July 30, 1946. A. J. BEVILLARD 2,405,086

METHOD OF MAKING ABRASIVE WHEELS

Filed July 19, 1944

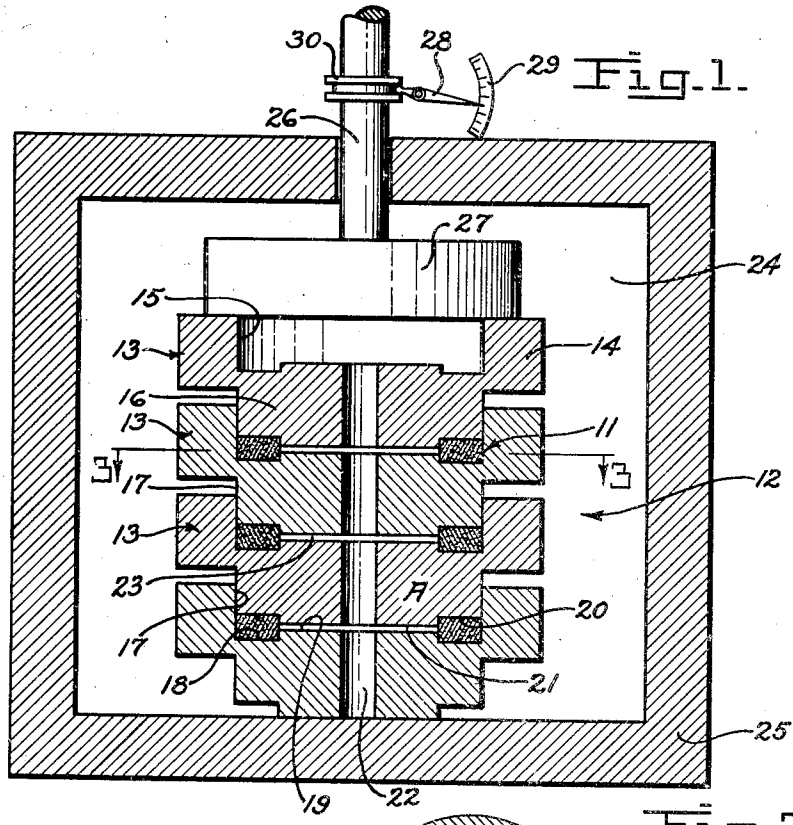


Fig. 1.

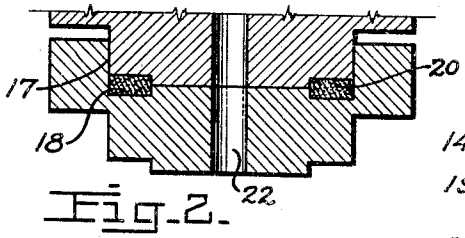


Fig. 2.

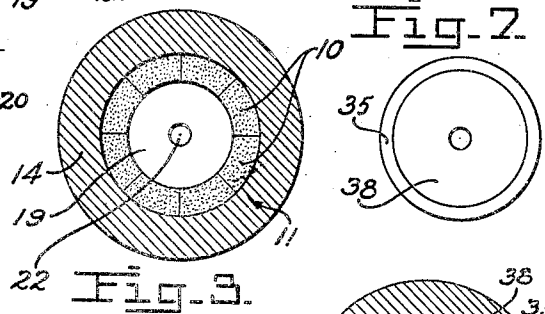


Fig. 3.

Fig. 7.

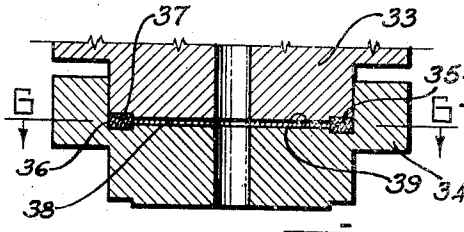


Fig. 4.

Fig. 5.

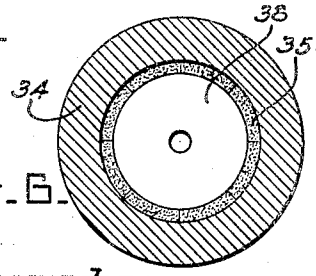
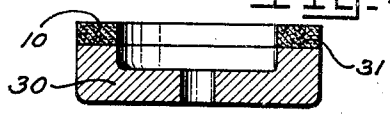


Fig. 6.



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METHOD OF MAKING ABRASIVE WHEELS

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Application July 19, 1944, Serial No. 545,657

11 Claims. (Cl. 51—309)

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This invention relates to the manufacture of abrasive wheels, and has for its primary objective to provide a method particularly adaptable to the making of relatively large diameter abrasive wheels whose manufacture in the past has not been practicable by reason of certain inherent requirements of the manufacturing process and limitations of the necessary equipment.

Typically, the invention is directed to the making of tools comprising an initially compressed or compacted abrasive annulus secured or bonded to a disc or wheel body. In accordance with the usual manufacturing process, the abrasive annulus is formed of an intimate mixture of powdered metal and finely divided abradants, such as diamond grit, molded and compacted in a continuously annular form under extremely high pressures, say in the neighborhood of 40,000 to 60,000 pounds per square inch. According to the customary practice, the compact is heated to a sintering temperature, i. e. a temperature sufficiently high to produce a limited or incipient fusion of the metal particles causing them to bond together at their boundaries. The resulting mass is known as a sintered product, characterized by the quality of cohesion between the constituent metallic particles and also an essentially porous formation. In considering the present invention, the distinction should be borne in mind between a sintered mass and an alloyed metallic body resulting from the heating of powdered metal or mixture of metals to a temperature beyond the temperature of incipient infusion, and to a degree at which the metal particles melt to form an alloy solution resulting, upon cooling, in a non-porous body or alloy of uniform composition.

Because of the extremely high pressures required for proper compression of the powdered metals to form the sintered body or annulus, a practical limitation has been placed upon the size (area) of the compact that can be compressed by presses of practical size and capacity. Accordingly, it has developed that of necessity, the sizes (diameters) of the sintered abrasive wheels have been limited, notwithstanding the need and desirability for making them available in larger sizes. My major object is to provide a process whereby the completed wheels or abrasive annuli may easily be made in any desired sizes and diameters, and whereby the presently manufactured larger size wheels and abrasive annuli may be more simply and economically manufactured than is possible by existing methods.

The invention obviates the necessity under conventional practices of high pressure compression

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of the entire annulus, by initially molding and compacting only segments thereof sufficiently small to conform with the capacity of ordinary size presses. Then, after formation of the individual segments, the latter are placed contiguously in annular arrangement and fused together or integrated to produce a completed abrasive mass of uniform and continuously annular composition.

In accordance with my preferred procedure, the invention departs from conventional practices with respect to the form and composition of the abrasive annulus, and when affixed to the cutter body or wheel in the same heating operation used to finally form the annulus, with respect also to the nature and composition of the bond between the wheel body and the annulus. Briefly, the invention contemplates formation of an annulus consisting of abrasive particles uniformly distributed throughout a non-porous matrix alloy, as distinguished from a sinter, itself having an alloy bond with the metal of the wheel body. Further, the invention provides a novel method whereby in a single heating operation it is possible to accomplish a triple effect in fusing together and integrating compact segments, converting the matrix metals into a true alloy, and simultaneously forming an alloy bond with a metallic wheel.

For present purposes I may employ methods for forming an abrasive annulus, and for simultaneous formation and bonding of an abrasive annulus to a metallic wheel, disclosed respectively in my co-pending applications Ser. No. 545,656 on Manufacture of abrasive wheels, and Ser. No. 545,655 on Abrasive wheels, both filed on even date herewith.

Further objects and details of the invention will be more fully understood from the following detailed description, throughout which reference is had to the accompanying drawing in which:

Fig. 1 is a sectional view of the furnace and mold assembly containing the segmental compacts in the condition prior to their heating and integration;

Fig. 2 is a fragmentary sectional view showing the relative positions of adjacent mold sections upon heating the compact to alloying temperature;

Fig. 3 is a cross-section on line 3—3 of Fig. 1;

Fig. 4 shows the abrasive annulus applied to a wheel;

Fig. 5 is a view similar to Fig. 2 illustrating a variational embodiment of the invention;

Fig. 6 is a cross-section on line 6—6 of Fig. 5; and

Fig. 7 is a side elevation of the abrasive wheel formed in the operations illustrated in Figs. 5 and 6.

Referring first to Figs. 1 through 3, the general purpose of the method therein illustrated is to form a relatively large diameter abrasive element or annulus by first molding individual segments under high pressures, and to then place the segments in circular arrangement within the mold assembly of Fig. 1 and therein heating the initially segmental annulus at temperature and pressure conditions resulting in fusion together and conversion of the segments to an alloy, to produce an integrated, continuous annulus of non-porous and uniform composition. Referring to Fig. 3, I first mold individually the segments 10 of a metallic composition capable of conversion to an alloy. Used as a matrix for finely divided diamond particles, the metal or metals additionally are selected to effectively bond with and retain the diamonds and to have such wear-resisting qualities that the alloy will not tend to wear away excessively in advance of the diamonds. Typically, the matrix metals may comprise a powder mixture of copper, 30% to 60%, nickel, 60% to 30%, and minor percentages of precipitation hardening agents such as iron, silicon, chromium, titanium, manganese, beryllium, aluminum, or boron. As a specific example, the alloy metals may be composed of 47.5% copper, 47.5% nickel, 3% chromium, and 2% silicon, the mixture having a melting temperature around 1250° C. The powdered alloy metals may uniformly be mixed with finely divided diamond particles or grit, preferably of such fineness as to pass a standard 20 mesh screen. The smallest diamond particles may be sufficiently fine to pass a 400 to 500 mesh screen.

The metal and diamond particle mixture initially is compressed under very high pressure to form individually the compact segments 10, preferably of definite shapes and dimensions so as to be capable of placement in the mold assembly of Fig. 1 and with close dimensional relationship to the mold parts. In the broad aspects of the invention, the segments 10 may have any suitable shape in accordance with the type and form of tool to which the alloyed abradant is to be applied. Typically, the units 10 are shown to be segments of an annulus having uniform width and thickness. Hereinafter, the annular assemblage of the segments 10, is referred to as "the compact 11."

Quantity production of the abrasive elements is greatly facilitated by conversion of the compacts to alloyed composition in a multiple mold assembly 12 as illustrated in Fig. 1. The latter comprises a plurality of relatively movable nested sections 13, of which there may be any desired number, preferably arranged in vertical series so that downward application of pressure to the top section may be transmitted through the mold assembly and to the individual compacts, as will appear. Each section comprises an upper flange portion 14 containing a cylindrical bore 15, and a lower portion 16 having a cylindrical surface 17 corresponding in diameter to the bore 15 of the section next below, so that when nested as illustrated, the contacting surfaces of the sections are in close engagement. Each mold section contains an annular recess 18 about the flat surface 19, and an opposed complementary annular recess 20 about the bottom surface 21. The mold

sections may have alined central openings 22. It is preferred to make the sections of refractory material which is heat-conductive and has the ability to retain its shape and dimensions after repeated heatings and uses.

The transverse shape and dimensions of the compacts 11 preferably are made to correspond closely with the corresponding dimensions of the recesses 18 and 20, and as illustrated, the compacts initially are confined by the engaging mold surfaces except at the inside where the bottom surface 21 of an upper section is spaced at 23 from surface 19 of the section next below. Also the dimensions of the compacts and the spacing at 23 between the mold sections preferably are carefully predetermined so that surfaces 19 and 21 will interengage, as in Fig. 2, as a result of volume diminution of the compacts when substantially the melting temperature of the metals is reached.

The mold assembly 12 is contained within the chamber 24 of a furnace 25 of any suitable type within which the molds and compacts may be heated to proper temperature, which preferably will not be permitted to exceed around 1400° C. The mold assembly is heated in a reducing atmosphere, which may be provided by introducing to the chamber 23 a gas such as hydrogen, natural gas, or coal gas.

Pressure is applied to the mold assembly by means of a plunger rod 26 bearing against member 27, the plunger being operated by suitable means, not shown, such as an air cylinder by which a determinable pressure may be applied to the mold assembly. Ordinarily the effective pressure applied to the surfaces of the compacts 11 need only be relatively low, and only sufficient to collapse voids and gas pockets in the melted matrix metal. Downward movement of the plunger 26 is indicated by suitable means such as a pointer 28, scale 29 and a ferrule 30 carried by the plunger and within which the pointer is retained.

In the process of alloying the compacts and integrating the segments 10, the mold assembly is heated while the compacts are maintained under pressure transmitted through the mold assembly from the plunger 26. Particularly as the compacts 11 approach melting or alloying temperature, their volumes reduce, permitting downward relative movement of the mold sections and of the plunger 26, the latter to a degree corresponding to the aggregate of the relative movements of the mold sections. As the compacts reach an initial melting temperature, they undergo a relatively rapid volume reduction, as indicated by corresponding movement of the indicator 28. At that instant, the operator interrupts the furnace heat supply so that the final temperature to which the matrix metals are heated will not rise excessively above that temperature at which the metals are melted sufficiently to fuse together the segments 10 and form a continuously annular non-porous alloy of uniform composition. The principal objective in limiting the temperature rise is to keep the viscosity of the melted metal sufficiently great that the diamonds, by reason of their lower specific gravity, will not tend to rise within and segregate at the surface of the metal, but instead will remain in the desired state of uniform distribution throughout the alloy solution.

As will be understood, upon cooling the metal solution forms a solid matrix alloy about the diamond particles, and the alloyed abrading ele-

ment then may be applied and secured to a tool body or wheel. As illustrated in Fig. 4, the alloyed annulus 11 may be applied to a cup wheel 31 of any suitable material, and bonded to the face 32 thereof by an adhesive of the type commonly used for bonding a metallic part to the surface of another member.

Figs. 5, 6 and 7 illustrate a variational adaptation of the invention in alloying and bonding a segmental compact to a metallic wheel, all in a single heating and molding operation. Here the mold sections 33 and 34 are adapted to be nested and to receive pressure during the heating operation, in essentially the same manner described with reference to Fig. 1. The compact 35, consisting of annularly arranged segments 35*a* of the matrix metals and diamond particles, initially are formed and compressed under high pressure as previously described, and placed between the mold sections so as to be received within annular recesses 36 and 37 about a disc 38, made for example of mild steel, resting on the mold surface 39. An initial slight annular clearance may be provided between the periphery of the disc and the compact in order to allow for radial expansion of the disc into engagement with the compact without excessively penetrating the latter. The axial dimension of the compact is predetermined with reference to its volume reduction upon heating to the alloying temperature, so that initially the bottom surface of mold section 33 is spaced at 39 above the disc 38, thus permitting downward relative movement of the mold section 33 until a melting or alloying temperature is reached, at substantially which point the disc 39 is engaged by the mold section above to arrest its further downward relative movement.

During the heating stage, downward pressure is applied to the mold section 33 in the manner previously described, and the furnace heat is interrupted upon relatively sudden or rapid volume reduction of the compact 35, as indicated by the pointer 29. A triple effect results in that the compact metals are converted to an alloy solution, the segments 35*a* are fused together and integrated, and a true alloy solution of the disc and matrix metals is formed at the peripheral surface of the disc. Also downward movement of the upper mold section will have become arrested by engagement with the disc 38 to confine the annular space containing the alloy solution. As before, the viscosity of the solution will be kept sufficiently great to prevent floating and segregation of the diamonds.

Upon cooling and removal from the mold, the completed abrasive wheel shown in Fig. 7 consists of a continuously annular rim 35 of substantially non-porous uniform composition alloy within which the diamond particles are uniformly distributed, and which has an alloyed bond with the peripheral edge of the disc 38.

In carrying out both of the described methods, it may be desirable to preclude the possibility of surface reaction of the metals with the mold surfaces. For this purpose I may apply to the mold surfaces engageable with the compacts and with the disc, a coating of suitable inert protective material such as pulverized silica admixed with sodium stearate in alcohol as a binder, and a colloid such as tannic acid.

I claim:

1. The method of making an abrasive annulus for tools of the character described, that includes compacting under pressure a pulverulent metal and abradant composition to form individual segments of the annulus, placing said segments in annular arrangement and heating the segments to a temperature at which said segments fuse together, and cooling the resulting mass to form a continuously annular integrated and homogeneous body of the solidified metal.

2. The method of making an abrasive annulus for tools of the character described, that includes compacting under pressure a pulverulent metal and abradant composition to form individual segments of the annulus, placing said segments in annular arrangement and applying pressure uniformly thereto while heating the segments to a temperature at which said segments fuse together, and cooling the resulting mass to form a continuously annular integrated and homogeneous body of the solidified metal having substantially uniform composition.

3. The method of making an abrasive annulus for tools of the character described, that includes compacting under pressure a mixture of finely divided matrix metals and abrasive particles to form individual segments of the annulus, placing said segments in annular arrangement and heating the segments to a temperature at which said metals melt to form an alloy solution and the segments fuse together, and cooling the resulting mass to form a continuously annular integrated and homogeneous body of solid alloy within which the abrasive particles are embedded and uniformly distributed.

4. The method of making an abrasive annulus for tools of the character described, that includes compacting under pressure a mixture of finely divided matrix metals and abrasive particles to form individual segments of the annulus, placing said segments in annular arrangement within a mold and applying pressure uniformly to said segments while heating the mold and segments to a temperature at which said metals melt to form an alloy solution and the segments fuse together, and cooling the resulting mass to form a continuously annular body of substantially non-porous alloy of uniform composition and within which the abrasive particles are embedded and uniformly distributed.

5. The method of making an abrasive annulus for tools of the character described, that includes forming a mixture of matrix metal and abrasive particles into individual segments of an annulus, placing said segments in annular arrangement and heating the segments to a temperature at which the matrix metal melts and the segments fuse together, and cooling the resulting mass to form a continuously annular integrated and homogeneous body of solid metal matrix within which the abrasive particles are embedded and uniformly distributed.

6. The method of making an abrasive annulus for tools of the character described, that includes compacting under high pressure finely divided metals and abrasive particles to form individual segments of the annulus, placing said segments in annular arrangement and heating the segments to a temperature at which said metals melt to form an alloy solution and the segments fuse together, cooling the resulting mass to form a continuously annular integrated and homogeneous body of solid alloy, and securing said body to a metallic wheel by a bond composed of an alloy of the metals of said body and wheel.

7. The method of making an abrasive annulus for tools of the character described, that includes compacting a mixture of finely divided matrix metals and hard abrasive particles to form indi-

vidual segments of the annulus, placing said segments in annular arrangement adjacent a surface of a metallic wheel, heating the segments and wheel to a temperature sufficiently high to form a completely liquefied alloy solution of the metals and an alloy solution of said metals with the metal of said wheel surface, and cooling said solutions and wheel to form a continuously annular integrated and homogeneous solid body of substantially non-porous alloy having an alloy bond with said wheel and within which said abrasive particles are embedded.

8. The method of making an abrasive annulus for tools of the character described, that includes compacting under high pressure a mixture of finely divided matrix metals and hard abrasive particles to form individual segments of the annulus, placing said segments in annular arrangement adjacent a surface of a metallic wheel, exerting pressure uniformly against said segments and simultaneously heating the segments and wheel to a temperature sufficiently high to form an alloy solution of the metals and an alloy solution of said metals with the metal of said wheel surface, and cooling said solutions and wheel to form a continuously annular solid body of substantially non-porous alloy having an alloy bond with said wheel and within which said abrasive particles are embedded.

9. The method of making an abrasive annulus for tools of the character described, that includes compacting under high pressure a mixture of finely divided matrix metals and hard abrasive particles to form individual segments of the annulus, placing said segments and a metallic wheel in a refractory mold with the segments arranged annularly about the periphery of the wheel, exerting pressure by a movable element uniformly against said segments and simultaneously heating said mold, segments and wheel to a temperature sufficiently high to form an alloy solution of the metals and an alloy solution of said metals with the wheel metal, and cooling said mold and its contents to form a continuously annular solid body of substantially non-porous alloy having an alloy bond with the periphery of said wheel and within which said abrasive particles are embedded.

10. The method of making an abrasive annulus for tools of the character described, that includes compacting under high pressure a mixture of finely divided matrix metals and hard abrasive particles to form individual segments of the annulus, placing said segments and a metallic wheel in a refractory mold with the segments arranged annularly about the periphery of the wheel, exerting pressure by a movable element uniformly against said segments independently of movement of said wheel while heating said mold, segments and wheel, ultimately raising the segments and wheel to a temperature sufficiently high to form an alloy solution of the metals and an alloy solution of said metals with the wheel metal, positively arresting movement of said element when said metals reach a melted condition, and cooling said mold and its contents to form a continuously annular integrated and homogeneous solid body of substantially non-porous alloy having an alloy bond with the periphery of said wheel and within which said abrasive particles are embedded.

11. The method of making an abrasive annulus for tools of the character described, that includes compacting under high pressure a mixture of finely divided matrix metals and hard abrasive particles to form individual segments of the annulus, placing said segments in annular arrangement adjacent a surface of a metallic wheel, exerting pressure uniformly against said segments independently of movement of said wheel while heating the segments and wheel, ultimately raising the segments and wheel to a temperature sufficiently high to form an alloy solution of the metals and an alloy solution of said metals with the metal of said wheel surface, and cooling said solutions and wheel to form a continuously annular integrated and homogeneous solid body of substantially non-porous alloy having an alloy bond with said wheel and within which said abrasive particles are embedded.

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