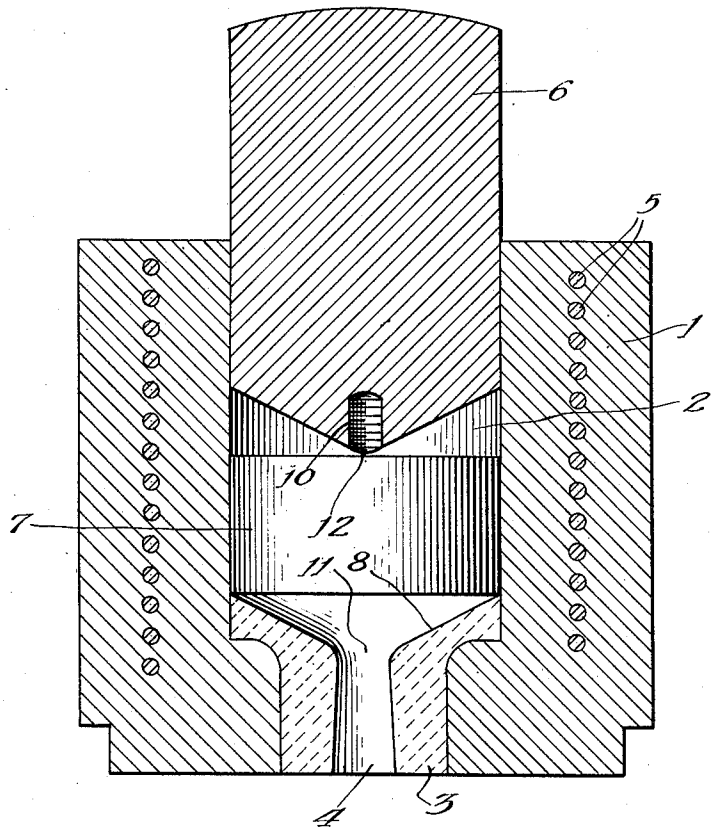
Aug. 11, 1959 E. C. CREUTZ 2,899,054

REFRACTORY DIE FOR EXTRUDING URANIUM

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FIG. 1.



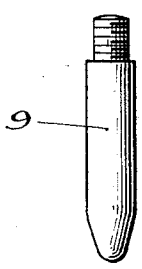


FIG. 2.

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REFRACTORY DIE FOR EXTRUDING URANIUM

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Application October 30, 1944, Serial No. 561,006

7 Claims. (Cl. 207—17)

My invention relates to a press for extruding metals at elevated temperatures and more particularly to extrusion dies suitable for this purpose.

The extrusion of such metals as uranium, beryllium, zirconium and thorium is preferably conducted at an elevated temperature because of the greater ductility of the metals obtained in the higher temperature ranges. This greater ductility makes extrusion easier and in some cases the extrusion can only be obtained at temperatures above 900° C. To insure the maintenance of the metal in a high-temperature range during extrusion the press and die through which a billet of the metal is being extruded is heated to a temperature approximating the temperature of the billet. Thus a die used for extruding metals such as uranium, beryllium, zirconium, and thorium must withstand contact with a metal heated to above 900° C. without alloying with it and withstand being heated to a high temperature without deteriorating. Refractory materials will not alloy and do not deteriorate at high temperatures but in the extrusion of metals through refractories these materials generally are brittle under shock.

It is an object of my invention to provide a die for metal extrusion that will withstand high temperatures without deterioration.

A further object of my invention is to provide an extrusion die of refractory material that is useful for the extrusion of metals at high temperatures such as above 900° C.

These and other objects, features and advantages of my invention will be apparent from the following detailed description of a preferred embodiment taken with the accompanying drawings in which:

Fig. 1 is a cross-sectional view of an extruding press, die and plunger; and

Fig. 2 is a view in front elevation of a piercing member suitable for use in the apparatus of Fig. 1.

In the extrusion of metals, it is frequently found advantageous to conduct the extrusion at high temperature, for example, 800° C. and above. For example, it has been found that uranium has three crystallographic phases which are referred to generally as the alpha, beta and gamma phases, the beta and gamma phases being formed in succession as metal in the low temperature alpha phase is increased in temperature. The extrusion of uranium is preferably carried on at a temperature within the gamma phase because of the greater ductility of the uranium metal in this phase over that of the alpha and beta phases. The transition temperature at which uranium is altered from the beta phase to the gamma phase is at about 780° C., the greatest plasticity of the uranium being reached at temperatures above 870° C. Therefore extrusion of uranium is preferably carried on at temperatures between about 900° C. and 1000° C. or even somewhat higher.

Beryllium is brittle at low temperatures but becomes ductile at red heat; therefore it is preferable to extrude beryllium at elevated temperatures, for example, in the

range of 900° C. to 1350° C. Other metals that are preferably extruded at elevated temperatures include zirconium, aluminum and thorium.

The extruding press used at these elevated temperatures is heated to near the temperature of the billet to be extruded so that the billet will not be appreciably cooled during the extrusion. Thus when extruding metals at elevated temperatures the extruding die is also raised to a high temperature, generally in excess of 700° C., not only by the heating of the extrusion press but also by contact with the preheated billet of the extruded metal. At these temperatures ordinary die metals alloy with the extruded metal causing a freezing of the billet to the die which prevents extrusion. This freezing between the extruded metal and the die continues despite substantial increases in pressure in attempts to force the extrusion metal through the die to which it is alloyed. The metal of the die is subjected also to oxidation when exposed to the atmosphere at these extruding temperatures, and the resultant oxide film is objectionable for some purposes.

I have found in accordance with my invention that refractory complex or double oxides having the general formula $M_nO_mR_xO_y$ where M is a metal of the group consisting of magnesium, zinc, divalent manganese and ferrous iron, R is aluminum, chromium, ferric iron, manganic manganese or silicon, and m, n, x and y are small whole numbers. Particularly satisfactory dies may be constructed of fosterite or the spinel-group double oxides. The spinel group of refractories is a series of minerals crystallizing in a regular crystallographic system and having the general formula $MO.R_2O_3$ where M is usually magnesium, zinc, manganese or ferrous iron, and R_2O_3 may be aluminum, chromium, ferric iron or manganic manganese. Typical members of this group are spinel $MgO.Al_2O_3$, magnetite $FeO.Fe_2O_3$, magnesioferrite $MgO.Fe_2O_3$, chromite $FeO.Cr_2O_3$ and franklinite $(FeZnMn)Fe_2O_4$. Fosterite has the formula $2MgO.SiO_2$, contains about 57.3 percent of MgO and 42.7 percent of SiO_2, and possesses excellent stability and strength at high temperatures. The hardness of these materials and their resistance to mechanical and thermal shock are particularly advantageous in their use for an extrusion die, since they will resist wear and retain their shape for several operations or for continued operation for a substantial period of time, and since they resist mechanical and thermal shock. In addition their chemical inertness and refractory nature is such that the temperatures involved in extruding uranium, beryllium, zirconium, thorium, aluminum and similar metals at temperatures above 800–900° C. are withstood readily and alloying or combination with the metal undergoing extrusion is substantially avoided. Magnesium aluminate, $MgO.Al_2O_3$, is particularly advantageous and is found to be the most suitable refractory for this purpose.

In the preferred embodiment of apparatus incorporating my invention shown in Fig. 1 the apparatus or extrusion press comprises a die block 1 with a central chamber 2 of circular cross-section terminating in an extruding die 3 having a channel 4 of circular or other cross-section, through which the metal is extruded and formed into an elongated shape such as a wire, rod, tube, etc. The die block 1 is provided with a resistance winding 5 or other heating means to heat the apparatus. A movable plunger 6 having a slightly smaller diameter than that of the chamber 2 is provided within the chamber so that it may slide freely and force a billet 7 of the metal being extruded through the die channel 4. The die 3 is preferably coextensive in area with the plunger 6 and is of the funnel type being characterized by sides 8 sloping towards the die channel 4 at an angle of approximately 30° with the horizontal. Starting at a narrow throat portion 11 the

walls of die channel 4 flare away from the center of the channel at a slight angle so that the metal after being formed by the throat 11 does not adhere to the die 4. The die 3, which shapes the extruded metal and determines the outside diameter of the rod or tube that is formed, is composed of a refractory complex or double oxide of great hardness such as magnesium aluminate or other oxide heretofore illustrated. For extruding tubing I prefer to provide a piercing member 9 shown in Fig. 2 affixed centrally of the plunger 6 in a threaded recess 10 provided in the plunger 6. The piercing member 9 forms the interior surface of the extruded tubing and should be of sufficient length to lie within the throat 11 of the die 3 at the start of extrusion. When using plunger 6 for rod extrusion the recess 10 should be filled by screw plug 12 as shown in Fig. 1.

The preferred mode of operation for extruding a rod will now be explained. The apparatus is heated by the resistance winding 5 at about 870° C. for a sufficient period to raise the temperature of the die to over 700° C. The billet 7 is preheated separately from the apparatus in a non-oxidizing atmosphere and preferably in a natural-gas atmosphere or in an atmosphere of argon. When the apparatus and billet 7 have received requisite preheating, the billet 7 is placed in the central chamber 2 of the die block 1 in an air atmosphere, and a few minutes are allowed for the apparatus and billet 7 to attain the same temperature. The extruding pressure is then applied to the plunger 6 and thereby against the billet 7 forcing it in turn against the funnelled sides 8 and through the throat 11 and into the die channel 4, thereby forming the extruded metal in the shape of a rod.

When it is desired to produce a tube rather than a rod, screw plug 12 is removed from the threaded recess 10 and the piercing member 9 is fitted into the recess 10. Thus when extruding a metal billet, the piercing member 9 precedes the plunger 6, pierces the billet, and extends into the throat 11 of the die 3 at the start of the extrusion. As the plunger 6 extrudes the billet through the die channel 4, the piercing member 9 moves into the die channel 4 creating a hollow center in the extruded metal.

It will be apparent to those skilled in the art that various modifications may be made without departing from the principles of the invention as disclosed herein, and for that reason it is not intended that the invention should be limited other than by the scope of the appended claims.

I claim:

1. A die for extrusion of metals, said die being formed of a refractory complex oxide having the composition $M_nO_mR_xO_y$ where M is a divalent metal of the group consisting of magnesium, zinc, manganese and iron, R is a member of the group consisting of aluminum, chromic chromium, ferric iron, and manganic manganese, and m, n, x and y are whole numbers.

2. A die for extrusion of metals, said die being formed of a refractory spinel.

3. A die for extrusion of metals, said die being formed of refractory magnesium aluminate.

4. A die for extrusion of metals, said die being formed of magnetite.

5. A die for extrusion of metals, said die being formed of magnesioferrite.

6. A die for extrusion of metals, said die being formed of chromite.

7. A die for extrusion of metals, said die being formed of franklinite.

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