May 29, 1951 J. C. HACKETT ET AL 2,554,701

TREATMENT OF ARTICLES TO REMOVE SOME OF THE OUTSIDE MATERIAL THEREFROM OR TO POLISH THE SAME

Filed March 4, 1947 2 Sheets-Sheet 1

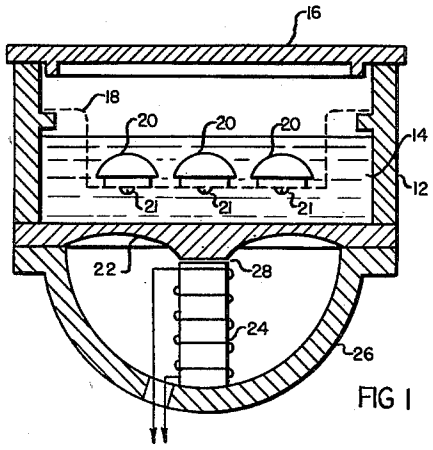

FIG 1

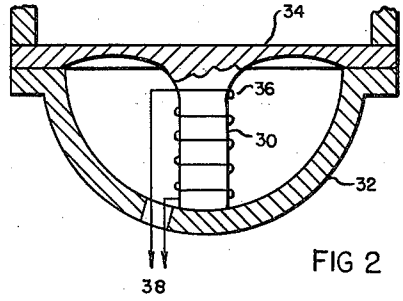

FIG 2

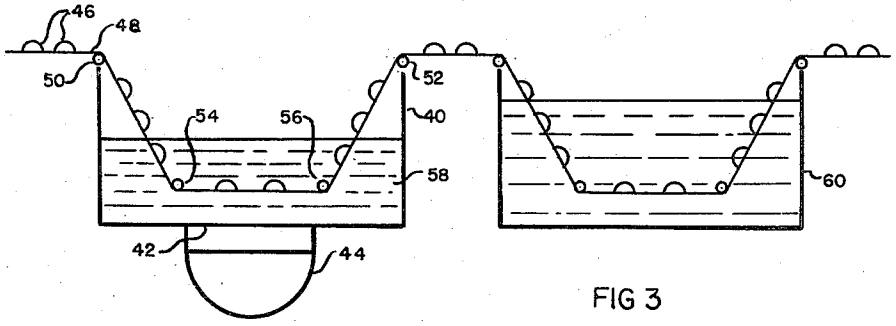

FIG 3

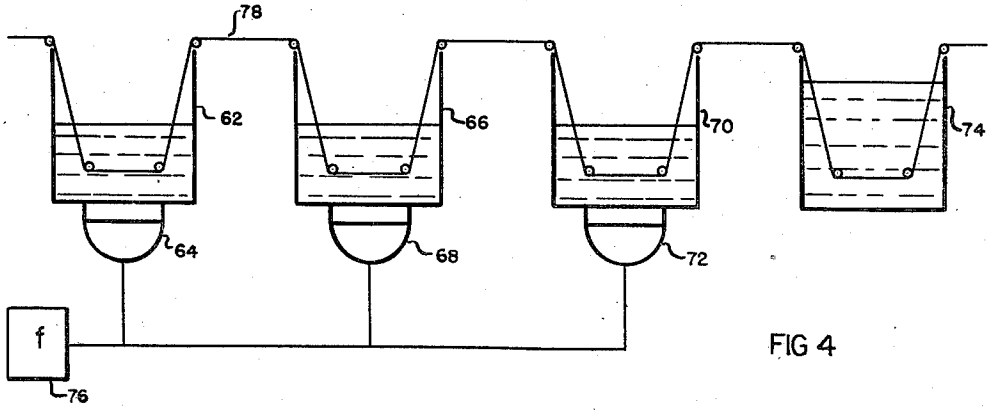

FIG 4

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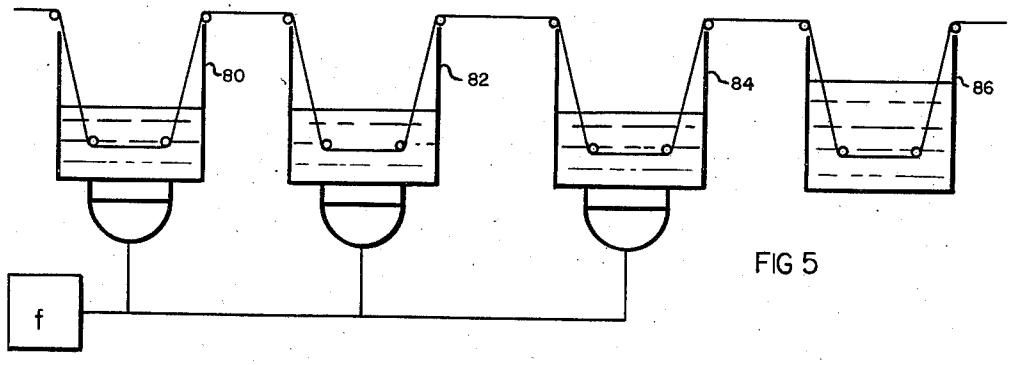

FIG 5

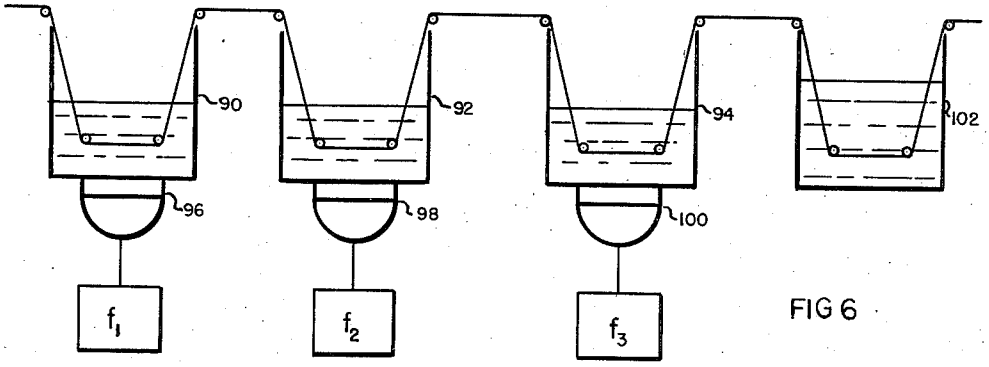

FIG 6

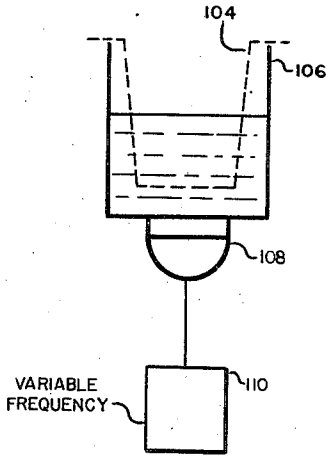

FIG 7

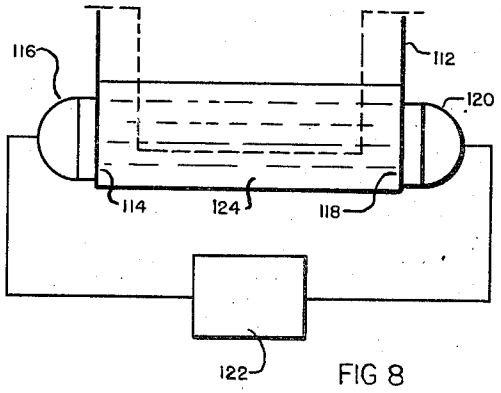

FIG 8

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Patented May 29, 1951

2,554,701

UNITED STATES PATENT OFFICE

2,554,701

TREATMENT OF ARTICLES TO REMOVE SOME OF THE OUTSIDE MATERIAL THEREFROM OR TO POLISH THE SAME

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Application March 4, 1947, Serial No. 732,196

4 Claims. (Cl. 51—281)

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This invention relates to the removal of some of the outside material from articles, and more particularly to the buffing or polishing of articles.

Heretofore objects and manufactured articles have been buffed or polished by hand rubbing, and by means of polishing wheels, such as brushing wheels, buffing wheels, and so on. Polishing compounds such as those using tripoli and similar abrasives are commonly used. Polishing in this manner requires considerable manual work, of distasteful character because of the grit-laden atmosphere. Moreover, the buffing or polishing action is most pronounced on convex or raised surfaces, and may not reach recessed surfaces at all.

This problem applies to metal objects whether cast, stamped, formed, coined or machined, and also applies to plastics, ceramics and glass.

In an effort to overcome the foregoing difficulties some work has been done in the field of electrolytic polishing, but this is of very limited use. It is applicable solely to certain metals, under special favorable conditions.

It has also been suggested that the article to be polished be immersed in a liquid having abrasive particles suspended therein, and that the liquid suspension be vibrated. The primary object of the present invention is to improve this method. A more particular object is to provide an improved method to obtain a finer or higher quality of polish.

To accomplish the foregoing general objects, and other more specific objects which will hereinafter appear, our invention resides in the method steps and apparatus elements, and their relation one to the other, as are hereinafter more particularly described in the following specification. The specification is accompanied by drawings, in which:

Fig. 1 is a section schematically illustrating one form of apparatus for practicing the invention;

Fig. 2 is a similar section through the lower portion of a modified form of apparatus;

Fig. 3 diagrammatically illustrates apparatus including a conveyor belt;

Fig. 4 diagrammatically illustrtaes a modification in which degreasing and rinsing are aided by vibrators;

Fig. 5 diagrammatically illustrates a modification for buffing in successive stages by changes in the abrasive employed;

Fig. 6 is a similar view of an apparatus for buffing in successive stages by changes in the vibration frequency;

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Fig. 7 is explanatory of buffing in successive stages in a single tank; and

Fig. 8 is explanatory of a modification in which the liquid is vibrated by diaphragms acting in push-pull.

Referring to the drawing, and in particular to Fig. 1, the apparatus there shown comprises a container 12 for a body of liquid 14, the latter containing abrasive particles. The container may be made substantially higher than the liquid level, or in the alternative a removable cover 16 may be employed as shown. The apparatus further includes means 18 to support one or more articles 20 in the liquid. There is also a means 22 to vibrate the liquid 14 at a relatively high frequency. In the present case, the liquid is vibrated at a sonic frequency by a diaphragm which acts as the bottom wall of the container. The support 18 is a highly perforate grid or basket. The diaphragm 22 is vibrated by means of an electromagnet 24, the said diaphragm forming a part of a magnetic circuit 26 having an air gap 28. The magnetic coil is connected to a suitable source of sonic frequency power.

It should be noted that the articles 20 are spaced apart and are preferably held in spaced relation to prevent one article from rubbing against or abrading another. In the present case this is indicated by the use of screws 21 which fasten the articles to the support 18. It will be understood, however, that the mounting means will vary in different cases according to the nature and configuration of the articles sought to be polished.

A modification of the vibrator portion of the apparatus is schematically shown in Fig. 2. This differs from Fig. 1 primarily in using a steel rod 30 fixedly connected between the housing 32 and the diaphragm 34. The diaphragm is vibrated by magnetostrictive elongation and contraction of the rod 30 in response to an alternating magnetic field applied thereto by the coil 36. The conductors 38 are connected to a sonic or supersonic frequency source of power.

In operation the abrasive particles are relatively fine and tend to remain in suspension in the liquid, but even if not, would be put into suspension upon operation of the vibrator. An elementary and perhaps too simplified explanation is that the liquid in the tank acts as a means to transfer vibration from the diaphragm to the abrasive particles, which in turn contact and buff the surface of the article immersed in the liquid. Concave surfaces as well as convex surfaces are

buffed, so that articles of complex configuration are given a substantially uniform polish.

Other liquids, for example oil, may be used instead of water, and in fact in some respects oil may be better than water, but in most manufacturing processes oil would have the disadvantage of requiring a separate degreasing operation which is not needed when using plain water.

The polish obtained by our new buffing method is a smooth high polish, and is better than that obtained by the use of an equivalent size grit in some other method, such as the use of a buffing wheel. For example, in using a 125 grit emery abrasive, the polish obtained was substantially equivalent to that which would be obtained in ordinary polishing methods by using a much finer abrasive, say 1200 grit.

The difference is probably due to the controllable uniform amplitude of vibration, the controllable high speed of the vibration, the controllable uniform pressure (which runs higher in a system of this type than might be expected), and perhaps also due to the fact that the abrasive particles contact the surface of the article to some extent by impact as well as by surface rubbing or buffing. This suggested explanation is not intended in limitation of the invention, and the improvement in polish for a given grit size may be considered an empirical discovery, regardless of what may later be found to be the true theory.

Fig. 3 of the drawing illustrates how the invention may be used for quantity production, as by means of a belt conveyor. In Fig. 3 the polishing tank is shown at 40. A diaphragm 42 constitutes a part of the bottom wall of the tank, and is vibrated by means of a suitable vibrator unit 44. The articles 46 to be polished are secured to a conveyor belt 48, which is guided over rollers 50 and 52 at the top of the tank. The tank is made substantially higher than the liquid level in order to avoid the use of a cover. Auxiliary rollers 54 and 56 engaging only the edges of the conveyor operate to immerse a section of the conveyor in the liquid 58. The liquid contains an abrasive, as previously explained. The articles 46 are secured in spaced relation on the conveyor belt, and it will be evident that by properly adjusting the speed of belt, the articles will be polished in continuous succession.

A rinsing tank 60 may be provided immediately after the polishing tank 40, thereby removing any grit or abrasive left on the article when leaving the tank 40. It will be noted that the liquid level in the tank 60 may be substantially higher than that in the tank 40, for the tank 60 is not provided with a vibrator. It will be understood that several such tanks may be used, including degreasing tanks in addition to ordinary rinsing tanks. If desired, the degreasing and rinsing tanks may be provided with vibrator units in order to provide a more thorough degreasing and/or rinsing. However, such tanks will not contain abrasive particles, as in the polishing or buffing tanks of our invention.

Such an arrangement is illustrated in Fig. 4, in which tank 62 is a buffing tank having a vibrator unit 64; tank 66 is a degreasing tank having a vibrator unit 68; tank 70 is a first rinsing tank having a vibrator unit 72; and tank 74 is a second rinsing tank which does not have a vibrator unit. The vibrator units 64, 68 and 72 may all be energized from a common source 76 if they are operated at a common frequency. Separate sources may be employed if different frequencies are desired for the different operations. It will be understood that the conveyor belt 78 is equivalent to that shown in Fig. 3, and that it is similarly guided by rollers not shown in Fig. 4. It will also be understood that a series of articles to be buffed are secured in successive stages. Thus, if the surface of the article is fairly rough, it may be found desirable for high operating speed to first polish coarsely, and to then polish more finely. An arrangement for this purpose is schematically illustrated in Fig. 5 in which the tanks 80, 82 and 84 are all buffing tanks containing liquid with abrasive particles suspended therein, but in which the abrasive in tank 80 differs from that in tank 82, which in turn differs from that in tank 84. The abrasive may differ in nature, or in size of grit, or in density of grit relative to the quantity of liquid. In most ordinary cases the relatively coarse abrasive will be used in the first tank 80; a finer or/and softer abrasive in the second tank 82; and a still finer or/and softer abrasive in the tank 84. If the density of the abrasive is varied, it will be most dense in tank 80; less dense in tank 82; and least dense or most dilute in tank 84. The fourth tank 86 is simply a rinsing tank. If desired, multiple rinsing tanks may be employed, as was explained in connection with Fig. 4.

We have found that the degree of the polish obtained may be varied by changing only the vibration frequency exciting the apparatus. An arrangement based on this principle is shown in Fig. 6, in which the polishing tanks 90, 92 and 94 all contain the same abrasive particles. However, the vibrator 96 of tank 90 is vibrated at one frequency; the vibrator 98 of tank 92 is vibrated at a different frequency, and the vibrator 100 of tank 94 is vibrated at still another frequency. In most cases the frequency will progressively increase, that is, lower frequencies will be used in tank 90 for the coarse polish, while a higher frequency will be used in tank 92 for a finer polish, and a still higher frequency in tank 94 for the final polish. Tank 102 is a rinsing tank, and here again it will be understood that multiple rinsing tanks may be employed, as was described in connection with Fig. 4.

Fig. 7 illustrates how an article may be polished in stages in a single tank. In this case the article is mounted on a support 104, immersed in the abrasive liquid of a tank 106 having a vibrator 108, the vibrator being connected to a variable frequency source 110. By changing the frequency from a relatively low frequency to a higher frequency, the article will be buffed in stages, although kept continuously in a single tank.

In connection with Fig. 6 and Fig. 7, the change in frequency may be obtained conveniently by using harmonics of a lower frequency. The use of harmonics will in many cases have the advantage of keeping an efficient relationship between the electrical frequency and the natural resonance frequency of the apparatus. When using a piezo-electric or magnetostrictive effect, the use of harmonics is even more important, because of the inherent nature of the driver.

In Figs. 1 through 7, a single vibrating diaphragm has been shown. It will be understood, however, that multiple diaphragms may be em-

ployed, and in Fig. 8 a tank 112 is shown having a diaphragm 114 and vibrator unit 116 at one end, and a diaphragm 118 and vibrator unit 120 at the opposite end. These vibrators are connected to a single power source 122, but are connected in phase opposition. Thus, the diaphragm 114 will advance or push when the diaphragm 118 retracts or pulls. This efficiently sets the body of liquid 124 and its suspended abrasive particles into vibration. The diaphragms 114 and 118 preferably form a part of the wall of the container, as shown. It is sufficient that they be spaced well apart, and they may both form a part of the bottom wall, for example, but it is preferable that they form parts of opposed walls of the container, as here shown.

Either a sonic or supersonic frequency of vibration may be employed. In general, it is simpler and easier to produce a sonic frequency vibration, for it is not essential in that case to employ vacuum tube oscillators and amplifiers, etc., although they may be used. On the other hand, a supersonic vibration has the advantage of avoiding the loud and disturbing noise produced by sonic equipment. (Even in the case of supersonic vibration, however, care must be taken not to employ a frequency which may adversely affect personnel working around the equipment.)

It will be understood that the vibration of the mechanical network may be produced in any of the known or conventional ways. It may be produced by mechanical means. The diaphragm may be vibrated by direct magnetic effect. It may also be vibrated by the use of a coil movably mounted in a suitable magnetic field, for example, a D. C. field, the coil carrying an excitation current, for example, a pulsating or an A. C. current. This would be analogous to the operation of a so-called "dynamic" loud speaker. The diphragm may also be vibrated by the used of a piezo crystal, for example, a quartz or a rochelle salt crystal.

The alternating current may be obtained from any conventional apparatus, such as a vacuum tube oscillator, or a frequency multiplier, or a motor-driven generator. A variable frequency source may be employed if it is desired to vary the frequency in accordance with the size of the objects being treated, or the hardness or/and the mass of the metal or plastic being treated.

It is believed that the method and apparatus of our invention as well as the advantages thereof will be apparent from the foregoing detailed description.

It will be understood that while we have illustrated apparatus in which the liquid and abrasive are vibrated relative to the article, the article instead may be vibrated relative to the liquid and its abrasive. Moreover, the article and the liquid both may be vibrated in suitable phase relation to each other to obtain the desired result.

The elementary explanation that the diaphragm vibrates the liquid and the abrasive particles in contact with the article, may be too simplified. Depending on how the article is suspended or held in the liquid, it too may be coupled to some extent to the source of vibration by the action of the liquid. Moreover, in an assembly of this sort, the volume and weight of the liquid mixture, etc., usually goes to form the mechanical equivalent of an impedance matching network which loads the entire system, keeping it in resonance with the excitation frequency.

The vibration may be obtained by using pulsating D. C. power, instead of A. C. power. Thus, for magnetic striction it is sufficient that the magnetic field build up and collapse at the desired frequency, the polarization of the field being unimportant.

It will also be understood that vibration may be produced in ways other than those specifically illustrated, as for example, by using a Hartmann and Trolles supersonic generator. This employs a high-velocity air jet. Simple mechanical means such as a motor-driven, high-speed eccentric shaft may be used. The vibrations may also be produced by explosions in a resonant chamber.

Spaced diaphragms may be used in a single tank without operating them in push-pull. Thus, multiple diaphragms may be disposed in a single wall and all be operated in unison. Or several spaced diaphragms may be operated with a difference in phase, but without necessarily being in phase opposition.

Moreover, basically, it is not even essential that there be a flexible diaphragm in an otherwise rigid wall. In theory, the entire tank may be vibrated, or in contrast with that, a vibratile diaphragm with its driver may be suspended in the liquid without touching or forming a part of the tank wall, in which case the tank wall need not be vibrated at all. However, it is believed that in every case it may be said that there is some form of mechanical network which is set into vibration as an entirety.

Almost any material may be polished, including not only metals, plastics, ceramics and glass, but also sintered materials.

A degreasing tank having a vibrator unit may, if desired, also include abrasive material, thus combining some polishing with the degreasing operation.

Various kinds of conveyors may be used in lieu of the belt schematically illustrated in the drawing. For example, overhead conveyors of known type may be employed, having arms which raise and lower the articles as they are moved from tank to tank.

A further point which may be mentioned is that in the case of certain special types of article, the article may itself act as a tank for the liquid. For example, if it be desired to polish the interior of an engine cylinder or other such hollow object, the abrasive-carrying liquid may be placed directly in the cylinder, and one or more vibrating units placed at the ends of the cylinder.

It will therefore be apparent that while we have shown and described the invention in several preferred forms, changes may be made in the method and apparatus shown without departing from the spirit of the invention as sought to be defined in the following claims. In the claims, the term "polish" is not intended to necessarily require the removal of material, there being some question as to whether material is actually removed or need be removed when polishing.

In the claims, the reference to vibration of the liquid is intended in a relative sense, for, if desired, the article being polished may be vibrated by the driver, relative to the liquid in which it is immersed, or both may be vibrated with a difference in phase such as to produce a relative vibration.

We claim:

1. The method of polishing an article in successive stages, which includes immersing the article in a liquid having abrasive particles and vibrating the liquid at a first frequency, then immersing the article in a liquid having abrasive

particles and vibrating the liquid at a different frequency.

2. The method of polishing an article in successive stages, which includes immersing the article in a liquid having abrasive particles and vibrating the liquid at a first frequency, then immersing the article in a liquid having abrasive particles and vibrating the liquid at a higher frequency.

3. The method of polishing an article in successive stages, which includes immersing the article in a liquid having abrasive particles, vibrating the liquid at a first frequency, thereafter vibrating the liquid at a second frequency.

4. The method of polishing an article in successive stages, which includes immersing the article in a liquid having abrasive particles, vibrating the liquid at a first frequency, thereafter vibrating the liquid at a higher frequency.

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