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(54) **Impeller for a shot blasting turbine and components**

(57) Shot blasting turbine and components refers to a shot blasting turbine to throw abrasive materials to a surface of a piece to be shot blasted, having said turbine at least two blades to direct the abrasive over the surface of the piece, said blade placed between two runner heads; an impeller that accelerates the abrasive towards the blade; and a control cage with an opening or window from which the abrasive leaves the impeller to the blade.

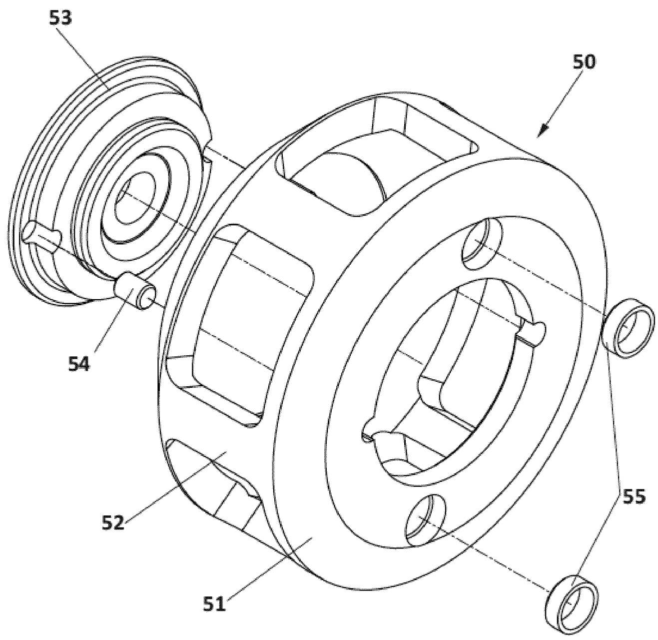

FIG. 18

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Description

Field of the art

[0001] The present invention relates to an impeller for a shot blasting turbine and components comprised in the same. It mainly refers to a shot blasting turbine to throw abrasive materials to a surface of a piece to be shot blasted, having said turbine at least two blades to direct the abrasive over the surface of the piece, said blade placed between two runner heads; an impeller that accelerates the abrasive towards the blade; and a control cage with an opening or window from which the abrasive leaves the impeller to the blade.

[0002] The invention is preferably addressed to be used in the foundry industry, although it can be used in other industries.

Prior State of the Art

[0003] There are several types of Shot Blasting Turbines available in the market, from different suppliers, most of them also producers of shot blasting machines. A shot blasting turbine throws abrasives of different natures and sizes to a surface to be shot blasted. The propelling force (centrifugal force) is given by a quantity of metallic blades placed on a runner head (or 2) moved by an electric motor. The abrasive is fed into the blades by an impeller that accelerates the abrasive towards the blade surface, involved on the control cage that has an opening from which the abrasive leaves the impeller to the blade. The position of the opening of the control cage determines the direction of the flow of the abrasive.

[0004] A variety of these main elements of a classical turbine can be found in the market. From straight blades to curved blades; casted or machined blades, with 1 or 2 Runner Heads; multiple sizes and diameters of runner heads; control Cages and impellers casted or machined, etc.

[0005] We could divide the different types of turbines available on the following main groups according to the most commonly used:

- Geometry of the blade: straight or curve, single or double active surface
- Fabrication technology of the components: casted or machined
- Number of runner heads : 1 or 2
- Sizes of turbines : from Ø200 to Ø600 mm
- Material of wear parts : Cast Iron alloy, Chrome Steel, Hard Metals, Ceramics

[0006] Regarding the abrasives suitable to be used on a shot blast turbines we can mention as examples: high and low carbon steel shot, steel grit, cast iron shot and grit, steel Cut Wire Pellets, Stainless Steel shot and grit, non-ferrous shot and grit (aluminium, bronze, zinc, etc.), plastic media, Glass Beads, etc.

[0007] Concerning the applications, the shot blasting turbines can be used for different main objectives, for example:

- Removal of an oxide or other contaminant from a metallic surface
- Surface preparation prior to protection (surface roughening)
- Elimination of sand or calamine of the castings on foundry industry
- Shot peening
- Peen forming

[0008] The main problem that affects a shot blasting turbine is that it suffers from the same effect that the thrown abrasive causes on the surface to be treated, which is the wear or wearing out. Wear is the key problem to solve when deciding which turbine and which abrasive should be used together.

[0009] On most shot blasting applications round steel shot or soft steel grit hardness (45 to 50 HRC) are used, and generally shot blasting turbines can cope with it with reasonable success as far as wear is concerned.

[0010] Different situations take place when there is a need to use medium hardness (52 to 56 HRC) or high hardness (> 64 HRC). In those specific applications, as for example, surface preparation prior to metalizing by zinc wire, or roll etching of laminator cylinders, the wear caused on shot blasting turbines is so high that in some hours the wear caused on the turbine parts will disrupt the abrasive jet direction, reducing dramatically the blasting performance and causing important damage on the shot blasting machine protections.

[0011] In those cases, turbines equipped with hard metal blades, control cages and impellers have shown a great resistance to wear, thus offering a much stable quality of blasting for much longer time. And, of those, the ones equipped with curved blades have the advantage to put together wear resistance and efficiency of throwing speed, i.e., energy saving or the possibility to throw the abrasive at higher speed using same motor as a classic straight blade turbine.

[0012] More recently it has been introduced in the market a new generation of curved blades, so called the Gamma blades. This blade presents two active surfaces, i.e., it is reversible as the 2 surfaces are identical, so the turbine can turn on the right or left directions, with the same efficiency. This technique already used on the straight blades turbines by several producers of turbines, had already been built by another constructor years before, but apparently without the same success.

[0013] This blade represents, as far as the applicant knows, the latest development regarding shot blasting turbines.

[0014] Anyway, and as usually happens, the same solution rarely has the same performance for all different applications and therefore the use of a shot blasting turbines has not the same performance in different applications. It is of special interest the use of shot blasting turbines in Foundry Industry.

[0015] Foundry Industry represents the most important industry on the shot blasting technique applications. To give an idea of its importance in the global shot blasting industries, Foundry Industry is the largest consumer of metallic abrasives for shot blasting applications as it consumes over 25% of the total consumption of metallic abrasives in the global market. This represents the largest concentration of shot blasting turbines in one single industry and, consequently, an enormous quantity of shot blasting turbines in operation every minute of the year. Further, among the foundry industry, the automotive sector represents almost 70% of the total foundry industry consumption and therefore its importance in the shot blasting technique and the need to pay special attention to it.

[0016] The following are the most common problems for a turbine on a foundry application with a reversible curved blade Gamma type:

a) High content of silica sand on the abrasive operating mix

[0017] The amount of silica sand on the abrasive mix is a fact that despite all elimination systems, such as air current separators and magnetic separators, still persists in high or low degree depending on the performance and quality of maintenance of the equipment. It is a fact with which the turbines have to cope when in use on foundry applications. Moreover, on the automotive foundry industry, the working 24 over 24 hours per day, 6 days per week, and sometimes 7 days, 48 and more weeks per year, does not leave much time for frequent maintenance.

[0018] This problem has been solved with success with the introduction of hard metal curved blades, which have proven a very good resistance to sand abrasion when compared with other materials. However, the support of the blades (runner heads) is made of hardened steel. And despite its hardness, the resistance to wear of sand particles is very limited when compared with the hard metals, such as Tungsten carbide. Because of this fact, while the hard metal blade is resisting quite well to the silica sand abrasion, its supports, therefore the runner heads, are being worn out, excavating the grooves where the blades are sit. This erosion allows the penetration of steel shot abrasive between the blades base and the said groove causing small cracks on the blades that increase with time. This often turns into a degradation point that makes it impossible, or represents a high risk, to re-use the blade on a new set of runner heads. Figure 1 shows this problem in a runner head while figure 2 show damages on a blade. Also while in use, such a degradation of the blade can cause imbalance on the turbine, with the consequent damaging on the motor bearings.

[0019] For the above reasons the use of a double active surface curved blade gamma type is not really an advantage, as in most of the cases in foundry applications that solution will almost never be used.

b) Frequent shock with castings inside of the shot blasting machine

[0020] Another frequent problem on foundry shot blasting machines is the shock of the castings with the turbine blades. Due to the geometry of the castings, most of them blasted with the feeding channels, it is frequent, and in most cases unavoidable and unpredictable, the shock of some of the castings or its feeding system with the turbine blades. This shock at a speed that most time runs at around 3.000 rpm, has a tremendous impact on a blade, breaking it, mainly those made of hard metals which are naturally fragile. This causes not only the loss of the blade, but usually also affects other parts of the turbine and frequently the adjacent turbines in the case of multiple turbines shot blasting machines.

[0021] It has been noted and registered over the last years that the double active surface blade Gamma type has important disadvantages compared with the single active surface curved blades as far as shock with castings is concerned. These are:

- The double extremity of the Gamma type blades: The shock of the castings with the blades occurs always on the exit extremity of the blades, as this is the closer part of the turbine to the inside of the machine. With two extremities, the double surface Gamma type blades increases to the double the chance of being hit by a casting or feeding channel.
- The "calyx" between extremities of the blade: It has been observed frequently the fact that the two extremities of the blade have a "calyx" shape does not allow the eventual escape of a potential casting to shock with the blades. It gets stuck on the "calyx".
- The non-active surface: In most of the shock events observed of castings with the Gamma type blade, it is the non-active surface that is hit by the casting. Its geometric position in relation to the rotation direction makes it less resistant to shock than the active surface._Figure 3 shows a damaged blade in its working position.

[0022] For the above reasons the use of a double active surface curved blade gamma type is not really an advantage, as in most of the cases in foundry applications that solution will almost never be used.

[0023] As happens with the blades, other components of the shot blasting turbines, such as the control cage and the impeller, which roles in the turbine have been briefly described before, are produced mostly in casted iron or steel, or from machined hard steel. They suffer from the same problem of severe wear, as they are in permanent contact with the abrasive that they feed continuously to the blades of the turbine. To prevent this problem, a few companies have produced those two elements in hard metal, namely in tungsten carbide.

[0024] However the production of control cage and impeller of big sizes (for example, for turbines of 380 mm diameters and bigger) in Tungsten Carbide becomes quite expensive. In order to solve this inconvenient it has been decided to produce those two components in a combination of two metals: hard steel as a support and hard metal as the wear part, which will be referred from now on as the bimetal solution.

a) Bimetal control cage

[0025] The hard steel part is a cylinder with a rectangular or square opening, exit window, through which the abrasive leaves to the blades and which orientates the direction of the jet stream. The hard metal (tungsten carbide) part is made up of a number of parallelepiped bars which line or cover the inside of the hard steel cylinder in order to protect it as a lining from the wear caused by the movement of the abrasive. All inside surface of the hard steel cylinder is lined with those tungsten carbide bars except the area of the exit window.

[0026] The purposes of this control cage are, on one hand, protect the inside of the control cage support against wear and on the other, to make it repairable by replacing totally or partially the worn out tungsten carbide bars, reusing the steel support.

[0027] However, leaving all other applications of the shot blasting turbines apart, in the foundry industry applications, those purposes have not resulted to be successful. The problems of this solution are:

- Indeed, what really happens is that the amount of silica sand and fine abrasive dust does destroy the steel support in the area adjacent to the exit window and also the window itself, leaving the tungsten carbide bars without support. As a consequence of this lack of support some of those bars, those 2 or 3 in the neighbourhood of the exit window get loose and will come off from the support damaging seriously the other elements of the turbine, namely the impellor and the blades, probably breaking them, when not causing the explosion of the entire turbine.
  There are numerous cases reported of turbine explosions due to this fact. This not only causes enormous costs to the owner of the turbine, due to the expensive materials used, as it interrupts the production of the entire shot blasting machine, which in fact, in the case of a foundry working continuously 24 hours per day, will seriously disturb the work of an entire production line, as the shot blasting machine is the last operation on a foundry production line.
  Because of the above, it is easy to conclude that the idea of replacing the worn out tungsten bars on the steel support is not feasible, as the wear process is really the opposite, that is to say, it is the steel support that wears first.
  On the other hand, to re-use the tungsten carbide bars on a new steel support is also not feasible: after wearing out the steel support, about half of the bars will already show noticeable wear, which in case of re use would represent a discontinuity on the circular inner surface of the control cage promoting again excessive wear and turbulence on the regular flow of the abrasive. On the other hand, to remove all "good" bars from the worn steel support would represent a lot of labour to detach them from the glued surface, remove the remaining glue and glue it again on a new support. This would mean a lot of work which is not economically interesting, and would be better to use new bars.
- The same applies to the case where shock may occur with any pieces of metal that might be mixed in the abrasive flow. Those pieces of metal of variable dimensions, usually from 8 to 12 mm will stuck between the control cage/impeller assembly and the blade, damaging the three pieces, more or less seriously, depending on the size and shape of the metal inclusion.
  Again, some tungsten carbide bars will break, making the control cage useless due to the difficulty and cost to repair it. This kind of accidents is quite frequent on cast steel and iron foundries.

[0028] Figure 4 shows a damaged window of a control cage, while figure 5 shows another window of a control cage where some bars might drop due to the damage on the control cage.

b) The bimetal impeller

[0029] As it happens with the bimetal control cage, the bimetal impeller is made up of two different parts: the support parts, the top and the bottom, connected between them by a number of hard metal bars, which represent the wear part of the impeller.

[0030] The main problems when these types of impellers are used on foundry are:

- The silica sand and fine dust that exist in the abrasive operating mix will rapidly wear the hard steel supports loosening the tungsten carbide bars that will sooner or later come off from the assembly, causing the same effect of destruction as described for the control cage.
- Also, the bimetal impeller suffers from the same effect as the control cage when metallic inclusions appear on the abrasive operating mix. These will seriously damage the tungsten bars, breaking them and often cheeping them out of the assembly, not only destroying the impeller itself, but also the control cage, the blades and sometimes causing the turbine explosion, among other collateral damages.
  The expected possibilities of repairing a worn out or broken impeller are virtually zero, not only due to the

damages caused on the steel support (that it wears much faster than the tungsten carbide bars), but also, in case of impact with metal pieces on the abrasive mix, it breaks one or more bars and its replacement is quite costly. Attempts to repair a damaged bimetal impeller have shown that the cost of the operation is similar to the cost of a new piece.

[0031] For the reasons described previously on a) and b), the applicant considers that the bimetal solution, as exists nowadays, is not a good solution for the Foundry Industry. Although the bimetal solution is a very good solution for other applications when compared with other existing solutions, in the case of Foundry Industry it is necessary to find a better way to extend the life of the wearing components of blast shot turbines. Figures 6 and 7 show the damages in a bimetal impeller.

[0032] In view of the above, the present invention intends to solve the above-mentioned problems, among others, existing in the shot blasting turbine field, and in particular in the Foundry Industry. Therefore, the main objectives of the invention are:

- Forecast and Programme the Maintenance to reduce accidents
- Eliminate the machine breakdown
- Reduce the maintenance to a minimum
- Replace repairs by preventive maintenance

<u>Description of the invention</u>

[0033] The invention, according to claim 1, relates to an iimpeller for a shot blast turbine, to accelerate abrasive materials towards at least one blade of the turbine characterized in that it comprises a body made up of a single block and a separated central core where the material of the body is harder than the material of the central core

[0034] It is described a shot blasting turbine that can be used with the impeller according to the invention to throw abrasive materials to a surface of a piece to be shot blasted, with at least two blades to direct the abrasive over the surface of the piece and placed between two runner heads, with the impeller that accelerates the abrasive towards the blade, and with a control cage with an opening or window from which the abrasive leaves the impeller to the blade, comprising said control cage at least one lining sector, piece or part covering at least a fourth part of the inside surface of the control cage.

[0035] Each blade comprises a straight segment followed by a curved one having an active side to propel the abrasive over the surface of the piece and a support side with a lump placed between the straight and the curved segments.

[0036] The impeller comprises a body made up of a single block and a separated central core where the material of the body is harder than the material of the central core.

[0037] The different mechanical resistance of the components is important for the behavior of the whole turbine but too for the behavior of each component independently, so that the mechanical resistance of the material of the lining in the control cage has smaller mechanical resistance than the blades and body of the impeller. Preferably, the material of the body of the impeller and of the blade is tungsten carbide, the material of the lining is harder tungsten carbide and the material of the control cage and central core of the impeller is hardened steel.

[0038] A component that can be used with the present invention is a blade for a shot blast turbine, for directing abrasive materials over a surface of a piece, comprising a straight segment followed by a curved one having an active side where the abrasive hits to be directed over the surface of the piece and a support side with a lump placed between the straight and the curved segments of the blade. Said lump is needed to place and hold the blade in the grooves practiced in the runner heads where the blade is inserted, and it is also needed to reinforce the curved segment of the blade. Said blade is made of tungsten carbide, preferably comprising between 87% and 91% of tungsten (Wc) and preferably between 9 and 13% of cobalt (CO).

[0039] This blade is mechanically stronger than the blades in the state of the art that will resist better the impact of the abrasive material at the same time that is simpler, easier and cheaper to produce than the prior art blades. It will eliminate at least 50% of the accident possibilities of impact with castings inside the blast chamber, saving maintenance costs and equipment breakdown periods

[0040] Another component that can be used with the present invention is a control cage for a shot blast turbine comprising at least one exit window to let abrasive material pass on to the blades of the turbine, further comprises at least one lining sector, piece or part covering at least a fourth part of the inside surface of the control cage. Said lining sector might be only one that covers all the inside surface of the control cage. An alternative to the above construction might be a lining made up of four lining sectors that cover al the inside surface of the control cage. The material of said lining is preferable tungsten carbide while the material of the control cage is steel.

[0041] The control cage will prevent the risk of loosening and cheeping of parts capable of damaging the turbine elements or components at the same time that it reduces the wear of the steel support or shell where the inside lining is placed. One important objective is to maintain intact the exit window of the shell intact by replacing the inside lining that covers said window. This exit window works as a fuse, so that when the same is damaged prevents the damaging of the rest of the parts of the turbine.

[0042] It is also described an impeller according to a preferred embodiment of the embodiment for a shot blast turbine, to accelerate abrasive materials towards the blades of the turbine that comprises a body made up of a single block and a separated central core where the material of the body is harder than the material of the central core. The material of the body is tungsten carbide while the central core is steel as it is not an area with high risk to wear.

[0043] The impeller, due to its properties, eliminates the possibility of accidents due to the impact on different parts of a metal particle mixed on the abrasive material and eliminates the steel support or body of the impellers in the state of the art eliminating therefore the wear of said support or body.

[0044] The above shot blast turbine and components object of the present invention have been designed to solve the described problems existing in the state of the art, and in special in the Foundry industry.

Brief Description of the Drawings

[0045] The previous and other advantages and features will be fully understood from the following detailed description of embodiments, with reference to the attached, which must be considered in an illustrative and non-limiting manner, in which:

Figures 1 to 7 show figures of prior art parts.
Figure 8 shows an exploited view of the main components of a shot blasting turbine.
Figure 9 shows the components of the previous figures together.
Figure 10 shows a section of the components together.
Fig. 11 shows a top view and a section of a blade.
Fig. 12 shows a perspective view of a blade.
Fig. 13 shows a runner head motor inner side where the blades are placed.
Fig. 14 shows a runner head abrasive inner side where the blades are placed.
Fig. 15 shows a runner head abrasive outside side.
Fig. 16 shows an exploited view of a control cage, with a monolithic lining inside.
Fig. 17 shows an exploited view of a control cage, with a four sector lining inside.
Fig. 18 shows an exploited view of an impeller according to the invention.

Detailed Description of the Preferred Embodiments

[0046] The present invention regarding an impeller which will be described herein along with its properties and advantages, referring to the mentioned figures.

[0047] The main components of a turbine that can be used with the impeller object of the present invention can be seen in figure 8, specifically these components are:

- Turbine disc or head runner (20) on the motor side
- Tungsten carbide blades (10)
- Hard steel shell or control cage (31)
- Tungsten carbide lining ring (40)
- Hard steel closing ring (32)
- Tungsten carbide impeller (50)
- Turbine disc or head runner (25) on the feeding side
- Hard steel support cone for control cage (53)

[0048] The following components are the main ones in order to reach the previously mentioned objectives:

- At least two blades (10),
- A control cage (31), and
- An impeller (50).

[0049] In figure 9 the components assembled can be seen, while in figure 10 a section of the assembly of said components is shown

[0050] The blades or blade 10 is made of Tungsten Carbide, composed by two main elements, the Tungsten (Wc) and the Cobalt (Co) on a proportion capable to offer the best compromise between wear resistance and mechanical strength. It is well known that those two physical properties are difficult to conciliate and the benefit of one will deteriorate the performance of the other. The reduction of Tungsten increases the mechanical strength but reduces the wear resistance, while when the Tungsten increases, the contrary happens. After extensive trials and tests it has been concluded that for the foundry application the best composition is a material comprising between 87% and 91% of WC and between 9 and 13% of Co. The blade 10 is placed in grooves 21, 26 located in the runner heads 20, 25, that are the discs of the turbine where the blade 10 is hold.

[0051] There are two types of runner heads 20, 25, one runner head 20 placed on the motor side of the turbine with grooves 21 on its inner surface 22 and a runner head 25 placed on the abrasive side with grooves 26 too in its inner side 27. The motor runner head 20 has a support 24 for connecting to said motor. The blades 10 are placed in the grooves 21, 26 and the runner heads are fixed together with the help of screws that get through orifices 23, 28 in both runner heads. These runner heads 20, 25 have outside surfaces 29.

[0052] The geometry of the blade 10 has a straight segment 13 followed by a curved or concave segment 14 on the active side 11 of said blade 10. This is the side 11 that propels the abrasive to the work piece to be shot blasted. The straight segment 13 starts from the centre of the turbine and its length varies between 35% and 55% of the total length of the blade 10. The curved or concave part 14 continues the straight segment 13 until the extremity of the support runner head 20, 25. The back side 12 of the blade 10 has a straight segment 15 followed by a curved or convex segment 16. This is the support side 12 of the blade 10. The straight segment 15 length varies from 65% and 75% of the total length of the blade 10. On this side it comprises a lump 17 that on one hand holds the blade in place not allowing it to get out of the groove 21, 26 in the runner heads 20, 25 where it is placed, and on the other hand reinforces the strength of the blade 10 on this specific area where the effort is higher, increasing its mechanical resistance.

[0053] By having only one active side 13, i.e., only one "harm", this blade 10 eliminates at least 50% of the possibilities of accident by direct contact with the castings inside of the blasting chamber, keeping the qualities and features of a curved blade made of Tungsten carbide, as far as throwing speed is concerned. The "lump" 17 on the support 12 side also increases considerably the strength of the blades 10 on the area where contact with a casting may occur, that is to say, the extremity of the blade 10, on the area where the abrasive leaves the blade 10.

[0054] This geometry of the blade 10 is cheaper to produce that the ones in the state of the art and specifically compared to the gamma type curved blade. Compared with this last prior art blade, it has about 20% less material and tungsten carbide is a very expensive metal. It is also easier to produce and to machine. Also the runner heads 20, 25 are made of hard steel that will need less hours to be machined, so a cheaper and faster production. By having only one active surface 13, there is no "obligation" to use the other side 12. This means that once the blade 10 is worn out, even if it has small cracks caused by the wear on the runner heads 20, 25, it will be scrapped a worn out blade 10 and not a blade 10 that had a potential of use and which cost was higher.

[0055] In summary, the advantages of this non-reversible blade 10, compared with existing reversible blades are:

- Curved blade, so higher speed of throwing abrasive,
- Made of tungsten carbide, so long extreme working life,
- Non reversible, so cheaper to produce, lower selling price,
- Use 100% of capacity,
- Only one "arm", so at least 50% less risk of damaging by shock
- Special geometry, so stronger and higher mechanical resistance
- Special composition of the WC/Co Carbide with and excellent rate Resilience/Wear Resistance

[0056] The control cage 30 that can be used with the present invention is made of two different metals, and intents to prevent the problems of the state of the art bimetal control cage, as described previously.

[0057] The control cage 30 comprises a steel support part or shell 31, made of tool steel, machined and heat treated to around 62 HRC with an exit window 32, which size depends on the application, on its surface and an inside lining 40. However, the inside lining protection 40 is made of a monolithic tungsten carbide cylinder 40 that covers the inside of the control cage 30. This lining not only protects the inside wall of the steel shell 31 of the control cage 30, but also covers fully the exit window 33. As a consequence, the exit window 33 stays as a full and integral window, on its initial dimensions during its working life. This will guaranty the direction of the abrasive from first day throughout the control cage 30 life. With this construction, there are no bars, preferably tungsten bars, that can be chopped from the lining 40 and cause the accidents previously described.

[0058] Usually, the steel shell 31 of the control cage will wear faster than the inside lining 40, and this allows the inside lining 40 to be re-used on a new steel shell 32, as the lining 40 will be intact or nearly intact, in one piece, not glued, and very easy to be removed and assembled again. The lining 40 is maintained inside the control cage 31 due to a locking ring 32 which is fixed to the control cage with locking pins 33.

[0059] Taking into account the tests performed with this product, the carbide lining 40 can be used at least with two different steel shells 32, that is to say, it can be used as a replacement. This represents an enormous saving of money and reduces considerably the investment in stocks.

[0060] Another alternative to the above describe lining 40, in order to attend difficult situations in continuous working foundries consists of a lining 40 that covers at least a fourth part or sector of the inside surface of the control cage shell 32. In this case, the lining 40 would comprise four independent parts, sectors or pieces 42, 43 that together form a lining 40 like the one previously described. In the example of figure 8, this new lining 40 divides the inside carbide lining in four parts, sectors or pieces 42, 43. Three of these part or pieces 43 are of similar dimensions and are pure lining. The fourth part, sector or piece 42, the one with the window 41, therefore the window sector or window part, includes the shape of the window 41 and has a length that will cover the area subjected to the most aggressive wear. These pieces are assembled together on the steel shell 32 without any glue or other type of agglomerate. They are just assembled together and get in place by two positioning pins. They are locked by a locking ring 32 tightened by locking pins 33. Other possibilities would be to have three lining parts, sectors or pieces, or even two lining parts, sectors or pieces. In this construction, the window sector 42 is used as a mechanical fuse.

[0061] The problem with the foundries is the amount of small pieces of metal that are carried together with the abrasive stream. These pieces of metal, when having a dimension of 5 or more millimetres, generally they are 6 to 12 mm on an inscribed circle, can cause serious damages on the turbine. As previously mentioned, the prior art state bimetal cages, will probably not only break the control cage but also the impeller and the blade.

[0062] Anyway, in the case of the present control cage 30, the above-cited pieces of metal would break a small piece of the exit window 41 which would not cause a major problem to the other elements of the turbine. It would only be necessary to replace the monolithic carbide lining 40, in case the lining is one piece, or the window sector 42 if the lining has more than one part or piece, which would result a better way to save money.

[0063] When a piece of metal of the previously mentioned dimensions, between 5 mm and 12 mm, is mixed together with the abrasive stream and enters the control cage 30 of a state of the art turbine, it will damage those pieces and will probably damage the blade too. On the other hand, if the window 32 of the control cage 31 is mechanically weaker than the impeller arms or the blade foot, then only the control cage window 32 will break, limiting enormously the damage in the turbine. In addition, the extension of the damage to the control cage 30 is limited to the window 32, reducing therefore the cost of the damage. By the described solution that divides the internal lining in four parts 42, 43, one for the window 42, the control cage 32 has a part or piece that is more fragile than the other components of the turbine, and specially the impeller and the blade. The discontinuity of this carbide lining with more than one part or piece 42, 43 instead of a monolithic lining 40, will limit the damage to only one piece instead of to the whole lining, and will leave intact, or almost intact, the other components, specially the impellor and the blade. As already mentioned this exit window 32 of the control cage works as a fuse, so that when the same is damaged prevents the damaging of the rest of the parts of the turbine.

[0064] As far the resistance to wear is concerned, for the working life expected with the monolithic lining 40, the four parts or sectors carbide lining 42, 43 has a similar life.

[0065] However, the lining with more than one sector or part 42, 43, therefore non monolithic, has an additional advantage compared with the monolithic solution 40, that it is easier to disassemble and reassemble. So, for those cases when despite the inexistence of foreign metallic inclusions the disassembling may present some difficulty for whatever reason, this sectors carbide lining is an extra option.

[0066] In summary, the advantages of this control cage 30, compared with existing control cages are in the monolithic carbide lining solution:

- No loose pieces that can chop off the cage
- No loose pieces to seriously damage the turbine
- Repairable and Reusable, and therefore with a lower cost

[0067] Further, the more than one sector lining solution has the following additional advantages:

- Use exit window as a mechanical fuse = limit the damages in case of accident
- Easier, faster and cheaper to repair
- Lower production and selling price

[0068] An impeller 50 according to an embodiment of the invention is made of a monolithic tungsten carbide wear part or body 51, with a central core 53 in hard steel, where the screw that fixes the impellor 50 to the turbine runner head is tightened. This central core 53 is fixed to the body 51 of the impeller 50 with the help of locking pins 54 fixed to hard steel reinforced rings 55.

[0069] This impeller 50 has been developed specially to work together with the previously described control cage 30, although it could be used with other control cages. Its arms 52 are fully made of tungsten carbide and its mechanical resistance is higher than that of the window of the control cage, which guarantees its integrity in case of collision with foreign metallic parts mixed on the abrasive stream, due to the mechanic fuse effect of the window control cage.

[0070] This is an important improvement when compared with the impeller used in the state of the art together with the bimetal control cage, which is a bimetal impeller that has the problems described previously.

[0071] In the impeller 50, all "arms" 52 are one piece together with the body 51, so there is no risk of detaching from its steel support and therefore damaging the other parts of the assembly as happens in the state of the art. The risk of strong wear of the steel head and base as do not exist as in the prior art bimetal solution because the new impeller 50 only has as steel part a small area core 53 for the tightening screw. This core 53 in hard steel is only small part of the impeller 50 and is not in the area where there is the most wear influence.

[0072] This kind of impeller 50 can resist to multiple impacts caused by the foreign metal inclusions in the abrasive stream. The thickness, the length and the geometry as well and the curve of the concordance lines have been studied to produce the maximum resilience, while being highly wear resistant. Also the selected tungsten carbide composition has contributed to this success.

[0073] The impeller 50 has no replaceable parts, as it has been designed as a single block or body 51. Once it is worn out, it must be replaced. It is expected that on a cast iron or steel foundry application, this type of new impeller 50 will have a working life at least two times higher than the existing prior art bimetal impeller, with very limited or inexistent breaking of the "arms" 52 followed by detachment of the same, with the consequent damaging to other assembly parts.

[0074] In summary, the main advantages of this monolithic carbide impeller are:

- No loosening parts
- Higher working life, compared to prior art impellers, and at least two times higher compared with the bimetal impeller
- Extremely reduced possibility of detachment of the arms
- Almost inexistent possibility of damaging other assembly parts
- Lower production and selling price

Claims

1. Impeller (50) for a shot blast turbine, to accelerate abrasive materials towards at least one blade (10)

of the turbine **characterized in that** it comprises a body (51) made up of a single block and a separated central core (53) where the material of the body (51) is harder than the material of the central core (53).

2. Impeller, according to claim 1, **characterized in that** the material of the body (51) is tungsten carbide.

3. Impeller, according to claim 1, wherein the body (51) is made of a monolithic tungsten carbide and the central core (53) is made of hard steel.

4. Impeller, according to claim 1, further comprising a screw to fix the impellor (50) to a turbine runner head (20).

5. Impeller, according to claim 1 wherein the central core (53) is fixed to the body (51) of the impeller (50) with the help of locking pins (54) fixed to hard steel reinforced rings (55).

6. Impeller, according to claim 1, further comprising arms (52) that are fully made of tungsten carbide.

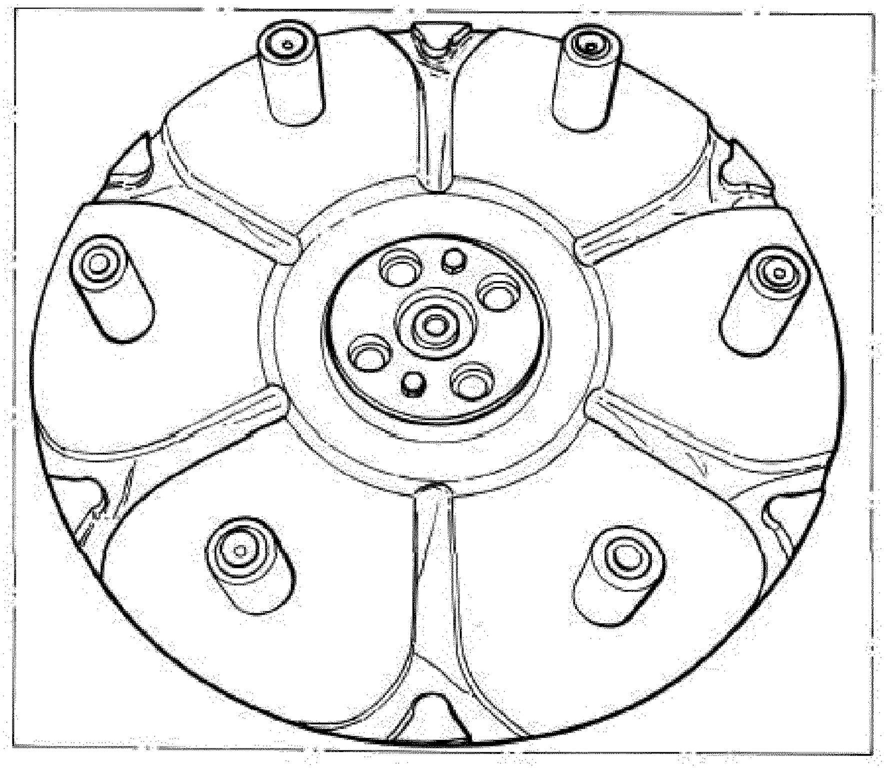

FIG. 1
PRIOR ART

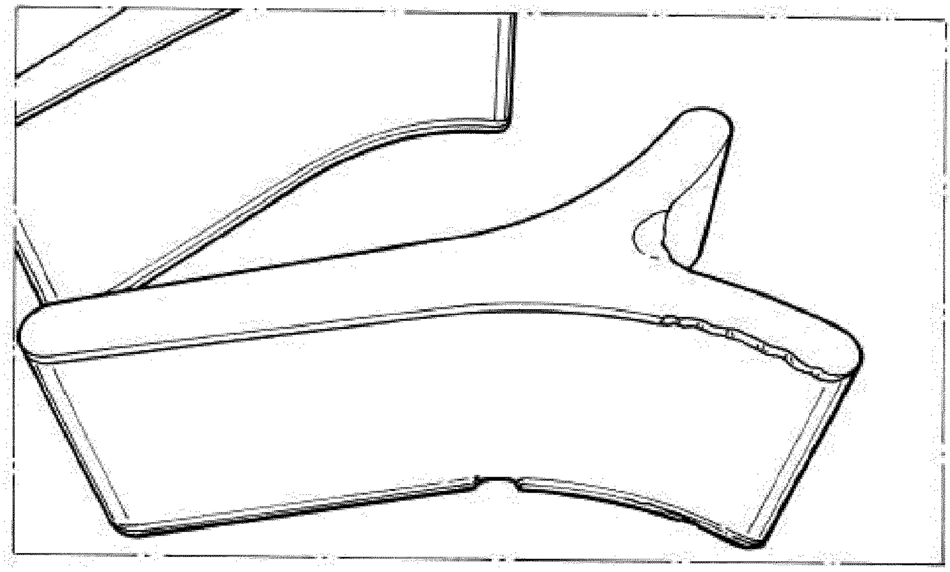

FIG. 2

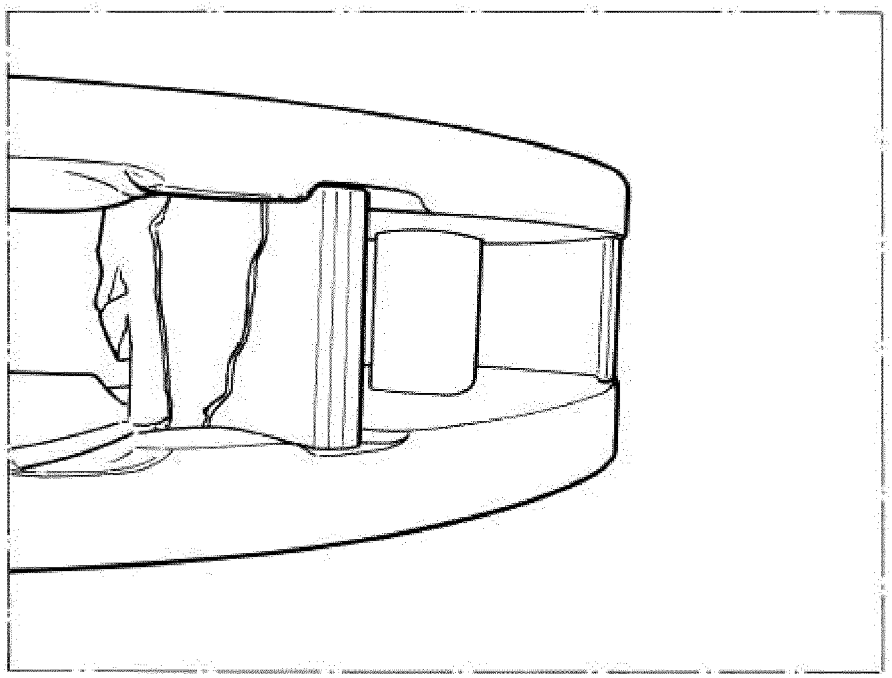

FIG. 3
PRIOR ART

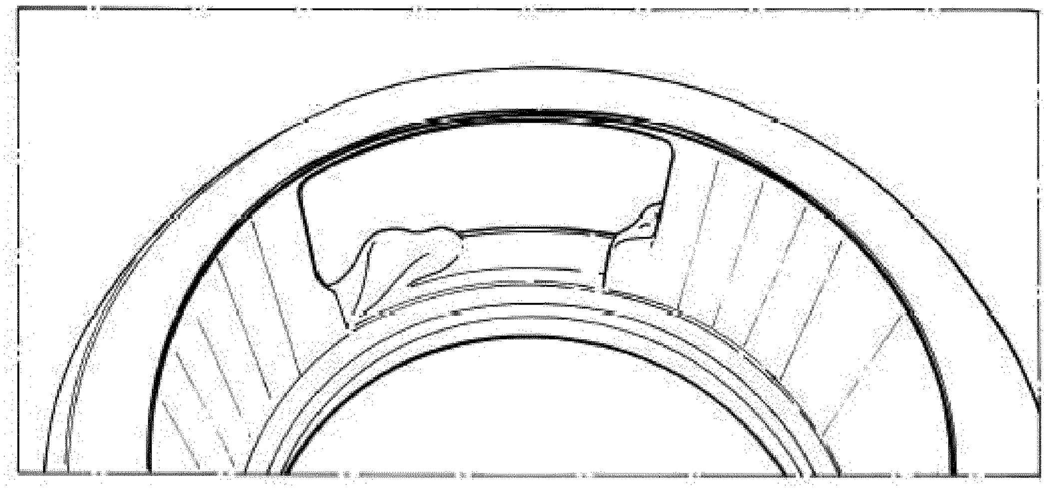

FIG. 4
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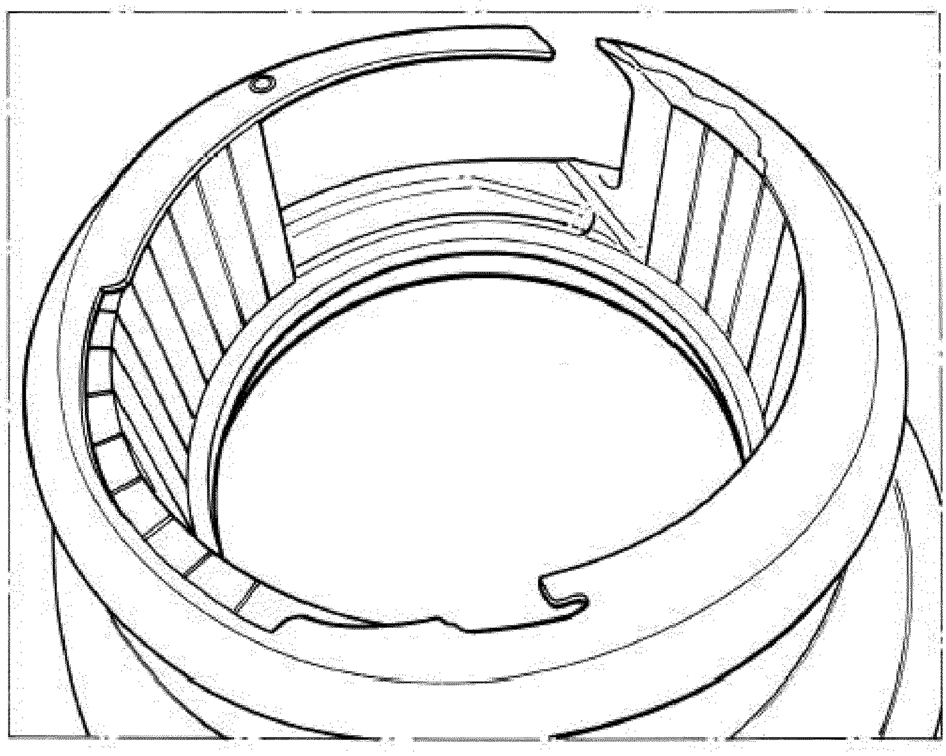


FIG. 5
PRIOR ART

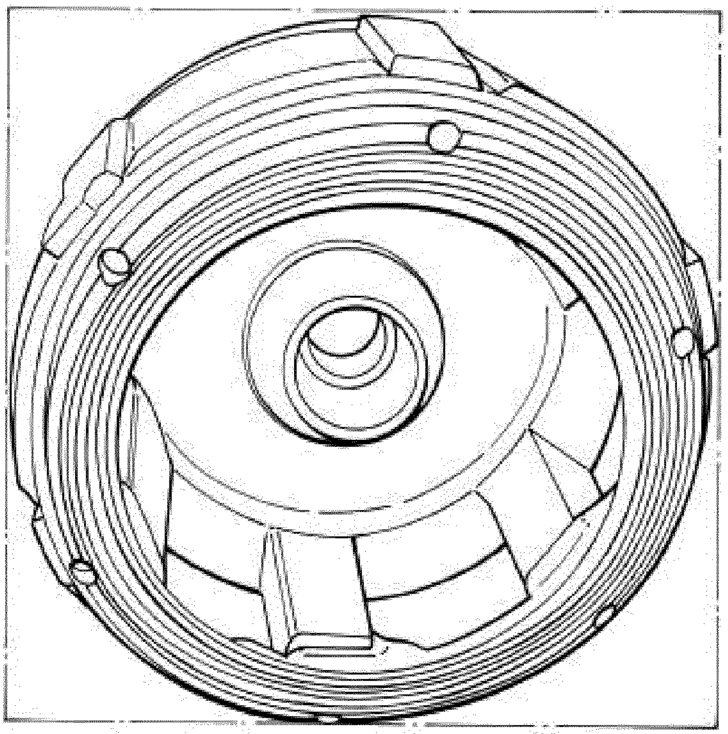


FIG. 6
PRIOR ART

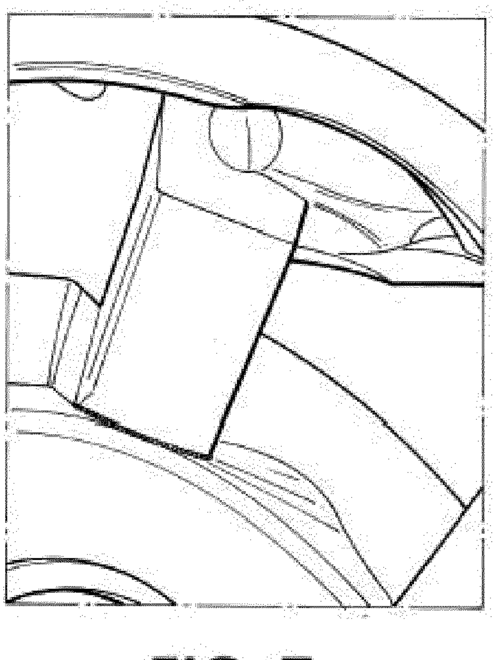


FIG. 7
PRIOR ART

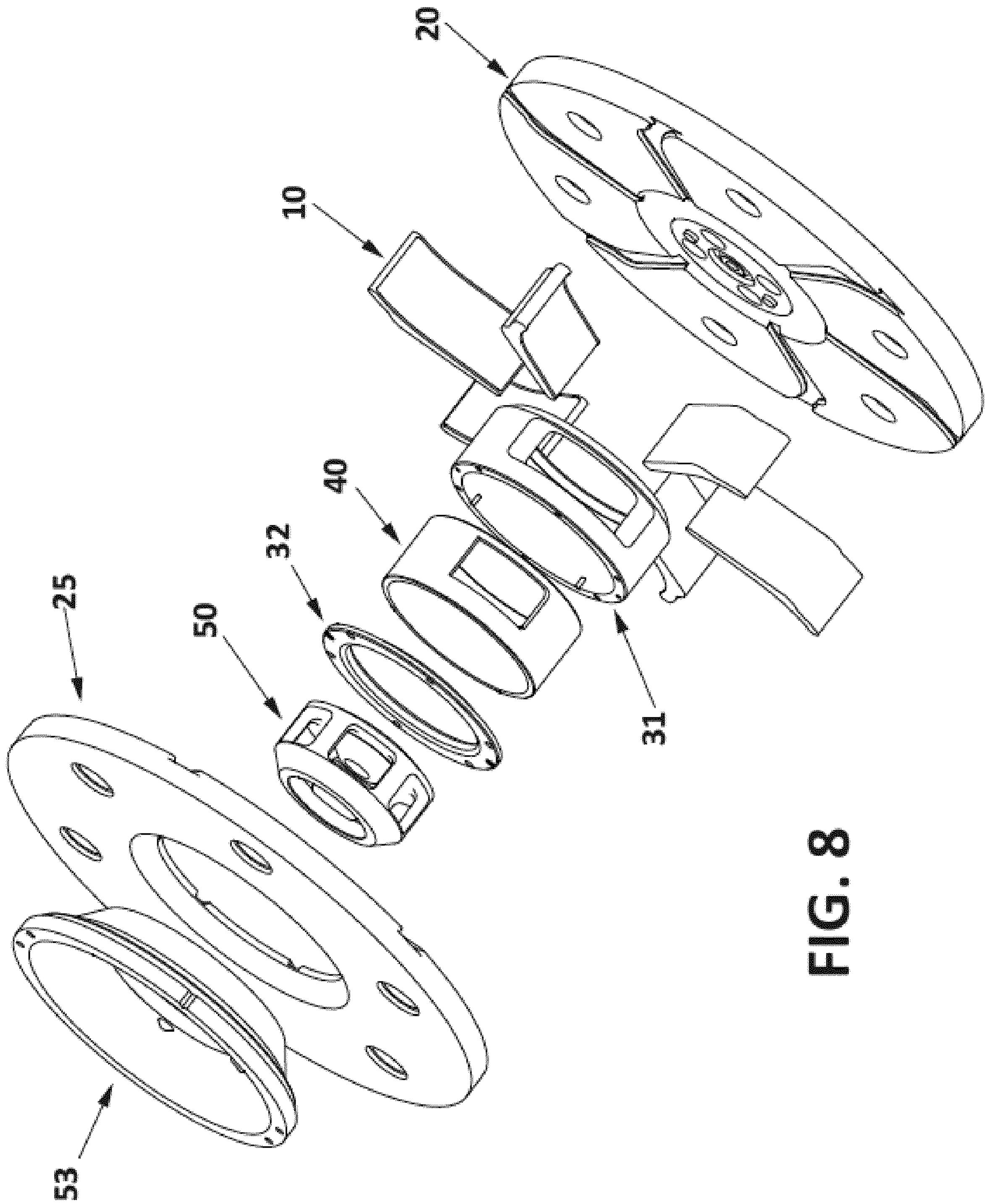


FIG. 8

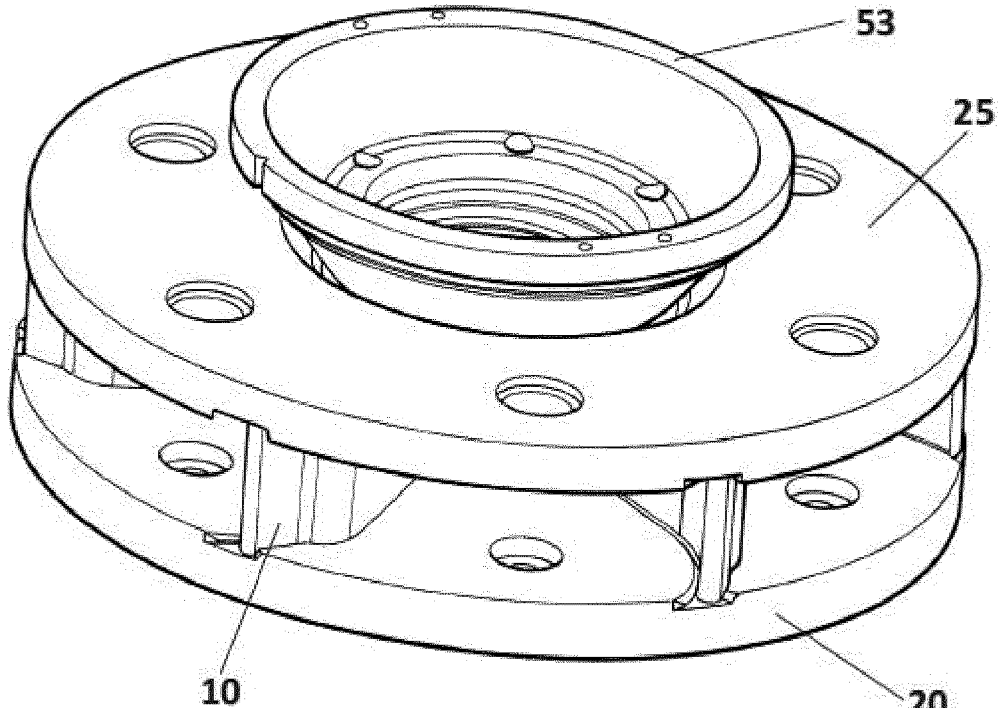


FIG. 9

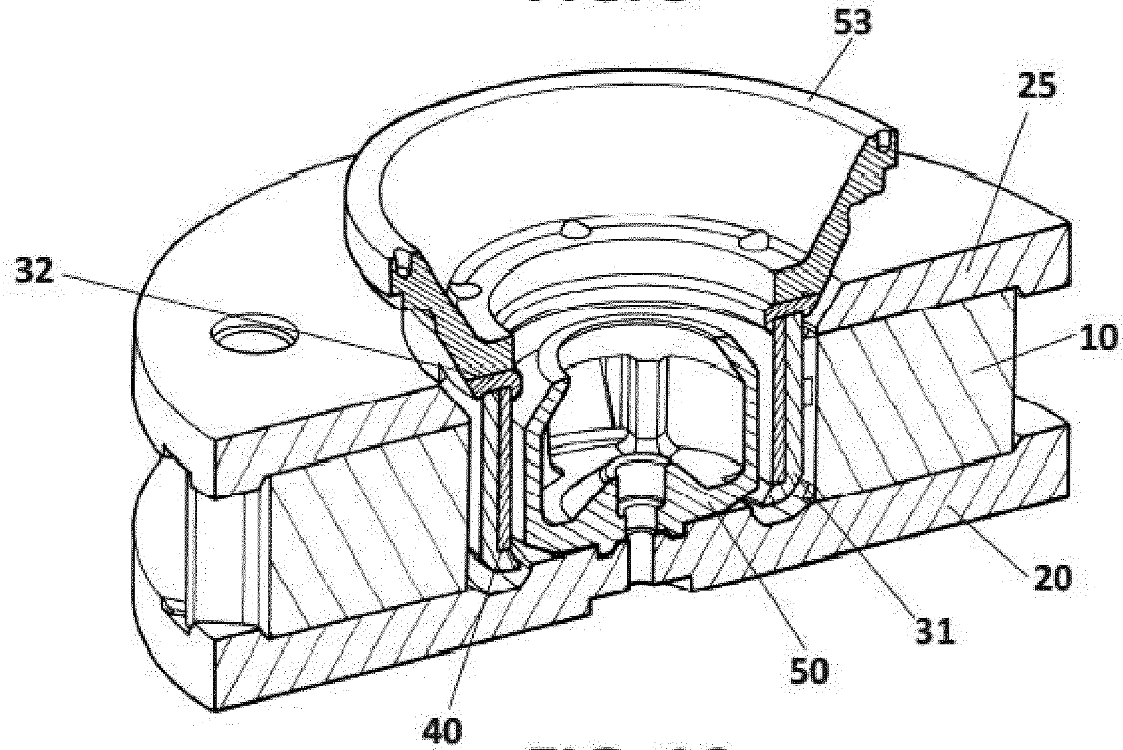
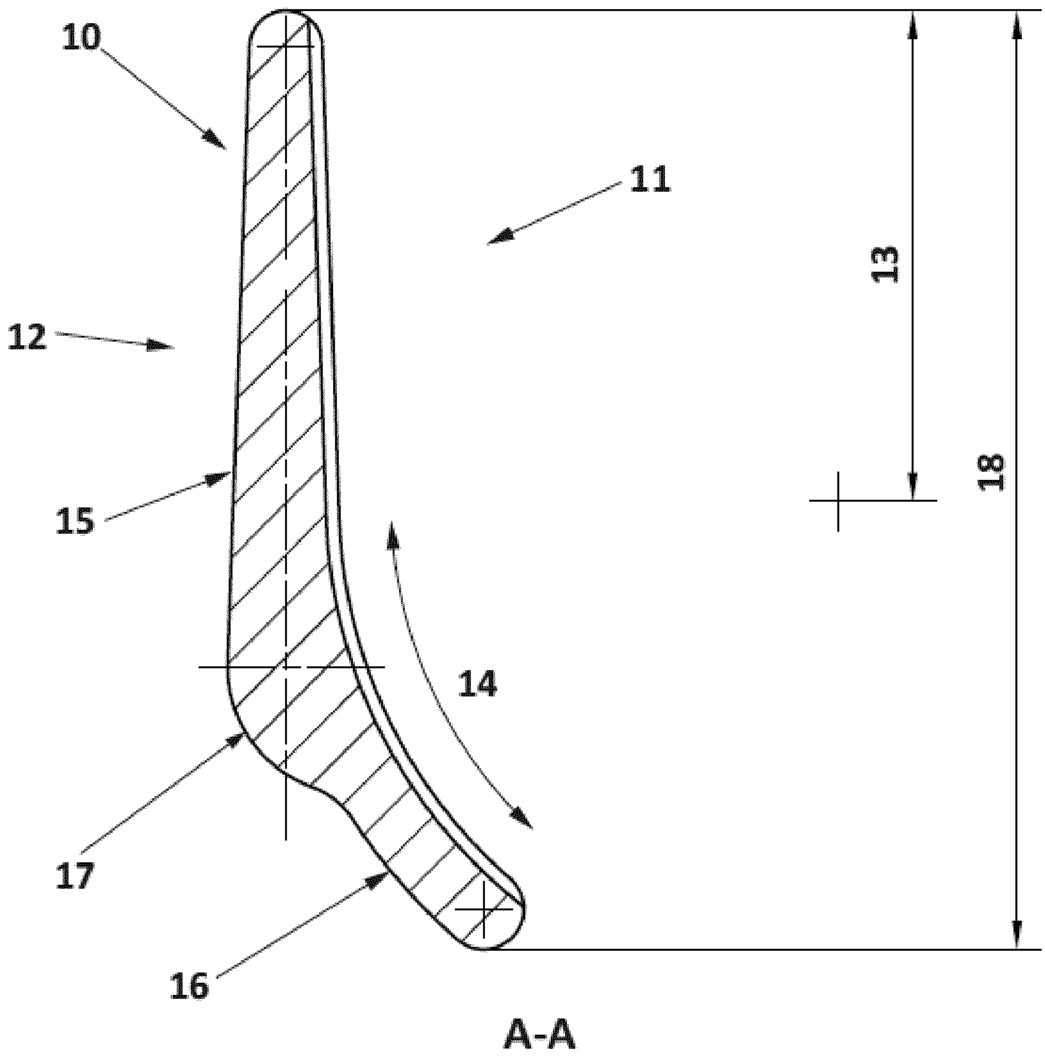


FIG. 10



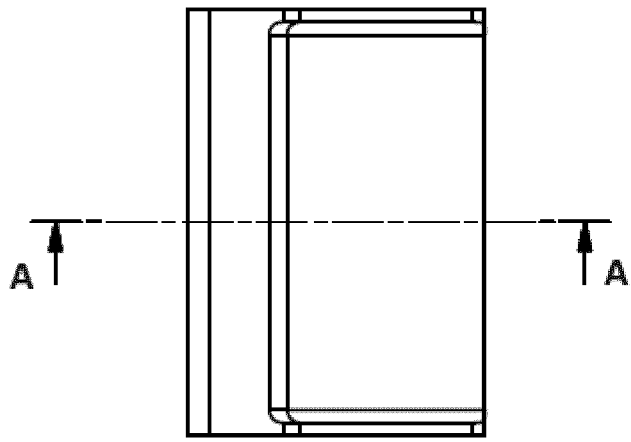


FIG. 11

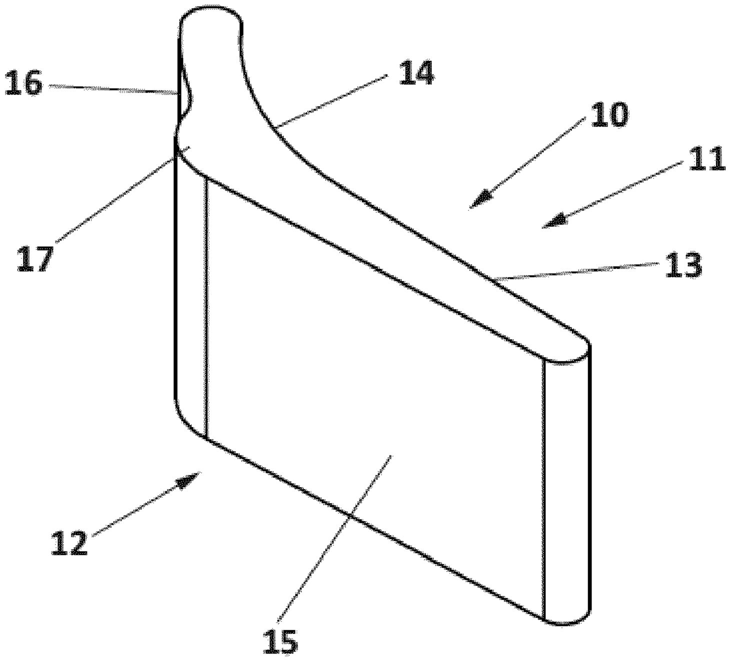


FIG. 12

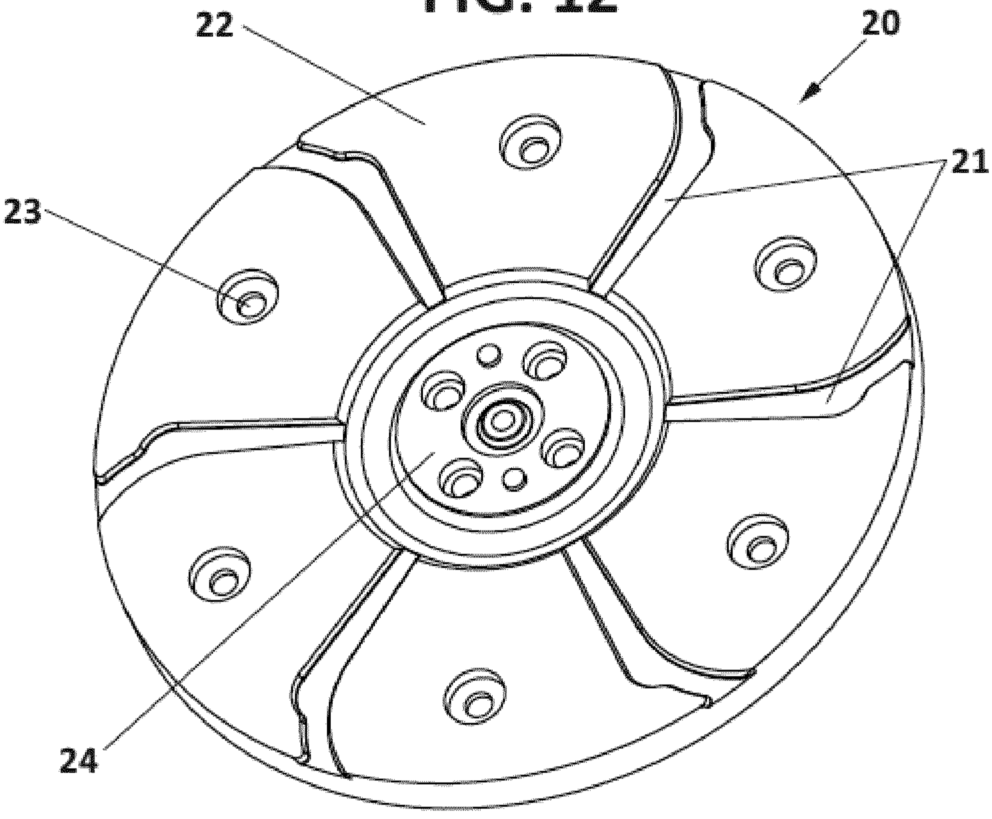


FIG. 13

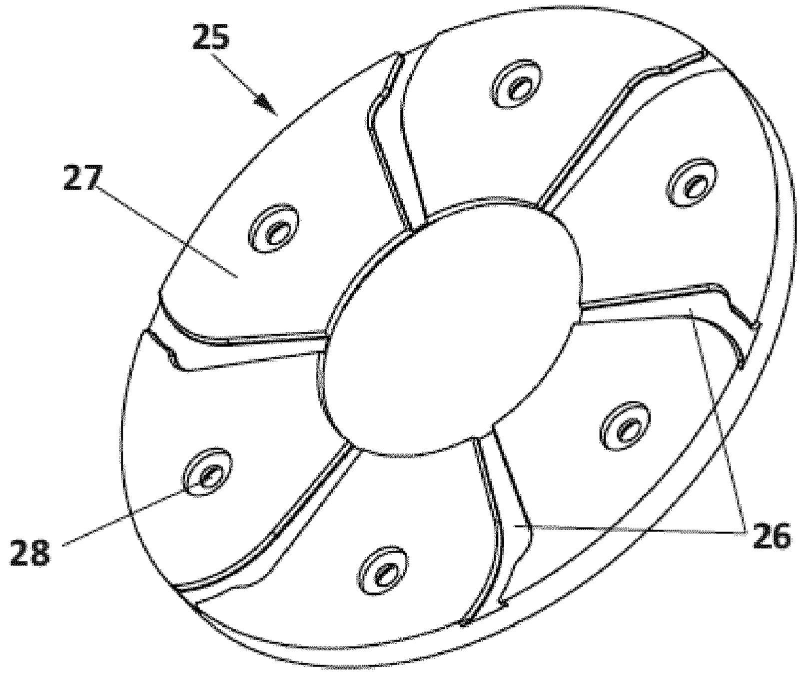


FIG. 14

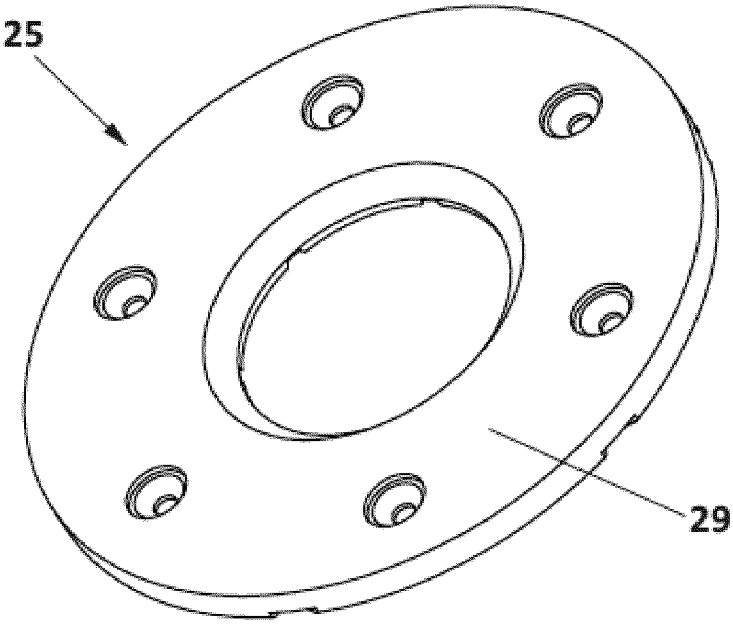


FIG. 15

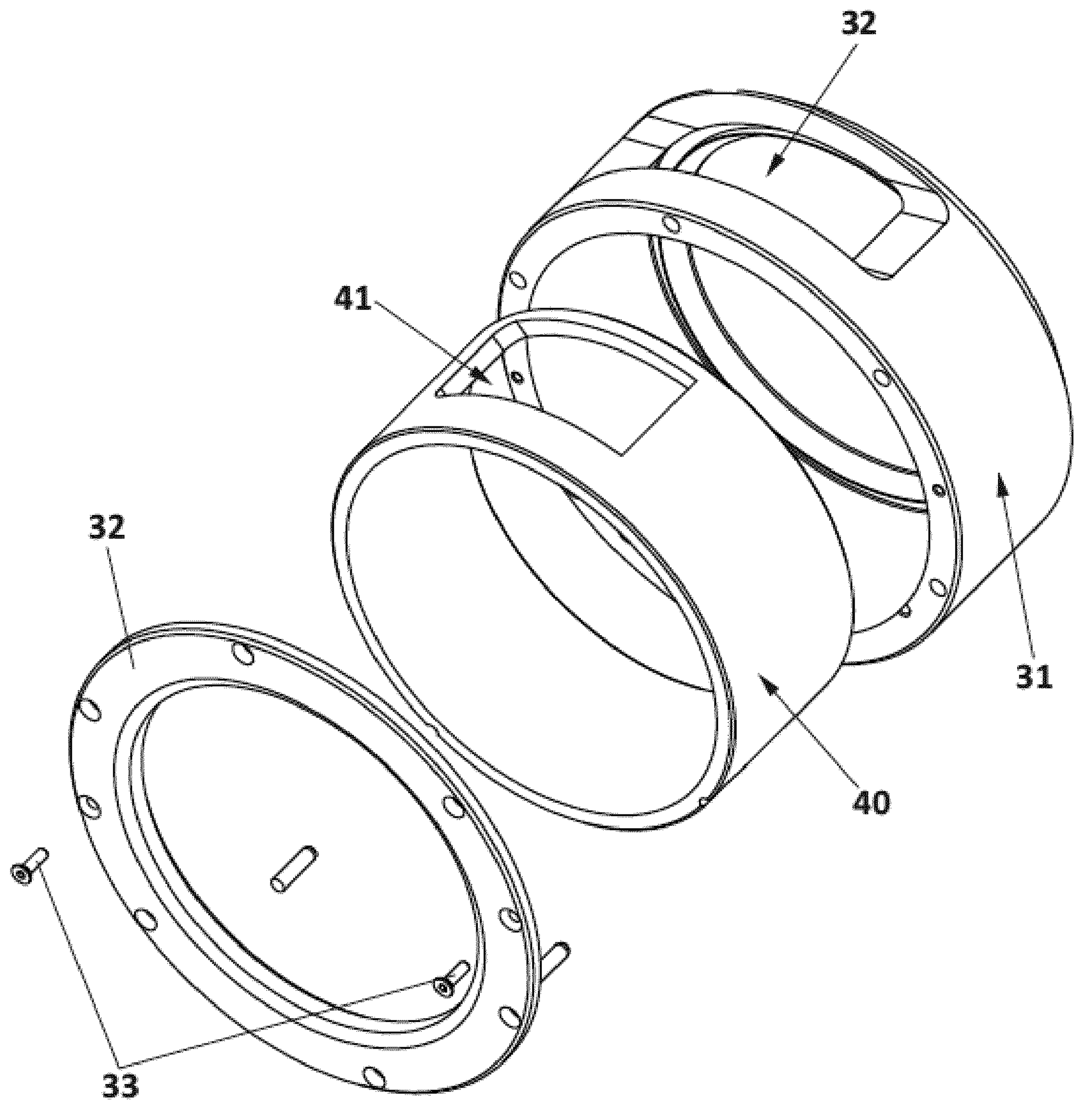


FIG. 16

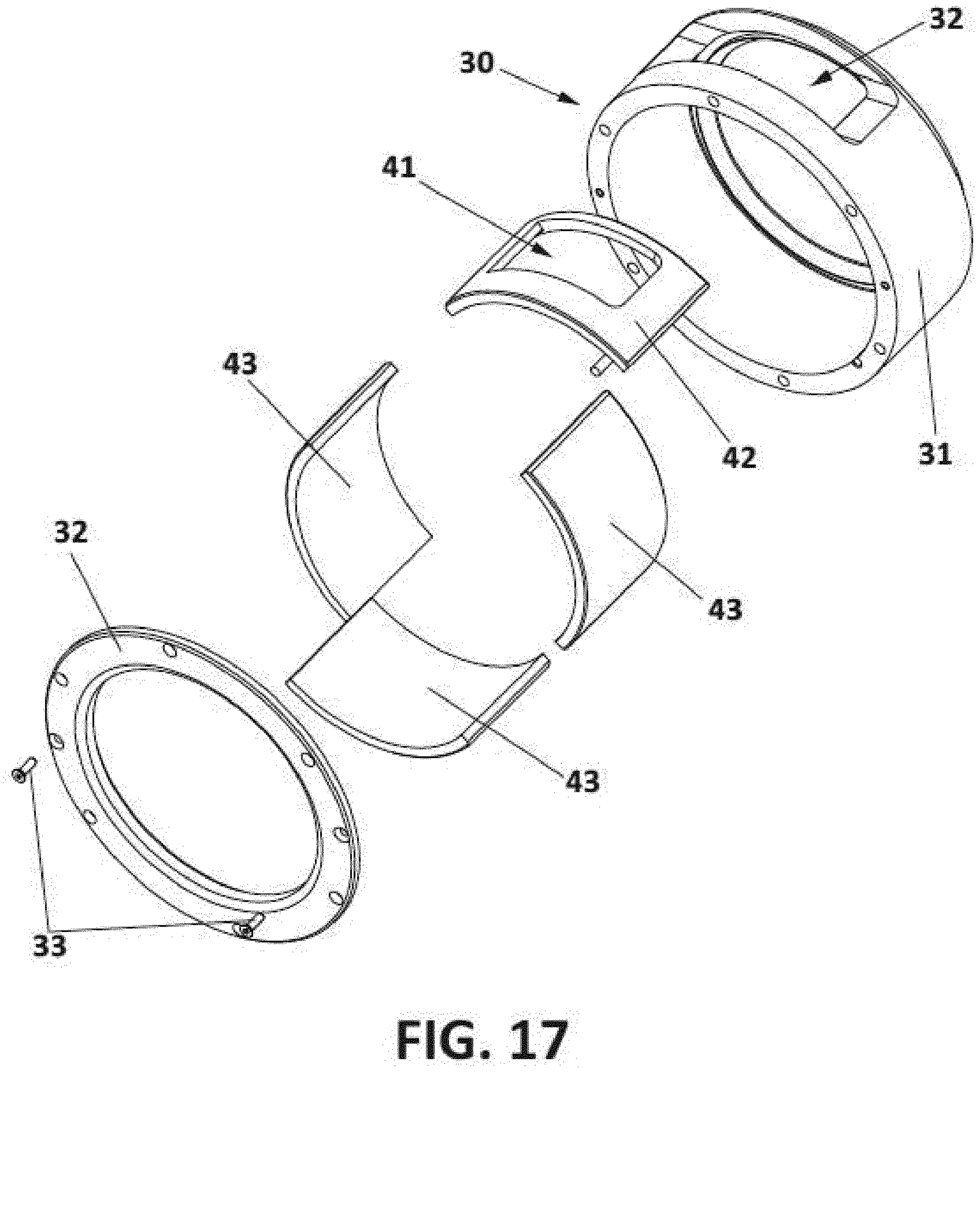


FIG. 17

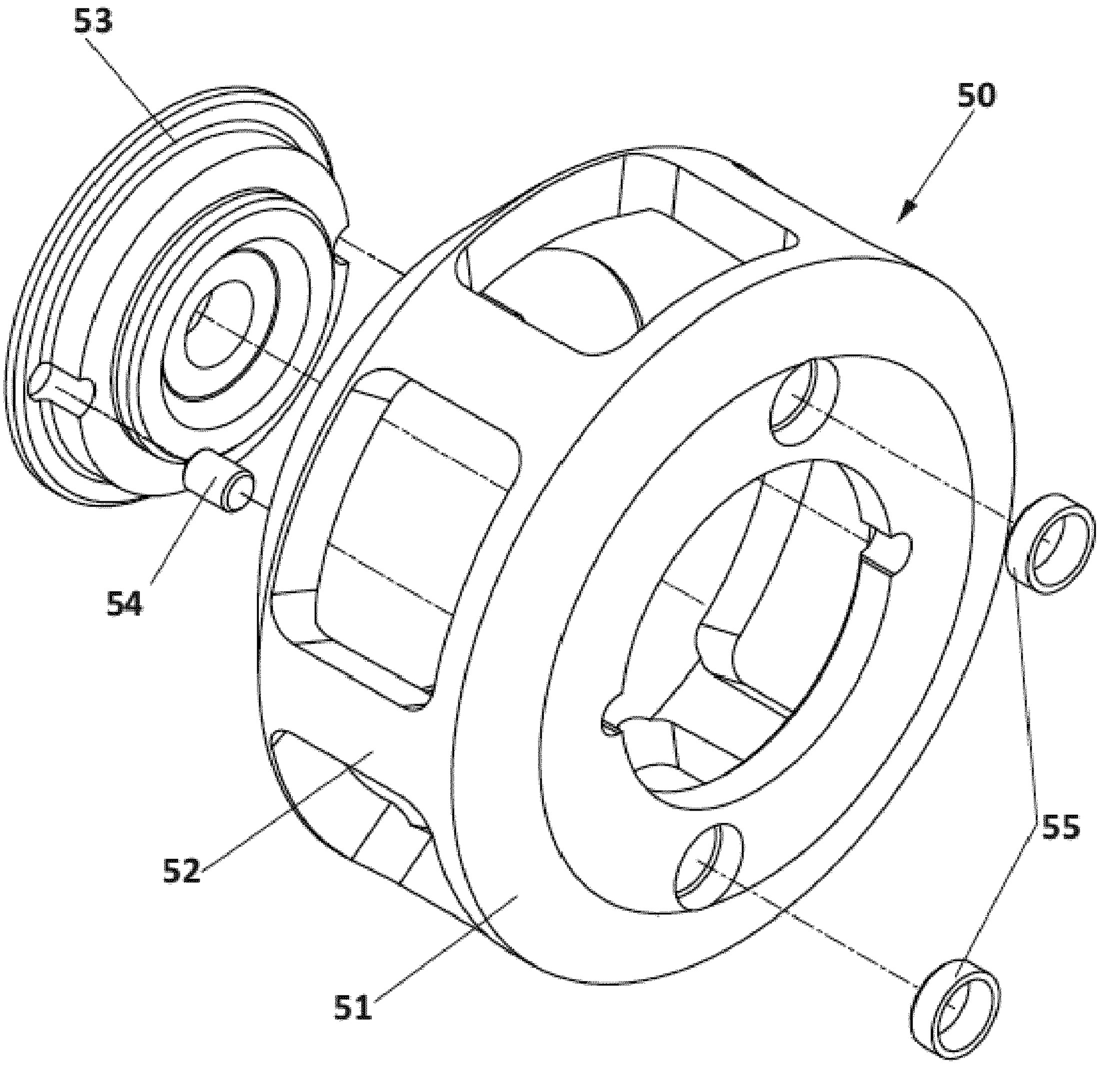


FIG. 18

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EUROPEAN SEARCH REPORT

Application Number
EP 14 18 1592

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Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (IPC)
Y	EP 0 673 718 A1 (SCHLICK ROTO JET MASCH [DE]) 27 September 1995 (1995-09-27) * column 1, lines 51-58 * * pages 1,2 * * abstract * -----	1-6	INV. B24C5/00
Y	EP 1 419 854 A1 (RUTTEN S A [BE]) 19 May 2004 (2004-05-19) * paragraphs [0041], [0042], [0046] * * figures 1,5A,5B,6 * -----	1-6	

TECHNICAL FIELDS SEARCHED (IPC)
B24C

The present search report has been drawn up for all claims

1

Place of search	Date of completion of the search	Examiner
Munich	30 September 2014	Eder, Raimund

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ANNEX TO THE EUROPEAN SEARCH REPORT ON EUROPEAN PATENT APPLICATION NO. EP 14 18 1592

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For more details about this annex : see Official Journal of the European Patent Office, No. 12/82