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[54] **INGOT FEED DRIVE**
4 Claims, 2 Drawing Figs.

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118/49.5, 164/250, 250/49.5
[51] Int. Cl..... **B05c 11/10**
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7, 9, 8; 117/DIG. 2, 106—107.2; 250/49.5, 218;
164/250, 49; 340/259

ABSTRACT: Apparatus for controlling the feed rate of a bar of coating alloy into the crucible from which the alloy is vaporized to be deposited on an article. By utilizing constant electron beam power and maintaining constant pool height a constant evaporation rate and constant vapor chemistry is achieved.

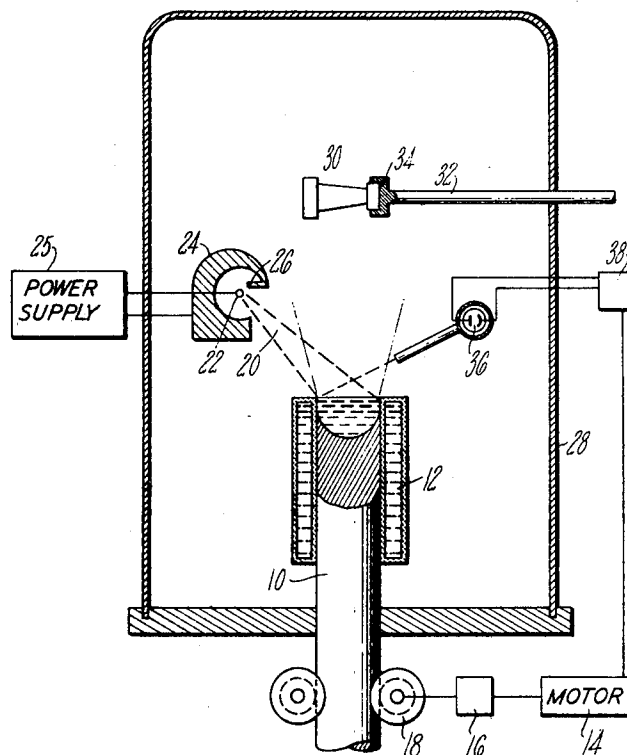


FIG. 1

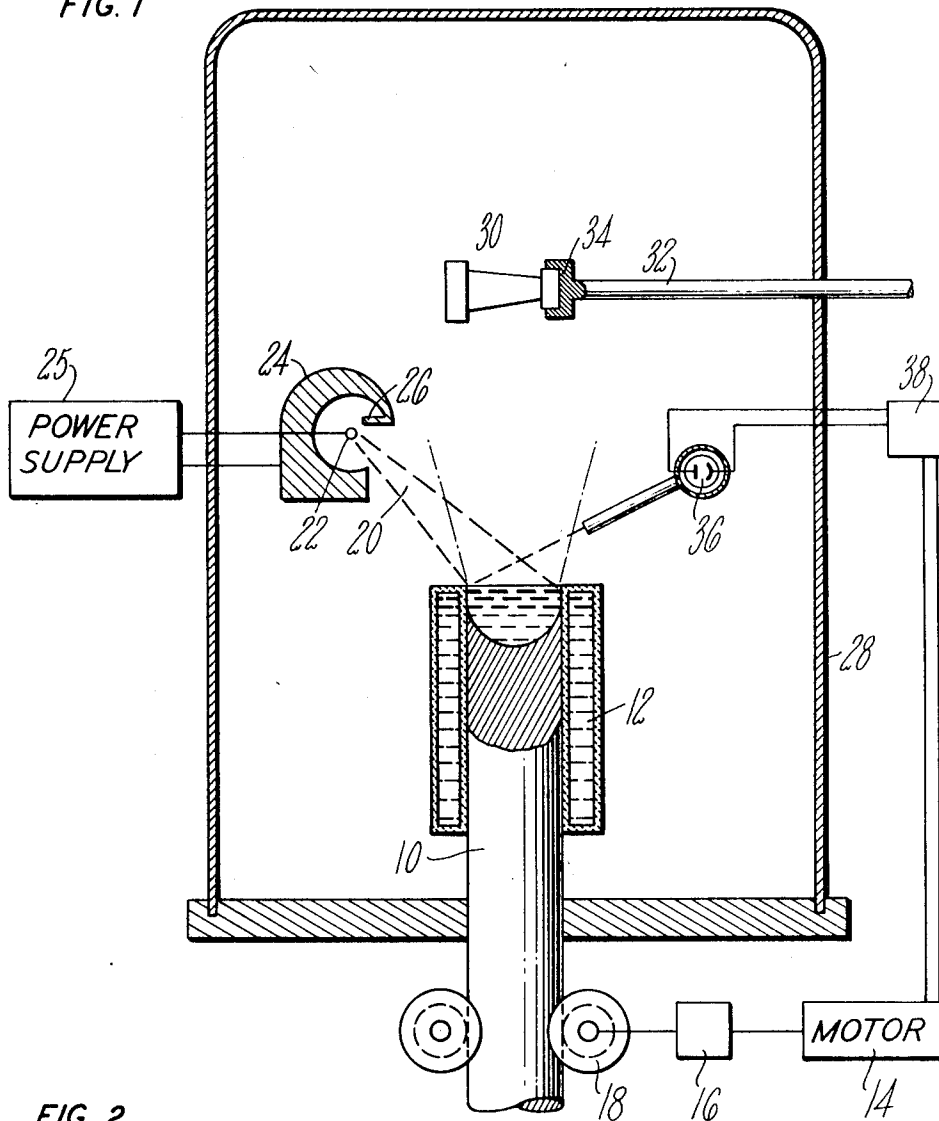
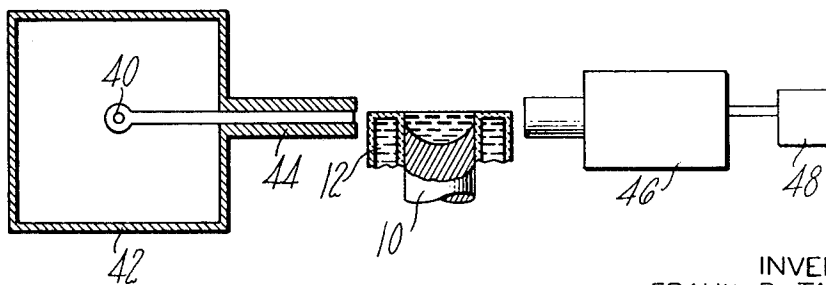


FIG. 2



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INGOT FEED DRIVE

BACKGROUND OF THE INVENTION

The coating of substrates by the evaporation of coating alloys of two or more components (constituents) requires that an equilibrium be maintained between the solid ingot, the molten pool and the vapors which leave the pool. If this equilibrium is disturbed by any of a number of variables, i.e. ingot feed rate, changes in beam intensity and position of the pool within the crucible, the resulting coating chemistry fluctuates so that the resultant coating chemistry cannot be reproduced reliably. Elimination of any of these variables will assist in producing coatings of constant and reproducible chemistry and by a control of coating time, producing coatings of reproducible and uniform thickness.

SUMMARY OF INVENTION

One feature of the invention is the control of the level of the pool of metal or alloy in the crucible thereby assuring, when using a constant electron beam power, a more uniform rate of vaporization and a vapor of constant chemistry. Another feature is the control of the pool height by a variable speed ingot feed which is responsive to a variable affected by the pool height. Because of the temperatures involved in the melting and evaporation of the alloy by an electron beam, it is necessary that the pool height sensing means not be affected by the beam. Accordingly, one feature of the invention is the sensing of pool height by a device insensitive to the beam and controlling the speed of the ingot feed in response to this device.

One particular feature is the maintenance of a constant evaporation rate and a constant vapor chemistry thereby assuring a uniform rate of vapor deposition and constant coating chemistry on the article being coated. This is assured by operating with a constant electron beam power and a constant pool height on which the beam impinges. In this way two of the variables that cause a nonuniform coating process are eliminated.

The copending application of Blecherman et al., Ser. No. 806,871, filed Mar. 13, 1969, describes a light sensitive device by which to measure and determine the pool height as a function of the light emitted by the molten pool or the vapors above the pool. One feature of the invention is the use of this level-sensing means to control the feed mechanism for the ingot, thereby precisely controlling pool level.

The copending application of Blecherman et al., Ser. No. 806,953, filed Mar. 13, 1969, describes a pool level-sensing device using radioactive isotopes. One feature of this invention is the use of this sensing device to control the ingot feed, thereby controlling pool height.

BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a vertical sectional view, diagrammatic, through a crucible and associated mechanism incorporating the invention.

FIG. 2 is a fragmentary view similar to FIG. 1 showing a modification.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The arrangement is shown in a device for the coating of articles by a metallic alloy in which the alloy is vaporized by use of an electron beam. In the drawing the vaporizing alloy is in the form of an ingot or bar 10 extending upwardly into a water-cooled bottom-feed crucible 12. The ingot is fed upwardly as it is consumed by a variable speed motor 14 driving, for example, through a reduction gear mechanism 16 to a pair of ingot feed rollers 18. The end of the ingot within the crucible is melted and vaporized by an electron beam 20 from a filament 22 forming part of an electron gun 24. A potential 25 is supplied from the filament to the accelerating electrode 26. The beam is focused directly on the end of the ingot and melts the surface of the ingot and then vaporizes it into the vacuum

chamber 28 that surrounds the gun and the crucible. In the preferred operation the power to the gun, the electron beam energy is maintained constant so that the pool is exposed to a substantially constant heat input.

Above the crucible in a position for the deposition of vapor thereon is a workpiece or article 30, shown as a turbine vane, held in position on a support device 32 preferably equipped with a clamp 34 for releasable attachment of the workpiece.

The level of the pool of molten alloy may be sensed by a suitable sensing device which is, for example, a light sensitive cell 36 beamed toward the wall of the crucible at the pool level, the light radiation increasing as the pool level rises. The light intensity is measured and through a suitable computing mechanism 38 adjusts the speed of the ingot-driving motor. Such a computing mechanism is conventional and does not require a detailed description. It will be understood that the motor speed is decreased as the light radiation increases to reduce the ingot speed and the speed is increased as the radiation decreases. The light-measuring means is described and claimed in Blecherman et al., Ser. No. 806,871.

The same type of device may be beamed directly into the vapors above the pool as these vapor atoms will be excited by the electron beam and will radiate light of an intensity proportional to the density of the vapor. If the beam energy is constant by reason of a constant power supply to the source of the beam, this density is directly related to the pool height and thus a satisfactory measure of pool height. This concept is also disclosed and claimed in the above-identified application of Blecherman et al., Ser. No. 806,871. With this arrangement the light sensitive device of FIG. 1 is beamed through the vapors above the pool and the operation is the same as above described.

Another device for controlling the speed of the ingot-feeding motor is a radioactive device described and claimed in the other above-identified copending application of Blecherman, Ser. No. 806,953. As shown in FIG. 2, the device uses a radioactive material 40, for example, cesium in glass, in a shielding chamber 42, with the radiation directed by a tube 44 horizontally through the crucible and across the pool surface to a radiation-sensing device 46 which may be an ionization chamber. This device measures the intensity of the radiation which increases as the pool level is lowered and the sensed variation in radiation is fed into a computer 48 that determines the change in driving motor speed for restoring the pool level to the desired position.

This level-sensing device may sense the liquid-solid interface level at the bottom of the molten pool which level is directly related to the top level of the pool so long as a beam of constant energy is directed onto the pool. Opposite to the device of FIG. 1, the speed of the ingot feed motor is reduced as the radiation is reduced as a reduced radiation represents a higher level of the pool within the crucible. Thus the motor speed is directly related to the intensity of the radiation sensed by the sensor.

We claim:

1. In electron beam vaporization apparatus for use in coating articles,

a chamber in which the article may be positioned, means within the chamber for supporting the article,

a bottom-feed crucible into which an ingot of the coating material is fed,

means for heating the material exposed in the crucible to form a molten pool of material therein and to vaporize the molten material,

means for sensing the pool height in the crucible, including ray emitting means and ray receiving means on opposite sides of the crucible with the position of the pool surface determining the rays received by said receiving means such that the receiving means senses pool height, variable speed drive means for feeding the ingot of material into the crucible to replace the vaporized material and means actuated by changes sensed by said receiving means for varying the rate of feed of the ingot to maintain a constant pool height during the coating operation.

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2. A coating apparatus for applying a metallic alloy to a substrate including:

a chamber in which the substrate may be mounted,

means within the chamber for supporting the substrate,

means for evacuating the chamber,

a crucible in said chamber,

variable drive means for feeding a bar of alloy into said crucible to replace vaporized material,

constant energy electron beam means for melting the alloy in the crucible and vaporizing it to provide a vapor to be deposited on the substrate,

means for sensing the level of the pool of molten alloy in the crucible including a radioactive source and a radiation sensor positioned to direct the radiation through the

crucibles with the sensed radiation varying as the pool height changes, and

means responsive to said radiation sensor for adjusting said feeding means to maintain a constant pool level in the crucible.

3. Apparatus as in claim 2 in which the crucible is a bottom-feed crucible and the radioactive source and sensor are positioned to direct the radiation across the top surface of the pool.

4. Apparatus as in claim 3 in which the radioactive source, and the radiation sensor are positioned for directing the radiation through the ingot at the level of the bottom surface of the molten pool.

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