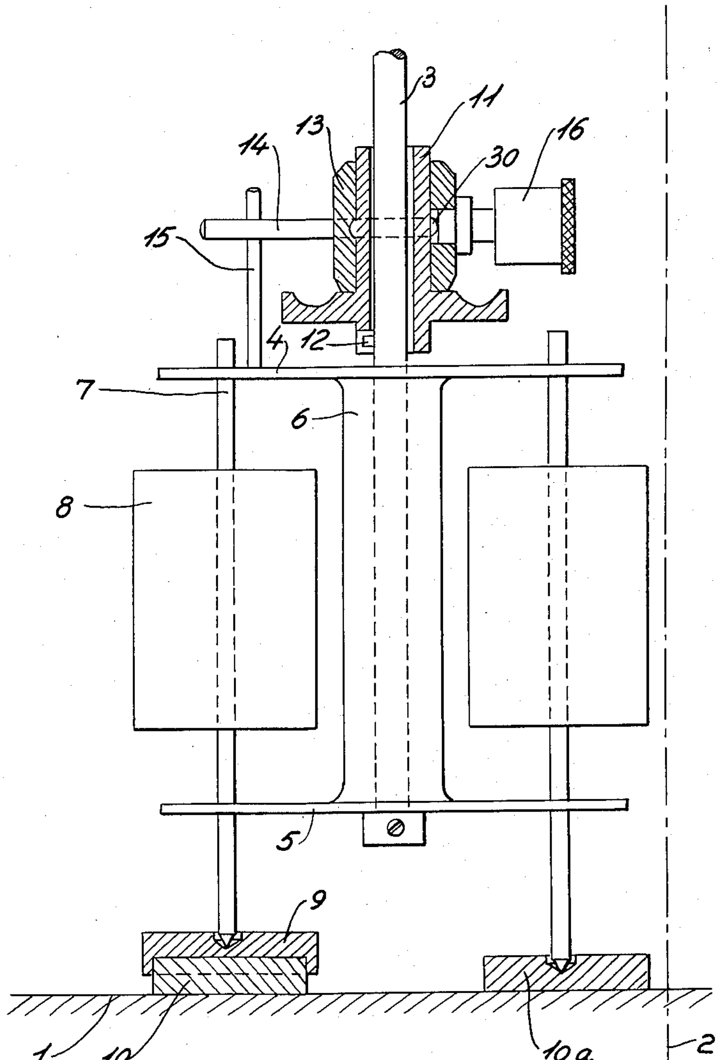

Fig. 1

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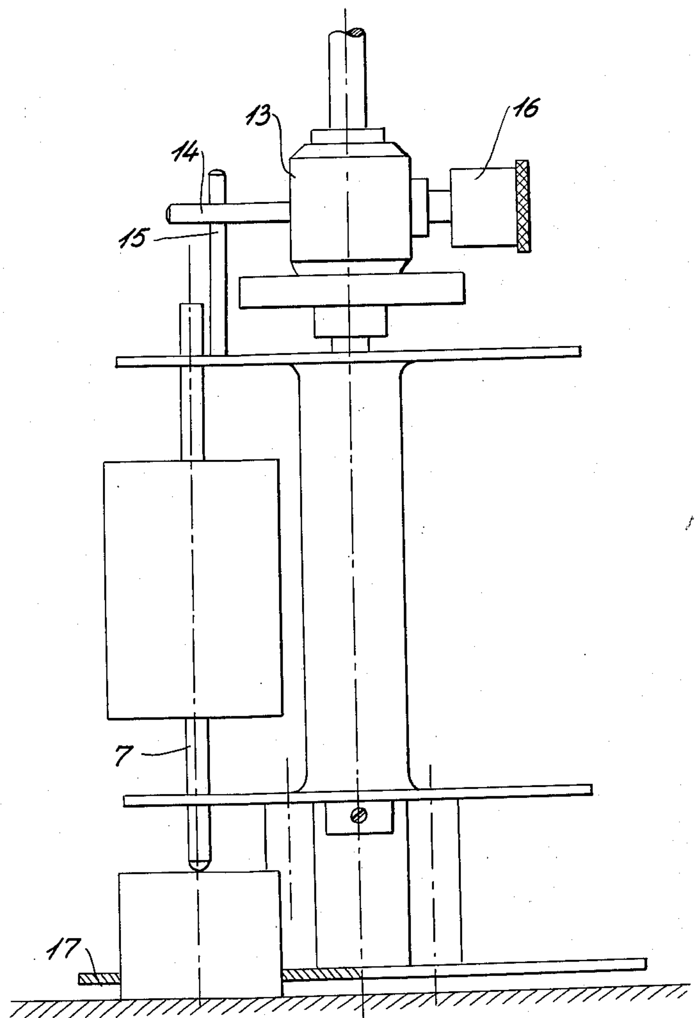

Fig. 2

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GRINDING OR POLISHING APPARATUSES

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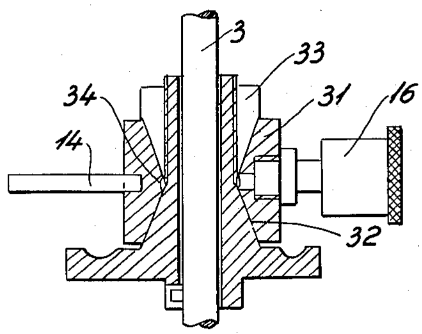

Fig. 3

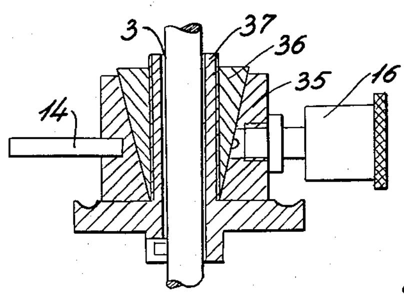

Fig. 4

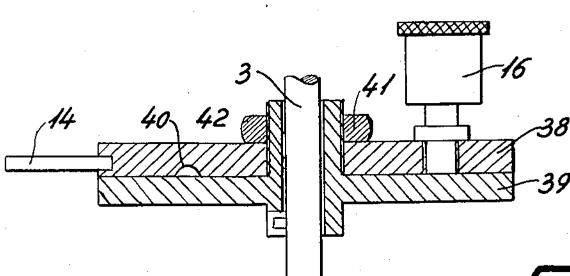

Fig. 5

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GRINDING OR POLISHING APPARATUSES

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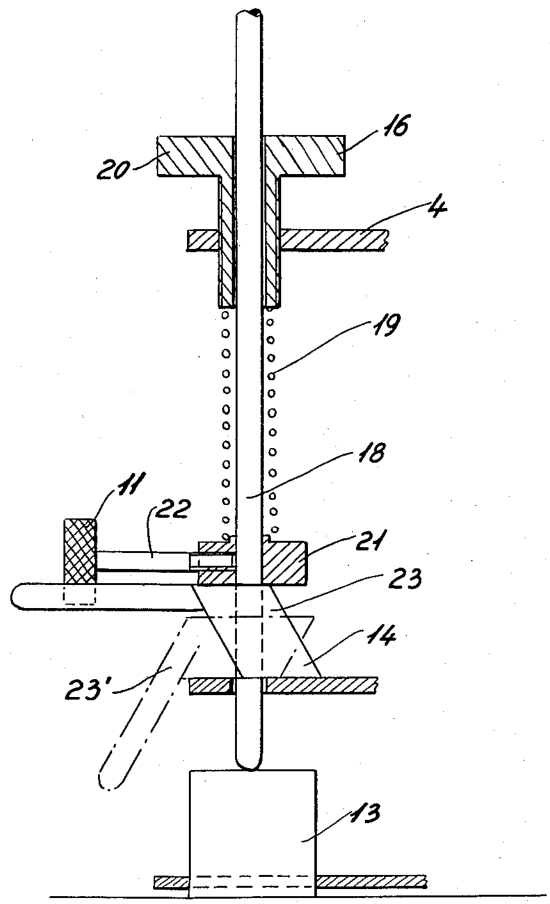

Fig. 6

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GRINDING OR POLISHING APPARATUSES

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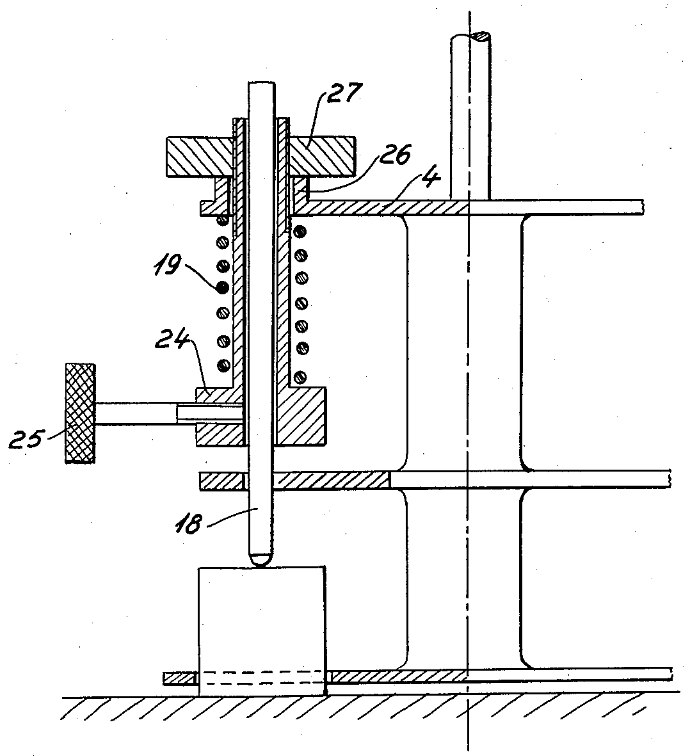

Fig. 7

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GRINDING OR POLISHING APPARATUSES

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4 Claims. (Cl. 51—133)

This invention relates to a grinding or polishing apparatus of the type comprising a rotatable disc and a rotatably mounted sample holder arranged to keep one or more samples in a grinding or polishing position eccentric with respect to the axis of rotation of said disc.

Such grinding or polishing apparatuses are particularly suitable for use for the metallographic grinding or polishing of samples in such cases where a relatively long time of treatment is called for and it is therefore inconvenient to press the sample against the revolving grinding or polishing disc by hand.

It is well known that by constructing a grinding or polishing apparatus in the manner described, the sample can be caused to perform a movement of its own with respect to the axis of the polishing disc. The object of this is to make sure that irregularities in the surface of the polishing disc will not form traces in the surface of the sample, and also to obtain a uniform wear of the polishing disc and to utilize the whole of its area, and finally to avoid the consistent polishing of each point of the sample in the same direction during the whole of the polishing operation since it is preferable that the inhomogeneities of the surface of the sample should be attacked alternately from many directions.

According to a previous proposal, the self centered movement of the sample—or of a plurality of samples that are treated simultaneously—has been obtained by arranging the sample holder to be driven through a transmission from the polishing disc. By suitably selecting this transmission, the speed and the direction of the self centered movement of the sample holder can be completely controlled, but the construction is rather complicated. It has also been proposed to arrange the sample holder for free rotation with its axis of rotation located eccentrically with respect to that of the polishing disc, so that the sample holder is caused to rotate as a consequence of the friction of the samples against the polishing disc. This is a relatively simple construction, but as hitherto carried into effect it has the drawback that the movements of the sample holder will be too haphazard and will in most cases take place at higher speed than desirable. A further drawback is that the system is only workable with a plurality of symmetrically distributed samples. A relatively high speed is disadvantageous because the relative movement between the samples and the polishing disc will be correspondingly low, and also because at high speeds the samples will have an increased tendency of tilting and digging their edges into the polishing disc instead of lying flat on the latter.

It is an object of the invention to eliminate these drawbacks, and with this object in view, according to the invention, a liquid friction brake means is operatively interposed between the sample holder and a stationary part of the apparatus.

Since it has been found that the liquid friction force increases more rapidly with increasing speed than the friction between the samples and the grinding or polishing disc, and since the liquid friction is zero at the speed

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zero, while the friction between the samples and the grinding or polishing disc has a certain initial value, a state of equilibrium between the last named force on one hand and the braking liquid friction force acting on the sample holder on the other hand will occur at a relatively well defined speed. This speed may be selected partly by selecting the construction of the fluid friction brake acting on the sample holder, partly by selecting a braking liquid having a viscosity suitable for the purpose. In this manner it becomes possible to keep the speed of rotation of the sample holder at a relatively low value and also to avoid too great fluctuations of this speed, which might result in a tendency towards tilting of the samples.

It has been found possible to make even a single sample move at a relatively uniform speed as long as the centre of the sample describes a circle enclosing the centre of the polishing disc so that the friction between the sample and the disc always acts in the same direction of rotation. If a plurality of samples are polished simultaneously, it is easier still to make the sample holder rotate at a relatively uniform speed and this is possible even if the path in which the samples move runs through the centre of the polishing disc, or even if it is located in its entirety on one side of the said centre. Moreover, it is possible to operate at a very small eccentricity or no eccentricity at all between the axes of the polishing disc and the sample holder respectively. This is of great importance when polishing with expensive diamond dust, because it then suffices to apply diamond dust to a narrow annular zone of the polishing disc, and the apparatus may then be started at a small eccentricity which is subsequently increased gradually as the diamond dust is smeared out over adjacent zones of the polishing disc.

According to a simple embodiment of the invention, the liquid friction brake is interposed between the sample holder and a stationary shaft on which the sample holder is rotatably mounted. In this construction, care should be taken to avoid direct contact between the relatively movable parts of the brake so that practically the whole of the braking force occurs in the form of a liquid friction force. This may e.g. be obtained by arranging for a symmetrical transfer of the braking force such as will be described in further detail below.

To permit the simultaneous polishing of a plurality of samples, while at the same time securing the best possible conditions of polishing for each individual sample without delays or other inconvenience resulting from the simultaneous polishing of the other samples, the sample holder, according to a preferred embodiment of the invention, may be arranged to receive samples freely displaceably in a vertical direction, means being provided for individually loading samples received in said sample holder.

In this manner, each individual sample will always be urged towards the polishing disc at the most favorable force, no matter whether a greater or smaller number of samples are polished at a time or possibly just one sample is polished at a time. The favorable conditions are also maintained if the number of samples in the apparatus is changed during the polishing of the individual samples.

It is observed that the samples, besides being freely displaceable in the vertical direction, should also be freely tiltable relative to the sample holder, so that they are not subjected to any restriction, but are free to find their correct positions by their engagement with the polishing disc. Thus, in the cirmustances described, the sample holder will only be effective as a conveying device exerting a lateral force on the samples.

Preferably, according to the invention, the sample holder and the loading means are so arranged as to permit the individual insertion and withdrawal of samples during operation of the apparatus, so that it will not be necessary to treat a prescribed number of samples at a time or to treat different samples for the same length of time.

Reference will now be made to the accompanying drawings, in which:

Fig. 1 diagrammatically shows one form of a grinding or polishing apparatus according to the invention, in side view,

Fig. 2 a similar view of another embodiment of such an apparatus,

Figs. 3–5 various forms of brakes for the apparatuses illustrated in Figures 1 and 2,

Fig. 6 a side view, partly in section, of one form of the loading means of the sample holder of an apparatus according to the invention, and

Fig. 7 a similar view of another embodiment of the loading means.

In Figure 1, **1** is a grinding or polishing disc, which rotates about a vertical axis **2**. **3** represents a stationary shaft, which is eccentrically located relative to the axis **2** and which by means not shown may be connected with the machine frame, in which the polishing disc **1** is rotatably mounted. A sample holder consisting of two horizontal discs **4** and **5**, which are connected with each other by means of a hub **6**, is rotatably mounted on the shaft **3**. The discs **4** and **5** have aligned holes forming guides for vertically slidable rods **7**, each of which carries a weight **8** and is pointed at its lower end. In the embodiment illustrated in the left-hand half of Figure 1, this pointed end is received in a recess of an inverted cup **9**, in which a sample **10** is inserted with or without the use of suitable washers. In the right-hand half of Figure 1, a recess to receive the pointed end of the rod **7** is formed directly in the upper face of the sample **10*a***.

The stationary shaft **3** carries a sleeve **11**, which is non-rotatably connected with the shaft by means of a pin **12**. The sleeve **11** is surrounded by another sleeve **13**, which carries a radially extending dog pin **14** adapted for engagement with a vertical drive pin **15** carried by the disc **4**. The two sleeves **11** and **13** define an annular interspace to which friction liquid is supplied from a lubricator cup **16**. Preferably, a friction liquid is used which has a high viscosity and a low temperature coefficient of viscosity. As will be seen, the dog pin **14** is arranged at the middle of the sleeve **13** and as a consequence of the engagement between the dog pin **14** and the vertical drive pin **15** the former will exclusively be influenced by a drive force, which in Figure 1 is perpendicular to the plane of the paper and thus extends through the centre of gravity of the sleeve **13**. In this manner the sleeve **13** will be subjected to a torque about the axis of the sleeve, and besides to a resulting force extending through the centre of gravity of the sleeve, which means that the sleeve is symmetrically loaded so that there is no danger of the upper end of the sleeve being urged towards the sleeve **11** at a greater force than the lower end of the sleeve or vice versa. Thereby a very uniform distribution of load between the sleeves **11** and **13** is obtained, which again means that the cross sectional area of the annular interspace will be identical in all sections, and this again means that the danger of metallic contact between the sleeves is very considerably reduced so that the friction between the sleeves will be constituted practically exclusively by inner friction in the friction liquid. In the embodiment of the brake illustrated in Figure 1, the gravity of the sleeve **13** may cause solid contact to occur between the underface of the sleeve **13** and the flange of the sleeve **11**, but the forces occurring at this location are very small as compared with the liquid friction, and moreover, the lubricant will have a tendency to penetrate into the interspace of the mutually engaging surfaces.

By making the two sleeves **11** and **13** from materials with different coefficients of thermal expansion, the size of the annular interspace may be caused to vary in such a manner as a consequence of the rise of temperature occurring during the use of the apparatus as to compensate for the variation of viscosity occurring in the lubricant as a consequence of the same heating. Moreover, it will be seen that the brake as a whole can be removed from the shaft **3** and replaced by another brake with a different braking force, such as when samples are to be ground or polished, which require a variation of the braking force.

To obtain a uniform distribution of the lubricant, the sleeve **13** is provided in its interior with a lubricating passage **30** which communicates with the lubricator cup **16**. In the embodiments of brakes for the apparatus according to the invention illustrated in Figures 3–5, the braking force has been made adjustable. In Figure 3, a sleeve **31**, the outer diameter of which increases toward both ends of the sleeve, surrounds a sleeve **32**, the lower part of which is conical and the upper part of which has a threaded portion to receive a conical bush **33**, which may be adjusted in different positions relative to the conical part **32** in order to control the thickness of the hour-glass shaped interspace of the sleeve **31** and the sleeves **32** and **33**. Also in this case the dog pin **14** is arranged centrally of the length of the sleeve **31** so as to be symmetrically loaded to avoid metallic contact between the parts, and likewise a circumferential lubricating passage **34** is provided in order to distribute the lubricant from the lubricator cup in a symmetrical manner. Of course, means are provided for holding the bush **33** in any adjusted position relative to the sleeve **32** so as to prevent the lubricating interspace from unintentionally varying during operation of the apparatus, but for simplicity these locking means are not shown in the drawing.

In the embodiment illustrated in Figure 4, the interspace is formed as a single cone and is present between an internally conical outer sleeve **35** and an externally conical inner sleeve **36**, the latter being screwed onto a thread of a stem **37**. Also in this case the dog pin **14** is arranged in such a manner that the sleeve **35** is only influenced for rotation about the axis of the shaft **3**.

In the embodiment illustrated in Figure 5, the brake consists of two plates **38** and **39**, to the inner space of which the lubricant is fed from the lubricator cup **16** and is distributed by means of a lubricating passage **40**. The distance between the plates **38** and **39** can be varied by means of a knob **41** engaging a screw thread formed on a hub portion **42** of the disc **31**.

When the grinding or polishing disc **1** rotates, the frictional force effective between the grinding or polishing disc and the samples will exert a resulting torque on the sample holder about the axis of the shaft **3**. With the arrangement illustrated in Figure 1, this torque results from the fact that the frictional force acting on the sample **10** is greater than the frictional force acting on the sample **10*a***. If the shaft **3** is located in a position such that the sample shown in the right-hand side of the figure will cross over to the right-hand side of the axis **2**, the frictional forces on both (or all) samples will act in the same direction of rotation so that the resulting torque will be a sum instead of a difference.

Under the influence of the torque resulting from the frictional forces on the samples, the sample holder will tend to rotate about the axis of the shaft **3**. This rotation is counteracted by the liquid friction in the frictional brake **11—13**, and the sample holder will consequently assume a speed of rotation in which a state of equilibrium exists between the forces involved. This speed may be selected as low as desired by suitably selecting the friction liquid and constructing the frictional brake.

As will be seen, each of the samples engages the grinding or polishing disc at a force which is determined by the gravity of the weight **8**. This force is the same no matter whether one or more additional samples are simultaneously ground or polished, and samples may therefore be inserted and withdrawn at any time even without stopping the apparatus, simply by lifting the rods **7** clear of the samples to be removed or exchanged. If only a single sample is ground at a time it will be necessary to adjust the position of the shaft **3** in such a manner that the path of this sample will circumscribe the centre of the grinding or polishing disc.

Upon removal of a sample, the rod **7** with the weight attached thereto may easily be removed and replaced by another rod if a different weighting is desired.

It will be seen that the rods **7** do not exert any other compulsion on the samples than the vertical loading and the necessary lateral force to make the samples move in the desired path. On the other hand, the samples are free to rotate about the axes of the rods **7** and also to tilt relative to this axis so that they are free to flatly engage the surface of the grinding or polishing disc without restriction or compulsion.

To ensure proper operation of the apparatus illustrated in Figure 1, the samples must be relatively flat, since they will otherwise have a tendency to tilt and dig their edges into the polishing disc, or they may tend to become rounded instead of flat.

Figure 2 shows an embodiment, in which no such restriction is placed on the shape of the samples. On principle, the arrangement is the same as in Figure 1, but in this case the rods **7** do not serve to move the samples, but only to load them. The rods **7** are therefore rounded at their lower ends and engage directly with the plane upper surfaces of the samples or the cups in which the latter are inserted. For the transmission of the braking force to the samples a separate disc **7** connected with the sample holder is used, which disc has holes in which the samples may be inserted with a certain play so that they are free to adjust themselves and to move in accordance with the forces acting on them, the disc **17** only serving as a conveying member for exerting the necessary lateral force on the samples in order to cause the latter to follow the prescribed path. Like in the embodiment of Figure 1, the samples are free to rotate about their axes and usually they will do this when they are in the neighbourhood of the centre so that the sample is oriented in a haphazard manner during use of the apparatus. This self-rotation of the samples is in itself desirable, because it contributes towards varying the direction of grinding in each individual point, but on the other hand, the self-rotation is not essential because grinding will at any rate take place in a multitude of different directions in each individual point of the surface of the sample, depending on the selected distance between the axis **3** and the axis **2**, even if no self-rotation takes place.

It will be seen that the disc **17** is located immediately adjacent the surface of the grinding or polishing disc so that the lateral force is exerted on the samples at a very small distance from the said surface. This is advantageous in order to avoid tendency towards tilting of the samples, and it will be seen that this advantage is obtained no matter whether the samples in themselves have a greater or a smaller height.

At greater pressures, such as ½ to 1 kg. per sample, it may be advantageous to replace the weight loading of the samples by a spring loading. One example of such a construction is illustrated in Figure 6.

Also in this case the top surface of each sample is engaged by a vertically slidable rod **18** corresponding to the rod **7** in the embodiments of Figures 1 and 2. However, the rod **18** instead of being loaded by a weight **8** is loaded by a spring **19** surrounding the rod **18** and acting between an adjustable bush **20** screwed into the upper disc **4** of the sample holder and surrounding the upper end of the rod **18**, and a support **21** surrounding the rod **18** and being displaceable relative thereto, a clamping screw **22** being provided for clamping the support **21** on the rod **18**. When inserting and withdrawing samples, a block **23** may be used, which has two possible positions, one of which is shown in full lines, while the other is shown in chain-dotted lines and denoted by the reference character **23'**. When inserting a sample, the clamping screw **11** is loosened and the block **23** is placed in the position shown in full lines. The rod **18** is now free to slide and under the influence of its gravity comes to rest against the upper face of the sample. Now, the screw **11** is tightened and the block **23** is tilted to the position shown in chain-dotted lines. Hereby the rod **18** is pressed against the upper face of the sample **13** at a spring force determined solely by the adjustment of the bush **20** but independent of the height of the sample, the only consequence of a varying height of the sample being that the support **21** is clamped on the rod **18** in a varying position.

In the embodiment illustrated in Figure 7, a spring loaded rod **18** similar to that in Figure 6 is provided, which rod serves to urge the sample against the upper face of the grinding or polishing disc. A bush **24** surrounding the rod **18** can be clamped to the latter by means of a clamping screw **25**. The bush **24** extends through a collar **26** formed in the upper disc **4** of the sample holder and at its upper end is provided with a screw thread engaged by a nut **27**.

In a similar manner as in Figure 6, the screw **25** is loosened when the sample is to be inserted so that the rod **18** loosely engages the sample. Then the screw **25** is tightened and the nut **27** is turned a certain angle in the outward direction on the screw thread of the bush **24** so that the pressure of the spring **19**, which has hitherto been taken up by the engagement of the nut **27** with the collar of the disc **4**, is now transferred to the rod **18**. In this case, too, the height of the sample has no influence on the spring tension because this is determined solely by the position in which the nut **27** is located while the sample is being inserted. When the sample is to be withdrawn the nut **27** is tightened against the collar **26** so that the spring tension may be maintained after replacement of the sample.

I claim:

1. A grinding or polishing apparatus comprising a frame, a disc mounted in said frame for rotation relative thereto about a first axis, a sample holder rotatably mounted in said frame for free rotation relative thereto about a second axis parallel to said first axis, and liquid brake means including two co-axially mounted brake members, which form a gap between them, which gap is filled with a braking liquid, one of said braking members being drivably connected to the said sample holder while the other brake member is secured to said frame.

2. An apparatus as in claim 1 in which said frame comprises a stationary shaft, on which said sample holder is rotatably mounted, said liquid friction brake means being interposed between said sample holder and said shaft.

3. An apparatus as in claim 2 in which said liquid friction brake means comprises two coaxially mounted sleeves, the inner one of which has an outer diameter smaller than the inner diameter of the outer sleeve so that a clearance is formed between the sleeves, and means for keeping said clearance filled with a high viscosity liquid.

4. An apparatus as in claim 3 in which said sleeves are made from different materials, the material of the outer sleeve having a smaller coefficient of thermal expansion than the material of the inner sleeve.

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