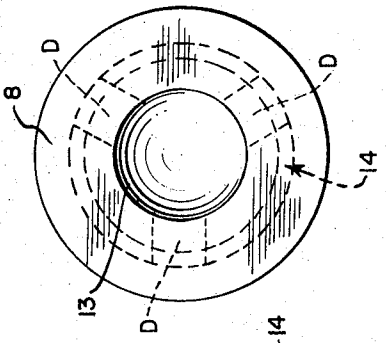
Sept. 12, 1967 W. H. LUDWIG 3,340,924

APPARATUS FOR CONTINUOUS CASTING OF HOLLOW BILLETS

Filed Sept. 24, 1964

FIG. 3



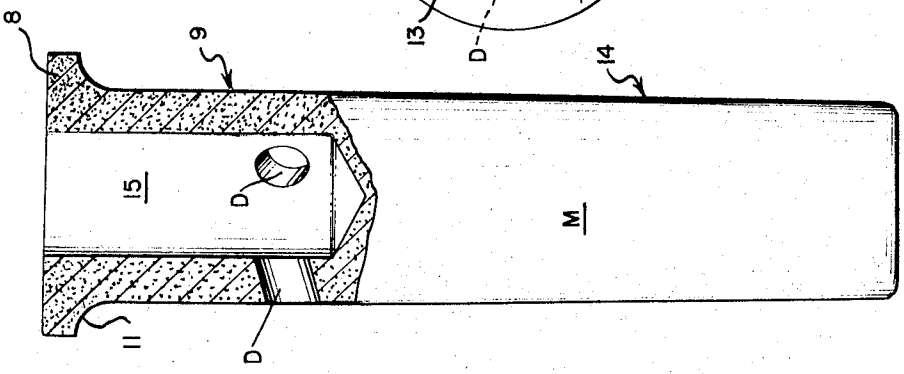


FIG. 2

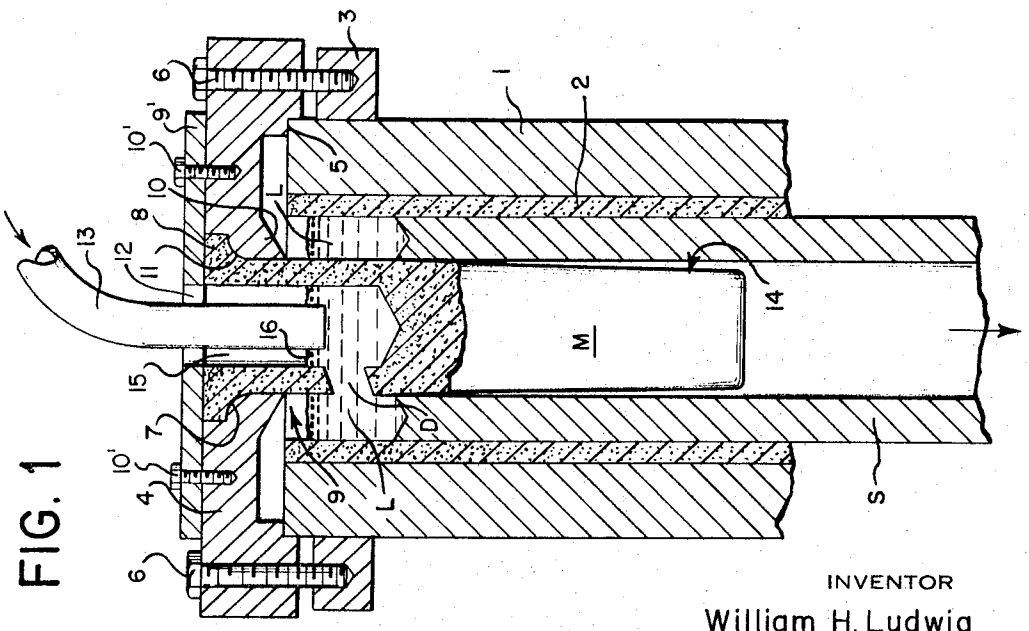


FIG. 1

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United States Patent Office 3,340,924 Patented Sept. 12, 1967

3,340,924

APPARATUS FOR CONTINUOUS CASTING OF HOLLOW BILLETS

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Filed Sept. 24, 1964, Ser. No. 398,844
1 Claim. (Cl. 164—281)

This invention relates to apparatus for the continuous casting of metal such as copper, brass or aluminum and has for its object the provision of an improved mandrel for use in a mold to cast hollow billets or tubes.

Apparatus for continuously casting hollow billets usually comprises a mold having an inner lining of graphite, a graphite mandrel suspended in the mold forming an annular upright space in which the metal is poured and solidified, means for lubricating the graphite surfaces and means for cooling and vibrating the mold and drawing the cooled billet out of the mold. The mandrel of the invention is used advantageously in a casting apparatus of this type.

The improved mandrel of the invention is formed of graphite and is suspended inside the graphite mold for casting hollow billets. The mandrel of the invention has a novel head construction including a top flange by means of which the mandrel is supported and centered in the casting mold, and a metal-receiving cup into which the metal is poured from a siphon tube. The cup has radially disposed ducts through which the metal flows into the annular space between the mold and the mandrel. The depth of this cup bears an important relationship to the casting rate to maintain a desired level of liquid metal in the cup and in the space surrounding the mandrel. The head of liquid metal in the cup and the radial ducts at the bottom effect a smooth and uniform flow of metal into the casting space.

In the accompanying drawings

FIG. 1 is a side elevation, with parts in section, illustrating parts of a continuous casting mold and one means of mounting the improved mandrel in the casting mold;

FIG. 2 is a side view of the mandrel of FIG. 1 with the upper or head part in section, and

FIG. 3, a plan view of FIG. 2.

The apparatus of FIG. 1 comprises a metal mold base **1**, preferably circular in cross-section, a graphite mold or liner **2**, and coupling ring **3**, preferably formed in two parts and bolted into snug contact with the mold base **1** to which is secured a mandrel support **4** for the mandrel M. The base **1** and the mold **2** are advantageously provided with cooling means and the mold **2** with lubricating means. The mandrel support **4** may be circular in plan, has an annular groove **5** which centers it on the mold base **1**, bolts **6** for securing it to the coupling ring **3** and an annular recess **7** for receiving the annular flange **8** of the mandrel head **9** which is preferably circular in transverse section. The mandrel support has a depending shield **10** which covers part of the mandrel head extending above the liquid metal to protect it from oxidation. The annular top flange **8** of the mandrel is fairly deep and is strengthened where it joins the rest of the mandrel by the fillet **11** which bears on a correspondingly curved part **7** of the annular recess. The cover plate **9'** is held by bolts **10'** on support **4** for securing the mandrel in place. The cover plate **9'** has a central hole **12** which is large enough for the easy insertion of the siphon tube **13**.

The graphite mandrel M illustrated may have any suitable interior cooling or lubricating means (not shown), if desired, and comprises two main parts a lower tapered part **14** and the upper head part **9**. The mandrel head has a cylindrical recess or cup **15** at the top for receiving molten metal and three radially and slightly downwardly

disposed ducts D through which metal flows into the casting space.

The siphon **13** delivers molten metal from a supply vessel (not shown) into the hollow cup **15** in the mandrel head and the rate of withdrawal of the hollow solid billet S is such as to maintain a level **16** of liquid metal L appreciably above the bottom of cup **15** so as to submerge the lower end of the siphon tube in the liquid metal. The rate of pouring the metal into the cup is carefully controlled to maintain this level. The maintenance of this metal in the cup assures a smooth, non-turbulent flow of metal into the space between the mold **2** and the mandrel M to form the billet.

The mandrel illustrated in detail in FIGS. 2 and 3 may be used advantageously in molds of various sizes. For example, for a mold $4\frac{3}{32}$ inches in diameter at the top, the mandrel has an upper diameter of about $3\frac{1}{8}$ inches, a cup diameter of about $1\frac{7}{8}$ inches in diameter and a cup depth of about 4 inches. The holes D are about $\frac{3}{4}$ inch in diameter and slope downward at an angle of about 15°. The flange **8** should be about $\frac{1}{2}$ inch or more in thickness. The arrangement and proportioning of the cup and ducts is very important in controlling the feed rate, withdrawal rate, and the level of molten metal in the mold. The total cross-sectional area of the three ducts is at least equal to the cross-sectional area of the cup. If the holes are too high, controlling the level of the metal in the mold is difficult due to insufficient molten metal acting as a reservoir to compensate for changes in siphon feed. If the holes are too low, the effective length of the mold for cooling is shortened, and at the casting speeds desired the billet may leave the mandrel before it is solid and metal will run out.

The starting of a casting operation in apparatus of the type disclosed is well known and need not be described. After the predetermined rate of casting has been determined, for example about 5 feet per minute, the copper is poured into the cup **15** so as to maintain the level **16** of liquid metal L about $1\frac{3}{4}$ inches above the bottom of the cup and about $\frac{3}{4}$ inch below the top of the mold **2**. The radial ducts D preferably slope slightly downward and effect a smooth flow of copper into the liquid metal in the casting space without causing turbulence. The solidification generally takes place about 6 inches below the level **16** so that there is a coherent mass of liquid metal in bearing contact with the solidifying copper S. The copper billet shrinks and decreases in diameter as it moves downward and the mold **2** is tapered to maintain close contact with the billet so that there is an effective transfer of heat from the billet to the cooled mold. The shrinkage causes the inner diameter of the billet to decrease and the lower part of the mandrel M is slightly tapered as shown in FIG. 2 to maintain close but free contact with the billet. After the billet leaves the mold it is further cooled by sprays of water as is customary in this art.

The mandrel support is the subject of the copending application of George C. Earl, Ser. No. 395,541, filed Sept. 10, 1964, to the same assignee as this application.

I claim:

In apparatus for the continuous casting of hollow metal billets which includes an upright stationary outer annular graphite mold with an open ended bottom mounted snugly within an annular mold support, an inner upright graphite mandrel extending into the annular mold from above to provide an interior annular space between the mandrel and the mold, the mandrel having in its upper end an upright cup for receiving and flowing therefrom a body of molten metal, the cup being open at its top and closed at its bottom and having a plurality of peripherally spaced ducts extending through the wall of its lower portion and communicating with the upper portion of the annular space between the mandrel and the annular mold, and a

siphon feed tube for molten metal extending into the cup so that molten metal may flow continuously through the tube downwardly into the cup and thence through the peripherally spaced ducts into the annular space between the mandrel and the annular mold where molten metal freezes to form a continuous progressively advancing hollow billet, the improvement in combination therewith which comprises:

(a) the end of the feed tube is disposed in said cup at about the level of the entrances to the peripherally spaced ducts and the level of the liquid metal in the cup is maintained above the end of the feed tube and consequently above the entrances to the peripherally spaced ducts which extend through the wall of the annular mandrel;

(b) the total cross-sectional area of the three peripherally spaced ducts is at least equal to the cross-sectional area of the cup in the upper end of said mandrel.

References Cited

FOREIGN PATENTS

743,603	12/1943	Germany.
751,356	5/1951	Germany.
843,138	7/1952	Germany.
902,433	1/1954	Germany.
231,523	6/1944	Switzerland.

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