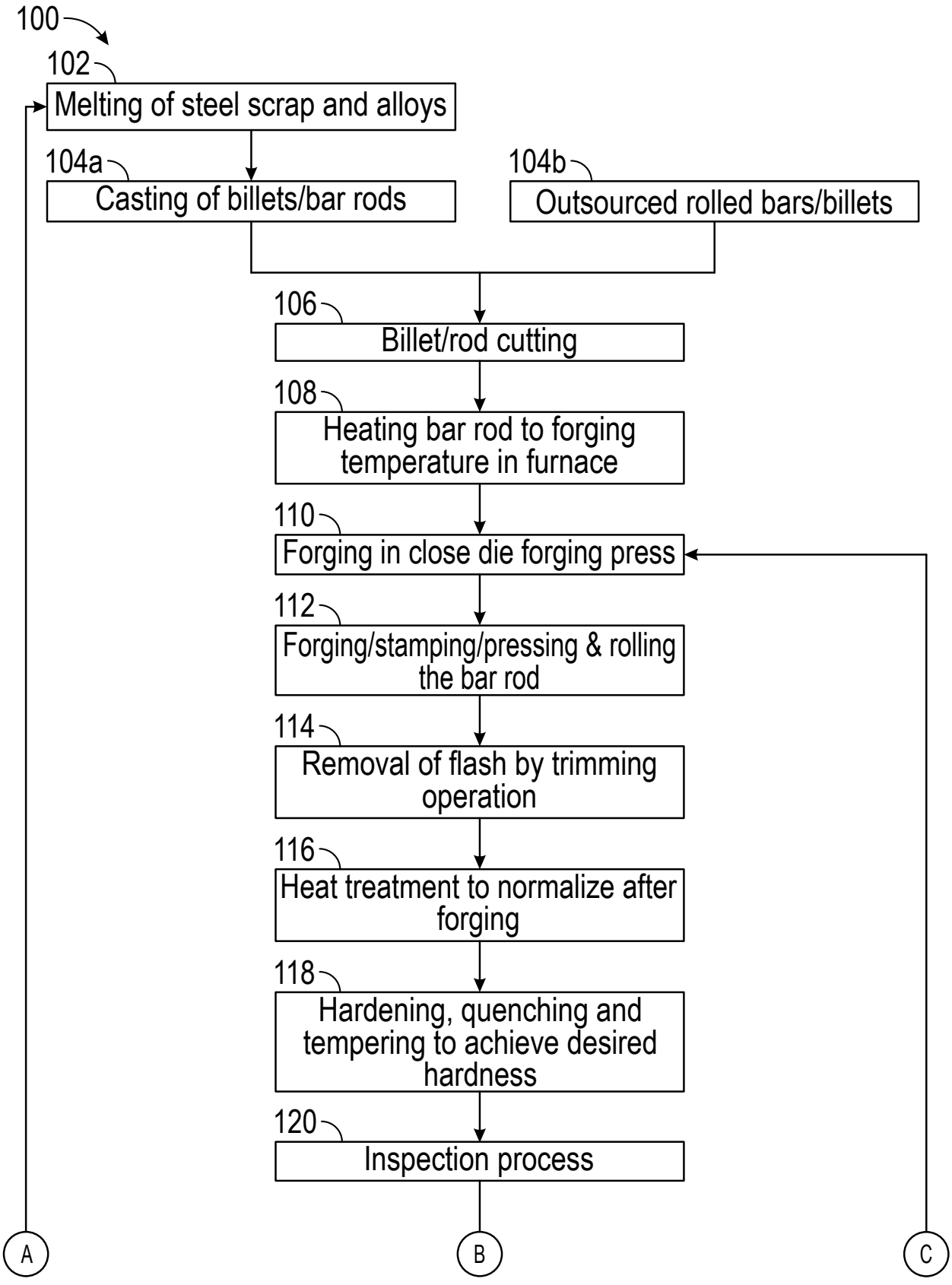


FIG. 1

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Authorized Patent Agent Name: **PUTTA GANESH**
(IN/PA/2933)

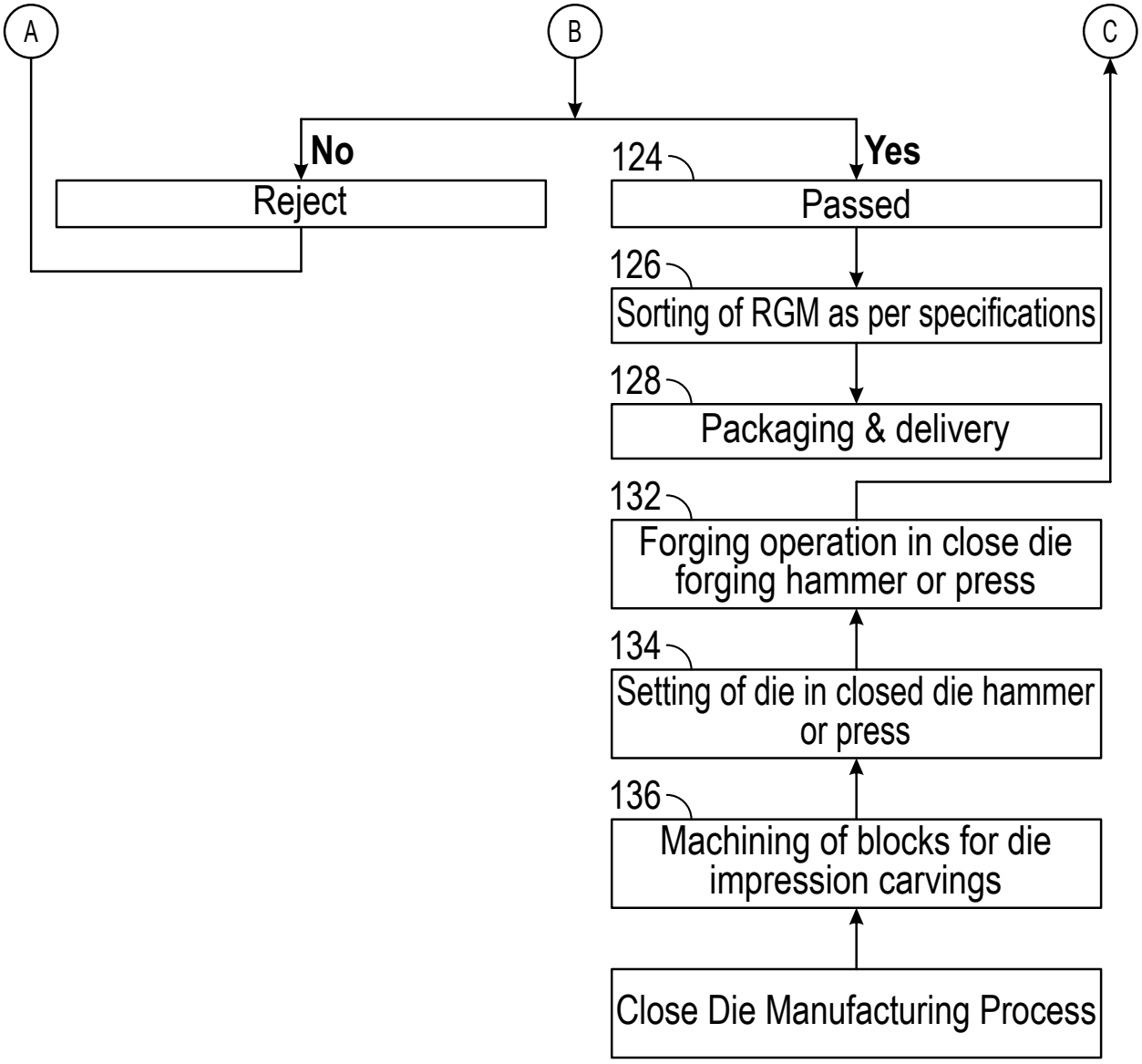


FIG. 1
(Continued)

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(IN/PA/2933)



FIG. 2A

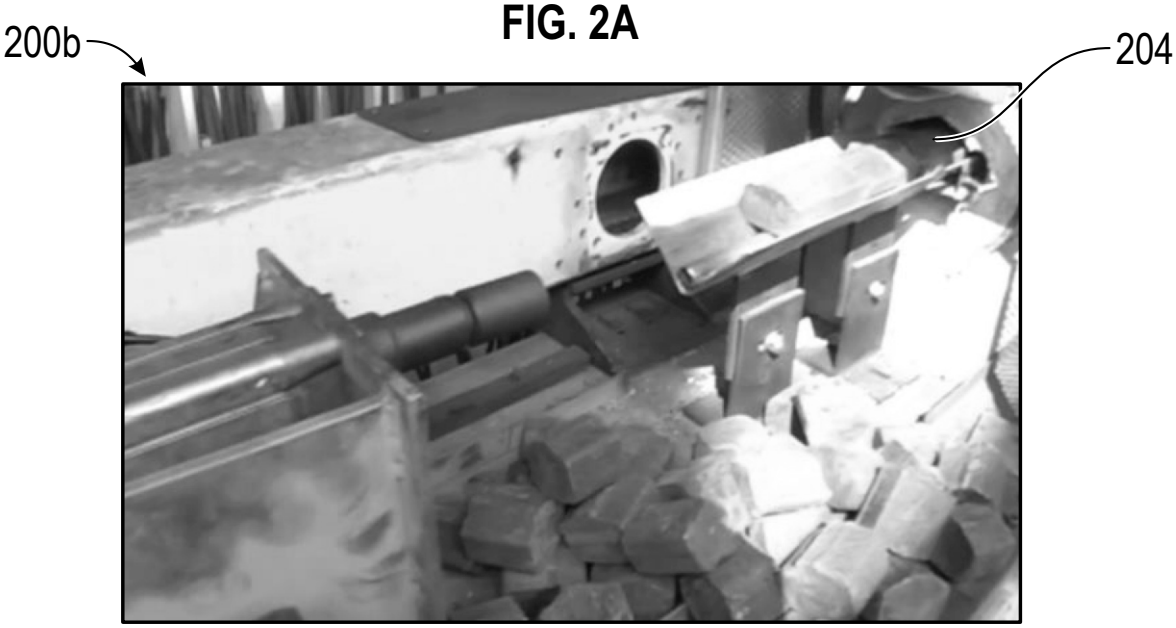


FIG. 2B

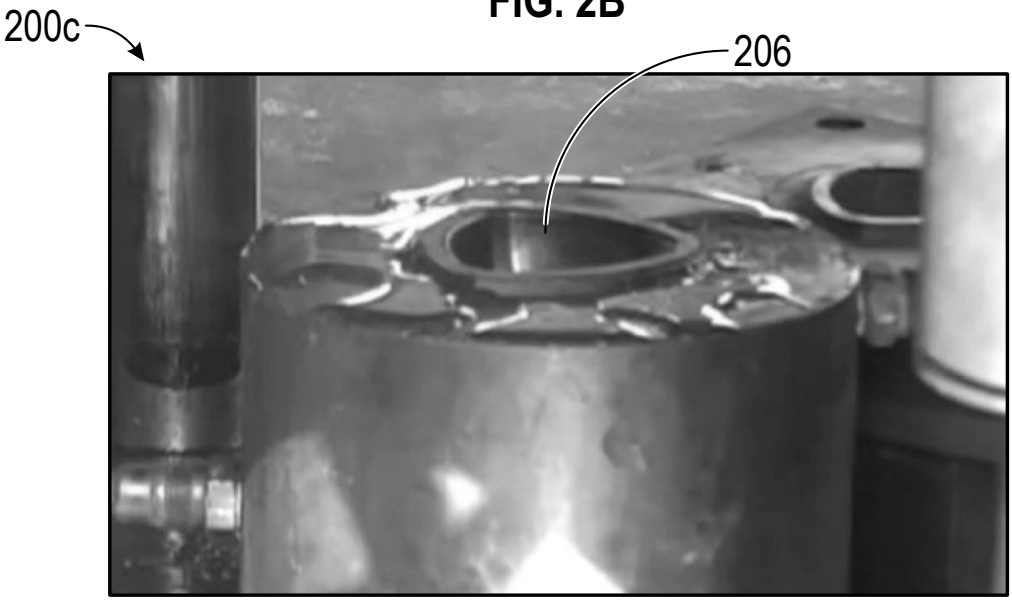


FIG. 2C

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(IN/PA/2933)

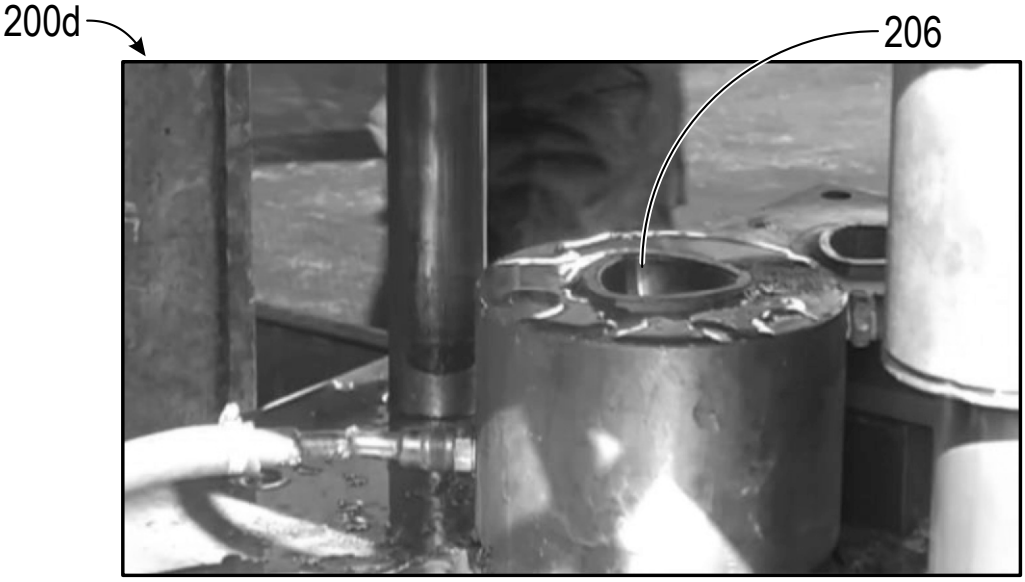


FIG. 2D

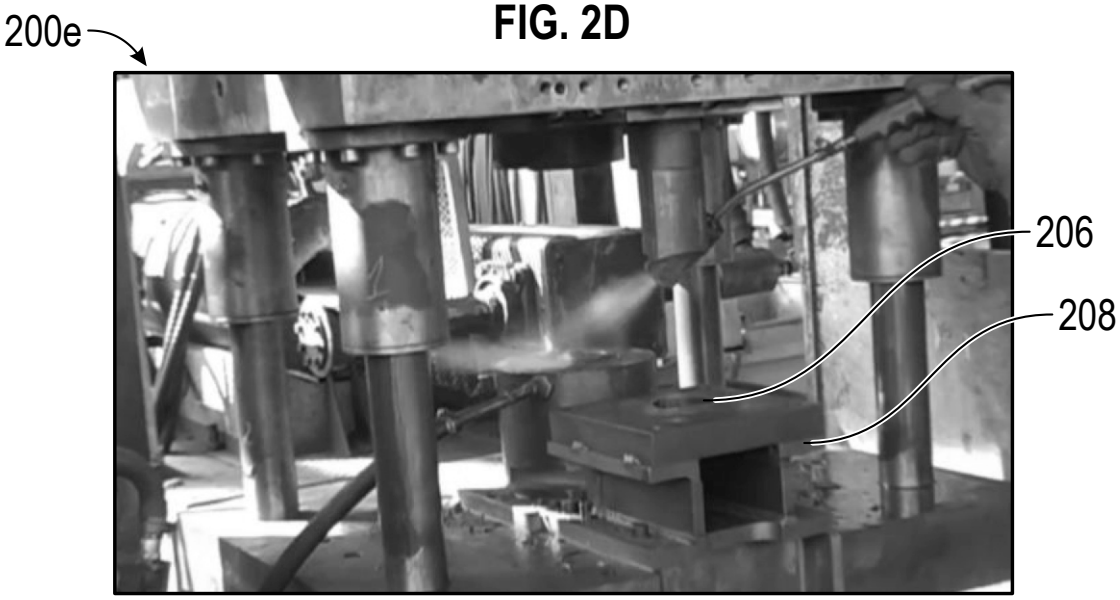


FIG. 2E

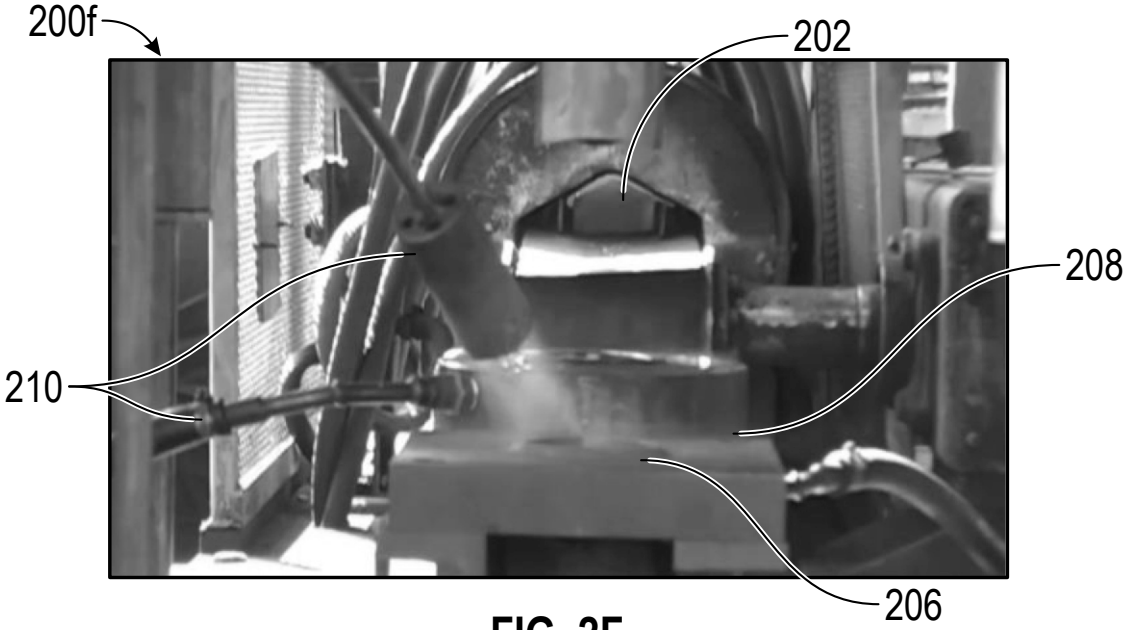


FIG. 2F

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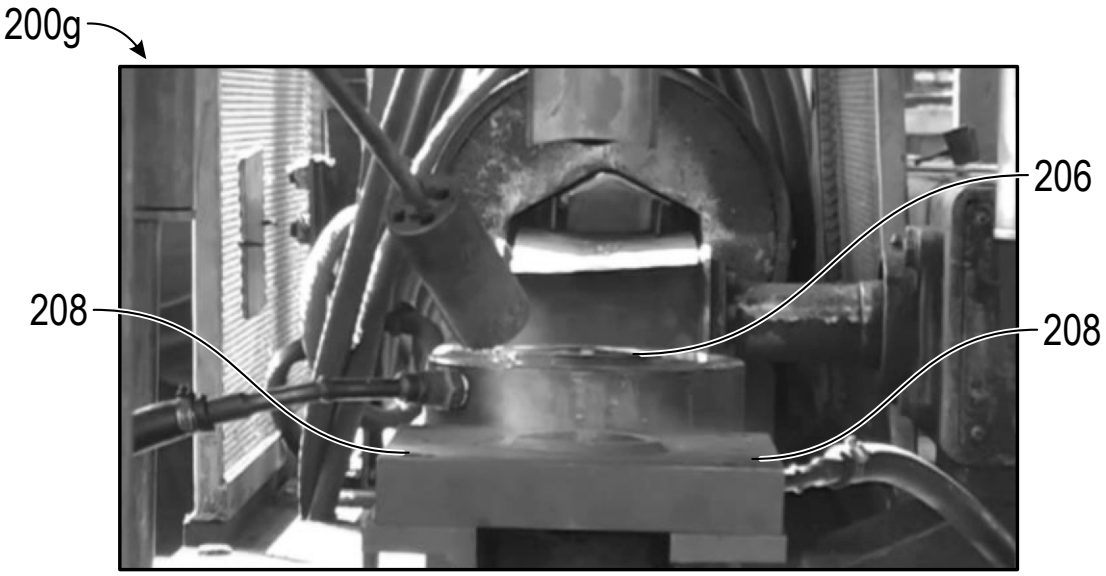


FIG. 2G

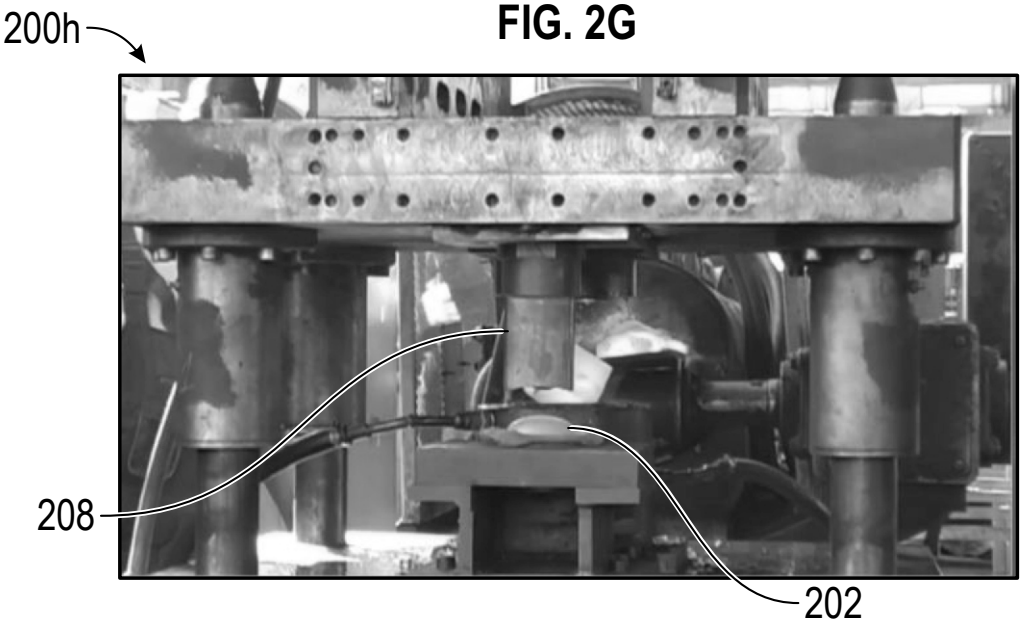


FIG. 2H

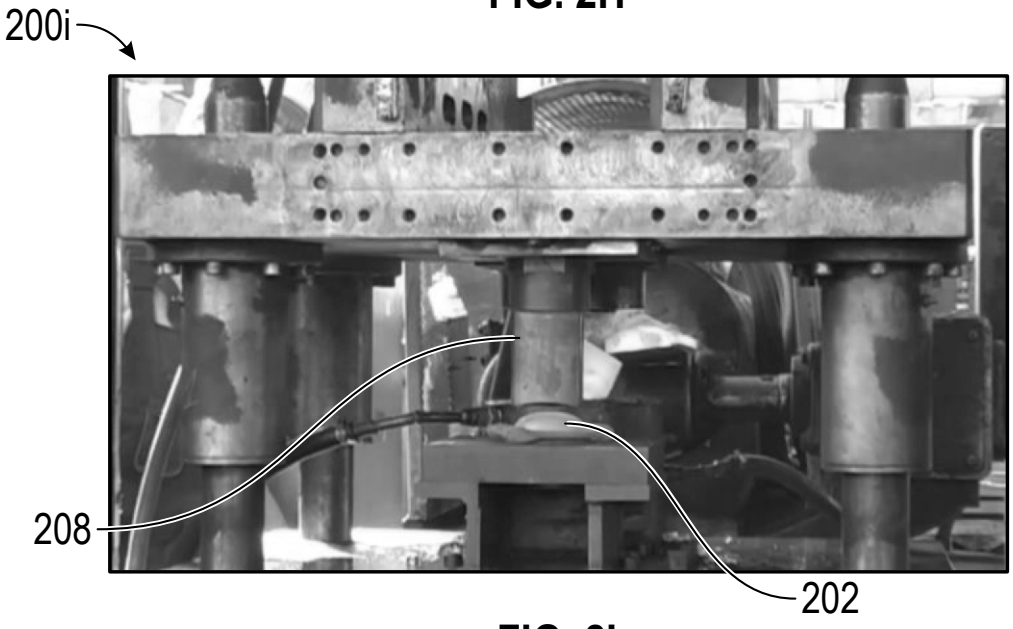


FIG. 2I

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(IN/PA/2933)

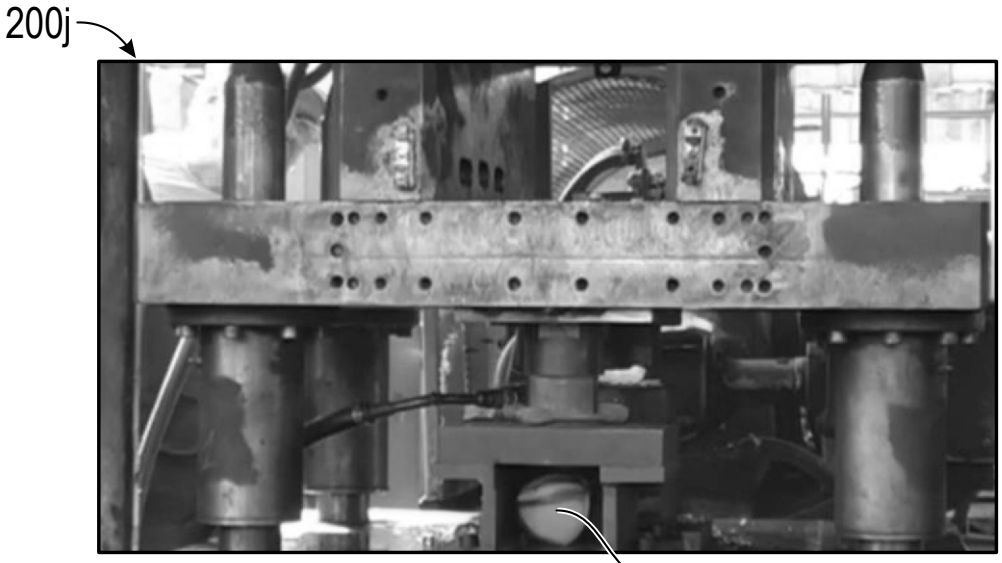


FIG. 2J

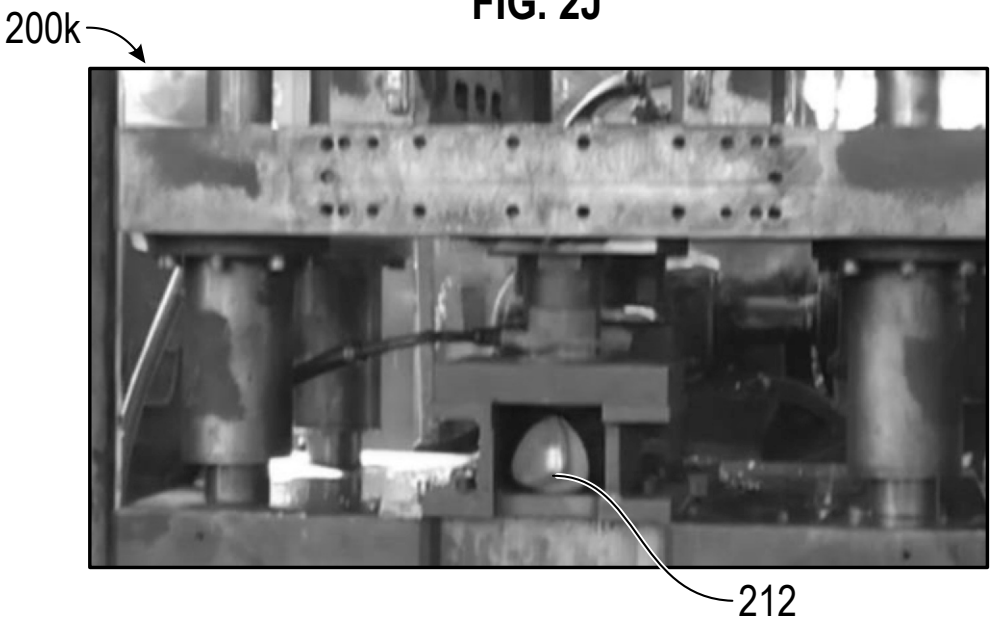


FIG. 2K

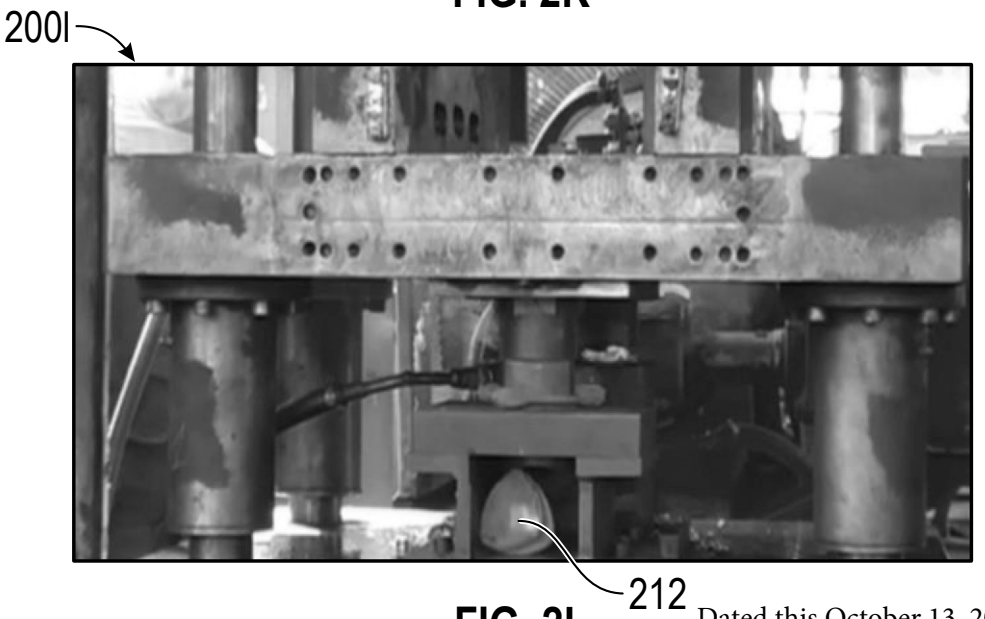


FIG. 2L

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FIG. 2M



FIG. 2N



FIG. 2O

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(IN/PA/2933)

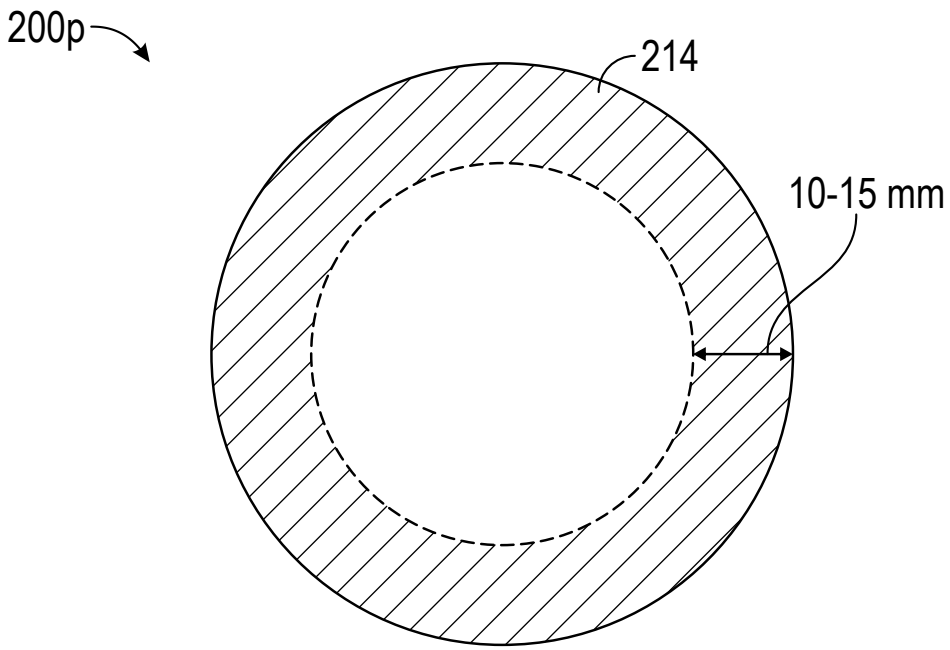


FIG. 2P
(Prior Art)

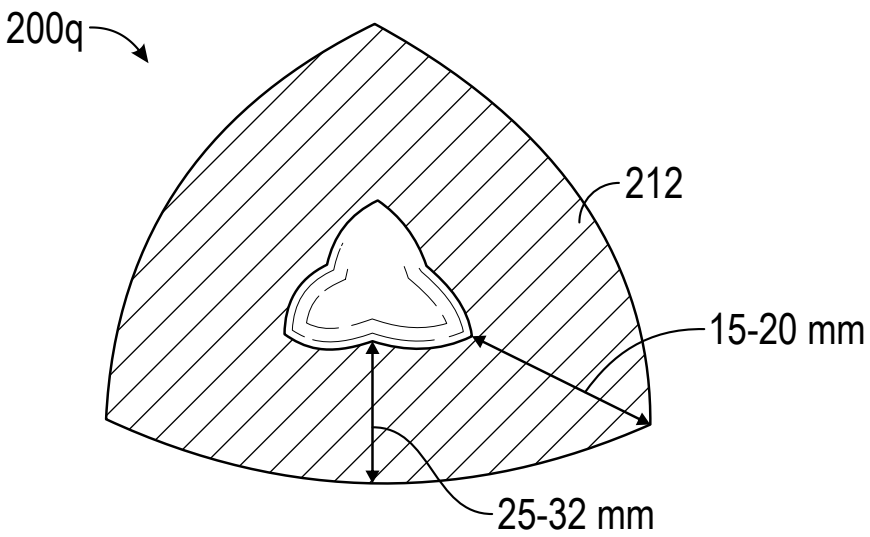


FIG. 2Q

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FIG. 2R



FIG. 2S

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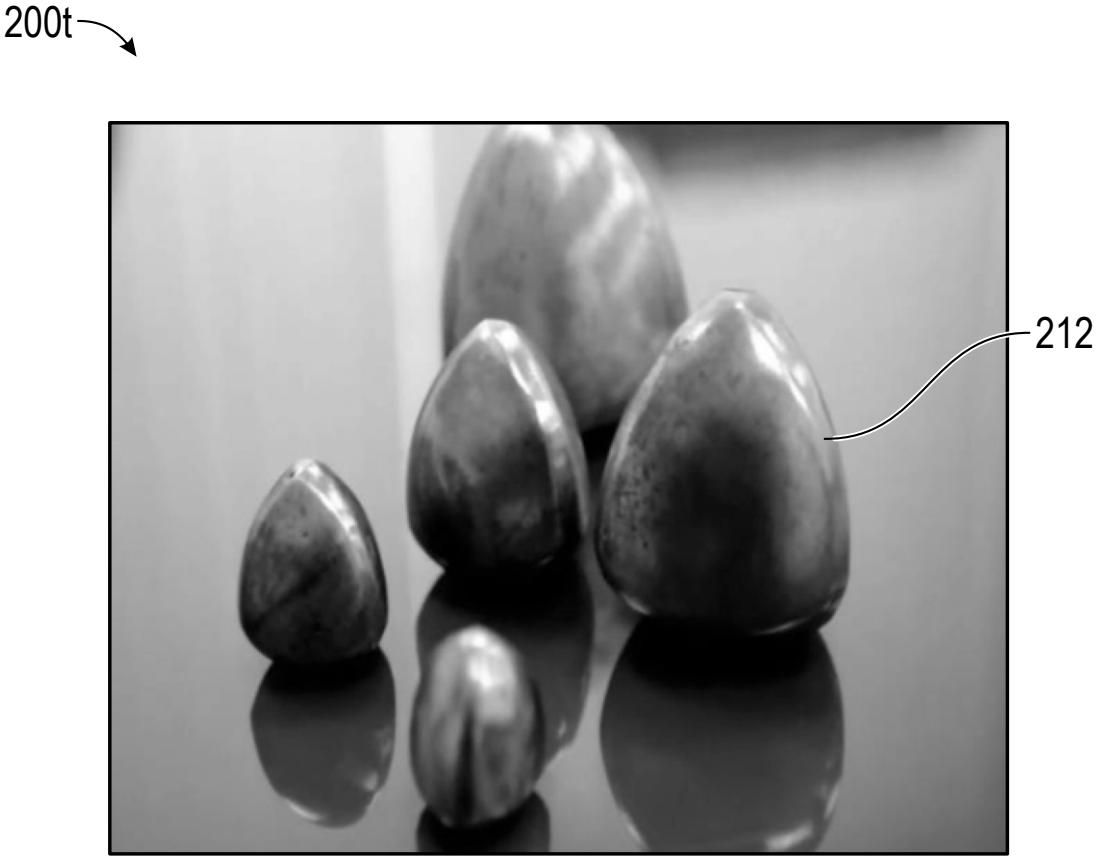


FIG. 2T

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(IN/PA/2933)

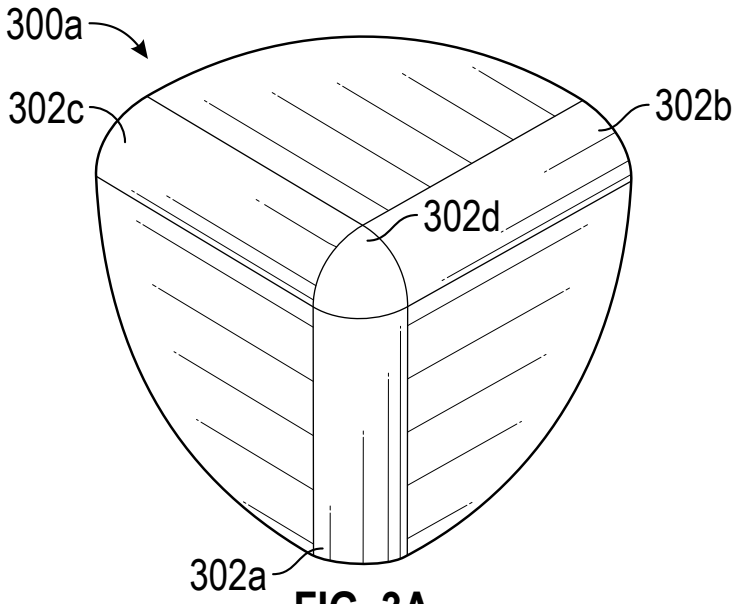


FIG. 3A

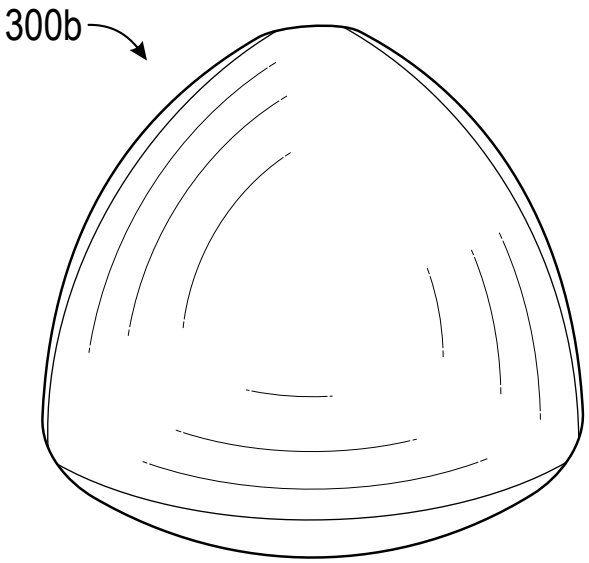


FIG. 3B

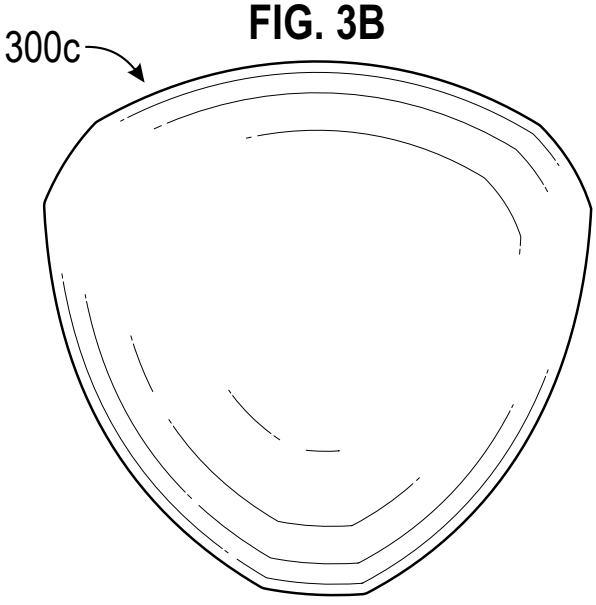


FIG. 3C

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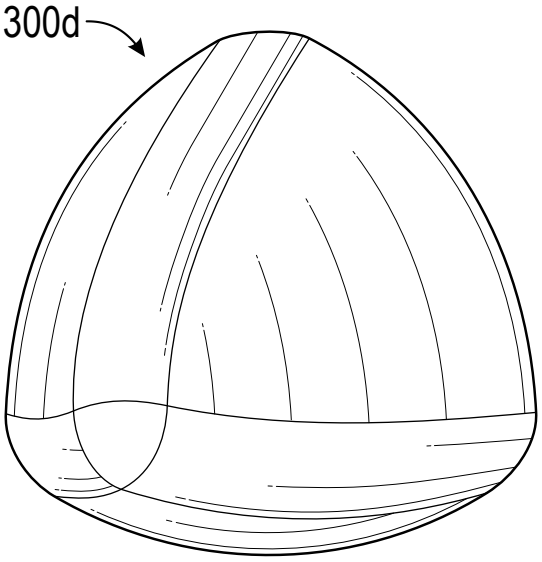


FIG. 3D

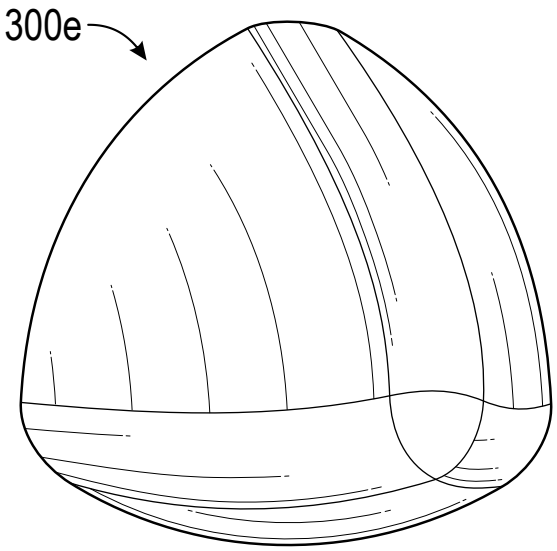


FIG. 3E

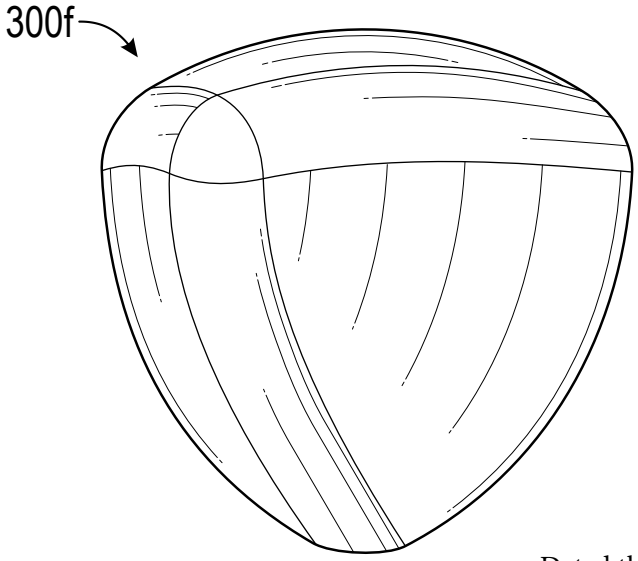


FIG. 3F

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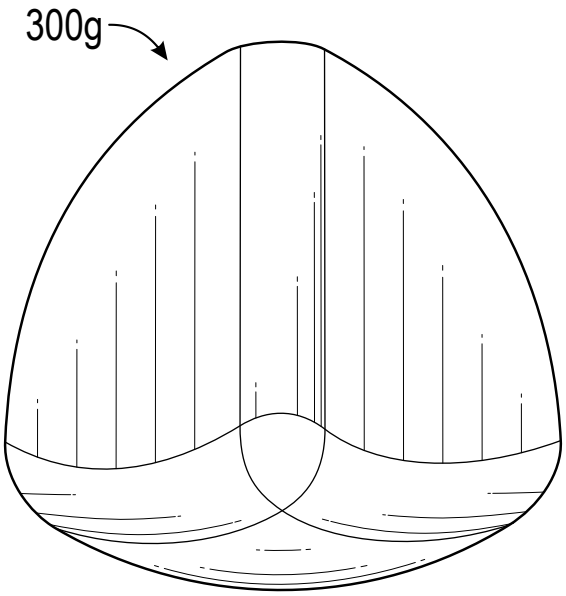


FIG. 3G

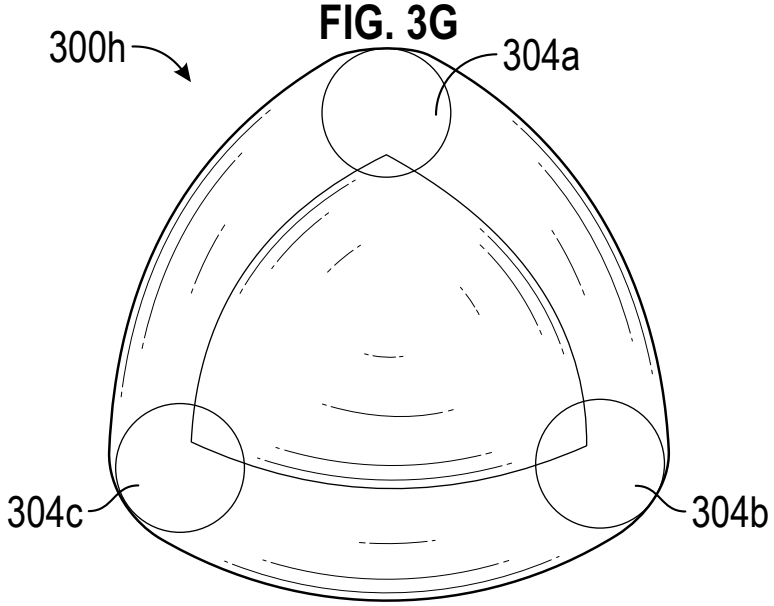


FIG. 3H

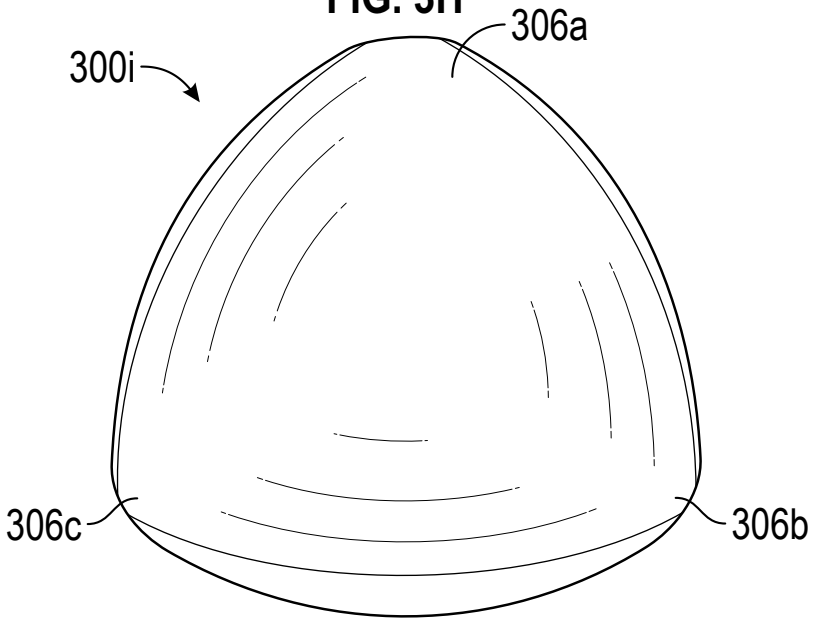


FIG. 3I

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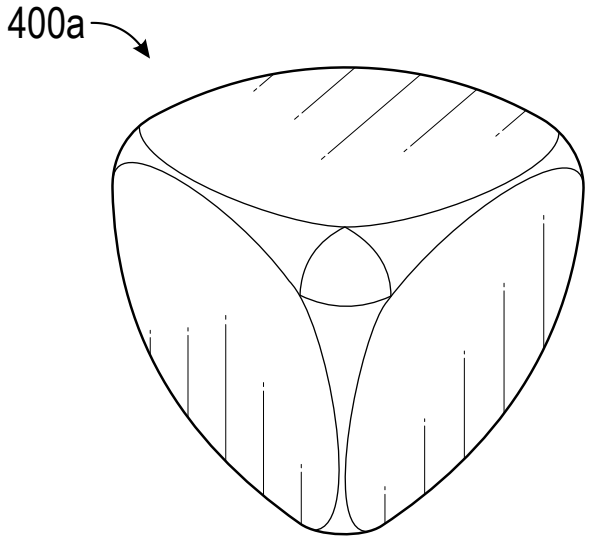


FIG. 4A

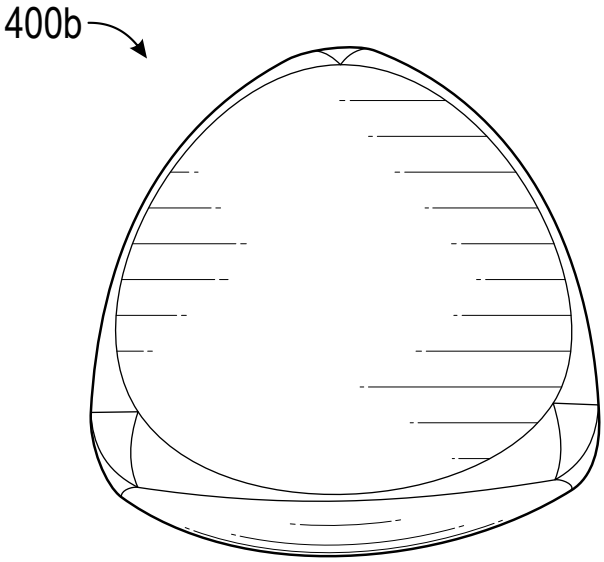


FIG. 4B

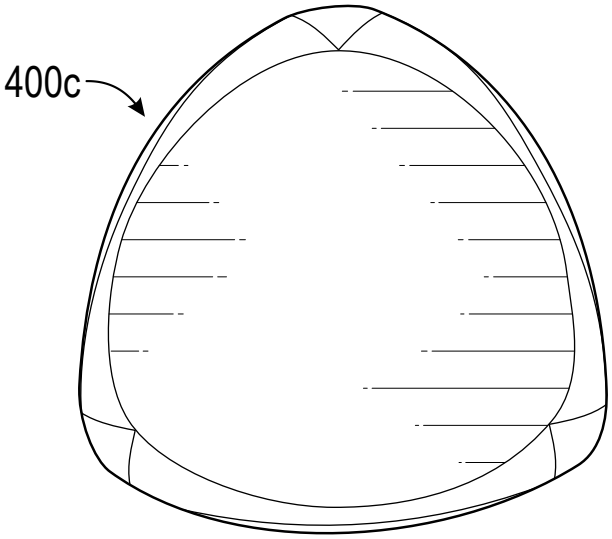


FIG. 4C

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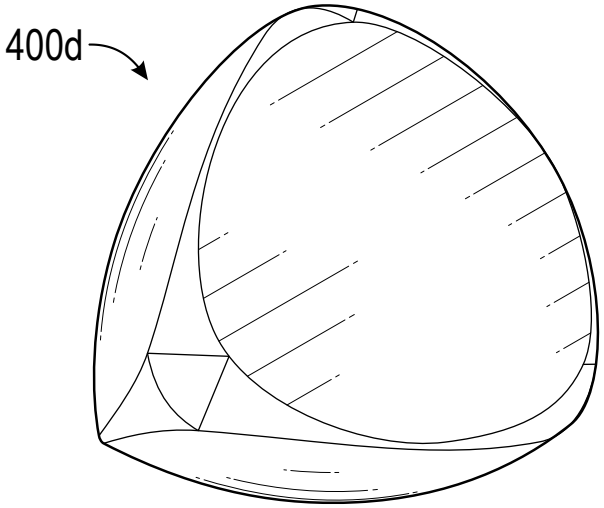


FIG. 4D

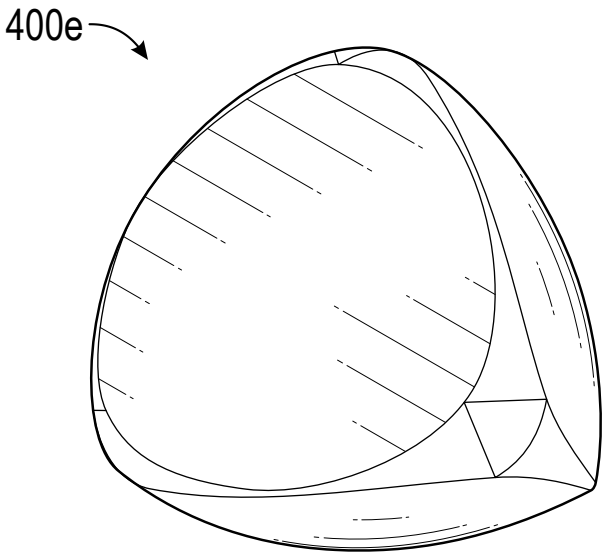


FIG. 4E

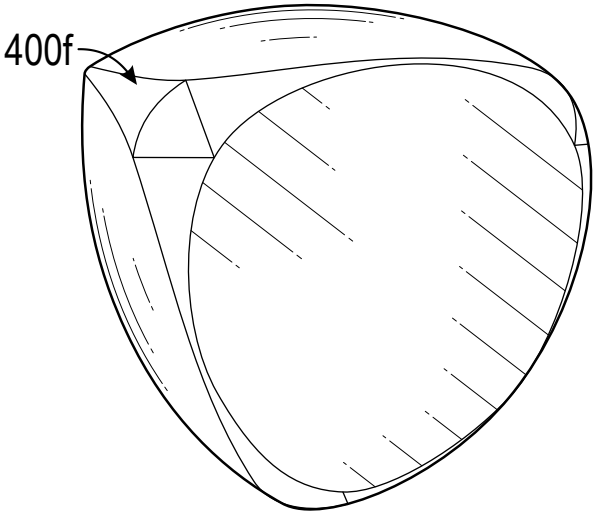


FIG. 4F

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(IN/PA/2933)

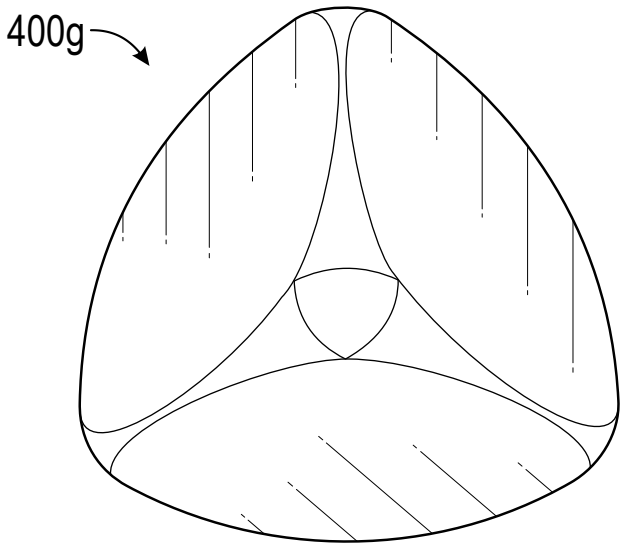


FIG. 4G

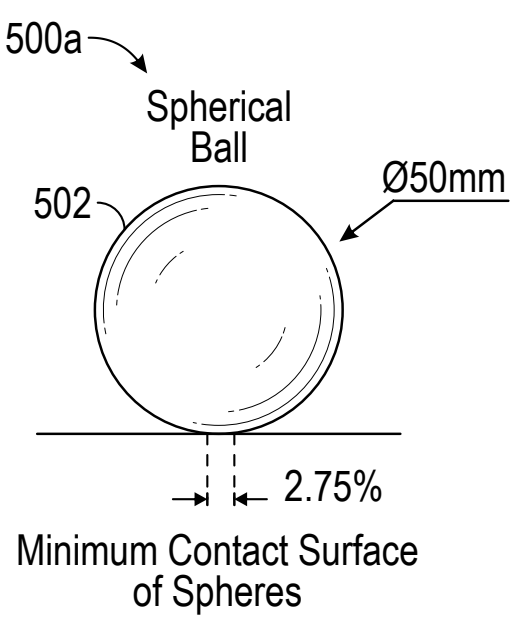


FIG. 5A

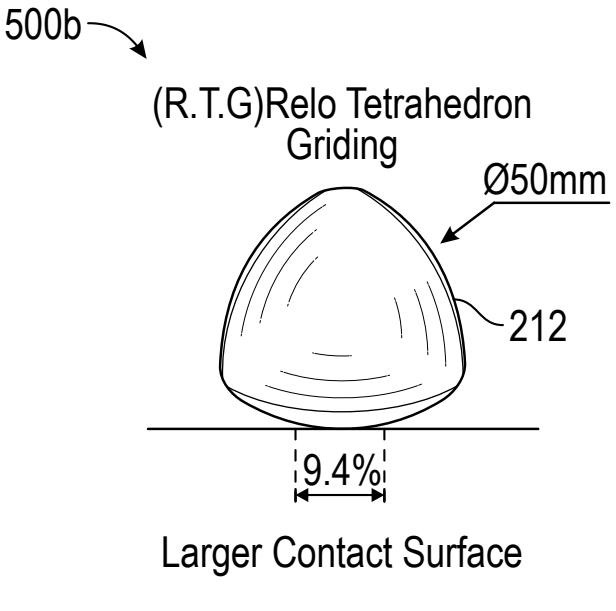


FIG. 5B

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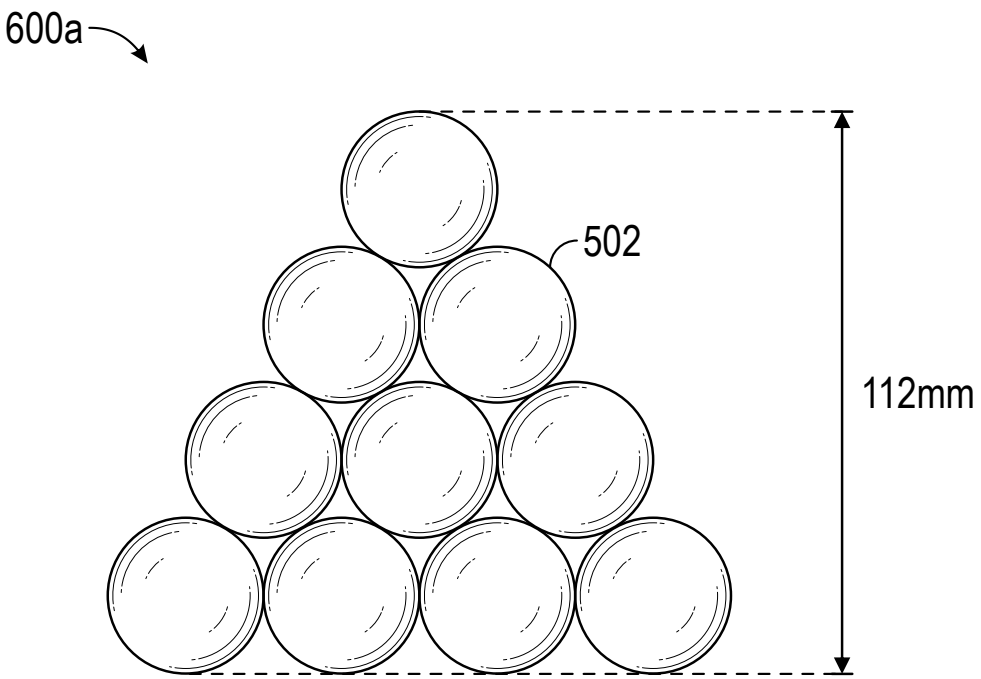


FIG. 6A
(Prior Art)

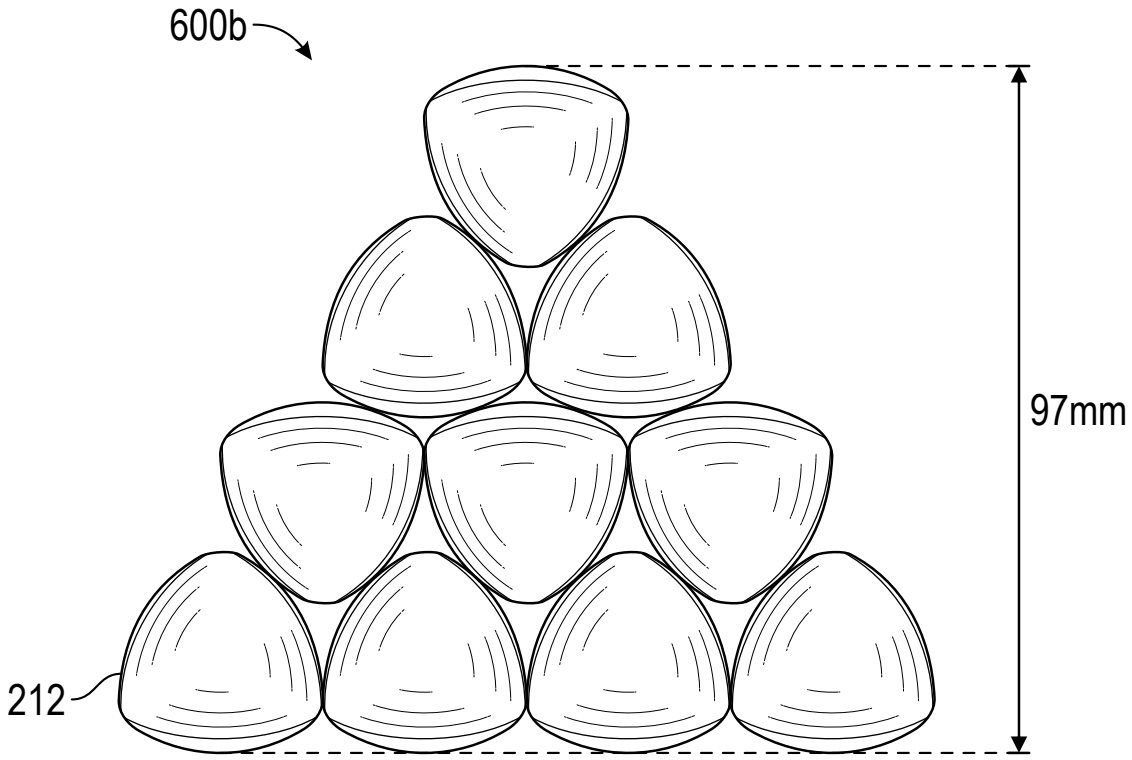


FIG. 6B

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(IN/PA/2933)

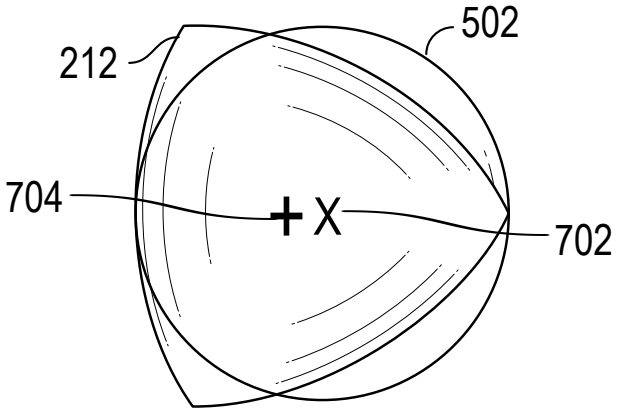


FIG. 7

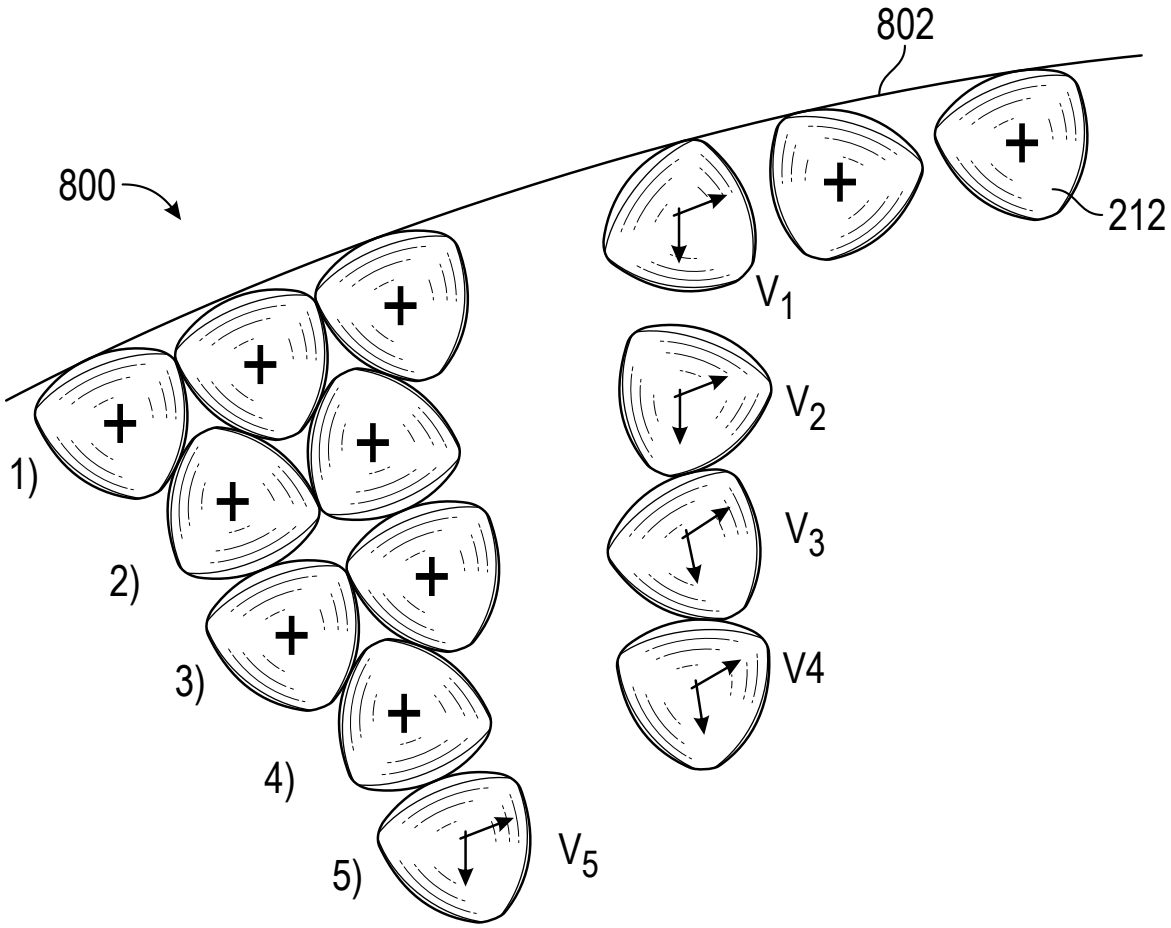


FIG. 8

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(IN/PA/2933)

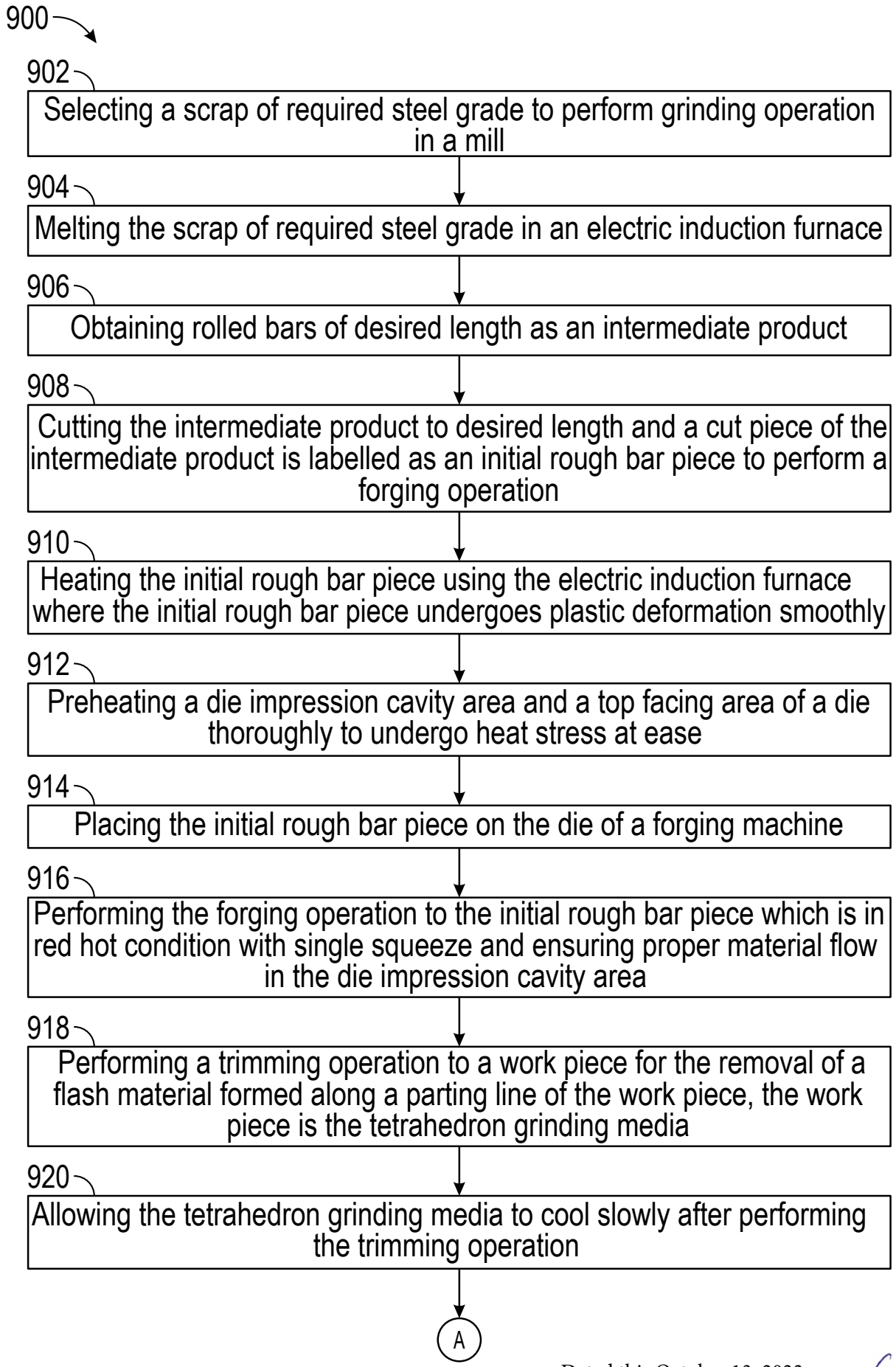


FIG. 9

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Authorized Patent Agent Name: **PUTTA GANESH**
(IN/PA/2933)

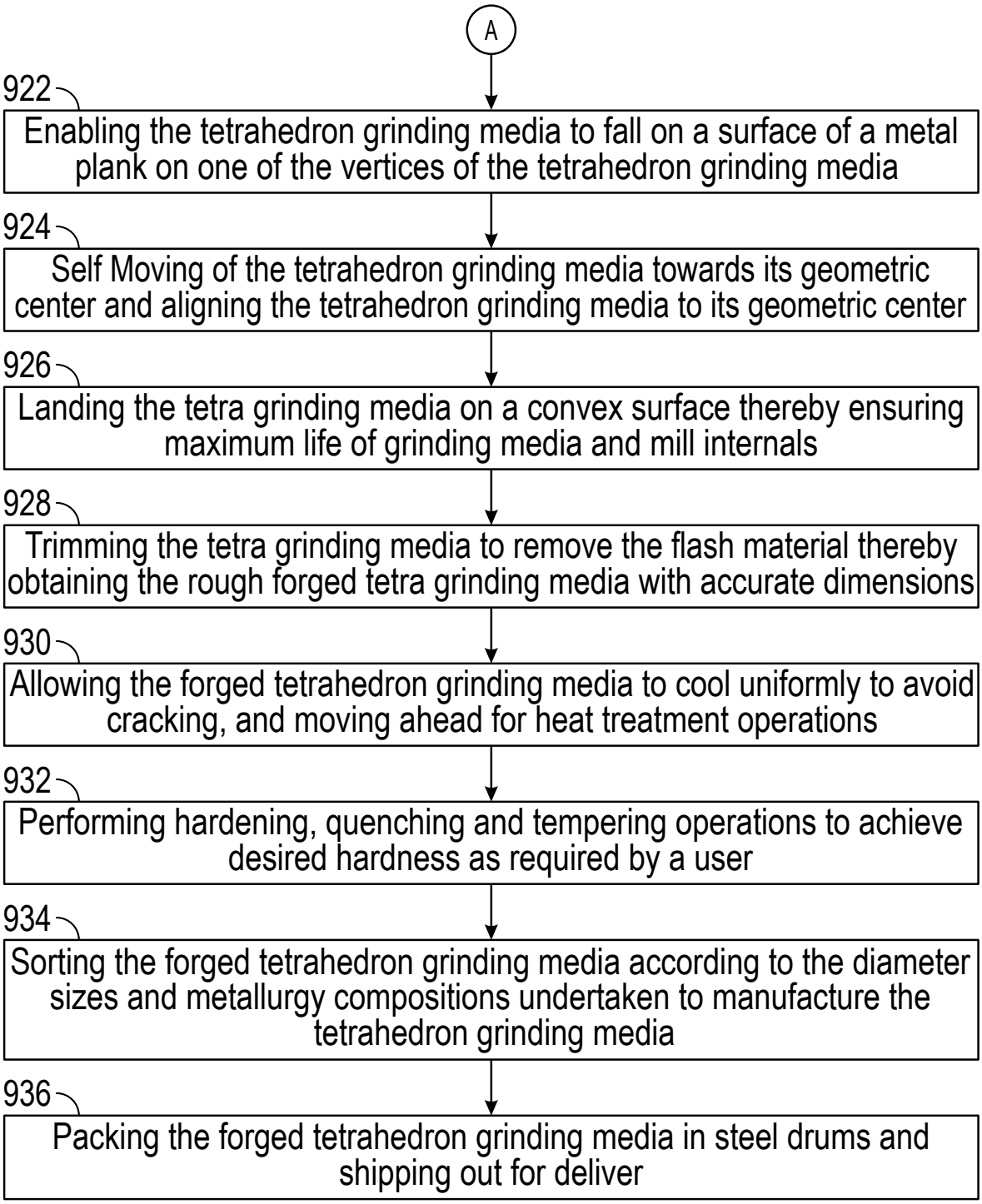


FIG. 9
(Continued)

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(IN/PA/2933)

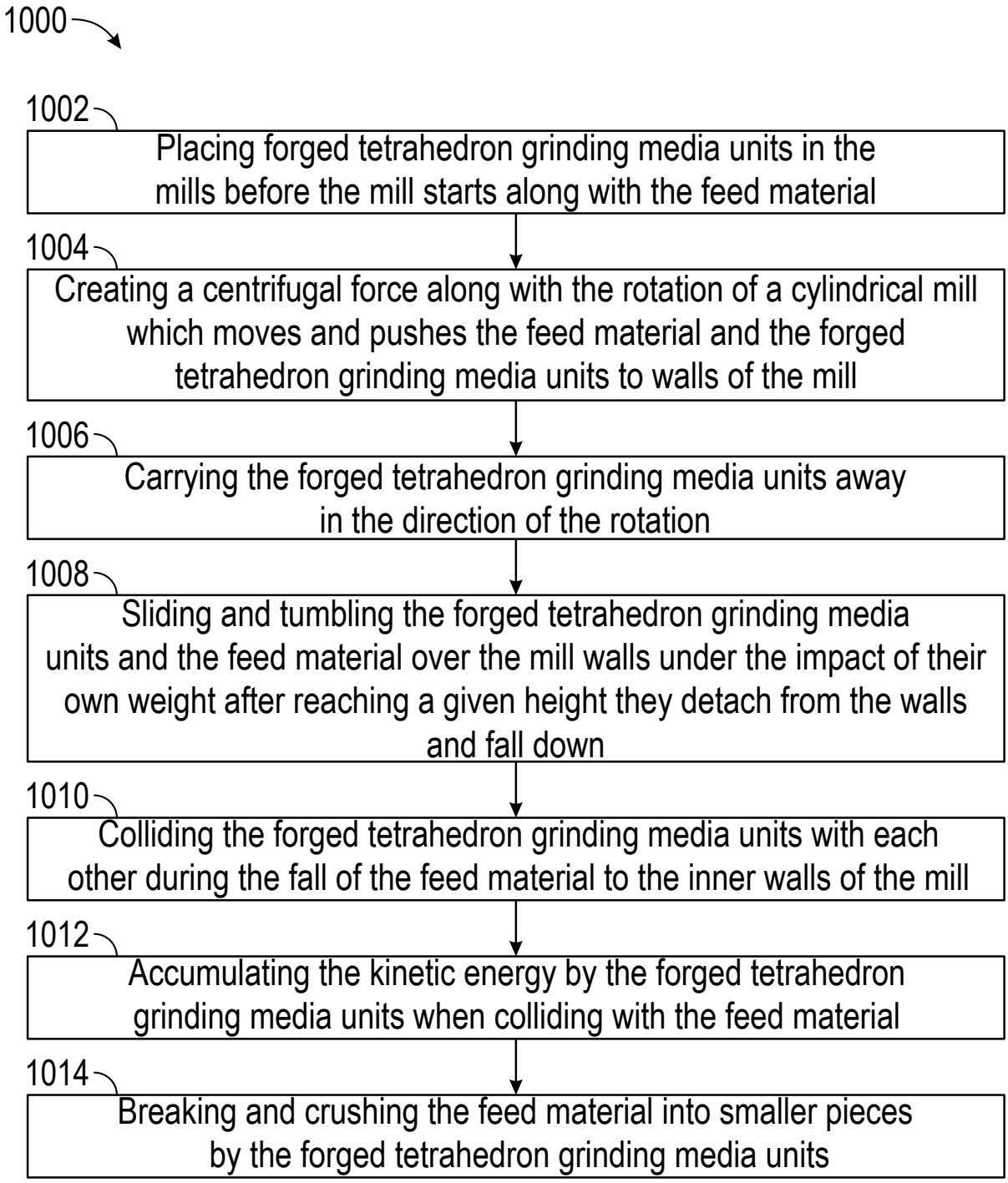


FIG. 10

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Authorized Patent Agent Signature:
Authorized Patent Agent Name: **PUTTA GANESH**
(IN/PA/2933)

FORM 2

THE PATENT ACT 1970

(39 of 1970)

&

The Patents Rules, 2003

COMPLETE SPECIFICATION

(See section 10 and rule 13)

1. TITLE OF THE INVENTION:

"METHOD FOR MANUFACTURING GRINDING MEDIA TO PERFORM FRAGMENTATION AND GRINDING OF FEED MATERIAL"

2. APPLICANTS:

Name **: SHIVANE OBEC TECH PRIVATE LIMITED.**

Address **:** D1-17, Shanti Shikara Apartments, Raj Bhavan Road, Somajiguda, Hyderabad, 500082,Telangana, India.

Nationality **:** Indian Company

3. PREAMBLE TO THE DESCRIPTION

The following specification particularly describes the invention and the manner in which it is to be performed.

4. DESCRIPTION

TECHNICAL FIELD

[001] The disclosed subject matter relates generally to a grinding media. More particularly, the present disclosure relates to a method for manufacturing grinding media to perform fragmentation and grinding of feed materials include ores, rocks and earth mass and other earth materials in sag-mills, ball mills, vertical mills and other horizontal tube mills.

BACKGROUND

[002] A grinding media that is used in various industries like cement, mines, power generation, chemical industry and the like. The grinding media may be in the form of different shapes, forms, and sizes used for the fragmentation and grinding of ores, rock, earth mass and other rare earth materials in both horizontal and vertical mills to be processed in downstream activities for extraction of metals and other rare earth elements. The widely used grinding media may be the spheroidal grinding media which have a disadvantage with regards to their low compaction in the working space and the lack of edges extends the time for breaking of the ores and reduces the effectiveness of the grinding media. The tetrahedron shape with smooth edges has been tried earlier and it is more effective than the spheroidal one because the tetrahedron shape allows for better compaction in the working space. However, the process of manufacturing the tetrahedron shape is difficult and it leads to increase in manufacturing costs and thereby impacting the mass adoption of the same in the different industries.

[003] Conventionally, there are other forms that have been developed, for example RU1 388088/1985 is more effective than those of the spheroidal, cylindrical or pyramidal form, as it allows better compaction. However, the manufacturing is complicated and requires more that makes the manufacturing process expensive and reduces the profitability of its adoption in the industries from its use in the grinding process. There is another form RU 2305 597/2007 where three rounded edges are formed by the rotation of the arcs of the edges

around the chords, connecting two tips. Those three edges of the tetrahedron have a cross-section similar to a circle and their cross-sections are variable along their lengths. This grinding media is known in geometry as Meissner Tetrahedron. Further the grinding media is exceptionally difficult and expensive to produce, and the additionally rounded edges with the described shape and variable cross-section would prevent the sliding of the grinding media bodies at each other, which in turn would make the grinding of ore materials impossible. Hence, there is a need to develop a method for manufacturing grinding media with the form of a spheroidal tetrahedron.

[004] In the light of the aforementioned discussion, there exists a need for a certain method with novel methodologies that would overcome the above-mentioned disadvantages.

SUMMARY

[005] The following presents a simplified summary of the disclosure in order to provide a basic understanding of the reader. This summary is not an extensive overview of the disclosure and it does not identify key/critical elements of the invention or delineate the scope of the invention. Its sole purpose is to present some concepts disclosed herein in a simplified form as a prelude to the more detailed description that is presented later.

[006] An objective of the present disclosure is directed towards a method for manufacturing tetrahedron grinding media to perform fragmentation and grinding of ores, rocks, earth mass and other rare earth materials in both horizontal and vertical mills.

[007] Another objective of the present disclosure is directed towards a method that creates a forged tetrahedron grinding media with a form that eases the manufacturing process and also ensures enhancement of grinding efficiency of the feed material.

[008] Another objective of the present disclosure is directed towards a method that reduces the prime cost of the forged tetrahedron grinding media and increases the profitability of the mill.

[009] Another objective of the present disclosure is directed towards a method that manufactures the forged tetrahedron grinding media with the form of a spheroidal tetrahedron, obtained from the crossing of four spheres with equal radii, the centres of each one lie on the surface of the others and are tips of a regular tetrahedron, and the radii of the spheres are equal to the edge of the regular tetrahedron.

[0010] Another objective of the present disclosure is directed towards a method that improves feasibility of manufacturing.

[0011] Another objective of the present disclosure is directed towards a method that manufactures the forged tetrahedron grinding media with the availability of flatly bevelled tip and rounded edges through stamping operation.

[0012] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that accelerates the breaking of the feed material and increases the effectiveness of the mills using the grinding media with sharp edges.

[0013] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that wear out evenly due to its center of gravity which coincides with the geometric center of the grinding media, and the likelihood of the wear rate and damages leading to the accelerated wearing out process, as a result of impact collisions undergone during work is enormously reduced.

[0014] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that includes tips and edges which are flatly beveled,

rounded and arc rounded depending on the choice of feed material and required working operation.

[0015] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that reduces energy consumption of grinding mills yielding maximum energy efficiency while milling the same quantity as compared to the conventional forms of grinding media such as spherical, cylindrical and pyramidal shapes resulting in a sustainable approach to energy consumption, thereby relieving the dependency on fossil fuel energy contribution and sustainable development goals.

[0016] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that increases efficiency of grinding leads to better recovery of metals even from the poor ores thereby increasing the quality and quantity of metal milled. The recovery of metals in the milling process itself leads to less accumulation of the same in the tailings assuring a healthy performing economical grinding circuit in all.

[0017] Another objective of the present disclosure is directed towards the tetrahedron grinding media which includes a great surface grinding by 9.4% when compared to the conventional grinding media available in the market.

[0018] Another objective of the present disclosure is directed towards the tetrahedron grinding media which includes the higher surface grinding capability intend to increase the productivity yield and draw minimum energy efficiency in recorded timeline when compared to the conventional media available in the market.

[0019] Another objective of the present disclosure is directed towards the grinding media that occupies less space by 15% in packaging than the conventional grinding media.

[0020] Another objective of the present disclosure is directed towards the geometry of the tetrahedron grinding media that allows a good compaction between the grinding media in the steel drums, the 15% reduction takes less packaging material such as steel drums and wooden pallets ensuring a sustainable approach while manufacturing and procuring the same.

[0021] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that improves the grinding performance by increasing of carbon content value in the final metallurgy.

[0022] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that improves the grinding performance by important factors which enhance a greater productivity and higher energy efficiency.

[0023] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media is designed in a shape of tetrahedron that supports greater penetration of heat treatment towards the inner core area.

[0024] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that provides three side grinding around the feed material and fourth side grinding dense particle lying on the bottom surface of at least one of: the Horizontal mill; and the Vertical Mill.

[0025] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that attain better microstructure of the forged tetrahedron grinding media by having less amount of retained austenite to maintain a superior tempered martensitic microstructure.

[0026] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that wear out evenly due to its center of gravity and strong inner core strength area which coincides with the geometric center of the grinding body, thereby reducing the grinding wear rate of the forged tetrahedron grinding media and thus retaining its shape throughout the milling process.

[0027] Another objective of the present disclosure is directed towards improving the grinding performance of the forged tetrahedron grinding media, results in increase in energy saving efficiency of the mill by 35%, Productivity increase by 25-30% within stipulated timeline, Reduction in wear rate of the forged tetrahedron grinding media by 40%; and Minimum downtime period for maintenance activity.

[0028] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that is used in a coal grinding Industry to contribute a better and more qualitative grinding of coal for the needs of the furnaces and boilers in the thermo-electric power-stations.

[0029] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that is used in a chemical industry for the production of paints, varnishes and intermediate products in powder form.

[0030] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that is used in an agriculture industry for the production of phosphate fertilizers.

[0031] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that is used in cement and construction industry for the production of raw meal and clinker grinding materials used in the production of cement.

[0032] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that is used in a pharmaceutical industry to grind the lumps into fine powder particles at initial stage as pre-meal and at the end process of chemical reactor to achieve final product.

[0033] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that is used in a mining industry to grind the ores for achieving qualitative and enormous quantity of desired metals and non-metals as finish product after milling and flotation process is executed in the earliest recorded timeline.

[0034] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that exhibits greater kinetic energy while undergoing centrifugal force at inner periphery of the mill along the mill lining resulting in uniform grinding of milling the feed material and reduced grinding wear rate of the grinding media.

[0035] Another objective of the present disclosure is directed towards the forged tetrahedron grinding media that includes the larger contact surface area, and ability of retaining its shape throughout the milling process improves the grinding efficiency of the mill.

[0036] In an embodiment of the present disclosure, a method for manufacturing grinding media to perform fragmentation and grinding of feed material, comprising selecting a scrap of required steel grade to perform grinding operation in at least one of: a Horizontal mill; and a Vertical Mill.

[0037] In another embodiment of the present disclosure, melting the scrap of required steel grade in an electric induction furnace; Obtaining one or more rolled bars of desired length as an intermediate product; Cutting the intermediate product

to desired length and a cut piece of the intermediate product is labelled as an initial rough bar piece to perform a forging operation.

[0038] In another embodiment of the present disclosure, heating the initial rough bar piece using the electric induction furnace where the initial rough bar piece undergoes plastic deformation smoothly; Preheating a die impression cavity area and a top facing area of a die thoroughly to undergo heat stress at ease; Placing the initial rough bar piece on the die of a forging machine.

[0039] In another embodiment of the present disclosure, Performing the forging operation to the initial rough bar piece which is in red hot condition with single squeeze and ensuring proper material flow in the die impression cavity area; Performing a trimming operation to a work piece for the removal of a flash material formed along a parting line of the work piece, the work piece is the tetrahedron grinding media; Allowing the tetrahedron grinding media to cool slowly after performing the trimming operation.

[0040] In another embodiment of the present disclosure, Enabling the tetrahedron grinding media to fall on a surface of a metal plank on one of the vertices of the tetrahedron grinding media; Self moving of the tetrahedron grinding media towards its geometric center and aligning the tetrahedron grinding media to its geometric center; Landing the tetra grinding media on a convex surface thereby ensuring maximum life of grinding media and mill internals; Trimming the tetra grinding media to remove the flash material thereby obtaining the rough forged tetra grinding media with accurate dimensions.

[0041] In another embodiment of the present disclosure, Allowing the forged tetrahedron grinding media to cool uniformly to avoid cracking, and moving ahead for heat treatment operations; Performing hardening, quenching and tempering operations to achieve desired hardness as required by a user; Sorting the forged tetrahedron grinding media according to the diameter sizes and

metallurgy compositions undertaken to manufacture the tetrahedron grinding media; Packing the forged tetrahedron grinding media in steel drums and shipping out for delivery.

BRIEF DESCRIPTION OF THE DRAWINGS

[0042] In the following, numerous specific details are set forth to provide a thorough description of various embodiments. Certain embodiments may be practiced without these specific details or with some variations in detail. In some instances, certain features are described in less detail so as not to obscure other aspects. The level of detail associated with each of the elements or features should not be construed to qualify the novelty or importance of one feature over the others.

[0043] FIG. 1 is an example flow diagram depicting a method for manufacturing the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0044] FIG. 2A is an example diagram depicting the initial rough bar pieces, in accordance with one or more exemplary embodiments.

[0045] FIG. 2B is an example diagram depicting the initial rough bar pieces placed for heating in the induction heating machine, in accordance with one or more exemplary embodiments.

[0046] FIG. 2C, FIG. 2D are example diagrams depicting the die impressions of tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0047] FIG. 2E, FIG. 2F, are example diagrams depicting the preheating of the die impressions of inner cavity and flash trimming cut section area, in accordance with one or more exemplary embodiments.

[0048] FIG. 2G is an example diagram depicting the preheated die impressions being ready for forging, arrival of initial rough bar piece from the induction heating machine in red hot condition, in accordance with one or more exemplary embodiments.

[0049] FIG. 2H, FIG. 2I, FIG. 2J, FIG. 2K, FIG. 2L are example diagrams depicting the manufacturing of the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0050] FIG. 2M, FIG. 2N are example diagrams depicting the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0051] FIG. 2O is an example diagram depicting the tetrahedron grinding media with flash material, in accordance with one or more exemplary embodiments.

[0052] FIG. 2P and FIG. 2Q are example diagrams depicting the difference between the heat penetration towards the core area of spherical grinding media and the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0053] FIG. 2R is an example diagram depicting the tetrahedron grinding media after performing the normalizing operation of the heat treatment process, in accordance with one or more exemplary embodiments.

[0054] FIG. 2S and FIG. 2T are another example diagrams depicting the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0055] FIG. 3A is an example diagram depicting a top view of an even shaped tetrahedron grinding media, in accordance with one or more exemplary

embodiments.

[0056] FIG. 3B is an example diagram depicting a rear view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0057] FIG. 3C is an example diagram depicting a bottom view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0058] FIG. 3D is an example diagram depicting a left view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0059] FIG. 3E is an example diagram depicting a right view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0060] FIG. 3G is an example diagram depicting a front view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0061] FIG. 3F is an example diagram depicting a perspective view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0062] FIG. 3H is an example diagram depicting a view with rounded or arch-rounded corners and vertices of the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0063] FIG. 3I is an example diagram depicting a view with flat bevelled corners and vertices of the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0064] FIG. 4A is another example diagram depicting a top view of an arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0065] FIG. 4B is another example diagram depicting a rear view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0066] FIG. 4C is another example depicting a bottom view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0067] FIG. 4D is another example diagram depicting a left view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0068] FIG. 4E is another example diagram depicting a right view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0069] FIG. 4F is another example diagram depicting a perspective view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0070] FIG. 4G is another example diagram depicting a front view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0071] FIG. 5A and FIG. 5B are example diagrams depicting the minimum contact surface area difference between the tetrahedron grinding media and the conventional spherical grinding media in milling stage, in accordance with one or more exemplary embodiments.

[0072] FIG. 6A and FIG. 6B are example diagrams depicting the packing and stacking difference between the spherical grinding media and the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0073] FIG. 7 is an example diagram depicting the geometric centre of the spherical grinding media and the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0074] FIG. 8 is an example diagram depicting an inside view of mill rotation and forces experienced by the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[0075] FIG. 9 is an example of flow diagram depicting a method for manufacturing grinding media to perform fragmentation and grinding of feed material, in accordance with one or more exemplary embodiments.

[0076] FIG. 10 is an example of flow diagram depicting a method for grinding feed material using forged tetrahedron grinding media units in grinding mills, in accordance with one or more exemplary embodiments

DETAILED DESCRIPTION OF EXAMPLE EMBODIMENTS

[0077] It is to be understood that the present disclosure is not limited in its application to the details of construction and the arrangement of components set forth in the following description or illustrated in the drawings. The present disclosure is capable of other embodiments and of being practiced or of being

carried out in various ways. Also, it is to be understood that the phraseology and terminology used herein is for the purpose of description and should not be regarded as limiting.

[0078] The use of “including”, “comprising” or “having” and variations thereof herein is meant to encompass the items listed thereafter and equivalents thereof as well as additional items. The terms “a” and “an” herein do not denote a limitation of quantity, but rather denote the presence of at least one of the referenced item. Further, the use of terms “first”, “second”, and “third”, and the like, herein do not denote any order, quantity, or importance, but rather are used to distinguish one element from another.

[0079] In another exemplary embodiment of the present disclosure, the manufacturing method of a tetrahedron grinding media through forging begins with the selection of correct alloy metal material required for the grinding operation in horizontal and vertical mills. The alloy metal material may include, but not limited to, Carbon Steels (Low, Medium and High Carbon) with presence of Chromium, Molybdenum and Nickel; Wear Resistant Steels; EN Steel series with other similar International steel grades; Silicon-Manganese Steel; Stainless Steel and Duplex Steel with other similar International steel grade alloys; Bearing Steel grades with other similar International Standards; and the Rail Steel scraps, and the like. The tetrahedron grinding media may be predominantly used in various industries for to perform fragmentation and grinding of feed materials. The feed materials may include, but not limited to, ores, rocks and earth mass and other earth materials. The industries may include, but not limited to, coal grinding, chemical industry, agriculture industry, cement and construction industry, and mining industry.

[0080] In another exemplary embodiment of the present disclosure, the tetrahedron grinding media units may be used in coal industry to contribute a better and more qualitative grinding of coal for the needs of the furnaces and

boilers in the thermo-electric power-stations. The tetrahedron grinding media units may be used in chemical industry for the production of paints, varnishes and intermediate products in powder form. The tetrahedron grinding media units may be used in agriculture industry for the production of phosphate fertilizers (phosphates and apatite's). The tetrahedron grinding media units may be used in cement and construction industry for the production of raw meal and clinker grinding materials used in the production of cement. The tetrahedron grinding media units may be used in the pharmaceutical industry to grind the lumps into fine powder particles at initial stage as pre-meal and at the end process of chemical reactor to achieve final product. The tetrahedron grinding media units may be used in mining industry to grind the ores for achieving qualitative and enormous quantity of desired metals and non-metals as finish product after milling and flotation process is executed in the earliest recorded timeline.

[0081] The tetrahedron grinding media is brought into trial test run of Lead Zinc ore, Cement Clinker and raw meal grinding. The test process is documented considering all standard operating procedures of the trial test, and the findings are recorded with set key performing index parameters to derive the final outcome. The results and advantages achieved by using this form of tetrahedron grinding media may increase energy saving efficiency of the mill by 35%, increase productivity (For example, 25-30%) within stipulated timeline, reduce wear rate of tetrahedron grinding media (For example, 40%), Minimum downtime period for maintenance activity, maintains uniformity in the production of the tetrahedron grinding media, Uniform retention of the shape, Shape retention with gradual wear tear rate noticed throughout the milling process due to its strong inner core strength area assuring uniform grinding.

[0082] In another exemplary embodiment of the present disclosure, the tetrahedron grinding media may be used in the horizontal and vertical grinding mills for the grinding of the feed material. The feed material may include, but not limited to, ores, rocks, earth mass, earth materials, other materials and the like.

The tetrahedron grinding media units are placed before the mill starts functioning along with the feed material. For example, the rotation of the cylindrical mill creates a centrifugal force, which moves and pushes the feed material and the tetrahedron grinding media units to the walls of the mill, carrying them away in the direction of the rotation, so under the impact of their own weight of the tetrahedron grinding media units and the feed material initially slide first and tumble over the mill wall and after reaching a given height they detach from the wall and fall down.

[0083] During the fall, the feed material keeps colliding with each other, and to the lumps of feed material or to the inner wall of the mill. The kinetic energy accumulated by the tetrahedron grinding media units when colliding with the feed material, where the tetrahedron grinding media units breaks and crushes the feed material into smaller pieces. If the lumps of the feed material have higher hardness and/or of larger size, the process of breaking is faster when the tetrahedron grinding media units consists of sharp edges. If the edges are ribbed, the tetrahedron grinding media units wear out more slowly. The constant crashes of the tetrahedron grinding media units with beveled edges lead to a slower wearing out process of the grinding media. If the feed material is finer, the use of the tetrahedron grinding media units with rounded edges is more profitable. After reaching the lower part of mill, the tetrahedron grinding media units are pressed by the centrifugal forces to the wall again or to other grinding media units and grind the feed material among them. The larger contact surface of the grinding media units during the collision with the feed material and with other grinding media units in the mill at equal conditions increases the effectiveness of the grinding process.

[0084] If the center of gravity of the tetrahedron grinding media units coincides with their geometric center, they wear out evenly and their life becomes longer and is observed during industrial trials. The lower geometric center may allow the tetrahedron grinding media units to rotate smoothly, and during rotation of mill,

the geometric center aligns with the center of gravity ensuring the tetrahedron grinding media units to land on its concave surface without causing any damages to the mill internal liners.

[0085] The higher density of arrangement is noticed with the tetrahedron grinding media units in comparison to spherical grinding units by 15% making way for increased productivity with the tetrahedron grinding media units. Secondly, the contact radius of the tetrahedron grinding media units are twice larger than the spherical surfaces, compared to the same area, creating a greater contact ratio of the tetrahedron grinding media units within the walls of the mill. The tetrahedron grinding media units may climb and fall from a greater height than the analogous spherical media. The tetrahedron grinding media units may move with greater kinetic energy generated within the mill movements, and thereby having larger productivity and crushing performance.

[0086] Further, a flatly beveled tip and rounded corners at edges and vertices allow for manufacturing through Forging/Stamping which is the most appropriate method for manufacturing of the tetrahedron grinding media units. This reduces the prime cost of the tetrahedron grinding media units and increases the profitability of the mill. The presence of sharp edges accelerates the breaking of the feed material and increases the effectiveness of the mills using the tetrahedron grinding media.

[0087] Referring to FIG. 1 is an example of flow diagram 100 depicting a method for manufacturing the tetrahedron grinding media, in accordance with one or more exemplary embodiments. However, the method 100 may be carried out in any desired environment. Further, the aforementioned definitions may equally apply to the description below.

[0088] The method commence at step 102, melting of steel scrap and alloys through the induction/arc furnace to form required size of Billets/bar rods. The

alloy metal material often preferred for manufacturing in forging process. Thereafter at step 104a, casting of Billets/bar rods. Thereafter at step 104a, outsourced Billets/bar rods. Thereafter at step 106, cutting the billets/bar rods to the required length for heating. Thereafter at step 108, heating the pieces of billets/bar rods at forging temperature in the induction/arc furnace. Thereafter at step 110, forging initial hot billet pieces in the close die forging press. Thereafter at step 112, Forging/stamping/pressing and rolling the hot pieces thereby obtaining the tetrahedron grinding media. Thereafter at step 114, removing the flash material on the tetrahedron grinding media by performing the trimming operation. Thereafter at step 116, performing the heat treatment to normalize the tetrahedron grinding media after forging. Thereafter at step 118, hardening, quenching and tempering the tetrahedron grinding media to achieve desired hardness. Thereafter at step 120, performing the inspection process to determine the hardness of the tetrahedron grinding media. Determining whether the desired hardness of the tetrahedron grinding media is achieved? If the answer is yes, the method continues at step 124, sorting of the tetrahedron grinding media as per specifications. Thereafter at step 126, packing and delivering the tetrahedron grinding media to the mills. If the answer is No, the method reverts at step 102, rejecting the tetrahedron grinding media and sending back for forging.

[0089] The manufacturing method of close die includes, at step 136, machining of blocks for die impression carvings. Thereafter at step 134, setting of die in a closed die hammer or press. Thereafter at step 134, Performing forging operation in close die forging hammer or press. Thereafter the method continues at step 110.

[0090] Referring to FIG. 2A is an example diagram 200a depicting the initial rough bar pieces, in accordance with one or more exemplary embodiments. The diagram 200a depicts rough bar pieces 202. The scrap of required steel grade along with the addition of Ferro alloys, subjected to the final composition required, undergo melting in an electric induction furnace/ induction heating machine/electric arc furnace to obtain rolled billets or rods of desired length as an

intermediate product. The compositions are checked with the help of a spectrometer to ensure the best metallurgical grade is drawn out from the melting furnace. The intermediate product is then cut to desired length, and the cut pieces of intermediate product are labeled as initial rough bar pieces 202 to perform forging/stamping operation.

[0091] Referring to FIG. 2B is an example diagram 200b depicting the initial rough bar pieces placed for heating in the induction heating machine, in accordance with one or more exemplary embodiments. The diagram 200b depicts an induction heating machine 204. The forging/stamping operation of the tetrahedron grinding media begins with the heating of initial rough bar pieces 202 to desired temperature higher than forging temperature of steel where the initial rough bar pieces 202 may undergo plastic deformation smoothly. The heating may be achieved by using the induction heating machine 204 or gas/oil/electric fired furnace. The rough bar pieces 202 may attain the required forging temperature, and the rough bar pieces 202 may be pressed or rolled to form the tetrahedron grinding media.

[0092] Referring to FIG. 2C and FIG. 2D are example diagrams 200c, 200d depicting the die impressions of tetrahedron grinding media, in accordance with one or more exemplary embodiments. The diagrams 200c and 200d depicts die impression cavity area 206. The efficiency and effectiveness of bulk production depends on the choice of dies selected to undergo forging operations in close die forging hammer or hydraulic driven forging press. Die impressions of final finish product is made on a single block with single die or multiple die carvings to increase the productivity and better the ease of handling and maintenance of Forging Hammer or Press machines. Also, if the forging machines are of smaller sizes with less die cross section, and if more similar machines being available to incorporate bulk manufacturing, then each die block size takes single die carvings in step sequential manner to hot form or press the bar piece to achieve the desired finish product. The dies are then locked properly to undergo forging operations

smoothly. The choice of die material is tool steel which may sustain heat from the initial bar piece 202 and ensure less wear tear rate while bulk manufacturing.

[0093] Referring to FIG. 2E and FIG. 2F are example diagrams 200e, and 200f depicting the preheating of the die impressions of inner cavity and flash trimming cut section area, in accordance with one or more exemplary embodiments. The diagram 200e and 200f depicts the preheating of the die impression cavity area 206 of inner cavity and flash trimming cut section area. The designing of die carving/die impression cavity area 206 is an optimized approach to ensure proper flow of material to bottom end area while heat operations are performed and grain structure remains uniform throughout the forged piece. The fillets and draft angles are calculated and drawn onto dies for maximum penetration of hot piece into the die cavity 206, the hot piece undergoes hydraulic powered three ram blows in hammer or single press blow powered in conventional presses. The die impression cavity area 206 and the top facing area of die are preheated thoroughly 210 to undergo heat stress at ease which is generated by the hot initial rough piece when placed over the die cavity 206 for forging operations. The shape of the die impression cavity area is in the form of a spheroidal tetrahedron. The shape of the die impression cavity area may be an even shaped die impression cavity area; and an arch shaped die impression cavity area. The die impression cavity area includes tips and edges which are flatly beveled, rounded and arc rounded depending on the choice of ore and working operation required.

[0094] Referring to FIG. 2G is an example diagram 200g depicting the preheated die impressions being ready for forging, arrival of initial rough bar piece from the induction heating machine in red hot condition, in accordance with one or more exemplary embodiments. The diagram 200g depicts a forging machine 208. The initial rough bar piece 202 after induction heating to 940 – 1080 ˚C are then placed on the die of forging machine 208 at the temperatures within the range 900 – 1050 ˚C to forge or roll form the initial rough bar piece to form the tetrahedron grinding media. The initial rough bar piece 202 undergo deformations on the

physical structure in closed die forging machines, Press forging are widely preferred over Drop forging hammer machines to maintain uniform pressure around the work piece assuring proper grain flow throughout the forged piece and dimensions to be more accurate. Press forgings normally take one squeeze at each die impression carvings than the conventional forging hammer requiring three ram powered counter blows to form the tetrahedron grinding media.

[0095] Referring to FIG. 2H, FIG. 2I, FIG. 2J, FIG. 2K, FIG. 2L are example diagrams 200h, 200i, 200j, 200k, and 200l depicting the manufacturing of the tetrahedron grinding media, in accordance with one or more exemplary embodiments. The diagram 200h depicts the forging operation, where the initial rough bar piece in red hot condition undergoes forging operation in press with single squeeze ensuring proper material flow in the cavity area 206. The diagram 200i depicts the trimming operation of the work piece for the removal of excess material after performing the forging/stamping operation. The excess material may be the flash material formed along the parting line. This process is continuing one with immediate arrival of another hot bar piece in the cavity area 206 for forging operations.

[0096] The diagram 200j depicts the tetrahedron grinding media 212. The tetrahedron grinding media 212 may be allowed to cool slowly after performing the trimming operation. It can be noticed that the work piece falls on the surface of the metal plank on one of the vertices of the tetrahedron grinding media. The diagram 200k depicts the work piece starts moving towards the geometric center of the die cavity. The diagram 200l depicts the work piece align to its geometric center of the die cavity. The convex surface of the tetrahedron grinding media 212 may land on the surface ensuring maximum life of grinding media and mill internals. The tetrahedron grinding media may be trimmed to remove extra material called as flash to have the rough forged product with accurate dimensions. The forged tetrahedron grinding media may be allowed to cool uniformly to avoid cracking, and then moves ahead for heat treatment operations.

[0097] Referring to FIG. 2M and FIG. 2N are example diagrams 200m and 200n depicting the forged tetrahedron grinding media, in accordance with one or more exemplary embodiments. The diagram 200i depicts the forged tetrahedron grinding media 212 with the flash material along the die parting line before trimming operation. The red hot piece is trimmed and allowed to cool slowly for its next schedule of desired heat treatment operations.

[0098] Referring to FIG. 2O is an example diagram 200o depicting the tetrahedron grinding media with flash material, in accordance with one or more exemplary embodiments. The diagram 200o depicts the tetrahedron grinding media 212 which is trimmed and is placed next to the flash material 216 generated while undergoing forging operation. The correct usage of dies with regards to the proper squeeze flow of the work piece (metal) in the die cavity area optimized, and manufactured by Forging Hammer/Press without any deviations shall guarantee a top quality product (Forged Tetra Grinding media).

[0099] The forged tetrahedron grinding media 212 is normalized at 920-930˚C, thereafter allow to cool in furnace till 550 ˚C and then air cooling in open to meet room temperature. The forged tetrahedron grinding media 212 is then hardened to the temperature 850-930˚C and quenched in water/oil/salt solution. The ideal temperature of the quenching medium may be around 10-50 ˚C or at the room temperature. The forged tetrahedron grinding media 212 after hardening may be tempered in the range 100-250 ˚C in order to attain hardness between 58-65HRC. The forged tetrahedron grinding media 212 may undergo soaking period for one inch per hour for Normalizing, Hardening and Tempering in order to attain better physical and mechanical properties throughout for any given forged media diameter size.

[00100] Referring to FIG. 2P and FIG. 2Q are example diagrams 200p and 200q depicting the difference between the heat penetration towards the core area

of spherical grinding media and the forged tetrahedron grinding media, in accordance with one or more exemplary embodiments. The diagram 200p depicts the spherical grinding media 214. The diagram 200q depicts the forged tetrahedron grinding media 212. The microstructure of the forged tetrahedron grinding media 212 is tempered martensitic along with secondary phases moving towards the core center area of the forged tetrahedron grinding media 212. The core area attains higher value due to its shape which increases the heat penetration inwards towards the core area from the surface when compared to the spherical grinding media 214. The surface penetration of the spherical grinding media 214 is 10-15 mm. The surface penetration of the forged tetrahedron grinding media 212 is 25-32 mm.

[00101] The desired hardness on the surface and the core area may be achieved by choosing correct metallurgy required along with the guaranteed process strength by selective optimization of the heat treatment process performed in order to obtain superior hardness throughout the tetrahedron grinding media based on the requirements of end user. The pusher type heat treatment furnace may be ideally used to heat treat the forged tetrahedron grinding media on bulk scale for enabling faster production cycle to meet global requirements.

[00102] Referring to FIG. 2R is an example diagram 200r depicting the tetrahedron grinding media after performing the normalizing operation of the heat treatment process, in accordance with one or more exemplary embodiments. The tetrahedron grinding media 212 may undergo oil hardening and tempering process operations after performing the normalizing operation of heat treatment process to obtain desired hardness as required by the user in their respective area of deployment tetrahedron grinding media.

[00103] The working performance of the forged tetrahedron grinding media improves by important factors which enhance a great productivity and higher energy efficiency when compared to conventional spherical grinding media,

pyramidal grinding media and cylindrical grinding media. The important factors to obtain greater productivity and higher energy efficiency may include, the shape of the tetrahedron grinding media which supports greater penetration of heat treatment towards the inner core area; the increase of carbon content value in the final metallurgy shall support greater grinding performance of the tetrahedron grinding media; the shape assuring three side grinding around the feed material and fourth side grinding dense particle lying on the bottom surface of the mill; By attaining better microstructure of the tetrahedron grinding media by having less amount of retained austenite to maintain a superior tempered martensitic microstructure; the tetrahedron grinding media may wear out evenly due to its center of gravity which coincides with the geometric center of the tetrahedron grinding unit, thereby reducing the grinding wear rate of the grinding media and thus retaining its shape throughout the milling process.

[00104] Referring to FIG. 2S and FIG. 2T are another example diagrams 200s and 200t depicting the tetrahedron grinding media, in accordance with one or more exemplary embodiments. The diagram 200s depicts an end product (the forged tetrahedron grinding media) undergone all parameters to achieve desired results. The diagram 200t depicts the different sizes of the forged tetrahedron grinding media from diameter 15mm to diameter 100mm (in Image) and maximum size of 180mm can be manufactured at ease.

[00105] The forged tetrahedron grinding media units are then sorted accordingly to their diameter sizes and metallurgy compositions undertaken to manufacture them. The sorting allows visual inspection of each media unit thoroughly by the gauge check for dimensions and hardness testing by digital hardness tester at the surface and towards the core area when the testing sample is cut in two half. The testing sample then goes for microstructure test analysis to achieve tempered martensitic structure. The forged tetrahedron grinding media 212 which is not approved after inspection process is then moved towards melting yard as scrap, rejects abiding the eco-friendly norms and maintaining a sustainable

environment. The forged tetrahedron grinding media units are then packed in steel drums and shipped out for delivery.

[00106] Referring to FIG. 3A is an example diagram 300a depicting a top view of an even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments. The diagram 300a depicts the tetrahedron grinding media 212. The tetrahedron grinding media 212 may be obtained from the crossing of four spheres with equal radii, the centers of each one lie on the top of the surface of the others and are tips of regular tetrahedron. The radii of the spheres are equal to the regular tetrahedron's edge. The four end tips 302a, 302b, 302c, and 302d of the spheroidal tetrahedron grinding media 212 are flatly beveled and the rest are rounded, so one and the same mass of material is taken away from each tip, the edges of the grinding media to be rounded, beveled or ribbed depending on the grinding ore. The ribbing can be even or arch-shaped.

[00107] Referring to FIG. 3B is an example diagram 300b depicting a rear view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00108] Referring to FIG. 3C is an example diagram 300c depicting a bottom view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00109] Referring to FIG. 3D is an example diagram 300d depicting a left view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00110] Referring to FIG. 3E is an example diagram 300e depicting a right view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00111] Referring to FIG. 3F is an example diagram 300f depicting a perspective view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00112] Referring to FIG. 3G is an example diagram 300g depicting a front view of the even shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00113] Referring to FIG. 3H is an example diagram 300h depicting a view with rounded or arch-rounded corners and vertices of the tetrahedron grinding media, in accordance with one or more exemplary embodiments. The diagram 300h includes rounded or arch-rounded corners and vertices 304a, 304b and 304c.

[00114] Referring to FIG. 3I is an example diagram 300i depicting a view with flat beveled corners and vertices of the tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00115] Referring to FIG. 4A is another example diagram 400a depicting a top view of an arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00116] Referring to FIG. 4B is another example diagram 400b depicting a rear view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00117] Referring to FIG. 4C is another example 400c depicting a bottom view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00118] Referring to FIG. 4D is another example diagram 400d depicting a left view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00119] Referring to FIG. 4E is another example diagram 400e depicting a right view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00120] Referring to FIG. 4F is another example diagram 400f depicting a perspective view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00121] Referring to FIG. 4G is another example diagram 400g depicting a front view of the arch shaped tetrahedron grinding media, in accordance with one or more exemplary embodiments.

[00122] Referring to FIG. 5A and FIG. 5B are example diagrams 500a and 500b depicting the minimum contact surface area difference between the tetrahedron grinding media and the conventional spherical grinding media in milling stage, in accordance with one or more exemplary embodiments. The diagram 500a depicts a conventional spherical grinding media 502, the tetrahedron grinding media 212.

[00123] The spherical grinding media 502 may include the circumference of circle of 50mm diameter Size = $2\pi R$ = (2 x π x 25) = 157.079 = 157mm (Rounded), and the minimum contact surface of spherical unit 502 at one point of contact = 2.75% of 157mm = 4.32mm. The tetrahedron grinding media 212 minimum contact surface at one point of contact = 9.4% of 157 = 14.65mm. The value of 14.65mm was achieved for 50mm diameter grinding media, but when the diameter size of grinding media increases, then the contact surface ratio may also increase accordingly. The above value of tetrahedron grinding media 212 includes

larger contact surface area throughout the milling stage which is obtained by the right selection of metallurgy, proper die design enabling maximum reach of material in the cavity area, and the ideal heat treatment process operations obtain required surface and core hardness resulting in greater grinding efficiency when put in comparison to conventional spherical, pyramidal and cylindrical grinding bodies. The tetrahedron grinding media 212 may include a greater surface grinding by 9.4% when compared to the conventional spherical grinding media available in the market. The higher surface grinding capability may increase the productivity yield and draw minimum energy efficiency in recorded timeline when compared to the conventional spherical grinding media available in the market.

[00124] Referring to FIG. 6A and FIG. 6B are example diagrams 600a and 600b depicting the packing and stacking difference between the spherical grinding media and the tetrahedron grinding media, in accordance with one or more exemplary embodiments. The diagram 600a depicts the spherical grinding media 502. The diameter of the spherical unit size may be of 30mm. The distance between the unit to unit while placing one above each other may be at 120 mm. The distance after Stacking/Packing may be at 112 mm, where the STACKING% = ((120 -112) / 120) X 100 = 6.67% = 7% (Rounded). Further, the spherical grinding media 502 occupies the required area with 7% spacing gap left open to accommodate excess grinding feed material in the mills, and also reducing the cost of the packaging material incurred while manufacturing the steel drums and the wooden pallets accordingly.

[00125] The diagram 600b depicts the tetrahedron grinding media 212. The diameter of the tetrahedron grinding media 212 may be of 30mm. The distance while placing the tetrahedron grinding media units one above each other is 120mm. The distance after Stacking/Packing is 97 mm, the stacking% = ((120 - 97) / 120) X 100 = 19.16% = 19%. The tetrahedron grinding media units occupies the required area with 15% above spacing gap left open to accommodate excess

grinding feed material in mills, and also reducing the cost of the packaging material incurred while manufacturing steel drums and wooden pallets accordingly.

[00126] The tetrahedron grinding media 212 is strong on material density achieved by the steps undertaken in manufacturing method and superior on spacing and occupying less volume when compared to other conventional spherical grinding media, the spacing gap achieved may also be accommodated by grinding feed material to enhance better productivity.

[00127] The tetrahedron grinding media 212 may occupy less space by 15% in packaging than the conventional spherical grinding media. The geometry of the tetrahedron grinding media 212 may allow a good compaction between the grinding media units in the steel drums, the 15% reduction may take less packaging material such as steel drums and wooden pallets ensuring a sustainable approach while manufacturing and procuring the same.

[00128] Referring to FIG. 7 is an example diagram 700 depicting the geometric center of the spherical grinding media and the tetrahedron grinding media, in accordance with one or more exemplary embodiments. The diagram 700 depicts the spherical grinding media 502, and the tetrahedron grinding media 212. The geometric center of the spherical grinding media 502 may be indicated as “x” 702, and the geometric center of the tetrahedron grinding media 212 may be indicated as “+” 704. The lower geometric center allows the tetrahedron grinding media 212 to rotate smoothly, and during rotation of mill, the geometric center aligns with the center of gravity ensuring the tetrahedron grinding media 212 land on its concave surface without causing any damages to the mill internal liners.

[00129] Referring to FIG. 8 is an example diagram 800 depicting an inside view of mill rotation and forces experienced by the tetrahedron grinding media, in accordance with one or more exemplary embodiments. The diagram 800 includes

a mill lining. 802, the tetrahedron grinding media 212. The rotation of the tetrahedron grinding media 212 may exhibits greater kinetic energy while undergoing centrifugal force at inner periphery of mill along the mill lining 802 resulting in uniform grinding of milling the feed material and reduced grinding wear rate of the tetrahedron grinding media.

[00130] The geometric center of the tetrahedron grinding media 212, the larger contact surface area of the tetrahedron grinding media, and the ability of retaining its shape design throughout the milling process may improve the grinding efficiency of the mill. The higher density of arrangement is noticed with the tetrahedron grinding media 212 in comparison to spherical grinding units by 15% making way for increased productivity with tetrahedron grinding media 212. Further, the contact radius of the tetrahedron grinding media 212 is twice larger than the spherical surfaces, compared to the same area, creating a greater contact ratio of the tetrahedron grinding media within the walls of the mill. The tetrahedron grinding media 212 may climb and fall from a greater height than the analogous spherical grinding media. The tetrahedron grinding media units may move with greater kinetic energy generated within the mill movements, and thereby having larger productivity and crushing performance.

[00131] The availability of a flatly beveled tip and rounded corners at edges and vertices allow for manufacturing through Forging/Stamping which is the most appropriate method for manufacturing of the tetrahedron grinding media 212. This reduces the prime cost of the tetrahedron grinding media 212 and increases the profitability of the mill. The presence of sharp edges accelerates the breaking of the feed material and increases the effectiveness of the mills using the tetrahedron grinding media 212.

[00132] Referring to FIG. 9 is an example of flow diagram 900 depicting a method for manufacturing grinding media to perform fragmentation and grinding of feed material, in accordance with one or more exemplary embodiments. The

method 900 may be carried out in the context of the details of FIG. 2A, FIG. 2B, FIG. 2C, FIG. 2D, FIG. 2E, FIG. 2F, FIG. 2G, 2 FIG. 2H, FIG. 2I, FIG. 2J, FIG. 2K, FIG. 2L, FIG. 2M, FIG. 2N, FIG. 2O, FIG. 2P, FIG. 2Q, FIG. 2R, FIG. 2S, FIG. 2T, FIG. 3A, FIG. 3B, FIG. 3C, FIG. 3D, FIG. 3E, FIG. 3F, FIG. 3G, 2 FIG. 3H, FIG. 3I, FIG. 4A, FIG. 4B, FIG. 4C, FIG. 4D, FIG. 4E, FIG. 4F, FIG. 4G, FIG. 5A, FIG. 5B, FIG. 6B, and FIG. 8. However, the method 900 may also be carried out in any desired environment. Further, the aforementioned definitions may equally apply to the description below.

[00133] The method commence at step 902, selecting a scrap of required steel grade to perform grinding operation in a mill. Thereafter at step 904, melting the scrap of required steel grade in an electric induction furnace. Thereafter at step 906, obtaining rolled bars of desired length as an intermediate product. Thereafter at step 908, cutting the intermediate product to desired length and a cut piece of the intermediate product is labelled as an initial rough bar piece to perform a forging operation. Thereafter at step 910 heating the initial rough bar piece using the electric induction furnace where the initial rough bar piece undergoes plastic deformation smoothly. Thereafter at step 912, preheating a die impression cavity area and a top facing area of a die thoroughly to undergo heat stress at ease. Thereafter at step 914, placing the initial rough bar piece on the die of a forging machine. Thereafter at step 916, performing the forging operation to the initial rough bar piece which is in red hot condition with single squeeze and ensuring proper material flow in the die impression cavity area. Thereafter at step 918, performing a trimming operation to a work piece for the removal of a flash material formed along a parting line of the work piece, the work piece is the tetrahedron grinding media. Thereafter at step 920, allowing the tetrahedron grinding media to cool slowly after performing the trimming operation. Thereafter at step 922, enabling the tetrahedron grinding media to fall on a surface of a metal plank on one of the vertices of the tetrahedron grinding media. Thereafter at step 924, self-moving of the tetrahedron grinding media towards its geometric center and aligning the tetrahedron grinding media to its geometric center. Thereafter at

step 926, landing the tetra grinding media on a convex surface thereby ensuring maximum life of grinding media and mill internals. Thereafter at step 928, trimming the tetra grinding media to remove the flash material thereby obtaining the rough forged tetra grinding media with accurate dimensions. Thereafter at step 930, allowing the forged tetrahedron grinding media to cool uniformly to avoid cracking, and moving ahead for heat treatment operations. Thereafter at step 932, performing hardening, quenching and tempering operations to achieve desired hardness as required by a user. Thereafter at step 934, sorting the forged tetrahedron grinding media according to the diameter sizes and metallurgy compositions undertaken to manufacture the tetrahedron grinding media. Thereafter at step 936, packing the forged tetrahedron grinding media in steel drums and shipping out for deliver.

[00134] Referring to FIG. 10 is an example of flow diagram 1000 depicting a method for performing fragmentation and grinding of feed material using forged tetrahedron grinding media units in grinding mills, in accordance with one or more exemplary embodiments. The method 1000 may be carried out in the context of the details of FIG. 2A, FIG. 2B, FIG. 2C, FIG. 2D, FIG. 2E, FIG. 2F, FIG. 2G, 2 FIG. 2H, FIG. 2I, FIG. 2J, FIG. 2K, FIG. 2L, FIG. 2M, FIG. 2N, FIG. 2O, FIG. 2P, FIG. 2Q, FIG. 2R, FIG. 2S, FIG. 2T, FIG. 3A, FIG. 3B, FIG. 3C, FIG. 3D, FIG. 3E, FIG. 3F, FIG. 3G, 2 FIG. 3H, FIG. 3I, FIG. 4A, FIG. 4B, FIG. 4C, FIG. 4D, FIG. 4E, FIG. 4F, FIG. 4G, FIG. 5A, FIG. 5B, FIG. 6B, FIG. 8, and FIG. 9. However, the method 1000 may also be carried out in any desired environment. Further, the aforementioned definitions may equally apply to the description below.

[00135] The method commence at step 1002, placing the one or more forged tetrahedron grinding media units in the mills before the mill starts along with the feed material. Thereafter at step 1004, creating a centrifugal force along with the rotation of a cylindrical mill which moves and pushes the feed material and the one or more forged tetrahedron grinding media units to walls of the mill.

Thereafter at step 1006, carrying the one or more forged tetrahedron grinding media units away in the direction of the rotation. Thereafter at step 1008, sliding and tumbling the one or more forged tetrahedron grinding media units and the feed material over the mill walls under the impact of their own weight after reaching a given height they detach from the walls and fall down. Thereafter at step 1010, colliding the one or more forged tetrahedron grinding media units with each other during the fall of the feed material to the inner walls of the mill. Thereafter at step 1012, accumulating the kinetic energy by the one or more forged tetrahedron grinding media units when colliding with the feed material. Thereafter at step 1014, performing fragmentation and grinding of the feed material into smaller pieces by the one or more forged tetrahedron grinding media units.

[00136] Reference throughout this specification to "one embodiment", "an embodiment", or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment is included in at least one embodiment of the present disclosure. Thus, appearances of the phrases "in one embodiment", "in an embodiment" and similar language throughout this specification may, but do not necessarily, all refer to the same embodiment.

[00137] Although the present disclosure has been described in terms of certain preferred embodiments and illustrations thereof, other embodiments and modifications to preferred embodiments may be possible that are within the principles of the invention. The above descriptions and figures are therefore to be regarded as illustrative and not restrictive.

[00138] Thus the scope of the present disclosure is defined by the appended claims and includes both combinations and sub-combinations of the various features described hereinabove as well as variations and modifications thereof, which would occur to persons skilled in the art upon reading the foregoing description.

5. CLAIMS:

We Claim:

1. A method for manufacturing grinding media to perform fragmentation and grinding of feed material, comprising:

Selecting a scrap of required steel grade to perform grinding operation in at least one of: a Horizontal mill; and a Vertical Mill;

Melting the scrap of required steel grade in an electric induction furnace;

Obtaining one or more rolled billets of desired length as an intermediate product;

Cutting the intermediate product to desired length and a cut piece of the intermediate product is labelled as an initial rough bar piece to perform a forging operation;

Heating the initial rough bar piece using the electric induction furnace where the initial rough bar piece undergoes plastic deformation smoothly;

Preheating a die impression cavity area and a top facing area of a die thoroughly to undergo heat stress at ease;

Placing the initial rough bar piece on the die of a forging machine;

Performing the forging operation to the initial rough bar piece which is in red hot condition with a single squeeze

and ensuring proper material flow in the die impression cavity area;

Performing a trimming operation to a work piece for the removal of a flash material formed along a parting line of the work piece, the work piece is the tetrahedron grinding media;

Allowing the tetrahedron grinding media to cool slowly after performing the trimming operation;

Enabling the tetrahedron grinding media to fall on a surface of a metal plank on one of the vertices of the tetrahedron grinding media;

Self-moving of the tetrahedron grinding media towards its geometric center and aligning the tetrahedron grinding media to its geometric center;

Landing the tetra grinding media on a convex surface thereby ensuring maximum life of grinding media and mill internals;

Trimming the tetra grinding media to remove the flash material thereby obtaining the rough forged tetra grinding media with accurate dimensions;

Allowing the forged tetrahedron grinding media to cool uniformly to avoid cracking, and moving ahead for heat treatment operations;

Performing hardening, quenching and tempering operations to achieve desired hardness as required by a user;

Sorting the forged tetrahedron grinding media according to the diameter sizes and metallurgy compositions undertaken to manufacture the tetrahedron grinding media;

Packing the forged tetrahedron grinding media in steel drums and shipping out for delivery.

2. The method as claimed in claim 1, comprising a step of selecting the scrap of required steel grades along with the addition of one or more Ferro alloys.

3. The method as claimed in claim 2, wherein the steel grades and one or more Ferro alloys preferred for manufacturing in the forging operation include Carbon Steels (Low, Medium and High Carbon); Wear Resistant Steels with presence of Chromium, Molybdenum and Nickel; EN Steel series(EN–8, EN-19, EN-24, EN-31, EN-353) with other similar International steel grades; Silicon-Manganese Steel and Rail Steel Scraps; Carbon and Carbon-Chromium steels; Stainless Steel and Duplex Steel with other similar International steel grade alloys; and Bearing Steel grades with other similar International Standards.

4. The method as claimed in claim 1, comprising a step of checking compositions with the help of a spectrometer to ensure the best metallurgical grade is drawn out from the electric induction furnace.

5. The method as claimed in claim 1, comprising a step of heating the initial rough bar piece at an effective temperature range from 940˚C to 1080˚C using the electric induction furnace.

6. The method as claimed in claim 1, comprising a step of placing the initial rough bar piece on the die of the forging machine at an effective temperature is in the range from 900˚C to 1050˚C.

7. The method as claimed in claim 1, comprising a step of normalizing the forged tetrahedron forged grinding media at temperature range from 920˚C to 930˚C.

8. The method as claimed in claim 1, comprising a step of allowing to cool the forged tetrahedron grinding media in the electric heat treatment furnace up to 550 ˚C.

9. The method as claimed in claim 1, comprising a step of hardening the forged tetrahedron grinding media at the temperature range from 850 ˚C to 930 ˚C.

10. The method as claimed in claim 1, comprising a step of quenching the forged tetrahedron grinding media in at least one of: water; oil; and salt solution.

11. The method as claimed in claim 10, wherein the quenching the forged tetrahedron grinding media in at least one of: water; oil; and salt solution at ideal temperature range between 10˚C to 50˚C or at room temperature.

12. The method as claimed in claim 1, comprising a step of tempering the forged grinding media in the temperature range from 100˚C to 250˚C in order to attain hardness between 58-65HRC.

13. The method as claimed in claim 1, comprising a step of soaking the tetrahedron forged grinding media for one inch per hour for normalizing,

hardening and tempering in order to attain better physical and mechanical properties throughout for any given forged media diameter size.

14. The method as claimed in claim 1, comprising a step of penetrating uniform heat towards an inner core area from the surface of the forged tetrahedron grinding media for 25MM to 32MM.

15. The method as claimed in claim 1, comprising a step of penetrating uniform heat towards the core area from the edges of the forged tetrahedron grinding media for 15MM to 20MM.

16. The method as claimed in claim 1, wherein a shape of the die impression cavity area is in the form of a spheroidal tetrahedron.

17. The method as claimed in claim 1, wherein the shape of the die impression cavity area comprising at least one of: an even shaped die impression cavity area; and an arch shaped die impression cavity area.

18. The method as claimed in claim 1, wherein the die impression cavity area comprising four end tips and one or more edges which are flatly beveled, rounded and arc rounded depending on the choice of the feed material and working operation required.

19. The method as claimed in claim 1, comprising a step of obtaining the forged tetrahedron grinding media in at least one of: an even shaped tetrahedron grinding media; and an arch shaped tetrahedron grinding media.

20. The method as claimed in claim 1, wherein the forged tetrahedron grinding media with the form of a spheroidal tetrahedron is obtained from the

crossing of four spheres with equal radii, wherein the centers of each one lie on the surface of the others and are tips of a regular tetrahedron, and the radii of the spheres are equal to the edge of the regular tetrahedron.

21. The method as claimed in claim 1, wherein the forged tetrahedron grinding media comprising four end tips which are flatly beveled tips depending on the choice of the feed material and working operation required.

22. The method as claimed in claim 1, wherein the forged tetrahedron grinding media comprising and one or more edges and vertices which are rounded, beveled or ribbed depending on the choice of the feed material and working operation required, where the ribbing can be even or arch-shaped.

23. The method as claimed in claim 22, wherein one or more edges accelerates the breaking of the feed material and increases the effectiveness of the mills.

24. The method as claimed in claim 1, wherein the forged tetrahedron grinding media is manufactured at different sizes from diameter 15mm to diameter 100mm and maximum size of 180mm.

25. The method as claimed in claim 1, wherein a minimum contact surface of the forged tetrahedron grinding media at one point of grinding surface contact area is 9.4%.

26. The method as claimed in claim 1, wherein distance of the forged tetrahedron grinding media unit to unit of size 30mm while placing four units on one above each other is of 120mm.

27. The method as claimed in claim 1, wherein the distance after stacking the forged tetrahedron grinding media is of 97 mm.

28. The method as claimed in claim 1, wherein the feed material comprising of ores, rock, earth mass and other rare earth materials.

29. A method for performing fragmentation and grinding of feed material using one or more forged tetrahedron grinding media units grinding media in mills, comprising:

placing the one or more forged tetrahedron grinding media units in the mills before the mill starts along with the feed material;

creating a centrifugal force along with the rotation of a cylindrical mill which moves and pushes the feed material and the one or more forged tetrahedron grinding media units to walls of the mill;

carrying the one or more forged tetrahedron grinding media units away in the direction of the rotation;

sliding and tumbling the one or more forged tetrahedron grinding media units and the feed material over the mill walls under the impact of their own weight after reaching a given height they detach from the walls and fall down;

colliding the one or more forged tetrahedron grinding media units with each other during the fall of the feed material to the inner walls of the mill;

accumulating the kinetic energy by the one or more forged tetrahedron grinding media units when colliding with the feed material;

fragmenting and grinding the feed material into smaller pieces by the one or more forged tetrahedron grinding media units.

31. The method as claimed in claim 29, comprising a step of breaking and crunching the feed material is faster when the forged tetrahedron grinding media comprising one or more sharp edges if the lumps of the feed material have higher hardness and/or of larger size.

32. The method as claimed in claim 29, wherein the forged tetrahedron grinding media wear out slowly if the one or more edges are ribbed.

33. The method as claimed in claim 29, wherein the forged tetrahedron grinding media comprising one or more constant crashes with one or more beveled edges lead to a slower wearing out process of the forged tetrahedron grinding media.

34. The method as claimed in claim 29, wherein the use of forged tetrahedron grinding media comprising one or more rounded edges is more profitable if the feed material is finer.

6. DATE AND SIGNATURE:

Dated this October 13, 2022

Authorized Patent Agent Signature: 

Authorized Patent Agent Name: **PUTTA GANESH (IN/PA/2933)**

7. ABSTRACT

“METHOD FOR MANUFACTURING GRINDING MEDIA TO PERFORM FRAGMENTATION AND GRINDING OF FEED MATERIAL”

A method for manufacturing grinding media to perform fragmentation and grinding of feed material, comprising: Selecting steel grade; Melting steel grade in electric induction furnace thereby obtaining rolled bars; Cutting to desired length and is labelled as initial rough bar piece; Heating initial rough bar piece using electric induction furnace; Preheating die impression cavity area and top facing area of die thoroughly to undergo heat stress and Placing on die of forging machine; Trimming tetra grinding media to remove flash material thereby obtaining rough forged tetra grinding media with accurate dimensions; Allowing to cool uniformly to avoid cracking, and moving ahead for heat treatment operations; Performing hardening, quenching and tempering operations to achieve desired hardness as required by user.

FIG. 1.