Jan. 7, 1969 F. J. BROWN ET AL 3,420,511

AGITATING A BATCH OF ARTICLES DURING HEAT TREATMENT TO PREVENT THERMAL BONDING OF THE ARTICLES

Filed July 10, 1967 Sheet 1 of 2

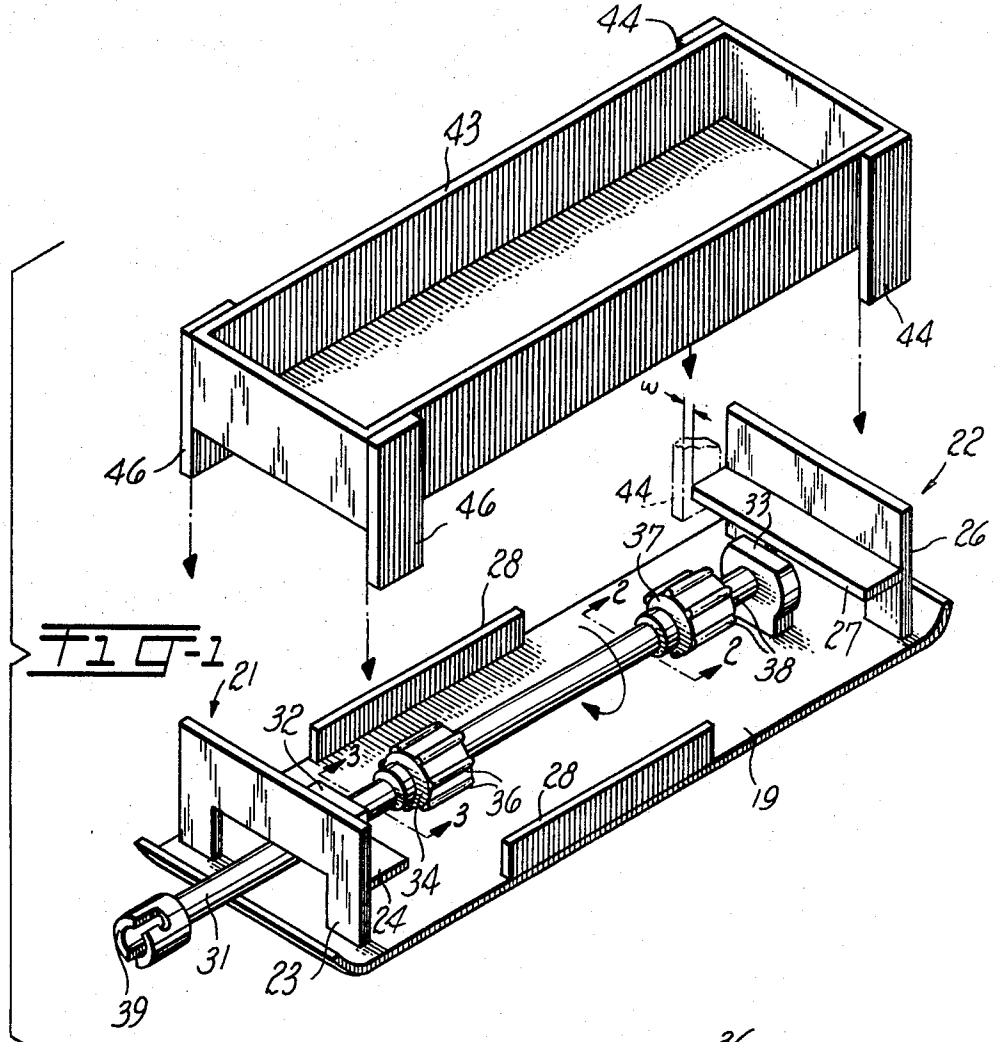

FIG-1

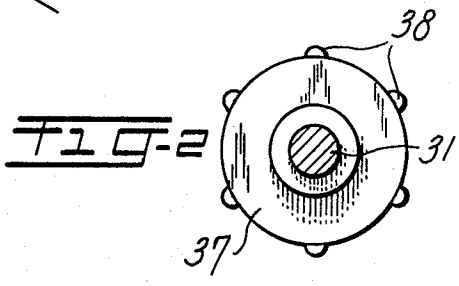

FIG-2

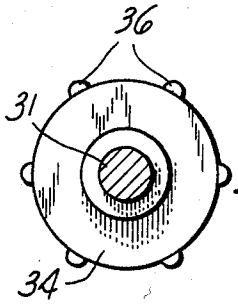

FIG-3

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Jan. 7, 1969 F. J. BROWN ET AL 3,420,511

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Filed July 10, 1967 Sheet 2 of 2

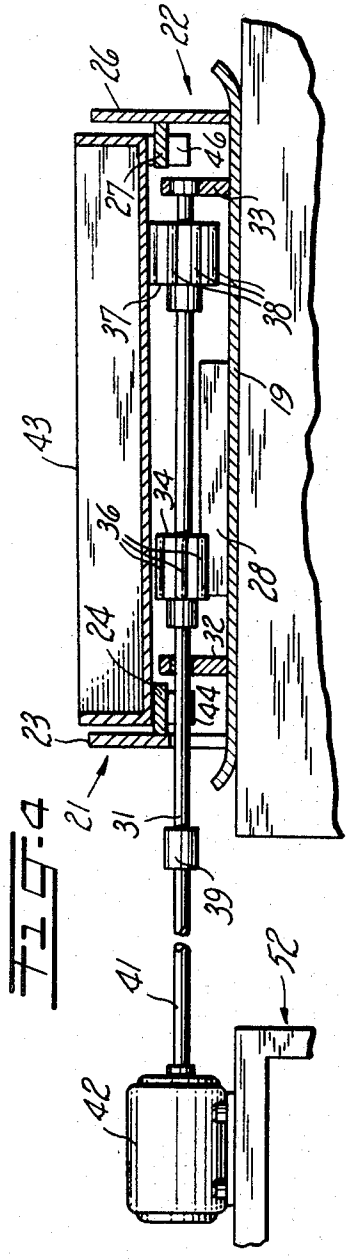

FIG-4

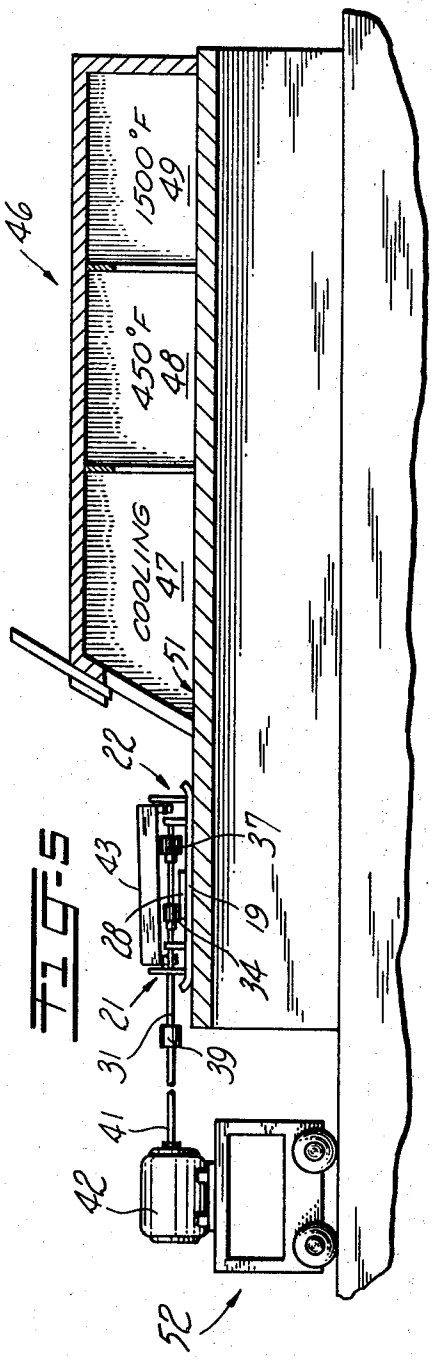

FIG-5

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AGITATING A BATCH OF ARTICLES DURING HEAT TREATMENT TO PREVENT THERMAL BONDING OF THE ARTICLES

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ABSTRACT OF THE DISCLOSURE

A batch of articles, such as contacts for a sealed contact switch, is heat treated by subjecting the articles to an elevated temperature and agitating the articles to prevent the articles from thermally bonding together. A vibrator having a container movably mounted for limited horizontal motion and unrestrained vertical motion and a pair of camming rollers mounted on a rotatable shaft beneath the container are used to agitate the articles during the heat treatment.

Background of the invention

Sealed contact switches are fabricated by automatic assembly machines which receive and assemble the switch components, a glass sleeve and a pair of paddle-shaped contacts. Before the sealed contact switches are assembled, however, a series of preliminary operations must be performed to impart desired electrical and magnetic properties to the contacts.

The contacts may be composed of an iron-nickel alloy. In order to improve the electrical conductivity of the contacts, a layer of highly conductive material, such as an alloy of copper and gold, is plated on the iron-nickel contacts. The contacts are then heat treated or sintered to magnetically anneal the contacts and to diffuse the copper-gold plating into the iron-nickel alloy to further improve the electrical conductivity of the contacts.

In the prior art, it has been necessary to separate the contacts from one another during the heat treating to prevent contacts from thermally bonding together. If the contacts are not separated, then the applied heat produces undesirable thermocompressive and diffusion bonds between adjacent contacts. To achieve the desired separation of contacts, a heat treating rack having a plurality of holes for receiving individual contacts has been used. The utilization of such a heat treating rack to separate the contacts entails several disadvantages. First, the loading of the contacts into the rack must be accomplished. If the loading is performed manually, a long period of time is consumed. If the loading is to be conducted automatically, then an automatic apparatus is necessary. Second, the number of contacts which can be simultaneously sintered is obviously limited by the number of holes in the rack.

To avoid the disadvantages of the prior art sintering techniques, it is desirable to provide a heat treating or sintering process in which a batch of unseparated contacts may be simultaneously treated. Therefore, an apparatus which eliminates the necessity of using a rack for separating the individual contacts is required.

Summary of the invention

The present invention involves a method of and apparatus for heat treating a batch of articles in which continuous relative movement is imparted to the articles. The articles, such as iron-nickel contacts for a sealed contact switch, are heat treated seimultaneously, and

agitated movement is imparted to the articles during the heat treatment to prevent the articles from bonding together. When the heat treatment is completed, the articles are moved to a cooling zone, and the agitation is continued until the temperature of the articles decreases to a level where the articles cannot bond together.

An agitating apparatus having a container for receiving the articles is used to agitate the articles during the heat treating process. The container is mounted for limited horizontal motion and unrestrained vertical motion. A pair of out-of-phase multi-lobed camming rollers mounted on a rotatable shaft beneath the container is used to impart vibratory motion to the container.

Brief description of the drawing

Various objects and advantages of the present invention will be apparent from the following detailed description when considered in conjunction with the accompanydrawing, wherein:

FIG. 1 is an exploded perspective view of an apparatus including a container for receiving a batch of articles and a pair of camming rollers rotatably mounted beneath the container for imparting vibratory forces to the container to agitate the articles in accordance with the principles of the invention;

FIGS. 2 and 3 are side views of camming rollers, taken along lines 2—2 and 3—3 of FIG. 1, showing a plurality of camming lobes projecting from each roller and arranged in an out-of-phase relationship;

FIG. 4 is a side view, partially in section, of the apparatus of FIG. 1 together with a motor for rotating the camming rollers; and

FIG. 5 illustrates a furnace into which the apparatus of the present invention is moved to heat treat a bath of articles held in the container.

Detailed description

FIG. 1 illustrates an apparatus which can be used to agitate articles in practicing the method of the present invention. The agitating apparatus includes a base **19** having a pair of supports **21** and **22** mounted at opposite ends thereof. The support **21** includes an end plate **23** extending perpendicularly from the base **19** and a flat supporting member **24** projecting from the plate **23** toward the support **22** and parallel to the base **19**. Similarly, the support **22** includes an end plate **26** extending perpendicularly from the base **19** and a flat supporting member **27** projecting from the end plate **26** toward the support **21** and also parallel to the base **19**. A pair of plates **28** are welded to opposite sides of the base **19** between the supports **21** and **22** to prevent the base **19** from warping when it is subjected to elevated temperatures.

A shaft **31** of stainless steel is rotatably mounted to the base **19** by a pair of bearings **32** and **33** positioned adjacent to the supports **21** and **22**, respectively. The bearings **32** and **33** may be composed of a commercially available cobalt base material. The shaft **31** is fitted loosely into circular bores in the bearings **32** and **33** to allow for expansion of the shaft **31** at elevated temperatures. A first roller **34** is mounted to the shaft **31** adjacent to the bearing **32**. As shown in FIGS. 1 and 3, the roller **34** has a set of camming lobes **36** projecting therefrom and equidistantly spaced about the pheriphery of the roller **34**. Similarly, a second roller **37** is mounted to the shaft **31** adjacent to the bearing **33**. The roller **37** has a set of camming lobes **38** projecting therefrom and equidistantly spaced about the periphery of the roller **37**. As shown in FIGS. 2 and 3, the camming lobes **36** on the roller **34** are arranged in an out-of-phase relationship with respect to the caming lobes **38** on the roller **37**. To resist wear at elevated temperatures, the camming lobes **36** and **38** are

preferably composed of a cobalt base material. A shaft coupling **39** is mounted to the shaft **31** so that a shaft **41** (FIG. 4) of a motor **42** may be coupled to the shaft **31** to rotate the rollers **34** and **37**.

The apparatus also includes an article receiving container **43** (FIGS. 1 and 4) formed of a material, such as stainless steel or nickel, capable of withstanding elevated temperatures. Opposite ends of the container **43** rest upon the upper surfaces of the flat members **24** and **27**. In this manner, the container **43** is mounted for unrestrained vertical motion relative to the base **19**. The supports **21** and **22** are spaced from each other by a sufficient distance such that the end plates **23** and **26** are spaced from the sides of the container **43** (FIG. 4). Thus, horizontal movement of the container **43** in the axial direction of the shaft **31** is limited by the end plates **23** and **26**. A pair of arms **44** are mounted to the container **43** at the end thereof supported by the flat member **27**. The arms **44** project downward toward the base **19** and span the flat supporting member **27** when the bottom of the container **43** rests upon it. The arms **44** are spaced from opposite ends of the flat supporting member **27** and limit horizontal movement of the container **43** in a lateral direction from the shaft **31**. FIG. 1 illustrates a portion of one of the arms **44**, cut away from the container **43**, adjacent to the supporting member **27** and spaced therefrom by a distance *w*. Similarly, a pair of arms **46** are mounted to opposite ends of the container **43**. The arms **46** span the flat supporting member **24** and are spaced from the ends of the flat member **24**. Thus, the arms **46** cooperating with the flat supporting member **24** also limit horizontal movement of the container **43** in a lateral direction from the shaft **31**.

FIG. 5 illustrates a furnace **46** which is used to heat treat articles placed in the container **43**. The furnace **46** is divided into three zones maintained at different constant temperatures at which the steps of the heat treatment are performed. A first zone **47** is maintained at room temperature (approximately 70° F.) and is used to cool the articles after the heat treatment is completed and before the articles are removed from the furnace **46**. A second zone **48** is maintained at a first elevated temperature (approximately 450° F.), and a third zone **49** is maintained at a second constant elevated temperature (approximately 1500° F.).

The agitating apparatus of the present invention is positioned at the entrance end of the furnace **46** (FIG. 5) and rests upon a flat supporting surface **51** which extends into the furnace **46**. The shaft **31** is connected by the coupling **39** to an elongated shaft **41** extending from the motor **42**. The motor **42** is mounted to a movable table **52** which can be moved toward the furnace **46** to move the agitating apparatus along the surface **51** to desired positions in the temperature zones within the furnace **46**.

Method and operation

The method of the present invention will be described in connection with the heat treatment of a mass of elongated contacts, composed of iron-nickel alloy, which are plated with a highly conductive material, such as an alloy of copper and gold. It should be understood, however, that the present invention is not limited to this specific heat treating process, but may be employed in any technique for heat treating a batch of articles.

In the manufacture of sealed contact switches, it is necessary to heat treat the contacts, prior to assembly of the switch components, to obtain contacts having desired electrical and magnetic properties. The heat treatment is performed at a temperature of 1500° F. for a time period of approximately six minutes to magnetically anneal the contacts and to sinter the copper-gold plating to the iron-nickel alloy in order to improve the electrical conductivity. Subjecting the contacts to this elevated temperature produces diffusion of copper-gold layer into the iron-nickel alloy thereby improving the surface conductivity of the contacts. In addition, at this temperature, the contacts lose any residual magnetism, i.e., the contacts are magnetically annealed.

A problem arises because at elevated temperatures the contacts tend to bond together if they remain in stationary contact. For example, at a temperature of 1200° F. stationary contact between adjacent contacts for a matter of a few seconds results in thermal bonding of the contacts. At a temperature of 1500° F. adjacent contacts bond together unless the contact therebetween is almost instantaneous. The present invention obviates this difficulty by agitating the contacts during heat treatment to preclude any of the contacts from remaining in stationary contact and bonding together.

In practicing the method of the present invention, a batch of contacts is loaded into the container **43** of the agitating apparatus. At this time, the contacts are positioned randomly within the container **43** with adjacent contacts overlying one another. Then the movable table **52** is advanced toward the furnace **46** to move the apparatus through an opening in the front end of the furnace **46** to position the apparatus in the temperature zone **49** where the temperature is 1500° F.

At the same time, the motor **42** is energized to rotate the shafts **31** and **41** and the rollers **34** and **37**. Rotation of the rollers **34** and **37** brings the camming lobes **36** and **38** into engagement with spaced sections of the bottom of the container **43**. Since the sets of camming lobes **36** and **38** are arranged in an out-of-phase relationship, opposite ends of the container **43** are alternately engaged thereby. When any one of the camming lobes moves into engagement with the bottom of the container **43**, horizontal frictional forces and vertical lifting forces are exerted on the container **43**.

It should be noted that at those sections of container **43** which are engaged by the camming lobes **36** and **38** a tungsten-carbide facing is formed on the container bottom to resist wear at the elevated temperature to which the apparatus is subjected. The agitating apparatus may be provided with a screen which fits over the container **43** to protect the contacts from flame impingement associated with zone **49** of the furnace **46**.

Since the container **43** is mounted for unrestrained vertical movement, the vertical forces imparted to the container **43** by the camming lobes **36** and **38** are unopposed. Thus, opposite ends of the container **43** are alternately lifted from the flat supporting members **24** and **27** to vibrate the container **43** with a tilting motion and agitate the contacts held therein. The horizontal forces exerted on the container **43** tend to move the container **43** horizontally in a direction away from the shaft **31**. Since horizontal movement of the container **43** is limited by the arms **44** and **46** cooperating with the flat supporting members **24** and **27**, the effect of these forces on the container **43** is limited but horizontal vibrations are imparted to the container **43**. As described above, horizontal movement of the container **43** in the axial direction of the shaft **31** is limited by the end plates **23** and **26**. Thus, any horizontal movement associated with the tilting motion imparted to the container **43** by the lifting forces exerted by the camming lobes **36** and **38** is confined between the end plates **23** and **26**.

The vibratory motion of the container **43** imparts random, agitated motion to the contacts. Because of the limitations on horizontal movement of the container **43**, the motion of the contacts is primarily in the vertical direction.

It has been determined experimentally that this vertical motion is important in preventing the contacts from bonding together. In order to prevent thermal bonding of the contacts, it is necessary to interrupt stationary contact between adjacent contacts subjected to elevated temperatures. Thus, sufficient vibratory forces must be imparted to the container **43** to agitate the contacts continuously such that any stationary contact therebetween

is merely instantaneous and not of sufficient duration to permit bonding.

After the contacts are subjected to the elevated temperature of 1500° F. for six minutes, the agitating apparatus is moved to the zone **48** of the furnace **46** where the temperature is maintained at 450° F. The vibratory motion of the container **43** is continued until the contacts have cooled to this temperature. Since the 450° F. temperature is not sufficient to bond the contacts together, the vibration of the container **43** can be terminated without the danger of thermally bonding the contacts. At this time, the motor **42** is deenergized to discontinue the rotation of the rollers **34** and **37** and the agitating apparatus is moved to the cooling zone **47** of the furnace **46** where the contacts are cooled to room temperature (approximately 70° F.). When the contacts have cooled to this temperature, the agitating apparatus is removed from the furnace and the heat treatment of the contacts is completed.

In one example of the present invention, an agitating apparatus in which the rollers **34** and **37** were provided with six camming lobes, ⅛ inch in height, was used to agitate a mass of contacts (approximately 15,000) during heat treatment at a temperature of 1500° F. It was noted that bonding of the contacts did not occur when the shaft was rotated at a speed of 500 r.p.m.

The utility of the method and apparatus of the present invention is not limited to the heat treatment of plated contacts to sinter the plated material to the contacts. The present invention may be employed in any heat treating process in which it is desirable to heat treat a mass of fusible articles without bonding the articles together. The above-described method and apparatus are merely illustrative of the principles of the present invention, and modifications in the steps of the method and in the elements of the apparatus can be made by persons having ordinary skill in the art without departing from the scope of the invention.

What is claimed is:

1. A method of heat treating a mass of articles to prevent the articles from bonding together, which comprises:

subjecting the mass of articles to an elevated temperature of sufficient value to normally bond the mass of articles when said articles are in stationary contact and subjected to said temperature for a predetermined time, and

agitating the mass of articles to impart continuous relative movement to the articles to preclude stationary contact between any of the articles for said predetermined time whereby the articles are prevented from bonding together.

2. A method of preventing a mass of fusible articles loaded into a container from bonding together during heat treating of the articles by precluding stationary contact between any of the articles for a predetermined time, which comprises:

alternately subjecting spaced sections of the container to vibratory forces having both horizontal and vertical force components, and

restraining horizontal movement of said container resulting from the horizontal components of said vibratory forces while permitting unrestrained vertical movement of said container resulting from the vertical components to impart continuous relative movement to the articles so as to preclude stationary contact between any of said articles for the predetermined time.

3. A method of heat treating a batch of plated articles to sinter the plated material to the article without bonding the articles together, comprising:

applying heat to the batch of plated articles to raise the temperature thereof sufficiently to sinter the plated material to the articles and to normally bond the batch of articles when said articles are in stationary contact and subjected to the raised temperature for a predetermined time, and

agitating the batch of articles during the application of heat to interrupt contact between the articles to prevent the articles from remaining in stationary contact for said predetermined time and bonding together.

4. A method of heat treating a batch of iron-nickel contacts, plated with a copper-gold alloy, to sinter the copper-gold alloy to the iron-nickel contacts and to magnetically anneal the contacts without bonding the contacts together, which comprises:

applying heat to the batch of contacts to raise the temperature thereof sufficiently (1) to magnetically anneal the contacts, (2) to sinter the copper-gold alloy to the iron-nickel contact, and (3) to normally bond the batch of contacts when said contacts are in stationary contact for a predetermined time, and

imparting sufficient agitation to the contacts during the annealing and sintering treatment to interrupt contact between the articles to prevent the articles from remaining in stationary contact for said predetermined time and bonding together.

5. In an apparatus for agitating a batch of articles during heat treatment thereof to prevent adjacent, contacting articles from bonding together:

a container for receiving the batch of articles,

means mounting said container for limited horizontal movement and unrestrained vertical movement, and

means for vibrating said container to impart limited horizontal movement and unrestrained vertical movement thereto to agitate the batch of articles to interrupt contact between adjacent articles to prevent bonding together of the articles during the heat treatment.

6. In an apparatus for agitating articles:

a container for receiving the articles,

a base,

means mounting said container to said base for limited horizontal motion and unrestrained vertical motion, and

means for alternately raising and lowering opposite ends of said container to tilt said container relative to said base to impart limited horizontal and unrestrained vertical motion thereto to agitate the articles.

7. In an apparatus for agitating articles, as set forth in claim **6**, wherein the means for alternately raising and lowering the opposite ends of the container comprises:

a shaft rotatably mounted to said base beneath said container,

first and second rollers mounted to said shaft in a spaced relationship therealong and positioned beneath opposite ends of said container,

a first set of camming lobes projecting from said first roller and equidistantly spaced about the periphery thereof,

a second set of camming lobes projecting from said second roller, equidistantly spaced about the periphery of said second roller and arranged in an out-of-phase relationship with respect to said first set of camming lobes, and

means for rotating said shaft and said rollers to bring the camming lobes on said rollers alternately into engagement with the bottom of said container to raise and lower the opposite ends of said container whereby the articles are agitated.

8. In an apparatus for agitating a batch of articles during heat treatment thereof, at a temperature of sufficient value to bond together articles in stationary contact for a predetermined time, to prevent bonding of the articles, comprising:

a base,

a container for receiving the batch of articles,

a pair of supports located at opposite ends of said base

for mounting said container for limited horizontal movement and unrestrained vertical movement relative to said base,

first and second rollers rotatably mounted to said base beneath the opposite ends of said container, said rollers having out-of-phase camming surfaces for engaging the bottom of said container, and

means for rotating said rollers with sufficient speed to bring said camming surfaces alternately into engagement with the bottom of said container to impart sufficient vibratory forces having horizontal and vertical components thereto to rock said container on said supports to agitate the articles and preclude stationary contact therebetween for the predetermined time whereby bonding of the articles is prevented.

9. In an apparatus for agitating articles:

a base,

a pair of supports mounted at opposite ends of said base, each support having an end plate extending perpendicularly from said base and a flat member projecting from said plate, parallel to said base, toward the other support,

an article receiving container having opposite ends thereof resting upon said flat members between and spaced from the end plates,

a pair of arms mounted at each end of said container, projecting downward toward said base, each pair of arms spanning and spaced from the flat member for supporting the end of said container to which the arms are mounted, and

means for alternately raising and lowering the opposite ends of said container to vibrate said container on said supports with a horizontal movement that is limited by said legs engaging said flat member and said container engaging said end plates, and a vertical movement that is unrestrained, to impart random, agitated motion to the articles.

10. In an apparatus for agitating articles, as set forth in claim **9**, wherein the means for alternately raising and lowering the opposite ends of the container comprises:

a shaft rotatably mounted to said base between said supports and beneath said container,

first and second rollers mounted to said shaft beneath the opposite ends of said container,

a first set of camming lobes projecting from said first roller and equidistantly spaced about the periphery thereof,

a second set of camming lobes projecting from said second roller, equidistantly spaced about the periphery of said second roller and arranged in an out-of-phase realtionship with respect to said first set of camming lobes, and

means for rotating said shaft and said rollers to bring the camming lobes on said rollers alternately into engagement with the opposite ends of said container to raise and lower said opposite ends to impart random, agitated motion to the articles.

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U.S. Cl. X.R.

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