May 10, 1955 S. M. DICKSON 2,707,813

APPARATUS FOR FORMING SEAMLESS TUBES AND COATING TUBULAR SECTIONS

Filed Nov. 25, 1950

3 Sheets-Sheet 1

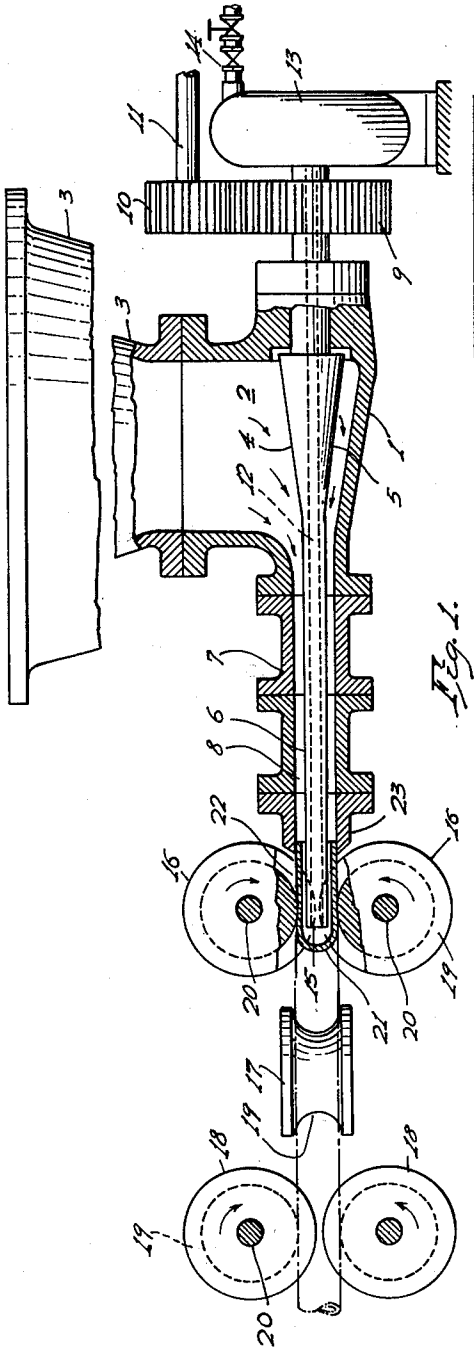


Fig. 1.

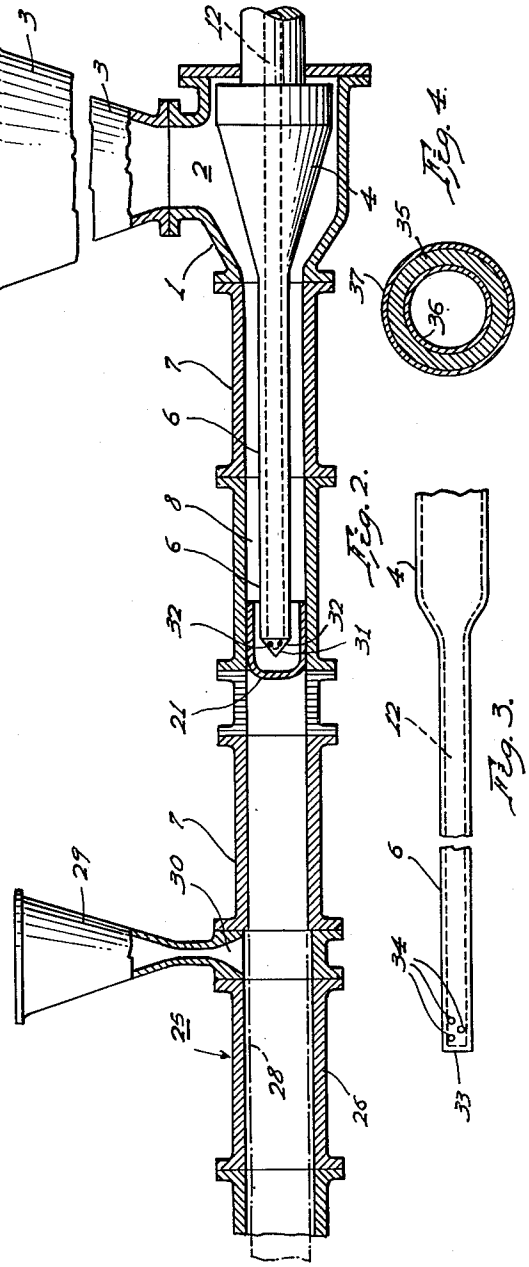


Fig. 2.

Fig. 3.

Fig. 4.

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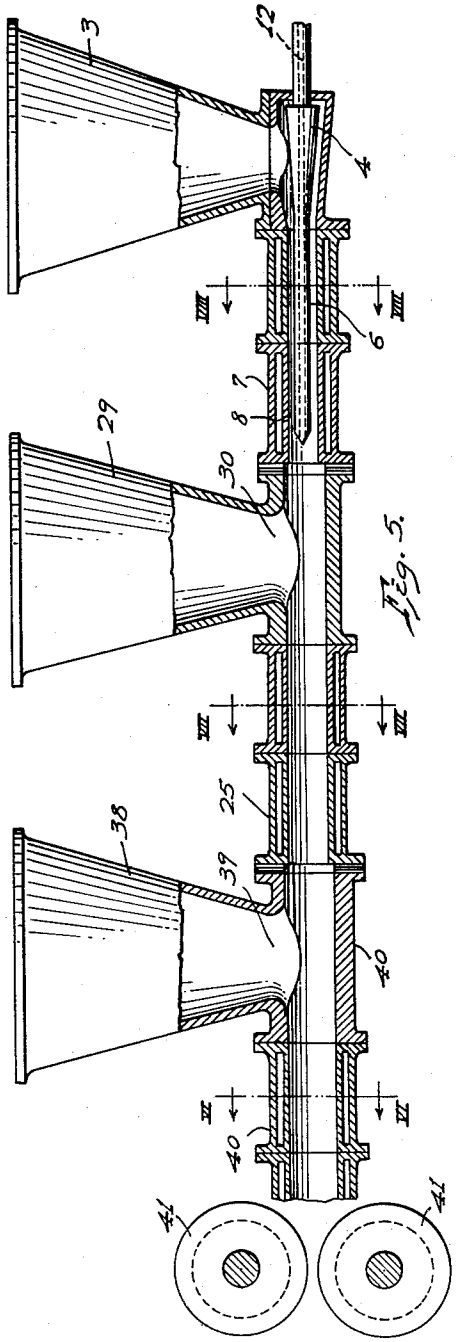


Fig. 5.

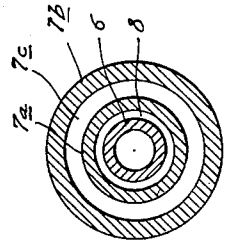


Fig. 8.

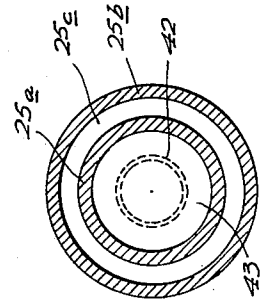


Fig. 7.

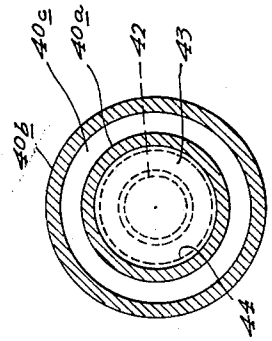


Fig. 6.

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Filed Nov. 25, 1950 3 Sheets-Sheet 3

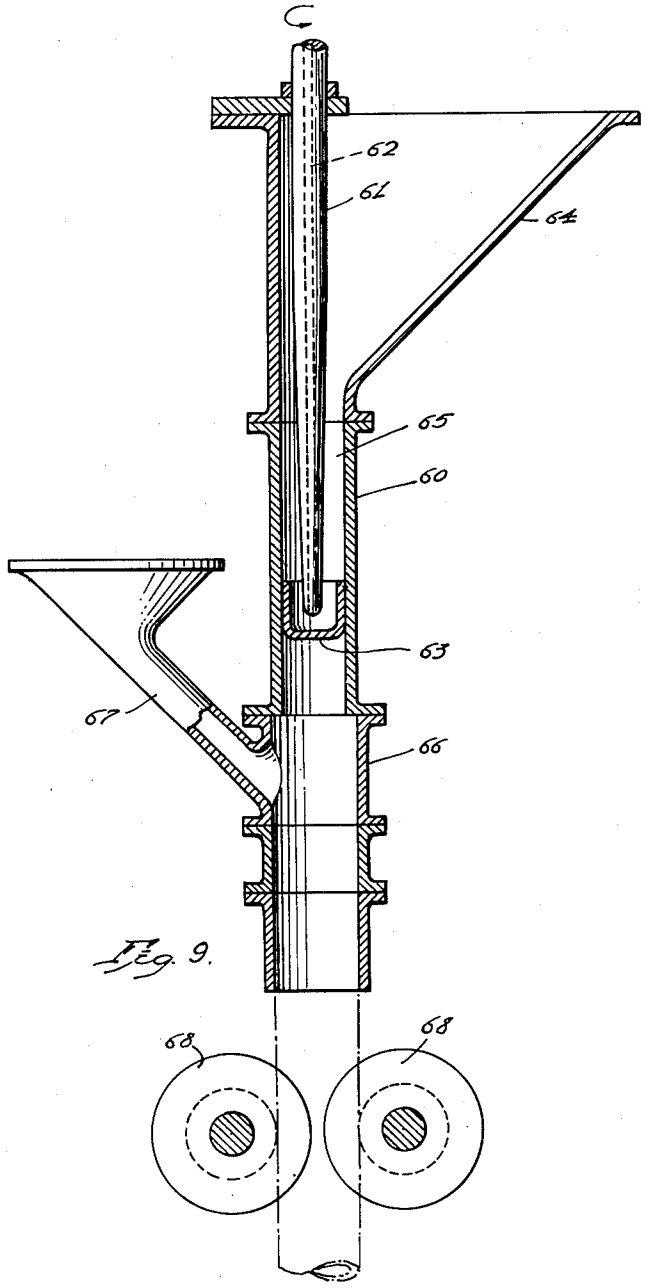


Fig. 9.

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APPARATUS FOR FORMING SEAMLESS TUBES AND COATING TUBULAR SECTIONS

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Application November 25, 1950, Serial No. 197,572

4 Claims. (Cl. 22—57.2)

This invention relates to an apparatus for forming seamless tubes and coating tubular sections with a layer of metal or other material.

The formation of the tubes and the coating applications are accomplished, in accordance with the principles of this invention, by a continuous casting process. The metal, ferrous or non-ferrous, or other material, is fed in a fluid condition by way of a hopper to a cooling or hardening chamber where it is formed into a section or applied as a coating to the surface of a section being moved endwise through the chamber. In the formation of tubular sections, the metal is flowed about a mandrel so that its inner dimension is formed to the shape of the mandrel. Although the casting of tubes by flowing the metal around a mandrel has been proposed previously, the mandrel of this invention is characterized by having a hollow formation with openings at its end so that a cooling medium may be passed therethrough, the cooling medium being exhausted through the open end of the mandrel directly into the interior of the tube being cast. The cooling medium discharged into the cast tube is thus effective to cool the tube so as to reduce the possibility of it being subsequently deformed while in a heated and plastic condition. In a manner to be described, the cooling medium discharged into the tube is additionally utilized to force the tube through the forming apparatus and cooling chamber and to otherwise assist in its formation.

In the application of a coating to the surface of a section, the section to which the coating is to be applied is moved endwise through a cooling or solidifying chamber which is of a larger dimension than the section being coated. The coating material is fed to this chamber by way of a hopper and in the process of cooling is hardened and applied as a coating to the section in such manner as to constitute an integral part thereof. By the provision of a plurality of cooling chambers along the path of section movement, a plurality of coatings may be applied in as many layers as desired.

From the foregoing, it will be noted that one of the principal objects of this invention is to provide improvements in the casting of tubular sections in which the tubular section being formed is utilized to exhaust or discharge a cooling medium from a mandrel about which the tube is being cast.

Another object of the invention is to provide improved apparatus for casting tubular sections in which a hollow mandrel having an opening in its end is provided for supplying a pressure and cooling action to the interior of the section being formed.

A further object of the invention is the provision of a novel apparatus for applying a coating material to the surface of a section which involves moving the section endwise through a casting chamber containing a body of the material wherein the material is cast as a layer on the surface of the section moving therethrough.

A still further object of the invention is to provide an improved apparatus for applying a protective coating of metal or other material to tubular sections which is adaptable to the application of the coating in several layers as a continuous casting operation.

Other objects and advantages of the invention will be apparent from the following description.

In the drawings, there are shown several embodiments of the invention. In this showing:

Fig. 1 is a fragmentary view in elevation and vertical section illustrating somewhat diagrammatically apparatus constructed in accordance with the principles of this invention and adapted to the formation of a tubular section;

Fig. 2 is a view similar to Fig. 1 illustrating a modification for providing the seamless tube being formed with an inner and outer protective coating;

Fig. 3 is a fragmentary view in side elevation of a modified form of mandrel usable with the apparatus shown in Fig. 2;

Fig. 4 is a sectional view of the tubular product formed with apparatus in Fig. 2;

Fig. 5 is a view similar to Fig. 1 illustrating apparatus for forming a tubular section consisting of a plurality of concentric layers;

Figs. 6, 7 and 8 are respectively sectional views taken along the lines VI—VI, VII—VII, VIII—VIII of Fig. 5;

Fig. 9 is a fragmentary sectional view in elevation and vertical section illustrating diagrammatically a modified form of apparatus in which the tubing formed with a coating is moved vertically.

Referring to Fig. 1 of the drawings, the numeral **1** designates a receptacle having a cooling chamber **2** therein to which molten metal or other materials which will solidify upon cooling may be fed from a hopper **3**. A mandrel **4** is rotatably supported in receptacle **1** and is provided with a conical portion **5** in the chamber **2** and with a cylindrical portion **6** at its outer end which is positioned concentrically of a tubular mold section **7**. The mandrel parts **6** and mold section **7** cooperate to define an annular space **8** having dimensions corresponding to the contour of the tubular section to be formed. The mandrel **4** is rotated by a gear **9** in meshing engagement with a pinion **10** which is driven by a drive shaft **11** connected to any suitable prime mover (not shown).

The mandrel **4** is provided with an axially extending opening **12** which is connected through the center of the gear **9** with a pump **13** which is driven by the gear **9**. The pump **13** is utilized to supply water or other fluid to the passage **12** from a supply line **14**. In place of water, this invention contemplates feeding liquid chemicals or gases through the opening **12**, such other materials being usable, for example, to create a non-oxidizing atmosphere interiorly of the tube to eliminate or reduce scale formation. The end of the tubular section **6** of the mandrel **4** is open at **15** for a purpose to be described.

A plurality of pairs of pinch rolls **16**, **17** and **18** having peripheral grooves as at **19** shaped to conform

to the exterior surface of the tubular section being formed are provided for moving the tubular section to the left as viewed in Fig. 1 and for working the surface of the tubular section being so formed. The pairs **16**, **17** and **18** of pinch rolls are provided with driving connections **20** to driving apparatus not shown for effecting positive and forcible rotation thereof to move the tubular section to the left as viewed in Fig. 1. A hollow plug **21** having an exterior surface corresponding to the shape of the tubular section to be formed is provided for facilitating the start of the operations by which such tubular section is formed. The hollow plug **21** has a cylindrical shank **22** of such length that it may be engaged by the first set of pinch rolls **16** while its inner end is positioned within the outer end **23** of the cylindrical mold **7** so that it is effective to form a closure for the mold **7** about the outer end of the mandrel **6**.

In operation, the hollow plug **21** is inserted into the position illustrated in Fig. 1 in which it forms a closure for the tubular mold **7**. With the movable parts of the apparatus at rest, molten metal is poured into the hopper **3** to thereby fill the compartment **2** of the receptacle **1**. The metal flowing into the receptacle **1** completely fills the annular space **8** about the mandrel and is prevented by the hollow plug **21** from flowing to the left beyond the first pair of pinch rolls **16**. As the metal in the receptacle **2** and annular space **8** cools it hardens to a plastic condition in which it may be worked. The drive shaft **11** is then operated to rotate the gear **9** and mandrel **4** to prevent the metal from adhering to the surface of the mandrel **4**. At about the same time that rotation of the shaft **11** is started, the drive (not shown) connected to the pairs of pinch rolls **16**, **17** and **18** is operated to apply a driving force thereto. The plug **21** is thus moved to the left and draws with it the tubular section the end of which will have adhered thereto. In addition to the force from the pinch rolls which is effective to move the tubular section being cast to the left, an additional driving force is had by operating the supply line **14** and pump **13** to deliver cooling water or other suitable fluid medium through the mandrel opening **12** and exit end **15** thereof to the interior of the tubular section being formed. The steam formed by heating of the water within the mandrel **4** and upon discharge into the interior of the tubular section creates a pressure of considerable proportion which is effective to move the tube to the left as viewed in Fig. 1. As a result of these combined operations, the metal will flow through the cooling chamber **2** of the receptacle **1** in the manner indicated by the arrows, and a tubular section will be formed by a continuous casting operation in the annular space **8**.

In addition to the force exerted by the steam generated from the water moving through the mandrel opening **12** for moving the tubular section to the left as viewed in Fig. 1, it will be noted that there is provided an effective arrangement for continuously cooling the mandrel **4**. The water is forced by the pump **13** continuously through the opening **12** and is exhausted into the tubular section being formed thereby effecting a continuous cooling operation of the mandrel **4**. The water delivered to the interior of the tube being cast is effective to further cool and harden the material of the tube so that it may be more effectively worked on by the pinch rolls. In addition, the pressure of the steam generated within the tubular section reacts outwardly against the tubular section against the inward pressure applied by the pinch rolls.

In the operation described above, the plug **21** serves as a dam to the metal which will flow thereagainst and harden. However, it will be appreciated that the apparatus is contemplated for use without a plug **21**. The metal in flowing about the mandrel **6** will cool and solidify, and, in so doing, will form its own plug about the end of the mandrel. When omitting the plug **21**, it will be desirable to have the end of the mandrel terminate short of the end of the mold in which it is located. Obviously, any equivalent structure capable of obstructing the flow of liquid metal until it is sufficiently hard to form a plug, such as, for example, a solid rod insertable into the end of a mold housing the mandrel, may be used in place of the hollow plug **21**.

The apparatus shown in Fig. 2 employs structure similar to that shown in Fig. 1, and like numerals have been employed to designate parts functioning in a manner similar to the parts of the apparatus shown in Fig. 1. In this showing, coating apparatus, designated as a whole by the numeral **25** is shown in a position in advance of the pinch rolls, and the showing of the pinch rolls at the exit end of the coating apparatus **25** has been omitted. The coating apparatus **25** comprises a cylindrical mold section **26** connected with the cylindrical mold section **7**. The mold section **26**, as illustrated, has an internal diameter greater than the internal diameter of the mold section **7**. As the tube emerges from the mold section **7** there is a space between its outer surface, as indicated by the dotted line **28**, and the interior surface of the mold **26**. A hopper **29** is provided for supplying coating material to this space, and feeds such material to a chamber **30** from which it flows to completely fill the space between the outer surface **28** and the inner surface of the mold **26**. The coating material fed to the hopper **29** may be a molten metal which will unite with the outer surface of the tube emerging from the mold **7**, or it may be any other coating material which may be applied to the outer surface of the tube. For example, powdered metal may be fed to the hopper **29** which will fuse to the surface of the tube being formed. As a further alternate form of coating material, a non-metallic liquid or solid coating material may be supplied to the hopper **29**.

In the modification of Fig. 2, the plug **21** which is used to start casting of a tubular section is placed over the end of the mandrel, but it need not have a length so that it may be engaged by pinch rolls as shown in Fig. 1. As explained above, the plug **21** may be omitted, or a solid rod may be substituted therefor. With the use of a plug **21** as shown in Fig. 2, the pressure of the fluid supplied to the interior of the tube being cast must be relied upon for moving the tube and the plug **21** to the left to a position where the tube with its protective coating may be engaged by driven pinch rolls.

In the modification shown in Fig. 2, the end **31** of the cylindrical mandrel section **6** is closed and has a conical shape with openings **32** therein communicating with the axially extending opening **12**. The openings **32** are inclined in such direction that fluid emerging therethrough is projected against the inner surface of the tube being cast. This fluid may be a coating fluid, or a fluid having coating material therein which will be deposited upon the inner surface of the tubular section being cast. As an alternative structure for projecting a coating onto the interior surface of the tube being cast, a mandrel **6** as shown in Fig. 3 may be employed. The mandrel **6** of Fig. 3 has its end closed as at **33**, and separate openings **34** are formed in the outer end of the cylindrical section **6** of the mandrel for supplying fluid from the opening **12** to the inner surface of the tubular section.

In Fig. 4 there is shown a sectional view illustrating the structure of a typical tube formed by the apparatus illustrated in Fig. 2. In this showing, the numeral **35** designates the body of the tube which is formed by the material flowing about the mandrel **4** from the hopper **3**. The numeral **36** designates the inner protective coating which is sprayed against the inner surface of the tube **35**. The numeral **37** designates the outer protective covering which is applied about the outer surface of the tube and which is supplied thereto from the hopper **29** and feed chamber **30**.

The coatings **36** and **37** may be any coating desirable for protecting the tubular product, and may be one which utilizes the heat of the tube for effecting a bond of the

coating material to be applied to the tube. Such coatings may include any of the metallic powders, porcelain enamel frits, baking enamels, high temperature asphalts, resins or plastics. The coatings may be applied in the absence of air or oxidizing gases which may be excluded by steam or other fluid pressure medium supplied to the interior of the tube through the axially extended opening **12** in the mandrel **4**. Although the description above has proceeded on the basis that the tube is fabricated from a metal, it will be understood that the principles of the invention are applicable to the fabrication of tubes from non-metallic materials. In such case, the material employed in the fabrication of the tube would be one which could be fed to the hopper **3** in a liquid condition, and it would solidify upon cooling in the chamber **2**, the principles of this invention being applicable to thermoplastic materials generally.

In Fig. 5 there is shown a modification of the structure illustrated in Fig. 2 which is adapted to the formation of a metallic tube having integral inner and outer coatings. In this modification, the inner coating is fabricated first and the tube itself is fabricated around the inner coating or liner as distinguished from the arrangement shown in Fig. 2 in which the tube itself is formed first and the inner coating or liner is sprayed into position. Referring to Fig. 5, those parts similar to like parts of Fig. 2 have been designated by like numerals. In the modification of Fig. 5, the material of the inner coating or liner is poured in the hopper **3** and is fabricated to a cylindrical shape about the rotating mandrel **4** in the mold section **7** as described above. The cylindrical liner as it emerges from the mold section **7** moves into the chamber **30** where the material in the hopper **29**, from which the tube is to be fabricated, is applied in position about the liner as in the case of the outer coating **37** described in connection with Fig. 2. As the tube and its inner liner leave the mold section **25**, it moves into the chamber **39** within a mold section **40** where the outer coating from a hopper **38** is applied thereto. As the tube with inner and outer liners emerges from the mold section **40**, it is picked up and moved to the left by a pair of driven pinch rolls **41** as described above. Figs. 6, 7 and 8 are sectional views respectively through the sections **40**, **27** and **7** of Fig. 5 and illustrate respectively the structure of such sections with the arrangement of the tube being fabricated illustrated diagrammatically therein. These mold sections are shown as being formed from inner and outer parts to provide space therebetween through which cooling water may be circulated to prevent overheating of the mold sections. For example, the mold section **7** is formed of an inner cylinder **7***a* and an outer cylinder **7***b* to provide an annular space **7***c* through which water may circulate. The numerals designating the mold sections shown in Figs. 6 and 7 are provided with similar suffixes to illustrate the structure of the mold sections **40** and **25**.

As described above, the inner liner is formed of the material from the hopper **3** in the annular space **8** about the rotatable mandrel **6**. The contour of such inner liner is shown by the concentric dotted lines **42** in Fig. 7, and the tube proper is formed from material fed from the hopper **29** into the annular space **43** between the outer of the two concentric circles **42** and inner surface of the mold section **25***a*. In Fig. 6 the outer surface of the tube section fabricated in the annular space **43** has its outer surface designated diagrammatically by the broken circle **44**, and the outer coating or liner from the material in the hopper **38** is fabricated in the space between the circle **49** and the inner surface of the mold section **40***a*. In this manner, the apparatus of Fig. 5 will function to fabricate a tube consisting of three concentric layers of different metals. For example, a metal tube having an inside wall of nickel, an intermediate wall of iron, and an outer wall of copper may be fabricated in this manner.

In Fig. 9, there is shown a modification of the invention which is adapted to continuously and vertically cast a hollow section with a protective coating thereabout. The hollow section is formed in a mold **60** about a rotating mandrel **61** having an axially extending opening **62** through which a cooling liquid may be passed. A starting closure plug **63**, similar in function and operation to the plug **21** of Fig. 2 may be applied for starting the casting operation of the hollow section. A hopper **64** is provided for receiving and delivering the molten metal from which the hollow section is formed to the space **65** in the mold section **60** about the rotating mandrel **61**. When a fluid metal or cooling liquid such as water is forced through the mandrel opening **62**, the pressure generated therein will move the plug **63** and tube section bonded thereto downwardly as viewed in Fig. 9. As the tube section being cast emerges from the mold section **60**, it moves into an enlarged mold section **66** where a protective coating is formed about its peripheral surface. The material forming the protective coating is supplied to the space about the hollow tube section within the mold section **66** by a hopper **67**. As the tube with protective coatings thereon moves out of the lower end of the mold section **66**, it is engaged by a pair of pinch rolls **68** which are rotated in opposite directions to move the coated tubular product in a downward direction.

Attention is particularly directed to the fact that sections fabricated as described herein are free from scale and other defects occurring in conventional fabricating operations. It will be noted that the provision of a hollow mandrel and its use in the introduction of a fluid or gas to the interior of the hollow section can be utilized to create a non-oxidizing atmosphere in the interior of the section. Moreover, it enables the application of a protective coating while in such non-oxidizing atmosphere. In addition, protective coatings may be applied to the outer surface before it is subjected to the action of an oxidizing atmosphere.

While I have illustrated and described several embodiments of my invention, it will be understood that such showings are merely by way of illustration, and that various changes and modifications may be made therein within the contemplation of my invention and under the scope of the following claims.

I claim:

1. Apparatus for the continuous casting of hollow metal sections comprising a receptacle for receiving molten metal, a mold having an inner contour conforming to the exterior of the hollow section to be cast, a molten metal accumulating and cooling chamber connecting the receptacle and mold, an axially rotatable mandrel extending through the cooling chamber and mold, the mandrel portion within the cooling chamber being substantially cone shaped to feed the cooling metal into the mold, the portion of the mandrel within the mold having an exterior contour substantially conforming to the inner contour of the hollow section being formed within the mold, said mandrel having an opening extending longitudinally of the mandrel portions within the cooling chamber and mold, a closure member slidably disposed within the exit end of the mold and enclosing the end of the mandrel for engagement with and attachment to the section being cast, and means for introducing a cooling medium flowing under pressure through the longitudinal opening of the mandrel and acting to build up pressure against the mold closure member to move the cast section axially of the mold and rotating mandrel.

2. Apparatus as in claim 1 in which the mold closure member extends outwardly of the mold and between rotating opposing rolls which act to withdraw the cast section axially of the mold.

3. Apparatus as in claim 1 in which the mold closure member feeds the cast section into a second and larger size mold attached to the first mold where a coating of metal is applied to the exterior of the previously cast section.

4. Apparatus as in claim 1 wherein the end of the mandrel is closed and provided with a series of inclined openings for spraying the coolant passing through the mandrel against the inner face of the extruded section to deposit thereon a coating material in the coolant fluid.

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