

APPARATUS FOR DRYING CLEANED WORKPIECES

The present invention relates to an apparatus for drying cleaned plate-like workpieces by removing a cleaning solution from the workpieces.

5 There has been known an apparatus for drying workpieces, such as small thin ceramic plates for use as crystal oscillators or capacitors, which have been cleaned by a cleaning apparatus using a cleaning solution such as water. In such an apparatus, a plurality of workpieces are placed in
10 a tray having an air-permeable bottom, and hot air is applied from above the tray and drawn from below the tray so that the hot air forcibly passes through the spaces between the workpieces. The hot air is heated to such a temperature that it can evaporate the cleaning solution that is attached to the
15 workpieces.

 The hot air which is supplied from a hot-air duct can not only evaporate moisture from the exposed surfaces of the workpieces in the tray, but also remove moisture in spaces or gaps between those workpieces which may overlap
20 each other, as the hot air enters those gaps.

 Before the workpieces are dried by the drying apparatus, the workpieces are cleaned by the cleaning apparatus. If the workpieces are small thin lightweight ceramic plates

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for use as crystal oscillators or capacitors, for example,
and cleaned ultrasonically while being supported on a tray
and immersed in a cleaning solution, then when the tray is
taken out of the cleaning solution, the workpieces in the
5 tray tend to be stacked into blocks in which they stick
closely together through the attached cleaning solution. The
gaps between the workpieces in each of the blocks are very
small, with the cleaning solution firmly retained in the
gaps. The gaps between the blocks of workpieces are larger
10 than the gaps between the workpieces, and may sometimes be
large enough for them to be interconnected vertically in the
tray.

When the cleaned workpieces are dried by the drying
apparatus, hot air supplied from the hot-air duct tends to
15 pass through the larger gaps between the blocks of work-
pieces, rather than being uniformly applied to the workpieces
in the blocks. Since the heat of the hot air cannot effi-
ciently be transmitted to the workpieces sticking together in
the blocks, it takes a relatively long period of time for all
20 the workpieces to be fully dried.

Viewed from one aspect the present
invention provides an apparatus for drying cleaned
plate-like workpieces, comprising a tray for housing

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a plurality of plate-like workpieces therein, the tray having an air-permeable bottom plate and a plurality of air-impermeable sidewall plates extending from peripheral edges of the bottom plate, a support base for supporting the bottom plate of the tray at an inclined attitude, a hot-air duct detachably coupled to respective edges of the sidewall plates of the tray which is supported on the support base, for supplying hot air into an interior space of the tray which is surrounded by the sidewall plates, and a suction duct coupled to the bottom plate of the tray supported on the support base, for drawing hot air supplied from the hot-air duct from within the interior space through the bottom plate.

Thus, after the workpieces are cleaned, the tray housing the workpieces is supported on the support base at an inclined attitude. The workpieces that are stacked in the tray move sideways out of the stacked condition, allowing an attached cleaning solution to drop off the workpieces. Since the amount of cleaning solution attached to the workpieces is reduced, the workpieces can be dried within a relatively short period of time. Even if the workpieces are stacked and clustered in blocks in the tray while they are being cleaned, the blocks are broken when the tray is inclined. Therefore, the gaps between the blocks are eliminated, and hot air drawn from the hot-air duct into the suction duct can pass thoroughly through the gaps between the workpieces. Since the heat of the hot air is uniformly transferred to the workpieces, the workpieces can be dried efficiently, quickly, and

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reliably.

The support base may comprise a support frame for intimately contacting the peripheral edges of the bottom plate of the tray, and legs supporting the support frame at an inclined attitude, the suction duct being integrally joined to entire peripheral edges of the support frame.

The tray may have a pair of grips mounted on outer surfaces of respective opposite ones of the sidewall plates thereof. The apparatus may further comprise lifting/lowering means for lifting the tray away from and lowering the tray toward the support base, the lifting/lowering means having a pair of hooks for engaging the grips, respectively, to support the tray and releasing the grips upon downward movement beyond a position in which the tray is supported on the support base. Therefore, the tray may be supported on the support base simply when the tray is lowered by the lifting/lowering means.

The hot-air duct may be suspended from the lifting/lowering means for upward movement with respect to the lifting/lowering means when the hot-air duct is coupled to the tray which is supported on the support base. Thus, even if the lifting/lowering means is further lowered when the tray is supported on the support base, the lifting/lowering means is allowed to move downwardly relatively to the hot-air duct, keeping the hot-air duct stably coupled to the tray.

Each of the plate-like workpieces may comprise a thin ceramic plate for use as a quartz oscillator or a capac-

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itor.

The above and other features and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawings which illustrate a preferred embodiment of the present invention by way of example.

FIG. 1 is a plan view of a cleaning system which incorporates a drying apparatus according to the present invention;

FIG. 2 is an enlarged fragmentary side elevational view, partly in cross section, of the drying apparatus;

FIG. 3 is a perspective view, partly broken away, of a tray used in the drying apparatus;

FIG. 4(a) is a fragmentary vertical cross-sectional view of workpieces in the tray which lies horizontally; and

FIG. 4(b) is a fragmentary vertical cross-sectional view of workpieces in the tray which is inclined.

As shown in FIG. 1, a cleaning system A for cleaning plate-like workpieces W such as thin ceramic plates for use as crystal oscillators or capacitors generally has a loading section 2 for successively loading trays 1 each containing a number of workpieces W, a cleaning section 6 including a preliminary cleaning tank 3 for cleaning workpieces W contained in trays 1 that are successively introduced from the loading section 2, an ultrasonic cleaning tank 4 for ul-

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trasonically cleaning workpieces W contained in trays 1,
an ultrasonic rinsing tank 5 for ultrasonically rinsing work-
pieces W contained in trays 1, a drying section 7 for drying
workpieces W that have been cleaned by the cleaning section
5 6, and an unloading section 8 for unloading trays 1 contain-
ing workpieces W that have been discharged from the drying
section 7.

The loading section 2 includes a loading conveyor 9
for supporting and successively charging a plurality of trays
10 1 into the preliminary cleaning tank 3 of the cleaning sec-
tion 6.

The preliminary cleaning tank 3 has a shower nozzle
10 for spraying a cleaning solution downwardly over work-
pieces W contained in a charged tray 1 to preliminarily
15 clean the workpieces W.

The ultrasonic cleaning tank 4 is filled with a
deaerated cleaning solution, and houses an ultrasonic vibra-
tor 11 supported on its bottom. The ultrasonic vibrator 11,
when actuated, generates cavities in the cleaning solution in
the ultrasonic cleaning tank 4. When the generated cavities
collapse, they produce shock waves which are applied to the
workpieces W thereby cleaning the workpieces W.

The ultrasonic rinsing tank 5 is filled with tap
water, and houses an ultrasonic vibrator 12 supported on its
25 bottom, the ultrasonic vibrator 12 being identical with the
ultrasonic vibrator 11. The ultrasonic vibrator 12, when ac-
tuated, generates cavities in the water in the ultrasonic

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rinsing tank 5. When the generated cavities collapse, they produce shock waves which are applied to the workpieces W thereby rinsing the workpieces W.

As shown in FIG. 3, each of the trays 1 comprises an air-permeable square-shaped bottom plate 13 in the form of a mesh-like network of wires, four air-impermeable sidewall plates 14 projecting upwardly from respective edges of the bottom plate 13, and a pair of grips 15 mounted on the outer surfaces of respective opposite two of the sidewall plates 14. Workpieces W can be taken into and out of the trays 1 through their upper open sides. The air-permeable square-shaped bottom plate 13 may alternatively comprise a punched plate with a number of perforations.

Transport means (not shown) for transporting trays 1 are provided between the preliminary cleaning tank 3 and the ultrasonic cleaning tank 4 and also between the ultrasonic cleaning tank 4 and the ultrasonic rinsing tank 5. Lifting/lowering means (not shown) are also provided above the preliminary cleaning tank 3, the ultrasonic cleaning tank 4 and the ultrasonic rinsing tank 5 for lowering trays 1 transported by the transport means into the tanks 3, 4, 5 and lifting trays 1 out of the tanks 3, 4, 5 upon elapse of certain periods of time.

The drying section 7 includes a drying apparatus 16 according to the present invention. As shown in FIG. 2, the drying apparatus 16 comprises a drying tank 17 for housing a tray 1, a pair of horizontally spaced vertical support arms

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18 positioned above the drying tank 17 for supporting the tray 1, a horizontal lifting/lowering arm 19 which supports the support arms 18 extending downwardly therefrom and can be lifted and lowered by an actuator (not shown) between a position to which the tray 1 has been fed and a position inside of the drying tank 17, and a support base 20 disposed on the bottom of the drying tank 17 for supporting the bottom plate of the tray 1 at its peripheral edges that has been lowered into the drying tank 17 by the lifting/lowering arm 19. The lifting/lowering arm 19 operates with the lifting/lowering means above the tanks 3, 4, 5 to lift and lower the trays 1. The support base 20 has a centrally open support frame 21 for supporting only the peripheral edges of the bottom plate 13 of the tray 1. The support frame 21 is fixedly mounted on the upper ends of legs 22 of different lengths and hence inclined for supporting the tray 1 at an inclined attitude.

A hot-air duct 23 for supplying hot air extends vertically through and is vertically movably mounted on the lifting/lowering arm 19. A suction duct 24 is disposed centrally below the support frame 21 for drawing hot air supplied from the hot-air duct 23.

The hot-air duct 23 is connected through a heater 25 to an air blower 27 which has an air filter 26. The heater 25 heats air supplied from the air blower 27 through the air filter 26 to a temperature that is high enough to evaporate the cleaning solution. A downwardly flaring hood 28 is attached to the lower end of the hot-air duct 23 be-

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tween the support arms 18 for vertical movement into and out of abutting engagement with the full peripheral edges of the upper opening of the tray 1 that is supported on the support base 20. The hood 28 is vertically movably suspended on the
5 lifting/lowering arm 19 by a pair of parallel support bars 29 extending upwardly from the hood 28. The support bars 29 are vertically movable along guides 30 in the lifting/lowering arm 19. When lowered, the downward movement of the support bars 29 is limited by stops 31 attached to the respective up-
10 per ends of the support bars 29 upon engagement of the stops 31 with the guides 30. The hood 28 is inclined in the same direction as the support frame 21 for snugly abutting engagement with the upper surface of the tray 1 that is supported on the support frame 21.

15 The suction duct 24 has an upper end integrally joined to the entire peripheral edges of the support frame 21 and an opposite end located outside of the drying tank 17 and coupled to a suction device 32. When the tray 1 is supported on the support base 20, the bottom of the tray 1 is coupled
20 to the upper end of the suction duct 24.

Operation of the cleaning system A will be described below.

First, a tray 1 housing a number of workpieces W is introduced into the cleaning section 6 by the loading conveyor 9 of the loading section 2. In the cleaning section 6,
25 the workpieces W in the tray 1 are successively preliminarily cleaned by the preliminary cleaning tank 3, ultrasonically

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cleaned by the ultrasonic cleaning tank 4, and ultrasonically rinsed by the ultrasonic rinsing tank 5.

After the workpieces W have been cleaned in the cleaning section 6, the tray 1 which contains the workpieces W that are wet with water is transferred to the support arms 18 suspended from the lifting/lowering arm 19 in the drying section 7. When the tray 1 is supported on the support arms 18, the grips 15 of the tray 1 are engaged by respective hooks 33 on the respective lower ends of the support arms 18. The lifting/lowering arm 19 is then lowered to lower the tray 1 into the drying tank 17 until the tray 1 is supported on the support base 20. When the tray 1 is supported on the support base 20, since the support frame 21 is inclined, the tray 1 on the support base 20 is inclined as shown in FIG. 2. At this time, the hooks 33 are lowered beyond a position in which the tray 1 is supported on the support base 20, releasing the grips 15 of the tray 1, which is now fully supported obliquely on the support base 20.

At the same time that the support arms 18 release the tray 1 upon descent of the lifting/lowering arm 19, the hood 28 on the lower end of the hot-air duct 23 abuts against the upper edges of the sidewall plates 14 of the tray 1 by gravity.

The hot-air duct 23 and the suction duct 24 are now held in communication with each other through the tray 1 that is sandwiched between the hot-air duct 23 and the suction duct 24. Now, hot air is supplied from the hot-air duct 23

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into the tray 1. Inasmuch as the bottom plate 13 of the tray 1 is permeable to air and the sidewall plates 14 thereof are not permeable to air, the workpieces W housed in the tray 1 are exposed to only hot air supplied from the hot-air duct 23, but isolated from ambient air surrounding sidewall plates 14 of the tray 1.

While hot air is being supplied to the tray 1 from the hot-air duct 23, the supplied hot air is forcibly drawn from within the tray 1 by the suction duct 24.

When the tray 1 is taken out of the cleaning solution in the ultrasonic cleaning tank 4, the workpieces W housed in the tray 1 that have been ultrasonically cleaned in the ultrasonic cleaning tank 4 are clustered in blocks Y in each of which the workpieces W are stacked with cleaning solution films X retained therebetween as shown in FIG. 4(a). At this time, the stacked workpieces W in each of the blocks Y stick together by the cleaning solution films X therebetween. When the tray 1 that houses the clustered workpieces W is then placed in the drying tank 17, since the tray 1 is inclined on the support base 20, the workpieces W move sideways in their inclined plane, breaking the blocks Y as shown in FIG. 4(b). The workpieces W that have stuck together with the cleaning solution films X are loosened, allowing the excessive cleaning solution to drop from the workpieces W. Since the amount of cleaning solution attached to the workpieces W is reduced, the workpieces W can be dried within a relatively short period of time.

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When the blocks Y are collapsed, the gaps between the blocks Y are eliminated. Therefore, the hot air drawn from the hot-air duct 23 into the suction duct 24 can flow thoroughly through the gaps between the workpieces W. As the heat of applied hot air can uniformly be transferred to the workpieces W, the workpieces W can efficiently, quickly, and reliably be dried by the applied hot air.

The hot air is supplied for a certain period of time until the workpieces W are fully dried. When the drying process is completed, the lifting/lowering arm 19 is elevated. On the ascending movement of the lifting/lowering arm 19, the grips 15 of the tray 1 are engaged by the hooks 33, and hence the tray 1 is lifted out of the drying tank 17 by the lifting/lowering arm 19. When the tray 1 is tilted back to a horizontal attitude, the hood 28 is separated from the tray 1, thereby disconnecting the tray 1 from the hot-air duct 23.

Thereafter, the tray 1 supported by the support arms 1 is discharged into the unloading section 8 by a discharging means (not shown), and then unloaded by an unloading conveyor 34 in the unloading section 8.

Although a certain preferred embodiment of the present invention has been shown and described in detail, it should be understood that various changes and modifications may be made therein without departing from the scope of the appended claims.

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CLAIMS:

- 5 1. An apparatus for drying cleaned plate-like
workpieces (W), comprising:
a tray (1) for housing a plurality of plate-like
workpieces therein, said tray having an air-permeable
bottom plate (13) and a plurality of air-impermeable
10 sidewall plates (14) extending from peripheral edges of
said bottom plate;
a support base (21) for supporting the bottom plate
of said tray at an inclined attitude;
a hot-air duct (23) arranged to be detachably
15 coupled to respective edges of said sidewall plates of
the tray when supported on said support base, for
supplying hot air into an interior space of the tray
which is surrounded by said sidewall plates; and
a suction duct (24) arranged to be coupled to said
20 bottom plate of the tray when supported on said support
base, for drawing hot air supplied from said hot-air
duct from within said interior space through said bottom
plate.
- 25 2. An apparatus according to claim 1, wherein said
support base (21) comprises a support frame for
intimately contacting the peripheral edges of said
bottom plate of the tray, and legs (22) supporting said
support frame at an inclined attitude, said suction duct
30 being integrally connected around the entire peripheral
edges of said support frame.
3. An apparatus according to claim 1 or 2, wherein
said tray (1) has a pair of grips (15) mounted on outer
35 surfaces of respective opposite ones of said sidewall
plates (14) thereof, and further comprising lifting and
lowering means (19) for lifting said tray away from and



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lowering said tray toward said support base, said
lifting and lowering means having a pair of hooks (33)
for engaging said grips to support said tray and
arranged to release said grips upon downward movement
5 beyond a position in which said tray is supported on
said support base.

4. An apparatus according to claim 3, wherein said
hot-air duct (23) is suspended from said lifting and
10 lowering means (19) for upward movement with respect to
the lifting and lowering means when said hot-air duct is
coupled to the tray when supported on said support base.

5. An apparatus according to any preceding claim,
15 wherein each of said plate-like workpieces (W) comprises
a thin ceramic plate for use as a quartz oscillator or a
capacitor.

6. Apparatus for drying workpieces (W) in an open-
20 topped container (1) having an air-permeable bottom
(13), such apparatus comprising means (21) for
supporting a said container with its bottom
substantially inclined to the horizontal, hot air supply
means (23) arranged to be connected to the open top of
25 said container with the container supported as
aforesaid, and suction means arranged to be connected to
the bottom of the container when so supported, whereby
hot air may be sucked through the interior space of the
container and out through the bottom thereof to dry
30 workpieces therein.

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