Sept. 21, 1943. E. A. KOETHER 2,329,995

GRINDER

Filed Jan. 24, 1940

Fig. 2

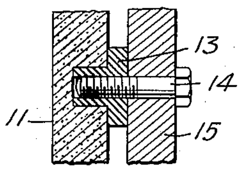


Fig. 6

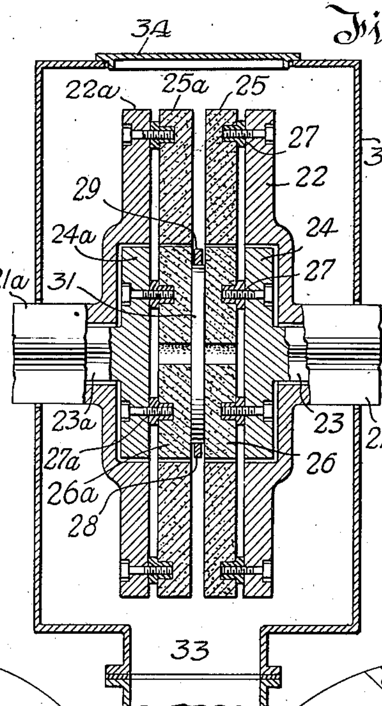


Fig. 4

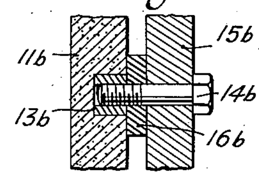


Fig. 3

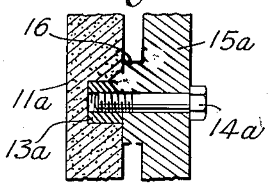


Fig. 5

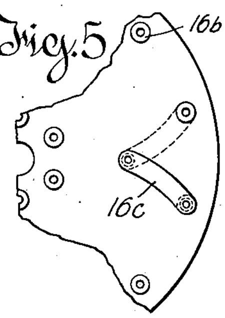


Fig. 1

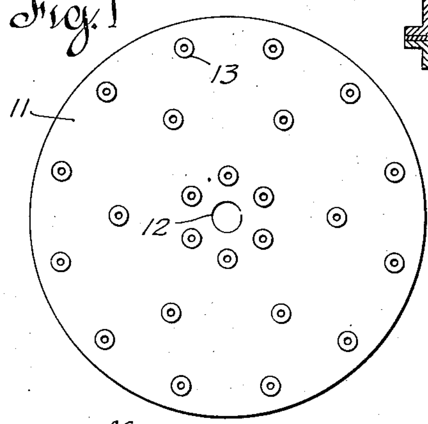


Fig. 7

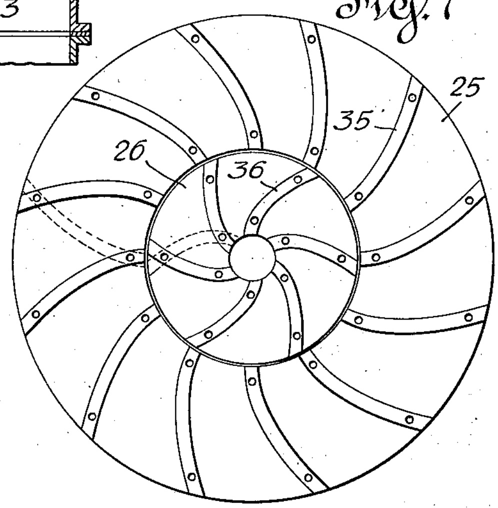
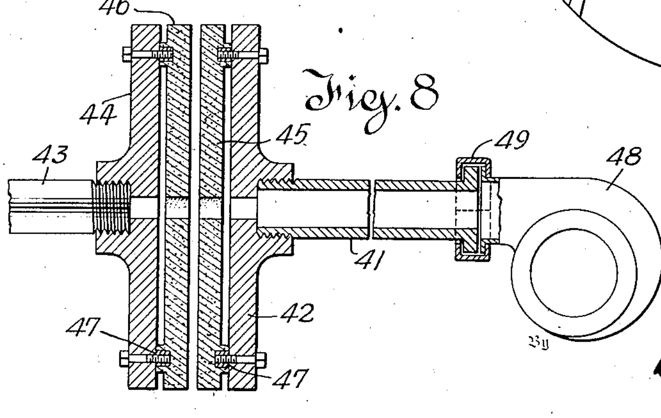


Fig. 8



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UNITED STATES PATENT OFFICE

2,329,995

GRINDER

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Application January 24, 1940, Serial No. 315,438

16 Claims. (Cl. 51—209)

This invention relates to abrading and particularly to means and methods for improving the accuracy of grinding operations by cooling the grinding elements as uniformly and as effectively as practicable and by substantially preventing the transfer of heat from the grinding member to the supporting portions of the grinding machine, particularly the shaft bearings.

Arrest of the flow of heat from the grinding member to such supporting portions is a substantial factor in the attainment of the desired result. Contrary to what might be expected, tests show that arrest of this heat flow (without stimulation of air cooling, and even when the grinding surface of the disc and the air flow over this surface of the disc are the same as with conventional mounts) results in enhanced heat dissipation, as evidenced by marked reduction in the temperature of the discharging ground articles. It is not here intimated that active cooling will not still further improve the operating conditions, particularly with heavy cuts. The significant fact is that arrest of heat flow from the grinding disc to its support has a beneficial effect which is always substantial and under some conditions appears to be as important as stimulated air cooling. Both effects are present in the preferred embodiments of the invention.

While the invention may be adapted to grinders of various types, it finds its greatest utility in connection with face grinders in which an abrasive disc is mounted on a face plate and the grinding is carried out on the plane surface of the grinding disc. Grinders of this type generate heat quite rapidly, and this is particularly true of face grinders in which two opposed discs afford a fixed gap through which the articles to be ground are fed in a substantially continuous stream. A typical example of such grinders is the type used for grinding the plane faces of piston ring blanks and the invention has been applied to this particular class of machine with marked success.

In the prior art, cooling during grinding has been provided for but it has been directed primarily to safeguarding the article being ground against undue heating. Very little consideration has been given in the past to cooling of the grinding elements themselves, or to the idea of maintaining uniformity of temperature as nearly as practicable throughout the grinding disc.

The effects of heat are numerous and diverse, and affect the grinding operation to an extent that was not appreciated until adequate cooling was had. Heating affects accuracy. If the grinding disc is unevenly heated, its form is affected and inaccuracies result. Similarly, if the face plate on which the disc is mounted is heated, and particularly if it is unevenly heated, similar distortions are caused. Finally, transmission of heat to the bearings increases the lubrication problem and requires the bearings to be more freely fitted when cold than would be required if it could be assured that the bearings would run cool at all times.

The present invention involves the mounting of the grinding disc on the face plate in such a way that the grinding disc is spaced uniformly from the face plate, is cooled approximately uniformly on its back face and on its grinding face, and, hence, is conditioned to operate with the utmost precision so far as any distortion of the grinding disc itself is concerned. At this point it may be mentioned that a resin bonded wheel is believed to transmit heat better than a ceramic wheel, so that the problem of uneven heating is less acute with the former than the latter. A Bakelite resin bonded wheel has a coefficient of expansion which approximates that of cast-iron, a point which is not without significance in view of the mode of mounting the discs. Further, the face plate is similarly cooled and it may be remarked that by insulating the connections between the grinding disc and the face plate, the heat is dissipated before it reaches the face plate in any considerable degree.

As a consequence, only a negligible portion of the heat developed by the grinding operation is transmitted through the shaft to the bearings, with the result that the bearings always run under normal temperature conditions and can be fitted with the utmost precision practicable in the bearing art, without risk that they will ever run hot.

All of these factors contribute to accuracy of grinding, but they have another and unexpected secondary result. The rate of development of heat increases rapidly as the abrasive becomes finer, and the heat effects impose a practicable limit on the fineness of the abrasive used in commercial grinding operations in which a substantial production rate is to be maintained. The effective and uniform cooling characteristic of the present invention permits the use of much finer abrasive at commercial rates and actually permits the production by grinding operations of finishes not heretofore commercially produced except by the coarser lapping operations. Since the production rate of a grinder is many times that of a lapping machine, the commercial importance of this secondary result is marked.

The invention contemplates the support of the disc on the face plate in such a way that the closest practicable approach to a continuous air gap between the disc and the plate is afforded. It contemplates further, the flow of air between the proximate faces of the grinding discs where two opposed discs are used and the flow of air between each disc and its face plate. In refined embodiments of the invention, the connections between the grinding disc and the face plate are thermally insulated.

While a useful and highly effective circulation can be produced by shrouding the grinding discs, drawing air from the shroud adjacent the peripheries of the grinding discs and admitting air to the shroud at a diametrically opposite point, better results can be secured by intensifying the air circulation. This can readily be effected by the use of hollow shafts through which air is delivered to the center of the disc. This air flows freely radially outward and discharges at the periphery of the disc. This direction of flow is advantageous because the greatest heating occurs at the center of the disc, at which point the coolest air is available. The desired circulation will be induced by a centrifugal blower action and may be intensified by shaping the connections between the disc and its face plate to the form of impeller blades, or, if preferred, a separate blower can be used to force air through the shaft. It is even possible to use an exhausting blower to draw air out through the shaft, but in such case, the direction of flow of the air in the interval between the disc and the face plate will not only be reversed but will be opposed to the natural centrifugal tendency. For that reason, the last-named arrangement is not considered desirable.

In referring to air as the cooling medium, its ready availability is a controlling consideration and the possible use of other gases is appreciated.

As indicative of the importance of the invention, it may be said that precision is appreciably improved, the over-all life of a grinding disc is increased by about one-fifth of its normal life as heretofore used, and the periods when the machine is out of operation for the purpose of dressing the discs are reduced by about one-third of the number of such periods formerly required. Thus, productivity of the grinding machine is substantially increased. The figures given are conservative and are exceeded in certain types of grinding operations.

The possibility of using finer grits on the wheels has already been suggested. This possibility arises from a reduced tendency to glaze. There is also less tendency of the grinding disc to assume what the operators call a "smeary" appearance. This appearance is attended with impairment of the grinding operation and while the exact cause is not known, it has been attributed on inconclusive evidence to fusion and flow of the bond in the grinding disc, particularly in resin bonded wheels.

In illustrating the invention, the effort will be to indicate controlling principles and to avoid the illustration of details of the grinding machine except where these enter into or affect, in one way or another, attainment of the desired results.

The manner in which the circulatory flow of air is induced is a secondary consideration and subject to variations to meet requirements of particular cases. The path of flow of the air is much more important, but it, too, is subject to some variation to conform to limits imposed by the nature of the grinding machine or to meet special requirements incident to the form or material of the piece to be ground.

The preferred embodiment of the invention will now be described in connection with the accompanying drawing, in which:

Figure 1 is a view of the rear face of a grinding disc showing the connecting bushings arranged according to a pattern known in the face-grinding art, but indicating the use of special connections according to the present invention.

Fig. 2 is an enlarged fragmentary section showing the connection between the disc of Figure 1 and the face plate upon which it is mounted;

Fig. 3 shows a modified construction in which the separating pieces are formed on the face plate;

Fig. 4 is a further modification in which the separating members are independent of the grinding disc and of the face plate;

Fig. 5 is a fragmentary view of a similar portion of Figure 1, and indicating the use of independent separators such as those shown in Figure 4, to produce an impeller blade in the air gap between the grinding disc and the face plate.

Fig. 6 is an axial section through the grinding elements of a double disc grinder constructed according to the patent to Koether, No. 2,169,252, dated August 15, 1939, and indicating one mode of applying the invention which has demonstrated marked utility. In this view the supporting bearings and driving motors are not indicated, the purpose being to simplify the view by limiting it to those feature which are directly involved in the cooling function;

Figure 7 is a rear face view of a modified form of grinder disc which may be used in the structure of Figure 6 and which affords a definite impelling action designed to intensify the cooling effect; and

Fig. 8 represents the grinding elements of an opposed disc machine in which one of the shafts is hollow and serves as a conduit to deliver air under pressure for cooling both discs.

In Figure 1, **11** represents the grinding disc. This is provided as usual with an aperture **12** at its center and is provided at its rear face with a number of tapped inserts **13**. These inserts are of a form better shown in Fig. 2 and receive bolts **14** which pass through the face plate **15** of ordinary form and connect the grinding disc to the face plate rigidly while maintaining between the proximate faces of the plate and disc, that is, between the forward face of the plate and the rear face of the disc, an air gap which is substantially continuous.

The inserts **13**, indicated in Figure 2, are formed to include the spacing elements, but this is not strictly necessary as alternative constructions are possible. For example, in Figure 3, the grinding disc **11a** has inserts **13a** which are tapped but which are flush with the rear face of the grinding disc. The face plate **15a** is formed with small bosses **16** through which the bolts **14a** pass. The effect is the same as the construction shown in Figure 2.

Another alternative structure sometimes preferred is shown in Fig. 4, in which, instead of a boss **16** as shown in Fig. 3, there is a separate insert **16b** interposed between the disc **11b** and the face plate **15b**. In this case, the inserts **13b** are identical with inserts **13a** of Fig. 3. The disc

16b can conveniently be made of heat insulating material, and while the use of this material is in the nature of a refinement, it is desirable.

In Fig. 5, which is a fragmentary view similar in proportion to Fig. 1, separate spacers 16b are used, but in lieu of certain of these, elongated spacers 16c are substituted. They span certain inserts in the two outer rows and form impeller blades.

In assembling the disc with the face plate, the spacers 16c can be set for either direction of rotation of the disc, that is, they may take the full line position, or, in lieu thereof, the dotted line position. This scheme involves no change in the spacing of the inserts indicated in Fig. 1, and offers a convenient means to secure an impeller action which may be adapted for either direction of rottaion of the disc, due regard being had for the desired direction of flow of the air which is usually radially outward, but not necessarily so.

The arrangements so far described contemplate that the simple rotation of the grinding disc and its face plate will induce active flow of air through the interval between the face plate and the disc and usually this air will enter the central aperture 12 and flow outward. Practically all grinding wheels are shrouded or enclosed and the shroud is provided with an air suction connection which, in the old type of grinder was designed chiefly to carry away dust. According to the present invention, this offtake assumes a new and secondary function of stimulating cooling air flow, and for best results it is considered desirable to increase the suction beyond that customarily used heretofore, thus circulating a greater quantity of air, to secure an adequate cooling effect.

Face grinding machines using a single grinding disc are known, but a more desirable form involves the use of two grinding discs. One form using two opposed discs, shown in the patent to Morton, No. 1,640,715, dated August 30, 1927, has the axes of the discs offset. The present invention can be used in such grinders. However, the offset disc type of grinder is being supplanted by the double disc type of grinder shown in the patent to Koether, above identified, in which there are two pairs of coaxial discs opposed to each other. The inner and outer discs of a given pair have their grinding faces in the same plane, and they are driven at different speeds, and quite commonly in opposite directions. These details depend on the type of finish desired.

The purpose of subdividing one grinding unit into two concentric parts driven at different angular velocities is to secure higher lineal speeds in the central grinding area so that the disparity between grinding speeds near the center and at the outer limits will not be too great.

A grinder of this type is indicated in Fig. 6. 21 represents the outer shaft for the right-hand outer face plate 22, and 23 represents the inner shaft for the right-hand inner face plate 24. There are similar left-hand units which bear similar reference numerals with the distinguishing letter *a*.

Mounted on the face plate 22 is an annular grinding element 25 and mounted on the face plate 24 is a smaller annular grinding element 26. These have their grinding surfaces in the same plane and their axes are concentric, so that the inner grinding unit 26 turns concentrically within the outer unit 25. Each of the grinding elements is connected to its face plate by rigid spacing connections generally indicated by the reference numeral 27, and illustrated as conforming to the showing in Figure 2.

Any of the arrangements illustrated in Figs. 2 to 4 can be used without affecting the mode of operation of the device.

A pair of trackways 28 and 29 extend between the discs and are narrower than the interval between the grinding faces. These serve to guide a series of piston ring blanks, one of which appears at 31 in a traverse diametrically through the interval between the grinding discs.

The construction of the guide is not material to the present invention, but is clearly shown in the Koether patent above identified.

Enclosing the grinding discs is a shrouding structure indicated at 32. This has at its bottom a large suction duct 33 which is connected through a dust-collecting means (not shown) to an exhausting blower (not shown). An access opening at the top is loosely covered by a cap 34 and air enters quite freely around this cover, and also through the slots which accommodate the guide tracks 28 and 29.

Grinding discs rotate at quite high speeds and there is a moderate centrifugal impelling effect so that air is drawn in through the central aperture of the inner grinding member and flows thence outward through the intervals between the various grinding members and their face plates. The effect is to keep the grinding members cool and at uniform temperature, front and back. As indicating the effectiveness of such cooling, it may be said that a given grinder of the type illustrated in Figure 6 operating according to the invention, is so effectively cooled that immediately after it is stopped, it is possible to place the hand on the grinding surface even of the inner disc which is the one where highest temperatures always exist.

Prior to the application of the invention, so much heat was developed and transmitted through the shafts to the bearings that after the machine had been running for two hours or more, the bearing housings were too hot to touch. After the application of the invention, the bearings were only slightly warm following many hours of running.

In Figure 7, a modified construction is illustrated. This view represents the backs of the two concentric grinding elements used in the structure of Figure 6. Curved spacers 35 are used and those for the outer grinding member 25 are set reversely as compared to the spacers 36 for the inner grinding member 26. It is here assumed that the two grinding members are to run in opposite directions. To accommodate reversal of direction of rotation, it is necessary only to reverse the spacers 35 and 36, either or both, as the case may be. It will be observed that this assembly is possible because the spacing of the connections is symmetrical in at least two circumferential series. See the dotted showing of one blade reversed.

While the cooling circulation with a structure such as that shown in Figs. 1 to 4 and 6 is satisfactory, for all practical purposes, and can be increased if desired by the simple expedient illustrated in Figs. 5 and 7, it is possible and would be desirable in certain extreme cases to mount a face plate on a hollow shaft and deliver air under pressure through the center of the face plate. A diagram illustrating such a scheme is shown in Fig. 8. In this figure, the tubular shaft 41 carries a face plate 42 and an axially aligned shaft 43 carries a face plate 44. The shaft 43 could be solid, as sufficient air can be furnished through one shaft, but it would involve mere duplication to apply the scheme to both the shafts **41** and **43** in the exact manner shown for shaft **41**.

Face plate **42** carries a grinding disc **45** and face plate **44** carries a grinding disc **46**, there being spacing connections generally indicated at **47**, in each case. Both discs and both face plates have apertures at the center, as shown, in free communication with the interior of the hollow shaft **41**. Some means of supplying air under pressure to the hollow shaft **41** may be used, for example, a rotary blower generally indicated at **48**. This has a swivel connection at **49** with the end of the hollow shaft **41**.

Air delivered by the blower **48** would flow outwardly between each grinding disc and its face plate and also between the proximate faces of the two opposed grinding discs. The spacing of the connections between the grinding discs and the face plates may follow the showing in any of the various figures. If the arrangement of Fig. 5 be adopted, the effect would be either to assist the blower **48** or even to render it unnecessary.

The purpose in illustrating various modified forms is to suggest the wide latitude possible in applying the invention. The inventive concept is not limited to any particular manner of circulating the air. It resides rather in the idea that the grinding discs are supported in such a way that a heat-insulating air gap is afforded between the disc and the supporting face plate and some means is provided to cause or permit circulatory flow of air. The effect is to dissipate the heat and maintain the grinding discs at substantially uniform temperature throughout the grinding operation. The result is to cause the discs to run cooler and truer. The interception of the heat which would otherwise be conducted to the shafts and bearings performs very valuable functions which have already been described in considerable detail, and which are useful irrespective of intensive air cooling.

What is claimed is:

1. A grinding unit comprising a rotatable face plate; a face grinding disc approximately coextensive with said plate; spaced connections rigidly connecting said plate and disc; spacing means associated with said connections and formed to preserve a substantially continuous air gap between the plate and disc, at least some of them being formed to serve as air impelling means when the unit is rotated; and means forming an air passage communicating with said air gap near the axis of rotation of the unit.

2. The combination defined in claim 1 in which at least the spacers having impelling characteristics are reversible to reverse their impelling characteristics and thus permit alternative assemblies for opposite direction of rotation of the unit.

3. The combination defined in claim 1 in which the air passage leads through the face plate.

4. In a grinding machine, the combination of a rotatable face plate; a face-grinding disc approximately coextensive with said plate; spaced connecting means rigidly connecting said plate and disc and serving to preserve an approximately continuous air gap between the plate and disc; and air circulating means for causing air to pass continuously through said air gap.

5. A grinding machine comprising a rotatable face plate; a face-grinding annulus approximately coextensive with said plate; spaced connecting means rigidly connecting said plate and annulus and serving to preserve an approximately continuous air gap between the plate and annulus; work-guiding means; a shroud enclosing said plate and annulus and said work-guiding means; a suction offtake leading from said shroud at a point adjacent the periphery of said annulus and plate; and means for admitting air to said shroud and so directing its flow that at least a portion of such air passes through the center of the annulus to the air gap and flows radially outward through the air gap to said offtake.

6. A grinding machine comprising a rotatable hollow shaft; a face plate carried thereby; a rigid face-grinding disc of substantial thickness and composed of abrasive material, said disc being approximately coextensive with said face plate; spaced connecting means rigidly connecting said plate and disc and arranged to preserve an approximately continuous air gap between the plate and disc; and means for circulating air through said shaft to the center of said air gap whereby an outward flow of air through the air gap is assured.

7. A grinding machine comprising two rotatable grinding units mounted in face-to-face relation with an interval between the same, each grinding unit comprising a rotatable face plate, a face grinding annulus approximately coextensive with said plate, and spaced connecting means rigidly connecting each annulus with the corresponding plate and serving to preserve an approximately continuous air gap between the plate and annulus; shafts upon which said face plates are respectively mounted, at least one of said shfts being hollow; and means for delivering air under pressure to said hollow shaft whereby air is supplied at their centers to the air gaps between the face plates and annuli, and to the interval between the proximate faces of the annuli.

8. The combination with the structure defined in claim 7 of guiding means for work pieces, a shroud partially enclosing said guiding means and enclosing said grinding units, and an air offtake leading from said shroud at a point adjacent to the peripheries of said grinding units.

9. The method of controlling heating effects in a rotary face grinding disc of substantial thickness and composed of abrasive material, which comprises so mounting the disc for rotation that its rear and front faces are exposed over substantially their entire superficial areas, and circulating confined streams of air over both surfaces.

10. The method of controlling heating effects in a rotary face grinding disc of substantial thickness and composed of abrasive material, which comprises so mounting the disc for rotation that its rear and front faces are exposed over substantially their entire superficial areas, and circulating confined streams of air from the center outward over both surfaces.

11. A grinding machine comprising a rotatable face plate; a rigid face-grinding disc of substantial thickness and composed of abrasive material, said disc being approximately coextensive with said plate; spaced connecting means rigidly connecting said plate and disc and arranged to preserve an approximately continuous heat insulating zone between the plate and disc; and means to guide articles to be ground in a path of limited width across and in contact with said

disc, whereby only a portion of the disc is active at any one time.

12. The combination defined in claim 11 in which the spaced connecting means have heat insulating characteristics.

13. A grinding machine comprising a rotatable face plate; a rigid face grinding disc of substantial thickness and composed of abrasive material, said disc being approximately coextensive with said plate; spaced connecting means rigidly connecting said plate and disc and arranged to preserve an approximately continuous air gap between the plate and disc; means providing an air passage leading to such air gap near the axis of rotation of the disc; and means to guide articles to be ground in a path of limited width across and in contact with said disc, whereby only a portion of the disc is active at any one time.

14. The combination defined in claim 13 in which the air passage leading to the air gap takes the form of a central aperture through said disc.

15. A grinding machine comprising two rotatable grinding units mounted in a face-to-face relation with an interval between the same through which interval the articles to be ground are passed, each grinding unit comprising a rotatable face plate, a rigid face grinding annulus approximately coextensive with said plate, and spaced connecting means rigidly connecting each annulus with the corresponding plate and arranged to preserve an approximately continuous heat insulating zone between the plates and the annuli.

16. A grinding machine comprising two rotatable grinding units mounted in a face-to-face relation with an interval between the same through which interval the articles to be ground are passed, each grinding unit comprising at least two coaxial independently rotatable face plates, rigid face grinding annuli approximately coextensive with each of said plates, and spaced connecting means rigidly connecting each annulus with the corresponding plate and arranged to preserve an approximately continuous heat insulating zone between the plates and the annuli.

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