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EXTRUSION OF CONTINUOUS METAL ARTICLES

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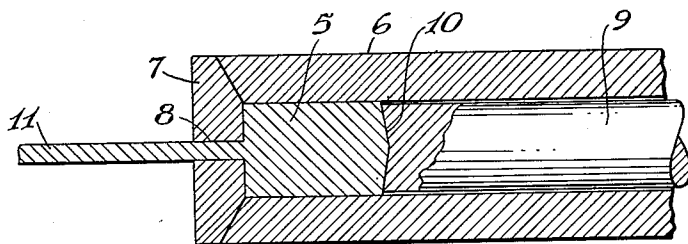


Fig. 1

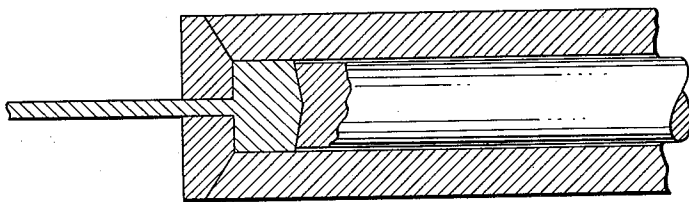


Fig. 2

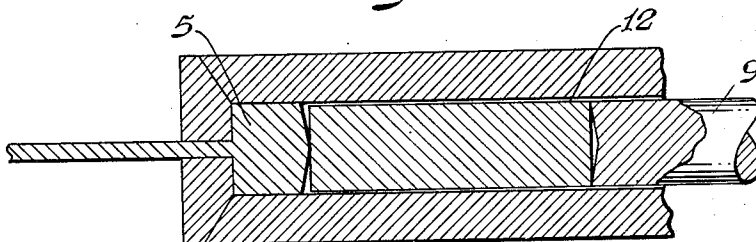


Fig. 3

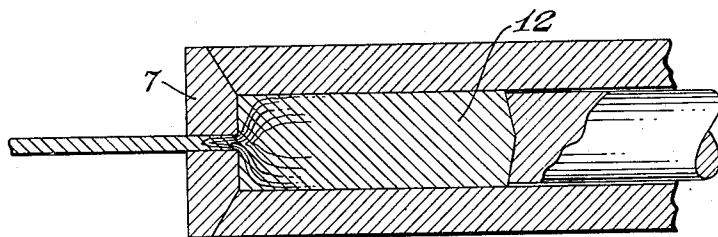


Fig. 4

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EXTRUSION OF CONTINUOUS METAL
ARTICLES

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This invention relates to an improved procedure for producing continuous extruded metal articles.

In the conventional direct extrusion process, billets of the metal to be shaped are cast or otherwise formed to a size only slightly smaller than that of the cylinder of the press to be used. Each billet, after being preheated to a hot-working temperature, is then placed in the press and extruded through a forming die at one end of the cylinder by the action of a ram entering the other.

This process, in which the billets are extruded one at a time, is subject to the disadvantage that inherent factors require part of each billet to be scrapped. In particular, the first metal of the billet to pass through the die, having come from directly behind the die opening, is not subjected to extensive mechanical working and is comparatively weak. This "nose" of the extrusion is therefore usually sheared off and discarded. Moreover, as the back end of the billet approaches the die, there is a strong tendency for the metal in the center to be pulled away from the ram, forming a cavity or pipe in which foreign particles and oxidized metal concentrate. These weaknesses then appear in the "tail" of the extrusion which must sometimes also be scrapped. In addition, a short butt is always left in the cylinder since the billet can seldom be forced completely through the die. This butt can be removed only by unlocking the die, pushing the die and butt out of the cylinder, and shearing them apart.

These various factors, which are usually unavoidable, not only make for a rather low efficiency of conversion of billet to acceptable product but likewise slow down production. They also make extrusion of a continuous product nearly impossible in all except a few instances involving mandrel dies, where special procedures are available.

With these difficulties in mind, it is the principal object of the present invention to provide an improved extrusion process in which no weak "nose" or "tail" is present in the extruded product and in which no butts are left to be removed from the press, each billet being converted wholly to acceptable product. Another object is to provide a simple process for making continuous extruded articles. A further object is to eliminate the need for preheating billets before inserting them into the press.

The invention may be illustrated with reference to the accompanying drawing, in which

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Fig. 1 is a schematic vertical cross-section of a direct extrusion press in the middle of an extrusion stroke;

Fig. 2 is a similar view at the end of the stroke;

Fig. 3 is a view before the start of the next stroke; and

Fig. 4 is a view shortly after the next stroke has begun.

In prior processes for extruding metal billets in a direct-extrusion press, it is customary to extrude as much of each billet as possible in order to leave a minimum butt to be scrapped. To this end, extrusion is allowed to proceed until the pressure required for further forward motion of the ram suddenly rises to a prohibitive value. At this point, the butt length is ordinarily about one-sixth of its diameter, seldom if ever exceeding one-fourth. This short butt is then removed and scrapped.

In contrast to this procedure, it has now been found that the advantageous objects of the present invention may be realized, and continuous extrusion made possible, by terminating each extrusion stroke long before the practical limit of ram travel is reached. There is intentionally left a butt having a length at least half its diameter. The next billet is then inserted in the press cylinder directly behind this long butt and the next extrusion stroke is made without removing it. During this next stroke of the press, the remainder of the butt is extruded as useful product and the new billet welds firmly to the butt and also issues from the die as an integral continuation of the previously extruded material.

In this manner, no butts are scrapped and one billet after another may be introduced into the press cylinder and extruded through the die to form a continuous product. The metal of the billets is converted to an acceptable extrusion with an efficiency approaching 100 percent and at a high rate of production. Moreover, the extruded product is straighter than the product of prior processes.

It is essential, in the process of the invention, that each extrusion stroke be terminated in time to leave in the cylinder a butt having a length at least half its diameter. Even longer butts, up to a length equal to the diameter, may offer further advantage in extruding complex shapes. With too short a butt, the metal of each newly inserted billet is apparently not subjected to enough plastic working to bond firmly to the metal already in the cylinder before the latter has been forced out of the die. In addition, with too short a butt, any oxide or other foreign ma-

terial which has concentrated in the rear of the butt does not become distributed harmlessly throughout the newly added metal, but remains near the interface, forming a zone of weakness which persists in the extruded product.

The adequate bonding of each billet to the preceding butt is most readily achieved when extrusion is accompanied by a large reduction in cross-sectional area of the metal, i. e. under conditions in which plastic working of the metal is extreme. In extruding magnesium-base alloys, to which the invention is especially applicable, each billet should be extruded through a die of sufficiently restricted open area that the reduction in area is at least 50:1, reduction over 75:1 being preferred. In making strip, in which the metal is forced through an elongated rectangular die opening, a reduction of at least 90:1 is most satisfactory. When extruding through a circular die opening to form rod, a reduction of 140:1 or more gives best results. In extruding through multiple-opening dies, the ratios given refer to the reduction at a single die opening.

In extruding billet after billet according to the invention, everything introduced into the press cylinder appears in the extruded product. It is accordingly necessary to exercise great care in preventing entry of foreign material into the press. The billets should be of high quality and should be carefully cleaned. Pre-extruded or scalped billets are advantageous. In addition, more than usual precautions should be exercised to prevent entrapment of air between each butt and new billet, since any such air is forced through the die with the extruding metal, forming blisters and blowholes. With a conventional extrusion press, air entrapment is best avoided by insuring that the forward face of each new billet is square with its sides and by inserting the billet carefully so that it lies flat against the butt already in the cylinder.

A more convenient way of avoiding air entrapment is to carry out the extrusion in a press the ram of which is provided with a concave pressure face. When the extrusion pressure is applied to the billet by such a ram, the rear end of the billet, which becomes the butt left in the cylinder, is formed with a convex face. When the next billet is inserted with the usual flat end against this convex face of the butt, there is metal-to-metal contact only at the center of the butt. Then, as the extrusion pressure is applied and the new billet is gradually forced against the convex butt, any air present at the interface, rather than being trapped, is positively expelled outwardly and then rearwardly through the clearances around the new billet and ram, and thus out of the press. By operating in this way, air blisters and blowholes in the extrusion are largely eliminated.

The degree of concavity in the ram for such a purpose is small, preferably being such that the angle formed between the center point of the ram face and opposite points on the periphery is 160° to 170°. The contour of the concavity is conveniently conical, although a wedge-shaped depression in the end of the ram is almost as effective.

The process of the present invention offers another advantage over conventional practice in that it is unnecessary to preheat each billet to a hot-working temperature prior to inserting it in the press. The first billet to be extruded must, of course, be preheated in the conventional way, and all billets may be, if desired. Alternatively, however, each billet except the first may be in-

serted at room temperature. When extrusion pressure is applied, the forward end of the new billet is forced into intimate contact with the already hot butt remaining in the cylinder from the previous stroke. Since excellent conditions of heat-transfer thus exist, the forward end of the new billet is heated rapidly to a hot-working temperature. Then, as extrusion proceeds, the entire billet picks up heat from frictional contact with the cylinder wall and from the mechanical working to which it is subjected, soon reaching hot-working temperature. In those instances where extrusion speeds have intentionally been held low because of excessive generation of heat, the insertion of cold billets according to the invention sometimes permits use of higher speeds because a part of the excess heat is absorbed by each billet.

The fact that preheating of the billets except the first is not required according to the invention is peculiarly advantageous in extruding metals which suffer a loss of strength on lengthy heating at hot-working temperatures. Typical of such metals are magnesium-base alloys containing zirconium in grain-refining proportion. Billets of such alloys may be inserted into the press without preheating and extruded into finished product without heating the metal long enough to cause appreciable grain growth.

The sequence of steps for carrying out the process of the invention in a preferred form may be understood with reference to the accompanying drawing. The initial billet 5 (Fig. 1), say of a magnesium-base alloy, after preheating to a hot-working temperature, e. g. 700° F., is inserted in one end of the press cylinder 6, the other end of which is closed by a die 7. The die opening 3 has a cross-sectional area less than $\frac{1}{15}$ that of the press-cylinder 6. The extrusion ram 9, provided with a concave end 10, is then operated to enter the cylinder and force the billet 5 out the die opening, forming the extruded product 11. Fig. 1 illustrates the condition existing in the middle of the extrusion stroke. As will be seen, the action of the concave end of the ram has formed a convex rear face on the billet.

Extrusion proceeds until the length of the billet becomes only slightly more than half its diameter, at which point the extrusion stroke is terminated (Fig. 2). The ram 9 is then withdrawn from the cylinder and the next billet 12, which is unheated, is inserted (Fig. 3). As the next stroke of the ram starts, the flat end of the new billet 12 is forced against the convex butt of the previous billet. The new billet then gradually upsets against the previous butt, any air present between them being forced outwardly and rearwardly around the billet and ram. As extrusion proceeds, the previous butt and new billet merge or weld together along the flow lines shown in Fig. 4, forming an integral mass which issues from the die. As the ram continues to move, it again reaches the position shown in Fig. 1, and a second cycle begins. These steps may be carried out repeatedly to produce a continuous uniform extrusion of any desired length.

What is claimed is:

1. In the hot extrusion of magnesium-base alloy billets to form a continuous product in a direct-extrusion press having a cylinder, ram, and die, the steps of: extruding each billet through a die of sufficiently restricted open area that the reduction in cross-sectional area during extrusion is at least 75:1, forming the rear end of each billet to a convex shape during ex-

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trusion thereof by applying the extrusion pressure thereto by means of a concave-ended ram, terminating each extrusion stroke when the length of the as-yet unextruded butt of the billet in the cylinder is between one-half and once its diameter, inserting the next billet in the cylinder behind the butt, and then making the next extrusion stroke, thus causing rearward expulsion of any air from the space between the butt and the inserted billet and welding of the butt and billet so that the latter issues from the die as an integral continuation of the extruded butt.

2. In hot extruding magnesium-base alloy solid billets in a direct extrusion press having a cylinder, ram, and die, the sequence of steps for producing a continuous product which comprises: extruding each billet through a die of sufficiently restricted open area that the reduction in cross-sectional area during extrusion is at least 50:1, terminating each extrusion stroke when the length of the as-yet unextruded butt of the billet in the cylinder is between one-half and once its diameter, inserting the next billet in the cylinder behind the butt, and then making the next extrusion stroke, thus causing the inserted billet to weld to the butt of the previous billet and issue from the die as an integral continuation of the extruded butt.

3. In hot extruding magnesium-base alloy solid billets in a direct extrusion press having a cylinder, ram, and die, the sequence of steps for producing a continuous product which comprises: extruding each billet through a die of sufficiently restricted open area that the reduction in cross-sectional area during extrusion is at least 50:1, terminating each extrusion stroke when the length of the as-yet unextruded butt of the billet in the cylinder is between one-half and once its diameter, inserting the next billet in the cylinder

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behind the butt, and then making the next extrusion stroke, thus causing the inserted billet to weld to the butt of the previous billet and issue from the die as an integral continuation of the extruded butt, preheating only the first billet to be extruded to a hot-working temperature and inserting the remaining billets into the cylinder without preheating.

4. In hot-extruding solid billets composed of a magnesium-base alloy containing zirconium in grain-refining proportions in a direct extrusion press having a cylinder, ram, and die, the sequence of steps for producing a continuous product which comprises: providing a number of billets of the composition hereinbefore stated and extruding each billet through a die of sufficiently restricted open area that the reduction in cross-sectional area during extrusion is at least 50:1, terminating each extrusion stroke when the length of the as-yet unextruded butt of the billet in the cylinder is between one-half and once its diameter, inserting the next billet in the cylinder behind the butt, and then making the next extrusion stroke, thus causing the inserted billet to weld to the butt of the previous billet and issue from the die as an integral continuation of the extruded butt, preheating only the first billet to be extruded to a hot-working temperature and inserting the remaining billets into the cylinder without preheating.

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