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 [73] Assignee **The United United States of America as**  
**represented by the Secretary of the Navy**

|           |         |                      |            |
|-----------|---------|----------------------|------------|
| 1,733,082 | 10/1929 | McCullough.....      | 118/425 X  |
| 2,750,681 | 6/1956  | Berry.....           | 118/DIG. 5 |
| 3,039,952 | 6/1962  | Fairchild et al..... | 118/49 X   |
| 3,197,328 | 7/1965  | Jung et al.....      | 118/DIG. 5 |
| 3,233,584 | 2/1966  | Angstadt.....        | 118/DIG. 5 |
| 3,282,249 | 11/1966 | Ramsay.....          | 117/21 X   |
| 3,379,174 | 4/1968  | Vodicka.....         | 118/DIG. 5 |
| 3,436,244 | 4/1969  | Yokawonis.....       | 118/312 X  |

## FOREIGN PATENTS

|           |        |              |            |
|-----------|--------|--------------|------------|
| 1,539,311 | 8/1968 | France ..... | 118/DIG. 5 |
|-----------|--------|--------------|------------|

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[54] **VACUUM FLUIDIZED-BED COATING APPARATUS**  
 4 Claims, 2 Drawing Figs.

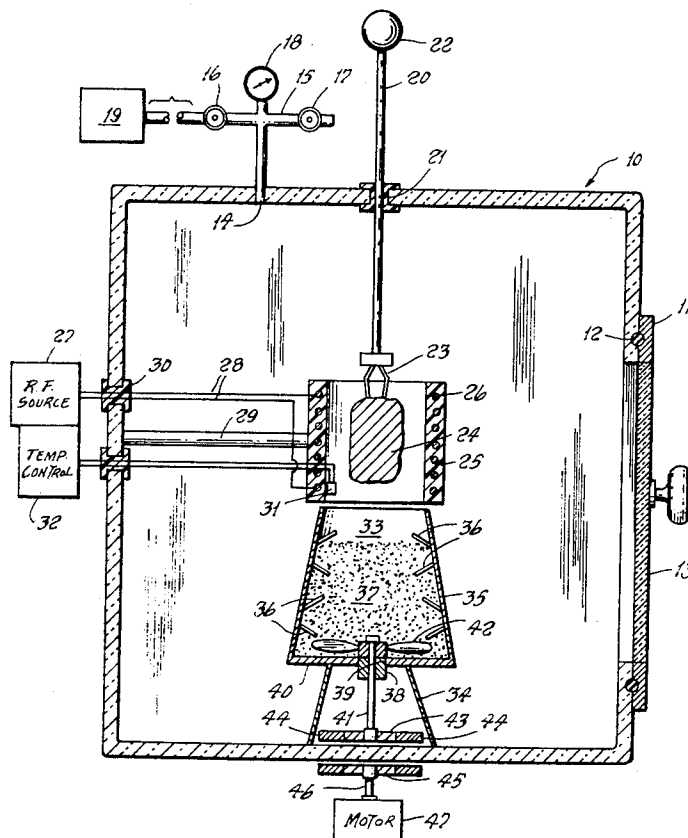
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 [50] Field of Search..... 118/DIG. 5,  
 425, 421, 24, 30, 308, 312, 50, 50.1; 117/2.1, DIG.  
 6

## References Cited

### UNITED STATES PATENTS

|           |        |                       |           |
|-----------|--------|-----------------------|-----------|
| 452,040   | 5/1891 | Mason, Jr. et al..... | 118/425 X |
| 1,343,842 | 6/1920 | Piersol.....          | 118/425 X |

**ABSTRACT:** A sealed chamber having means for evacuating the same and including means for suspending therein a workpiece to be coated and providing for the heating of said workpiece. A lower portion of said chamber contains the material for coating in fluidizable powder form. The coating powder is agitated and thereby fluidized the workpiece lowered and brought into direct contact with the fluidized bed while it is heated and the chamber is under vacuum. The workpiece is then raised and reheated to cure the powder adhering thereto. Additionally a partial vacuum is maintained by admitting a gas into the chamber while it is being evacuated at a greater rate.



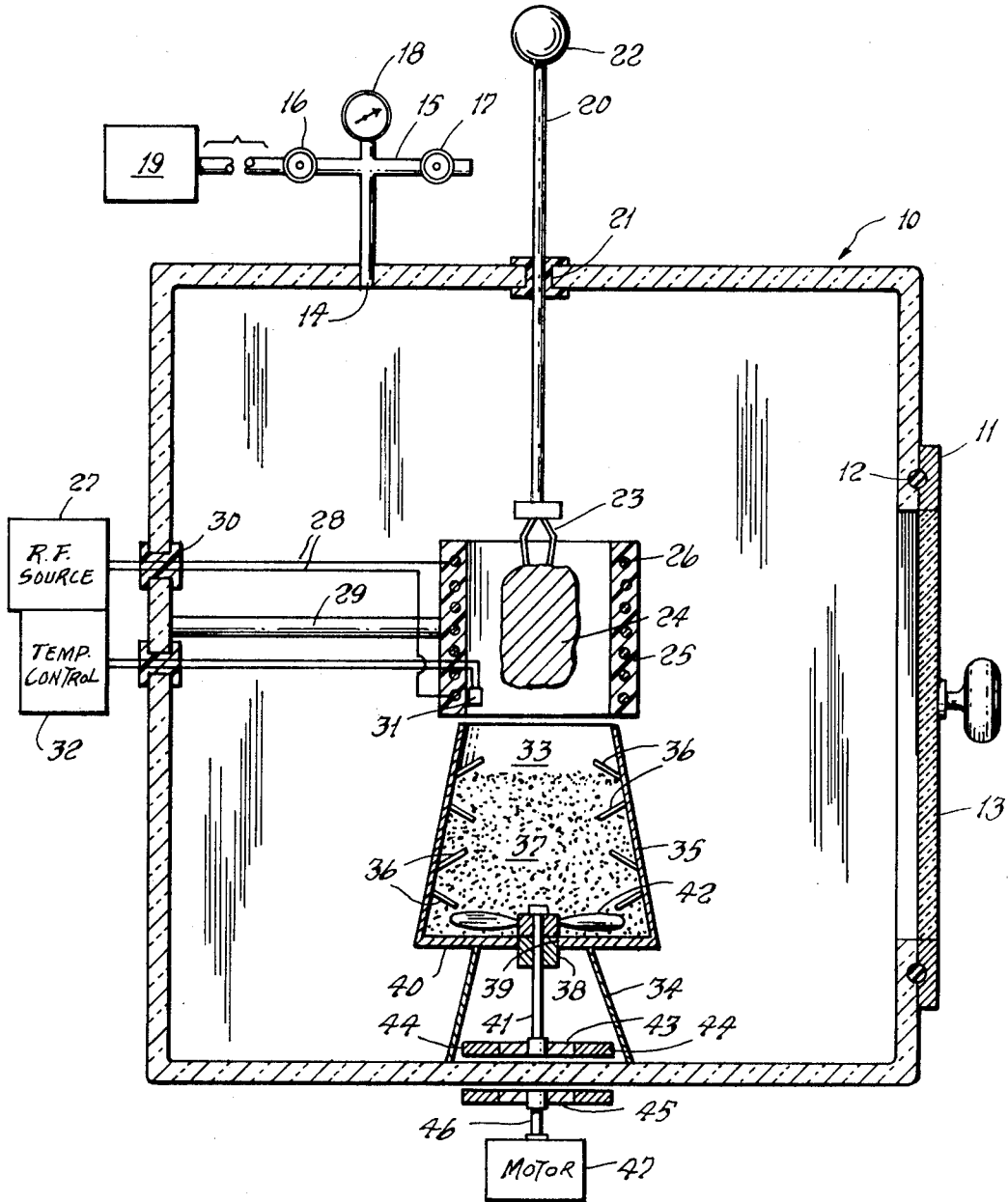
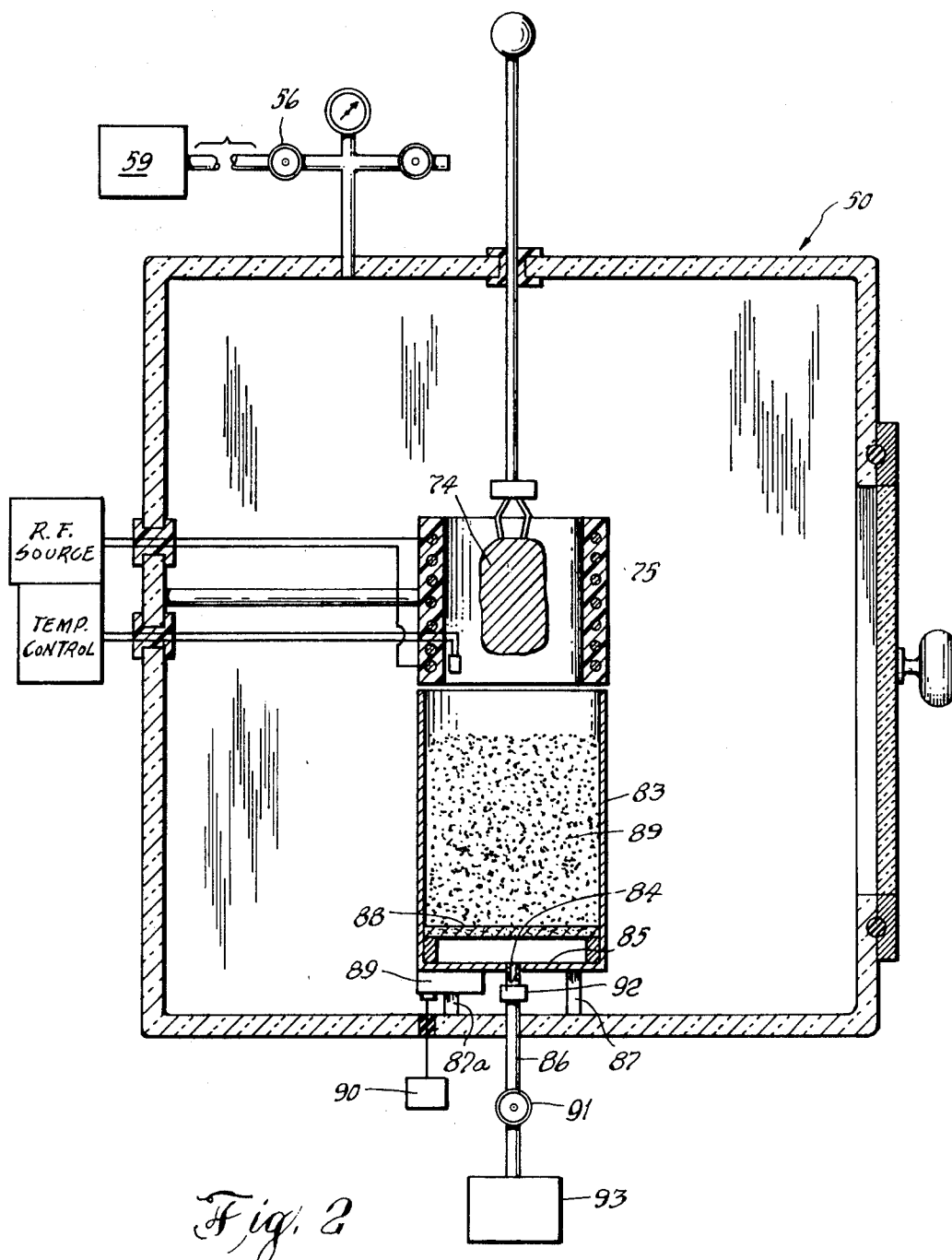


Fig. 1

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## VACUUM FLUIDIZED-BED COATING APPARATUS

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

### BACKGROUND OF THE INVENTION

#### 1. Field of the Invention

The present invention relates to coating methods and apparatus and more particularly pertains to improvements in fluidized-bed coatings as applied to resins and polymers.

#### 2. Description of the Prior Art

In the field of polymer coatings, it has been the general practice to employ fluidized-bed processes to coat various high-temperature materials. This process consists in providing a fluidized bed which by definition is a mass of solid particles which exhibits the liquidlike characteristics of mobility, hydrostatic pressure, and an observable upper free surface across which a marked change in concentration of particles occurs. Localized auxiliary motion can be imparted to the particles by a stream of air or gas entering at the bottom and passing upwardly through the bed. The part to be coated is preheated above the melting point of the polymeric resin coating powder and then dipped into the fluidized bed. The powder striking the hot surface melts and adheres to the surface of the part.

These methods and apparatus have been unsatisfactory in certain regards: oxidation of the surface of the part to be coated takes place generally during the preheating. Atmospheric and generated gases are entrapped at the interface between the surface of the part and the polymer coating, thus substantially reducing the adhesion therebetween and the coating integrity. This is especially evident in the case of fluorinated polyethylenes in addition to the problem of elevated preheat temperatures. Coatings for these materials, where possible, are nonuniform, extremely thin, porous, and exhibit poor coating adhesion.

### SUMMARY OF THE INVENTION

The general purpose of this invention is to provide a polymer-coating apparatus and technique that has all the advantages of similarly employed prior art devices and has none of the above-described disadvantages. To attain this, the present invention provides an evacuated sealed chamber into which are placed a fluidized-polymeric powder, and the suspended workpiece to be coated therewith. The member is heated and the bed is placed in motion or physically agitated so as to cause the particles thereof to become fluidized and the heated workpiece is lowered into direct contact with the fluidized bed to provide a durable uniform, integral coating which is then cured by removing the workpiece and reheating it while still under a partial vacuum. While still in its heated state, the partial vacuum is released and the coating thereby is physically pressed against the workpiece surface.

An object of the present invention is to provide a new and improved apparatus for the uniform coating with polymeric materials.

Another object is to provide an apparatus for coating from a fluidized-polymeric powder bed which is simple, inexpensive and reliable, and which results in a uniform coating having good adhesion and which is applicable to fluorinated polyethylenes.

Still another object is to provide a coating apparatus suitable for coating in cavities and interlaminar spaces, thus being a sound coating and relatively free of voids, pinholes and other similar defects.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings.

### BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional view of an embodiment made in accordance with the principle of this invention; and

FIG. 2 is a sectional view of another embodiment made in accordance with the instant invention.

In the illustrated embodiment of FIG. 1, a chamber 10 which defines a sealed plenum is provided with a sealing gasketed door 11 for access therinto. The door is sealed by a circumferential "O" ring 12 against the chamber and carries a window 13 for visual observation of the chamber interior. A single opening 14 in the chamber wall serves as an access therein whereby the plenum may be readily evacuated. For this purpose the piping 15, which is affixed to the chamber, is coupled to a pair of T-connected valves 16 and 17 and directly to a vacuum gage 18. One of the valves 16 is coupled to a vacuum pump 19 while the opposite valve 17 is employed to break the vacuum and provide additional safety or flexibility.

Manipulator arm 20 pierces the upper chamber wall by way of mechanical feed-thru 21. The arm 20 should preferably be coated or covered with an insulator so as to minimize the possibility of accidental electrical shorting and terminates at its outer end in a handle 22. Glass window 13 permits observation during manipulation as by the handle 22 and thereafter. Clamp 23 depends from arm 21 and supports a ferromagnetic workpiece 24 therebelow. Disposed about the workpiece is a coil form 25 which supports an induction coil 26, whose ends are connected to an external source of r.f. energy 27 via wires 28. The coil form is affixed to the chamber wall by extension 29 while the wires 28 pass through the wall at feed-thru 30. A thermocouple 31 proximate the workpiece 24 senses the temperature thereof and, in conjunction with temperature controller 32, regulates the current output of the r.f. source 27 to maintain the proper temperature of the workpiece for the coating powder being employed.

A container 33 is supported by a hollow base 34 directly under the workpiece 24. The container walls 35 converge inwardly and are provided on the inner side with vanes 36 which alternately are directed upwardly and downwardly to produce a uniform fluidization of the powder 37 within the container 33. Supported by a thrust bearing 38 and passing through an opening 39 in the base 40 of the container is a shaft 41 which carries at one end an impeller 42 proximate the base 40. The opposite end of the shaft 41 carries a plate 43 on or in which are disposed a plurality of magnets 44. This magnetic plate 43 is supported just above the base of the chamber opposite a similar magnetic plate 45 which is rotatably supported on motor shaft 46 and driven by motor 47.

In operation the system is assembled as shown, the chamber is evacuated by the pump 19 via valve 16. The r.f. source 27 is activated and the workpiece 24 inductively heated to the proper temperature for the coating powder. High-temperature polymers such as tetrafluoroethylenes, trifluorochloroethylene, chlorinated polymers, silicone modified epoxies and polyesters using high-temperature hardeners or catalysts are suitable coating powders since they are not seriously degraded, distilled or sublimed by high temperatures in a vacuum.

After the workpiece has been heated, the motor 47 is energized and the impeller set in motion creating a fluidized bed within the container 33. The workpiece is then lowered into the fluidized bed of coating powder, coated with the powder, and thereafter retracted to a position above the container within the induction coil 25. The coated workpiece is now reheated to properly cure the coating powder thereon. During the cooling of the workpiece, the vacuum may be released by way of valve 17 which effectively causes the still soft coating to be firmly pressed against the workpiece due to the differential pressure on opposite faces of the coating.

In the embodiment of FIG. 2 the upper structure of the chamber 50 is identical to that aforescribed in FIG. 1 and the description thereof has been deleted to avoid repetition.

Disposed directly below the workpiece 74 is a container 83 which is open at the top and has an opening 84 in the base 85 thereof which communicates with the lower portion of the container and the outside of the chamber via a hollow pipe 86. This pipe 86 can be employed to support the container or a pair of legs 87 can serve this purpose. The container 83 carries a porous plate 88 spaced slightly above the base 85. The openings in this plate are of such dimensions as to prevent the coating powder 89 from passing therethrough but capable of admitting freely a gas. Supported on leg 87a is a vibrator 89 which abuts the base 85 of the container and is controlled by a switch 90.

In operation, the chamber is evacuated through the high-capacity pump 59 and valve 56, and the workpiece 74 is heated by induction coil 75. After the workpiece has been heated an inert gas is introduced into the lower portion of the container 83 via valve 91 and pipe 86 and elastomeric coupling 92 from the source 93. The gas passes through the porous plate 88 and enters the powder area causing the powder to become fluidized. The term "inert" used hereinabove is defined in its broadest sense as not only including an inert gas but any gas which will not react or cause a reaction with the workpiece. Additionally, it should be noted that the chamber is continually being evacuated at a rate so as to maintain a partial vacuum or a reduced pressure within the chamber although gas is being introduced. With the powder in the fluidized state, the workpiece is lowered therein so as to be coated by the powder. The vibrator 89 is activated and the container set into motion to aid in fluidization. It is evident that either the vibration or the introduction of the "inert" gas will fluidize the powder and that they may be used individually or in combination.

After the fluidized powder has coated the workpiece, it is retracted and reheated to complete the curing. At this point the partial vacuum can be removed as hereinbefore described.

As a simple direct method, the entire process can be summarized in the following steps:  
evacuation of the chamber,  
fluidization of the powder,  
heating of the workpiece,

lowering the workpiece into the fluidized-powder bed.  
removing the workpiece and reheating to complete the cure, and  
releasing the vacuum while the workpiece coated powder is still soft.

We claim:

1. A coating apparatus for applying a fluidizable coating powder to a workpiece which comprises:

a sealed chamber,

means for selectively evacuating said chamber,

means for supporting said workpiece within said chamber and movable therein,

an induction coil supported about said workpiece,

a source of r.f. energy electrically connected to said induction coil,

a container open at its upper portion and disposed directly below said workpiece,

said container having a plurality of vane elements extending from the inner walls thereof,

fluidizing means carried by said container for providing a fluidized-powder bed of the powder placed therein,

said fluidizing means comprising a bladed impeller means horizontally disposed at the bottom of said container and rotatably supported on one end of a vertical shaft extending through said bottom,

means to drive said impeller comprising a magnetic couple wherein one magnet is supported on the other end of said shaft within said chamber and a driving magnet is disposed externally of said chamber, and

means to move said work support whereby said workpiece may be preheated at said induction heater, carried within said fluidized bed of powder for a coating application and subsequently moved back to said heater for a final heating treatment.

2. The apparatus of claim 1 wherein a temperature control means is operatively associated with said source of energy.

3. The apparatus of claim 1 wherein door means provides access to said chamber.

4. The apparatus of claim 3 wherein said door means includes a window element.

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