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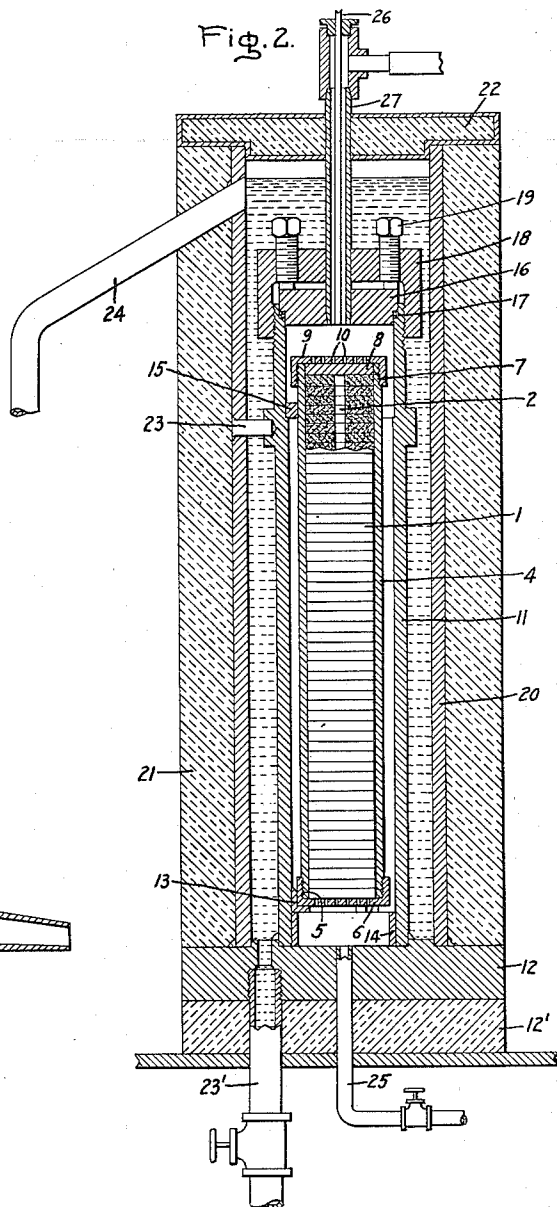
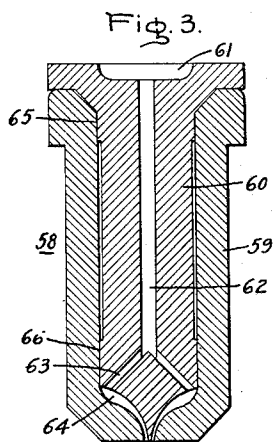
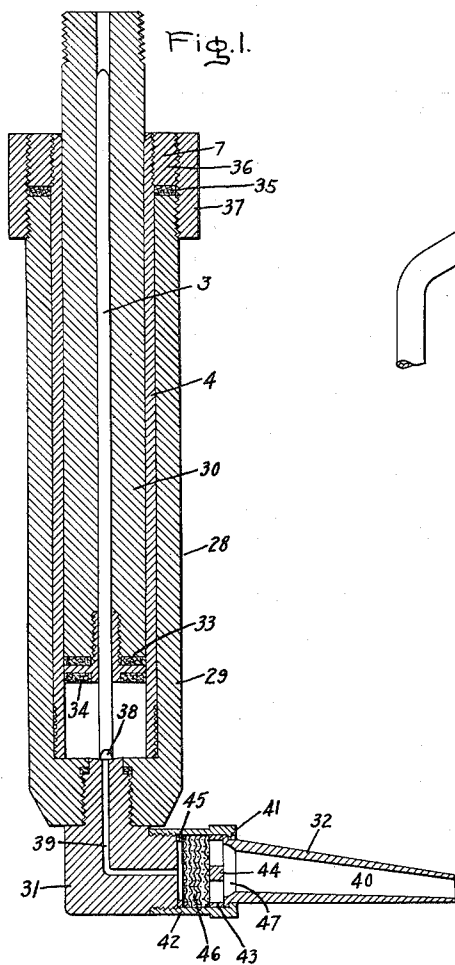
G. F. TAYLOR

2,271,960

EXTRUSION PROCESS

Filed Nov. 4, 1939

2 Sheets-Sheet 1



Inventor:
George F. Taylor,
by *Harry E. Dunbar*
His Attorney.

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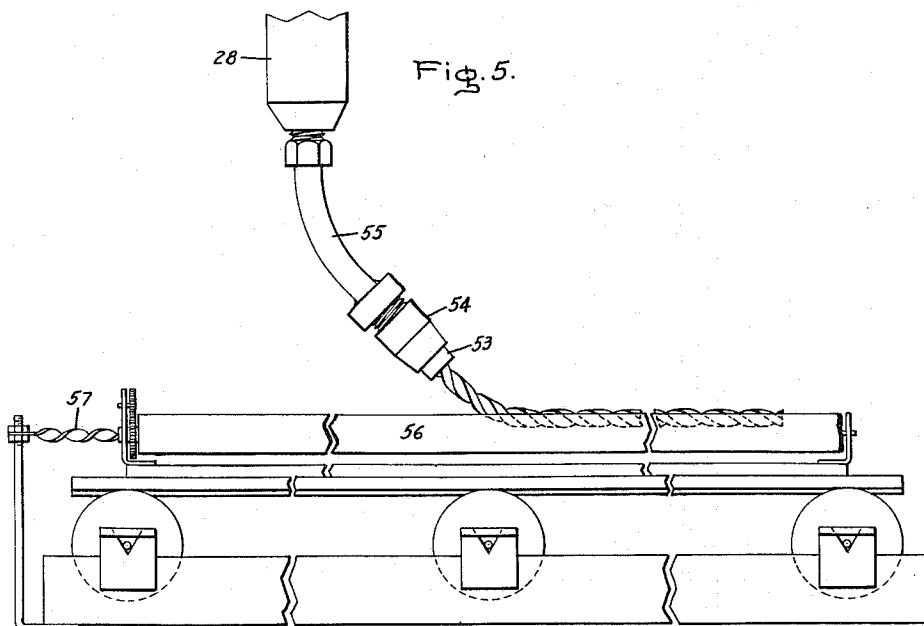
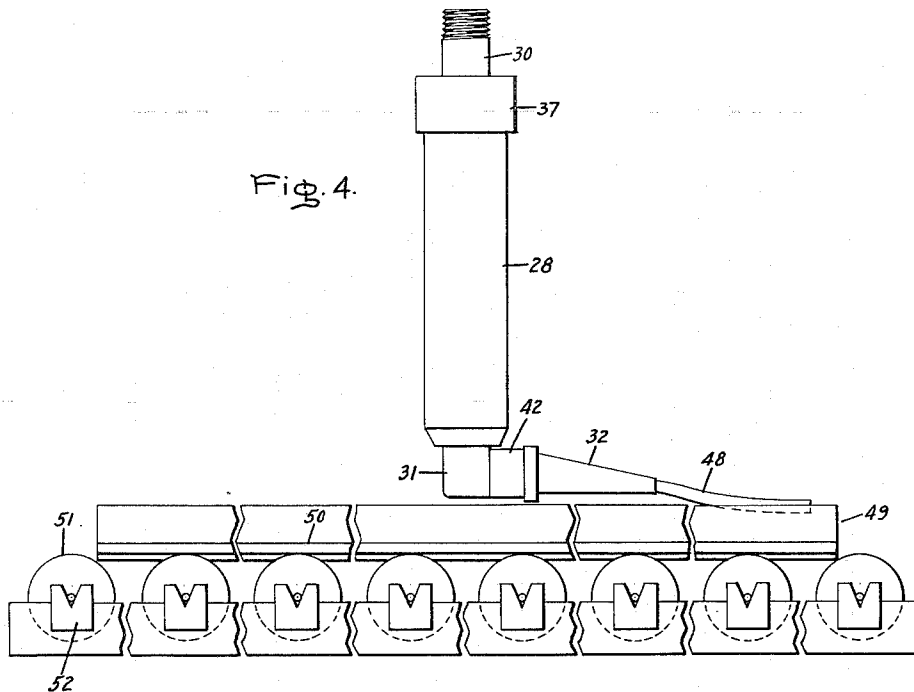
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EXTRUSION PROCESS

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2 Sheets-Sheet 2



Inventor:
George F. Taylor,
by *Harry C. Dunham*
His Attorney.

UNITED STATES PATENT OFFICE

2,271,960

EXTRUSION PROCESS

George F. Taylor, Detroit, Mich., assignor to
Carboloy Company, Inc., Detroit, Mich., a cor-
poration of New York

Application November 4, 1939, Serial No. 302,901

20 Claims. (Cl. 75-137)

The present invention relates to extruded material and to a method for producing the same. More particularly my invention relates to a method for extruding rods, tubes, shapes and the like which may consist of a mixture of one or more hard metal carbides and a binder metal therefor. Sintered compositions consisting of these ingredients are known as cemented carbides and generally are made by a cold press process which comprises pressing the dry mixed powdered ingredients in a steel mold and thereafter sintering the pressed material. If desired, however, the mixed powdered ingredients may be manufactured into desired shapes by a hot press method which comprises applying pressure to the mixture while it simultaneously is heated at its sintering temperature. The extrusion gun or apparatus which is employed in my process is disclosed and claimed in my copending divisional application Serial No. 341,757, filed June 21, 1940.

While the present process is applicable to metals and alloys generally, as well as to non-metallic compositions such as porcelain etc., for simplicity and brevity it will be described only as applied to cemented carbide compositions and particularly as applied to a cemented carbide which consists of about 3 to 25% binder metal of the iron group with the remainder tungsten carbide.

It is one of the objects of the present invention to produce extruded cemented carbides compositions which when sintered are hard, dense, strong and substantially free from cracks or porosity. It is a further object of my invention to produce various shapes of extruded materials such as rods, tubes, spirals, twist drills and the like which, when sintered, shall have these physical attributes.

The novel features which are characteristic of my invention are set forth with particularity in the appended claims. My invention however will best be understood from reference to the following specification when considered in connection with the accompanying drawings in which Fig. 1 is a vertical sectional view of an extrusion gun employed in my process; Fig. 2 is a vertical cross section of apparatus employed in carrying out my improved process; Fig. 3 is a vertical cross section of a die employed in the production of tubes; Fig. 4 is a vertical elevation partly broken away illustrating the delivery of extruded material onto a movable receiving table; while Fig. 5 is a vertical elevation partly broken away of an apparatus whereby shapes such as spirals, drills or the like may be extruded.

In carrying out my improved process, powdered ingredients, which in the manufacture of hard metal compositions such as cemented carbide may be for example powdered tungsten carbide and cobalt, are placed in a ball mill together with a quantity of dry starch or equivalent material which is capable of acting, when wet, as a plasticizing medium. The quantity of starch employed may vary but generally will not exceed about 1.75% by weight of the mixed tungsten carbide and cobalt. I may employ cassava starch although other starches and other plasticizing agents such as casein or equivalent material may be employed if desired as a bond for the metallic particles. The powdered ingredients are placed in the ball mill with sufficient alcohol to cover the powder and tumblers and produce a thin sludge and then ball milled until a very intimate mixture is obtained. Instead of alcohol, acetone, ether, or other material which wets the starch but does not produce a change in its properties may be employed. The tumblers employed in the mill generally are very small in order that the particle size of the hard metal particles may remain substantially unchanged during mixing with the starch. A mixing period of about twelve hours gives satisfactory results but this time may be increased or decreased as desired. After the mixture has been ball milled to the desired extent it is placed in an oven and dried usually for about three hours at a temperature of about 100° C. The temperature employed should not be high enough to oxidize the metal particles or scorch the starch and preferably should not exceed about 150° C. After substantially all the alcohol has been driven off, a small quantity of a mixture of about 80% alcohol and 20% glycerine is added to the mixed powdered ingredients. Only enough alcohol and glycerine mixture, for example about 0.17% is added to make the mixed powdered ingredients somewhat cohesive. Instead of alcohol any equivalent liquid which, as hereinbefore pointed out, does not dissolve or otherwise change the properties of the starch or the other powdered ingredients may be employed.

The mixture is now pressed into flat plate-like members which may have a slight convexity. Disks about one-quarter inch thick and one inch in diameter having a small central hole 2 one-quarter inch in diameter give satisfactory results. The disks or plates preferably should be compressed hard enough to permit handling without breaking but should not be compressed so compactly that when subsequently immersed in a water and glycerine solution, as hereinafter set

forth, the solution will not penetrate thoroughly into the disks and in sufficient quantity to satisfy the starch and form a bond of the proper consistency.

The pressed disks 1 are threaded onto a steel rod 3 and inserted in a cylindrical metal tube or container 4. The container 4 has a plurality of circumferentially arranged substantially equally spaced longitudinally extending openings, not shown, which extend from the lower end of the container 4 to a point adjacent the top thereof. These openings permit the escape of water from the disks 1 when they are subjected to pressure during the extrusion process. Container 4 is provided with screw threads 5 at its lower end which engage a perforated closure member 6. The upper end of the container is screw threaded, as indicated at 7. After the disks have been inserted in the container 4 the rod 3 is removed and a flat felt disk 8 placed on the top of the disks. A screw-threaded cap 9 provided with openings 10 extending therethrough is applied to the upper end of the container 4. The disks 1 have a diameter slightly less than the diameter of the container 4 in order to provide a space for the escape of air and gases from the interior of the disks and also to provide room for their expansion after they have been wetted and the starch in the disks cooked, as will be set forth hereinafter.

The loaded container 4 is positioned within a cylindrical metal member or container 11 which is supported on and soldered or welded to a metal base plate 12 which in turn is supported on an insulating plate 12'. The container 4 is supported within the member 11 upon spaced metal blocks 13 which are positioned on a metal ring 14 secured in position at the lower end of the member 11. Metal blocks 15 space the container 4 at its upper end from the cylindrical member 11. The upper end of the cylindrical member 11 is provided with a closure member 16 which seats against a lead gasket 17. A screw cap 18 engages cooperating screw threads on the member 11 while a pair of screws 19 which extend through cap 18 are adapted to exert pressure on the closure member 16 and force it against the lead gasket 17.

The cylindrical containers 4 and 11 are arranged concentrically within a third cylindrical metal container 20 which is also mounted on and rigidly secured to the base 12. The container 20 is covered with thick insulating material 21 and provided at its upper end with an insulated cap or closure member 22. Three equally spaced pins 23 support the upper end of container 11 and position it centrally in the container 20. Pipes 23' and 24 are connected respectively to the lower and upper ends of the container 20 and to a pump, not shown, which is adapted to circulate oil through the container. Pipe 25 supplies a water-glycerine solution to containers 4 and 11. A pipe 26 is connected to a source of distilled water, while pipe 27 is connected to an evacuating pump.

When the loaded container 4 has been positioned within container 11, the closure member 16, which is rigidly secured to pipe 27, is applied to the upper end of container 11 and forced into intimate contact therewith by means of the screw cap 18 and screws 19. The insulating cap 22 is then applied to the top of the container 20 and connections made to a water supply and evacuating pump through pipes 26 and 27 respectively. Hot oil having a temperature of about 120 to 180° C. is admitted to container 20 and circu-

lated therethrough for about one hour or longer if desired. After the container has been filled with hot oil, evacuation of containers 4 and 11 is initiated through pipe 27. The process of evacuation may be discontinued for short periods from time to time and on each such occasion a very small quantity of distilled water is admitted to the containers 4 and 11 where it is immediately converted into steam having any desired pressure depending upon the amount of water forced in. A steam pressure of about 100 pounds is desirable in order that the steam may penetrate all intergranular spaces of the disks 1 and purge them of air or other non-condensable gases. After each admission of water or steam the evacuation of containers 4 and 11 is resumed until the desired final degree of vacuum is obtained. The hot oil in container 20 is now drawn off through pipe 23' and, with the vacuum still on in containers 4 and 11, refrigerated oil is admitted to container 20 through pipe 23' and circulated through the container in the same manner as the hot oil. When disks 1 have been cooled to a temperature of about -8° C. the vacuum in containers 4 and 11 is shut off and a mixture of water and glycerine containing about 15 to 25% glycerine, and having a temperature of about -8° C. is admitted slowly to the containers 4 and 11 through a small pipe 25 until container 11 is entirely filled and disks 1 saturated, care being taken to prevent any sudden inrush of the water-glycerine solution. The glycerine lowers the freezing point of the water and facilitates the penetration of the water into the disks 1. It also permits subsequent uniform drying and hardening and prevents cracking of the extruded material during drying. I prefer to employ a mixture of glycerine and water. However, in extruding very small rods or tubing having a wall thickness of about $\frac{1}{8}$ of an inch or less the use of glycerine may be omitted if desired. The steel pin 3 previously removed from the disks 1 is reinserted in the central hole 2 at this time, and the disks 1 reheated to a temperature of about 80 to 95° C. for about ten minutes to cook the starch. The heating may be accomplished in various ways. A convenient means for doing so is to raise the temperature of the oil surrounding container 11 to a temperature of about 95° C. or, if desired, cold oil may be drained and replaced with hot oil having a temperature of about 80 to 95° C. allowing containers 11 and 4 to remain in the hot bath until the heat has penetrated to the disks 1 and cooked all of the starch therein.

After the starch has been cooked the loaded tube 4 is removed from container 11 and placed in the extrusion gun designated as a whole by numeral 28. The gun comprises a relatively heavy steel casing 29, a plunger 30, a connector 31, and a die 32. The plunger 30 has a central opening therethrough to accommodate the steel pin 3 and is provided at its lower end with a pair of spaced leather washers 33 and 34. A washer 35 is positioned between the upper end of the casing 29 and a screw ring 36 which has inner and outer screw threads thereon. Ring 36 engages the screw threads 7 on container 4. A second screw ring 37 engages the outer threads on ring 36 and the screw threads on the upper end of the casing 29. The lower end of the steel pin 3 is in the shape of a chisel as indicated at 38 in Fig. 1 so that it cannot close the small opening or passage 39 extending through the connector 31. The connector 31 is screw threaded at its

opposite ends for connection respectively with casing 29 of the extrusion gun and the die 32.

Die 32 comprises a nozzle 40 outwardly flanged at its inner end to fit against an intumed flange 41 on the end of a sleeve 42 which is joined to the connector 31 by means of screw threads. A ring 43 is positioned against the outwardly extending flange on the nozzle 40. The ring may be provided, if desired, with a central circular portion 44 supported on four thin radial arms.

A ring 45 abuts the outer end of the connector 31. Between rings 43 and 45 a series of wire screens 46 are positioned. These screens vary in mesh from about 35 to 65, the coarsest screen being positioned at the end nearest the connector 31 and the finest screen near the end of the nozzle 40. The meshes of the successive screens in the series vary and may be substantially as follows 35-20-48-20-55-20-65. The 20 mesh screens serve as separators between the other screens and are employed for the purpose of preventing clogging in the screens.

When pressure is applied to plunger 30 the material in the container 4 is forced through the small passage 39 in connector 31. As the material comes out of the passage 39 it strikes the first of the screens 46 and spreads over it in the space provided by ring 45. Further pressure on plunger 30 forces the material through the successive screens 46. By varying the mesh of the successive screens, as indicated above, the material forced through them becomes progressively more limp and plastic. The material forced through screens 46 enters nozzle 40 of the die 32. The nozzle, illustrated in Fig. 1, is adapted for the production of solid rods and is provided with a rounded portion 47 at its inner end to permit the free passage of material from the outer edge portions of the screens 46.

As the extruded material 48 comes out of the die 32, it is deposited onto a carriage consisting of parallel adjacent rollers, one of which is indicated at 49 in Fig. 4. The rollers are mounted on a platform 50 which is movable in a longitudinal direction on wheels 51 mounted on bearings 52. The platform 50 and rollers 49 are moved by any suitable means in a straight line and in the same direction and at the same speed as the extruded material 48. After the material has been extruded onto the rollers 49 to the desired extent it is thereafter dried. The rate of drying which can be maintained without danger of cracking depends upon the size of the extruded article. Small objects or rods up to a thickness of about one-eighth inch may be dried in the open air. Larger objects generally are enclosed and heated in a closely fitting graphite boat which surrounds the extruded material. An electric current may be passed through the carbon boat to heat the extruded material at a temperature of about 70 to 95° C. A heating period of about 3 to 12 hours generally is sufficient to remove any water from the extruded material. Thereafter the extruded material is further heated in the carbon boat at a temperature of about 150° C. for about 24 hours or longer if desired. This latter heat treatment evaporates any glycerine in the extruded material. Thereafter the extruded material is placed in a graphite boat, covered with Alundum and sintered in a well known manner into a hard, dense mass.

If it is desired to extrude shapes such as spirals or twist drills, an extrusion die is formed, which has the shape desired to be imparted to the ex-

truded material. The extrusion die 53 disclosed in Fig. 5 comprises a holder 54 which in turn is secured to the end of a metal tube 55. Tube 55 opens into the extruding gun 28 which contains tube 4 which in turn contains the material to be extruded. A series of wire screens similar to the screens 46 are positioned within the die 53. The material extruded through the die is in the form of a spiral and rotates the same number of times per unit length as the pitch thereof. To compensate for this rotation the extruded material is deposited onto two adjacent parallel rollers 56 one of which is provided at one end thereof with a longitudinal slot in which a spiral strip of metal 57 is fitted so that as rollers 56 are moved forward on their support they rotate at the same speed as the extruded material. The rollers 56 are geared together so that both rotate in the same direction. Another purpose of rollers 56 is to provide an easy means for turning over the larger sized extruded rods so that they may be painted or brushed if desired with a water-glycerine solution to thereby obtain uniform drying. The material which is extruded through die 53 is dried and sintered as hereinbefore pointed out.

Various forms of dies may be made for extruding different shapes. In the manufacture of a die for extruding a spiral such as illustrated in Fig. 5, a twist drill bit is placed in a vertical position in a mold. Fused metal, for example type metal, is poured into the mold and flows around the drill bit. After the type metal solidifies the bit is forced out of the mold. The die thus formed is an exact negative of the object to be produced.

In the manufacture of tubular products, a die 58 (Fig. 3) may be employed. This die comprises a casing 59 and a mandrel 60. The latter is provided at its upper end with a depressed portion 61. A central opening 62 extends lengthwise through a mandrel and terminates at its lower end in four or more passageways 63 of smaller dimension than the central opening 62. The passageways 63 preferably open into a slightly enlarged space 64 formed between the casing and mandrel. This latter space is gradually reduced in size as it approaches the end of the die. The die 58 may be substituted in Fig. 1 for the die 32 and provided with a series of screens 46 similar to those employed with the die 32. When paste material is extruded through die 58 the diameter of the opening in the end of the casing 59 determines the outside diameter of the tube to be extruded while the diameter of the lower end portion of the mandrel will determine the inside diameter of the extruded material. In order to center the mandrel 60 accurately within the casing 59 the mandrel is provided at its upper and lower end portions with bearing rings 65 and 66.

For the production of certain articles of manufacture, the process hereinbefore disclosed may be simplified for example the tube 4 may be filled with disks or plates of pressed powdered materials and, without evacuating the gases from the tube and disks therein, the loaded tube is cooled down to a relatively low temperature, for example about -8° C. and then placed in a jar or other suitable receptacle. A water-glycerine solution such as hereinbefore mentioned, and which is likewise at a low temperature, for example about -8° C. is then slowly dripped into the jar so as to first wet the bottom of the stack of disks in the container 4. The rate at which the water-

glycerine solution is admitted to the jar generally is approximately the rate at which the wave of wetness travels upward in the column of disks by capillary attraction. In this way air and other gases occupying intergranular spaces in the pressed powder are slowly driven ahead of the water-glycerine solution so that the intergranular spaces in the pressed powder material are completely filled with the solution and all gases driven out. After the disks have been wetted completely the container 4 with the disks therein is heated to cook the starch and the subsequent steps of the process are then carried out in the manner hereinbefore set forth.

In extruding rods having a relatively large diameter, for example greater than $\frac{3}{8}$ " diameter, the usual short nozzle 40 may be replaced by a longer one which may be substantially equal to the length of the rod to be extruded. The paste material in container 4 is then extruded into the nozzle. To remove the paste material from the nozzle into which it has been extruded, container 4 is filled with paraffin which is extruded into the nozzle to force out the paste material therein. If desired, a cork or similar obstruction may be placed at the entrance of the long nozzle so as to offer resistance and cause the extruded paste to be compacted very closely. A second cork may be placed in the nozzle to separate the paste therein from the paraffin which is employed to force the paste out of the tube.

Ordinarily it may be found desirable to place an obstruction such as a cork in the throat of any die employed in my improved extrusion process. When pressure is then applied to the plunger 30 the obstruction in the die not only causes the strands of extruded material to be welded but causes the paste stream to spread out and fill all spaces in the die and as a result the extruded material will contain little, if any, air.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In an extrusion process, the steps which comprise mixing ingredients to be extruded with a plasticising agent, pressing the mixture into a desired shape, removing gases from said material, and thereafter extruding it.

2. In an extrusion process, the steps which comprise mixing ingredients to be extruded with starch and alcohol or its equivalent, drying the mixture, pressing it into a compact body, removing gases therefrom, and thereafter extruding the pressed material.

3. In an extrusion process, the steps which comprise mixing ingredients to be extruded with starch, pressing the mixture into a compact body, removing gases therefrom, impregnating the pressed material with a liquid to render it plastic and thereafter extruding the pressed material.

4. In an extrusion process, the steps which comprise adding dry starch to pulverized metallic material, mixing said material and starch in alcohol or its equivalent, drying the mixture under non-oxidizing conditions, pressing the mixture into a compact body, removing gases from said pressed material, impregnating the pressed material with a mixture of water and glycerine, cooking the starch in said pressed material, extruding the pressed material, slowly drying the extruded material, and thereafter sintering it.

5. In an extrusion process in which water and glycerine have been added to the material to be extruded, the steps which comprise drying the extruded material for several hours at a tempera-

ture in the neighborhood of 70° C. and thereafter heating the material for several hours at a temperature in the neighborhood of 150° C.

6. In an extrusion process, the steps which comprise adding dry starch to the material to be extruded and thereafter mixing said material and starch in alcohol.

7. In an extrusion process, the steps which comprise adding dry starch to the material to be extruded, wet mixing said material and starch in alcohol, drying the mixture, pressing it into plate-like members, impregnating said members with water and thereafter extruding them.

8. In an extrusion process, the steps which comprise wet mixing the material to be extruded with starch and alcohol, drying the mixture, pressing it into plate-like members, removing residual gases from said members, impregnating said members with a water and glycerine solution, and thereafter extruding the material in said members through a die.

9. In an extrusion process, the steps which comprise mixing the material to be extruded with starch and alcohol, drying the mixture, pressing it into plate-like members, supporting a stack of said members in a holder, removing residual gases from said members, cooling the members to a relatively low temperature, impregnating them with a mixture of glycerine and water, cooking the starch in said members and extruding the material in said members.

10. In an extrusion process, the steps which comprise mixing the material to be extruded with dry starch and alcohol, drying the mixture, pressing the mixture into a stack consisting of a plurality of plate-like members, removing residual gases from said members, cooling the members to a temperature in the neighborhood of 0° C., impregnating them with a mixture of water and glycerine, cooking the starch in said members and thereafter extruding the material in said members through a die and onto a support movable in the direction of the extruded material.

11. In an extrusion process, the steps which comprise mixing the material to be extruded in the starch and alcohol, drying the mixture, pressing it into plate-like members, stacking said members in a tube, removing residual gases from said stacked members, cooling the members to a relatively low temperature and impregnating them with a mixture of glycerine and water, cooking the starch in said members at a temperature below about 95° C., and extruding the material in said members successively through a series of wire mesh screens and a die.

12. In an extrusion process, the steps which comprise pressing a mixture of the metal and starch into ring-shaped discs, stacking said discs in a tube, removing residual gases from said stacked discs, cooling the discs to a relatively low temperature and then impregnating them with a mixture of glycerine and water, cooking the starch in said discs at a temperature below about 95° C., and extruding the material in said discs onto a supporting member movable at substantially the same rate and in the same direction as the extruded material.

13. In an extrusion process, the steps which comprise applying pressure to a pressed, powdered mixture to thereby force said material through a die and onto a transversely rotatable support longitudinally movable in the same direction and at substantially the same speed as the extruded material.

14. In an extrusion process, the steps which comprise applying pressure to a pressed, powdered mixture to thereby force said material successively through a series of wire screens of varying mesh and an extrusion die.

15. In an extrusion process, the steps which comprise mixing the metal with starch, pressing the mixture into plate-like members, removing residual gases from said members, cooling them to a relatively low temperature, introducing a mixture of water and glycerine into the members, cooking the starch in said members, and extruding the material in them successively through a series of wire mesh screens and a die, and then onto a supporting member movable in the same direction and at the same rate as the extruded metal.

16. A process for extruding cemented carbide composition which comprises mixing the ingredients of said composition with dry starch and alcohol, heating the mixture to remove the alcohol, thereafter adding sufficient inert liquid to the mixture to make it cohesive, pressing the mixture into plate-like members, placing said members in a container, removing residual gases from said members, cooling them to a relatively low temperature and then impregnating them with a mixture of water and glycerine, cooking the starch in said members, and extruding the material in said members successively through a series of wire mesh screens and a die, and onto a support movable in the same direction and at substantially the same speed as the extruded metal.

17. In an extrusion process in which the material to be extruded has been impregnated with

a solution of water and glycerine, the steps which comprise enclosing the extruded material in a container and heating it at a temperature not materially higher than 95° C. to thereby remove water from the extruded material and thereafter heating the extruded material at a temperature in the neighborhood of 150° C. to remove any glycerine therefrom.

18. In an extrusion process, the steps which comprise applying pressure to a pressed powdered mixture to thereby force said material successively through a series of wire screens of varying mesh and an extrusion die, the finest mesh screen being adjacent to and the coarsest mesh screen being farthest away from said die.

19. In a process for extruding shapes such as spirals and the like, the steps which comprise applying pressure to a powdered mixture to thereby force said material through a die capable of imparting the desired shape to the extruded material and onto a support longitudinally movable in the same direction and at substantially the same speed as the extruded material, and compensating for the rotation of the extruded material as it is deposited onto said support.

20. In a process for manufacturing sintered bodies, the steps which comprise mixing ingredients to be sintered with starch and alcohol or its equivalent, drying the mixture, pressing it into a compact body, removing gases from the compact body, applying further pressure to said body to thereby form it into a desired shape, slowly drying said body and thereafter sintering it into a compact mass.

GEORGE F. TAYLOR.