United States Patent

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[54] **MOBILE EVAPORATIVE FIRING SOURCE**
10 Claims, 5 Drawing Figs.

[52] **U.S. Cl.** **118/48,** 219/271, 219/388
[51] **Int. Cl.** **C23c 11/00**
[50] **Field of Search** ..... 118/48-—49.5; 117/(Inquired), 106—107.2; 219/271, 388; 13/(Inquired)

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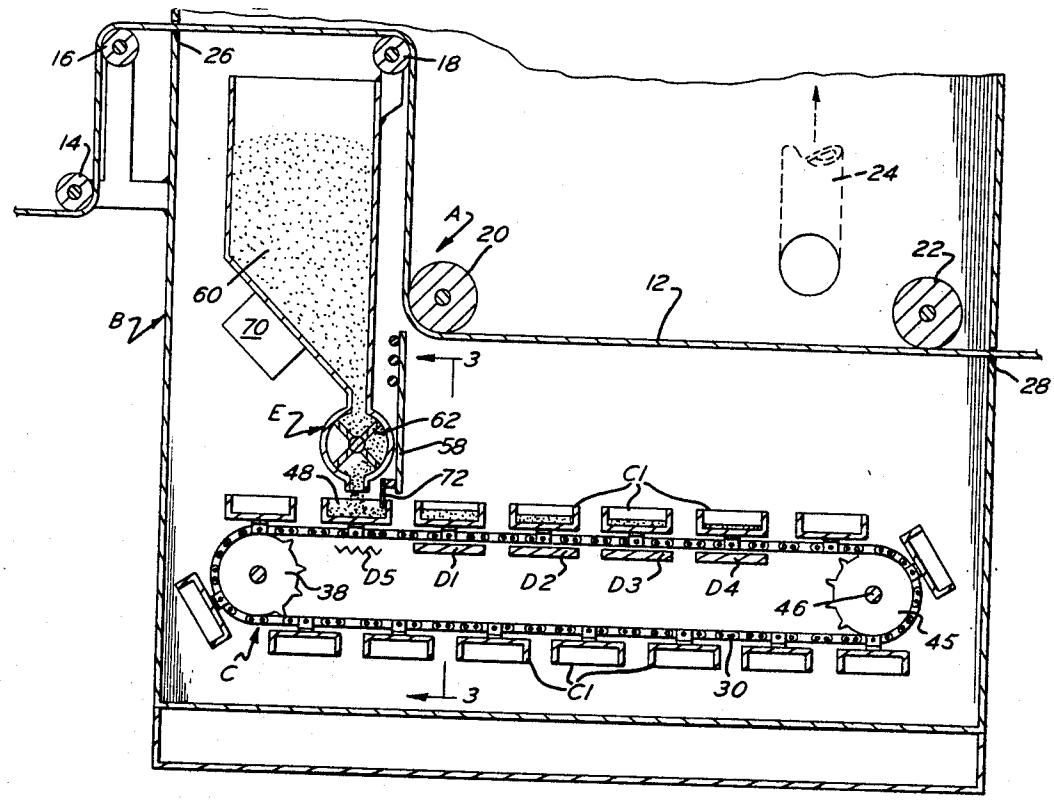
ABSTRACT: Apparatus for evaporatively coating a continuously moving strip comprising a plurality of boats which are filled with a measured quantity of evaporative material at a dispensing station and transported through a vacuum chamber in spaced disposition with the strip. The material is fired from the boats as they pass over stationary heating elements whereby a uniform coating on the substrate is achieved.



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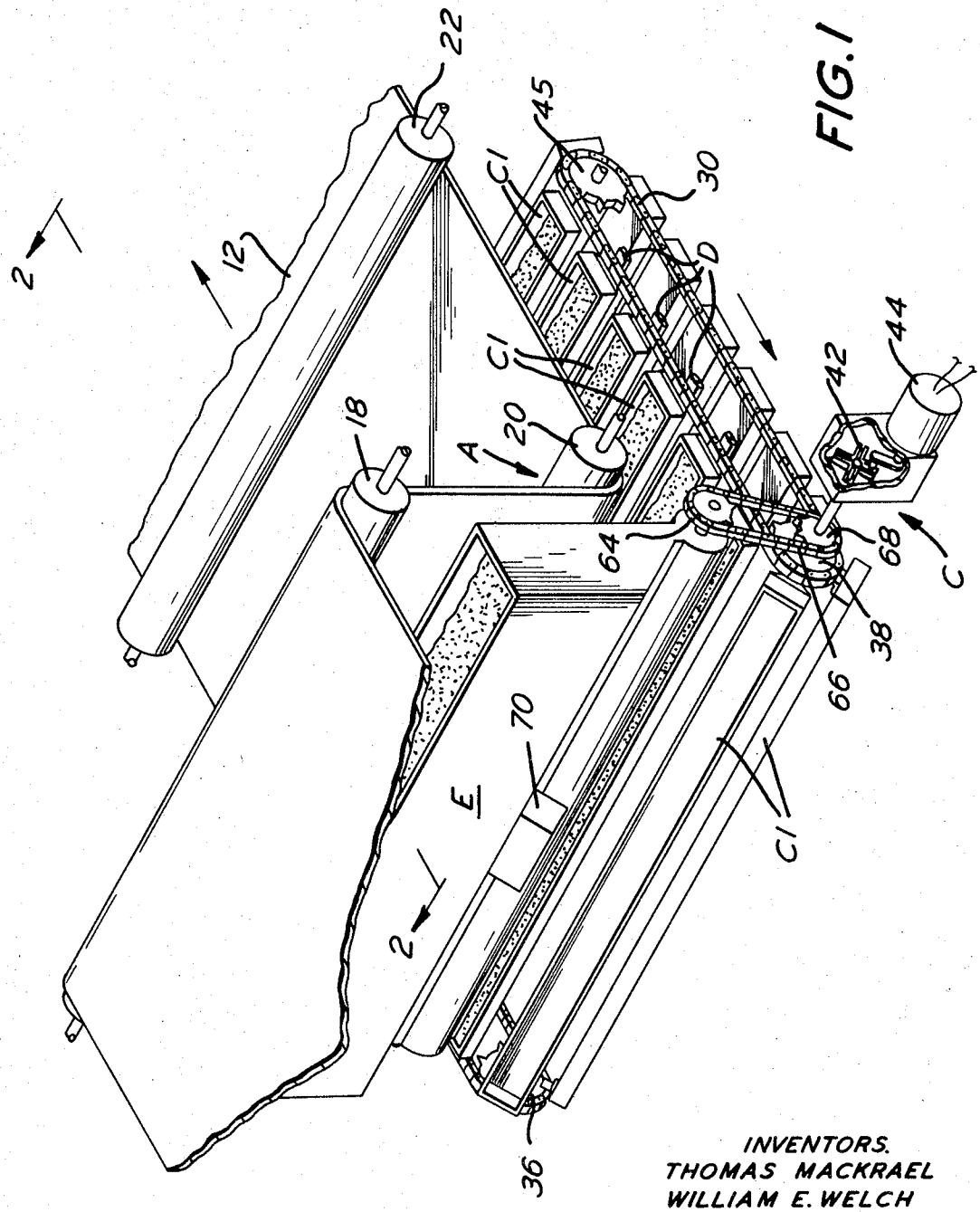

FIG. 1

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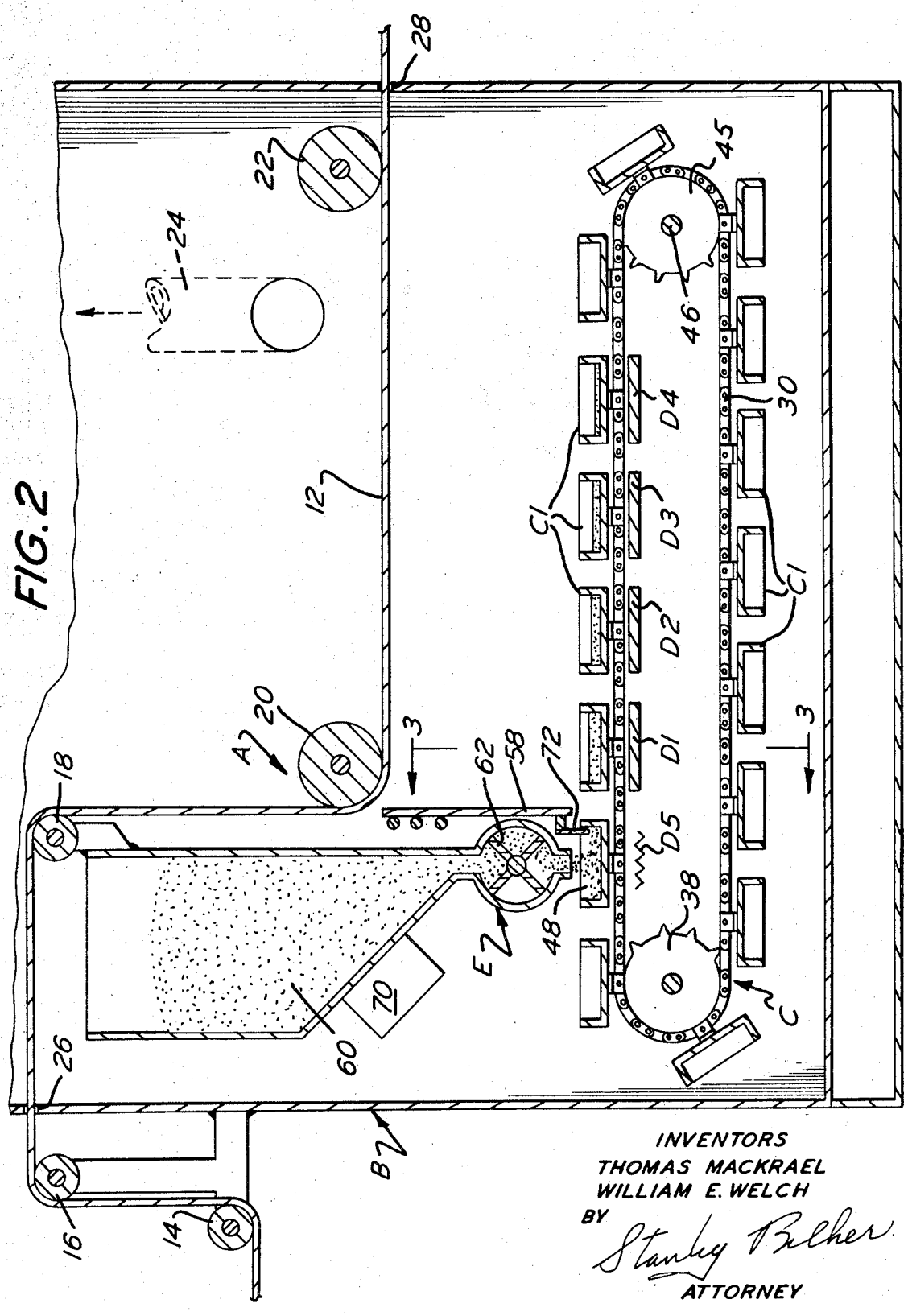

FIG. 2

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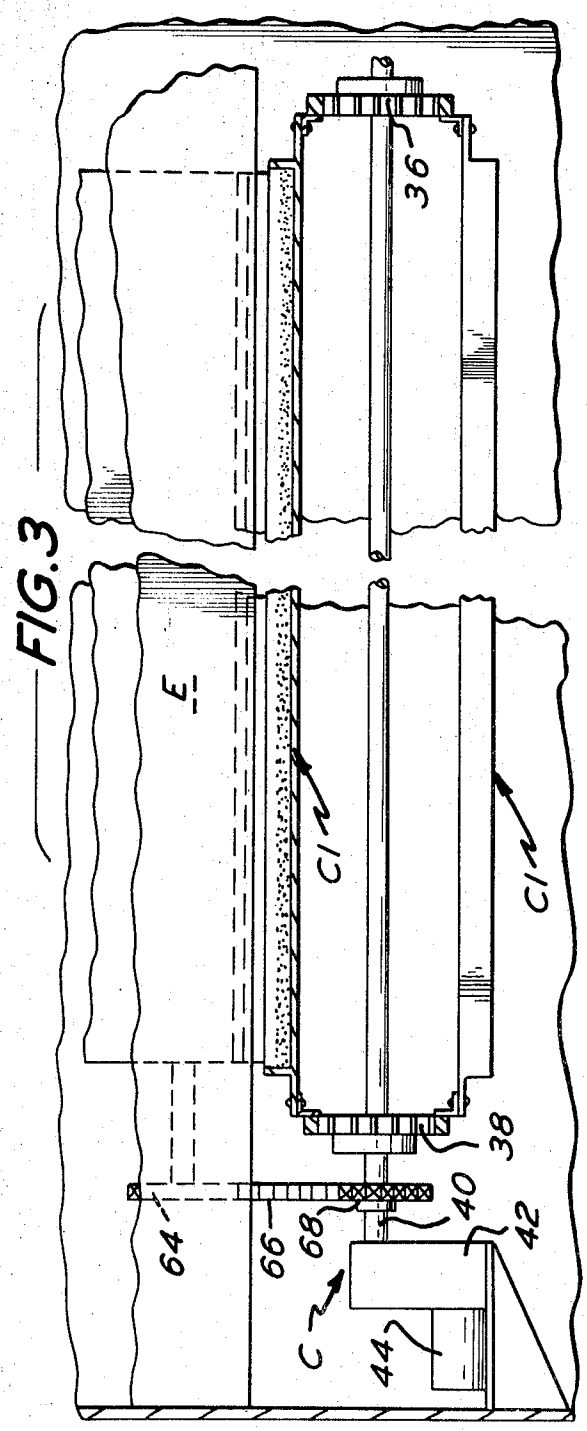

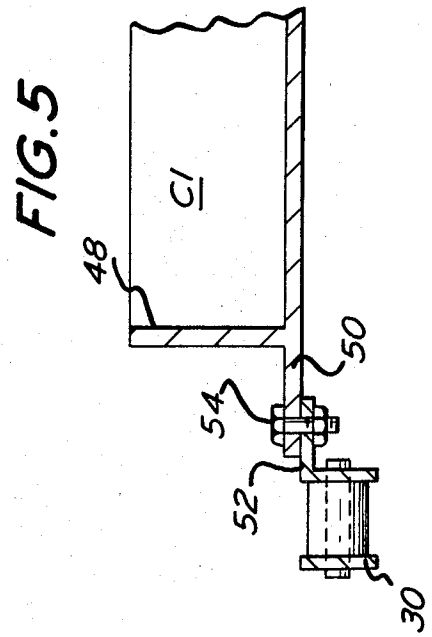

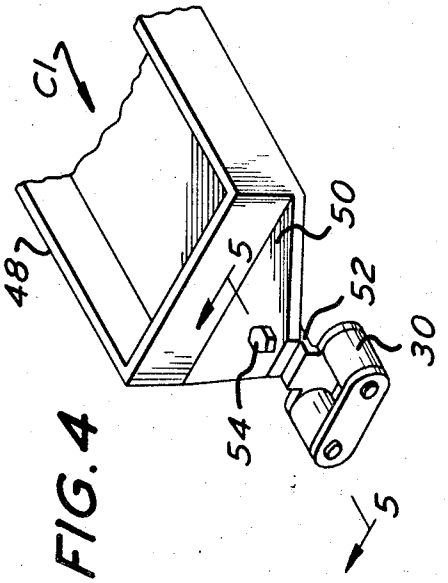

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MOBILE EVAPORATIVE FIRING SOURCE

This invention relates to an apparatus for evaporation of materials upon a substrate, and more particularly relates to a system in which uniform deposition may be effected upon a continuously moving strip or web. The invention is especially advantageous in the evaporation of granular, crystalline or noncontinuous evaporates and in producing relatively heavy depositions thereof.

Heretofore, with evaporation of a coating upon a continuously moving strip or web, it was extremely difficult, if not impossible, to obtain uniformity of deposition owing to nonuniform feeding of evaporate, in particular when granular, crystalline and other discontinuous evaporates were employed. The problem primarily resulted from the fact that the material being evaporated from the boat or other firing source became partly or entirely depleted as the process continued. Accordingly, it was necessary to stop the operations, shut down the vacuum, and discontinue transportation of the web or strip through the vacuum chamber in order to refill the evaporation vessel. The problem became notably acute when relatively heavy depositions from discrete or particulate feed stocks were required.

It is therefore an object of this invention to provide an evaporation system in which relatively heavy and uniform depositions may be applied to a continuously moving web or strip substrate.

Another object of this invention is to provide an evaporation system for continuously moving substrates wherein the rate of deposition may be easily adjusted.

Another object of this invention is to provide a continuous system for evaporation of discrete particulate materials.

Another object of this invention is to provide a continuous evaporative system in which a precise measured amount of material is fed to the firing source.

Yet another object of this invention is to provide an apparatus for evaporating a material to be deposited on a substrate and for controlling the temperature of operation during the entire deposition process.

Still another object of this invention is to provide a continuous evaporative system in which the speed of operations can be precisely controlled.

Yet still another object of this invention is to provide a continuous evaporative system in which the need to break vacuum for refilling of the firing source is completely eliminated.

Other objects of this invention are to provide an improved device of the character described that is sturdy in construction, which is easily and economically produced, and which is both highly efficient and effective in operation.

With the above and related objects in view, this invention consists of the details of construction and combination of parts as will be more fully understood from the following detailed description when read in conjunction with the accompanying drawings in which:

FIG. **1** is a perspective view, and partly broken away, of a mobile evaporative firing source embodying this invention.

FIG. **2** is a sectional view taken along lines **2–2** of FIG. **1**.

FIG. **3** is a sectional view taken along lines **3–3** of FIG. **2**.

FIG. **4** is a fragmentary perspective view of an evaporation boat embodied in this invention, and

FIG. **5** is a sectional view taken along lines **5–5** of FIG. **4**.

Referring now in greater detail to the drawings in which similar reference characters refer to similar parts, there is shown a mobile evaporation system and apparatus for depositing under vacuum material upon a moving substrate in the form of a plastic or metallic strip or web. The present apparatus includes a web drive roll assembly, generally designated as A, for transporting the strip substrate through a vacuum chamber B, and a conveyor, generally designated as C, for carrying a plurality of evaporation boats C1 in the same direction as the substrate. The conveyor C is intermittently actuated and moves at a different and usually slower speed from that of the substrate being conveyed by the roll assembly A. The boats C1 containing material to be evaporated pass over and dwell upon longitudinally spaced heating elements D to heat the material to evaporation temperature and deposit it on the strip substrate. The boats C1 are charged with a measured amount of material which is metered from a dispensing hopper E in timed disposition with boat position.

The roll assembly A constitutes any suitable carrier for transporting a continuous strip or web **12** to be coated through the chamber B. The web **12** may be, for example, plastic film or metal foil 48 inches wide and dispensed from a roll outside the chamber. Conventional idler rollers **14**, **16**, **18**, **20** and **22** direct the web **12** in a prescribed path through the chamber, the drive or takeup mechanism (not shown) conveying the strip or web at a fixed speed of perhaps 10 to 100 feet per minute. As can be seen, the underside of the web **12** is exposed for deposition.

The vacuum chamber B is quite conventional and may consist of a steel structure capable of withstanding, when evacuated, an external pressure approximating one atmosphere. The conduit **24** couples the interior of the chamber with an evacuation pump or system which is capable of reducing the internal pressure in the range of a few microns. Suitable seals are provided at slot **26** where the web **12** enters the chamber B and at exit opening **28**. A door (not shown) is also provided for access to the chamber B during maintenance and startup operations. Continuous or semicontinuous operations can be accommodated.

The conveyor C comprises a pair of laterally spaced endless chains **30** and **36** which are adapted to be straddled by the boats C1. A pair of side-by-side conveyors C are demonstrated to illustrate a suitable arrangement for deposition of extremely wide sheets **12**. Drive sprockets **38** are coupled to main shaft **40** through a Geneva drive mechanism **42** whereby motor-reducer drive unit **44** will produce intermittent stop-and-go motion of the conveyor C. Idler sprockets **45** mounted on suitably journaled shaft **46** support the distal ends of the chains and takeup units (not shown) tension them so that the boats C1 do not sag.

The boats C1 are preferably made of quartz although other refractory materials, including boron nitride may be satisfactory. Each boat C1 is in the form of a flat bottomed, generally rectangular vessel **48** having ears or lugs **50** outwardly extending from both ends. The lugs **50** are secured to inwardly turned fingers **52** on opposing chains by means of bolts **54**. See FIGS. **3**, **4** and **5**. The boats C1 are thereby carried in an upright position at the upper level of the chains and inverted at the lower or return level. Each boat C1 is approximately 3 inches wide, 1 inch deep, and perhaps 24 to 30 inches long. The boats are longitudinally spaced from each other by approximately 1 inch.

The heaters D are strip elements which may be fabricated from tungsten ribbon, for example. The strip elements have a width dimension just under the width of a boat and are spaced on the same centers. The first heating element D1 adjacent to the metering hopper E is operated at the highest temperature, 1,300° F. for example in the case of evaporation of zinc. The two intermediate heaters D2 and D3 may operate at 1,000° F., and the most distal heater D4 at 800° F. Such an arrangement permits an initially peaked temperature just as soon as a newly filled boat C1 passes beyond water cooled barrier or shield **58**.

The operation of the motor-drive unit **44** through Geneva drive **42** produces an intermittent stop-and-go motion of the boats C1 in the same direction as the moving web **12**. The speed of the conveyors C is in the neighborhood of 2 feet per minute and having approximately a 5 second motion with a 30 second dwell period. During the dwell period, each of the boats C1 on the upper chain level beyond the shield **58** lies immediately spaced above a corresponding heating element D and hides the same.

The boats C1 are successively charged with material from the metering dispenser E which may contain powdered zinc, for example. The dispenser E includes a hopper **60** which may be divided into multiple sections to allow dispensing of material for various web widths. A rotatable star wheel **62** is jour-

naled at the lower portion of each hopper 60 whereby a measured amount of evaporative powder can be dispensed into a boat stationed therebelow. Referring to FIGS. 1 and 3, it may be seen that the shaft of the star wheel 62 has a sprocket 64 which is coupled to drive shaft 40 through chain 66 and sprocket 68. The rotation of the star wheel dispenser 62 is in timed relation with the movement of the boats. When the boat directly below the dispenser is moving thereunder, the star wheel 62 dispenses a precise quantity of powder into its vessel 48. Correspondingly, when the boats are at rest, there is no star wheel rotation. Vibrator 70 coupled to the lower portion of hopper 60 insures that the powder therein and in the star wheel 62 are kept in flowing motion to prevent clumping or bridging. A brush 72 suspended from the rear wall of the shield 58 evens out the level of powdered material charged into the boat.

The powdered material is dumped into the hoppers 60 from outside the vacuum chamber B. A bulk charger arrangement (not shown) may be employed with a vacuum valve to maintain the low pressure in the firing chamber B during loading of the chargers. When the chargers are filled the lid is closed. "-High-low" signaling devices may be used to indicate when the hoppers 60 require additional material or that sufficient loading has occurred.

The powdered material is fed into the metering drum or star wheel 62 which is timed to coordinate the position of the boat being loaded with the loading station. Each boat C1 which has been filled passes under the water-cooled shield 58 and then passes over the high temperature heater D1 which is peaked to insure immediate evaporation just as soon as that particular boat enters the firing chamber. A preheater D5 may be incorporated behind the barrier 58 so that the temperature of the material in the boat may be elevated somewhat even before that boat is in place under the substrate 12.

During evaporation, the temperature of the boats can be accurately controlled by individual control of the respective heater strips D. The lineal speed of the substrate 12 may be controlled by way of the web drive A, and the speed of the boat conveyor C can be correlated with that of the substrate. Accordingly, the thickness and uniformity of the coating can be controlled to a very fine degree.

Since the boats C1 are sequentially refilled, there may be continuous evaporation of the firing source. Accordingly, the continuous operation of the firing source eliminates the need to shut down the vacuum chamber.

We claim:

1. Apparatus for continuously evaporating material into a moving web comprising:
   a vacuum chamber;
   conveying means for carrying the web through the vacuum chamber at a predetermined speed;
   a plurality of vessels containing material to be evaporated;
   means for transporting said vessels through said chamber in spaced disposition from said conveying means and at a second predetermined speed; and
   means for heating said vessels to evaporate the material therefrom upon the moving web.

2. The apparatus of claim 1 wherein said means for heating comprises a plurality of longitudinally spaced stationary heating elements oriented below said means for transporting.

3. The apparatus of claim 2 wherein said heating elements are individually controlled for temperature.

4. The apparatus of claim 3 wherein said means for transporting constitutes an intermittently actuated endless conveyor.

5. The apparatus of claim 4 wherein said endless conveyor supports the vessels directly over respective heating elements during the dwell periods of intermittent actuation.

6. The apparatus of claim 5 including means for successively loading the vessels with the material prior to subjecting the vessels to said means for heating.

7. The apparatus of claim 6 wherein said means for successively loading comprises a metering dispenser in timed disposition with said means for transporting.

8. The apparatus of claim 7 wherein the metering dispenser comprises a star wheel.

9. The apparatus of claim 1 wherein said means for transporting moves in substantially the same direction as said conveying means.

10. The apparatus of claim 2 wherein the speed of said conveying means and said means for transporting is adjustable and wherein the temperature of the vessels may be controlled to vary the thickness of the deposition.