

Feb. 8, 1949.

J. M. WOLFSKILL

2,461,489

CRYSTAL DRIER

Filed Nov. 17, 1944

3 Sheets-Sheet 1

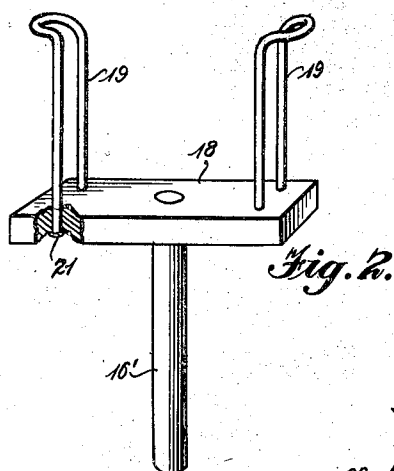


Fig. 2.

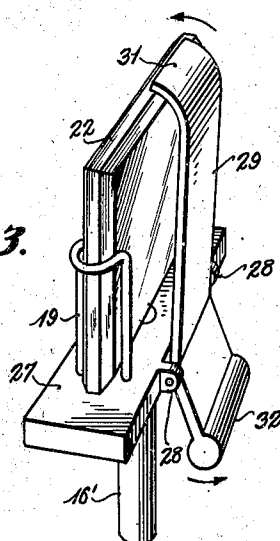


Fig. 3.

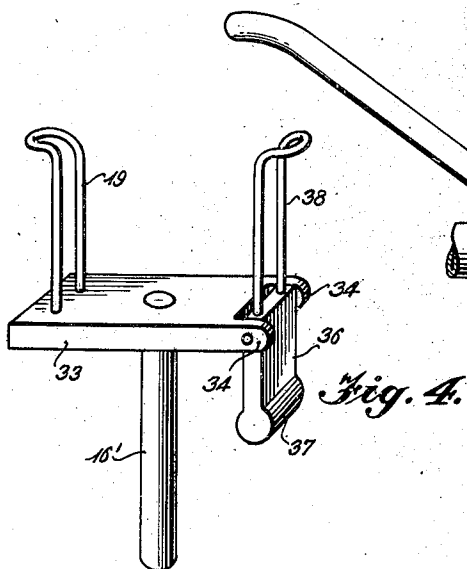


Fig. 4.

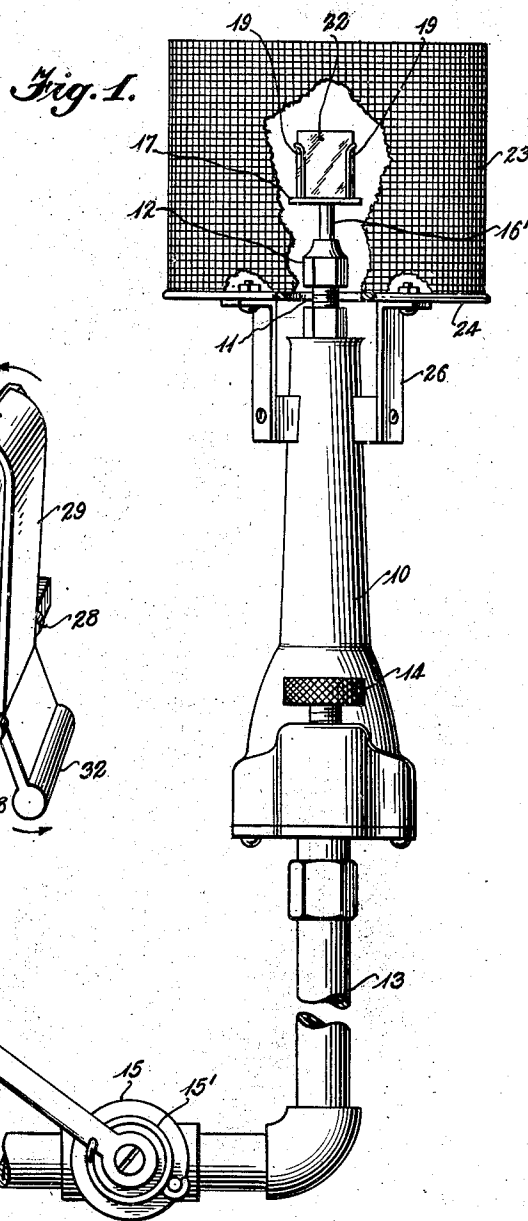


Fig. 1.

Inventor

John M. Wolfskill

By Bacon & Thomas

Attorneys

Feb. 8, 1949.

J. M. WOLFSKILL

2,461,489

CRYSTAL DRIER

Filed Nov. 17, 1944

3 Sheets-Sheet 2

Fig. 5^a

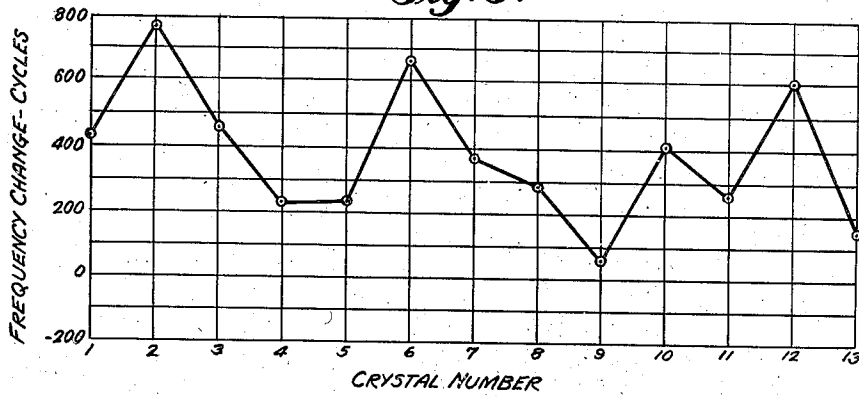


Fig. 5^b

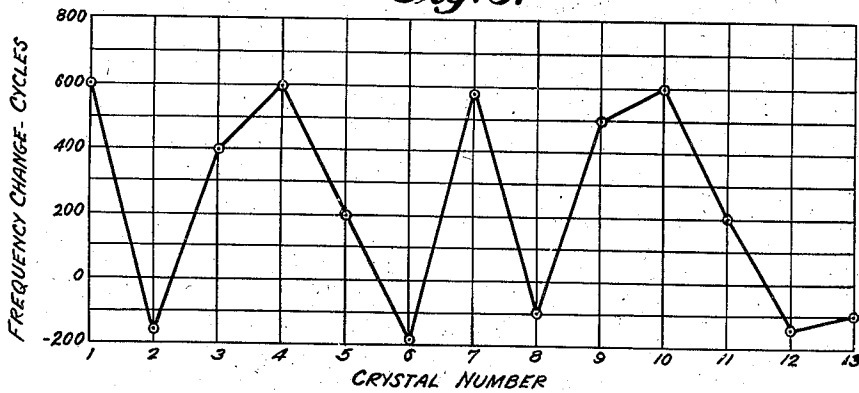
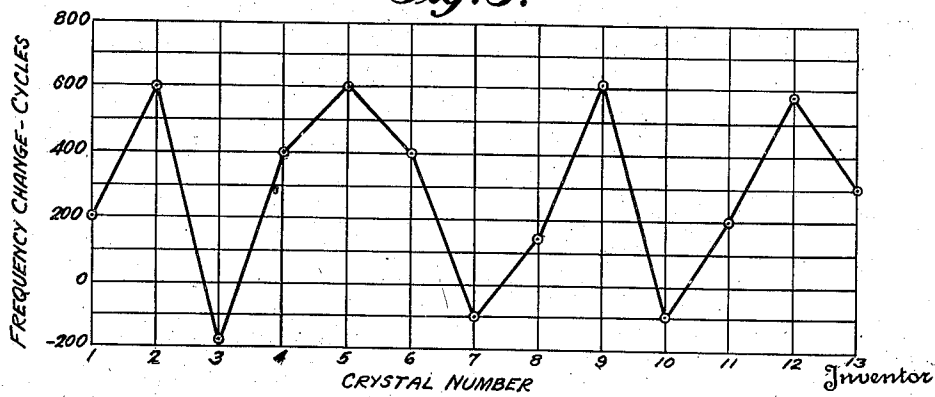


Fig. 5^c



John M. Wolfskill

By Bacon & Thomas

Attorneys

Feb. 8, 1949.

J. M. WOLFSKILL

2,461,489

CRYSTAL DRIER

Filed Nov. 17, 1944

3 Sheets-Sheet 3

Fig. 6^a

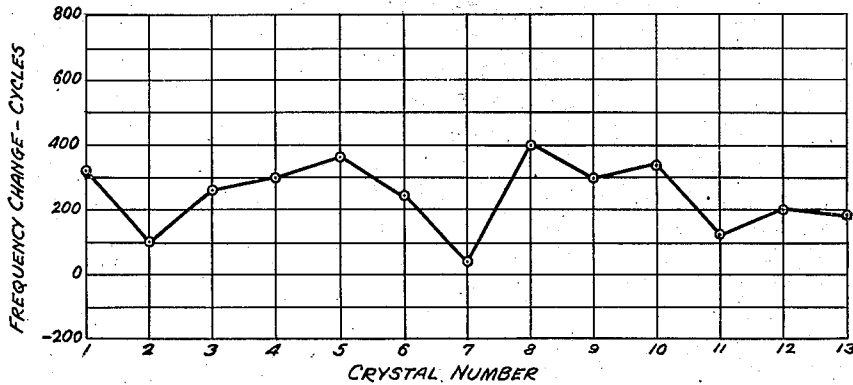


Fig. 6^b

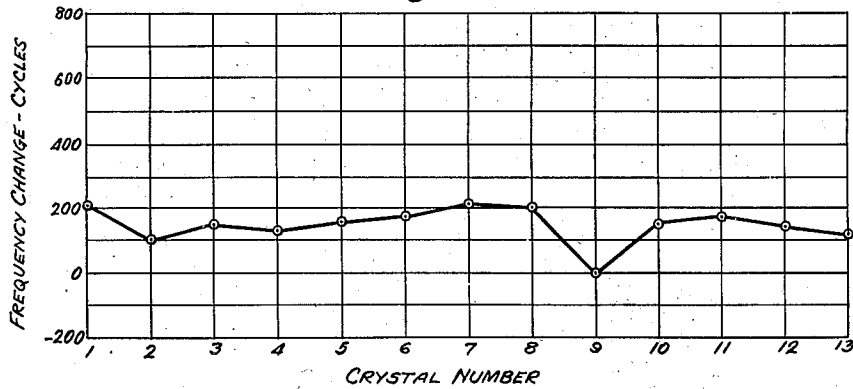
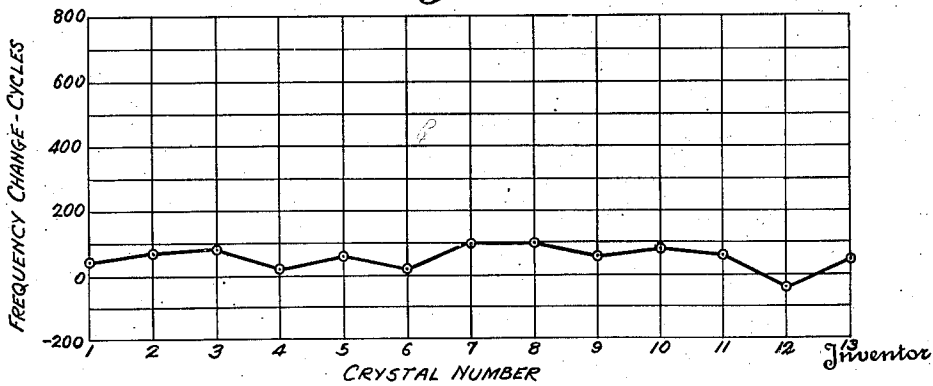


Fig. 6^c



John M. Wolfskill

By Bacon & Thomas
Attorneys

UNITED STATES PATENT OFFICE

2,461,489

CRYSTAL DRIER

John M. Wolfskill, Erie, Pa., assignor to Billey Electric Company, Erie, Pa., a corporation of Pennsylvania

Application November 17, 1944, Serial No. 563,966

5 Claims. (Cl. 34—58)

1

This invention relates to a crystal drier and more particularly to a device for rapidly rotating a piezoelectric crystal so as to remove excess moisture therefrom by centrifugal force while at the same time producing effective contact between the crystal surfaces and drying air.

In the manufacture of piezoelectric quartz crystals, it is frequently necessary to wash and dry such crystals in order to prepare the crystal for testing in an oscillator circuit. Crystals are ordinarily ground to approximate dimensions in lapping machines after which the crystals are further reduced in size to bring them to a desired frequency either by hand lapping or etching operations. After the machine lapping operations, the crystals are usually tested for frequency in an oscillator circuit and edge ground to bring them to maximum activity, the latter operation frequently requiring several tests in the oscillator circuit. When hand lapping operations are employed to bring the crystal to desired frequency and activity, repeated tests in the oscillator circuit are usually required. In carefully controlled etching operations the number of frequency tests required is considerably less than that for hand lapping operations, but, nevertheless, a plurality of frequency and activity tests must usually be made. Prior to such tests the abrasive and carrier therefor or residual etching solution must be washed from the crystal surfaces and the crystal then dried. It will thus be seen that in the manufacture of piezoelectric crystals frequent washing and drying operations must be carried out.

Any appreciable amount of foreign material adhering to a crystal will modify the characteristics of the crystal. Thus, lint from towels used in drying the crystal or solid materials in solution or suspension in water and deposited on the crystal during drying of the water will, in general, lower the frequency of the crystal an unpredictable amount or otherwise modify its characteristics.

Various methods of drying crystals after washing and rinsing and prior to testing have been employed by the art. Of these, probably the most common means of drying was by towels. In some cases, ordinary laundry towels have been employed but usually special types of towels such as lint free towels, paper towels and blotting paper have been used. The results obtained, however, were extremely variable. They depended upon the general cleanliness of the towel itself, how long it had been in use, and in the case of laundry towels the manner in which it had been laundered, for example, the type of soap used in

2

laundering and the starch content imparted to the towel. The lint characteristics of the towel were of particular importance as even small amounts of lint left on the crystal materially modified its operation. Because of the variable results, the art had long recognized that even reasonably clean crystals were in fact not being produced by drying with towels.

Other methods of drying including the employment of currents of heated air from blowers having heating elements associated therewith and strong blasts of air from sources of compressed air were tried. The velocity of air from blowers was not sufficient to blow all of the rinse water from the crystal surfaces. Water was slowly evaporated thereon, leaving on the face of the crystals any solids in solution or suspension in the water. These solids were irregularly deposited on the crystal surface leaving "water spots" materially affecting the performance of the crystal. In using high velocity blasts from compressed air sources, it was possible to blow off some of the excess water after the crystal was rinsed. The chief difficulty with this method of drying was, however, that it was not possible, as a practical matter, to obtain a compressed air source that was completely free of moisture and oil particles. The solubles in dirty water from a compressed air line and oil particles in the air were irregularly and unpredictably deposited on the crystal surface during drying, resulting in oil and water spots on such surfaces. Attempts to filter the compressed air were not successful and consistent results were not obtained.

In accordance with the present invention a washed and rinsed crystal is properly supported and rotated at an extremely high speed. Large centrifugal forces are developed which throw the water off of the crystal surfaces and at the same time intense currents of air relative to the crystal surfaces are set up so that drying air is effectively brought into contact with such surfaces. Rapid drying of the crystal is effected, primarily by bodily removing water with its associated solids from the crystal surfaces. The resulting crystal surfaces are substantially completely cleaned. Also, the drying operation is much more rapid than those heretofore proposed. The crystal can ordinarily be completely dried in from three to five seconds.

It is therefore an object of the present invention to provide an improved method and apparatus for drying piezoelectric crystals.

Another object of the invention is to provide a method of drying piezoelectric crystals in which

3

the crystal is spun at a rapid rate to throw off adhering water and cause drying air to effectively contact the surfaces of the crystal.

Another object of the invention is to provide an improved drying apparatus for piezoelectric crystals which facilitates rapid and easy mounting of the crystal in the drying device and removal of the crystal therefrom after drying.

A further object of the invention is to provide a crystal drying apparatus in which the crystal is held in a manner enabling rinse water to flow rapidly from the surfaces thereof.

A still further object of the invention is to provide an improved crystal drying apparatus in which the crystal is spun about an axis passing through the body of the crystal.

Other objects and advantages will appear in the following description of preferred embodiments of the invention illustrated in the accompanying drawings, in which:

Figure 1 is an elevation of a drying apparatus with certain parts broken away;

Figure 2 is an isometric view of the crystal holding element shown in Figure 1;

Figure 3 is a view similar to Figure 2 showing a modified type of crystal holding element;

Figure 4 is a view similar to Figure 2 showing a further modified type of crystal holding element;

Figures 5a to 5c, inclusive, are graphs showing the results of drying crystals by contact with towels; and

Figures 6a to 6c, inclusive, are graphs similar to Figures 5a to 5c showing results of drying in accordance with the present invention.

Referring to the drawings, Figure 1 shows a complete drying apparatus in accordance with the present invention. This apparatus may include a motor 10, shown in the drawings as being an air motor mounted with its shaft 11 in a vertical position, the shaft 11 carrying a chuck 12 at its upper end. The internal structure of the motor 10 is not shown as such motors are available on the market in various forms, the particular motor shown being capable of rotating as fast as 20,000 R. P. M., and being provided with a compressed air inlet conduit 13 and a speed regulating screw 14. The motor may be started and stopped by means of a valve 15 in the air inlet line 13, the valve being shown as a rotary valve normally held in closed position by a spring 15' and provided with an operating lever such as a foot pedal 16 for opening the valve against the action of the spring 15'. While an air motor is shown, it will be understood that a high speed electric motor, also commercially available, can be employed in conjunction with a starting and stopping switch, if properly shielded, the chief disadvantage of high speed electric motors being that they frequently produce radio frequency interference which may cause difficulties in carrying out certain test procedures in crystal manufacturing operations.

The chuck 12 may receive the shank 16' of a crystal carrier 17. The crystal carrier shown in Figures 1 and 2 may include a cross member 18 carried by the shank 16' and supporting a pair of wire loops 19. Each of the wire loops 19 preferably includes vertically extending parallel portions connected at their tops by an outwardly extending loop portion 20. The wire loops 19 may be secured to the cross member 18 in any desired manner, for example by inserting their lower ends in bores 21, one of which is shown in Figure 2 and soldering or brazing the wires in such

4

bores. The wire loops 19 are preferably made of relatively stiff spring metal and as shown in Figure 1, the wire loops 19 provide a recess for receiving a crystal 22 to be dried.

It will be apparent that the crystal 22 may be easily inserted between the wire loops 19 by sliding the same downwardly therebetween and removed by merely lifting the crystal from the recess between the wires. While the wire loops 19 may fit the crystal sufficiently close that they must be sprung apart slightly to insert the crystal, it is preferred to mount the crystal loosely between the wires. When the crystal holder is rotated at a high speed, the crystal moves slightly off center and is held snugly against one of the loops by centrifugal force. There is then no danger of chipping the crystal while inserting or removing it. The crystal holding means described presents substantially unobstructed paths for liquids thrown from the crystal surfaces by centrifugal force due to rotation of the crystal.

To guard against any possibility of injury to operators by reason of the crystal being thrown from the crystal carrier during rapid rotation, it is preferred to surround the crystal carrier by a stationary open topped screen 23, the screen being preferably a cylindrical member of solid sheet material although it may be of foraminous material. The screen 23 may be mounted on a base member 24 in turn supported by brackets 26 secured to the casing of the motor 10 in any desired manner. Even if the possibility of a crystal being thrown from the carrier is remote, crystals sometimes shatter when being rapidly spun and the screen 23 prevents injury to operators due to particles of the glass-like materials of the crystal being thrown off at high speed.

The modified type of crystal carrier shown in Figure 3 is designed to prevent any possibility of a crystal being bodily thrown from the crystal carrier during rotation thereof. In the modification of Figure 3, the cross member 27 mounted on the shank 16' and carrying the wires 19 may be provided with bearing members 28 extending from one longitudinal edge thereof. A pivoted guard member 29 may be journaled in the bearing members 28 and be provided with a crystal guard portion 31 at its upper end and a weight member 32 at its lower end. The guard portion 31 extends over the top of the crystal 22 when the weight member 32 is caused to move outwardly from the shank 16' due to centrifugal force during rapid rotation of the crystal carrier. It is not necessary that any portion of the member 29 actually contact the crystal when the crystal is in its normal position in the carrier. That is to say, the device is preferably constructed so that the pivoted member 29 engages the cross member 27 as a stop prior to contacting the crystal. This structure, however, obviates any possibility of the crystal being thrown bodily from the crystal carrier.

Another modified form of crystal carrier is shown in Figure 4. This crystal carrier may include a cross member 33 provided with a wire loop 19 at one end thereof and with projecting bearing members 34 at the other end thereof. A weighted member 36 may be journaled in the bearing members 34 and carry a weight 37 in its lower end. A spring wire loop 38 may be suitably secured to the upper portion of the weighted member 36. The wire loop 38 may have a form similar to the loop wire 19. Upon rotation of the crystal carrier shown in Figure 4, the weight 37 moves outwardly from the shank 16'

5

due to centrifugal force and presses the wire 38 against a crystal mounted in the crystal carrier. This structure also tends to eliminate the possibility of the crystal being thrown from the crystal carrier during rotation, although the crystal carrier of Figure 4 may be also provided with the pivoted guard member 29 of Figure 3. One advantage of the crystal carrier of Figure 4 is that it will accommodate crystals varying considerably more in lateral dimensions than is possible with the crystal carriers of Figures 2 and 3. It will be apparent, however, that different sized crystal carriers can be rapidly substituted for each other in order to accommodate crystals of different size by merely releasing the chuck 12 of Figure 1, removing one crystal carrier and inserting another.

The curves of Figures 5a to 5c illustrate the variable results which are obtained when an attempt is made to dry crystals by means of towels. These curves were derived from data obtained from thirteen different crystals in the 8 megacycle range. The curve of Figure 5a shows frequency change in cycles plotted against crystal number. In order to obtain this data, each crystal was tested for frequency, then washed and dried with a clean, lintless towel employing the best technique thus far developed. The crystals were then again tested for frequency and the difference between the original frequency and the frequency after washing and drying was plotted against the numbers of the various crystals in Figure 5a.

The crystals were then again washed and dried with the towels and the results plotted in Figure 5b. The same crystals were then washed and dried with towels a third time and the results plotted in Figure 5c. It will be noted that the frequency change for each of the three washings were of substantially the same order and that they varied unpredictably. As a specific example, crystal number 2 increased its frequency by nearly 800 cycles in the first washing and drying, decreased its frequency by over 150 cycles in the second washing and drying operation and then increased its frequency by approximately 600 cycles in the third washing and drying operation.

A similar set of curves is shown in Figures 6a, 6b and 6c. The same type of crystals were employed but instead of being dried by towels after washing were dried in accordance with the present invention. As was to be expected, the results of the first operation showed considerable variation as removal of foreign materials from the surface would be expected to increase the frequency of the crystal. The second and third washing and drying operations provided much more consistent results, the third drying operation, shown in Figure 6c, exhibiting very little change in frequency. This can only be explained on the basis that the first washing and drying operation substantially completely cleaned the crystal and that very little foreign material was either deposited upon or removed from the crystals in the second and third washing and drying operations. In fact, the maximum frequency change for any crystal during the third washing and drying operation was approximately 100 cycles, whereas the third washing and drying operation using towels, shown in Figure 5c, resulted in several of the crystals exhibiting frequency change of approximately 600 cycles.

The curves of Figures 6a, 6b and 6c thus illustrate that the drying operation of the present invention produces extremely clean crystals.

6

This is of importance not only for test purposes but for insuring consistent performance of the crystal both as to frequency and activity over a long period of time. Dirt or other foreign material deposited or left upon the surfaces of a crystal by improper washing and drying operations can cause complete failure of the crystal unit in service. The foreign material can actually dislodge itself from the crystal surface during oscillation even years after the crystal has been put into service. This, at the very least, causes a change in frequency and, if the foreign material then lodges between the crystal surface and the electrodes, it may cause a loss in activity, a spurious response or even complete failure to oscillate.

Not only does the method and apparatus of the present invention produce improved results as to crystal cleanliness over prior washing and drying operations, but the drying operation itself can be carried out extremely rapidly. It is merely necessary to insert the washed and rinsed crystal between the wires 19 on the crystal carrier and then rotate this crystal carrier at high speed for a few seconds. Speeds of from 15,000 to 20,000 R. P. M. have been found particularly suitable when the axis of rotation passes through the crystal although lower speeds down to approximately 5,000 R. P. M. can be employed with effective results. In general, the higher the speed the more quickly the crystal is dried and the less foreign material is left upon the crystal. Also, in general, it has been found that extremely high speeds with the crystal mounted close to the axis of rotation produce the best results. The crystal acts as a small paddle wheel to accelerate the air in its vicinity and cause rapid currents of air to sweep the sides of the crystal. Also, minimum stresses in the crystal structure relative to the centrifugal force available to throw water off the crystal surfaces are developed by rotating the crystal at high speed about an axis passing through the body of the crystal, although it is possible to mount the crystal substantially off center and employ lower speeds of rotation.

While I have disclosed the preferred embodiments of my invention, it is understood that the details thereof may be varied within the scope of the following claims:

I claim:

1. A device for drying piezoelectric crystals after washing, which comprises, a high speed motor having a shaft extending vertically upwardly therefrom, a crystal carrier mounted on said shaft, said crystal carrier having upwardly extending wire loops forming a recess for receiving said crystal to provide substantially unobstructed paths for liquid thrown from the surfaces of said crystal by centrifugal force, said loops being positioned to hold said crystal with its major surfaces substantially in vertical planes and with the axis of said shaft passing through said crystal.

2. A crystal drying apparatus comprising, a crystal carrier provided with means for supporting a crystal to be dried, said means providing substantially unobstructed paths for liquid thrown from the surfaces of said crystal by centrifugal force, means including a motor for rotating said crystal carrier at a rotation speed between approximately 5,000 and 20,000 R. P. M. to throw said liquid from said surfaces, said supporting means including a base member secured to said shaft, a pair of spring wire loop members having their legs spaced from each other and

7

secured to said base member and their looped ends spaced from said base member, said looped ends being bent away from each other to provide a recess for receiving said crystal.

3. A crystal drying apparatus comprising, a crystal carrier provided with means for supporting a crystal to be dried, said means providing substantially unobstructed paths for liquid thrown from the surfaces of said crystal by centrifugal force, means including a motor for rotating said crystal carrier at a rotation speed between approximately 5,000 and 20,000 R. P. M. to throw said liquid from said surfaces, and a shield around said carrier to restrain projection of crystals or portions thereof in the event of shattering or loss of said crystals from said carrier, said supporting means including a base member secured to said shaft, a pair of spring wire loop members having their legs spaced from each other and secured to said base member and their looped ends spaced from said base member, said looped ends being bent away from each other to provide a recess for receiving said crystal.

4. A crystal drying device comprising, a crystal carrier, a rotatable shaft for supporting said crystal carrier, said carrier comprising a support member mounted on said shaft and having a pair of projecting wire loops having an opening for receiving said crystals; means including a high speed motor for rotating said shaft to throw said liquid from the surfaces of said crystal by centrifugal force during rotation of said carrier, a shield around said carrier to restrain projection of crystals or portions thereof in the event of shattering or the loss of a crystal from said carrier, and a guard member pivotally carried by said support member, said guard member having a guard portion movable to a guard position in the path of movement of said crystals from said opening for preventing accidental displacement of said crystal from said carrier during rotation of said shaft, said guard member also having a weighted portion for retaining said guard portion in said guard position by action of centrifugal

8

force during rotation of said shaft, said carrier having means to prevent said guard member from contacting said crystal when said crystal is correctly positioned in said loops.

5. A crystal drying device comprising, a crystal carrier, a rotatable shaft for supporting said crystal carrier, said carrier comprising a support member mounted on said shaft and having a pair of projecting members providing an opening for receiving said crystals, means including a high speed motor for rotating said shaft to throw said liquid from the surfaces of said crystals by centrifugal force during rotation of said carrier, and a guard member pivotally carried by said support member and having a guard portion movable to a guard position in the path of movement of said crystals from said opening to prevent accidental displacement of said crystal from said carrier, said guard member having a weighted portion holding said guard portion in guard position by action of centrifugal force during rotation of said carrier, said carrier having means for preventing contact of said guard member with said crystal when said crystal is correctly positioned in said projecting members.

JOHN M. WOLFSKILL.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
817,801	Pittock	Apr. 17, 1906
817,802	Pittock	Apr. 17, 1906
970,108	Pierman	Sep. 13, 1910
1,010,511	Mesta et al.	Dec. 5, 1911
1,694,541	Harry	Dec. 11, 1928
2,212,317	Friedman	Aug. 20, 1940
2,218,165	Gaebel	Oct. 15, 1940

OTHER REFERENCES

Webster's New International Dictionary, 2nd edition, 1937, page 2471.