April 5, 1949. A. J. PHILLIPS ET AL 2,466,612

CONTINUOUSLY CASTING HOLLOW METAL SHAPES

Filed July 2, 1946

Fig. 2

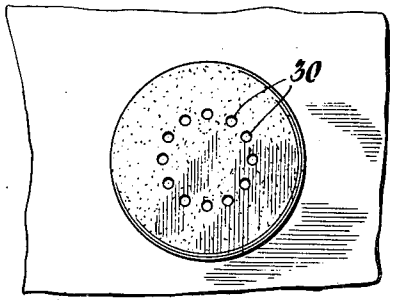


Fig. 3

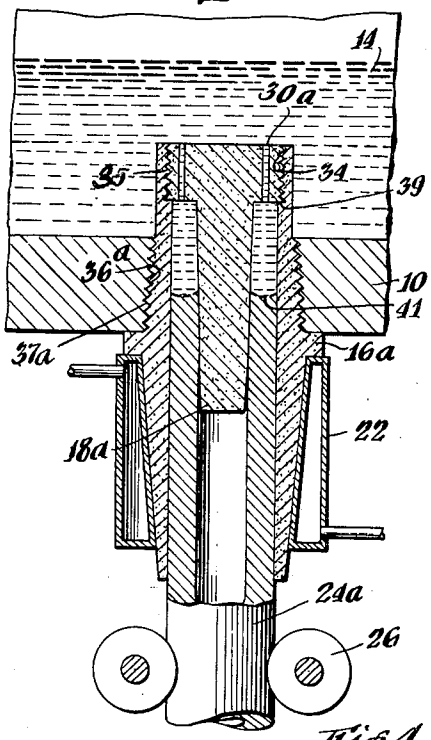


Fig. 1

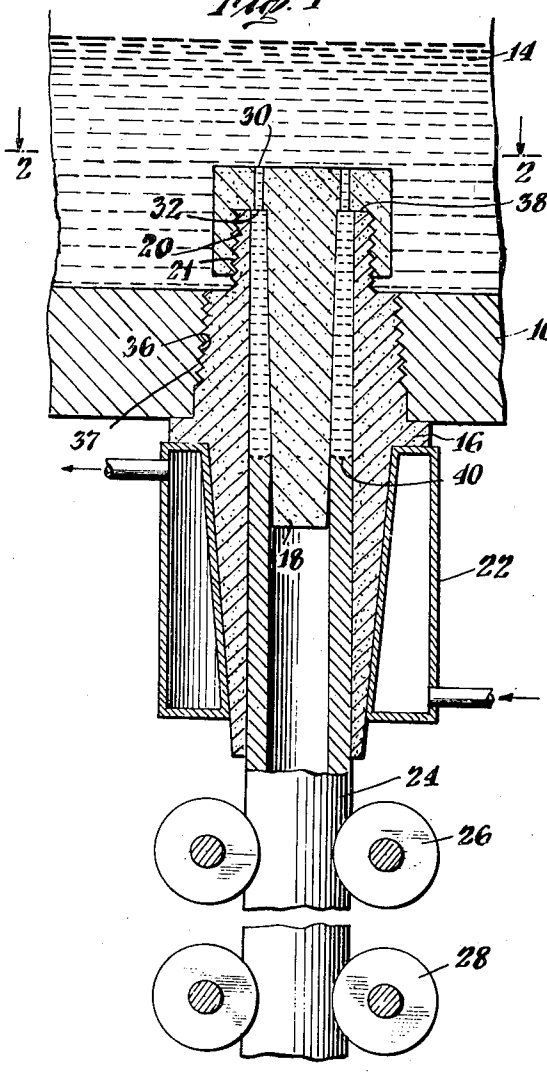
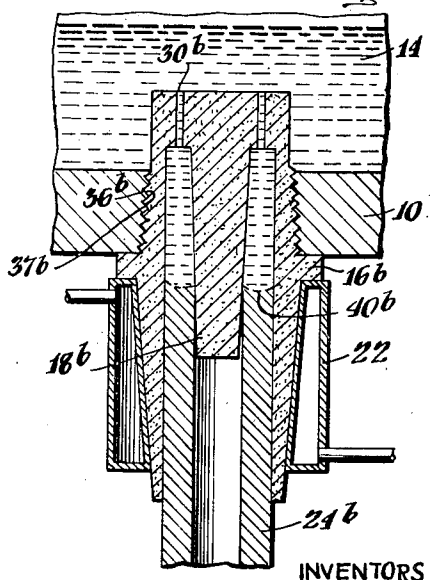


Fig. 4



INVENTORS
Albert J. Phillips
John S. Smart, Jr.

BY J. R. Fenn

ATTORNEY

Patented Apr. 5, 1949

2,466,612

UNITED STATES PATENT OFFICE

2,466,612

CONTINUOUSLY CASTING HOLLOW METAL SHAPES

Albert J. Phillips, Plainfield, and John S. Smart, Jr., Westfield, N. J., assignors to American Smelting and Refining Company, New York, N. Y., a corporation of New Jersey

Application July 2, 1946, Serial No. 681,014

2 Claims. (Cl. 22—57.2)

1

This invention relates to apparatus for continuously casting hollow metal shapes.

Various proposals have been made to continuously cast pipes, tubes and other hollow metal shapes by leading molten metal into a mold cavity defined by the inner walls of a mold body and a mandrel disposed longitudinally therein, and withdrawing the cast shape from such cavity, the metal undergoing solidification in the cavity during its passage therethrough. Despite such proposals and notwithstanding the fact that many of them were long since advanced, the adaption of continuous casting to the commercial production of hollow shapes has yet to be generally realized.

While various factors are probably responsible for the fact that continuous casting has yet to generally replace the standard practices for producing hollow shapes, it is applicants' belief that this is probably to be attributed in large measure, either to the inability of the particular continuous casting proposal to yield a product equal or superior in quality to that obtained by the older practices, or to do so at a comparable or permissible cost. For instance, if a particular continuous casting operation will produce a tube but only with an accompanying variation in wall thickness of, say 10–20%, or will produce a quality product but only at a prohibitive cost, it has little to commend itself for general adoption.

The present invention provides improved apparatus for continuously casting hollow metal shapes on a commercial basis, the products manifesting uniformity in their dimensions—both inner and outer, and exhibiting minimum variation in wall thickness—less than 1% being commonly achieved.

Although the novel features which are believed to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, and the manner in which it may be carried out, may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which

Fig. 1 is an elevation in section of one form of casting apparatus in accordance with the invention.

Fig. 2 is a view taken at the line 2—2 of Fig. 1, looking in the direction of the arrows.

Fig. 3 is an elevation in section of a modified form of such casting apparatus, and

Fig. 4 is a further modification of such casting apparatus.

2

Like reference characters denote like parts in the several figures of the drawings; similar parts bear the suffix *a* or *b*.

Referring to the drawings, and particularly Fig. 1, 10 represents the floor of a crucible or other suitable vessel containing molten metal 14 to be cast. A mold, having body portion 16, is provided at its upper end with a mandrel 18 which is fixedly secured thereto by the cooperating male and female threaded segments 20 and 21, respectively. A cooling jacket 22 surrounds the lower portion of the mold 16 for solidifying the molten metal into the hollow casting 24. Two pairs of oppositely disposed rolls 26—28 are provided for controlling the withdrawal of the casting 24 from the mold. The cap portion of the mandrel 18 is provided with a number of holes 30 for introducing molten metal 14 from the holding vessel into the mold cavity at 32.

In the modification shown in Fig. 3 the top portion 34 of the mandrel 18*a* is externally threaded and is fixedly secured to mold body 16*a* which is internally threaded at its top portion 35, all as indicated at 34. In the modification shown in Fig. 4 mold body 16*b* and mandrel 18*b* are formed of a single piece of material, holes 30*b* being provided for ingress of molten metal to the mold cavity. In all cases, the mold is provided with external threads 36 which engage threads 37 in the base or floor 10 for mounting and dismounting the mold simply by screwing or unscrewing the mold into or out of the base from below. In mounted position, as shown in the drawings, the top of the mold extends through the floor of the vessel so that the upper region of the mold cavity communicates directly with the interior of the vessel to receive molten metal therefrom by gravity in response to withdrawal of the cast shape from the mold thereby precluding any free surface of molten metal in the mold during casting.

It is to be noted that in all three forms of apparatus the body and mandrel portions of the mold are structurally joined and united one to the other in fixed relationship thereby precluding both horizontal and vertical relative movement between the portions, which feature has been found to be of major importance in maintaining the mold cavity with constant dimensions throughout the continuous casting of metal therein. The aforesaid structural union of the mandrel and body portions of the mold is accomplished in the types of apparatus shown in Figs. 1 and 3, by male and female threaded segments 20, 21 and 34, 35, respectively; in the modi-

fication shown in Fig. 4, it is accomplished by making same from a single unitary piece of graphite. To insure proper longitudinal alignment of the mandrel in the forms of mold shown in Figs. 1 and 3, provision is made for seating the mandrel on the mold body as at **38** and **39**, respectively.

A further feature of importance in continuously casting hollow shapes of most metals and alloys, is the kind and position of tapers provided for both mandrel and body portions of the mold. In this connection, attention is drawn to the fact that the zone of solidification in the mold cavity varies vertically according to whether the casting operation is just being inaugurated or is established. This difference is indicated, for illustrative purposes, in the several figures of the drawings; the zone of initial solidification being indicated by reference character **41** in Fig. 3 with the zone of normal solidification being indicated at **40** and **40***b* in Figs. 1 and 4.

For the inner wall of the mold body portion there is provided, from the zone of normal solidification through the zone of initial solidification, an upwardly-extending inverse taper sufficient to permit inauguration of the continuous casting process; and at the zone of normal solidification, the mandrel is provided with a downwardly-extending converging taper sufficient to permit progressive, non-seizing contraction of the cast shape in its downward movement. By observing the taper standards just mentioned and giving proper consideration to such factors as the characteristics of the metal being cast, the dimensions of the hollow cast shape, etc., the skilled operator can arrive at the optimum degree of taper for both mandrel and mold body for the particular casting operation. Excellent results have been obtained in machining the correct mold body and mandrel tapers in molds made of very dense graphite such as is described by Poland and Lindner in their U. S. Patent No. 2,136,394.

As illustrative of a properly tapered mold body and mandrel in accordance with the invention, is a mold of the following dimensions which has been successfully employed for the production of silver continuous cast tube having an outside diameter of one and one-half inches and an inside diameter of five-eighths of an inch. The mold is of the general type illustrated in Fig. 1 with an over-all length of 6 inches, the mandrel portion being three and one-eighth inches long exclusive of the cap portion containing the molten metal feed holes **30** which was five-eighths inch. The mandrel was provided with a taper of three-eighths inch per foot, the diameter of said mandrel being 0.605" at its bottom. At the zone of normal solidification, which had a depth of 0.75", the diameter of the mold body was 1.548" and the inner wall was straight. In the next two and nine-sixteenths inches above that zone, the inner wall was provided with an upwardly-extending inverse taper to a diameter of 1.522 inches. To enhance the cooling of the cast metal a taper was also provided for the inner wall from the bottom of the normal zone of solidification to the mold exit so that the diameter of the latter measured 1.527".

To continuously cast hollow metal shapes in the apparatus of the invention, the mold is closed with a starting plug of the configuration of the casting to be made, cooling fluid such as water is circulated through the jacket **22**, molten metal to be cast is supplied through the holding vessel from whence it enters the mold cavity by the holes **30**, and the withdrawal rolls **26**, **28** actuated—all as will be understood by the operator skilled in the art.

The following specific examples of actual operating runs will serve to illustrate the utility of the invention in casting hollow metal shapes:

Example I.—Tin bronze metal tubing (95% copper, 5% tin) having an outside diameter of 2" and a wall thickness of 0.2" was continuously cast at the rate of one foot per minute in a graphite mold assembly of the type illustrated in Fig. 1. Examination of the product revealed a uniformly concentric bore with a very smooth inner wall surface and a variation in wall thickness of less than 1%.

Example II.—In this instance silver tubing of one and one eighth inches outside diameter and a wall thickness of 0.625" was continuously cast at the rate of 14 inches per minute. The casting was of excellent quality with smooth surfaces and exhibited less than 1% variation in wall thickness.

Example III.—Employing an alloy of 10% tin, 0.2% phosphorus, balance copper, phosphor-bronze tubing having an inside diameter of 0.734" and an outside diameter of 1.112" was continuously cast with a variation in wall thickness of approximately 1%. The tubing was of excellent quality.

It will be appreciated that the invention is applicable for the continuous casting of metals and alloys other than those above given by way of illustrating the use of the invention and for the production of such hollow shapes, other than pipe and tube, as present uniform cross-sectional dimensions. While certain novel features of the invention have been disclosed and are pointed out in the appended claims, it will be understood that various changes may be made by those skilled in the art within the scope and spirit of the claimed invention.

What is claimed is:

1. Apparatus for continuously casting hollow metal shapes comprising a vessel affording a supply of molten metal, a vertically-disposed graphite mold comprising body and mandrel portions structurally joined and united one to the other in fixed relationship precluding both horizontal and vertical relative movement therebetween and thus defining a mold cavity of constant dimensions throughout the continuous casting of metal therein, the inner wall of said body portion having an upwardly-extending inverse taper from the zone of normal solidification through the zone of initial solidification permitting inauguration of the continuous casting process and said mandrel portion having a downwardly-extending converging taper at the zone of normal solidification permitting progressive, non-seizing contraction of the cast shape in its downward movement, means mounting said mold in the floor of said vessel with the top of the mold extending therethrough so that the upper region of said mold cavity communicates directly with the interior of said vessel to receive molten metal therefrom by gravity in response to withdrawal of the cast shape from the mold thereby precluding any free surface of molten metal in the mold cavity during casting, cooling means for solidifying metal in its passage through said cavity, and means controlling the withdrawal of the continuous cast shape from the mold.

2. Apparatus for continuously casting hollow metal shapes comprising a vessel affording a supply of molten metal, a vertically-disposed graph-

ite mold comprising body and mandrel portions structurally joined one to the other by cooperating male and female threaded segments in manner precluding both horizontal and vertical relative movement therebetween and thus defining a mold cavity of constant dimensions throughout the continuous casting of metal therein, the inner wall of said body portion having an upwardly-extending inverse taper from the zone of normal solidification through the zone of initial solidification permitting inauguration of the continuous casting process and said mandrel portion having a downwardly-extending converging taper at the zone of normal solidification permitting progressive, non-seizing contraction of the cast shape in its downward movement, means mounting said mold in the floor of said vessel with the top of the mold extending therethrough so that the upper region of said mold cavity communicates directly with the interior of said vessel to receive molten metal therefrom by gravity in response to withdrawal of the cast shape from the mold thereby precluding any free surface of

molten metal in the mold during casting, cooling means for solidifying metal in its passage through said cavity, and means controlling the withdrawal of the continuous cast shape from the mold.

ALBERT J. PHILLIPS.
JOHN S. SMART, JR.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
777,561	Stravs et al.	Dec. 13, 1904
1,503,479	Coats	Aug. 5, 1924
2,130,202	Tama	Sept. 13, 1938
2,136,394	Poland et al.	Nov. 15, 1938
2,264,288	Betterton et al.	Dec. 2, 1941
2,277,375	Tama	Mar. 24, 1942

FOREIGN PATENTS

Number	Country	Date
280,717	Germany	Sept. 21, 1922