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by
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His Attorney.
This application is a division of my copending application, Serial No. 302,901, filed November 4, 1939, which is assigned to the same assignee as the present application.

The present invention relates to an extrusion apparatus. More particularly my invention relates to an apparatus 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 then 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.

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.

The novel features which are characteristic of my invention are set forth with particularity in the appended claim. 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. Cassava starch as well as 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 tumbler 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 150°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 0.175%, 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 when they are subjected to pressure during the extrusion process. Container 4 is provided with screw threads 8 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 is 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 have a diameter slightly less than the diameter of the container 4 in order to provide 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 extend through the upper end of closure member 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 steam through the container. Pipes 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 23 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 circulated 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 preferably is 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-condensible 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 the 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% and preferably 20% 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 intrush of the refrigerant. The glycerine lowers the freezing point of the water and facilitates the penetration of the water into the disks. It also permits subsequent drying, from drying and hardening and prevents cracking of the extruded material during drying. I prefer always to employ a mixture of glycerine and water. However, in extruding very small rods of tubing having a wall thickness of about 4 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 reheat 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 4 and 11 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 the number 28. The gun comprises a relatively heavy steel casing 29, a plunger 30, a connector or extension 31, and a die 32. Casing 29 has a relatively large bore of substantially uniform diameter. 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 1 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 restricted bore or small opening 39 extending through the container 4. 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 intumescing 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 pro-
vided, 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 is provided, these screens varying 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 may vary and may be substantially as follows: 35–20–40–20–55–20–65. 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 generally forced in a continuous stream 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 succeeding 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 successive screens 46 enters the 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 screen 46. After the 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 damage to the product 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 drying oven. The rate of drying is the same as 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 drum 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 extruded 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. The 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 55 one of which is provided as one end thereof with a longitudinal slot in which a portion 51 is fitted so that as rollers 55 are moved forward on their support they rotate at the same speed as the extruded material. The rollers 55 are geared together so that both rotate in the same direction. Another purpose of rollers 55 is to provide an easy means for turning over the last layer of 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 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. 9) 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 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 56.

For the manufacture of disks in the container 4, the process herebefore disclosed may be simplified for example the tube 4 may be filled with disks or plates of pressed powdered materials and, without evacuating the gaseous contents of the container, 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, 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 powdered material are 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 3/4" 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:

An extrusion apparatus comprising a cylinder, an open ended tube mounted therein and adapted to contain material to be extruded, a die secured to one end of said cylinder, a series of wire screens of gradually varying mesh positioned between said die and cylinder, the finest screen being adjacent said die and the coarsest screen farthest away from said die, and means for applying pressure to material in said tube to thereby extrude it successively through said screens and said die.

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