

May 1, 1956

H. A. TOULMIN, JR.
CONTINUOUS METAL PRODUCTION
AND CONTINUOUS GAS PLATING
Original Filed Sept. 10, 1949

2,743,700

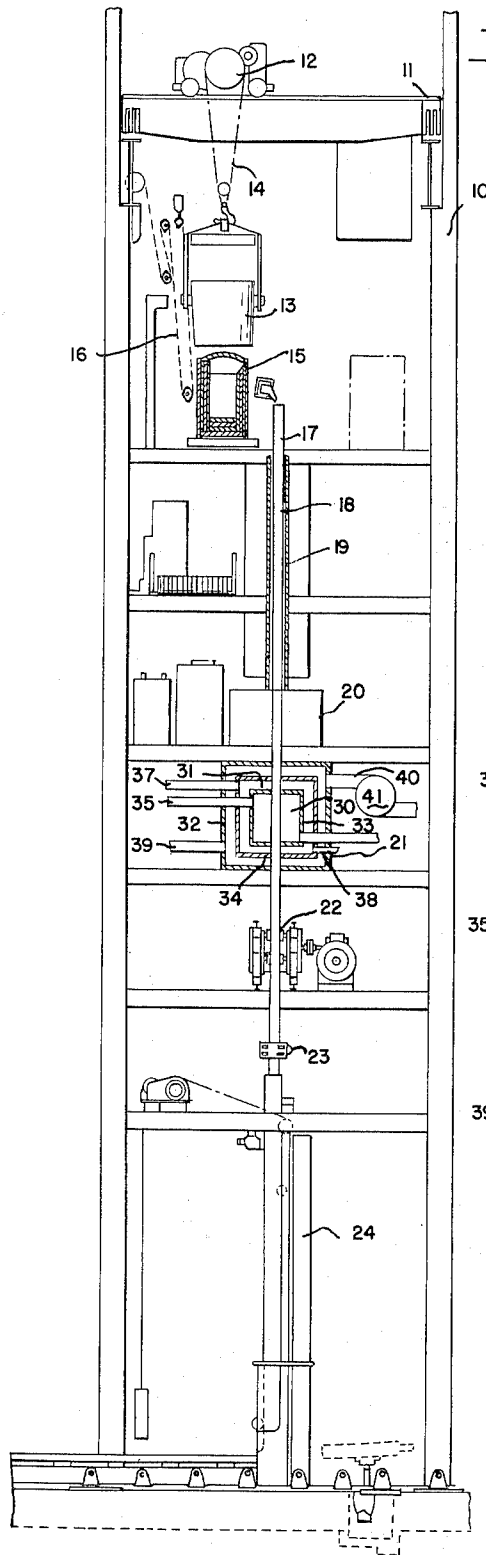


Fig. 1

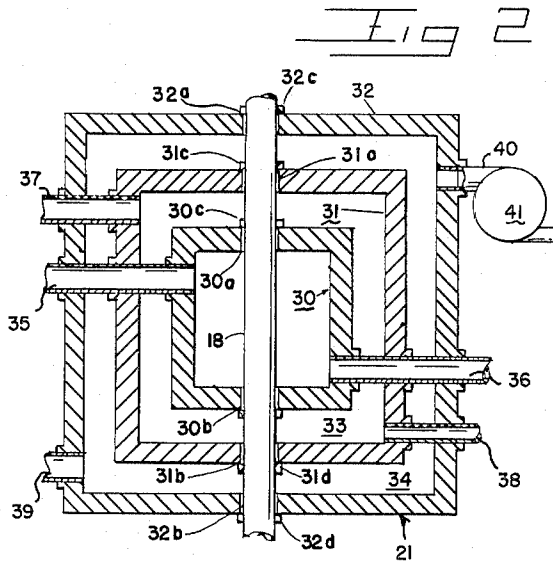


Fig. 2

INVENTOR

H. A. Toulmin Jr.
Toulmin & Toulmin
ATTORNEYS

1

2,743,700

CONTINUOUS METAL PRODUCTION AND CONTINUOUS GAS PLATING

Harry A. Toulmin, Jr., Dayton, Ohio, assignor to The
Commonwealth Engineering Company of Ohio, Day-
ton, Ohio, a corporation of Ohio

Original application September 10, 1949, Serial No.
115,033, now Patent No. 2,657,457, dated November
3, 1953. Divided and this application April 14, 1953,
Serial No. 348,726

4 Claims. (Cl. 118—48)

This invention relates to protective metal coatings. More particularly, it relates to the coating of cast metals by deposition of protective metals through decomposition of volatile metal compounds, and apparatus for carrying out the process.

Special types of carbon and alloy steel and non-ferrous alloys have been manufactured heretofore by pouring the molten metal into ingot molds.

Large size ingots while still hot are removed from the molds and shipped to the soaking pits where they are held until the internal and external ingot temperatures equalize.

The soaked ingots then are rolled in blooming mills into billets preparatory to further processing.

Rough billets require more or less surface conditioning because, for example, the steel is particularly prone to form loose scale and become badly oxidized while cooling, thus necessitating the surface treatment.

This process has now been at least partially superseded by the so-called continuous casting process. Continuous casting has been successfully performed upon a commercial scale, both in conjunction with ferrous and non-ferrous alloys.

While the continuous casting process eliminates several expensive steps, such as making and soaking ingots and rolling them on a blooming mill, it does not, for example, prevent scaling, oxidizing and other surface conditions.

Other and more specific objects and advantages will be apparent to one skilled in the art as the following description proceeds.

In brief, the process is carried out by casting metals and when the continuous ribbon of hot but solidified metal issues from the mold, bring the hot metal into contact with vapors of decomposable metal compounds.

In this way at least a portion of the heat in the molded material instead of being wasted is utilized to decompose volatile metal compounds and deposit a protective coating. In sequence the molten metal is poured into a shaping mold and cooled to a solid form. The formed cast metal progresses through an insulating sleeve, where cooling is controlled until the cast metal is reduced to a temperature in the range of approximately 300 to 600° F., depending upon the type of metal being cast and the thickness of the casting.

This hot metal then progresses through a plating chamber where the temperature of the metal decomposes vapors of volatile metal compounds continuously fed into contact with the continuously moving cast object.

The metal at this stage is solidified to the point where its speed of movement may be controlled by a roll drive or equivalent mechanism.

The plated cast metal is then cut to desired length by suitable means such as saws, acetylene torches, and the like.

In the plating step the hot cast metal is brought into

2

contact with continuously changing atmosphere which is made up of gaseous material, at least a portion of which is decomposable at the temperature of the continuously moving cast metal to deposit a metal coating.

Inasmuch as the cast metal is progressing continuously through this chamber, one of the factors important to the successful operation is control of gas pressure not only within the plating chamber itself, but in each of the surrounding annular spaces, of design which will be hereafter explained.

In order to insure against leakage of plating gases which are toxic from the plating chamber and still have openings in the partition walls for the continuous passage of the cast metal, it is necessary to maintain a metal-vapor free gas atmosphere at a slightly higher gas pressure in the annular spaces surrounding the plating chamber.

The leakage of inert gas into a plating chamber is limited to small quantities by having apertures in the partition walls of a configuration providing a loose sliding fit with the object passing therethrough or enlarged holes with shims encircling the moving object in close proximity to these holes and by keeping the pressure differential small.

It will be recognized that the inert gas leaking into the plating chamber is not a harmful operation because the metal-bearing gases are usually diluted with an inert gaseous medium and the gas decomposing reaction in the plating chamber produces relatively inert decomposition products.

The stream of gaseous material brought into contact with the hot cast metal may be formed by mixing an inert gas with the vapors of a volatile metal compound or by atomizing a liquid metal compound into a blast of hot inert gas or other equivalent method.

Carbon dioxide, helium, nitrogen, hydrogen, the gaseous product of controlled burning of hydrocarbon gases free of oxygen, and the like, have been utilized as a carrier medium or inert gas medium.

Metals to be deposited may be introduced as gaseous metal carbonyls or vaporized solutions of certain of the metal carbonyls in readily vaporizable solvents (for example, petroleum ether), also nitroxyl compounds, nitrosyl carbonyls, metal hydrides, metal alkyls, metal halides, and the like.

Illustrative compounds of the carbonyl type are nickel, iron, chromium, molybdenum, cobalt, and mixed carbonyls.

Illustrative compounds of other groups are the nitroxyls, such as copper nitroxyl; nitrosyl carbonyls, for example, cobalt nitrosyl carbonyl; hydrides, such as antimony hydride, tin hydride; metal alkyls, such as chromyl chloride; and carbonyls halogens, for example, osmium carbonyl bromide, ruthenium carbonyl chloride, and the like.

Each material from which a metal may be plated has a temperature at which decomposition is complete. However, decomposition may take place slowly at a lower temperature or while the vapors are being raised in temperature through some particular range. For example, nickel carbonyl completely decomposes at a temperature in the range of 375° F. to 400° F. However, nickel carbonyl starts to decompose slowly at about 175° F. and therefore decomposition continues during the time of heating from 200° to 380° F.

A large number of the metal carbonyls and hydrides may be effectively and efficiently decomposed at a temperature in the range of 350° F. to 450° F. When working with most metal carbonyls we prefer to operate in a temperature range of 375° F. to 425° F.

The process is illustrated without provision for anneal-

ing the deposited coating in order to increase their adhesion and ductility. If such an operation is desired provision can be made for an anneal in the inert gas filled annular space, as will be more definitely explained.

Annealing temperatures are higher than plating temperatures and generally in the range of 800 to 1200° F. An anneal may be carried out, for example, by induction heating.

The invention will be more clearly understood from the following description taken in connection with the drawing in which:

Figure 1 is a diagrammatic elevational view of a complete unit for continuously casting and plating metals; and

Figure 2 is an enlarged sectional view of the plating equipment.

Referring to the drawings, there is illustrated a continuous method of casting and plating as utilized in connection with steel manufacture without any intention that the invention be limited thereto.

In Figure 1 there is shown the supporting framework 10 of a multi-story building. On the top floor of said building framework 10 supports tracks 11 for a movable overhead crane 12.

A ladle 13 is suspended from crane 12 by suitable cables 14. Ladle 13 is shown suspended over a heated holding ladle 15. Ladle 15 is actuated for tipping and pouring by suitable means 16 such as pulleys or levers.

Adjacent the ladle 15 is a liquid-cooled mold 17 in which ladle 15 is adapted to empty. A cast steel tube 18 is shown issuing from the mold 17 and moving downward through an insulating sleeve 19 within which there is generally maintained an atmosphere of hydrogen.

Steel tube 18 moves downward from the sleeve 19 through a unit 20 designed to accurately maintain and control the temperature of the steel tube. Steel tube 18 passes on downward through a plating unit 21 which will be described in more detail.

Plated steel tube is drawn downward at a predetermined rate, generally in the range of 3 to 7 feet per minute for a tube of about 3 inch radius, by squeeze rolls 22.

The coated steel tube is cut into predetermined lengths by an acetylene torch 23 and the tubular units lowered to the horizontal by suitable cradle means 24.

Referring to Figure 2, it will be seen that the plating unit 21 consists of an inner wall member 30 and outer wall members 31 and 32, which enclose annular spaces or chambers 33 and 34, respectively.

Each of the wall members is provided with two aligned ports indicated as *a* and *b*, respectively, of size adapted for close sliding fit with the steel tube 18 passing vertically downward therethrough. The closure of each chamber may be tightened by use of shims indicated as *c* and *d*.

The inner chamber is provided with gas inlet and outlet means 35 and 36, respectively. Chamber 33 is provided with gas inlet and outlet means 37 and 38, respectively. Chamber 34 is provided with inlet and outlet means 39 and 40, respectively. Outlet means 40 is adapted with an exhaust means 41, such as a fan, for maintaining less than atmospheric pressure in annular space 34.

Operation of the equipment is as follows:

Hot molten metal is poured at a temperature in excess of 2000° F. In the primary mold the temperature is reduced to that necessary to set the cast metal, for carbon steel this is in a temperature range of 1200° F. to 1600° F.

In the insulating sleeve or "after cooler" the temperature is reduced to a temperature in the range of approximately 300 to 600° F. and preferably to 350 to 450° F. in an atmosphere of hydrogen.

The hot metal then travels through the plating unit. In this unit, the inner chamber is the plating chamber, where the hot metal contacts an atmosphere, preferably of carbon dioxide and vapors of a volatile metal compound. These vapors may be maintained under a variety of pressures, ranging from a pressure below to pressures above atmospheric pressures and generally in the range

of 6 inches of water vacuum to 6 inches of water positive pressure.

In the outer annular space there is maintained an atmosphere of inert gas. The gas is maintained under a pressure generally slightly under atmospheric in order that all gas, either that inert introduced or atmospheric air leaking into this annular space 34, will be removed by the exhaust fan and there will be no tendency for gas to leak out, contaminating the atmosphere which must be frequented by workmen.

In the intermediate annular space 33 there is maintained an inert gas atmosphere under a pressure generally higher than is maintained in either the inner chamber or the outer annular space. While other arrangements could be used, the high pressure is preferred for the intermediate annular space because gas flow is then inward into the plating chamber through the free space around the traveling rod.

In the plating of nickel, by way of specific example, upon a 3 inch diameter rod of cast steel, the following conditions may be maintained:

The steel may be poured at the rate of approximately 400 pounds per minute, which rate will supply continuously cooled rod traveling at a rate of approximately 5 feet per minute.

The temperature of the rod entering the plating chamber may be controlled to be approximately 425° F.

The rate of flow of gaseous medium to the plating chamber may be approximately 20 cubic feet per hour per cubic foot of chamber space, with nickel carbonyl vapors being present in the ratio of approximately 10 ounces of carbonyl per cubic foot of carbon dioxide gas passed through the plating chamber.

The rate of flow of carbon dioxide gas through the intermediate annular space 33 may be maintained at approximately 30 cubic feet of gas per hour per cubic foot of chamber space.

The rate of flow of gas in the outer annular space 34 may be at the rate of 5 cubic feet per hour per cubic foot of chamber space, and the actual pressure maintained on the space by the exhaust equipment being 2 inches of water vacuum.

It will be understood that while the method and apparatus disclosed and described herein illustrate a preferred form of the invention, modification can be made without departing from the spirit of the invention, and that all modifications that fall within the scope of the appended claims are intended to be included herein.

This application is a divisional application of Serial No. 115,033, filed September 10, 1949, now Patent No. 2,657,457, issued November 3, 1953.

I claim:

1. In continuous casting and gaseous metal plating apparatus for melting and continuously casting molten metal by flowing said metal into a mold and continuously withdrawing the hot metal as a solidified continuous length casting, the combination with means for holding and pouring molten metal including an open-ended vertically disposed fluid cooled mold, of a gaseous metal plating chamber having passageways therethrough for the passage of hot solidified metal as withdrawn from said mold, said chamber being arranged to fit closely about said hot solidified metal casting, and conduit means communicating with said chamber for introducing a heat-decomposable gaseous metal compound into said chamber and in contact with said hot metal casting as the same is drawn from said mold and through said chamber, and power-driven means for withdrawing said casting from the mold and through said plating chamber.

2. In continuous casting and gaseous metal plating apparatus, the combination with means for holding and pouring molten metal including a mold assembly comprising an open-ended, stationary, vertically disposed fluid cooled mold, of a gaseous metal plating chamber disposed in vertical alignment with said open-ended mold,

5

ports in said plating chamber in alignment with said mold and adapted to receive said casting as the same moves downwardly from said mold, and power-driven roller means for engaging said casting and drawing the same downwardly from said mold and through said plating chamber at a controlled rate of speed.

3. In continuous casting and gaseous metal plating apparatus, the combination with means for holding and pouring molten metal including a mold assembly comprising an open-ended, stationary, vertically disposed fluid cooled mold, of gaseous metal plating chamber disposed in vertical alignment with said open-ended mold, ports in said plating chamber in alignment with said mold and adapted to receive said casting as the same moves downwardly from said mold, power-driven roller means for engaging said casting and drawing the same downwardly from said mold and through said plating chamber at a controlled rate of speed, and conduit means communicating with said plating chamber for introducing a heat-decomposable gaseous metal compound into said chamber and in contact with said casting while hot and as drawn from said mold.

4. In continuous casting and gaseous metal plating apparatus, the combination with means for holding and pouring molten metal, a mold assembly comprising an open-ended stationary vertically disposed mold, means

6

for fluid cooling said mold, a gaseous metal plating chamber disposed in vertical alignment with said mold, ports in said plating chamber in vertical alignment with said open-ended mold and adapted to receive said casting as the same moves downwardly from said mold, and power driven roller means for engaging said casting and withdrawing the same downwardly from said mold and through said plating chamber at a controlled rate of speed, and means for cutting off the resulting gas plated continuous casting into segments of predetermined lengths.

References Cited in the file of this patent

UNITED STATES PATENTS

1,835,679	Van Derau	Dec. 8, 1931
2,271,209	Schlotter	Jan. 27, 1942
2,285,017	Christensen	June 2, 1942
2,332,309	Drummond	Oct. 19, 1943
2,475,854	Ogle	July 12, 1949
2,508,500	De Lange	May 23, 1950
2,508,509	Germer et al.	May 23, 1950
2,516,058	Lander	July 18, 1950
2,590,311	Harter et al.	Mar. 25, 1952
2,657,457	Toulmin	Nov. 3, 1953