

Sept. 5, 1967

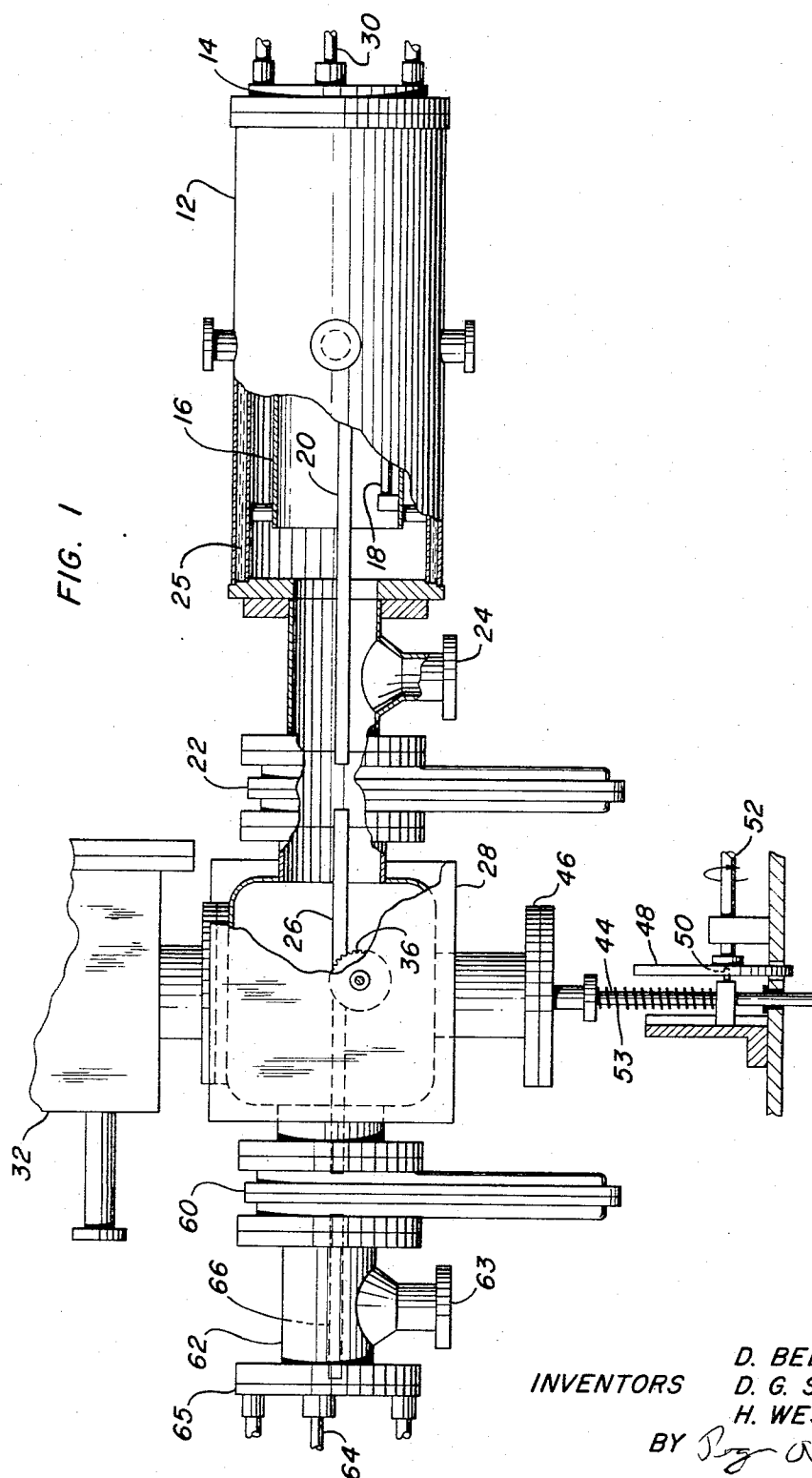
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3,340,176

VACUUM PROCESSING MACHINE

Filed July 28, 1965

5 Sheets-Sheet 1



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Sept. 5, 1967

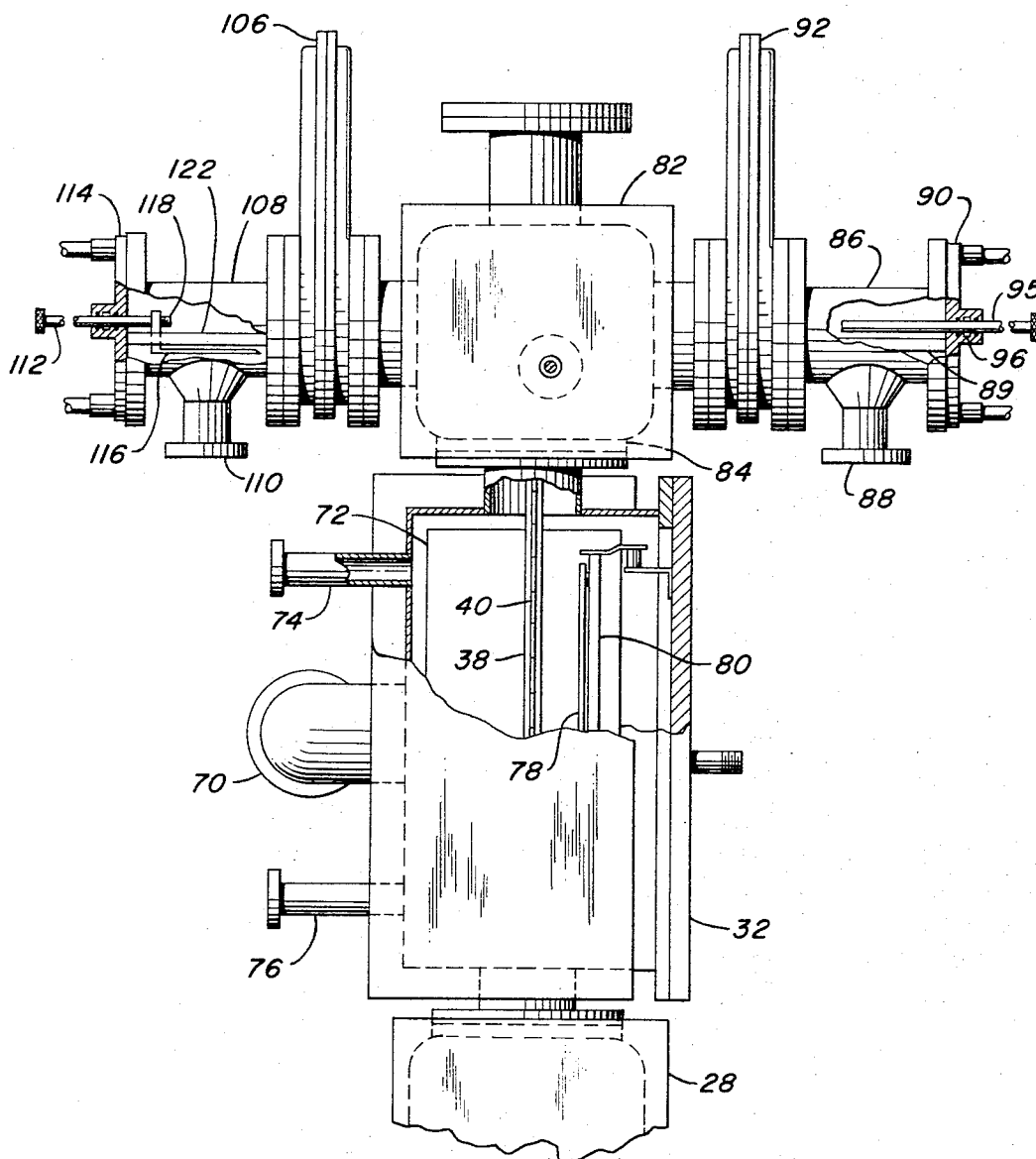
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FIG. 2



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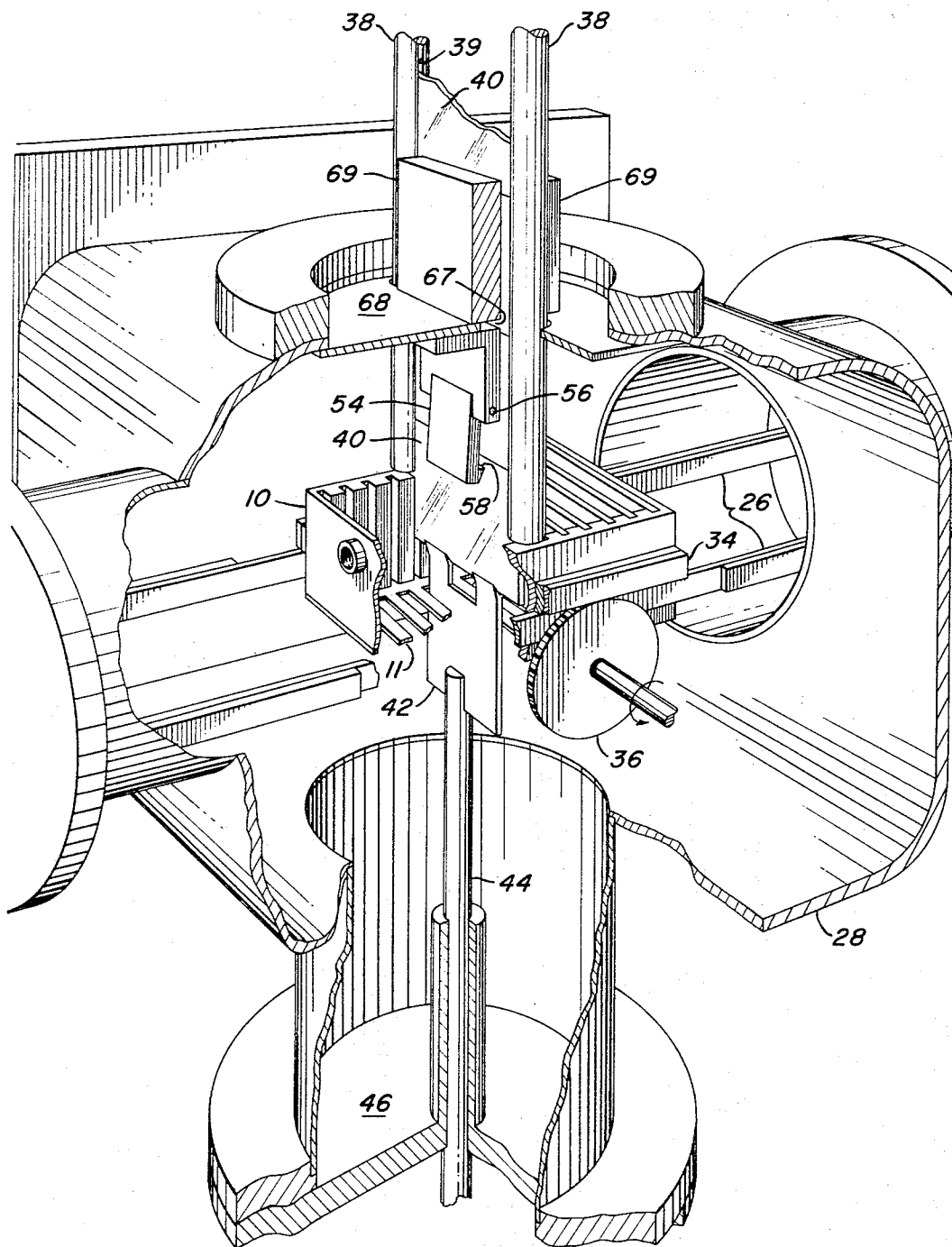
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VACUUM PROCESSING MACHINE

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FIG. 3



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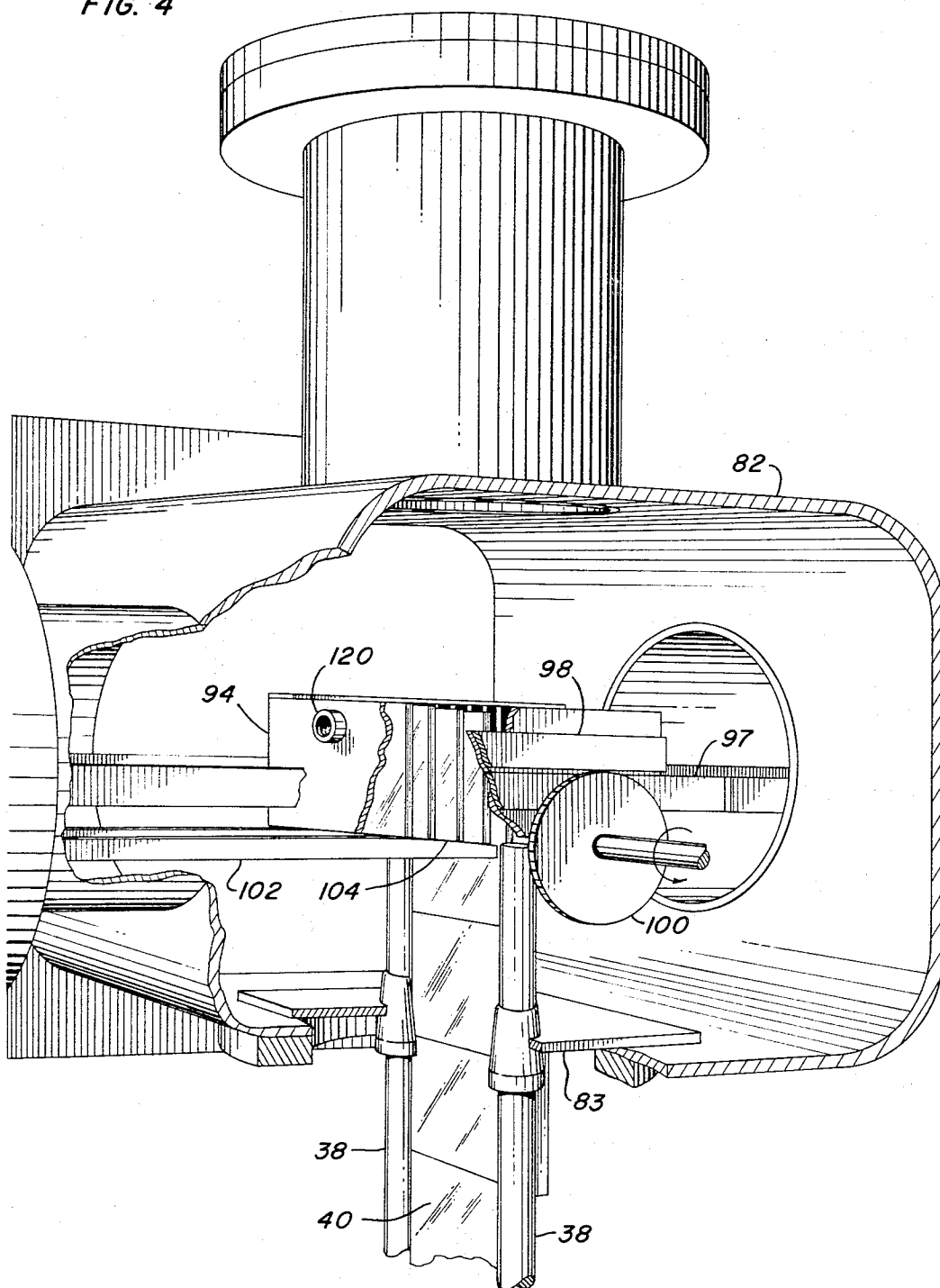
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FIG. 4



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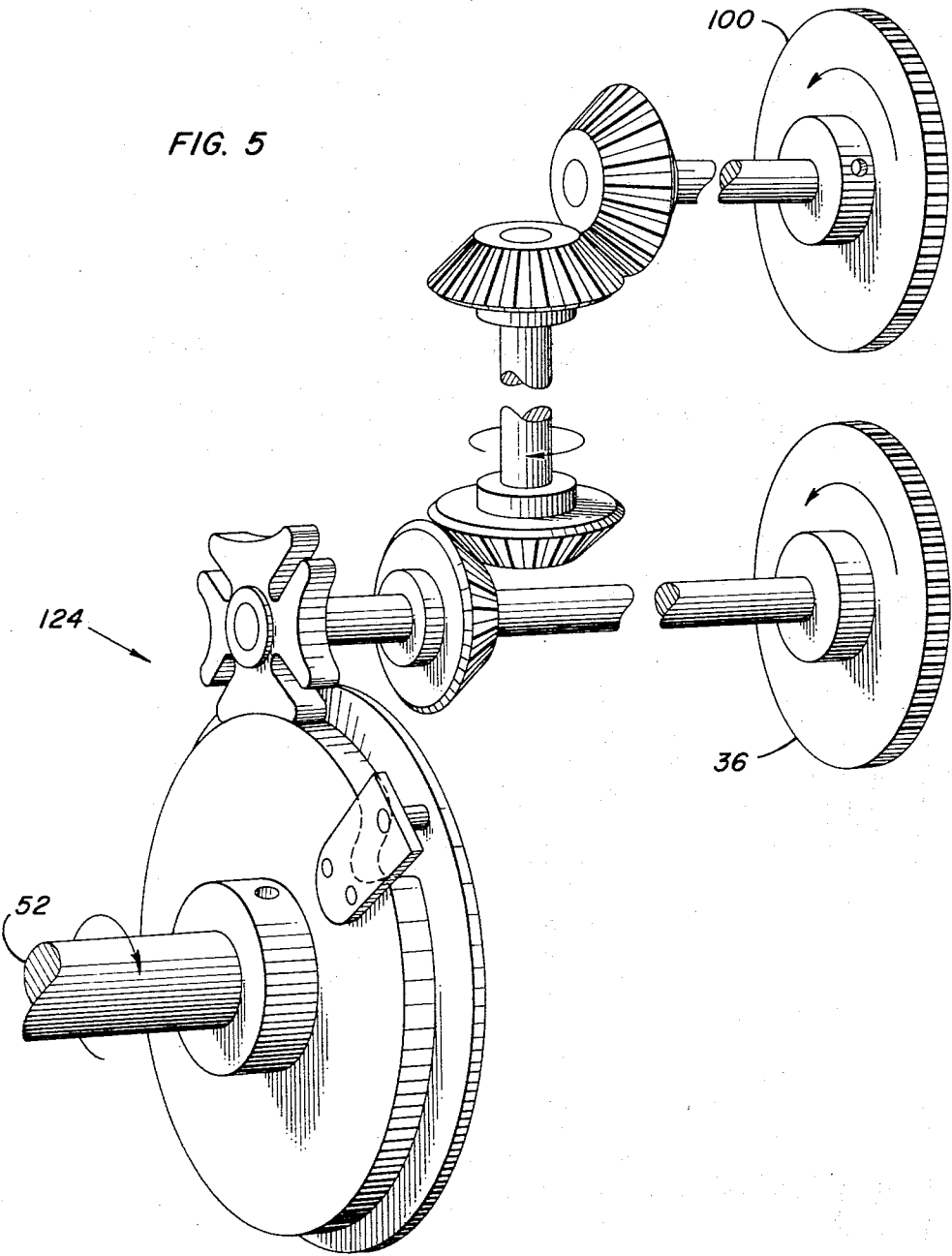
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VACUUM PROCESSING MACHINE

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FIG. 5



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VACUUM PROCESSING MACHINE

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Filed July 28, 1965, Ser. No. 475,529

10 Claims. (Cl. 204—298)

ABSTRACT OF THE DISCLOSURE

Apparatus for subjecting articles to a treatment, such as sputtering, in a controlled environment chamber. Magazines containing the articles to be processed are introduced into the entrance end of the chamber from the ambient atmosphere through means, such as an air lock, which prevents the ambient atmosphere from adversely affecting the chamber environment. The articles are removed individually from the magazines, fed through the chamber wherein they are treated and then loaded into magazines at the exit end of the chamber. The latter magazines, after loading thereof, are discharged from the chamber into the ambient atmosphere through means, such as an air lock, which prevents the ambient atmosphere from adversely affecting the chamber environment.

This invention relates to the transmission of articles through a processing chamber in substantially continuous fashion. More particularly, this invention is directed to conveying articles from the ambient atmosphere through a treating environment and back into the ambient atmosphere.

While not limited thereto, this invention has particular utility in the preparation of thin films of conductive, semiconductive or insulating materials which may be converted into thin-film devices and circuits. Due, among other reasons, to their ease of manufacture, volumetric efficiency and reliability, thin-film devices and circuits are attracting wide interest in the electronics and communications industries. In order to minimize the cost of fabrication of thin-film electronics, it is desirable to form the devices and circuitry from standard stock consisting of one or more films of conductive, semiconductive or insulating materials deposited on a non-conductive substrate. For a discussion of the various processing steps which are associated with the conversion of thin films into capacitors and resistors, reference may be had to U.S. Patents 2,993,266 to R. W. Berry and 3,148,129 to Basseches et al., respectively.

As is well known and as is shown by the above-mentioned Berry patent, thin films are commonly formed by vapor deposition or cathodic sputtering. These processes must be performed in an evacuated chamber. While vacuum deposition can be successfully carried on in batch-type operations in apparatus such as a bell jar, thin-film electronics becomes economically practicable only when the films are formed on the substrates in substantially continuous fashion.

Apparatus is presently available which will convey articles to be treated or coated through a treating environment, such as an evacuated chamber, in continuous fashion. For example, it has long been the practice in the electron tube industry to transmit the unsealed devices through a vacuum furnace prior to sealing so as to "bake out" deleterious materials. However, it must be noted that these prior art vacuum furnaces universally employ some form of container in which the articles to be treated are disposed. For many applications, and especially in the formation of thin films, it has been found desirable to

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dispense with such reusable containers. Thin films, and particularly those of the refractory or film-forming metals and the semiconductor materials, have been found to be highly susceptible to contamination by any impurities present in the deposition chamber. Reusable containers for conveying articles to be coated into the processing chamber are, of course, potentially vehicles for transmitting such impurities into the deposition chamber.

The present invention permits the transmittal of articles through a treating environment in substantially continuous fashion and obviates the need for containers or holders for said articles during such transmittal.

It is therefore an object of this invention to transmit articles through a treating environment.

It is another object of this invention to transmit articles through a processing chamber in substantially continuous fashion.

It is also an object of this invention to transmit articles through a treating environment independently of any carriers.

It is yet another object of this invention to transmit articles through a processing chamber in which a low pressure is maintained in substantially continuous fashion and independent of any article carriers.

It is another object of this invention to minimize the transmission of contaminants in to a processing chamber.

These and other objects of this invention are accomplished by apparatus which includes a chamber in which a controlled environment may be maintained. A first magazine, containing a plurality of articles, is fed from the ambient atmosphere into the chamber in a manner such that the ambient atmosphere is prevented from adversely affecting the chamber environment. The articles are then individually removed from the magazine, fed single file through the chamber and then loaded individually into a second magazine, which is discharged from the chamber into the ambient atmosphere in essentially the same manner as the first magazine was fed into the chamber. The operation is substantially continuous since succeeding groups of articles may be waiting their turn at the entrance to the chamber as the first group is passed individually therethrough.

This invention may be better understood and its numerous advantages will be apparent to those skilled in the art by reference to the accompanying drawings wherein like reference numerals refer to like elements in the various figures and in which:

FIGURE 1 is a partially cut-away side view of the entrance or receiving portion of a specific embodiment of this invention,

FIGURE 2 is a partially cut-away side view of the processing chamber and exit portions of the specific embodiment of this invention being described; FIGURES 1 and 2 together being an overall side view of said specific embodiment,

FIGURE 3 is an enlarged, partially cut-away side view of a portion of the apparatus of FIGURE 1 depicting means for converting group to individual movement of the articles to be processed,

FIGURE 4 is an enlarged, partially cut-away side view of a portion of the apparatus of FIGURE 2 depicting means for removing groups of processed articles from the apparatus, and

FIGURE 5 is a partial view of the means for synchronously driving the various moving parts depicted in FIGURES 1-4.

The specific embodiment of this invention shown in the drawing will be explained below in connection with the deposition of a thin film of sputterable material on a nonconductive substrate in an evacuated container. However, it is to be understood that the invention has far

wider utility and may be employed either with or without minor modification to perform various other functions. Basically, the specific embodiment of the invention to be described encompasses an entrance air lock into which magazines loaded with articles to be treated may be placed. After evacuation of the air lock and baking to drive off impurities, the magazines are transmitted into a feed chamber wherein they are indexed in relation to a pair of stationary tracks. After each step of movement of a magazine, an article is removed therefrom and transmitted onto said tracks. The tracks lead through a processing chamber and terminate in a receiving chamber wherein empty magazines are similarly indexed relative to the tracks so as to receive the processed articles. It thus will be readily apparent that the tracks are ultimately filled with articles to be processed abutting one against another. As each new article is fed onto the tracks a processed article is urged out of the tracks and into a receiving magazine. When the receiving magazine has been filled, it is transmitted into an exit air lock and thence out of the apparatus. From the foregoing, it may be seen that the apparatus of this invention encompasses a feed section, a processing section and an article removal section.

Referring now to FIGURES 1 and 3, the feed section which encompasses means for delivering loaded magazines to the feed chamber is shown. The magazines, an example of which is shown at 10 in FIGURE 3, comprise rectangular shaped, metal containers having oppositely disposed slots in their side walls. These slots are machined so as to accept the articles 40, square or rectangular glass or ceramic slides in the case of the embodiment being described, to be processed. Each magazine 10 has a slotted bottom 11, the solid edge portions of which cover the bottom of the sidewall slots to prevent the articles from dropping through the magazine. The function of the bottom slots will be described below. After being loaded with unprocessed articles, the magazines 10 are placed in an air lock, generally indicated at 12, through an entrance door 14 which, when closed, provides a vacuum tight seal.

As best seen in FIGURE 1, positioned within the air lock is an oven 16 having a plurality of heat lamps 18, only one of which is shown, disposed therein. Also disposed in the oven 16 are a pair of rails 20. The rails 20, which are adapted to receive loaded magazines 10, extend from the oven 16 to a position just short of a valve 22. The valve 22 seals off the air lock from the rest of the apparatus until such time as the air lock chamber has been completely evacuated. Such evacuation is accomplished by a pump, not shown, connected to a flange 24. It should be noted that, in order to prevent overheating and possible warping of the air lock chamber, the outer walls thereof are provided with passages for a cooling fluid 25 which may be circulated by means, not shown, well known in the art.

After complete evacuation of the air lock 12, the valve 22 is opened and the magazine 10 is driven across the gap in the supporting rails and onto the rails 26 in the feed chamber 28. It should be noted that the purpose of the gap between the rails 20 and the rails 26 is to enable operation of the valve 22. As will be described below in greater detail, in the explanation of FIGURE 4, the means for driving the magazine out of the air lock comprises, in its least complicated form, a push rod 30. The rod 30 extends through the end door 14 of the chamber 12 and is capable of movement in a direction parallel to the rails 20.

The feed chamber 28 is continuously evacuated by a pump connected to a flange, both of which are not shown, extending from the back of the chamber. Communication with a processing chamber, indicated generally at 32, is provided through one side of the chamber 28. In the embodiment being described, communication between these chambers is provided through the top of chamber

28. However, it is to be understood that FIGURES 1 and 2, which are being described as side views, could equally well depict top views of the apparatus. The magazine 10 enters the chamber 28 on rails 26, and a rack 34 (FIGURE 3) on each magazine is engaged by a gear 36. The gear 36, as will be explained below in connection with the discussion of FIGURE 5, is driven by a conventional Geneva mechanism and accordingly drives magazine 10 in a stepwise fashion. Thus, the magazine is indexed beneath a pair of vertically oriented tracks 38.

The tracks 38 have slots 39 therein adapted to receive the articles 40 to be processed. In the embodiment being described, the articles 40 comprise square or rectangular shaped glass or ceramic wafers suitable for use as substrates for thin-film devices or circuits. The articles 40 are pushed out of the magazine 10 by a blade 42 having a pair of spaced Y shaped projections thereon. The blade 42, which fits through the slots in the bottom 11 of the magazine 10, is driven by a push rod 44 which extends through the bottom 46 of the chamber 28. Standard vacuum seal means, not shown, are provided to prevent a leakage of environmental gas into the chamber 28 about the push rod 44.

As may be seen from FIGURE 1, the portion of the rod 44 which extends out of chamber 28 is driven upwardly by a cam 48 which contacts a cam follower 50 extending through the rod 44. The cam 48 is driven by a shaft 52 which, in turn, is driven from the same source which supplies the motive power to gear 36. Thus, movement of the magazine 10 and the push rod 44 are synchronized so that the push rod 44 is fully retracted during periods that the magazine is being indexed. A spring 53, compressed by upward movement of the push rod 44, is provided to cause rapid retraction of the push rod as soon as it has pushed each article 40 completely out of the magazine. At the limit of upward movement, the cam follower 50 falls off the high point of the cam and the spring 53 drives rod 44 downwardly. The sequence of operations is: (1) indexing of a magazine 10 followed by, (2) a slow upward movement of the push rod 44, then (3) a rapid retraction of the push rod. The feed operation then begins to repeat by indexing of the magazine 10 to a second position. By operating in the abovescribed manner, a column of articles 40 is caused to move up the tracks 38 in substantially continuous fashion. There are, of course, slight pauses in this upward motion during which the push rod retracts and the magazine indexes so that a new article can be fed into tracks 38.

After the articles 40 have been pushed out of the magazine 10, it is necessary to prevent their falling back into the magazine when the rod 44 retracts. For this purpose there is provided a latch 54 (FIGURE 3) mounted so as to pivot about a pin 56. The latch 54 has a shoulder 58 formed thereon. Because of its weight and balance, the latch 54 tends to swing forward so that the shoulder 58 will be underneath the column of articles. An article 40 being pushed upwardly by member 42 causes the latch 54 to pivot about the pin 56 and thus move out of the way. However, when the article 40 passes above the shoulder 58, the latch 54 pivots forward into the space between the Y shaped projections on the blade 42. Accordingly, when the push rod 44 retracts, the column of articles will drop only slightly until it rests upon the shoulder 58 of the latch 54. The operation is then repeated with the next article camming the latch 54 back out of the way and pushing the entire column of articles upwardly.

Referring to FIGURE 1, after a magazine 10 has been emptied, it is engaged by means, not shown, and pulled along the rails 26 through a valve 60 into an exit air lock chamber 62. The chamber 62 is evacuable by a pump, not shown, connected to a flange 63. The means for drawing an empty magazine into the chamber 62 may take various forms. In its simplest configuration, this means may comprise merely a push rod 64 having means thereon such as

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a magnet which will exert a force on the empty magazine. The rod 64 extends through an exit door 65 of the air lock 62 and is longitudinally movable relative to a set of rails 66 which are similar to and aligned with the rails 26 in the chamber 28. An alternate means for drawing empty magazines into chamber 62 will be discussed below in connection with the removal of processed articles from the apparatus.

In many cases it is desired to maintain a gaseous environment in the processing chamber. For example, when a coating is to be cathodically sputtered onto the articles passing through the processing chamber, it is necessary to create a low-pressure inert gas atmosphere in the processing chamber while a higher degree of vacuum is maintained in the feed chamber. In order that sputtering may be maintained, the gas flow out of the processing chamber must be limited. For this reason, referring again to FIGURE 3, in leaving the chamber 28, the articles pass through a shaped opening 67 in the top 68 of the feed chamber 28. A pair of blocks 69, 69 extend from the top 68 of the chamber 28 into the processing region defined by the chamber 32. The opening 68 and the blocks 69, 69 are machined so as to closely fit the articles to be processed. The opening 68 and the blocks 69, 69 thus form a controlled leak which minimizes the flow of treatment gas out of the chamber 32 and into the feed chamber 28.

Referring now to FIGURE 2, the articles 40 which leave the chamber 28 proceed upwardly through the processing chamber 32. The desired degree of vacuum is maintained in the chamber 32 by a vacuum pump, not shown, connected to a flange 70. In the usual instance, an open-ended chamber 72 is supported within the chamber 32 by means, not shown. The desired atmosphere, for example a trace of argon or nitrogen, may be created within the chamber 32 by furnishing gas through conduits 74 and 76. In the case where a film of sputterable material is to be formed on the articles while they are within the chamber 32, a cathode 78 of the film forming material is supported within and insulated from the chamber 72. In a manner well known in the art, a potential is applied between the cathode 78 and the chamber 72. To insure that the cathode material will be sputtered generally in the direction of the column of articles, an electrically grounded shield plate 80 is positioned behind the cathode 78 and insulated therefrom. It should be noted that the inner chamber 72 may actually be a plurality of series-connected chambers in which case the outer chamber 32 will be maintained at a higher vacuum. Thus, the outer chamber 32 may serve as a guard vacuum to prevent cross migration of gas molecules between the treatment chambers and gas migration between the treatment chambers and the feed and removal regions.

As can be seen from FIGURES 2 and 4, after processing, the articles leave the chamber 32 and enter a chamber 82 through a controlled leak similar to that through which they entered the chamber 32. This leak extends downwardly from the bottom 84 of the chamber 82. The chamber 82 is continuously evacuated by a pump, not shown, connected to a flange on the back of the chamber. In the chamber 82, the processed articles are loaded into magazines in a manner to be described below. The empty magazines are transmitted to the chamber 82 through an air lock chamber 86 (FIGURE 2) which may be evacuated by a pump, not shown, connected to a flange 88. Empty magazines are placed on a pair of rails 89 in air lock chamber 86 by opening a door 90 on the end thereof. During periods when empty magazines are being loaded into the air lock chamber 86, the chamber is sealed off from the rest of the apparatus by a valve 92. The chamber 86 subsequently is evacuated.

Upon the opening of valve 92, after evacuation of chamber 86, an empty magazine, such as is shown at 94 (FIGURE 4), will be driven into the chamber 82. The driving means may take several forms and, in its most

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basic configuration, consists merely of a push rod 95 which extends through the door 90 and is movable parallel to the longitudinal axis of the chamber 86. Leakage of environmental gas into the chamber 86 about the rod 95 is prevented by sealing means 96 of a type known in the art. The push rod 95 may be identical to the push rod 30 (FIGURE 1) for urging the loaded magazines from the chamber 12 into the chamber 28. As seen in FIGURE 4, the magazine 94 will bridge the gap in the supporting rails at the valve 92 and will be urged along a set of rails 97 in the chamber 82 to a point where the rack 98 thereon is engaged by a drive gear 100. The gear 100 is driven from the same source which drives the gear 36 in chamber 28; accordingly, the magazines 94 are indexed in synchronism with the feed magazines 10 and the push rod 44 so that the magazine 94 presents an empty slot at the end of tracks 38 during each short interval that the processed articles are not moving upward.

Since the magazine 94 which receives the processed articles is inverted, means must be provided to prevent the articles from falling out of the slots in the magazine once they are indexed past the end of the tracks 38. To accomplish this, a shelf 102 having a tapered end portion 104 is provided. The tapered portion 104 terminates between the tracks 38 and adjacent the plane defined by the slots therein. The upward movement of the column of articles produced by the push rod 44 causes each article to be driven well up into a slot in the magazine 94. When the magazine 94 is indexed to a new position, the articles will drop down onto the tapered portion 104 of the shelf 102 and then will ride along the shelf 102 which cams them back up into the magazine.

When receiving magazine 94 is filled, another is caused to take its place and the loaded magazine will be drawn through a valve 106 (FIGURE 2) into an exit air lock chamber 108. The chamber 108 is evacuated by a pump, not shown, connected to a flange 110. The means for propelling the loaded magazines into a chamber 108 comprises a push rod 112 which extends through a door 114 of the chamber 108. Mounted on the rod 112 is a shovel 116 which extends past the end of the rod a distance equal to the length of a magazine. The rod 112 is both movable longitudinally of the chamber 108 and rotatable. Means, not shown, are provided to permit the rod 112 to rotate independently of the shovel 116. When a loaded magazine is to be withdrawn from the chamber 82, the rod 112 is urged forward through the valve 106 until it contacts the end of the magazine. At this time, the shovel 116 will have entered a slot provided in shelf 102 and will abut the bottoms of the articles in the magazine. Rod 112 is then rotated such that the threaded end 118 thereof engages a complementary threaded projection 120 on the end of the magazine (FIGURE 4). The magazine is then withdrawn through valve 106 and onto rails 122 in the chamber 108. The shovel 116 prevents the articles from falling out of the inverted magazine when it bridges the gap in the tracks at the valve 106 and while in the chamber 108. It should be observed that this same type of mechanism, a rotatable, threaded push rod, less a shovel attachment, may be employed to withdraw empty magazines from the feed chamber 28.

Referring briefly to FIGURE 5, the gearing arrangement for synchronizing magazine driving gears 36 and 100 and push rod 44, and for driving gears 36 and 100 in stepwise fashion, is shown as a Geneva mechanism, indicated generally at 124. This mechanism is connected to shaft 52, as is cam 48 which operates push rod 44, and is driven by a motor, not shown.

Operation

In operation, referring to FIGURE 1, the feed chambers 28 and 82 and the processing chamber 32 are continuously evacuated. With the valve 22 closed, the door 14 on the chamber 12 is opened and a magazine 10 loaded

with uncoated glass or ceramic substrate wafers is inserted therein. The door 14 is then closed and sealed, and the chamber 12 is evacuated by the pump attached to the flange 24. After evacuation, the lamps 18 are turned on to "bake out" impurities from the chamber 10 and its contents. After a suitable "bake out" time, the valve 22 is opened and the loaded magazine 10 is driven forward by the push rod 30 until it is engaged by the gear 36. The valve 22 is then closed and the vacuum in the chamber 12 broken so that a new magazine loaded with uncoated wafers may be placed therein. It should be noted that the time for pumping down and baking out the chamber 12 is considerably less than that necessary to unload a magazine in chamber 28 and thus there will always be a loaded magazine ready to begin feeding the articles 40 onto the tracks 38 (FIGURE 3). It should also be noted that while operation of the invention is being disclosed in relation to single magazines, each of the chambers may be made large enough to accommodate several magazines.

Referring to FIGURE 3, in chamber 28, the articles 40 are urged out of the magazines and into the slots in the rails 38. The articles 40 thus proceed upward through the processing chamber 32 wherein they typically will receive coatings of one or more materials. Again, it should be observed that, while in the specific embodiment being described, the chamber 32 is adapted for coating the articles passing therethrough by sputtering from a single cathode, the chamber 32 could in fact have a plurality of cathodes of different materials therein or alternatively could consist of a plurality of series-connected sputtering chambers. During unloading of the magazines, the valve 60 (FIGURE 1) may either be opened or closed, as desired, and the chamber 62 is evacuated by the pump (not shown) attached to the flange 63. When a magazine has been emptied, it is drawn into the chamber 62 by the rod 64, the valve 60 is closed, the pump valved off, the vacuum broken by opening the door 65 and the empty magazine removed. The door 65 is then reclosed and sealed and the chamber 62 again evacuated so as to be prepared to accept the next unloaded magazine. As with the chamber 12, the time required to pass a magazine through and reevacuate the exit chamber 62 is much less than that required for unloading the magazine in the chamber 28 and thus the chamber 62 is always ready to accept the unloaded magazines as soon as the last article is removed therefrom.

Simultaneous with the above-described operations, an empty magazine is placed in the chamber 86 (FIGURE 2) and the chamber is evacuated. In the initial start-up of the apparatus, the empty magazine is retained in the chamber 86 until the track 38 is entirely filled with articles at which time the valve 92 is opened and the magazine urged forward by the push rod 95 to the point where it is engaged by the gear 100. The valve 92 is then closed and an additional empty magazine placed in the chamber 86 via the door 90. As with the chambers 12 and 62, the pump down time for the chamber 86 is relatively short so that there will be no delay between the time that the first magazine is completely loaded and the second magazine is engaged by the gear 100.

The magazines loaded in the chamber 82 are drawn, by the rod 112, through the valve 106 and into the exit air lock chamber 108 wherein they are removed in essentially the same manner as the empty magazines are taken from the chamber 62. However, in removing magazines from the chamber 108, since the magazines are inverted, care must be taken to prevent the articles from falling from the magazines.

While a specific embodiment thereof has been disclosed, it should be obvious that various modifications and substitutions may be made without departing from the spirit and scope of this invention. For example, while the ap-

paratus disclosed has been discussed in terms of forming coatings on articles, the chamber 32 could be the evacuated work chamber of a device which generates and utilizes a beam of charged particles for cutting, machining, welding, irradiating or injecting impurities into materials. Also, as noted above, while the change in direction imparted to the articles being processed has been disclosed as from the horizontal to the vertical, such change could, for example, be an east-west to north-south change in the same horizontal plane. Accordingly, it is to be understood that this invention has been described by way of illustration rather than limitation.

What is claimed is:

1. Apparatus for treating articles, which comprises:

a chamber in which a controlled environment may be maintained;

means for feeding first magazines, each containing a plurality of articles, from the ambient atmosphere into the chamber in a manner such that the ambient atmosphere is prevented from adversely affecting the environment within the chamber;

means in the chamber for treating the articles;

means for individually removing articles from the first magazines, feeding them through the chamber wherein they are treated and then loading the articles individually into second magazines at the exit end of the chamber, said means effecting the removing, feeding, and loading operations such that, as one article is removed from a first magazine, simultaneously therewith a second article is treated and a third article is loaded into a second magazine; and

means for discharging the second magazines, after loading thereof, from the chamber into the ambient atmosphere in a manner such that the ambient atmosphere is prevented from adversely affecting the environment with the chamber.

2. Apparatus as recited in claim 1, wherein the controlled environment chamber includes:

a feed chamber at the entrance end thereof for receiving the first magazines and in which an environment with a pressure P1 different than the ambient pressure may be maintained;

a receiving chamber at the exit end thereof for receiving the second magazines and in which an environment with a pressure P2 different than the ambient pressure may be maintained; and

a treatment chamber in which the treating means is disposed and in which an environment with a pressure P3 different than the pressure P1 and P2 may be maintained, the treatment chamber having an article passageway at one end thereof in communication with the feed chamber and an article passageway at the opposite end in communication with the receiving chamber, each passageway being complementary in shape to the articles and being dimensioned such as to closely fit about the articles as they pass therethrough, so as to provide respective controlled leaks between the treatment chamber and the feed and receiving chambers to inhibit the migration of gas molecules between the treatment chamber and the feed and receiving chambers.

3. Apparatus according to claim 2, wherein the pressure P3 is greater than the pressures P1 and P2 so that any gas flow between the treatment chamber and the feed and receiving chambers is outwardly of the treatment chamber.

4. Apparatus according to claim 2, wherein the removing, feeding and loading means feeds the articles into and out of the treatment chamber in a single file such that at least a portion of an article is always disposed in each passageway to maintain the controlled leaks.

5. Apparatus according to claim 1 wherein:

each first magazine has a plurality of open-ended article receiving compartments, one open end of each compartment being shaped and dimensioned such as to

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permit exit of an article therefrom, while the opposite end is shaped and dimensioned such as to permit access to an article so that the article can be pushed out of the compartment, the first magazines being fed to the entrance end of the controlled environment chamber such that the exit openings thereof face the treating means;

each second magazine has a plurality of article receiving compartments, each of which has an open end shaped and dimensioned such as to permit entry of an article therein, the second magazines being located at the exit end of the controlled environment chamber such that the entry openings thereof face the treating means; and

the removing, feeding and loading means includes:

guide means passing through the controlled environment chamber and having an entry end and an exit end;

means for indexing the first magazines relative to the entry end of the guide means such that the article receiving compartment thereof are successively aligned with the entry end of the guide means;

means aligned with the guide means, and operable in timed relationship with the first magazine indexing means, for successively pushing the articles out of their compartments and delivering the articles to the entry end of the guide means such that a continuous file of articles extends from the entry end to the exit end of the guide means and each article entering the guide means causes an article to exit therefrom; and

means, operable in timed relationship with the first magazine indexing means, for indexing the second magazines relative to the exit end of the guide means such that each article as it emerges from the guide means is loaded into a different one of the second magazine, article receiving compartments.

6. Apparatus according to claim 1, further including:

means for discharging the first magazines, after unloading thereof, from the chamber into the ambient atmosphere in a manner such that the ambient atmosphere is prevented from adversely affecting the environment within the chamber; and

means for feeding empty second magazines from the ambient atmosphere to the exit end of the chamber in a manner such that the ambient atmosphere is prevented from adversely affecting the environment with the chamber.

7. Apparatus according to claim 5, wherein the first and second magazine feeding means and discharge means, each include a lock chamber having alternatively openable doors at opposite ends, one door enabling communication of the lock chamber with the controlled environment chamber, while the other door enables communication of the lock chamber with the ambient atmosphere.

8. Apparatus according to claim 7, wherein the controlled environment chamber includes:

a feed chamber at the entrance end thereof for receiving the first magazines and in which an environment with a pressure P1 different than the ambient pressure may be maintained;

a receiving chamber at the exit end thereof for receiving the second magazines and in which an environment with a pressure P2 different than the ambient pressure may be maintained; and

a treatment chamber in which the treating means is disposed and in which an environment with a pressure P3 different than the pressures P1 and P2 may be maintained, the treatment chamber having an article passageway at one end thereof in communication with the feed chamber and an article passageway at the opposite end in communication with the receiving chamber, each passageway being comple-

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mentary in shape to the articles and being dimensioned such as to closely fit about the articles as they pass therethrough so as to provide respective controlled leaks between the treatment chamber and the feed and receiving chambers to inhibit the migration of gas molecules between the treatment chamber and the feed and receiving chambers.

9. Apparatus according to claim 8, wherein:

each first magazine has a plurality of open-ended article receiving compartments, one open end of each compartment being shaped and dimensioned such as to permit exit of an article therefrom, while the opposite end is shaped and dimensioned such as to permit access to an article so that the article can be pushed out of the compartment, the first magazines being fed to the entrance end of the controlled environment chamber such that the exit openings thereof face the treating means;

each second magazine has a plurality of article receiving compartments, each of which has an open end shaped and dimensioned such as to permit entry of an article therein, the second magazines being located at the exit end of the controlled environment chamber such that the entry openings thereof face the treating means; and

the removing, feeding and loading means includes:

guide means passing through and forming a part of the controlled leak passageways of the treatment chamber, the guide means having an entry end disposed in the feed chamber and an exit end disposed in the receiving chamber;

means for indexing the first magazines relative to the entry end of the guide means such that the article receiving compartment thereof are successively aligned with the entry end of the guide means;

means aligned with the guide means, and operable in timed relationship with the first magazine indexing means, for successively pushing the articles out of their compartments and delivering the articles to the entry end of the guide means such that a continuous file of articles extends from the entry end to the exit end of the guide means and each article entering the guide means causes an article to exit therefrom; and

means, operable in timed relationship with the first magazine indexing means, for indexing the second magazines relative to the exit end of the guide means such that each article as it emerges from the guide means is loaded into a different one of the second magazine article receiving compartments.

10. Apparatus according to claim 9 for sputtering a sputterable material on one face of a flat article, wherein:

the guide means includes a pair of parallel spaced rails, each of which has a slot facing the other for receiving an edge of an article such that the article is supported between the rails; and

the treating means includes a flat cathode composed of a sputterable material and arranged parallel with the rails such that as an article proceeds along the rails it passes the cathode in a facing, parallel relationship therewith.

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