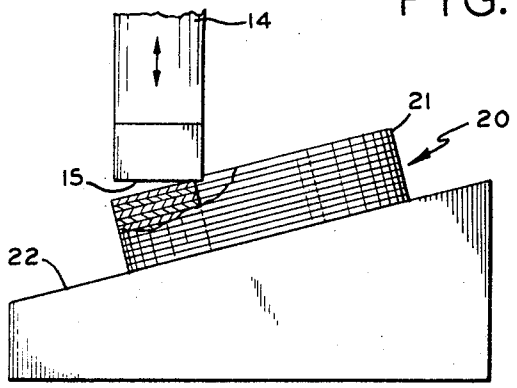
Sept. 17, 1968 E. G. OBEDA ET AL 3,401,446

METHOD FOR DELAMINATING ARTICLES

Filed April 7, 1966

FIG. 1



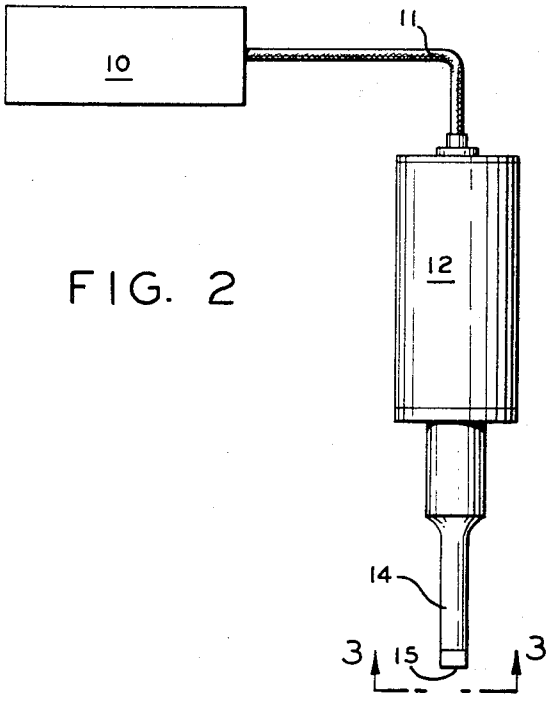
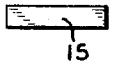


FIG. 2

FIG. 3



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METHOD FOR DELAMINATING ARTICLES

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This invention concerns a method for separating or delaminating bonded articles and, more specifically, refers to a method for delaminating relatively thin articles which are held temporarily in stack form.

Quite specifically, the present invention concerns a method for separating articles, such as circular disks and washers, which are arranged in stack form, possibly under compression, and are subjected to treatment, for instance heat treatment, and then must be separated from one another.

A typical example of this type concerns the manufacture of standard steel washers which are machined or stamped from raw stock material, then bolted together to form a stack, and heat treated which includes oil quenching. Under the influence of the heat, the oil used for quenching decomposes and bonds the washers to one another. Subsequently, it is necessary to separate the individual washers from the stack, a procedure which heretofore has proven to be rather cumbersome and time consuming. Typically, the individual washers are separated by a light pounding action, being careful not to damage the individual washer edges, or using a knife edge and separating each washer consecutively by a prying action. In this manual manner it has been possible to separate only about a thousand washers per hour.

One of the important objects of this invention is, therefore, the provision of a new and improved method for delaminating elements from a stack, avoiding one or more of the shortcomings and limitations of the prior art.

Another important object of this invention is the provision of a new and improved method for delaminating elements in a more expeditious and convenient manner.

Another important object of this invention is the provision of an improved procedure for delaminating elements using sonic vibrations.

A further important object of this invention is the provision of an improved method and arrangement for delaminating plates and disks which are bonded temporarily to each other as the result of a preceding treatment.

Further and still other objects of this invention will be more clearly apparent by reference to the following description, when taken in conjunction with the accompanying drawings, in which:

FIGURE 1 is a schematic view of the typical arrangement for practicing the method described herein;

FIGURE 2 is a schematic illustration of the ultrasonic apparatus for applying sonic energy to the stack of elements, and

FIGURE 3 is a view along lines 3—3 in FIGURE 2.

The invention, as indicated heretofore, concerns typically the method for separating plates and disks, for instance steel washers, after heat treatment. The washers are generally bolted together in stack form by means of a central bolt and heat treated which includes an oil quench. Under the influence of heat, the oil confined between the sides of the washers decomposes and the tacky residue bonds the washers to one another. After the removal of the central bolt the washers still adhere to one another and must be separated individually. Separation or prying loose of individual washers is done by means of light pounding, a knife edge or other manual means which are not satisfactory. Also, in many instances, this haphazard manual operation damages the outer edges of

washers and a certain number thereof no longer meets rigid inspection standards.

Tests have shown that delamination of such elements can be accomplished quite readily by the use of sonic energy, such as is provided by the apparatus schematically illustrated in FIGURE 2 wherein numeral **10** refers to a high frequency generator which provides electrical energy at approximately 20 kc. per second via a cable **11** to an electro-acoustic converter unit **12**. The converter **12** converts the electrical energy supplied by means of a piezoelectric element or a magnetostrictive transducer to mechanical vibrations as is well known to those skilled in the art. The converter unit **12** is fitted with an output horn **14** which amplifies the mechanical vibrations.

A typical generator **10** with converter **12** and a horn **14** coupled thereto may be purchased commercially from Branson Sonic Power, a Division of Branson Instruments, Inc., Danbury, Connecticut, under Model No. J–17V or J–32. In the typical case, the horn **14** is a bar horn, having a rectangular frontal surface **15** as seen in FIGURES 2 and 3, the frontal surface being 2 inches long by ⅜ inch wide.

The ultrasonic unit, when energized, provides at the frontal surface **15** longitudinal vibrations at 20,000 cycles per second and an excursion of approximately 0.002 inch. One important characteristic of this vibration to be noted is the inherently high acceleration, it being in the order of 1,000 g. and more.

When during tests the vibrating frontal surface **15** of the horn **14** was first applied to the outside edge **21** of a stack of washers **20**, FIGURE 1, delamination of the washers occurred in groups of two or three, the washers with such a group remaining bonded to one another. Using the same arrangement on the face of the stack no significant improvements were achieved. However, a vast improvement was discovered by arranging the stack of washers **20** on an inclined plane **22** and contacting the topmost washer with the horn **14** at a location along the rim of the central aperture as shown in FIGURE 1, the horn being held vertically and the frontal surface **15** being disposed generally along a radial axis of the washer. Under these conditions the topmost washer always detached itself from the stack and this process could be repeated until each washer was delaminated singly from the stack.

It is believed that this surprising result can be attributed to the fact that the energy imparted to the topmost washer applies a shear force to the bond of the juxtaposed washers, such shear force being parallel to the juxtaposed sides. The relatively high acceleration inherent in the vibrations weakens the adhesive bond and ultimately breaks the adhesion, causing the topmost washer to slide from the stack so that the process can be repeated with the next washer, now in the topmost position. The frequency of twenty kilocycles per second stated is convenient since the noise is in the ultrasonic or inaudible frequency range, but no particular limitation shall be implied.

The above described arrangement was tested with washers ranging from 2 inch outside diameter to 5 inch outside diameter and having a thickness ranging from 0.030 inch to 0.100 inch. Steel washers could be separated at the rate of 15,000 pieces per hour.

It will be apparent, therefore, that the arrangement described and illustrated in FIGURE 1 is very convenient for separating elements which are bonded to each other by a separable bond, and that the unsatisfactory means and methods used heretofore are avoided.

While there has been described and illustrated a preferred embodiment of the present invention, it will be apparent to those skilled in the art that various changes and modifications may be made without deviating from

the intent and spirit of this invention, which shall be limited only by the scope of the appended claims.

What is claimed is:

1. The method for delaminating elements which are bonded together along parallel sides in a stack comprising: contacting a selected element which is to be separated from the stack with an instrumentality vibrating at least at 1000 cycles per second, the peak acceleration of said vibrations applied to said selected element in a manner to develop a force having a shear component and being of sufficient magnitude to weaken and break the bond between said selected element and the other elements remaining in said stack.

2. The method for delaminating elements as set forth in claim 1 wherein said instrumentalty is driven in the ultrasonic frequency range.

3. The method for delaminating elements as set forth in claim 1 wherein said instrumentality is an acoustic horn coupled to an electro-acoustic converter.

4. The method for delaminating elements as set forth in claim 1 wherein said elements are flat metal washers.

5. The method for delaminating flat washer-like apertured elements which are bonded together in a stack comprising the steps of:

supporting said stack of elements on an inclined surface;

contacting the end element to be separated from said stack with a sonically vibrating instrumentality, such contact being made substantially at a location near the edge of said aperture and in a manner to cause a shear force in the bond holding said end element to said stack, and

said instrumentality vibrating at an ultrasonic frequency and with a peak acceleration sufficient to weaken and break the bond which holds said end element to said stack.

6. The method for delaminating elements as set forth in claim 5 wherein said instrumentality is applied consecutively to the element which constitutes one of the two end elements in said stack.

7. The method for delaminating as set forth in claim 5 wherein said stack of elements is supported so that the flat surface of one of the end elements rests on said inclined surface, the longitudinal axis through said stack intersects the plane of the inclined surface, and said instrumentality is brought into contact with the other end element.

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