FINISHING AND POLISHING METHOD

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This application is a continuation-in-part of my application Serial No. 48,736, filed August 10, 1960, now abandoned, for Finishing and Polishing Method and Apparatus.

The invention relates to the finishing and polishing of metal parts or the like and particularly to a new and improved method for producing markedly new and better finish on such parts when they are finished by means of vibration in a mass with stone chips or the like under the influence of a vibrator.

Herefore it has been the practice to polish metal parts in this way and the surface has generally been well smoothed and burrs and the like have been removed, but the parts themselves have been materially off color or darkened.

Apparently there was no way to avoid this when the parts were finished as set forth above.

Herefore, in carrying out the aforesaid finishing or polishing of metallic parts it has been the practice to employ a finishing or polishing machine comprising a tub with a semi-cylindrical bottom. Mounted directly on the tub there has been a vibrator comprising an electric motor driving an eccentric weight which rotates on an axis parallel to the axis of the semi-cylindrical bottom of the tub.

The tub and the vibrator are supported as a unit for independent movement in space on suitable spring mountings. The parts to be finished are placed in the tub along with the stone chips or other polishing materials which are generally abrasive in nature. However, the polishing medium may be steel balls or some other suitable particles.

When the vibrator is actuated, the mass of polishing medium and the parts are vibrated with the result that there is minute vibratory motion between the parts and the polishing medium and a further en masse orbital movement of the mass about an axis extending generally parallel to the axis of the semi-cylindrical bottom of the tub.

The vibrations impart a vibratory rubbing motion between parts of the mass and a gentle tumbling motion of the entire mass and the result is a speedy complete finishing or polishing of the parts.

In many instances, a liquid finishing compound is added to the mass. It is common to include in such finishing compound detergents such as soap or the commercial surfactants or wetting agents which employ hydrophobic or lyophobic radicals and which tend to maintain the surface free from objectionable deposits. There may also be included such compounds as rust inhibitors and brighteners such as alkylamides which are particularly useful in giving a suitable finish to dye castings of zinc base alloys.

When reference is made herein to finishing compounds, it is intended to encompass all such compounds as those described above or equivalent or similar compounds which are generally used in connection with the finishing of metallic parts in tumbling barrels or equipment similar to that described above.

When the various finishing compounds described above are employed in the vibratory polishing equipment, they tend to lose their effectiveness as the treatment continues. The heat or friction of the violent mechanical action and rubbing of the parts and finishing materials together tends to break down soap base compounds and the synthetic surfactants or detergents above mentioned, to the point where there is a definite tendency to alter their effectiveness as surface active agents. The breakdown leads to the formation of metallic soap scums and scums and gelatinous precipitates which tend to produce dirty parts.

There is also a tendency for foam to build up in the tub. In addition, there is a tendency for the fines or other sediment to collect in the liquid finishing compounds and it is believed that because of this the parts finished by the above described vibration process are many times given a dark surface color which is difficult, if not impossible, to remove due to the rubbing of the parts with the fines or sediment either from the parts or the finishing medium present in the mass.

In some instances this may lead to scratching of the parts so that plating after finishing will not be satisfactory.

Although it would appear that dilution of the finishing compounds would solve some of these problems, I have found that if the quantity of liquid utilized in connection with the finishing of parts in the above described vibratory equipment and process is materially increased over a very small percentage by volume of the mass, uniformity of mechanical treatment is not maintained. The desired vibratory and orbital en masse movement is not achieved and there is a tendency to produce a condition of surging, thus materially impairing the mechanical effectiveness and speed of the process.

In fact, if the amount is increased greatly, the entire finishing action ceases. This necessitates in the prior process, as described above, that the concentration of the active agents in the finishing compound be high in order to permit them to work effectively.

One of the objects of this invention is to provide a method for obviating the above difficulties.

Another object is to provide such a method which effectively does away with discoloration or darkening of the parts during the polishing of the vibratory procedure described above.

Another object is to provide a method in which the finishing compounds may be effectively employed without interfering with the necessary mechanical action.

Another object is to provide such a method in which the finishing liquid is employed in the necessary concentrations and in suitable quantities and is employed to flush the parts and prevent discoloration and in which the cleaning fluid is removed from the mass continually in small quantities, thus carrying away the objectionable sediment.

Another object is to provide such a method in which the amount of finishing fluid is controlled to control the mechanical action.

Another object is to provide such a method in which the cleaning liquid is employed in the mass continually and is freed from undesirable sediment and is then returned cyclically, thus providing an efficient, inexpensive operation.

Other objects and advantages will appear from the following specification and drawings, where for the purpose of illustrating the invention, there is shown and described a form of apparatus which gives desirable and satisfactory results.

It is to be understood, however, that instrumentality and steps involved in this invention may be variously arranged and organized and that the invention is not limited to the specific equipment shown and described which is merely illustrative of one way of carrying out the invention.

In the drawings

FIG. 1 is an end elevation of a machine suitable for carrying out the invention, and
FIG. 2 is a side elevation of the machine shown in FIG. 1.

The invention is specifically applicable to and is preferably carried out in a tub which has a semi-cylindrical bottom on which a vibratory is directly mounted. The vibratory mass of a motor having an eccentric weight which is mounted for rotation on an axis parallel to the axis of the semi-cylindrical bottom of the tub. The tub and vibrators are supported for free movement in space on suitable springs.

When the vibrators including the eccentric weight are rotated, vibratory and orbital en masse motion is imparted to the contents of the tub which consists of the parts to be finished and the finishing or polishing material, such as stone chips.

The vibratory motion brings about a rubbing action between the pieces making up the mass and the orbital motion is in general around an axis parallel to the axis of the semi-cylindrical bottom of the tub.

This particular form of equipment provides suitable circulation and gentle tumbling of the parts and also brings about the necessary rubbing action for the speedy finishing of the pieces. The present invention it continuously exposes the parts to the action of the compound which cleans, flushes or otherwise treats the parts.

In carrying out the invention the liquid finishing compound which may be any of the compounds described above, is added to the mass of parts to be finished and finishing materials such as stone chips.

It may be added in amounts up to 5% by volume of the volume of the mass in the preferred form of the invention. When the amount is thus limited the mechanical action imparted by the vibrators includes both the vibratory and orbital motion and the mass orbital motion is highly efficient. The amount may be increased up to 10% without seriously interfering with the action and it may be increased up to 15% where although the operation is not as efficient as at the lower percentages, it is acceptable.

If the amount of liquid is increased to materially more than 15% of the volume of the mass of pieces and finishing material the desired vibratory and en masse orbital motion will cease. Surging will also accompany reduction in the amount, thus materially interfering with the mechanical finishing operation which is desired.

In carrying out the operation, a portion of the liquid is continually removed from the mass during the vibratory and orbital motion thereof and an equal quantity of liquid is continually added. Thus, the quantity of liquid in the mass is controlled and by controlling the quantity of liquid in the mass it is possible to control and maintain the desired vibratory and en masse orbital movement.

The removal of the liquid during the period of vibratory and orbital motion of the mass serves the function of carrying away from the mass such fines as are developed by abrasion of the metal pieces and the pieces of finishing material as well as any of the degradation products resulting from the breakdown of any of the soaps or synthetic surfactants and the residues or sediments which might be formed through the vibratory action and the development of heat in the mass of parts and finishing materials due to the friction and tumbling.

In the preferred form of the process the withdrawal of liquid serves the function of maintaining the mass substantially free from the fines and sediment created by the vibratory and orbital movement of the pieces and should be carried out at such a rate as to achieve this end. It has been found that highly satisfactory removal is achieved in a seven cubic foot tub where a load of about 54 cubic feet of parts and finishing material are mixed with about two gallons of liquid finishing compound or about 4% by volume thereof if the liquid is withdrawn at the rate of about ten gallons per minute.

Withdrawal at this rate tends to keep the mass and the liquid free from the fines and sediments which if left in the vibrating mass, would tend to produce surface discoloration of the work pieces.

Clean liquid is added continually and in quantities equal to the withdrawal. The clean liquid being added to the surface of the parts and free them from the fines and sediment and the liquid finishing compound being free from degradation products, fines and the like, is able to perform its function more satisfactorily than would otherwise be the case.

By controlling the withdrawals and additions, it is possible to maintain the quantity of liquid in the vibrating mass substantially constant, which in turn maintains the vibrating and tumbling action constant so that uniform results are obtained in the mechanical finish applied to the parts.

The addition of new compound is preferably made with the temperature of the new liquid finishing compound lower than the temperature of the mass. This tends to prevent the buildup of temperature in the vibrating mass to greatly retard the breakdown of the soap, surfactants or other materials utilized in the liquid finishing compound.

In the preferred form of the invention the elimination of the fines and sediment from the liquid finishing compound and the cooling thereof can be effected through the use of a settling tank. The liquid withdrawn from the vibrating tub and massing compound is led to a settling tank. After suitable settling time the supernatant liquid is withdrawn from the settling tank and is sprayed on the mass in the vibrating tub. It is well distributed on and tends to flush the pieces in the mass because of their vibratory and orbital mass motion. The equipment for handling the withdrawal, settling and spraying is generally adequate for reducing the temperature of the liquid to be returned, although cooling means can be supplied if necessary.

By carrying out the process as indicated above, it is possible to utilize higher concentration of active agents in the liquid finishing compound than would otherwise be the case. They are thus more effective in the mass and it is possible to limit the amount of liquid in the mass to control the vibratory and orbital motion in the vibratory tub.

There is less breakdown of the active agents and the parts are in effect under the influence of full strength liquid finishing compounds unimpeded by degradation products, such as metallic soap, scum and gelatinous precipitates. The parts are thus kept cleaner and the mechanical action is not impeded by the undesirable residues or foam.

Furthermore, it is possible to retard oxidation of the parts which might occur if the temperature builds up to as high as 200°F. and the process is maintained even and stable throughout, even though the parts may be treated for a considerable period of time.

Although it is possible to use relatively high concentrations of chemicals in the present process, it is possible to obtain highly satisfactory results with concentrations lower than one would have to employ in a long cycle operation because the concentration of the active agents in the finished compound may be kept constant whereas without the process it may be necessary in order to insure full activity throughout the treatment cycle to use concentrations which are too high at the beginning in order to have adequate concentration near the finish of a long treatment cycle. In other words, it is not necessary to use overstrong solutions to compensate for reduction in strength during the processing.

In utilizing the process it may be possible to eliminate rinsing operations and where steel or iron parts are concerned, rust preventative agents such as nitrates may be employed in the finishing compound. Since the compound does not deteriorate, gum up and dirty the parts, the rinsing is eliminated and thus oxidation is
It is possible to use aluminum oxide without producing a sludge which will fill the grain structure of the aluminum parts, thus rendering them ineffective after only a short cycle of operation. It is also possible to use certain brightening chemicals such as alkylamidates, on zinc base die castings. Such compounds have a tendency to contaminate the surface of the parts and darken them when excessive heat is involved. By utilizing the present process with its cooling effect, it is possible to eliminate this disadvantage and the life of the alkylamidates is increased giving here-tofore unobtainable bright finishes on zinc base die castings.

In the drawings is illustrated a form of apparatus suitable for use in carrying out the invention. This equipment includes a tub or hopper 1 which has a semi-cylindrical bottom 2 and an open top 3. Mounted directly on the tub or hopper 1 is a vibrator consisting of an electrical motor 5 having a rotor on a shaft 6 which also carries an eccentric weight 7 for imparting vibrations to the tub.

The axis or shaft of the vibrator extends parallel to the axis of the semi-cylindrical bottom 2 of the tub or hopper 1. The tub or hopper and motor are mounted as a unit for free movement in space on coil springs 8 which rest at 9 on a suitable support or frame 10 and which bear against the under sides of the brackets 11 which are secured rigidly to the tub or hopper 1. The tub or hopper is adapted to receive a plurality of work pieces to be finished, indicated at 12, and a finishing or polishing medium which may be stone chips or the like, indicated at 13. The polishing medium is generally abrasive in nature although it may consist in some instances of steel balls.

When the motor is activated and the vibrator becomes effective the chips and the work pieces are vibrated and rubbed against one another. They also, because of the arrangement of the vibrator with respect to the rounded bottom of the tank, take on an orbital movement or mass following generally the path indicated at 14. At each end of the hopper 1 is a discharge opening 15 provided with a screen 16 to retain the work pieces and finishing or polishing material during vibration of the tank. A discharge spout 16a extends laterally from each opening and discharges into a trough 17. This trough leads to a settling tank 18 having a draw-off valve 19.

Within the settling tank is a pump 20 driven by a motor 21 through a shaft 22. This pump has an intake 23 and a discharge 24, which is connected by a pipe 25 through a valve 26 to a spray head 27 having a plurality of discharge openings 28, opening into the upper portion of the tub or hopper 1.

The heater 29 may be provided in the tank. The liquid indicated at 30 is preferably a liquid finishing compound such as described above.

This fluid may, in some instances, be water alone or it may be a chemical cleaning agent such as described above, such as soap or a surfactant dissolved in water or a suitable solvent. It may in some instances be a solvent.

In some instances where it is desired to expeditate chemical or solvent action, heat may be applied to the fluid by the heater 29.

In other forms of the invention, where heat of the mechanical action provided by the vibration of the parts and the polishing material, tends to build up and may be deleterious to the liquid finishing compound, the heater 29 may be used as a heat exchanger for cooling the liquid.

In other instances, the withdrawal and return circuit may serve as a heat transfer unit for cooling down the liquid prior to addition to the tub.

It will be understood that the hopper may be unloaded in any suitable fashion and no effort has been made to illustrate the specific means. For instance, it may be tilted as a unit as shown in copending application Ser. No. 815,559, now abandoned, filed May 25, 1939, for Finishing Apparatus, or the operation may be a continuous type of operation which is illustrated in my copending application Ser. No. 862,901, now abandoned, filed December 30, 1939, for a Continuous Finishing and Polishing Machine.

Generally, in carrying out the process, one of the liquid finishing compounds of the type described above will be added to the tub or hopper during the processing of the parts. Care must be taken when this is done to be sure that there is no interference with the vibratory and en masse orbital movements of the mass or parts and polishing material by adding undesirable amounts of the liquid finishing compound.

In the preferred form of the invention, the liquid finishing compound is added in an amount by volume equal to up to 5% of the volume of the mass of work pieces and polishing materials. When the amount of liquid finishing compound is thus limited the full vibratory and en masse orbital motion takes place and the work pieces receive the desired finishing or polishing therefrom. Satisfactory results may be obtained if the volume of the liquid finishing compound is increased up to a volume equal to 15% of the volume of work pieces and polishing compound. If greater volumes of the liquid finishing compound are added, there is serious interference with the vibratory and en masse orbital motion and surging will occur, giving unpredictable, uneven and unsatisfactory results.

It is thus possible to, in some measure, control the action by controlling the amount of liquid finishing compound added to the hopper or tub.

The parts may be kept evenly distributed in the mass without separation and a satisfactory rolling or orbital motion of the mass is maintained. The speed of the rotation or orbital movement of the mass is kept constant and under control.

When steel balls are used as burnishing or finishing media it is very essential that the amount of the liquid finishing compound be carefully controlled.

During the work cycle of the unit, particularly where abrasive materials are involved, there is a tendency toward the creation of fines consisting of metal removed from the work pieces and pieces of the finishing material which come off during the vibration and orbital motion. There is also a tendency toward the degradation of the liquid finishing compound itself particularly in the presence of soap base compound or one involving synthetic surfactants or wet agents. The breakdown or deterioration of these materials tends to lead to the formation of metallic soaps, scum and gelatinous precipitates.

If the fines of such degradation products remain en masse during the vibration and orbital movement, the proper action is not obtained and hence it is desirable to continually withdraw a portion of the liquid finishing compound and the precipitates formed in it, so that the parts will in general be exposed to clean, fresh compound which will be more effective and which is maintained at the proper strength and does not carry with it undesirable fines which on rubbing can discolor the surface of the work pieces.

In carrying out the invention, as the liquid finishing compound is constantly withdrawn, it should be constantly replaced thus controlling the volume of liquid present during the operating cycle. It is of course possible to add new liquid finishing compound and discard the old and if water alone or very weak compound is employed, this may be economical.

However, in general, it is better to separate the fines and precipitated material from the withdrawn liquid finishing compound so that the compound can be recirculated, thus effecting a saving. This separation is brought about
in the settling tank described above or it may be done by other suitable separation equipment. Should water alone be employed, it may be supplied from a suitable source 32, which is controlled by a valve 33. When water alone is used, the liquid passing from the settling tank is diverted by any suitable means to a drain, thus by-passing or omitting the settling tank from the operation.

In operation, the hopper or tub 1 is charged with work pieces 12 and the finishing material 13, which may be stone chips or the like. The vibrator motor 5 is energized and the liquid is fed into the tank, which along with the motor vibrates in a rotary, orbital fashion, free in space. This brings about the rubbing action above described between the parts 12 and the chips 13 and also causes an en masse orbital movement, the direction of which is indicated by the arrow 14 in FIG. 1. The parts and the chips move and tumble as they follow the path and do not separate. While the machine is in operation, the liquid 30 is circulated by means of the pump 26. It is discharged directly on the parts 12 and the chips 13, which, because of their orbital movement, are all subjected to the finishing or chemical action if the liquid has the properties to provide such action.

The fluid thoroughly bathes the parts and the finishing or polishing material, and removes from the mass any fines such as finely divided stone or metal and discharges through the openings 15. The liquid then flows to the settling tank as indicated at 31. In the settling tank any fines or precipitated solids will tend to settle to the bottom of the tank and will thus be removed from the liquid or supernatant, which is then carried by the pump up to the discharge 27.

A typical operation involves the controlling and the changing of the liquid finishing compound constantly and frequently enough so that the mass is kept substantially free from fines and sediment created by the vibratory and orbital movement of the pieces in the mass. As a typical example, a tub or hopper having a capacity of 7½ cubic feet may be charged with about 5½ cubic feet of work pieces and finishing material such as stone chips. Up to 5% of the volume of the mass of work pieces and finishing material of the liquid finishing compound is added. The vibrator is energized and en masse orbital motion is brought about.

In such a case about two gallons of liquid may be added to the mass, which is slightly under 5% by volume. If the liquid is withdrawn at the rate of about ten gallons per minute, it will keep the mass substantially free from undesirable fines, sludge and precipitates.

The withdrawal of liquid may be determined by controlling the size of the aperture 15. The size of the pump to use will depend upon the amount of recirculation and a closed circuit system may be employed if desired.

It will be understood that the amount of liquid preferred is up to 5% of the volume of the mass of work pieces and finishing material such as stone chips. However, as pointed out above, the amount may be increased up to 15% of the volume of the mass.

In general, when the operation is in progress, the vibrations and the en masse orbital movement will, because of the friction involved, tend to raise the temperature of the mass. As the liquid finishing compound is removed the generated heat is carried away and the new compound which is added tends to cool the mass because in the preferred form of the invention it is at a temperature lower than the mass after the vibration and orbital movement has been initiated.

As pointed out above, means may be employed for cooling the liquid in the settling tank, although generally when the liquid is removed at the rate indicated above, or at any reasonable rate, the liquid circuit and the settling tank will serve as heat transfer means tending to cool the liquid.

When the liquid is thus cooled so that the temperature cannot build up in the vibrating mass, the life of the liquid finishing compound is generally extended. The degradation and breakdown which would occur if one permitted the temperature to rise by maintaining the liquid finishing compound would tend to hasten the degradation.

This would of course tend to weaken the liquid finishing compound by destroying active ingredients and would likewise tend to impair the action because of the sludge and fines which would collect.

By carrying out the processes outlined above, these difficulties are obviated. Furthermore, the freeing of the surfaces of the work pieces and the finishing materials of sludge and other impurities, tends to increase the efficiency of the operation. The liquid finishing compound is thus present in full strength and the surfaces are kept free to receive the most efficient treatment.

In the case of alkylolamides which are used on zinc based die castings, contamination with metal ions which would darken the zinc surface is greatly reduced. The elimination of overheating through the recirculation preserves the liquid alkylolamides and brings about a heretofore unobtainable bright finish on zinc based die castings.

By combining the flushing operation with the orbital vibrating en masse equipment, the thorough flushing of the parts and the finishing or polishing material, is achieved continually, and the fines are removed from the mass. This is of particular advantage because it is possible to eliminate the necessity for rinsing after completion of the treatment. The obviating of this rinsing makes it possible to employ rust preventive chemicals, such as nitriles, in the liquid finishing compound and steel or iron parts are protected against oxidation and against such increased oxidation as would be brought about by a water rinse. It is not necessary to even expose the parts for a short period of time, which would be necessary with a water rinse even though dipped in rust preventive solutions immediately after rinsing.

The recirculation and maintenance of the strength of the liquid finishing compound allows the processing to proceed completely and uniformly. The progressive deterioration which would occur without the continual removal and return of the liquid finishing compound is eliminated. The parts and the chips themselves are kept in clean and effective condition. It is not necessary to replace or wash the chips after each cycle.

Apparently the removal of the fines is the answer to the darkening or discoloration of the surface of the parts accomplished by vibration as above stated. Also, the rubbing or peening action in the presence of the fines tends to force them into the surface of the metal in such a way that they cannot be removed by any practicable procedure. The result is that when the process of this invention is employed unexpectantly, the parts do not have the discoloration which has been common as a result of such treatment heretofore.

The use of the process also assures quick and efficient cleaning of the chips, an operation which has heretofore been troublesome and time consuming. It has not been necessary to place a heavy washout door on the hopper for rinsing the chips. Such rinsing has many times called for from two to five washings without completely cleaning the chips after a cycle of operation.

It will be appreciated that the form of the invention described above and the form of apparatus illustrated in the drawings is illustrative only and that the process may be carried out in other ways and with other equipment without departing from the spirit or essential attributes of the invention. It is desired and indicated that the embodiment described above be considered merely as illustrative and not restrictive, reference being had to the appended claims rather than the foregoing description to indicate the scope of the invention.
What is claimed is:

1. The method of finishing and polishing work pieces and of providing a finished surface on said work pieces substantially free of discoloration comprising mixing said work pieces with abrasive pieces of polishing material to form a mass, adding to said mass a limited quantity, up to 15% of the volume of said mass, of a liquid finishing compound, imparting vibratory and en masse orbital motion to said mass including said liquid and during said vibratory and orbital motion, while maintaining the vibratory and orbital motion substantially uniform by maintaining the quantity of liquid in said mass substantially constant, removing heat generated in said mass by friction created by said motion and maintaining said mass substantially free from fines and sediment created by the vibratory and orbital motion of the pieces in the mass by continually and cyclically withdrawing a portion of the liquid along with entrained fines and sediment from said mass when fines and sediment have formed and heat has been generated and separating the fines and sediment from and cooling the removed liquid for return to said mass and simultaneously adding an equal quantity of said liquid free from fines and sediment at a temperature below that of the mass whereby fines and sediment and heat created by vibratory and orbital motion of the mass are maintained at a low level in the mass.

2. The method of finishing and polishing work pieces and of providing a finished surface on said work pieces substantially free of discoloration comprising mixing said work pieces with abrasive pieces of polishing material to form a mass, adding to said mass a limited quantity, up to 5% of the volume of said mass, of a liquid finishing compound, imparting vibratory and en masse orbital motion to said mass including said liquid and during said vibratory and orbital motion, while maintaining the vibratory and orbital motion substantially uniform by maintaining the quantity of liquid in said mass substantially constant, removing heat generated in said mass by friction created by said motion and maintaining said mass substantially free from fines and sediment created by the vibratory and orbital motion of the pieces in the mass by continually and cyclically withdrawing a portion of the liquid along with entrained fines and sediment from said mass when fines and sediment have formed and heat has been generated and separating the fines and sediment from and cooling the removed liquid for return to said mass and simultaneously adding an equal quantity of said liquid free from fines and sediment at a temperature below that of the mass whereby fines and sediment and heat created by vibratory and orbital motion of the mass are maintained at a low level in the mass.

3. In the finishing and polishing of work pieces where the work pieces and pieces of polishing medium are placed in a tub having a semi-cylindrical bottom with a vibrator mounted thereon having an eccentric weight on an axis parallel to the axis of the semi-cylindrical bottom, said tub and vibrator being supported for free movement in space, and in which, through rotation of the eccentric weight, vibratory and orbital en masse motion is imparted to the mass of work pieces and polishing material and heat and fines and sediment are created in the mass, the steps comprising adding to said mass of work pieces and polishing material a limited quantity, up to 5% of the volume of said mass, of a liquid finishing compound, while imparting to said mass the vibratory and orbital motion maintaining the quantity of liquid substantially constant, cyclically and continually withdrawing a portion of the liquid from said mass along with entrained fines and sediment, separating the fines and sediment from the removed liquid and cooling it, and simultaneously adding to said mass an equal quantity of said liquid substantially free from fines and sediment and at a temperature lower than the temperature of the mass whereby said vibratory and orbital motion is maintained substantially uniform and the sediment is continually removed from the mass and the surfaces of the pieces are flushed and the temperature of the mass is lowered.

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