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[54] **SPUTTER-COATING APPARATUS WITH END FEED**

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[52] **U.S. Cl.** **204/298**

[51] **Int. Cl.** **C23c 15/00**

[58] **Field of Search** 204/192, 298

[56] **References Cited**

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Assistant Examiner—Sidney S. Kanter

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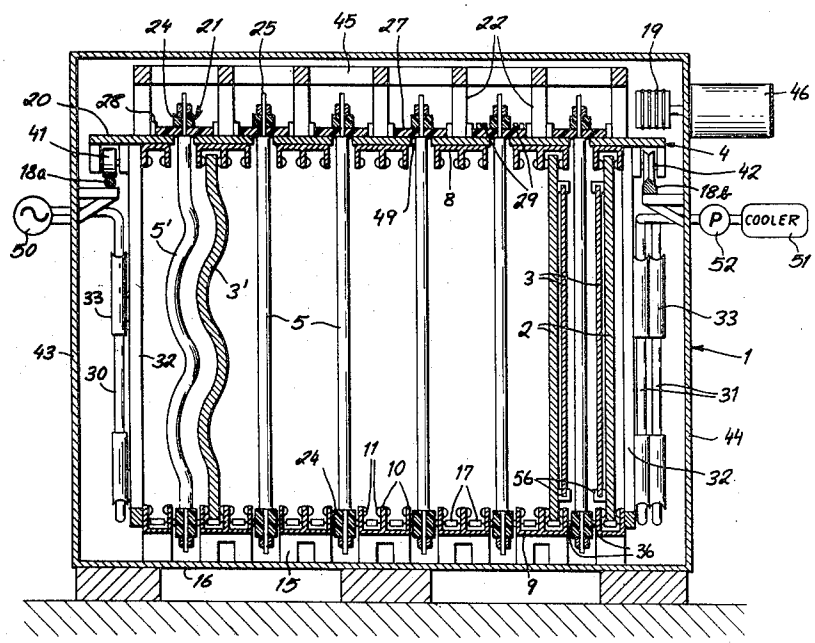
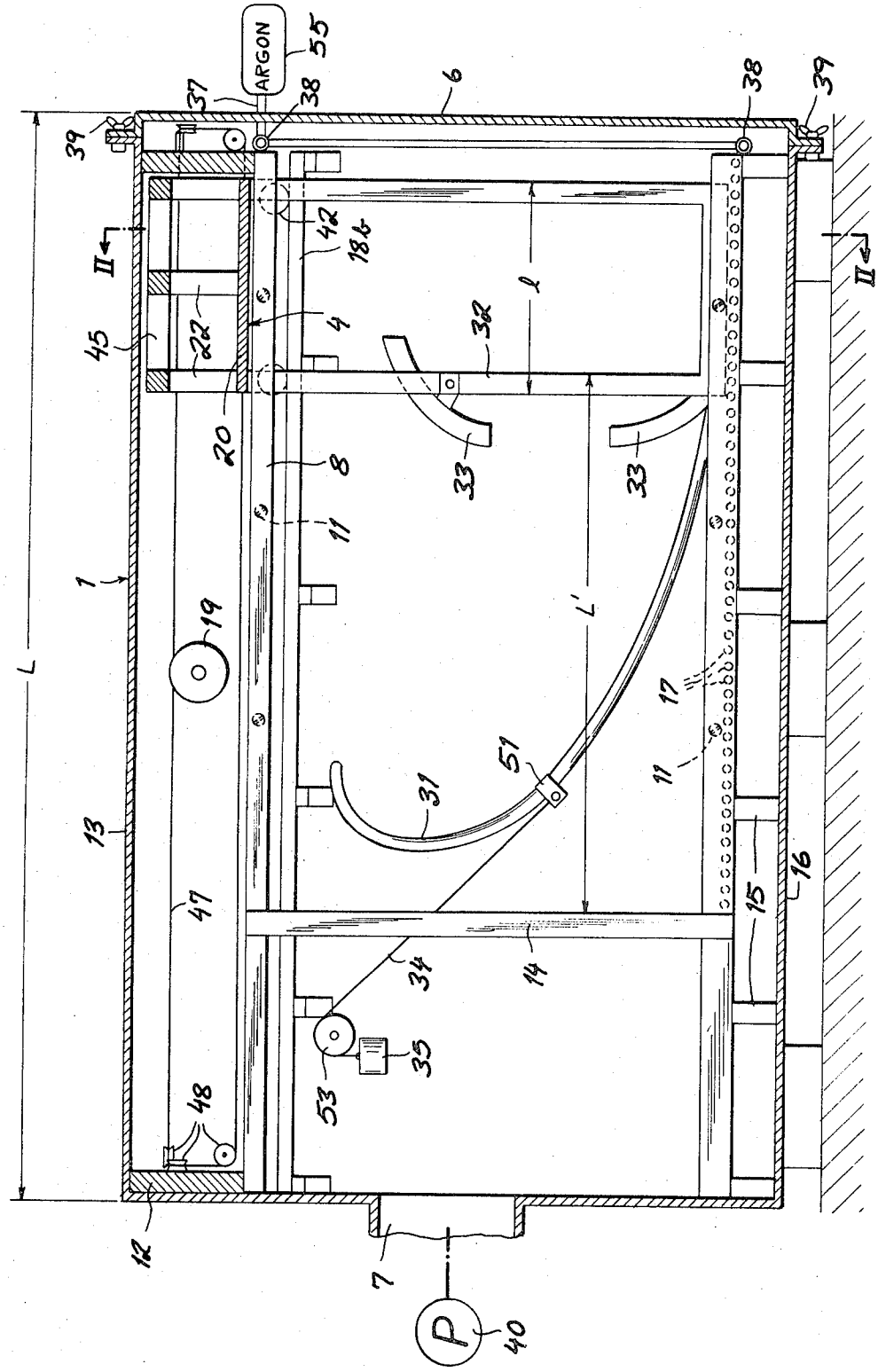
[57] **ABSTRACT**

A sputter-coating apparatus comprises an elongated chamber provided at one end with a loading door and having internally a plurality of pairs of guide rails between which vertical platelike workpieces are stood. A carriage is horizontally displaceable above the workpieces and is provided with a plurality of suspended sputter-coating cathodes connected together as a rack whose lower end is guided between the lower rails. All of the rails are formed as U-section channels to receive the workpieces between their flanks, which are provided with adjustable spacers in order to maintain an exact positioning of the workpieces.

9 Claims, 3 Drawing Figures




ARGON
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37
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II
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20
8
33
33
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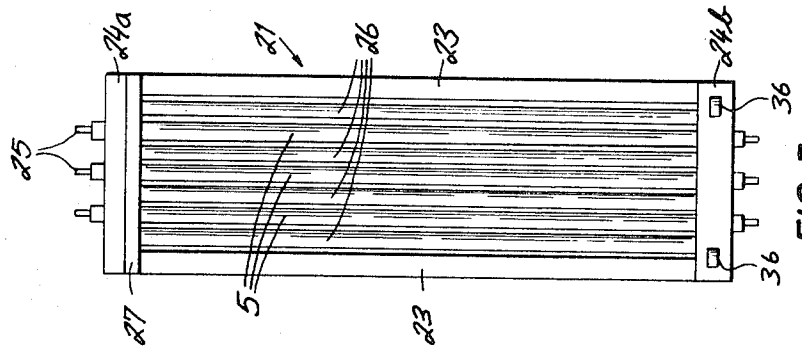
P
40

FIG. 1


24a
21
26
23
24b
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23
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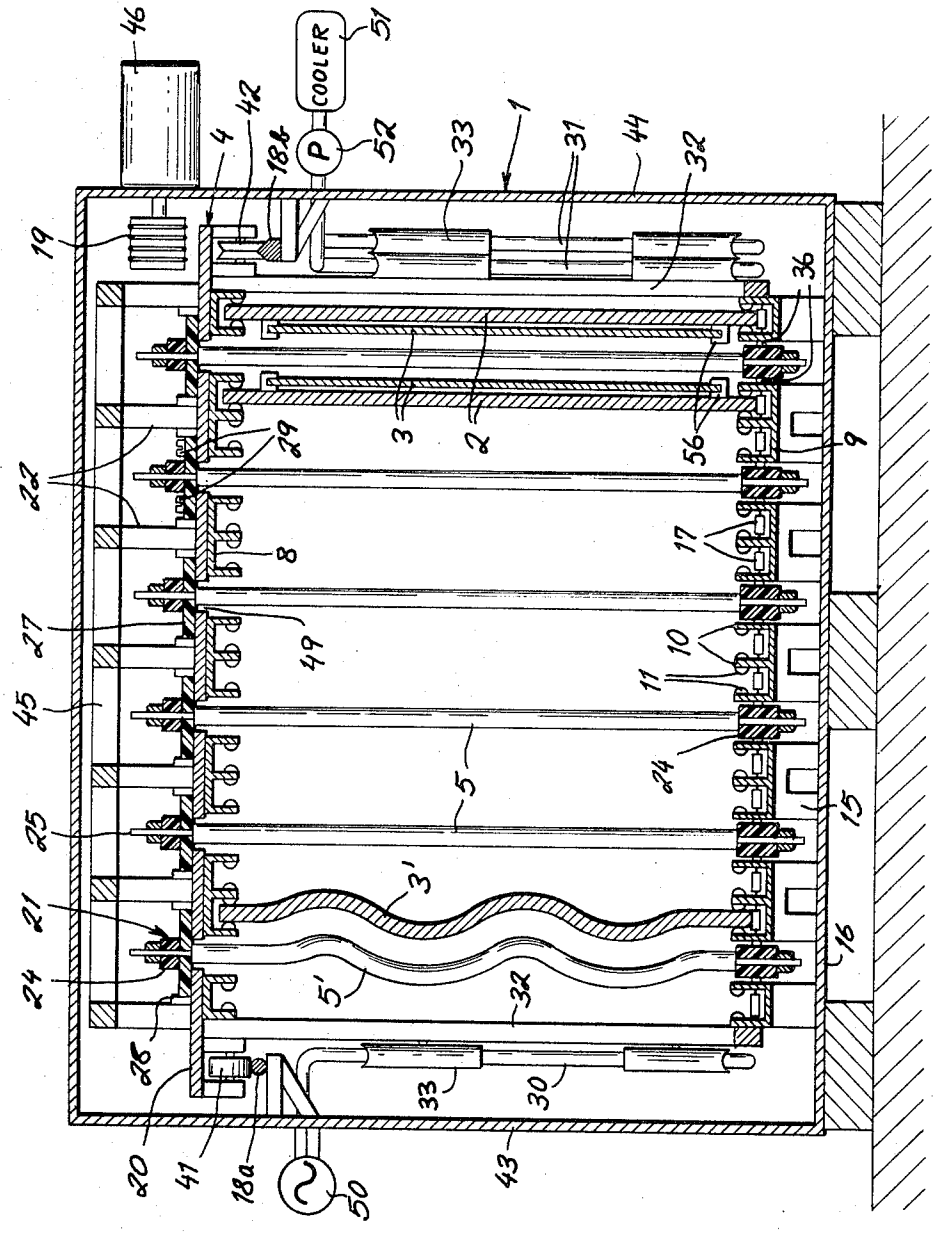
FIG. 3


46
COOLER
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11
45
5
24
15
25
3'
21
16
24
5'
32
26
33
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20
41
18a
50
43

FIG. 2

SPUTTER-COATING APPARATUS WITH END FEED

FIELD OF THE INVENTION

The present invention relates to an apparatus for the sputter-coating of a sheet-like workpiece and, more particularly to an apparatus for use in the sputter-coating of a glass, ceramic, or synthetic-resin plate.

BACKGROUND OF THE INVENTION

A glass plate or the like which is to be sputter coated on one face is usually affixed to a rigid support frame which is lowered through a slot in the roof. To this end the frame and its plate (henceforth referred to as the workpiece) are lifted by a crane and then painstakingly fitted, usually with the help of a worker or two standing on top of the treatment chamber, down into the apparatus. Care must be exercised to prevent breaking of the workpieces, which often are as large as 15 square meters. In order to increase efficiency by loading and unloading the treatment apparatus as quickly as possible all of the sheets are fitted into a large frame which is dropped by automatic means into the top of the treatment chamber. Such equipment is extremely costly and, when a workpiece of different thickness is used, it is often necessary to allow several days of downtime for readjustment of the spacing between parallel racks.

Furthermore the electrodes are usually arranged horizontally in vertical planar arrays which are displaced vertically up and down next to the stationary workpiece, or more often between two workpieces. To this end the rack of electrodes (sputtering cathodes) is mounted as a carriage on four vertical threaded spindles which are driven to raise and lower these electrodes. Once again this complicated arrangement is difficult to adjust and at best rarely gives perfectly uniform coatings to the workpieces since the complexity of the drive, inter alia, makes it impossible to maintain a uniform electrode-workpiece gap.

OBJECTS OF THE INVENTION

It is the principal object of the present invention to provide an improved apparatus for sputter-coating a sheetlike workpiece.

Another object is the provision of an apparatus for the purpose described wherein uniform coating results can be obtained and loading and unloading time is reduced.

Yet another object is the provision of a sputter-coating apparatus wherein adjustment of the workpiece-electrode gap is simple and rapid.

SUMMARY OF THE INVENTION

The above objects are attained according to the present invention in an apparatus wherein the workpieces are held in place by upper and lower guides. The electrodes hang vertically from a carriage which is horizontally reciprocal in the upper region of the treatment chamber, and the lower end of the electrode rack is received between adjacent lower guides which form an upwardly open guide slot.

According to another feature of the present invention the carriage for the electrodes rides on a pair of rails in the upper region of the treatment chamber. These rails are independent of the upper guides so that the carriage will have no effect on these guides as it is reciprocated back and forth during the sputtering operations. Preferably the rails are located on opposite sides and outwardly of the array of guides.

Each lower guide is preferably a straight upwardly open channel provided with a plurality of spaced-apart anti-friction rollers. The upper guide is a downwardly open channel without rollers so that the workpiece (the body to be coated clipped to a rigid support plate or frame) can be slipped in the end of the apparatus, horizontally. These various guide channels can be shifted transversely for any desired spacing of the workpieces from the electrodes.

According to a further feature of this invention the electrodes are arrayed in a plurality of racks which are straight for planar workpieces or curved for warped or intentionally profiled workpieces. Each rack hangs through a respective slot formed in the carriage, and is blocked into an exact position in the slot. Similarly the lower end of each rack is provided with rollers rotatable about vertical axis and rising on the outer edges of the lower guide channels.

DESCRIPTION OF THE DRAWING

The above and other objects, features, and advantages of the invention will become more readily apparent from the following description, reference being made to the accompanying drawing in which:

FIG. 1 is a longitudinal section through the apparatus according to the present invention;

FIG. 2 is a transverse section taken along line II — II of FIG. 1, the electrode racks being removed for simplification of the view; and

FIG. 3 is a side elevational view of a rack of electrodes according to the present invention.

SPECIFIC DESCRIPTION

The sputter-coating apparatus according to the present invention has a housing 1 with a removable end wall 6 that is held in place by means of wing nuts 39 to form an elongated gastight chamber in this housing. Plates 3 to be coated are held by adjustable clips 56 on rigid supports 2 in a vertical position, and the chamber is evacuated by a pump 40 connected at its rear end by means of a conduit 7.

More specifically each support plate 2 rides on rollers 17 journaled between the flanks 10 of an upwardly open U-section lower guide channel 9. The flanks 10 of each channel 9 are provided with inwardly projecting alignment or spacer screws 11 which can be screwed in and out so that the plate 2 is snugly received in the channel 9. These channels are carried on support blocks 15 which rest on the floor or base 16 of the housing 1.

Similar guide channels 8 are arranged above the channels 9, no rollers 17 being necessary. Adjustment screws 11 are also provided here to prevent lateral movement of a support plate 2. The upper guide channels are secured at their ends by means of support blocks 12 to the roof or top of the housing 1 and to the lower guide channels 9 by means of respective uprights 14. The channels 8 and 9 are parallel to each other. The upright 14 defines, as seen in FIG. 1, the maximum left-hand travel of a plate between the guides 8 and 9. A carriage 4 rides by means of a cylindrical wheel 41 allowing expansion of the carriage under heating and a circumferentially grooved wheel 42 on a round rail 18*a* supported on one side wall 43 of the housing and on a sharp-edged rail 18*b* secured to and defining the posi-

tion of the other side wall 44 of the housing 1. This carriage comprises a plurality of heavy steel plates 20 suspended by stout support beams 22 from a grid 45. This grid has a length *l* substantially one-fifth of the length L of the housing 1, and is able to fit between the uprights 14 and the end wall having the conduit 7. Since the workpieces are sheets pushed in against the uprights 14 and have a length equal to L' which is equal to substantially three-fifths L the entire carriage 4 will be able to move past the entire workpiece 3. A reversible motor 46 carries a cable drum 19 on which is wound a cable 47 that is spanned over pulleys 48 and connected to one of the plates 20 of the carriage 4. As the motor rotates in one direction the carriage 4 travels in one longitudinal direction and when the motor is reversed, by means of simple limit switches, the carriage returns.

Each pair of plates 20 defines a slot 49 in which hangs a planar electrode rack 21 comprising three live cathodes 5 connected by means of end contacts 25 and cables 30 to a three-phase alternating-current source 50 and hanging vertically between planes defined by flanking guides 8 and 9. Four grounded electrodes 26 are interleaved with the electrodes to form a comb and all of the electrodes 5 and 26 are cylindrical sleeves through which water is circulated from a cooler 51 by a pump 52 through flexible conduits 31. These electrodes are arrayed parallel to each other in an upright position in a rectangular frame formed by horizontal cross pieces 24*a* and 24*b* interconnected by side members 23. The lower crosspiece 24*b* is provided with four small horizontal rollers 36 which engage the flanks 10 of the channels 9 so that the electrode assembly 21 does not wobble from side to side as it is displaced by the carraige 4 through the chamber 1. The upper crosspiece 24 is provided with two outwardly projecting flanges 27 which lie on top of the confronting edges of the plates 20. Spacer blocks 28 are employed to insure an exact positioning of the upper portion of each rack 21 relative to the respective slot 49. Screws 29 may be used to secure the flanges 27 to the plates 20. The clips 56 ensure an exact positioning of each plate 3 on its frame 2.

In order to prevent the conduits 31 and cable 30 from kinking and interfering with operation of the device a counterweight 35 suspended on a cable 34 from a pulley 53 is provided, with the cable 34 attached by means of a bracket 54 to the center of the respective conduit or cable. In addition depending side members 32 are provided on the carriage 4 with guide shields 33 which will prevent such kinking or interference.

It should also be noted that, shown in FIG. 2, when an undulating or otherwise nonplanar workpiece 3' is to be coated, similarly curved electrodes 5' may be employed, but these particular sheets 3' being received directly between the guides 8 and 9, without a support frame 2.

A process gas such as argon is fed from a source 55 through conduits 37 into distributing pipes 38 which extend across the full width of the chamber 1 at its top and bottom adjacent the door 6.

The apparatus is operated as follows:

Twelve workpieces 3 carried on support frames 2 are slid into the apparatus between respective channels 8 and 9 and up against the uprights 14. Then the door 6 is closed and secured by means of the wingnut dogs 39.

The suction pump 40 is actuated and once pressure in the chamber 1 has dropped below a predetermined level argon is admitted from the perforated pipes 38 to thoroughly sparge the chamber. The power source 50 is now hooked up and the pump 52 is started in order to circulate cooling water through the cathodes 5. With the carriage 4 in the antechamber behind upright 14, the gas discharge between the electrodes is ignited. Then the motor 46 is started to draw the carriage along the workpieces and thereby to sputter coat that face of each workpiece turned toward the cathodes 5. Cathodes of different metals are used to obtain multilayer coating.

Since the electrode racks 21 are snugly guided both at their tops and at their bottoms the spacing between each electrode 5 and the workpieces 3 remains almost perfectly uniform as these racks are displaced through the chamber. Proper adjustment by use of the blocks 27 and the seating of the supports 15 allows any irregularity to be canceled out with little difficulty.

The door 6 permits the workpieces to be loaded horizontally into the apparatus so that complicated equipment for lifting and guiding these workpieces 3 is not required.

We claim:

1. A sputter-coating apparatus comprising:
   - a gastight chamber;
   - suction means connected to said chamber for at least partially evacuating same;
   - at least one upper horizontal rail in said chamber;
   - at least one lower horizontal rail in said chamber below and parallel to said upper rail, a sheetlike workpiece being retainable in an upright position between said upper rail and said lower rail;
   - means forming with said lower rail a lower guide;
   - a horizontally displaceable carriage in said chamber above said upper rail;
   - a rack of sputter-coating electrodes having an upper end attached to said carriage and a lower end engaged with said guide; and
   - means for displacing said carriage horizontally in said chamber with said lower end riding along said guide and thereby moving said electrodes past said sheetlike workpiece while sputtering a coating thereon.

2. The apparatus defined in claim 1 wherein said means forming said guide is another such lower rail parallel to the first-mentioned lower rail, said apparatus including another such upper rail parallel to the first-mentioned upper rail, another such sheetlike workpiece being retained between the second-mentioned upper and lower rails.

3. The apparatus defined in claim 2, wherein said rails are formed as channels having flanks, each workpiece being received between the flanks of one of the upper rails and between the flanks of the corresponding lower rail.

4. The apparatus defined in claim 3 wherein said chamber has a top, bottom, side, and end walls, one of said end walls being provided with a door, said upper rails being suspended from said top wall, and said lower rails being supported on said bottom wall.

5. The apparatus defined in claim 3 wherein said rails are provided with spacing means on their flanks for snugly engaging the faces of a workpiece received therebetween.

6. The apparatus defined in claim 5 wherein said spacing means are displaceable transverse to the longitudinal axis of said rails.

7. The apparatus defined in claim 3 wherein each electrode rack includes a plurality of elongated vertical electrodes and upper and lower cross members interconnecting said electrodes at said upper and lower ends of said rack, said lower cross member being provided with a plurality of rollers engaging the flanks of said lower rails.

8. The apparatus defined in claim 7 wherein said rollers are rotatable about vertical axes.

9. The apparatus defined in claim 3 wherein each said lower rail is provided with a plurality of rollers rotatable about respective parallel horizontal axes, said workpieces resting on said rollers.

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