March 12, 1940. P. WRIGHT 2,193,413

PROCESS FOR PRODUCING HARD METAL CARBIDE ALLOYS

Filed April 14, 1938 2 Sheets-Sheet 1

FIG.1.

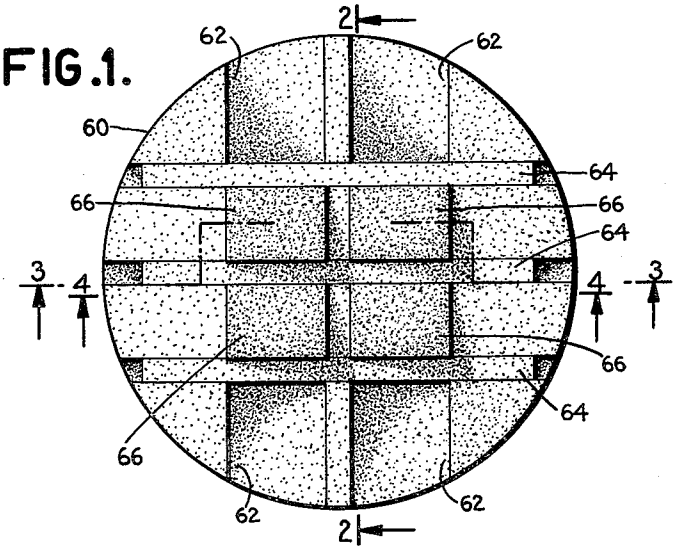


FIG.2.

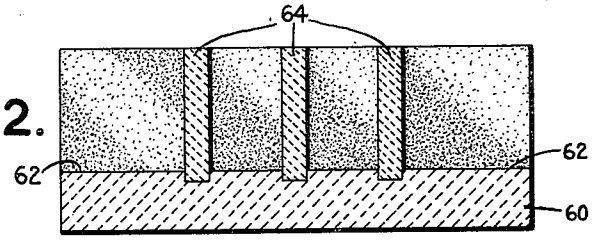


FIG.3.

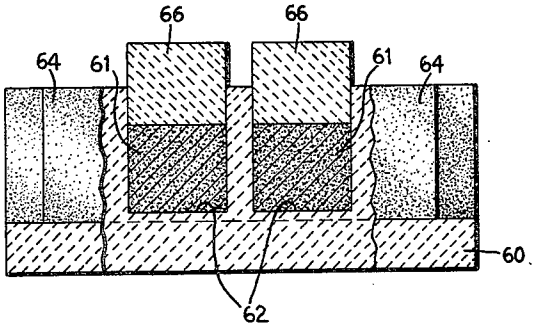
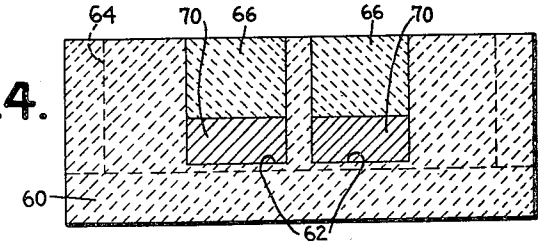


FIG.4.



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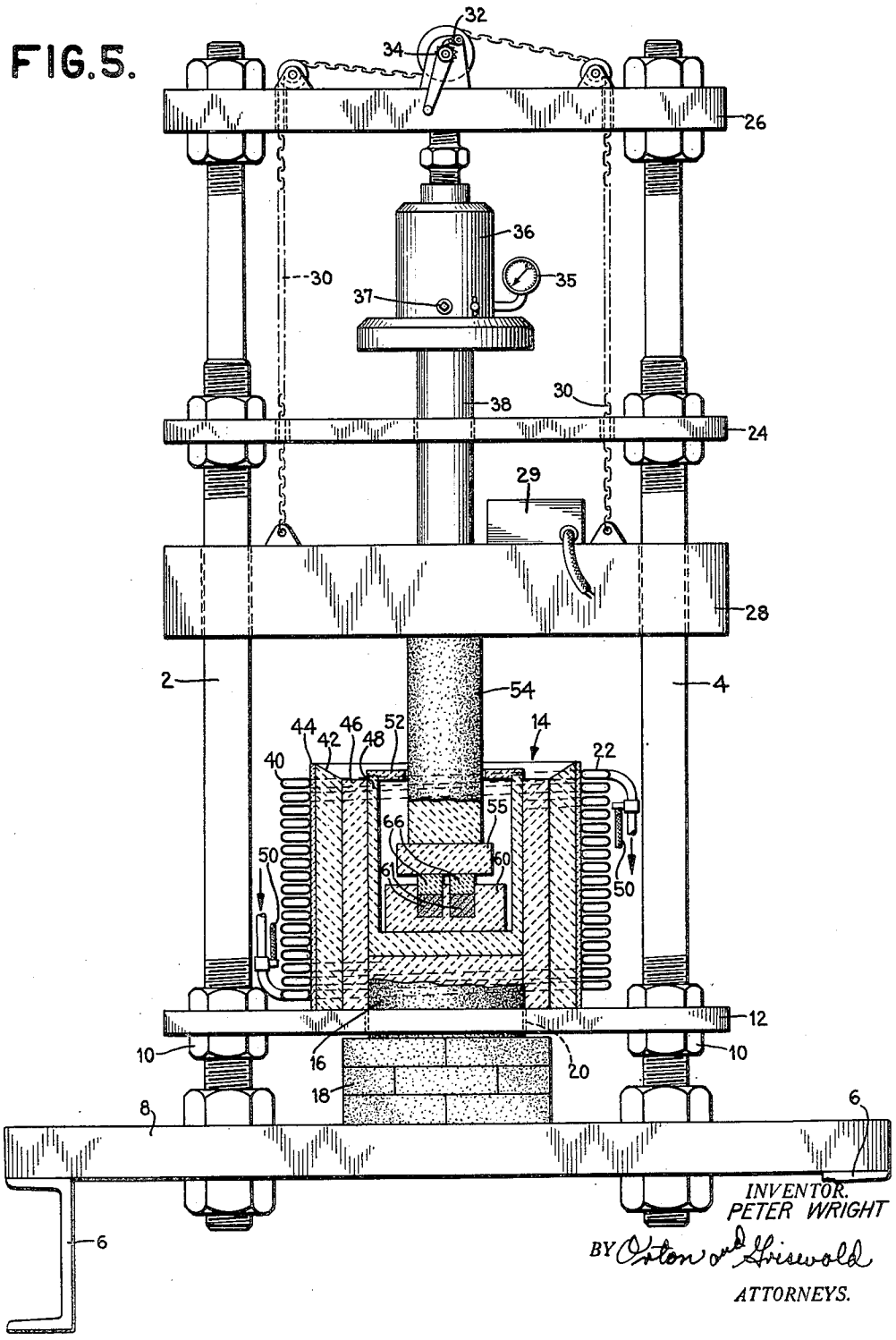
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PROCESS FOR PRODUCING HARD METAL CARBIDE ALLOYS

Filed April 14, 1938 2 Sheets-Sheet 2

FIG.5.



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UNITED STATES PATENT OFFICE

2,193,413

PROCESS FOR PRODUCING HARD METAL CARBIDE ALLOYS

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Application April 14, 1938, Serial No. 202,035

13 Claims. (Cl. 75—137)

This invention relates to hard metal carbide alloys useful for cutting tools, tool bits, wearing parts, wire drawing dies, and other uses as well as to a process for making such hard metal carbides.

Hard metal carbides have been known for a long time and within the past decade have assumed considerable commercial importance particularly in compositions which are principally tungsten carbide or in which tungsten carbide is the most important controlling element in so far as either wear or cutting properties are concerned. In the commercial development of these hard metal carbides of various compositions many processes have been proposed for the preparation of the raw materials, reduction of oxides to metal where necessary, carburizing those metals which form carbides, forming the carbides into proper shapes for cutting tools, wearing parts, tool tips and the like, heating the carbides to sintering temperatures thereby forming hard alloys, etc. These developments in hard metal carbides have not been confined to those in which tungsten carbide is the predominating property controlling material. A number of suggestions have been made particularly in the patented art of other metallic carbides alleged to have desirable properties for the purpose to which the tungsten carbide alloys have been put. Among these suggestions is that of employing titanium carbide, usually, however, with the inclusion of other metallic carbides. At the present time there is no commercially produced metal carbide in which titanium carbide is present in the major proportion of the carbides of the alloy. Some commercial alloys have been prepared for particular purposes in which are included up to about 25% of titanium carbide the remainder being principally tungsten carbide. Such commercial products have been found to be extremely brittle and are useful only in very limited fields.

It has been proposed to prepare hard metal carbides comprising titanium carbide by the usual methods as applied to tungsten carbide which includes specifically the pressure forming of the article from the powdered carbide and powdered auxiliary combining or cementing metals and then sintering the formed article. However, these methods, while apparently producing satisfactory hard alloys wherein the tungsten is the predominating hard metal carbide, are not satisfactory to produce titanium carbide alloys.

I have discovered a method for producing hard metal carbide alloys that can be used for preparing various metal carbide alloys but is peculiarly adapted for producing a titanium carbide alloy having superior properties to those heretofore attained not only in titanium carbide alloys but also in the various tungsten carbide alloys.

The invention resides in a process for preparing refractory metal carbides which comprises heating a metal carbide and an auxiliary metal to a temperature above the melting point of the auxiliary metal and below the melting point of the metal carbide then gradually applying increasing continuous pressures to the alloy accompanied by vibration independently applied until the temperature has fallen below the melting point of any constituent of the alloy.

In a more specific sense the invention resides in a process for preparing a titanium carbide alloy which comprises heating titanium carbide and auxiliary metals comprising chromium and nickel to a temperature above the melting point of at least one of the auxiliary metals and below the melting point of the titanium carbide then gradually applying increasing pressures to the alloy accompanied by vibration until the temperature has fallen below the melting point of any constituent of the alloy.

Another specific aspect of the invention resides in a process for preparing hard metal carbide alloys which comprises preparing a composition containing at least fifty percent of titanium carbide and from five to fifty percent of auxiliary metal comprising chromium and nickel, placing the composition in a mold, heating to an alloying temperature above the melting point of the nickel and below the melting point of the titanium carbide while applying a slight pressure to maintain the heated composition in contact with the mold, stopping the application of heat and gradually applying increasing pressures accompanied by vibration until the alloy has been compressed in the ratio of 80 to 125 grams of original mixture to each cubic inch of finished alloy and the temperature is below the melting point of any constituent of the alloy.

A very specific aspect of the invention is the process for preparing hard metal carbide alloys which comprises heating a mixture of approximately seventy-five percent of titanium carbide with approximately eight percent of chromium and seventeen percent of nickel under non-oxidizing conditions to a temperature above about 2000° centigrade and until the mixture is alloyed to form a slightly shrunk friable material, breaking up the said material, placing from 80 to 125 grams of the powdered material

per cubic inch of finished alloy in a mold, heating the material until it is again at the alloying temperature, stopping the application of heat and gradually applying increasing pressures accompanied by vibration until the alloy has been compressed to the predetermined size and the temperature is below the melting point of any constituent of the alloy.

My invention also provides a hard metal carbide alloy comprising a metal carbide of the 4th, 5th or 6th periodic group and an auxiliary metal of a member of the iron group with about one half as much chromium thoroughly alloyed at a temperature below the melting point of the carbide and having its maximum density.

Specifically my invention resides in a titanium carbide alloy comprising approximately seventy-five parts of titanium carbide thoroughly alloyed at a temperature below the melting point of the titanium carbide with approximately seventeen parts of nickel and eight parts of chromium, of maximum density and exhibiting a hardness of 91 on the Rockwell scale A useful for cutting tools, dies and wearing surfaces.

The invention will be specifically described with reference to certain preferred embodiments thereof and particularly as applied to alloys in which titanium carbide is the principal metal carbide constituent but it will be understood that many of the steps of the process are subject to modification in the light of some of the general principals understood in this art and also that certain features of the invention are applicable to tungsten, tantalum or other hard metal carbides, silicides, tellurides or borides of the fourth, fifth and sixth groups of the periodic table or mixtures of them.

To prepare a hard titanium carbide alloy a mixture is made comprising about seventy-five parts of titanium carbide, eight parts of chromium and seventeen parts of nickel.

The titanium carbide should contain approximately seventeen percent of combined carbon and be relatively free of graphitic carbon. Preferably, the titanium carbide is ground to a very fine mesh. This can be obtained by barreling titanium carbide for extended periods of time as is well understood in the art. A fineness of at least 300 mesh is preferable. The relative amount of the titanium carbide may be varied from as low as forty percent to as high as ninety-eight percent but is preferably within about sixty percent to ninety percent of the original mixture.

The chromium and nickel may be collectively considered as an auxiliary metal or auxiliary metals. Broadly, in place of nickel the other members of the iron group i. e. cobalt or iron, may be substituted but while cobalt is preferable for tungsten carbide, nickel appears to give superior results with titanium carbide. These metals either alone or in combination when alloyed with the titanium carbide serve as binding metals i. e., they cement the titanium carbide particles together by an alloying action.

Such auxiliary metals may be present in varying amounts but increasing their relative proportion in the mixture while tending to increase the toughness of the alloy also produces a softer or less abrasive product. Varying amounts may be employed from 1 or 2% to as high as 40 to 50% but usually about 15%, not including the chromium is preferable.

The chromium or an equivalent metal serves as the hardening agent in the sense that while the binding metal produces a tough coherent product the presence of the binding metal has a softening effect The presence of the chromium in the proportion of about half that of the metals of the iron group not only overcomes this softening effect but actually increases the hardness of the alloy produced. For best results the auxiliary metal should comprise at least 1% of chromium or other equivalent hardening metal.

It is usually satisfactory to add the auxiliary metals, the chromium and nickel, as metallic powders preferably finely ground, however, relatively coarse titanium carbide and the coarse powders of the metallic elements may be mixed and then barreled ground in a ball mill together. Instead of mixing the ingredients as carbides and metals, titanium oxide may be mixed with oxides of the other metals which are reduced together and carburized to produce the titanium carbide. As an alternative method, the prepared titanium carbide may be mixed with solutions of chromium and nickel salts which are precipitated on the titanium carbide and reduced with a gaseous reducing agent as for example, hydrogen. In any of these processes wherein the auxiliary metals are added to the titanium carbide other than as finely ground metallic powders, the mixtures must of course be barreled or ground to insure minute subdivision and thorough mixing.

After a suitable mixture of titanium carbide with proper proportions and amounts of auxiliary metals in finely divided form have been prepared it is, in the preferred embodiment of the invention, placed in a crucible provided with a non-oxidizing liner. Conveniently the lining of the crucible may be magnesite, alundum, graphite or the like. The crucible containing the loose powder is then covered to prevent access of air or subjected to an indifferent atmosphere and heated, conveniently in an electric induction furnace to an alloying temperature preferably about 2000° centigrade which may be described broadly as a temperature above the melting point of at least one of the auxiliary metals but below the melting point of the carbide. The heating, when small amounts of the mixture are in a crucible, should continue for a few minutes after the requisite temperature has been attained. In the case of a crucible containing 200 grams of mixture heated by a 25 KVA induction heater in a crucible surrounded by a layer of graphite a period of less than fifteen minutes after the material had been brought to heat was sufficient. This step as well as other heating steps may if desired be carried out in a hydrogen atmosphere or other neutral atmosphere to prevent oxidation of the constituents.

The step just described produces an alloying of the auxiliary metals with the titanium carbide but does not melt the titanium carbide and therefore the material obtained after the crucible is cooled is a friable chalk-like substance which is easily broken down to a relatively fine powder.

The alloyed material may be given a grinding or disintegrating treatment to reduce it to a powder but it has been found preferable to barrel this material to insure extreme fineness of the alloy. The finer the material is ground the better the properties of the ultimate product, as a general rule.

The pre-allowed titanium carbide and auxiliary metals after being reduced to a powder of the degree of fineness desired is then placed in a

mold, hereinafter more specifically described which is made of graphite.

Such molds are illustrated per se in Figures 1 to 4 of the accompanying drawings and positioned in the furnace under pressure in Figure 5. Specifically;

Figure 1 is a view in plan of a refractory mold with the plugs in position;

Figure 2 is a view in section along the line 2—2 of Figure 1, but without the plugs;

Figure 3 is a view in section along the irregular line 3—3 of Figure 1 showing the powdered alloy in the mold and the plugs partly inserted as at the beginning of a heat;

Figure 4 is a view also in section along the line 4—4 of Figure 1 showing the mold, alloy and plugs at the end of a heat; and

Figure 5 is a view principally in elevation of the compression and vibrating apparatus associated with the furnace shown in section.

The graphite mold is provided with recesses of the shape of the product to be produced. These shapes will, of course, vary depending upon whether tool tips, tool bits, wearing parts or the like are to be produced. Each of the recesses is also provided with tight fitting graphite plugs which have a thickness less than the depth of the recess. The difference in depth between the recess and the thickness of the plug would be the thickness of the article to be produced and the dimensions of this space in the recess, which would not be filled when the plug has been forced down to where its top is even with the surface of the mold, is considered the size of the article. This volume is carefully computed and for each cubic inch of volume there is introduced from 80 to 125 grams of the prealloyed material. Where the composition of the prealloyed material is substantially 75 parts of titanium, the preferred ratio is 95 to 100 grams per cubic inch. When the proportion of titanium carbide is increased the number of grams per cubic inch is reduced. For tungsten carbides, of higher density, ratios as high as 225 to 250 grams per cubic inch are recommended depending on the amount of binder. Using the proper weight per volume is usually very important.

After the proper weight of prealloyed material has been put into the mold, the plug or plugs, if more than one article is made in a single mold, is inserted into the recess to lightly compact the material but is not forced down with any substantial pressure. As the powdered prealloyed material has a substantially larger volume than the finished article will have, the plugs project a substantial distance from the surface of the mold.

The graphite mold is then placed in an induction furnace provided with a graphite lining which, along with the mold, is heated by induction. The mold is supported on a substantial base and a graphite post set on the plug or plugs. At the upper end of the graphite post, a body having considerable inertia, as for example a steel bar weighing about 150 pounds, is permitted to exert its weight on the graphite post thereby applying pressure to the powdered alloy within the supported mold. This pressure is constant but relatively light, being only sufficient to follow the creep of this metal.

After the mold has been placed in the furnace under the conditions described, the current is turned on to bring the contents of the furnace up to heat. This temperature is about 2000° centigrade or slightly higher but below the melting point of the carbide. As the material is brought up to heat the pressure exerted by the steel bar maintains the prealloyed material within the mold in contact with the walls and does not permit it to creep away as it would if no pressure were being applied. The pressure being applied by the steel bar may be considered as one sufficient to maintain the material in the mold in contact with the walls thereof which in the sense as herein used would include the plug as a wall of the mold.

When the temperature has reached approximately 2000° centigrade, it is maintained for a short period of time which, in the case of tool bits about 2½ inches long by ⅜ inch square in a single mold was about 10 minutes. The current for the induction furnace is cut off and the pressure on the plugs in the mold or molds gradually increased in a manner that may be described generally as inversely of the falling temperature. At first the pressure exerted is very slight then as the temperature in the furnace falls, the pressure is increased but at such a rate that the mold itself is not broken. Graphite molds under the high temperature here employed will not withstand excessive pressures. The pressure is also raised in accordance with the "feel" of the alloy as transmitted through the handle of the hydraulic jack conveniently used to apply the pressure.

The application of pressure to the steel bar and through it to the heated material in the mold is accompanied by vibration applied either through the mold or more conveniently on the plugs. Proper vibration is attained by sharp impacts on the steel bar. The direction, force, and position on the steel bar to which the impacts are delivered may be varied widely. For example, light but rapid tapping of one end of the bar with a small hammer has proved sufficient. There is no direct application of the impacts to the material in the mold. Obviously the impacts may be delivered by hand while the operator is increasing the pressure or it may be attained by mechanical means. The combination of pressure with vibration under the conditions described produces a hard metal carbide alloy of maximum density for the constituents present. Such a condition insures superior performance of the hard metal carbides when used for the purposes to which they are adapted.

It has been found that pressures actually applied to the alloy are less than 1000 pounds per square inch and usually of the order of 600 pounds per square inch, based on the area of the plugs in contact with the alloy being limited by the strength of the mold. Such pressures are attained before the plugs are driven down into the mold so that their exposed faces are substantially flush with the surface of the mold. After this condition has been attained, the further application of pressure would be across the entire surface of the mold and thereby have a negligible effect in compressing the alloy within the mold.

This pressure and the driving of the plugs to the condition wherein their tops are flush with the surface of the mold is attained substantially at the time when the temperature of the alloy is just above the melting point of any constituent of the alloy but the pressure is maintained until the contents of the furnace have fallen to below the melting point of any constituent of the alloy. Further cooling is usually desirable before removing the mold from the furnace. When the mold is removed from the furnace while still hot

it may be cooled in air but to prevent excessive oxidation of the graphite mold it is usually preferable to submerge it in powdered graphite to exclude atmospheric air.

When the mold and its contents have been cooled sufficiently, the hard metal carbide alloy is removed from the mold as a finished product its shape corresponding to that of the mold in which it was formed.

The metal carbide alloy produced by this process when the composition comprises 75% titanium carbide with 25% of nickel and chromium in the approximate ratio of two to one is a cutting material with a hardness of 91 on the Rockwell Scale A. It has a high tensile strength above that of the commercial tungsten carbide alloys. Its specific gravity is approximately one-half that of the usual tungsten carbide cutting alloy. Because of the method of preparation alloys produced according to this invention have the maximum density obtainable for the constituents present. It will be understood that varying the constituents will affect the actual density but in all cases maximum density is assured. In the processes of the prior art involving pressing before sintering or forging after removal from the furnace it was not possible to insure freedom from pores. One of the important properties of this alloy is its high heat resistance as a result of which it can be used in cutting hard steels very rapidly so that the steel comes off as a white hot spiral yet the tool does not break down or crater.

Although the alloy exhibits extreme hardness and is useful for fast cutting and freedom from fracture or cratering while giving long service, it may be ground readily on a 60 mesh green grit wheel and finished on a 120 mesh green grit wheel. The alloys heretofore used as cutting alloys were particularly subject to the limitation that they could not be satisfactorily ground and that after a tool had become dull it was impossible to regrind it without so weakening its structure that when reused it readily cracked in many instances.

In the preferred embodiment of the invention two principal steps are employed, viz: prealloying followed by a second heating in a mold including pressure and vibration. It has been found that good results are also secured when finely ground carbide and thoroughly mixed auxiliary metal are placed directly in the mold as a loose powder in the manner heretofore described for the second heating in the mold. By this method the alloying is done in the strongly reducing environment of the graphite mold instead of the more desirable neutral crucible. This may be partly overcome by lining the mold. Except that a slightly longer heating may be found preferable before the application of the increasing pressures accompanied by vibration the process of the mold step is substantially the same. Both the one and two step methods as herein defined are a part of the invention.

In the description of the process it was stated that the heating step in the mold was carried out in an induction furnace. An apparatus which I have made up and successfully used with my process is illustrated in Figure 5 and comprises a pair of upright members 2 and 4 suitably supported at 6 on the floor or other base and connected near the bottom by angle irons or the like 8 to provide a firm foundation. Spaced above the lower member may be projections 10 on which can be placed an asbestos or other insulating board 12 which extends between the uprights to support the furnace 14. As such a board will not carry any substantial load, a refractory plug 16 is placed on the base members 8 or on refractory brick 18 and of sufficient height to go through a hole 20 in the central portion of the asbestos board 12 into the lower part of the furnace coil 14. The coil 22 of the induction furnace rests on the asbestos board 12. Near the top of the apparatus the uprights are connected by suitable reenforcing members 24 and 26 conveniently angle irons. Slidable upon the uprights, a relatively heavy steel bar 28, which may weigh about 150 pounds, is mounted. Means comprising chains 30 attached to a pawl and ratchet mechanism 32, 34 are also provided to raise and lower the steel bar and between the top connecting members and the steel bar is placed a hydraulic jack 36 which, when pressure is applied, will force the connecting member 38 and steel bar 28 downwardly. Within the coil 22 of the induction furnace 14, which may be helical copper tubing 40 through which water may be circulated for cooling, is placed a refractory sleeve 42 of quartz which may have a mica layer 44 on the outside. The refractory sleeve is lined with a composition 46 known as Norblack, or lampblack, within which is a graphite sleeve 48, which is heated when the high frequency current is passed through the copper coil by the wires 50. The inner diameter of the graphite is sufficiently large to receive either the crucible for the prealloying treatment or the mold and may have a cover 52.

The molds Figures 1 to 4 are made from a refractory material that retains its strength at the temperatures involved and may be made from graphite rods of a few inches in length and of a diameter which can be received within the lining. One face of the mold 60 is drilled, if circular pieces of alloy are to be made, or milled where tool bits are desired. The recesses formed are of the size which the final product is to have. Where the recesses 62 are formed by milling, suitable stops or side pieces 64 must also be inserted to close the ends of the slots 62 milled out. Each recess is then closely fitted with a plug 66 of such height that when it is forced downwardly within the recess to the point where its upper surface coincides with that of the mold that the dimensions of the unfilled space correspond to those of the finished article. It is usually preferable that the plugs 66 correspond with the larger surface of the article formed. When the molds 60 have been filled with powdered alloy 61 in the manner above described, the plugs will project substantially from the upper surface of the mold (Figure 3) and in this condition are placed within the induction furnace 14 preferably resting upon a graphite plug 16 which in turn is supported by the cross members 8 through the refractory brick 18 below the asbestos board above described. The graphite post 54 is rested upon the plugs 66 and projects out of the top of the coil for a short distance where it may be engaged by the steel bar 28 when it has been slightly lowered. The space between the graphite post and the edge of the coil is conveniently closed by an annular refractory disc as for example 52.

When the steel bar 28 has been lowered to rest upon the graphite post 54, the weight of the bar exerts pressure on the plugs 66 and maintains this slight pressure upon the material within the mold. This pressure is sufficient to maintain the contents of the mold in contact with the walls thereof.

After the mold and its contents have been brought up to the proper temperature by the passage of current through the coils, the heat is continued to insure thorough alloying of the constituents. For relatively small pieces a matter of a few minutes as above described, is sufficient.

Pressure is then applied by operation of the hydraulic jack 36 through the medium of a lever attached thereto at 37 to force the steel bar downwardly and away from the upper cross member. The operator by reciprocating the handle of the hydraulic jack gradually increases the pressure upon the plugs and in turn upon the heated alloy 70 within the mold. The pressure as exerted by the hydraulic jack is applied gradually in a manner which an experienced operator learns to feel and increased slowly but continually until as high a pressure as the mold will withstand has been imposed.

Coincident with the application of the increasing pressures, and in some instances during the application of the slight pressure exerted by the steel bar, the apparatus is subjected to vibration which is transmitted to the heated alloy. For small operations the vibration is attained by rapidly striking the steel bar with a hammer. The apparatus may comprise mechanical or electrical means 29 for setting up the vibrations. In most instances it has been found preferable to produce the vibration by impact against the steel bar, or other equivalent member having a large mass as compared to the striking object.

The maximum pressure will usually be coincident with the driving of the plug to the point where it is flush with the surface of the mold and as the graphite post 56 and enlarged portion 55 usually covers several plugs or at any rate is larger than any single plug, any further pressure is exerted over the entire surface of the mold. Gage pressures 35 on a ten ton hydraulic jack have been as high as 6000 pounds where three tool bits, 2½ by ⅜ by ⅜ inches were made in a single mold before the plugs were driven to the point where they were flush with the surface of the mold.

When the material is prealloyed as in the two-step process above described, the crucible may be put into the same electric furnace 14 in place of the mold but in such cases, of course, the pressure applying apparatus is not necessary nor used.

Alloys prepared according to the process of this invention with the compositions set forth or with small amounts of other metals such as tin, vanadium, zinc, etc., which preferably do not have a sufficient affinity for carbon to form carbides at the expense of the titanium carbide are very useful industrially for the purposes heretofore recognized. The titanium alloys are particularly useful as or for cutting tools. Their great strength, toughness, freedom from internal strains, and hardness coupled with high heat resistance and freedom from cratering provide tools for fast cutting at high surface speeds. Such advantageous properties are not at the expense of difficulty in keeping the tools in best cutting condition because the alloy may be readily ground as above described. A particular abrasive application of the instant alloys is in grinding wheels. For example, an alloy of about the following analysis, titanium carbide 60%, aluminum 25%, nickel and chromium 15% may be formed as a wheel with a diamond abrasive surface, or for mounting diamonds generally.

While the invention has been described in great detail as to certain preferred embodiments these are to be considered as illustrative of the invention and not in limitation thereof.

What is claimed is:

1. The process for preparing refractory metal carbides which comprises heating a metal carbide and an auxiliary metal to a temperature above the melting point of the auxiliary metal and below the melting point of the metal carbide then gradually applying increasing continuous pressures to the alloy accompanied by vibration independently applied until the temperature has fallen below the melting point of any constituent of the alloy.

2. The process for preparing a titanium carbide alloy which comprises heating titanium carbide and an auxiliary metal to a temperature above the melting point of the auxiliary metal and below the melting point of the titanium carbide then gradually applying increasing pressures to the alloy accompanied by vibration until the temperature has fallen below the melting point of any constituent of the alloy.

3. The process for preparing a titanium carbide alloy which comprises heating titanium carbide and auxiliary metals comprising chromium and nickel to a temperature above the melting point of at least one of the auxiliary metals and below the melting point of the titanium carbide then gradually applying increasing pressures to the alloy accompanied by vibration until the temperature has fallen below the melting point of any constituent of the alloy.

4. The process for preparing hard metal carbide alloys which comprises preparing a composition containing at least fifty percent of titanium carbide and from five to fifty percent of auxiliary metal, placing the composition in a mold, heating to an alloying temperature above the melting point of an auxiliary metal and below the melting point of the titanium carbide while applying a slight pressure to maintain the heated composition in contact with the mold, stopping the application of heat and gradually applying increasing pressures until the alloy has been compressed in the ratio of 80 to 125 grams of original mixture to each cubic inch of finished alloy and the temperature is below the melting point of any constituent of the alloy.

5. The process for preparing hard metal carbide alloys which comprises preparing a composition containing at least fifty percent of titanium carbide and from five to fifty percent of auxiliary metal comprising chromium and nickel, placing the composition in a mold, heating to an alloying temperature above the melting point of the nickel and below the melting point of the titanium carbide while applying a slight pressure to maintain the heated composition in contact with the mold, stopping the application of heat and gradually applying increasing pressures until the alloy has been compressed in the ratio of 80 to 125 grams of original mixture to each cubic inch of finished alloy and the temperature is below the melting point of any constituent of the alloy.

6. The process for preparing hard metal carbide alloys which comprises prepasing a composition containing at least fifty percent of a hard metal carbide and from five to fifty percent of auxiliary metal, placing the composition in a mold, heating to an alloying temperature above the melting point of an auxiliary metal and below the melting point of the metal carbide while applying a slight pressure to maintain the heated composition in contact with the mold.

stopping the application of heat and gradually applying increasing pressures accompanied by vibration until the alloy has been compressed in the ratio of 80 to 125 grams of original mixture to each cubic inch of finished alloy and the temperature is below the melting point of any constituent of the alloy.

7. The process for preparing hard metal carbide alloys which comprises preparing a composition containing at least fifty percent of titanium carbide and from five to fifty percent of auxiliary metal, placing the composition in a mold, heating to an alloying temperature above the melting point of an auxiliary metal and below the melting point of the titanium carbide while applying a slight pressure to maintain the heated composition in contact with the mold, stopping the application of heat and gradually applying increasing pressure accompanied by vibration until the alloy has been compressed in the ratio of 80 and 125 grams of original mixture to each cubic inch of finished alloy and the temperature is below the melting point of any constituent of the alloy.

8. The process for preparing hard metal carbide alloys which comprises preparing a composition containing at least fifty percent of titanium carbide and from five to fifty percent of auxiliary metal comprising chromium and nickel, placing the composition in a mold, heating to an alloying temperature above the melting point of the nickel and below the melting point of the titanium carbide while applying a slight pressure to maintain the heated composition in contact with the mold, stopping the application of heat and gradually applying increasing pressures accompanied by vibration until the alloy has been compressed in the ratio of 80 to 125 grams of original mixture to each cubic inch of finished alloy and the temperature is below the melting point of any constituent of the alloy.

9. The process for preparing hard metal carbide alloys which comprises heating a mixture of at least fifty percent of a hard metal carbide with auxiliary alloying metals under non-oxidizing conditions to a temperature above about 2000° centigrade and until the mixture is alloyed to form a slightly shrunk friable material, breaking up the said material, placing from 80 to 125 grams of the powdered material per cubic inch of finished alloy in a mold, heating the material until it is again at the alloying temperature, stopping the application of heat and gradually applying increasing pressures accompanied by vibration until the alloy has been compressed to the predetermined size and the temperature is below the melting point of any constituent of the alloy.

10. The process for preparing hard metal carbide alloys which comprises heating a mixture of at least fifty percent of titanium carbide with auxiliary alloying metals under non-oxidizing conditions to a temperature above about 2000° centigrade and until the mixture is alloyed to form a slightly shrunk friable material, breaking up the said material, placing from 80 to 125 grams of the powdered material per cubic inch of finished alloy in a mold, heating the material until it is again at the alloying temperature, stopping the application of heat and gradually applying increasing pressures accompanied by vibration until the alloy has been compressed to the predetermined size and the temperature is below the melting point of any constituent of the alloy.

11. The process for preparing hard metal carbide alloys which comprises heating a mixture of at least fifty percent of titanium carbide with chromium and nickel under non-oxidizing conditions to a temperature above about 2000° centigrade and until the mixture is alloyed to form a slightly shrunk friable material, breaking up the said material, placing from 80 to 125 grams of the powdered material per cubic inch of finished alloy in a mold, heating the material until it is again at the alloying temperature, stopping the application of heat and gradually applying increasing pressures accompanied by vibration until the alloy has been compressed to the predetermined size and the temperature is below the melting point of any constituent of the alloy.

12. The process for preparing hard metal carbide alloys which comprises heating a mixture of approximately seventy-five percent of titanium carbide with approximately eight percent of chromium and seventeen percent of nickel under non-oxidizing conditions to a temperature above about 2000° centigrade and until the mixture is alloyed to form a slightly shrunk friable material, breaking up the said material, placing from 80 to 125 grams of the powdered material per cubic inch of finished alloy in a mold, heating the material until it is again at the alloying temperature, stopping the application of heat and gradually applying increasing pressures accompanied by vibration until the alloy has been compressed to the predetermined size and the temperature is below the melting point of any constituent of the alloy.

13. The process for preparing a titanium carbide alloy which comprises heating titanium carbide, a boride and auxiliary metals comprising chromium and nickel to a temperature above the melting point of at least one of the auxiliary metals and below the melting point of the titanium carbide then gradually applying increasing pressures to the alloy accompanied by vibration until the temperature has fallen below the melting point of any constituent of the alloy.

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