May 15, 1962 K. T. GRUBB ET AL 3,034,266

METALLOGRAPHIC POLISHING

Filed Oct. 3, 1958

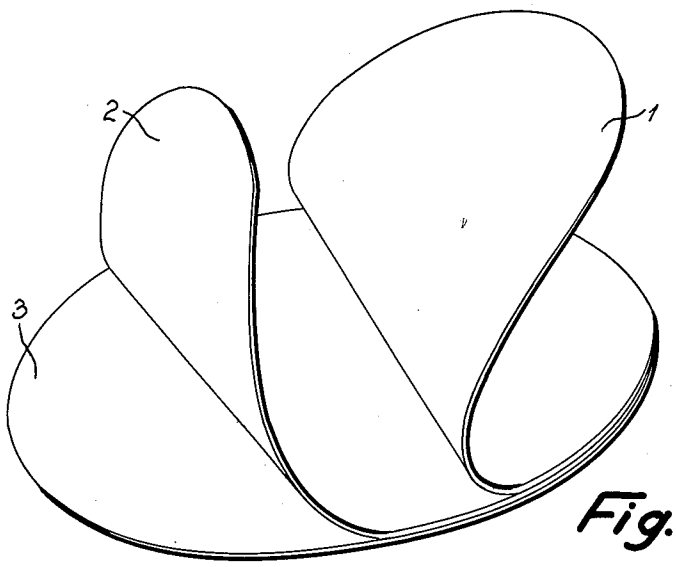


Fig. 1

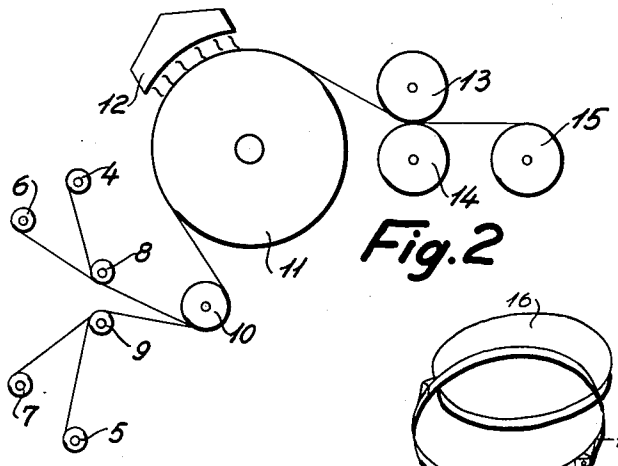


Fig. 2

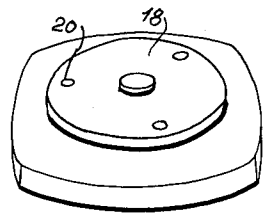


Fig. 3

Fig. 5

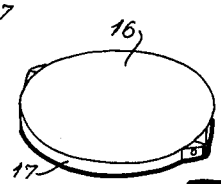


Fig. 6

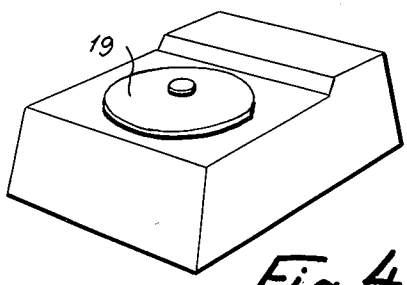


Fig. 4

INVENTORS

Kjeld Vue Grubb and
Bendt Grubb

BY

Watson, Cole, Grindle & Watson

ATTORNEYS

United States Patent Office 3,034,266 Patented May 15, 1962

3,034,266

METALLOGRAPHIC POLISHING

Kjeld Tue Grubb and Bendt Grubb, both of 38 Skindergade, Copenhagen, Denmark

Filed Oct. 3, 1958, Ser. No. 765,223
Claims priority, application Denmark Feb. 7, 1956
1 Claim. (Cl. 51—185)

This application is a continuation-in-part of application, Serial No. 635,810, filed January 23, 1957, now abandoned.

This invention relates to the polishing of metal surfaces with diamond dust for metallographic purposes.

The invention is based on theories regarding the manner, in which polishing should be carried out in order to obtain a polished surface as truly representative as possible of the natural structure of the material and at the same time being as free as possible from scratches of a size to be of disturbance when the polished sample is viewed in the microscope, as is desirable in metallographic polishing.

To illustrate the character of polishing desirable for metallographic purposes, a comparison may be made with the industrial polishing methods used in the making of metal articles. The metallographic polishing differs from the so-called "lapping" process in that the latter is exclusively the result of the cutting effect of the polishing grains, i.e. even with a relatively small microscopic enlargement the polishing scratches resulting from even very small polishing grains, say of particle sizes in the order of 1μ, will be clearly visible. Such scratches should be avoided as far as possible in metallographic polishing.

On the other hand, the process known as "honing," which is used in the manufacturing of metal articles for the purpose of obtaining extremely smooth surfaces, is not recommendable for metallographic polishing, because honing is on principle based on a smearing of the metal particles, whereby a distortion of the true structure of the metal surface takes place, i.e. the mircroscopic picture does not show the true structure of the sample, but a structure resulting from cold working.

In fact, the only known polishing process, which is absolutely distortion free and scratch free, is electrolytic polishing, where the metal molecules are removed from the surface of the metal without any mechanical treatment.

However, electro-polishing is not suitable for use for all metal surfaces. Especially this method fails in the polishing of very heterogeneous materials, such as cast iron and silumin, that contain non-metallic constituents which do not or practically do not take part in the electrolytic process. The same applies to certain slag particles.

There are therefore many cases where it is still necessary to use the mechanical polishing method for metallographic purposes, while in other cases it is desirable to have a mechanical polishing method available as an alternative to electrolytic polishing.

For this purpose it has been proposed to use various abrasives, among these also soft abrasives such as Al_2O_3, MgO or the like. However, such soft abrasives have been found to have a too great smearing effect in many cases, so that the treatment will be similar to honing, and the glossy surface obtained will not be truly representative of the undistorted structure of the metal. Moreover, owing to the relative softness of the abrasive grains, the polishing will consequently take a very long time.

To avoid smearing even of very hard metals and alloys and also to reduce the polishing time, the best polishing grains available are diamond dust. For the reasons explained above with reference to the so-called lapping process it will be understood, however, that the polished surfaces will not be scratch-free, with the exception of very hard materials such as very hard steel, sintered metal carbides etc.

In many cases it has therefore been found necessary in the past to remove the scratches resulting from diamond polishing by a subsequent polishing with a softer polishing material, such as Al_2O_3 or MgO. This, however, is a time consuming and inconvenient complication.

It is the object of the invention to provide methods and means, whereby the polishing properties of diamond dust can be utilized more advantageously, efficiently and economically than with previously known methods.

With this object in mind, according to the invention, use is made of the fact that a polishing cloth, by means of which the polishing is performed, besides serving as a medium for holding the diamond grains also has a smearing effect on the metal surface subjected to polishing. In accordance with the principles of the invention, this smearing effect should not be so great as to distort the true microscopic structure of the metal surface, but on the other hand should be great enough to remove disturbing scratches resulting from the cutting effect of the diamond grains to a greater or smaller extent. As contrasted to the effect of a honing process, the smearing caused by the cloth itself should only result in a submicroscopic displacement of the particles of material in the surface subjected to polishing.

To achieve the object outlined, a suitable balance should be established between the hardness of the metal to be polished, the size of the diamond grains used for the polishing and the hardness of the fibres from which the polishing cloth is made.

Now, when diamond dust is distributed over the surface of a polishing cloth, e.g. by means of a suitable paste in which the diamond dust is suspended in well known manner, some of the grains will penetrate into the polishing cloth, and this process will be continued during use of the polishing cloth. For this reason it is a difficult problem to maintain the balance specified above because the amount of diamond dust in active position on the very surface of the polishing cloth may vary in an uncontrollable manner. The penetration of diamond particles into the interior of the polishing cloth is also disadvantageous in other respects because the consequence is that when a suitable quantity of diamond powder is to be present in the very surface, there must be an excess of diamond powder present in a certain depth below the surface. This excess amount of diamond powder will never be put to use, but will be wasted when the cloth must be discarded after some time owing to the deposition in the cloth of metal particles that have a harmful influence on the polishing effect.

The described waste of diamond powder is very objectionable because the price of diamond powder is rather high.

Based on the recognition described it is attempted according to the invention to carry out the metallographic polishing with diamond dust in such a manner that it is possible to obtain a condition of suitable balance between the various factors as described and at the same time the consumption of diamond powder is kept as low as possible by avoiding the presence of too large quantities of inactive diamond particles in the polishing cloth. According to the invention a method of polishing metal surfaces for metallographic purposes comprises the step of subjecting a surface to be polished to the polishing action of diamond dust distributed over the area of a thin layer of textile fabric superposed on an impervious layer in fixed, non-displaceable connection therewith.

In a polishing cloth of this construction, the diamond powder can only penetrate into the thin surface layer, and the surface of the cloth can therefore be suitably saturated with a considerably smaller amount of diamond powder than hitherto possible. The said impervious layer contributes towards strengthening and re-inforcing the thin surface layer so that the polishing cloth can be stretched tightly on a polishing disc, and since the surface layer is non-displaceably united with the impervious layer and the diamond powder cannot penetrate through the latter, it will never be capable of proceeding to the space between the underside of the polishing cloth and the surface of the polishing disc. This is of advantage because it has been found that when an abrasive is present at this location, it will tend to collect in waves owing to the inevitable displacements of the polishing cloth relative to the polishing disc, which would again result in irregularities of the active surface of the polishing cloth.

According to a preferred embodiment of the invention, said impervious layer is in turn superposed on a cushion layer in fixed, non-displaceable connection therewith. In this manner, a polishing cloth can be obtained which has a suitable softness and volume and at the same time the desirable polishing properties outlined besides the advantage of absorbing a considerably smaller quantity of diamond dust than previously known polishing cloths.

The invention will now be described in further detail with reference to the accompanying drawings, in which

FIG. 1 is a perspective view of a polishing cloth according to one embodiment of the invention, the layers of the cloth being partly separated for better illustration,

FIG. 2 illustrates one way of manufacturing a polishing cloth of the type illustrated in FIG. 1,

FIG. 3 is a perspective view of one form of an apparatus for carrying out the method according to the invention,

FIG. 4 a similar view of another form of an apparatus for carrying out the invention,

FIG. 5 a perspective view of a polishing disc and a clamping ring for use with the apparatus of FIG. 3 or 4, and

FIG. 6 the polishing disc of FIG. 5 with a polishing cloth stretched thereon by means of the clamping ring.

In the drawing, **1** is a layer of woven textile fabric referred to as the surface layer, **2** is a layer which is impervious to diamond particles, this layer being referred to as stop layer, and **3** is a layer of a woven textile fabric referred to as cushion layer. The three layers are united with one another to form a composite sheet of circular configuration adapted to be stretched on the polishing disc to be described in the following with reference to FIGURES 5 and 6.

The surface layer may consist of various materials depending on the material to be polished by means of the cloth. This is easily ascertained by experiments. It is important that the surface layer should not consist of a material which in itself might have a non-desirable smearing effect on the material to be polished, but on the other hand a moderate smearing effect is often desirable to establish the above mentioned balance between the various polishing factors. As an example of a material that has been found suitable in many cases raw silk may be mentioned. This is available in great strength at a small thickness with consequent small depth of penetration of the diamond dust, preferably the thickness of a surface layer of this type should not exceed 0.2 mm. A so small thickness has the further advantage of ensuring the desired flat polishing surface without relief. Moreover, raw silk is relatively resistant to the chemical influences to which the cloth is subjected. Thus, it is sufficiently acid proof to permit the necessary periodical chemical dissolution of metal particles from the metal surface that has been polished, so that the polishing cloth may be chemically reactivated when, after having been used for some time, it has absorbed a so great quantity of metal

particles that these begin to have an unfavourable smearing effect on the surfaces to be treated. In this manner a still greater saving can be obtained of the total quantity of diamond powder used for the polishing. The liquid used for reactivation is usually a weak acid such as 5% HCl or H_2SO_4. Materials capable of withstanding treatment with an acid of this character will in the following be referred to as acid resistant.

For the polishing of relatively soft materials, such as copper and aluminum, it has been found that the smearing effect of a surface layer of raw silk is sometime greater than desirable. A textile fabric, which, due to its extreme softness and acid resistance, is advantageous for use in such cases, is the so-called zein fibre cloth, and it has been found that this should preferably have a thickness not exceeding 0.3 mm. in order to obtain a suitable balance between the cutting effect of the diamond particles and the smearing effect of the fibres of the cloth.

The stop layer may advantageously consist of a thermoplastic material which is united with both said surface layer and said cushion layer by the application of heat and pressure. A layer of this character is suitable for obtaining a high degree of proofness against the penetration of diamond dust and a reliable and undisplaceable union between the various layers. A suitable thermoplastic material for the purpose here in question is polyethylene. Polyethylene has the additional advantage of being able to withstand washing of the composite sheet with an acid, as above mentioned.

If a cushion layer is used, this should preferably also consist of a textile material capable of withstanding washing with a metal dissolving acid. In other respects the choice of this material is not nearly as critical as that of the surface layer. It has been found that raw silk of a similar thickness as specified for the surface layer is also suitable for use as cushion layer, but other materials such as cotton fabric may also be used, and the thickness of this layer may be somewhat greater, but on the other hand not too great because this may undesirably affect the flatness and smoothness of the surface layer.

Examples of polishing cloths are as follows:

Example 1

Surface layer: Silk cloth, plain weave
- Warp: Spun silk yarn, metric count 270/2, 135 ends per inch,
- Weft: Reeled silk yarn, crepe twist 2×12/14 deniers 105 picks per inch,
- Grade: 100% A-grade,
- Weight:

$$14 \text{ mmé} \left(\sim\frac{14{\cdot}36}{10}=50 \text{ g./yd.}\right)$$

Stop layer: Polyethylene sheet, two-layer, 0.03 mm. each, "soft" (low softening temperature)

Cushion layer: Same as surface layer.

Example 2

Surface layer: Zein cloth, plain weave,
- Warp: 2/60 metric count with 780 spinning twist and 760 twisting twist, staplelength 4 inches, 63 picks per inch,
- Weft: As warp,

Stop layer: Polyethylene as under Example 1,

Cushion layer: Silk as under Example 1.

FIGURE 2 illustrates one way of making a polishing cloth according to the invention. **4** and **5** represent supply rollers for a woven fabric of raw silk, **6** and **7** supply rollers for polyethylene sheets, **8**, **9** and **10** guiding rollers, **11** a heating roller, which is internally heated so that the surface thereof has a temperature of about 160° C., **12** an infra red heat radiator, **13** and **14** pressure and cooling rollers, and **15** a take-up roller. With polyethylene as stop layer the laminating temperature may advan-

tageously be about 160° C. and the laminating pressure about 2 kgs./cm.^{2} (28.5 lbs./square inch). The speed of travel may be about 1.7 yards per minute. These figures have been found suitable in manufacturing a polishing cloth in accordance with the above Example 1.

For the polishing cloth of Example 2 the same method may be used, only the roller **5** would then be a supply roller for zein fibre cloth and the operating speed should preferably be somewhat lower, say about 1 yard per minute.

It is important that the heat and pressure in the laminating process should be sufficient to make the polyethylene adhere firmly to the yarns of the woven fabrics, but on the other hand the polyethylene must not become softened to such an extent that it will be squeeezed into the meshes of the woven fabrics. It has been found that the operating conditions specified will fulfill these requirements.

The composite sheet collected on the take-up roller **15** is subsequently cut into circular blanks of suitable size.

For carrying out the polishing according to the invention a composite sheet of the character described is preferably stretched firmly on the surface of a circular polishing disc **16** by means of a clamping ring **17** as illustrated in FIGURES 5 and 6. The polishing disc may e.g. consist of hard polyvinyl chloride, and it may be in the form of a separate part that may be detachably supported either on a stationary base member **18** as illustrated in FIGURE 3 or on a rotatable base member or disc **19** as illustrated in FIGURE 4, e.g. by means of pegs (not shown) on the bottom face of the disc fitting into holes **20** of the base member.

Diamond dust is then applied to the polishing cloth preferably by charging the surface of the latter with a paste in which diamond particles are suspended. Care should be taken to use diamond dust of suitable particle size in order to obtain a suitable condition of balance between the cutting effect of the diamonds and the smearing effect of the cloth itself in accordance with the principles outlined above. Thus, it has been found that with the polishing cloth according to Example 1, the grain size of the diamond particles should preferably not be below 1μ. On the other hand when using the polishing cloth according to Example 2, the grain size of the diamond particles should not exceed 1μ.

In both cases it is desirable to use diamond particles of the greatest possible homogeneity or in other words the range of particle sizes should preferably be small and the proportion of particle sizes close to the optimum value should be as high as possible. The grading of diamond dust for the purposes of the invention should therefore be made with the greatest possible care.

Also the viscosity of the diamond charged paste is of considerable importance in order to obtain best results. It has been found that the synthetic resin Carbo-Wax is a very useful medium as the base of diamond pastes for use with the method according to the invention. Moreover, in order to obtain a suitable viscosity during continued polishing it is desirable that the paste should have lubricating properties which may be obtained by dissolving the synthetic resin above specified in ethanol.

We claim:

A metallographic polishing cloth comprising a thin surface layer of woven textile fabric having a thickness of not more than 0.3 mm., a suspension in a paste-like carrier of diamond dust the particles of which are of the order of one micron in size, said suspension being carried on one face of and penetrating into said surface layer, and a stop layer of material impervious to said suspension united to the other face of said surface layer in fixed connection therewith.

References Cited in the file of this patent

UNITED STATES PATENTS

115,293	Forbes	May 30, 1871
1,227,622	Hope	May 29, 1917
1,332,896	Hoffman	Mar. 9, 1920
1,873,503	Stewart	Aug. 23, 1932
2,237,344	Evans et al.	Apr. 8, 1941
2,403,821	Morgan et al.	July 9, 1946
2,468,853	Williamson	May 3, 1949
2,598,090	Yung et al.	May 27, 1952
2,714,571	Irion et al.	Aug. 2, 1955
2,734,289	Heaton et al.	Feb. 14, 1956

OTHER REFERENCES

Industrial Diamond Review, volume 5, No. 57, August 1954, pages 169 to 181.