United States Patent [19]

Wollam

[11] **3,783,822**

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[54] **APPARATUS FOR USE IN DEPOSITION OF FILMS FROM A VAPOR PHASE**

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[52] **U.S. Cl.** **118/49.1**
[51] **Int. Cl.** **C23c 13/08**
[58] **Field of Search** 118/48–49.5, 500, 503, 53, 118/319; 117/107.1; 269/55–57

[56] **References Cited**

UNITED STATES PATENTS

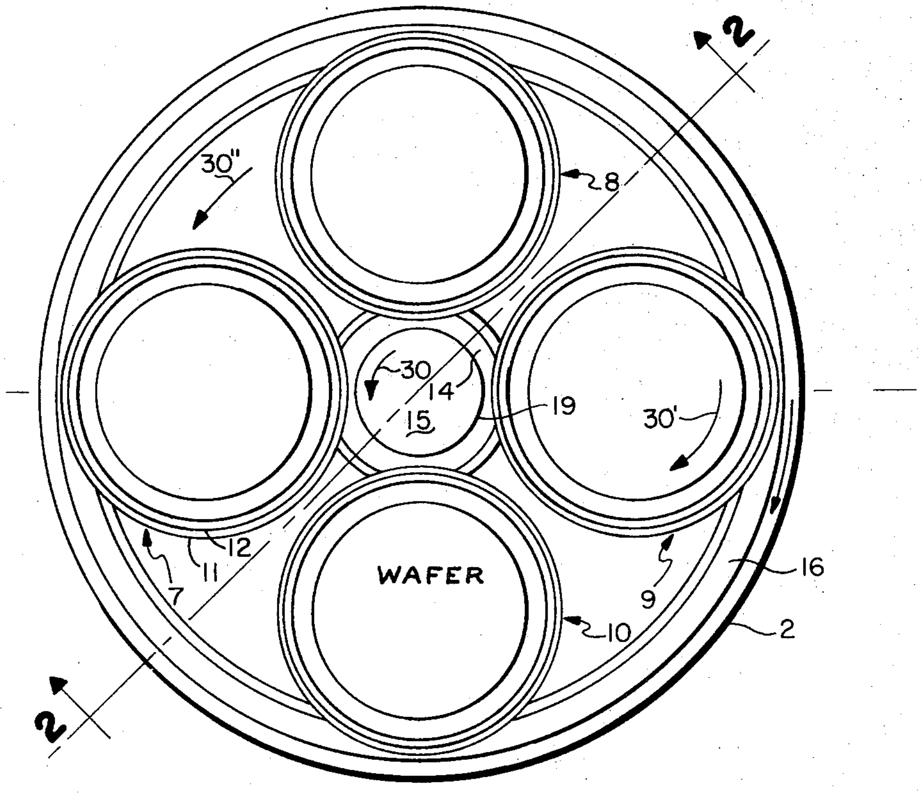
3,424,628	1/1969	Winings	118/49.5 X
3,436,255	4/1969	Harris et al.	118/503 X
3,523,517	8/1970	Corbani	118/500
3,594,227	7/1971	Oswald	117/107.1 X
3,608,519	9/1971	Richardson et al.	118/48
3,633,537	1/1972	Howe	118/48
3,675,624	7/1972	Hunts et al.	118/503

Primary Examiner—Morris Kaplan

[57] **ABSTRACT**

Separate platform discs for carrying workpieces or substrates such as slices or wafers of semiconductor material in a deposition environment are moved in a common circular orbit and rotated by the action of two co-axial annular support surfaces upon which each disc rests at opposite areas of the lower periphery of the disc, one of these support surfaces being driven with respect to the other in rotation about the axis common to the two annular supports. The temperature of the discs and/or substrates is maintained by proximity to a heat or other energy source or sink, with deposition occurring on the exposed upper surface of the substrate resting on the disc.

9 Claims, 8 Drawing Figures



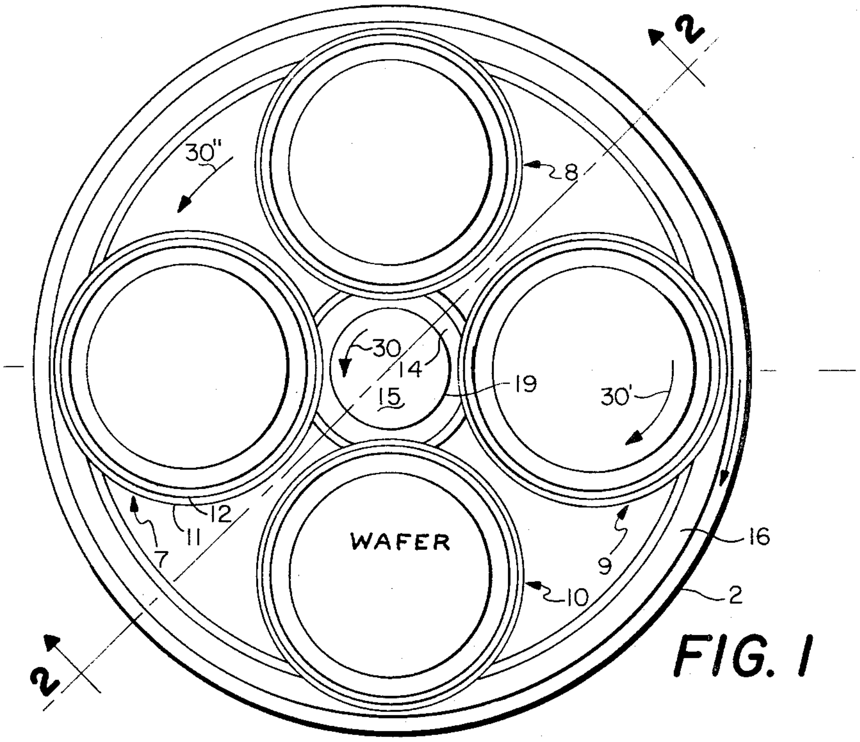

2
2
30"
8
30
14
19
15
30'
WAFER
12
11
7
9
16
10
2

FIG. 1

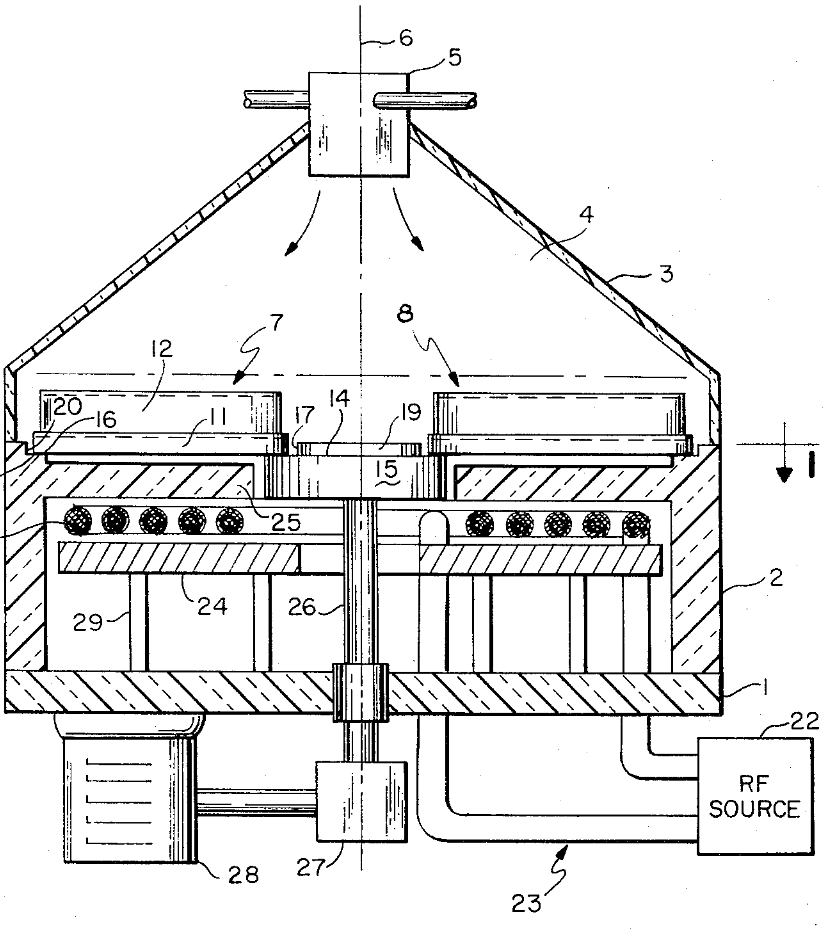

6
5
4
3
7
8
12
20
16
11
17
14
19
1
1
18
15
25
21
2
24
29
26
1
22
RF SOURCE
28
27
23

FIG. 2

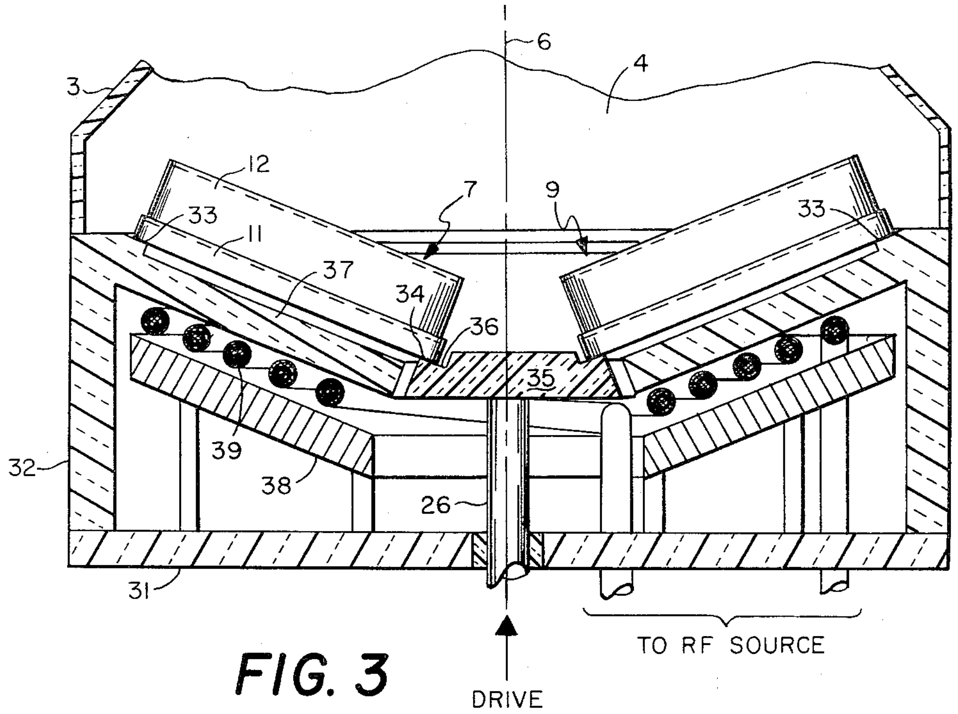

6
4
3
12
33
11
7
9
33
37
34
36
35
39
32
38
26
31
TO RF SOURCE
DRIVE

FIG. 3

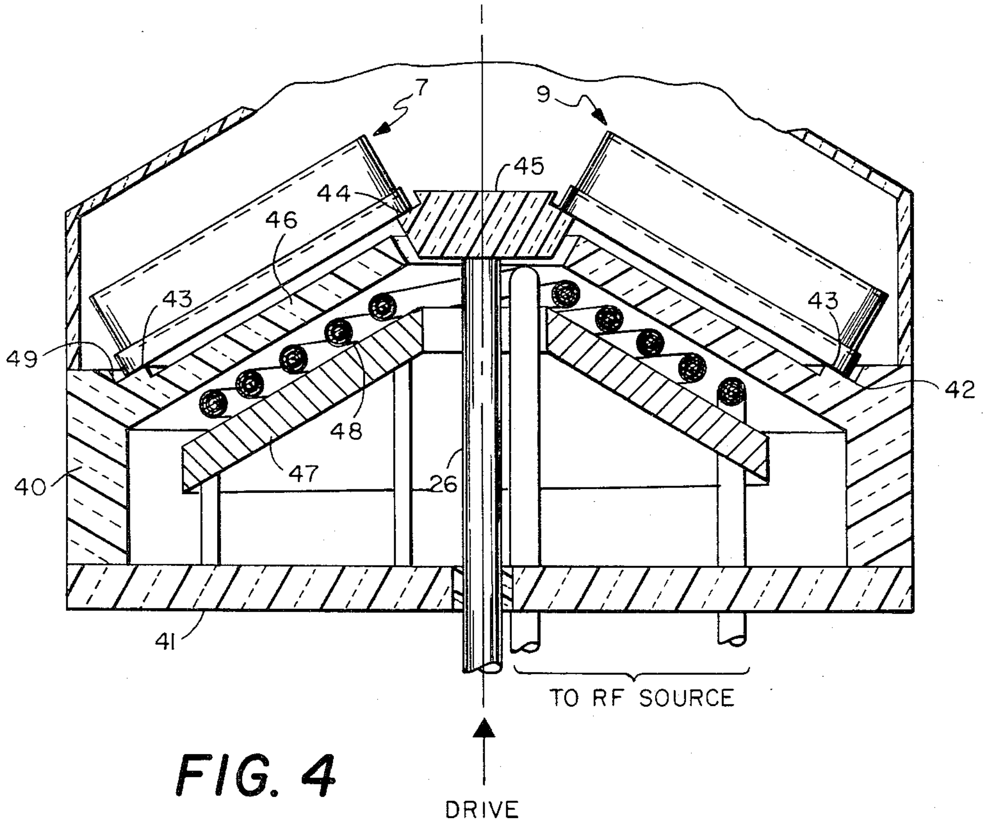

7
9
45
44
46
43
43
49
42
48
40
47
26
41
TO RF SOURCE
DRIVE

FIG. 4

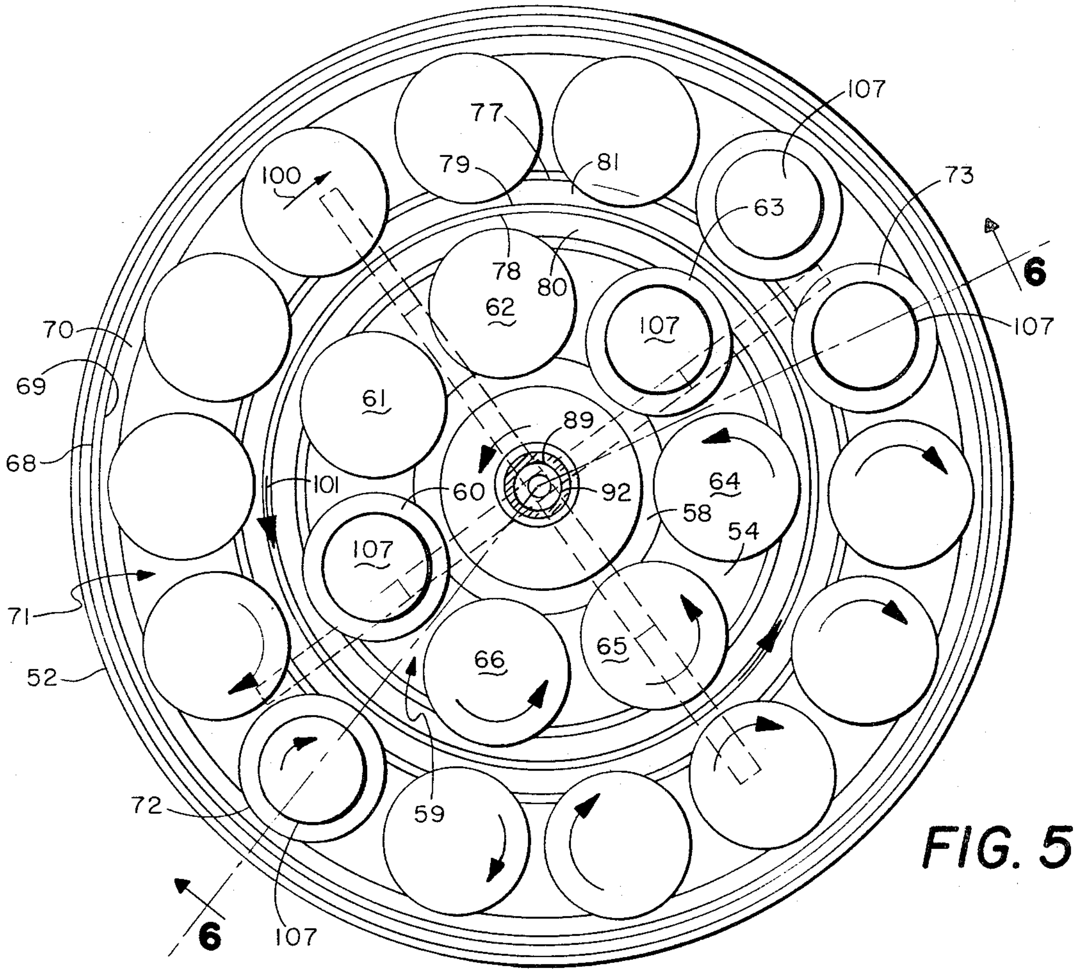

107
77
79
81
100
63
73
6
78
80
62
107
107
70
69
61
89
68
101
60
92
64
58
54
107
71
52
65
66
72
59
6
107

FIG. 5

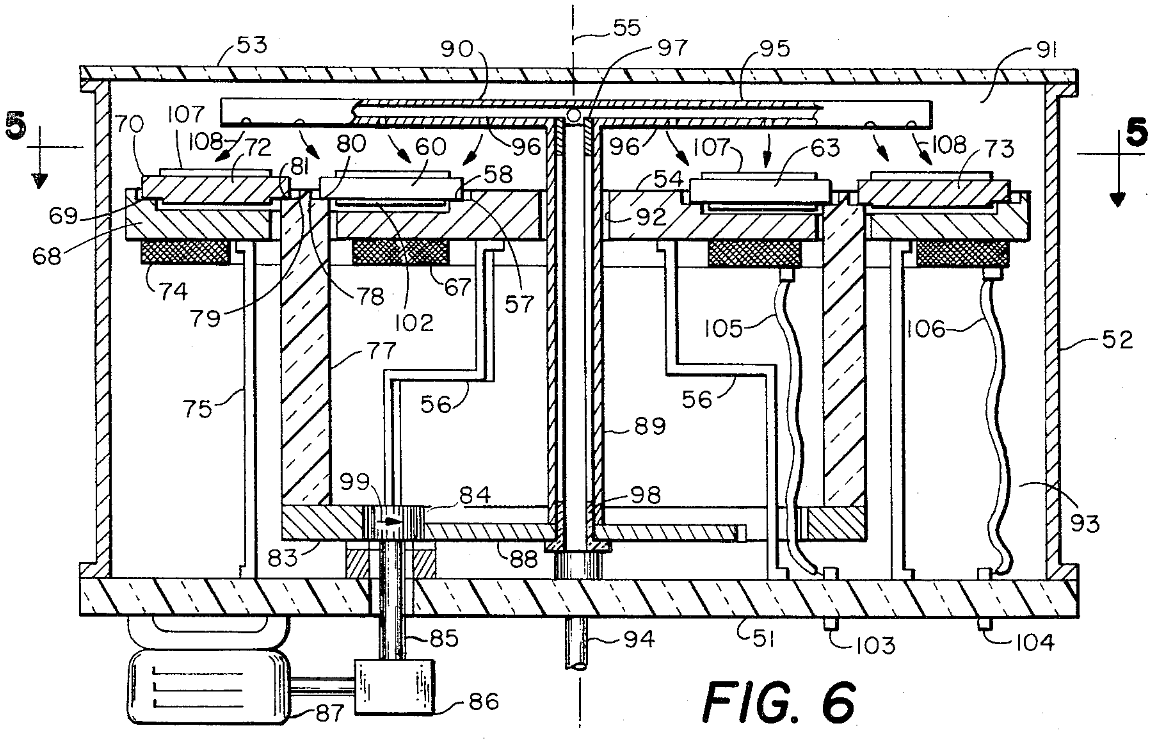

53
55
90
97
95
91
5
5
70
107
108
72
80
60
96
96
107
63
108
73
81
58
54
69
92
68
74
79
78
102
67
57
105
106
52
75
77
56
56
89
99
84
98
93
83
88
85
94
51
103
104
87
86

FIG. 6

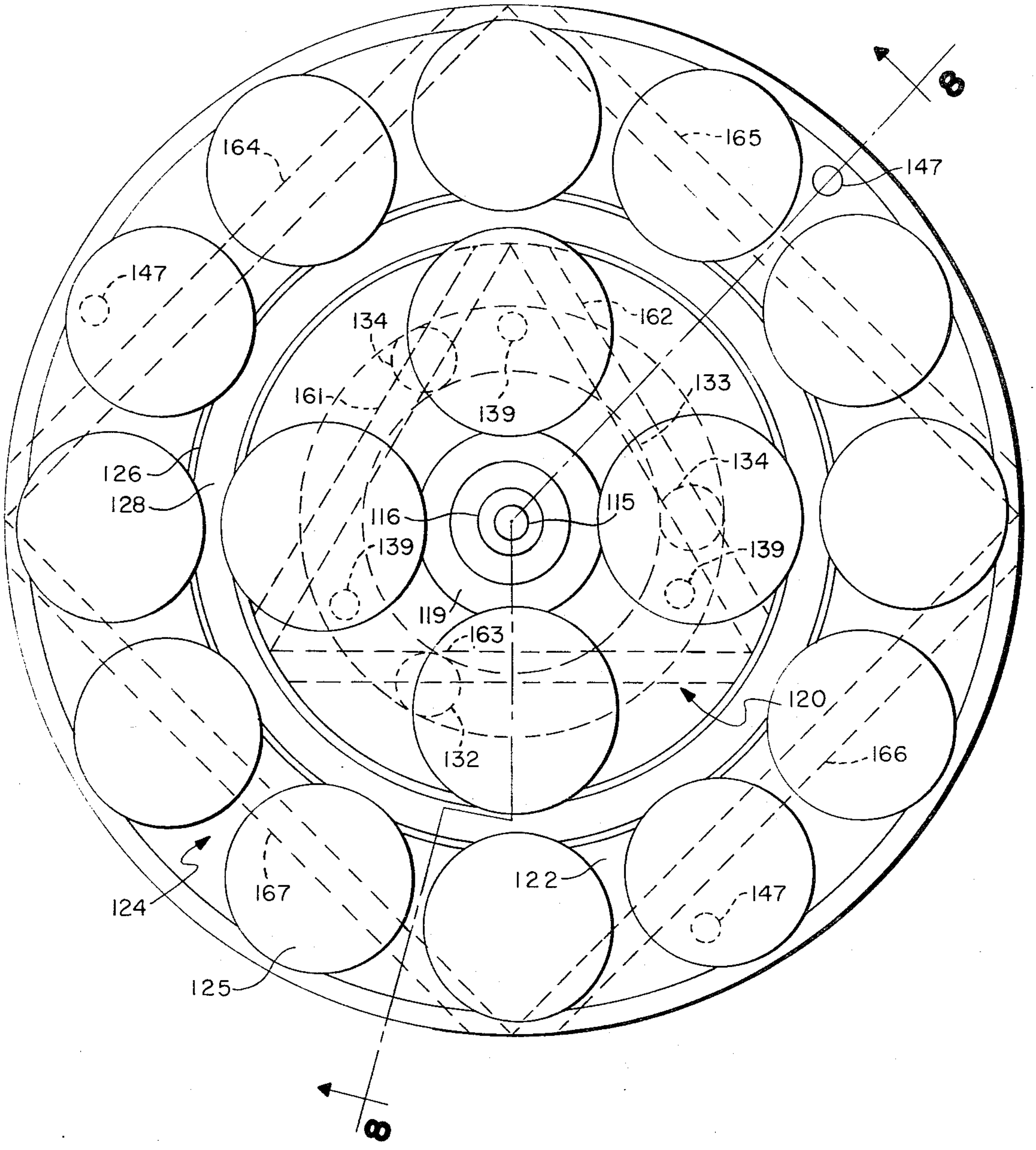

8
164
165
147
147
134
162
161
139
133
134
126
128
116
115
139
139
119
163
120
166
132
124
167
122
147
125
8

FIG. 7

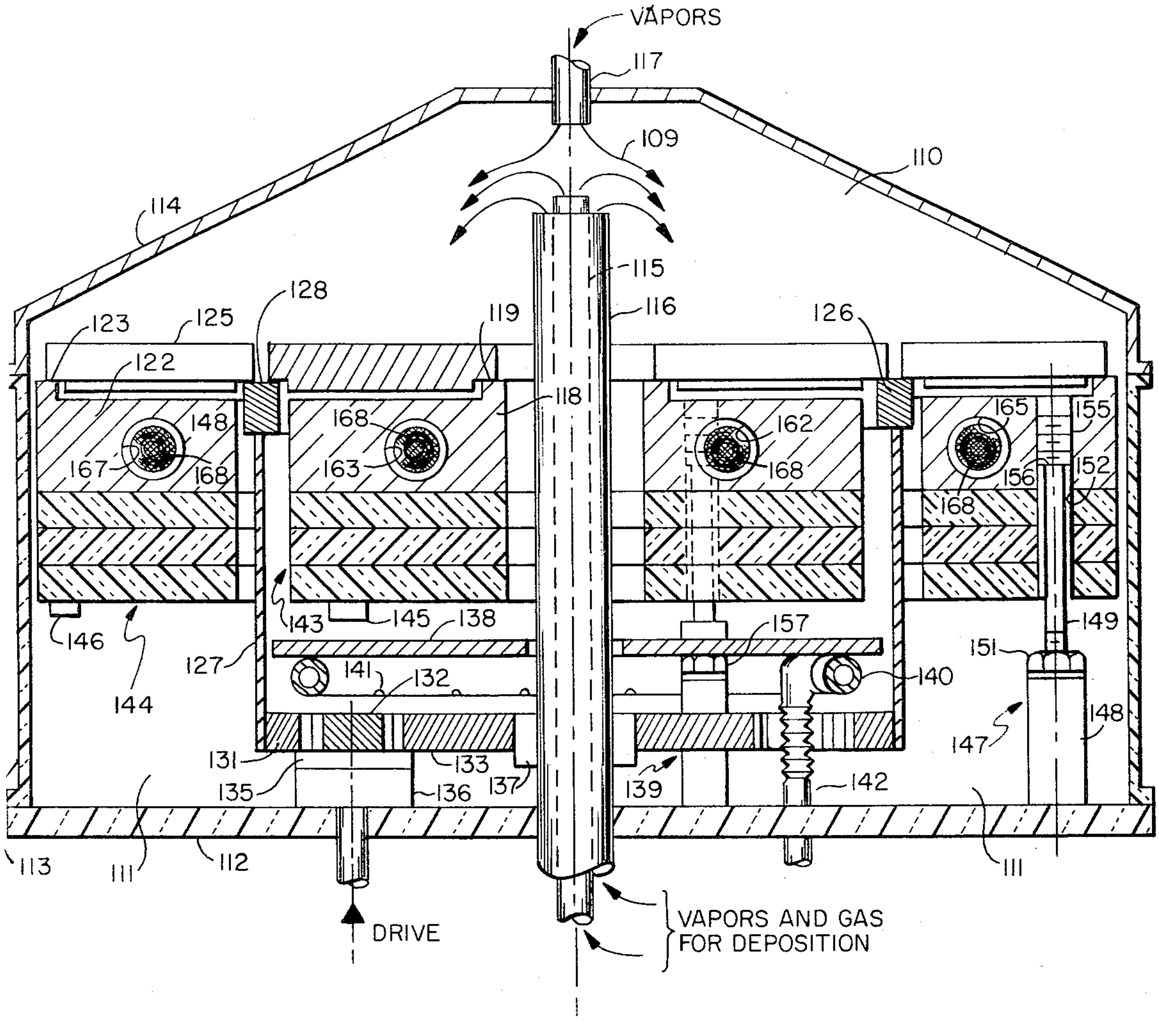

VAPORS
117
109
110
114
115
116
128
123
125
119
126
122
118
148
168
165
155
162
167
163
168
156
152
168
146
144
143
145
138
157
149
127
141
132
140
151
148
147
131
133
139
135
136
137
142
113
111
112
111
DRIVE
VAPORS AND GAS
FOR DEPOSITION

FIG. 8

APPARATUS FOR USE IN DEPOSITION OF FILMS FROM A VAPOR PHASE

This invention relates to apparatus used in the formation of films on workpieces such as substrates of semiconductor material where the workpieces are exposed in an environment of vapor or gas to be etched or to produce a condensed film on the substrate. The invention is particularly applicable to the deposition of films of material formed at the substrate surface by a chemical reaction of gaseous substances, wherein the chemical reaction which produces the material of the film is initiated or enhanced by heat or other energy imparted to the reactants at or near the surfaces to be coated.

In semiconductor technology, the treatment of a substrate or slice or wafer of semiconductor material often includes etching or the deposition of films from the vapor phase such as epitaxial single-crystal silicon, polycrystalline silicon or metals, or amorphous silicon dioxide, or silicon nitride, or other films on the substrate. The deposition occurs when the wafer is heated while exposed to a mixture of gaseous materials which react to form a condensible substance which then deposits on the wafer. The uniformity of these films is highly dependent upon the success achieved in eliminating or minimizing variations in temperature across the surface of the wafer and eliminating or minimizing differences in flow and composition of the vapor or gaseous reactant materials at the wafer surfaces.

Methods of eliminating or minimizing variations in the factors affecting film uniformity have been the subject of much study and experimentation. Some efforts to ensure that all wafers in a multi-wafer deposition apparatus, or that all areas of a single wafer in a lot of wafers, are exposed to essentially indentical conditions during deposition have entailed provision for the movement of rotation of the wafer or wafers and/or the source of the gaseous materials, with the objective of averaging out the effects of variations in these conditions. Some of these efforts have included a planetary rotating system supporting the wafers during the deposition process.

Heretofore, some planetary drive systems used to move the wafers throughout the gaseous and thermal environment during deposition have consisted of a multitude of planetary gears with a sun gear inside the planetary orbit and a ring gear outside the planetary orbit. Either the sun gear or ring gear is held stationary while the other is rotated to move the planet gears in orbit and at the same time rotate each about its own axis. The planetary gears carry the wafers or substrates and so they are, in effect, disc shaped orbiting, rotating platforms for supporting the wafers in the gaseous and thermal environment during deposition. The wafers are heated to control the rate of deposition by heating the planetary gears which carry the wafers and so there is a substantial amount of deposition and formation of matter on the gears as well as on the wafers. This raises the requirement for frequency cleaning and/or replacement of the gears.

These planetary rotating systems using orbital gears as described above are limited in temperature by the characteristics of materials suitable for use in constructing gear drives. Materials of sufficient strength and toughness to perform well as planetary gears are usually not appropriate for use in vapor deposition apparatus, while materials such as quartz, alumina, silicon carbide, silicon, or graphite which are suitable for the high temperatures, sometimes required for a particular process, cannot be used for constructing gear drive systems, because they are either not machineable, or are too brittle or too soft for satisfactory operation.

It is one object of the present invention to provide a planetary rotating system for carrying a multitude of substrates in an environment for etching or deposition of films on the substrate.

It is another object to provide such a planetary rotating system which does not have any gears exposed to the gaseous and thermal environment needed for etching or deposition.

It is another object of the present invention to provide a structure for carrying substrates during etching or vapor deposition on orbiting rotating platforms, each platform experiencing no more stress in operation than that imposed by the platforms own weight and the weight of the substrate or substrates carried thereon.

It is another object to provide such a planetary rotating system for etching substrates or for vapor deposition on substrates, wherein deposition on the planetary support disc for the substrates produces little or no deleterious consequences.

It is another object of the present invention to provide a planetary structure which allows the orbiting components to be fabricated of materials which are not usually incorporated into gear drive systems, including materials such as quartz, alumina, silicon carbide, silicon, or graphite.

It is another object to provide a planetary rotating system for supporting and heating substrates in an etching or a deposition process in which all moving parts in the vicinity of the etching or deposition area, exposed substantially to the etching or the deposition environment, are driven by simple friction forces.

It is another object of the present invention to provide etching or deposition apparatus having orbiting rotating platforms for substrates, the platforms being heated or maintained at a predetermined temperature by proximity to energy sources or a temperature sink to maintain the substrates at the predetermined temperature; the apparatus being so constructed that it is readily disassembled for cleaning and/or replacement of parts.

It is another object to provide an etching or deposition system for substrates having at least one set of orbiting rotating platforms for the support of substrates in an atmosphere of gases and vapors which are fed into a reaction space above the substrates via an axial conduit supported by the base of the apparatus, whereby a cover closing the apparatus does not have any connection to sources of the gases and vapors.

Embodiments of the present invention described herein include single and double circular arrays or sets of orbiting, rotating disc platforms for carrying substrates during etching or deposition on the exposed surfaces of the substrates, the platforms being heated to heat the substrates as a control of the etching or the deposition rate and all movement of the discs being induced by friction forces. Thus, deposition on the discs or on the parts in contact therewith does not interfere with operation of the apparatus and the discs can be made of the most suitable materials available both from the view of inertness of the material to the deposition environment and the effectiveness of heating the discs and/or substrates either by the transfer of heat energy, or by induced electrical energy or radiation, in an effort to achieve uniform temperature distribution throughout each disc and from disc to disc and, therefore, throughout all parts of all substrates concerned. A substantially uniform mixture of vapor and/or gaseous material for the etching or the deposition is produced in the space above the discs either by introducing the vapor or gas through ports in a lid enclosing that space or by carrying the vapor or gas through axial conduits supported by the base of the apparatus and extending into and discharging into the reaction space.

Other objects and features of the invention will be more apparent from the following specific description of several embodiments of the invention. These embodiments represent the best known uses of the invention and are illustrated by the figures in which:

FIG. **1** is a plan view of one embodiment showing apparatus with the cover removed revealing four planetary disc-shaped platforms driven in orbit and rotation by a central simple friction drive race and heated by induction coils below the discs;

FIG. **2** is a front sectional view of the apparatus in FIG. **1** shown with the cover attached whereby vapor and gas is introduced through ports in the cover;

FIG. **3** is a front sectional view of apparatus similar to the apparatus in FIGS. **1** and **2** with the discs tilted so that the substrates face toward the axis of the apparatus;

FIG. **4** is a front sectional view of another similar embodiment wherein the discs are tilted so that the substrates face away from the center of the apparatus;

FIGS. **5** and **6** are plan and front sectional views of another embodiment of the invention including two sets of orbiting platform discs having a common drive ring or annular support surface, all drives to the discs being simple friction forces, and an axial rotating branched conduit, or nozzle array, for carrying gaseous or vapor deposition materials into the deposition space above the discs and mechanically stirring the gas by a drive which is common to the drive for the disc drive ring; and

FIGS. **7** and **8** are plan and front section views of another embodiment having heater elements imbedded in the supports for the orbiting discs, leveling posts for the supports, a common drive ring for the discs which has very low thermal mass and low thermal conduction and axial conduits supported by the base of the apparatus for carrying more than one gas or vapor into the reaction space above the discs for mixing and etching or deposition on the substrates carried on the discs.

Turning first to FIGS. **1** and **2**, there is shown apparatus for etching or for carrying out vapor or gaseous deposition on the exposed surfaces of substrates which may be wafers or slices of semiconductor material carried on a single set of orbiting, rotating discs driven in orbit and rotation by simple friction forces and heated by an induction coil below the discs. Apart from the parts of the apparatus shown in this and other embodiments of the invention described herein, the apparatus can be used for other treatment of the substrates in addition to etching and deposition. For example, the apparatus can be used for sputtering processes whereby material is added to or removed from the exposed surfaces of the substrates. The apparatus in FIGS. **1** and **2** consists of a base plate **1** and a cylindrical housing **2** for containing and supporting the induction heating coil and the orbiting, rotating discs. A cover **3** is fitted on top of the housing defining the reaction space **4** above the discs and selected gases and vapors are introduced into the space by a mixing port **5** at the top of the cover centrally located along the axis **6** of the apparatus.

Each of the platform discs **7, 8, 9,** and **10** such as disc **7** is a composite or assembly of two discs; a quartz disc **11** beneath a graphite susceptor disc **12.** The lower or quartz disc in each of these oribiting disc platforms rests on an inside annular drive surface **14** which is part of the central support rotor **15,** and also rests on the outer annular support surface **16** which may be part of the lower housing **2.** The driven surface **14** is defined by a step **17** in the support rotor **15** (also called the drive race) and the outer annular support surface **16** is defined by a step **18** on the inside of the lower housing **2** (also called the fixed race). The orbiting disc assemblies are prevented from leaving the desired circular orbit by the rise **19** on the step **17** and by the rise **20** on the step **18.**

The graphite susceptor discs, such as discs **12,** on each of the platforms discs **7** to **10** are directly heated by radiation from a radio -frequency (*rf*) induction coil **21** below the discs. This coil is powered by energy from an rf source **22** which is outside of the apparatus. Transmission lines **23** couple rf energy from the source to the coil. The coil is substantially flat and may be disposed immediately beneath the composite platform discs **7** to **10** in close proximity to the quartz discs, such as quartz disc **11,** on the bottom thereof. The *rf* coil **21** is preferably supported over a highly electrically conductive plate **24** which does not absorb, but reflects the *rf* energy towards the platform discs **7** to **10.** Between the rf coil and the discs may be interposed a dielectric plate **25** made of a material which is substantially transparent to the *rf* energy and so does not reflect nor absorb the energy, but tends to focus the *rf* energy onto the graphite susceptor disc above. The quartz disc beneath the graphite susceptor disc also does not absorb or reflect the rf energy and tends to focus it into the graphite susceptor. The support rotor **15** is also preferably quartz and so is the drive shaft **26** which extends through the base plate **1** to a gear box **27** and drive motor **28.** Thus, the materials composing the parts surrounding the *rf* coil are such that these parts are not heated by the *rf* energy; only the graphite susceptor **12** on which the substrate (which may be a wafer or slice of semiconductor) rests is heated. The quartz disc **11** which is the bottom part of each of the platform discs **7** to **10** provide a hard non-wearing surface for contact with the driven and stationary annular support surfaces defined by the driven and fixed races, **14** and **16** respectively, and so there is no frictional wear on the softer graphite susceptor material. Other hand refractory materials such as alumina or silicon carbide could be used in place of quartz for the quartz discs **11.**

This apparatus is particularly designed for high temperature deposition processes up to about 1,300° C, for example, deposition reactions such as the pyrolysis of silane or silicon tetrachloride in the growth of epitaxial silicon films. At this temperature range, quartz and silicon carbide coated graphite are satisfactory for use in enclosing the reaction or deposition space **4** as they are substantially inert to the vapors and gases used and do not produce undesirable gases or vapors. The rest of the parts of the apparatus below the reaction space **4** are compatible with the environment in that they absorb no power from the *rf* field which heats the graphite susceptors in the orbiting platform discs. Accordingly, these parts are made of materials which are either good insulators such as alumina or other ceramics, or good conductors of electricity such as copper, silver, or red brass. These same considerations apply to the materials used in the construction of the vapor and gas ports **5** and the drive shaft **26.** They apply to a lesser extent to the base plate **1** and housing **2** which are substantially shielded from the *rf* coil by the plate **24.**

This shielding effect as well as the position of the *rf* coil may be varied by moving the plate **24** up and down on its support legs **29.**

In operation, the motor **28** drives the shaft **26** with its support rotor **15** in the counter-clockwise direction indicated by arrow **30** as viewed from above. The frictional forces between the bottom peripheral edge of the quartz disc, such as **11,** under each of the platform discs **7** to **10,** where the quartz disc of each engages the annular support surface **14,** causes each of the platform discs to rotate in the clockwise direction, indicated by arrow **30'** as viewed from the top and so the discs roll along the outer annular support surface **16** following an orbital path indicated by arrow **30'** in the counter-clockwise direction about the axis **6** as viewed from the top. Clearly, each of the composite platform discs **7** to **10** is supported at small areas at opposite ends of the bottom periphery of the composite disc and so there is a minimum of heat conduction from the disc to the points of support.

The platform discs **7** to **10** are spaced from each other by their own dimensions as they substantially fill the annulus between the two annular support surfaces **14** and **16** with equal contiguous circles and they are constrained in the orbital path by the rises **19** and **20** on their rotating and stationary races. This orbiting, rotating motion imparted to the substrates, such as semiconductor wafers, on the graphite susceptors insures a uniform temperature thorughout the exposed surface of the substrates and insures an average uniformity in the flow and composition of the reactant gases delivered to the exposed surfaces.

Modifications of the apparatus shown in FIGS. **1** and **2** for tilting the platform discs **7** to **10** relative to the axis of the apparatus so that the discs tilt toward or away from the axis are illustrated in FIGS. **3** and **4.** In FIG. **3,** the housing **32** on base **31** provides an outer annular support surface **33** which is raised above the inner annular support surface **34** defined by the driven race **35** on the support rotor **36.** The dielectric and metal plates **37** and **38** between which the *rf* coil **39** is sandwiched are conical in shape, the cone being upside down, to fit the contour defined by the inward tilt of the discs **7** to **10.** This configuration tends to promote a normal incidence of flow of the ingredients for deposition to the deposition surfaces of the workpieces carried by the discs **7** to **10.**

Another purpose for tilting the discs and workpieces toward the axis is that this configuration lends itself conveniently to heating the substrates by infra-red or other radiation whose source is exterior to a transparent cover of the reaction chamber.

The structure shown in FIG. **4** tilts the discs away from the axis. Here, the housing **40** on the base **41** provides the outer step or race **42** including annular support surface **43** lower than the inner annular support surface **44** on the support rotor **45.** The dielectric and metal plates **46** and **47** with the rf coil **48** in between have conical shapes to conform with the tilted positions of the discs. Here, the conical confirmation of these parts is upright. The purpose for tilting the substrates away from the axis **6** may be to insure that there is no direct or normal projection of the ingredients for the deposition reaction onto the exposed surfaces of the substrates on the disc. Another purpose for tilting the discs and substrates away from the axis **6** is that this configuration lends itself conveniently to heating the workpieces by infra-red or other radiation whose source is exterior to a transparent wall of the reaction chamber. This configuration also increases the frictional forces on each disc at the outer race **42.** The quartz disc in each of the support discs abuts the surface or rise **49** defined by the outer race **42** and since the frictional forces are greater here, at least because of greater contact surface, than at the inner driven annular support surface **44,** each disc is inclined to roll along the race **42** without slipping and so the orbital rate of rotation of the discs in the apparatus is very constant.

The planetary deposition system illustrated in FIGS. **5** and **6** contains two sets of orbiting rotating platform discs for carrying the substrates or workpieces, an axial mechanically driven branched conduit for the vapors and gases supported at the base of the apparatus for carrying the vapors and gases to the reaction space above the substrates and resistance heaters attached to stationary plates beneath the discs for heating the plates so that they in turn heat the discs resting thereon. This apparatus is particularly designed for operation in the temperature range of 300° to 600° C. One common deposition reaction carried out at this temperature range is the reaction of gaseous silane with oxygen to produce a deposited amorphous film of silicon dioxide. In an atmosphere of silane and oxygen at temperatures up to 600° C, ordinary steel can be used and since resistance heaters are used rather than induction heating, the electrical qualitites of the materials used for the various parts are not important. On the other hand, it becomes most important to conduct heat by radiation, conduction, or convection from the races to the discs and so there must be an intimacy between the races and discs such as will accomplish this.

In FIG **6,** the base plate **51** carries the whole structure, the housing **52** and cover **53** serving merely to enclose the structure.

The inner stationary race and heating plate **54** coaxial with the axis **55** of the apparatus is supported from the base by support legs **56.** This part is circular and contains the inner stationary race **57** which defines the first or inner annular support surface **58** for supporting the inner edge of the first set of discs **59** consisting of seven discs in all denoted **60** to **66.** The inner plate **54** carries a ring shaped resistor element **67** beneath on the portion thereof that extends beneath the annular space occupied by the discs **60** to **66,** and so the heater is positioned substantially in registration with that space and is directly below the first set of discs.

The outer stationary race and heating plate **68** concentric with the axis **55** provides the outer stationary race **69** which defines the outer annular support surface **70** for supporting the discs in a second set of discs **71** at their outer edges. This second set includes the discs **72** and **73** shown in cross section in FIG. **6.** The outer plate **68** carries beneath it a resistor heater element **74** substantially in registration with the portion thereof that extends beneath the discs in the set **71** and so the heater element **74** is in registration with the discs in this set. A support for the plate **68** includes legs **75**.

The outer edges of the discs in the set **59** and the inner edges of the discs in the set **71** are supported by the driven race sleeve or cylinder **77**. The driven races **78** and **79** at the end of this sleeve for the disc sets **59** and **71** define the annular support surfaces **80** and **81** for supporting discs in the sets **59** and **71**, respectively. These driven support surfaces, **80** and **81**, are referred to also as the second and third support surfaces and the stationary support surfaces **58** and **70** are referred to also as the first and fourth support surfaces, respectively.

A ring gear **83** attached to the opposite end of the drive cylinder **77** is driven by planetary drive gear **84** at the end of drive shaft **85** from a gear box **86** driven by motor **87**. Drive gear **84** also drives axial gear **88** connected to the lower end of shaft **89** which supports the rotating gas nozzles **90** at the other end of the shaft for conducting vapor or gaseous materials into the reaction or deposition space **91** above the discs. The shaft **89** passes through an opening **92** at the center of the inner plate **54**, this opening being just sufficient to pass the shaft without friction and so limit the escape paths for the dispensed deposition products into the heater space **93** below the race plates.

The vapors and gases for deposition are introduced to the apparatus via tube **94** which passes axially through the drive shaft **89** for the nozzles and empties these ingredients into the nozzle tube **95** in the interaction space. These vapors and gases are injected into the interaction space from the nozzle via orifices **96**.

The rotating nozzle **90** may include two or four or more arms which reach across the sets of discs, each having orifices distributed therealong to insure uniform spraying of the gases and vapors for deposition over the surfaces of the disc. The nozzle and its drive shaft are supported on the inlet pipe **94** by bearings such as **97** and **98** at each end thereof. This pipe provides a clear passage without moving or slipping parts from outside the apparatus to inside the nozzle in the reaction space **91** above the discs and workpieces. The nozzles are rotated mechanically as the driven races **78** and **79** for the inner and outer sets of discs are driven and the arrangement of gears may quite easily be such that the nozzles rotate in the same direction or in the opposite direction to the direction of orbiting of the discs.

With the drive system shown and the planetary drive gear **84** driving in the direction of arrow **99**, the nozzles will rotate in the clockwise direction viewed from the top as indicated by FIG. **5** and the race drive cylinder **77** will drive in the counter-clockwise direction as indicated by arrow **101** in FIG. **5**. This will cause both sets of discs **59** and **71** to orbit in the direction of arrow **101** in the annular spaces in which they are contained. The inner discs **59** will individually rotate counter-clockwise and the discs in the outer sets will rotate clockwise as indicated by direction arrows on the discs in FIG. 5. In this structure, the relative orbiting and rotational directions of the discs in these sets are determined by the driven races at the inside of the outer set and at the outside of the inner set of discs. However, the relative direction or rotation of the nozzles depends upon the drive mechanism arranged by the gears in space **93**.

Each of the platform discs in sets **59** and **71** preferably contains at the bottom thereof a projecting disc-shaped protuberance such as **102** on the disc **60**. This protuberance or projection projects toward the extending portion of the race plate immediately below, but does not touch the extending portion. The only points of contact of the disc with anything but the workpieces remains still the stationary and driven annular support surfaces such as **58** and **80** for the disc **60**. The purpose of the projection **102** is to place as much surface area of the disc immediately adjacent, but not touching, the heated plate **54** as it is feasible so that the heat is carried with reasonable efficiency by convection, conduction, and radiation from the plate into the discs.

In operation of the apparatus shown in FIGS. **5** and **6** electrical power to the heaters is carried via terminals **103** and **104** and cables **105** and **106** to the heaters **67** and **74**. The motor drive drives the sets of discs carrying workpieces which may be wafers of semiconductor such as **107** in orbit and rotation while the driven nozzle dispenses the vapors **108** for deposition in the space **91** immediately above. The effective uniform distribution of heat throughout the discs is insured by the continual movement and rotation of each of the discs and so the wafers carried by the discs are heated uniformly throughout. The vapor and gases for deposition are distributed evenly throughout the space **91** by the distribution of the orifices and the stirring action of the rotating nozzles. This in combination with the heating technique and motion of the discs insures even deposition on the exposed surfaces of the wafers **107**. Since the only contacting moving parts are the friction contacts at the annular support surfaces defined by the stationary and driven races, the effects of deposition on the parts in the reaction space are insignificant. In the heater space and drive area **93** beneath, some deposition occurs on the hotter parts due to gases and vapors leaking into this area. However, the moving parts which are the gears are not heated and so they accrue very little deposition.

Another embodiment of the invention containing two sets of rotating orbiting platform discs and particularly adapted for operation at the lower temperature range of 300° to 600° C is illustrated in FIGS. **7** and **8**. Here, the vapors or gases **109** for deposition are introduced to the reaction space **110** axially through the base and also through a port in the cover. Resistor heater elements are imbedded in the inner and outer stationary heating and race plates and means are provided for clearing vapors and gases from the drive gears in the space **111** beneath the heaters. This structure is constructed to facilitate quick disassembly to clean or replace parts and replace the heaters imbedded in the stationary plates.

All these structures inside the apparatus are mounted to the base plate **112** and enclosed by the cylindrical housing **113** and cover **114**. Some of the reactants for deposition are introduced through two coaxial pipes **115** and **116** extending through the base and sealed thereto and into the reaction space **110** where the reactants are discharged from the pipes. Other vapors or gases may be introduced through port **117** in the cover.

The inner heating and race plate **118** has the inner annular support surface **119** for carrying the inner set of discs **120** at the inner edge of each of the discs such as **121** in the inner set. The outer heating and race plate **122** provides the outer annular support surface **123** for supporting the twelve discs in the outer set **124** at the outer edges of discs in that set such as the disc **125.**

In the relatively narrow annular space between the outer plate **122** and the outside edge of the inner plate **118** is located the drive ring **126** at the end of a thin walled cylinder **127** which extends toward the bottom of the apparatus into the drive space **111.** The top surface **128** of the drive ring **126** provides an annular support surface for both sets of discs. This is also referred to as the driven race. On this surface rest the inner edges of the outer set of discs and the outer edges of the inner set of discs.

The drive mechanism is similar to the drive mechanism in the embodiment shown in FIGS. **5** and **6.** It may include a ring gear **131** attached to the end of cylinder **127** and engaged by a planetary drive gear **132** all held in position by a central sun gear **133** and idling planetary gears **134** suitably placed between the sun gear and the ring gear. At the planetary drive gear **132** and at the planetary idle gears thrust bearings such as thrust bearing **135** are provided against the meshing points of these gears with the ring gear and sun gear and a support pad such as **136** to the base is provided for each. The sun gear **133** may be mounted to a bearing **137** attached to the central pipe **116** which carries deposition ingredients into the apparatus.

A plate **138** which shields the gears from the deposition gases and vapors is located inside the cylinder **127** between the bottom of the inner plate **118** and the gears. This plate is supported by three pedestals such as pedestal **139** mounted to the base **112.** These pedestals **139** also support the inner plate **118** and parts attached thereto. Between the shield plate **138** and gears and carried by this plate is a pipe **140** which conducts an inert purging or cleaning gas into the gear space **111** and discharges the gas through nozzles **141** which direct the gas particularly to the ring gear **131** clearing the teeth of that gear of deposition gases and particles which could tend to clog gears. The inert gas is fed to the ring tube **140** through a flexible tube **142** which goes through the base plate for external access.

The inner and outer heating and race plates **118** and **122** are generally washer-shaped, the inner fitting inside the outer and defining the annular space in between for the drive race ring **126.** To the bottom of each of these plates is attached a plurality of layers of thermally insulating material such as the layers **143** attached to the bottom of the inner plate and layers **144** attached to the bottom of the outer plate which thermally insulate the gear space **111** from the heated plates. These layers are attached to the bottom of the inner and outer plates by bolts such as **145** and **146,** respectively.

The inner and outer plates with their attached layers of insulation are each supported from the base **112** by at least three adjustable support pedestals. The inner plate is supported by adjustable pedestals such as **139** and the outer plate is supported by adjustable support pedestals **147.** In addition, the inner supports **139** carry the shielding plate **138.** Otherwise the support pedestals **139** and **147** are identical.

Each support pedestal such as **147,** consists of a pillar **148** attached to the base **112.** A support rod **149** screws into the pillar and is locked thereto by lock nut **151.** The rod **149** extends into the bottom end of a hole **152** bored through the layers of insulator **143** and the plate **122** emerging from the top of the plate beneath the outer set of discs. This bored hole provides a substantial clearance for the rod **149** to allow for lateral thermal expansion of the various parts during operation. The portion of the hole bored in the plate **122** is tapped and a leveling set screw **155** screws into this and abuts the end **156** of the rod. With three such support points provided for each of the inner and outer plates, the plates can be quickly leveled by merely removing the cover **114** and a few of the discs to gain access to the screws **155** and then turning these screws from above to level the plates.

The axial position of the shielding plate **138** carrying the ring tube for discharging cleaning gas is less critical, however, this can be adjusted by adjusting the nut **157** on the support pedestals **139.**

Heating elements are contained in holes bored in the inner and outer heating and race plates. These holes are bored through each plate parallel to the plane of the plate and located so that they do not cross the taps for the bolts **145** or **146** and do not cross the holes such as **152** bored for the support pedestals. Three heating element bored holes such as holes **161** to **163** are provided in the inner plate **118** and four holes **164** to **167** are provided in the outer plate **122.** The heating elements denoted generally **168** are loaded in these holes and may be electrical cartridge heaters each made to the length of the hole in which it is located. The cartridge heating elements may connect in electrical series or in parallel by wires which are not shown and which emerge through the base plate for coupling to an electrical power source. The leads to the elements are preferably sufficiently long that the inner and outer heating and race plates can be lifted from their support posts sufficiently so that the heating elements can be individually removed from the plates and replaced when necessary. The disconnection of the lead wires to these elements and reconnection of the wires to the replacement elements can all be done while the plates are lifted vertically from the apparatus. Thereafter, the plates are simply returned to the support pedestals. Once the plates are correctly adjusted, the levelling set screws such as screw **155** generally need no further attention but may be readjusted as necessary to bring the plates into the proper level aspect.

Numerous embodiments of the invention are described herein each incorporating certain features of the invention whereby certain advantages for relatively high and low temperature deposition operation are gained. These embodiments are intended to represent the best known uses of the invention. The various structural features described herein with relationship to the different embodiments may be combined in somewhat different manners from described herein and some modifications and variations may be made to these within the state of the art without deviating from the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. In apparatus for use in uniformly treating the surfaces of separate workpieces, a plurality of separate platform discs for carrying the workpieces in a treating area and means in combination therewith comprising,

first and second parts on a common axis for providing first and second spaced concentric support surfaces, respectively, for the disc,

each disc being large enough to span the space between said support surfaces and rest at the bottom periphery of the disc at opposite points thereof on the first and second surfaces, and

means for driving one of said disc support surfaces in rotation about the common axis relative to the other support surface,

whereby the discs move in an orbit about the common axis and each disc rotates on its own axis in the treating area

two sets of said platform discs being provided, an inner set and an outer set,

the inner set resting on the first and second disc support surfaces,

a third disc support surface for the outer set of discs on said second part,

a fourth disc support surface for the outer set of discs on a third part concentric with the first and second parts, and

drive means coupled to said second part for producing a relative rotational motion about the common axis of the second part, relative to the first and third parts,

whereby the inner set of discs moves in one orbit about the common axis, the outer set of discs moves in a large orbit about the common axis and each disc in both sets rotates on its own axis.

2. Apparatus as in claim **1** wherein,

the first and third parts are stationary and the second part is driven in rotation.

3. Apparatus as in claim **2** wherein,

the first and third parts are annular plates the outside diameter of the first plate being less than the inside diameter of the third plate and defining an annular space in between in which the second part is located,

the first annular support surface is substantially at the inner edge of the first plate, and

the fourth annular support surface is substantially at the outer edge of the third plate,

whereby a substantial area of the first and third parts are adjacent the bottoms of the discs in the first and second sets, respectively.

4. Apparatus as in claim **3** wherein,

the second part is attached to the end of a cylinder concentric with the common axis, and

the drive means connects to the other end of the cylinder.

5. Apparatus as in claim **15** wherein, the apparatus is in a housing, means are provided for introducing a vapor into the housing for treating the workpieces.

6. Apparatus as in claim **1** and further including,

electrical heater elements contiguous with the first and third parts for applying heat thereto.

7. Apparatus as in claim **1** wherein,

the discs are composed of a material relatively highly susceptible to predetermined radiation,

means are provided for directing said radiation to the discs to heat the discs, and

the first and second parts are made of a material not relatively highly susceptible to the radiation.

8. Apparatus as in claim **6** wherein,

the discs are of high purity iron.

9. Apparatus as in claim **7** wherein,

the radiation is rf radiation, and

the discs are composed at least partially of graphite.

* * * * *

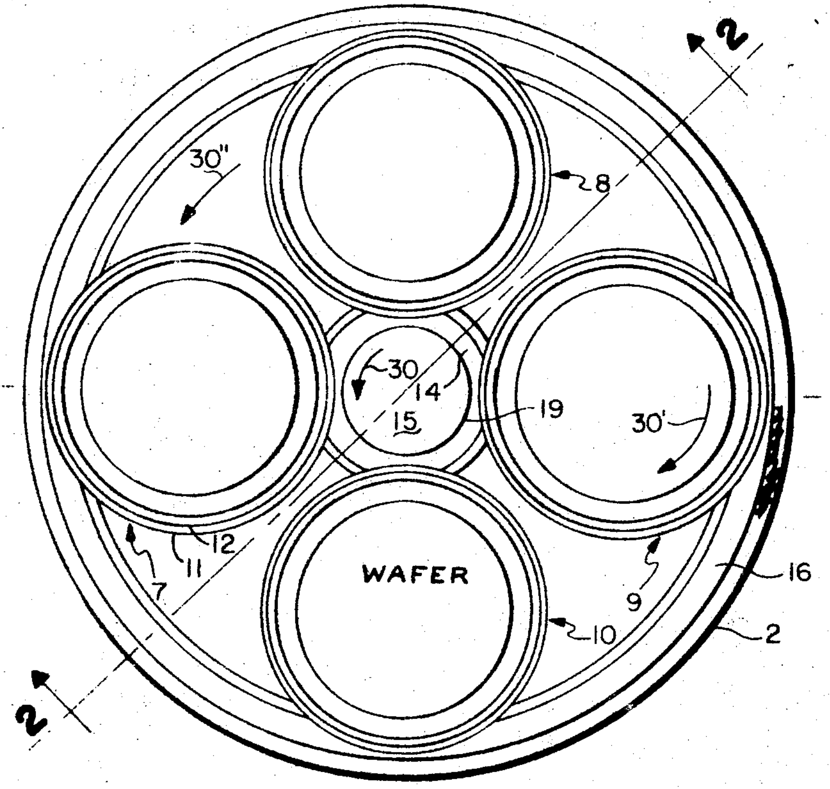
UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,783,822 Dated January 8, 1974

Inventor(s) John S. Wollam

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Drawing on page 1 and Fig. 1, should appear as shown below:



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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,783,822 Dated January 8, 1974

Inventor(s) John S. Wollam Page - 2

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Figure 6, should appear as shown below:

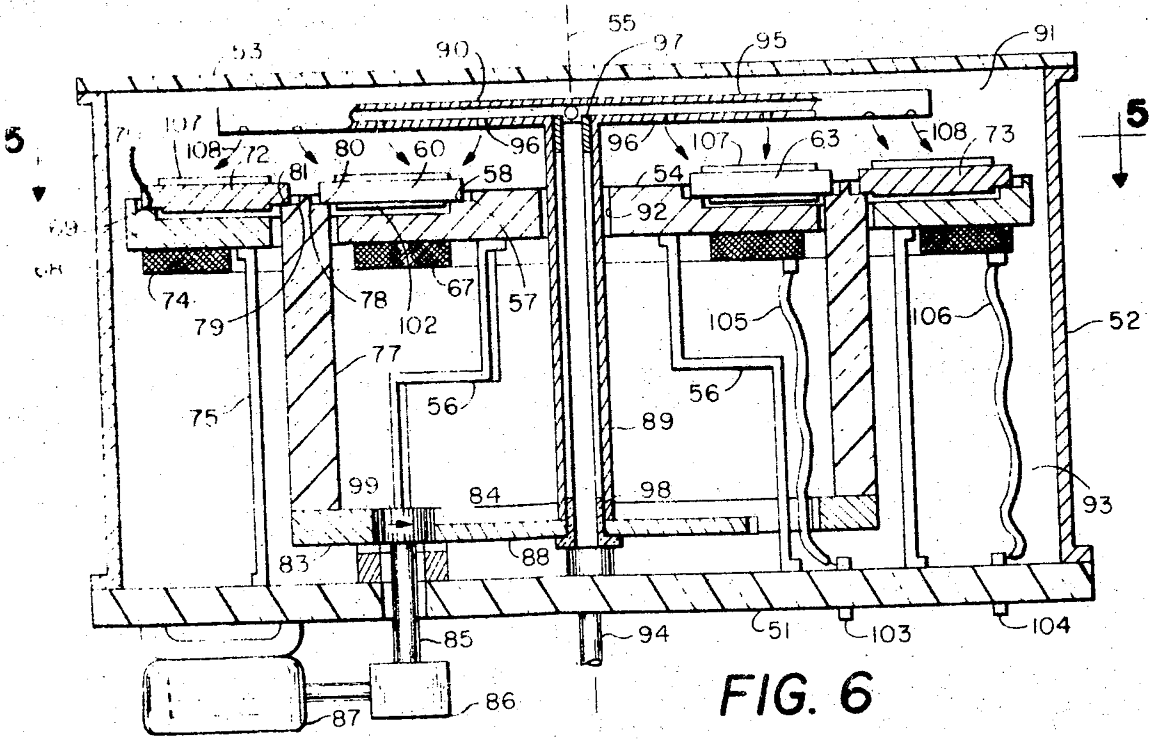

FIG. 6

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,783,822 Dated January 8, 1974

Inventor(s) John S. Wollam Page - 3 -

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Figure 7, should appear as shown below:

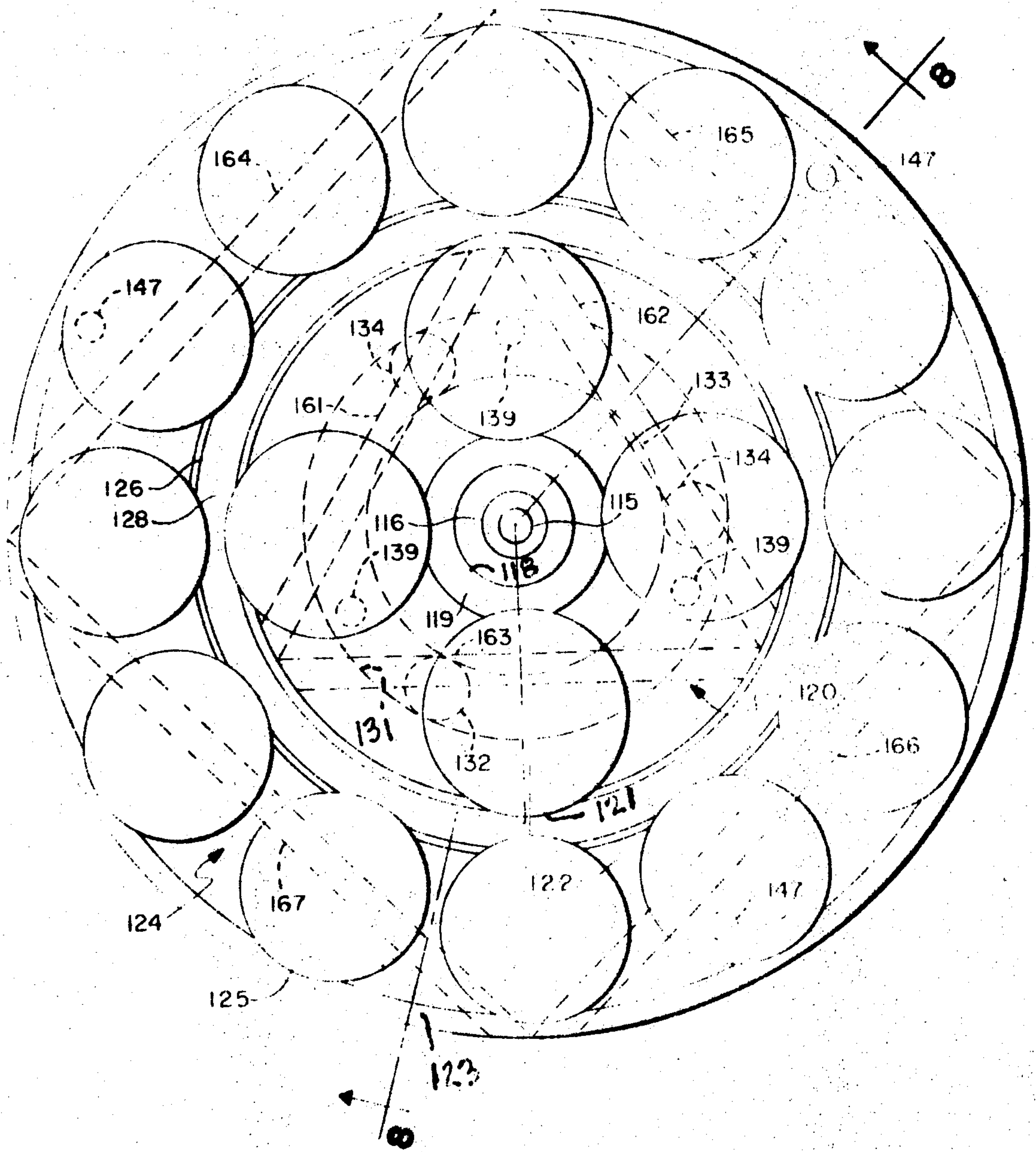

FIG. 7

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,783,822 Dated January 8, 1974

Inventor(s) John S. Wollam Page - 4 -

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the cover sheet item [76] "Atcott" should read -- Alcott --. Column 1, line 59, "frequency" should read -- frequent --. Column 4, line 20, "discs" should read -- disc --; line 54, "hand" should read -- hard --. Column 5, line 23, "30′" should read -- 30″ --; line 26, "ends" should read -- sides --. Column 6, line 13, "firctional" should read -- frictional --; line 39, "qualites" should read -- qualities --; line 2, "confirmation" should read -- conformation --. Column 7, line 53, after "by" insert -- arrow 100 in --; line "or" should read -- of --. Column 8, line 12, delete "it". Column 10, claim 1, line 66, "disc" should read -- discs --. Column 11, claim 1, line 8, after "area" insert -- , --; claim 1 , line 24, "large" should read -- larger --; claim 3, line 3 delete the first occurrence of "in"; same line, after "between insert -- , --. Column 12, claim 3, line 2, "annular" should read -- disc --; claim 3, line 6, "parts" should read -- plate --; claim 3, line 7, after "adjacent" insert -- to --;

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,783,822 Dated January 8, 1974

Inventor(s) John S. Wollam Page - 5 -

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Claim 5, line 14, "15" should read -- 4 --; claim 5, line 15, after "housing," insert -- and --.

Signed and sealed this 7th day of January 1975.

(SEAL)
Attest:

McCOY M. GIBSON JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents