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WHEELHEAD

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3 Sheets-Sheet 1

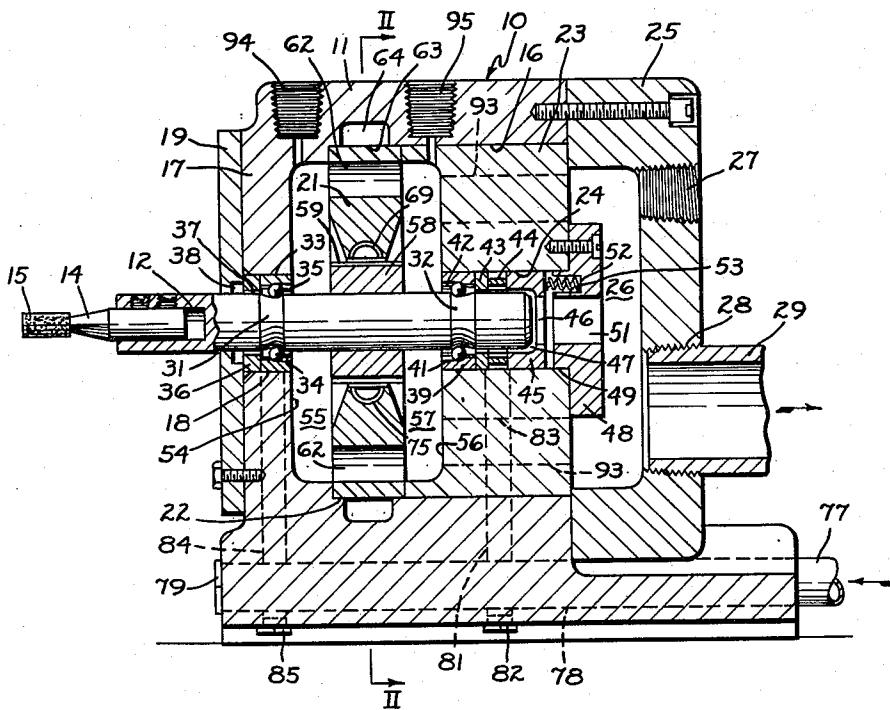


Fig. 1

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3 Sheets-Sheet 2

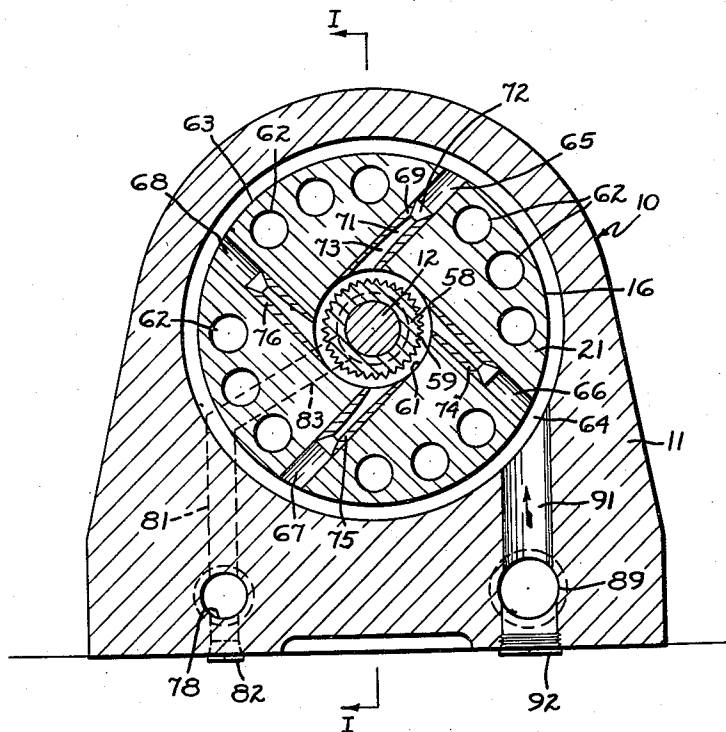


Fig. 2

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1

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WHEELHEAD

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6 Claims. (Cl. 253—50)

This invention relates to a wheelhead and more particularly to a high-speed driving head for an abrasive tool or the like.

In the operation of high-speed rotary tools, such as abrasive grinding wheels, there are occasions when the operation may be improved considerably by rotating the tool at a very high rate of speed. A high speed of rotation for the tool is particularly important when one attempts to grinding an internal bore of small diameter. In order that the wheel spindle may be of sufficient diameter to withstand the grinding forces without bending, it is necessary that the wheel spindle be almost as large as the internal bore of the workpiece. It is, of course, necessary that the wheel be slightly smaller than the said bore to permit the wheel to enter the bore and later to be moved laterally to perform a grinding operation to finish the surface to a desired accuracy. It has been determined that the lineal movement of the surface of an abrasive wheel past the surface which is to be finished should take place at a certain optimum value; all other factors being equal. Now, when the wheel is of small diameter, as it must necessarily be in the case of a small internal bore, the only way the optimum linear surface speed of abrasion may take place is by rotating the wheel at a higher angular velocity for a smaller diameter. However, considerable difficulty has been experienced in obtaining a wheelhead which will rotate at speeds sufficient to permit the surface speed of grinding to be at this optimum value. The desirable speeds for small work such as the inner race of a miniature ball bearing would be in the order of 100,000 to 200,000 revolutions per minute. At this speed ordinary induction motor wheelheads are incapable of operation. The principal problem which is encountered in connection with developing a high-speed wheelhead is in providing bearings which will not be destroyed by the high speeds, this destruction being brought about principally by the heating developed. It has been suggested that the high-speed wheelhead be driven by an air turbine, but attempts to obtain such a wheelhead have failed because of bearing problems and the like. These and other difficulties experienced with the prior art devices have been obviated in a novel manner by the present invention.

It is, therefore, an outstanding object of the invention to provide a wheelhead capable of rotating at extremely high speeds without bearing failure.

It is another object of this invention to provide a turbine-type wheelhead having a novel manner of cooling the bearings to permit high-speed operation.

A still further object of the present invention is the provision of a high-speed wheelhead for grinding machine operating on the air turbine principle and having a novel method of cooling and lubricating the bearings.

A still further object of the instant invention is the provision of an air turbine in which the speed of the periphery of the rotating wheel approaches the speed of sound.

With these and other objects in view, as will be appar-

2

ent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

The character of the invention, however, may be best understood by reference to certain of its structural forms, as illustrated by the accompanying drawings in which:

Figure 1 is a vertical sectional view of a wheelhead embodying the principles of the present invention taken on the line I—I of Figure 2,

Figure 2 is a vertical sectional view of the invention taken on the line II—II of Figure 1, and

Figure 3 is a plan view of the wheelhead of the invention.

Referring first to Figure 1, wherein are best shown the general features of the invention, the wheelhead indicated generally by the reference numeral 10, is shown as consisting of a main housing 11 carrying a shaft 12 which is connected to the shaft 14 of an abrasive wheel 15. The abrasive wheel is of the type ordinarily used in the grinding of internal bores and is shown as having a diameter considerably greater than would be used in grinding the type of internal bore which needs a very high-speed operation; the enlargement for the purposes of illustration is made for purposes of clarity.

A main housing 11 is provided with a bore 16 which does not extend through the housing but leaves a front wall 17 intact. Extending through the front wall 17 is a somewhat smaller bore 18. Bolted to the outer surface of the front wall 17 is a plate 19. Mounted in the bore 16 in the main housing is a turbine stator 21. The bore 16 terminates in a shoulder 22 against which the stator rests. Also mounted in the bore 16 is a partition member 23, having a bore 24 extending therethrough co-axially with the bore 18 in the front wall 17. When the stator 21 and the partition member 23 are mounted in the bore 16 the rearward surface of the partition member lies in the same plane as the rearward surface of the main housing 11; a chamber member 25 is bolted to the rearward surface of the main housing 11 and serves to retain the partition member 23 in place within the bore 16. The inner surface of the chamber member 25 is counterbored to provide a chamber 26 to which access is gained by a pressure gage, not shown, by means of a threaded port 27. Another threaded port 28 engages a conduit 29.

The shaft 12 lies co-axial with the bore 18 and 24 and the bores 16 in the main housing 11. In the portion of the shaft which lies co-extensive with the front wall 17 there is provided a groove 31 of rather unusual configuration. The portion of the groove which lies inwardly of the wheelhead has a toroidal surface configuration of circular cross-section, whereas the portion which lies away from the center of the wheelhead is conical in configuration. The conical portion is tangential to the toroidal portion. A similar groove 32 is formed in the portion of the shaft 12 which lies within the partition member 23. The outer race 33 of a ball bearing lies within the bore 18 and the balls 34 lie in the toroidal portion of the groove 31. A retaining ring 35 is provided. Outwardly of the outer race 34, but within the bore 18, lies an orifice ring 36 which is co-extensive with part of the groove 31, and also overlies a portion of the main part of the shaft which is adjacent the groove; the orifice ring 36 fits tightly in the bore 18 and is provided with a central bore 37 which is a few thousandths of an inch larger than the shaft 12, so that a gap lies therebetween. A shallow pocket 38 is provided in the surface of the plate 19 co-axially of the shaft 12. The groove 32 is provided with a similar ball bearing having an outer race 39 which lies within the bore 24 of the partition member 23 and having balls 41 which engage the toroidal portion of the groove 32. This toroidal portion being that portion of the groove 32 which lies closest to the groove 31. A re-

taining ring 42 is provided. Within the bore 24 and against the outer race 39 is placed an orifice plate 43 which has an outer periphery which fits tightly in the bore 24 but an inner bore which is co-axial with the shaft 12, but is larger by a few thousandths than that shaft. The orifice ring 43 is co-extensive with a portion of the groove 32 and also overlies a portion of the main cylindrical surface of the shaft 12 so that a slight gap is provided therebetween. Within the bore 24 lies a spacer of tubular conformation 44 followed by a pressure member 45. The outer periphery of the pressure member fits slidably within the bore 24 and a bore 46 extends axially of the shaft 12 therethrough. A counterbore 47 extends part way into the pressure member to provide a clearance around the end of the shaft 12. A closure member 48 is bolted to the rearward surface of the partition member 23 and is provided with a cylindrical protuberance 49 which fits tightly in the bore 24. A bore 51 extends axially through the closure member 48 co-axially of the shaft 12. A number of closed bores 52 extend into the innermost surface of the protuberance 49 and in each of these bores is a spring 53 which presses against the outer surface of the pressure member 45. A smoothly formed pocket 54 is formed in the housing 11 as an extension of the bore 16 to form a chamber 55, while a similar pocket 56 is formed on the left hand end of the partition member 23 to define a chamber 57. The pockets 54 and 56 are exactly similar and are in opposed relationship, with the stator 21 lying therebetween. A turbine wheel 58 is mounted on the shaft 12 by a shrink fit and is co-extensive with the stator 21. As is evident in Figure 2, the stator is of a generally cylindrical conformation and is provided at its outer surface with serrations or teeth 59. The stator 21 is of a generally disclike configuration and is provided with an axial bore 61 which lies closely adjacent to the surface of the turbine wheel 58. For the purposes of clarity in presentation, the gap between the teeth 59 and the surface of the wheel 58 and the surface of the bore 61 is shown as being fairly large but, in actuality, it will be understood that the surfaces will be much more clearly arranged. The stator 21 is provided with a plurality of bores whose axes extend parallel to the shaft 12. The bore 62 providing access between the chamber 55 and the chamber 57. The stator 21 has a cylindrical outer surface which fits tightly in the bore 16 in the main housing, and surrounding the cylindrical surface 63, is a toroidal groove 64 formed in the inner surface of the housing 11.

Extending through the stator 21 from the surface 63 to the bore 61 are four bores 65, 66, 67 and 68. The axes of these bores lie in a common plane at right angles to the axis of the shaft 12 and the axes of the adjacent bores extend at a right angle to each other; furthermore, each of the axes is tangential to a cylindrical surface which is representative of the mean diameter of the teeth 59 of the wheel 58. In the bore 65 is situated a nozzle insert 69 having a passage 71 therethrough. The outer portion of the passage 71 is provided with a generally conical mouth 72 whose surface extends inwardly toward the axis of the bore 65 in the direction of the wheel 58. The rest of the passage 71 consists of a long, generally conical expansion portion 73, the large end of which is adjacent the bore 61. It will be understood that the shape of the passage 71 is that of a venturi of the de Laval type and that the mouth 72 and the expansion portion 73 have a carefully formed, mathematical shape common to such venturi passages. Similar inserts 74, 75, and 76 are provided in the bores 66, 67, and 68, respectively.

A conduit 77 is attached to a source of air under pressure, having a lubricant mist-dispersed therein. The conduit 77 is threaded into the threaded opening of a passage 78 which extends axially through the main housing 11 and is closed at the end opposite the conduit 77 by a plug 79. A passage 81 extends upwardly through the main body 11 intersecting the passage 78 as is best shown in Figure

2, the lower end of the passage being closed by a plug 82. At its upper portion the passage 82 merges with a passage 83 extending inwardly toward the axis of the shaft 12, the passage 83 terminating in the bore 24 in the portion thereof occupied by the spacer 44; it will be understood that the spacer 44 is provided with radial openings therethrough so that access is provided for air to flow from the outer portion adjacent the bore 24 to the inner portion adjacent the shaft 12. Extending vertically through the housing 11 is another passage 84 closed at its lower end by a plug 85 and intersecting the passage 78. The passage 84 extends vertically upwardly to the level of the shaft 12 where it intersects a passage 86 which extends parallel to the axis of the shaft and toward the plate 19. The plate 19 is provided on its inner surface with a groove 87 whereby access is obtained from the passage 86 to the pocket 38, these latter details being best shown in Figure 3.

The conduit 88 is attached to a source of air under pressure, not shown. In the preferred embodiment this air is at a pressure of 90 pounds per square inch and the course is capable of furnishing air at this pressure from 30 to 35 cubic feet per minute. The conduit 88 is threaded into a threaded opening of a passage 89 extending into the main housing 11 parallel to the axis of the shaft 12, and terminating in a vertical passage 91 which is closed at its lower end by a plug 92. The passage 91 extends vertically and intersects the toroidal groove 64.

It should be noted that a series of passages 92 extend through the partition member 23 in a direction parallel to the axis of the shaft 12 and serve to join the chamber 57 to the chamber 26. A threaded port 94 permits the attachment of a pressure gage to measure pressure in the chamber 55 and a similar threaded port 95 serves the same purpose with regard to the chamber 57. These ports are not necessary, of course, to a commercial unit. In the preferred embodiment, the clearance between the orifice rings 36 and 43 and the surface of the shaft 12 is ten thousandths of an inch, permitting a flow of about two cubic feet per minute of the air with the lubricant mist suspended therein.

The operation of the apparatus will now be readily understood in view of the above description. Air under pressure enters the conduit 88, passes through the passage 89, and upward through the passage 91 to the toroidal groove 64. Air flows around in the groove and into the bores 65, 66, 67, and 68. The flow of air then takes place through the nozzle inserts 69, 74, 75, and 76, respectively. With regard to the nozzle insert 69, the air flows through its venturi pipe passage 73 in such a manner as to strike the teeth 59 of the turbine wheel 58 with considerable force. It is believed that the provision of a long, tapered expansion portion 73 permits the velocity of flow to take place at considerably greater than the speed of sound, despite the generally accepted view that the flow of air through an orifice is limited to the speed of sound because of shock waves. This high velocity permits the imparting of energy to the turbine wheel 58 in such a manner that the peripheral speed of the wheel approaches the velocity of flow of air from the nozzle and this speed is not limited to the speed of sound. The same action takes place in all of the nozzles of the stator 21. The impetus supplied to the wheel 58 carries the shaft 12 and the wheel 15 at the same rotational rate.

In order to cool and lubricate the bearings, a mixture of air and lubricant mist enters the apparatus through the conduit 77 and passes longitudinally through the passage 78. A portion of the air passes upwardly through the passage 81 and the passage 83 to the portion of the bore 24 in the partition member 23 occupied by the spacer 44. Because of the spacer being perforated, the air and mist flow radially inwardly to a position adjacent the shaft 12. The air and mist then flow axially toward the wheel 58, passing through the small gap between the bore of the orifice ring 43 and the surface of the shaft 12. The

5

air flow into the ball bearing is such as to cause a condensation of the lubricant from the air on the surface of the groove 32 and the balls 41. After passing through the ball bearing, the air enters the chamber 57. Some of the air passing along the passage 58 passes upwardly through the passage 84 and the passage 86 into the groove 87 in the plate 19. It then flows into the pocket 38 in the plate and from there through the bore 37 in the orifice ring 36. Here again, the particular arrangement of the orifice ring with the groove 31 causes a condensation of lubricant from the air and a deposit on the surface of the groove 31 and the balls 34. From there the air passes into the chamber 55. We find, then, that in the chamber 55 there exists a mixture of, first, air coming from the nozzles after passage over the wheel 58 with resultant release of energy thereto and, second, the air which has passed over the ball bearing 33 residing in the bore 18 in the front wall 17. This mixture passes rearwardly through the passages 62 formed in the stator 21 and enters the chamber 57. The chamber 57, of course, already has air which originally came from the nozzles and passed over the wheel 58 as well as air which has passed over the ball bearing 41 in the bore 24. The resultant mixture then passes rearwardly and axially of the shaft 12 through the passages 93 into the chamber 26, and from there through the conduit 29 to the atmosphere or other areas of disposal.

It can be seen, then, that by the use of the present invention a linear peripheral speed is possible for the turbine wheel 58 which is considerably in excess of the speed of sound, and, therefore, a rotational speed of the shaft 12 can be obtained far in excess of that formerly thought possible. Furthermore, the provision of an air and lubricant mist mixture passing through the bearings assures that, not only is heat removed from the bearings, but lubricant is supplied. The particular shape of admission of air to the bearings, particularly the orifice rings, resulting in a deposit of lubricant in a manner which would not have been possible otherwise.

It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to include all such as properly comes within the scope claimed.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent is:

1. A wheelhead comprising a main housing having a hollow interior, a shaft rotatably mounted in bearings in the housing, means for causing air with lubricant in suspension therein to pass through the bearings, a wheel having a serrated periphery mounted on the shaft and rotatable therewith, a stator fixed to the interior of the housing, the said bearings being of the ball type and surrounding the shaft on opposite sides of the wheel, a groove in the shape of an inner bearing race formed in the shaft to accommodate the balls of each bearing, an orifice plate mounted adjacent each bearing to bring about a drop of pressure in the air passing therethrough for condensation of the lubricant, the said groove associated with each bearing having a generally conical portion located adjacent the orifice plate and a toroidal portion for contact with the bearing balls, the conical portion receiving the condensed lubricant and carrying it to the bearing balls, a plurality of nozzles mounted in the stator and terminating adjacent the periphery of the wheel, the nozzles being adapted to receive air under pressure to rotate the wheel and shaft at a high rate of speed.

2. A wheelhead comprising a main housing having a hollow interior, a shaft rotatably mounted in bearings in the housing, means for causing air with lubricant in suspension therein to pass through the bearings, a wheel having a serrated periphery mounted on the shaft and rotatable therewith, a stator fixed to the interior of the housing, the said bearings being of the ball type and sur-

6

rounding the shaft on opposite sides of the wheel, a groove in the shape of an inner bearing race formed in the shaft to accommodate the balls of each bearing, an orifice plate mounted adjacent each bearing to bring about a drop of pressure in the air passing therethrough for condensation of the lubricant, the said groove associated with each bearing having a generally conical portion located adjacent the orifice plate and a toroidal portion for contact with the bearing balls, the conical portion receiving the condensed lubricant and carrying it to the bearing balls, a plurality of nozzles mounted in the stator and terminating adjacent the serrated periphery of the wheel, the nozzles being adapted to receive air under pressure to rotate the wheel and shaft at a high rate of speed, the nozzles being of venturi form with an elongated expansion portion through which the air passes immediately prior to arrival at the wheel.

3. A wheelhead, comprising a main housing having a hollow interior, a shaft rotatably mounted in bearings in the housing, means for causing air with lubricant in suspension therein to pass through the bearings, a wheel having a formed periphery mounted on the shaft and rotatable therewith, a stator fixed to the interior of the housing, the said bearings being of the ball type and surrounding the shaft on opposite sides of the wheel, a groove formed in the shaft to accommodate the balls of each bearing, a reduced passage located adjacent each bearing to bring about a drop of pressure in the air passing therethrough for condensation of the lubricant, the said groove associated with each bearing having a toroidal portion for contact with the bearing balls and having a smooth portion of slight curvature merging with the toroidal portion located adjacent the reduced passage, the smooth portion receiving the condensed lubricant and carrying it to the bearing balls, a plurality of nozzles mounted in the stator and terminating adjacent the periphery of the wheel, the nozzles being adapted to receive air under pressure to rotate the wheel and shaft at a high rate of speed.

4. A wheelhead comprising a main housing having a hollow interior, a shaft rotatably mounted in bearings in the housing, means for causing air with lubricant in suspension therein to pass through the bearings, wheel having a formed periphery mounted on the shaft and rotatable therewith, a stator fixed to the interior of the housing, the said bearings being of the ball type and surrounding the shaft on opposite sides of the wheel, a groove in the shape of an inner bearing race formed in the shaft to accommodate the balls of each bearing, a passage of small cross-sectional area located adjacent each bearing to bring about a drop of pressure in the air passing therethrough for condensation of the lubricant, the said groove associated with each bearing having a generally conical portion located adjacent the orifice plate and a toroidal portion for contact with the bearing balls, the conical portion receiving the condensed lubricant and carrying it to the bearing balls, a plurality of nozzles mounted in the stator and terminating adjacent the periphery of the wheel, the nozzles being adapted to receive air under pressure to rotate the wheel and shaft at a high rate of speed, the nozzles being of venturi form with an elongated expansion portion through which the air passes immediately prior to arrival at the wheel.

5. A wheelhead comprising a main housing having a hollow interior, a shaft rotatably mounted in bearings in the housing, a wheel having a formed periphery mounted on the shaft and rotatable therewith, a stator fixed to the interior of the housing, a plurality of nozzles mounted in the stator and terminating adjacent the periphery of the wheel, the nozzles being of venturi form with an elongated expansion portion adapted to receive air under pressure to rotate the wheel and shaft at a high rate of speed, the air leaving the wheel at both sides thereof, the shaft being mounted in ball bearings, each bearing having an inner race with a toroidal portion for contact with the

7

balls and a generally conical portion tangential of the toroidal portion, a passage of small cross-sectional area located adjacent the conical portion of each bearing and adapted to receive a flow of mist lubricant for passage to the bearing, and a chamber formed in the housing on each side of the wheel and stator, apertures formed in the stator to permit passage of air from one chamber to the other, the housing having an end wall constituting the wall of one chamber and carrying one bearing, the housing having a partition wall forming the wall of the other chamber and serving as a wall of a third chamber, the partition wall carrying another bearing, passages through the partition wall joining the two first-mentioned chambers to the third chamber.

6. A wheelhead, comprising a main housing having a hollow interior, a shaft rotatably mounted in bearings in a housing, means for causing air with lubricant in suspension therein to pass through the bearing, a wheel having a formed periphery mounted on the shaft and rotatable therewith, a stator fixed to the interior of the housing, the said bearings being of the type having anti-friction elements and surrounding a shaft on opposite

8

sides of the wheel, a groove the surface of which is rotatable with the shaft to accommodate the anti-friction elements of each bearing, a reduced passage located adjacent each bearing to bring about a drop in pressure in the air passing therethrough for condensation of the lubricant, the said groove associated with each bearing having a toroidal portion for contact with the bearing elements and having a smooth portion of slight curvature merging with the toroidal portion located adjacent the reduced passage, the smooth portion receiving the condensed lubricant and carrying it to the bearing elements, a plurality of nozzles mounted in the stator and terminating adjacent the periphery of the wheel, the nozzles being adapted to receive air under pressure to rotate the wheel and shaft at a high rate of speed.

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