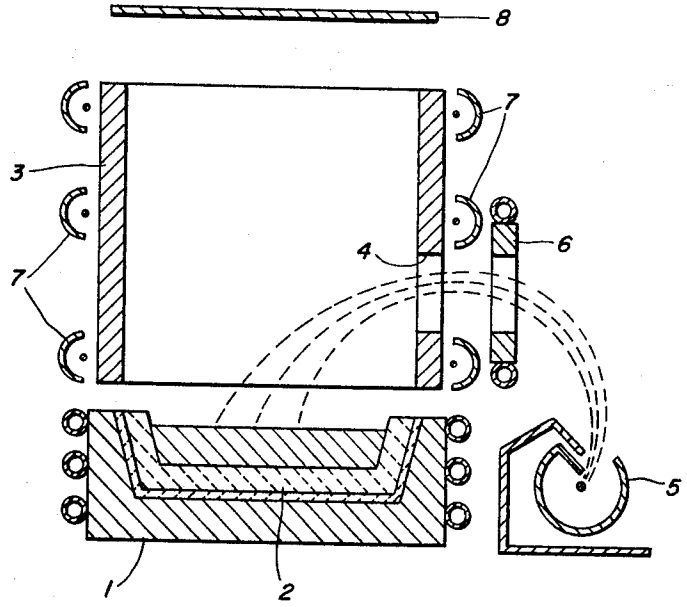
Oct. 11, 1966 H. R. SMITH, JR 3,277,865

METAL-VAPOR SOURCE WITH HEATED REFLECTING SHIELD

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FIG. 1.



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FIG. 2.

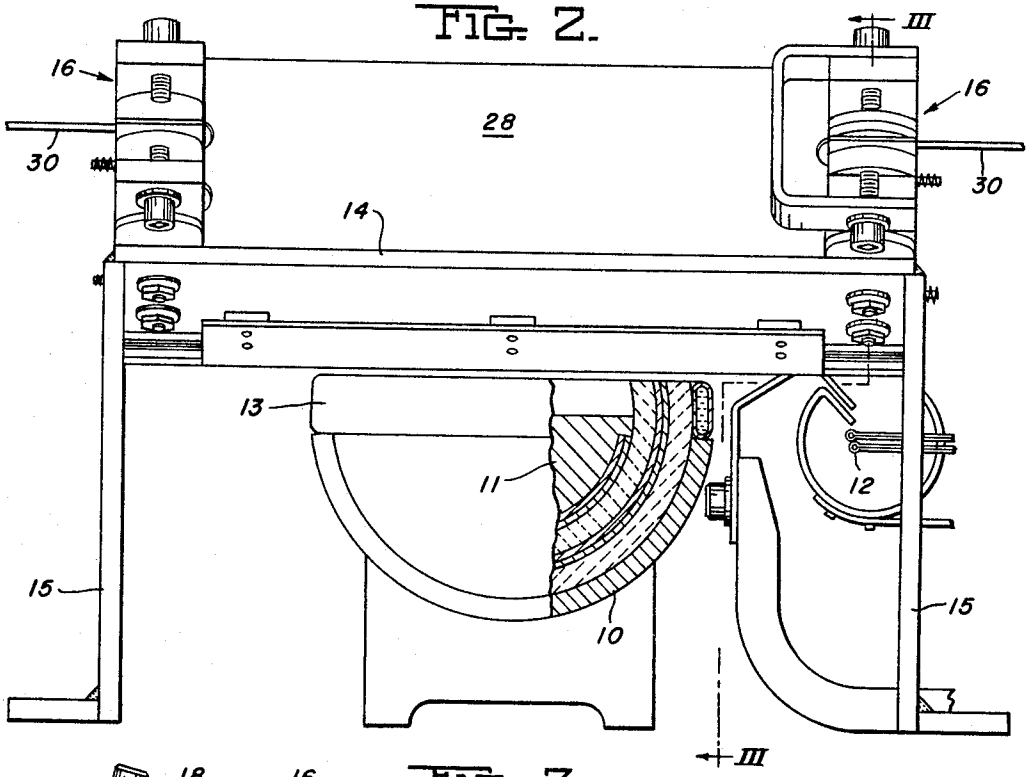
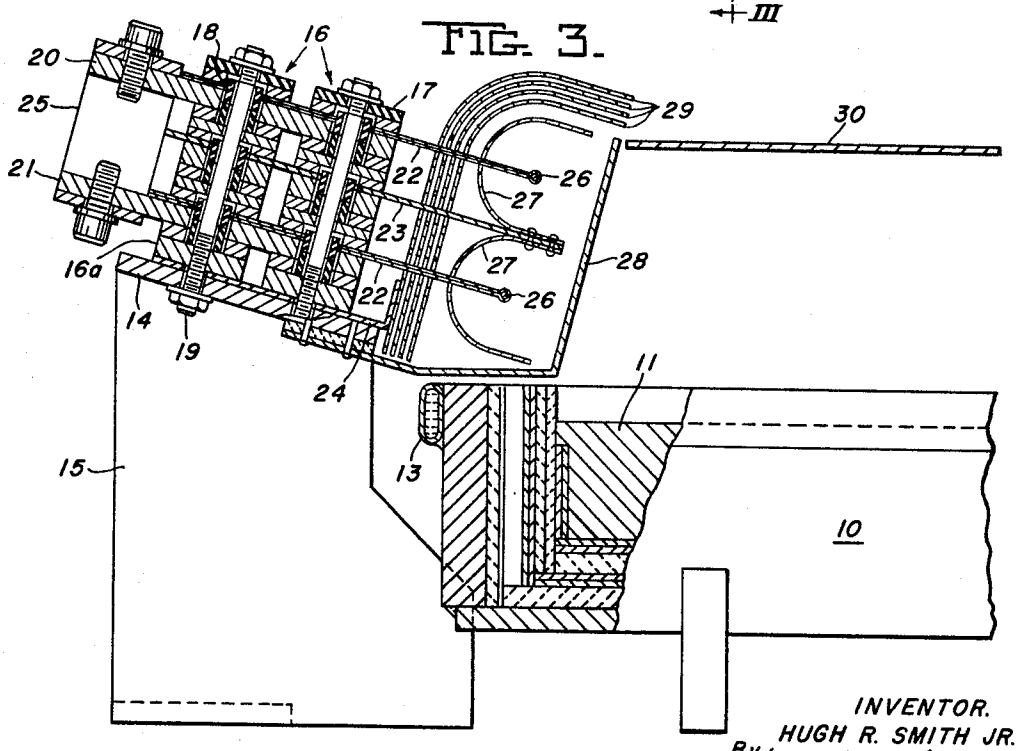


FIG. 3.



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METAL-VAPOR SOURCE WITH HEATED REFLECTING SHIELD

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Filed Apr. 1, 1963, Ser. No. 269,444
1 Claim. (Cl. 118—49.5)

This invention relates to coating material by vapor deposition and, more particularly, to a vapor source having a heated shield to limit the condensation of metal vapor on areas other than the surface of the material to be coated.

It has been recognized by users of vacuum-evaporation techniques that the utilization of the evaporated material is very inefficient but such small quantities of material are ordinarily involved that, even in the largest existing commercial installations, no special attempt is made to increase it. Present semi-continuous strip coating lines bring the strip into very close proximity to the source, principally for the reason that a large percentage of evaporating material must be deposited on the strip in order to operate at a commercially acceptable speed. In a system required to evaporate many pounds per hour in continuous operation, however, the economics, to be acceptable, may depend on highly efficient utilization of the evaporating material. This is also important from an operational point of view since, in a short period of time, large quantities of material will condense on all inner surfaces of the vacuum vessel and may interfere with the operation of various components located therein.

I have discovered that, in the coating of strip material, the utilization of vapor can be greatly improved by providing a hot reflecting shield between the strip and the surfaces of evaporation and extending generally around the latter. I preferably maintain the shield above the critical condensation temperature of the evaporating metal. Thus vapor molecules which have velocities such that they would ordinarily miss the strip, impinge on the hot shield and are thereby re-evaporated. Such re-evaporation of individual atoms is random in direction, and there is finite probability that they will next impinge on the strip and condense. They may also, of course, impinge on other portions of the hot shield or other portions of the source. In either case, re-evaporation would occur again, still with the probability of subsequent condensation on the strip. I find that, if the greater portion of the gap between the evaporation surfaces and the strip is enclosed by the shield, the probability of vapor atoms escaping becomes quite small and the utilization efficiency is increased materially.

A complete understanding of the invention may be obtained from the following detailed description and explanation which refer to the accompanying drawings illustrating the present preferred embodiment. In the drawings:

FIGURE 1 is a central vertical section through one form of the invention, shown somewhat diagramatically;

FIGURE 2 is a side elevation with a portion in section showing the invention applied to an elongated crucible; and

FIGURE 3 is a transverse section through FIGURE 2 on the plane of line III—III thereof, with a portion in elevation.

Referring first to FIGURE 1, a water-cooled copper crucible **1** has a depression therein lined with suitable thermal insulation such as alumina or felted graphite, adapted to receive a dish or bowl **2** containing aluminum to be

melted and vaporized. The dish is of refractory material such as that sold by National Carbon Co. under the trademark "HDA."

Mounted in any suitable manner above dish **2** and spaced slightly thereabove is a tubular shield **3** of molybdenum, for example. Shield **3** has a hole **4** therein to admit an electron beam from a conventional source **5** at one side of crucible **1**. A water-cooled focussing ring **6** for the beam is alined withe hole **4**. An electromagnetic field produced by conventional means (not shown) serves to direct the electron beam through the hole onto the evaporating surface of the molten aluminum. Electron guns **7** of conventional type (see "Theory and Design of Electron Beams" by J. R. Pierce) are disposed about shield **3** and serve to heat it to a temperature above that at which atoms of vaporized aluminum will condense thereon.

A metal strip **8**, e.g., steel strip, traveling across the top of shield **3**, receives a coating of aluminum by condensation of the vaporized metal arising from the surface of the bath in dish **2**. Atoms striking shield **3** are thermally ejected therefrom because of its high temperature. The shield thus confines the ascending vapor and prevents condensation thereof until it strikes strip **8** and deposits a film thereon.

Referring now more particularly to FIGURES 2 and 3, an elongated crucible **10** contains a metal charge **11**, e.g., aluminum, adapted to be heated by electron bombardment. An electron-beam gun **12** extending along one side of the crucible delivers a beam which is deflected so as to strike the surface of the charge **11**, by an electromagnetic field produced by conventional means (not shown). A cooling coil **13** surrounds the periphery of the crucible. A bridge plate **14** carried on posts **15** extends transversely of the crucible **10** at each end thereof.

Two stacks **16** of insulation discs **17** and sleeves **18** at each end of plate **14** stand on blocks **16***a* and have clamp bolts **19** extending therethrough. Conductor bars **20** and **21** are disposed in each pair of stacks in spaced relation as well as supporting and conducting strips **22** and **23** and brackets **24**. Electrode straps **25** connect bars **20** and **21**. At their inner ends, strips **22** support filament cathodes **26** extending therebetween. Strips **23** support a pair of elongated focussing reflectors **27**, trough-shaped in section. A reflecting shield **28** in the form of a metal plate of molybdenum, for example, is attached to the inner edge of plate **14** and extends upwardly between cathodes **26** and away from metal charge **11**. Brackets **24** support a plurality of spaced radiant-heat baffle plates **29** extending upwardly on the outer side of reflectors **27** and inwardly thereover.

Cathodes **26** may be heated by current supplied through suitable connections to electrode straps **25**. The cathodes and reflectors **27** are maintained at a high negative voltage, say 10,000 volts, while shield **28** and plates **29** are grounded. It will be evident that, when filaments **26** are heated and the voltage is applied, electrons will bombard plate **28** and heat it to a high temperature. When this temperature has reached, say 2500° F., any atoms of coating metal, e.g., aluminum vaporized from the surface of crucible **10**, impinging on the shield, will not condense thereon but will be maintained in vapor state and immediately returned to the main stream of atoms emigrating from the metal charge **11** to the strip **30** traveling thereacross. Thus shielding plate **28** serves as a "reflector" confining the atoms to a path most likely to end on strip

30. Baffle plates 29 reduce the loss of heat from the shielding plate to the adjacent walls of the vacuum tank enclosing the entire coating apparatus.

Although I have disclosed herein the preferred embodiment of my invention, I intend to cover as well any change or modification therein which may be made without departing from the spirit and scope of the invention.

I claim:

In a metal-vapor deposition device, the combination with a crucible containing a charge of metal to be evaporated for coating a substrate disposed thereabove, of a first electron emitter for heating said crucible, said emitter being disposed at a level below the top of said crucible, electromagnetic means disposed to cause electrons from said emitter to travel in a curved path so as to impinge on the surface of said charge, a shielding wall extending substantially between said crucible and substrate adapted to confine vapor ascending from the former to the latter, said wall having an opening to admit electrons traversing said path, and additional electron emitters adjacent said wall effective to heat it by bombardment to a temperature sufficient to inhibit condensation of vapor thereon.

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