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Goodfellow

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[54] **BIG HOLE CUTTER**

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[52] **U.S. Cl.** **175/53**, 175/345, 175/355, 175/375

[51] **Int. Cl.** **E21c 23/00**

[58] **Field of Search** 175/53, 344, 334, 335, 175/353, 355, 357, 361, 363, 375

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Attorney, Agent, or Firm—Melvin A. Crosby

[57] **ABSTRACT**

A big hole cutter such as are employed in connection with raise drilling machines and box hole drilling machines in which a support frame is provided for connection to the drill string of the machine and on which support frame there is mounted rotary cutters on the side facing the formation to be reduced. The frame is a skeleton-like structure in that openings are provided extending axially therethrough which the muck and debris taken by the cutters can fall thereby preventing the cutter from becoming clogged up in operation. The big hole cutters for either raise drilling or box hole drill operations can include stabilizer rollers about the periphery to engage the surface of the hole being drilled and thereby stabilize the big hole cutter in the lateral direction. With raise drilling cutters, the actuating drill string connects to the cutter at the top and the raise drilling cutter is pulled upwardly while in a box hole machine the drill string connects to the bottom of the big hole cutter and the cutter is pushed upwardly. In respect of the big hole cutters for the last mentioned type of machine, the cutter also includes a pilot cutter extending axially from the upper end thereof and the aforementioned stabilizing rollers are particularly important for guiding the big hole cutter during working operations.

15 Claims, 8 Drawing Figures

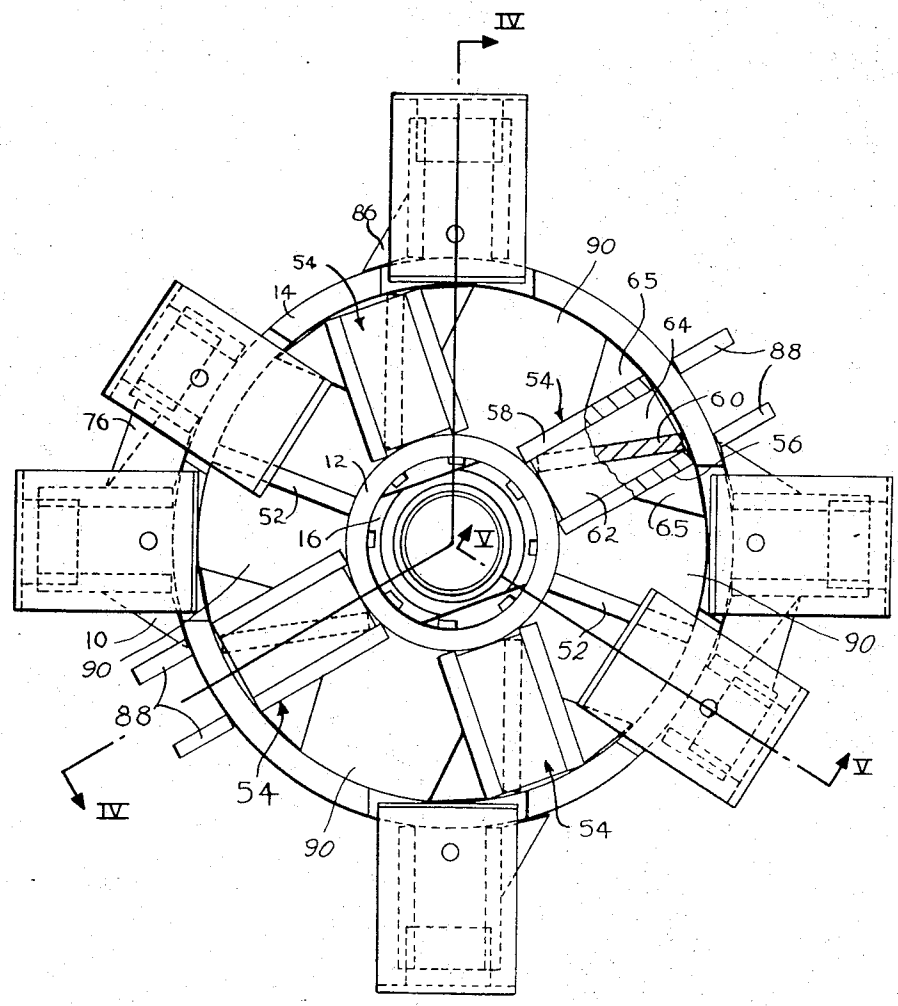


FIG. 1

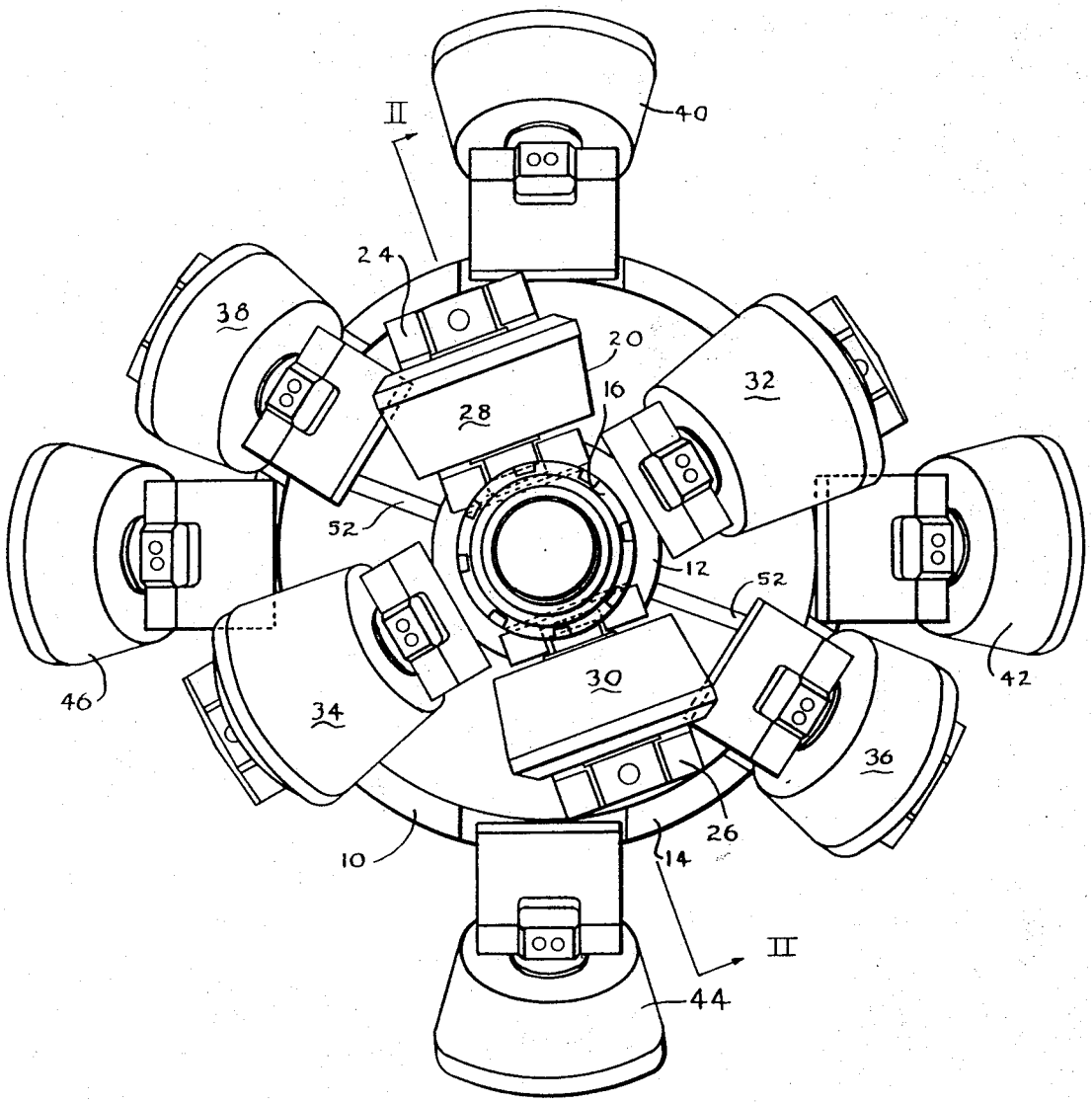


FIG. 2

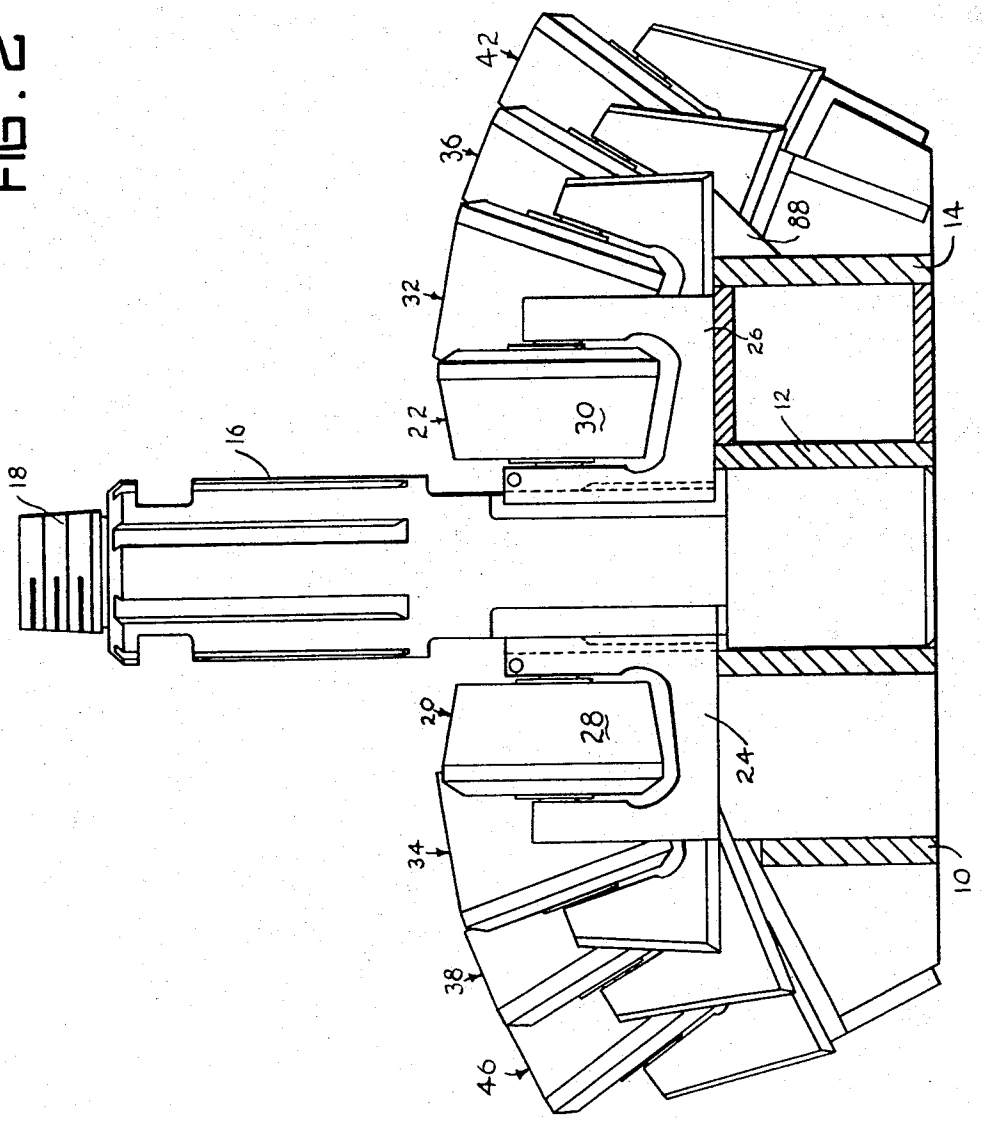


FIG. 3

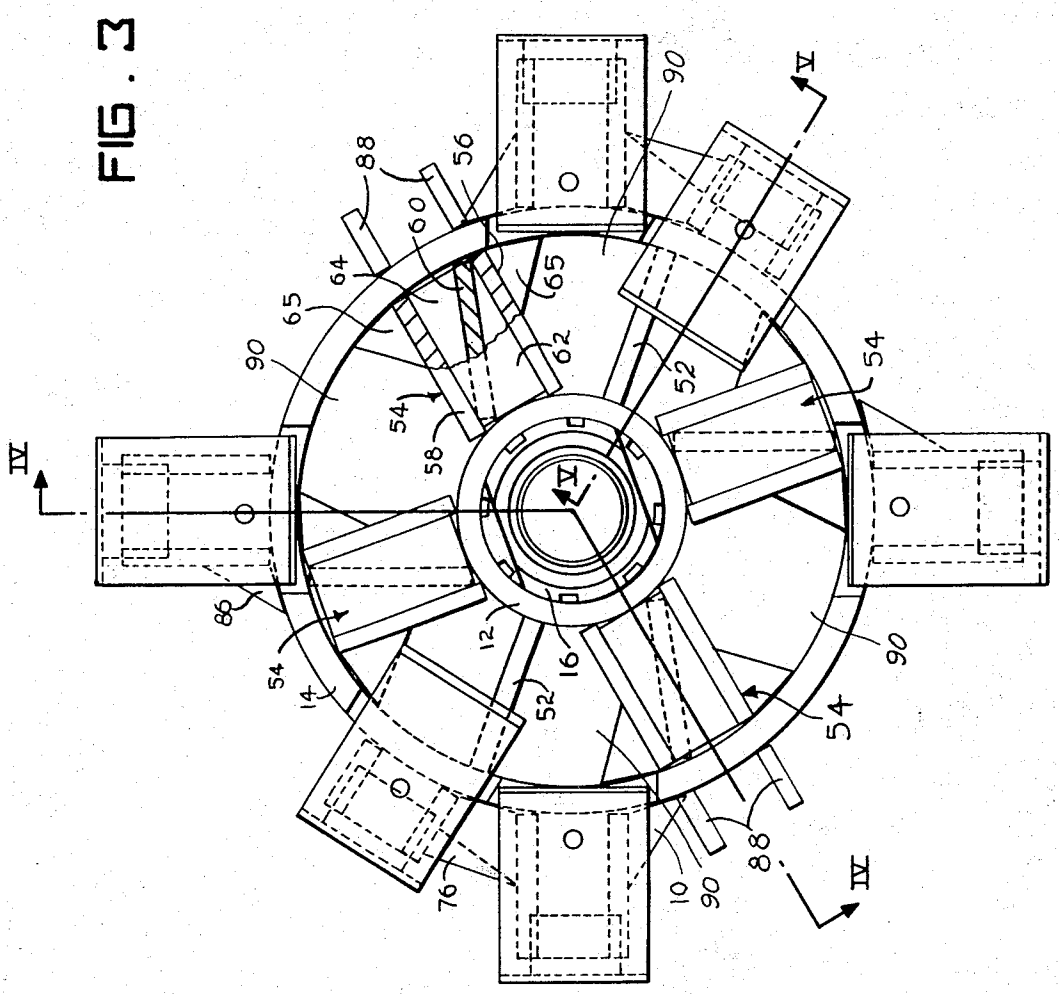


FIG. 4

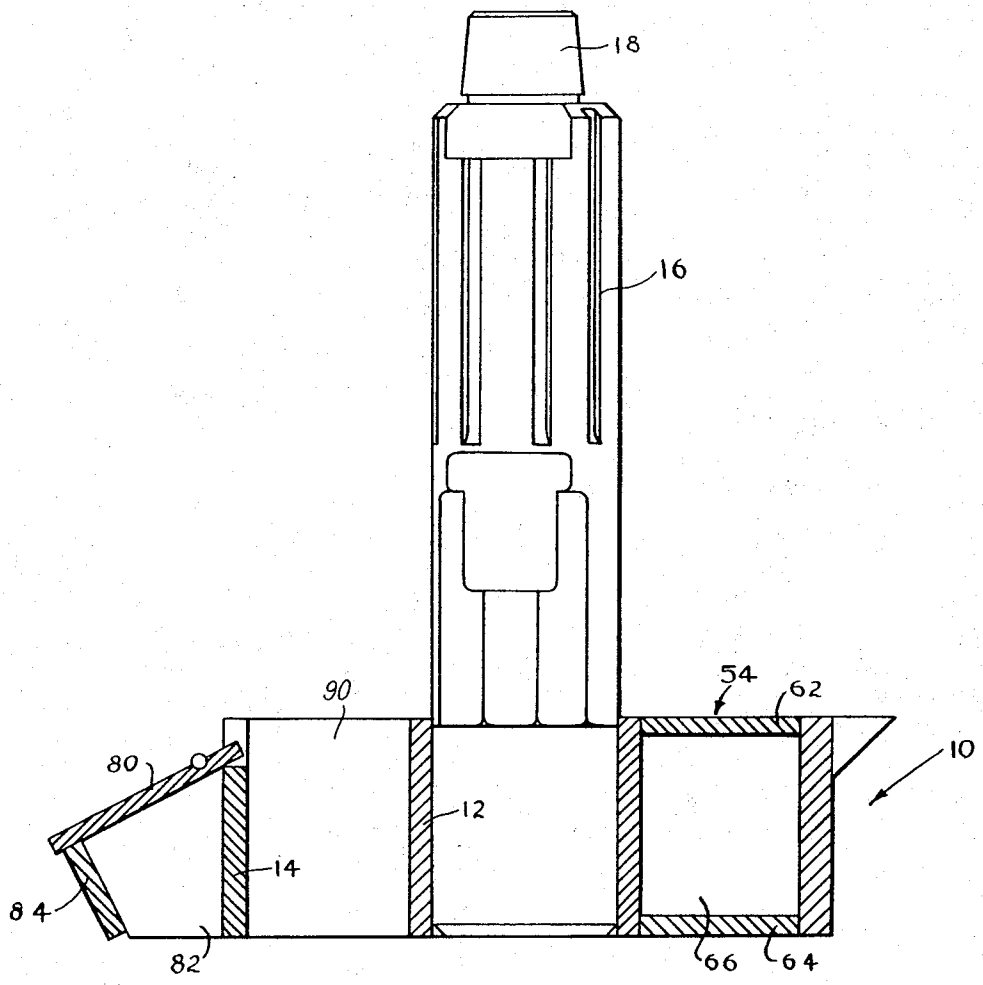


FIG. 5

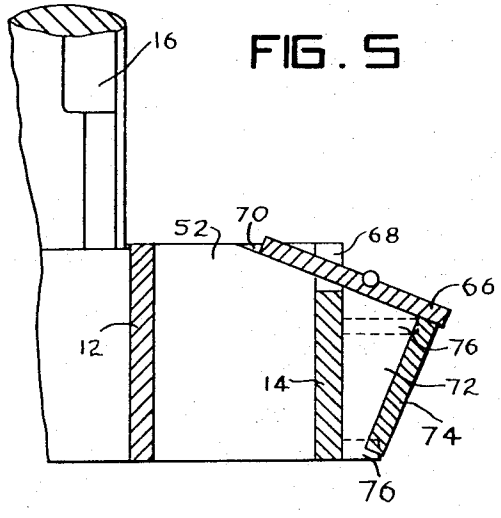


FIG. 6

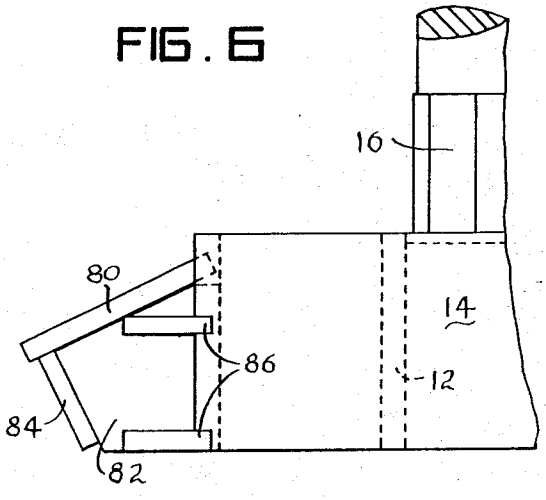


FIG. 7

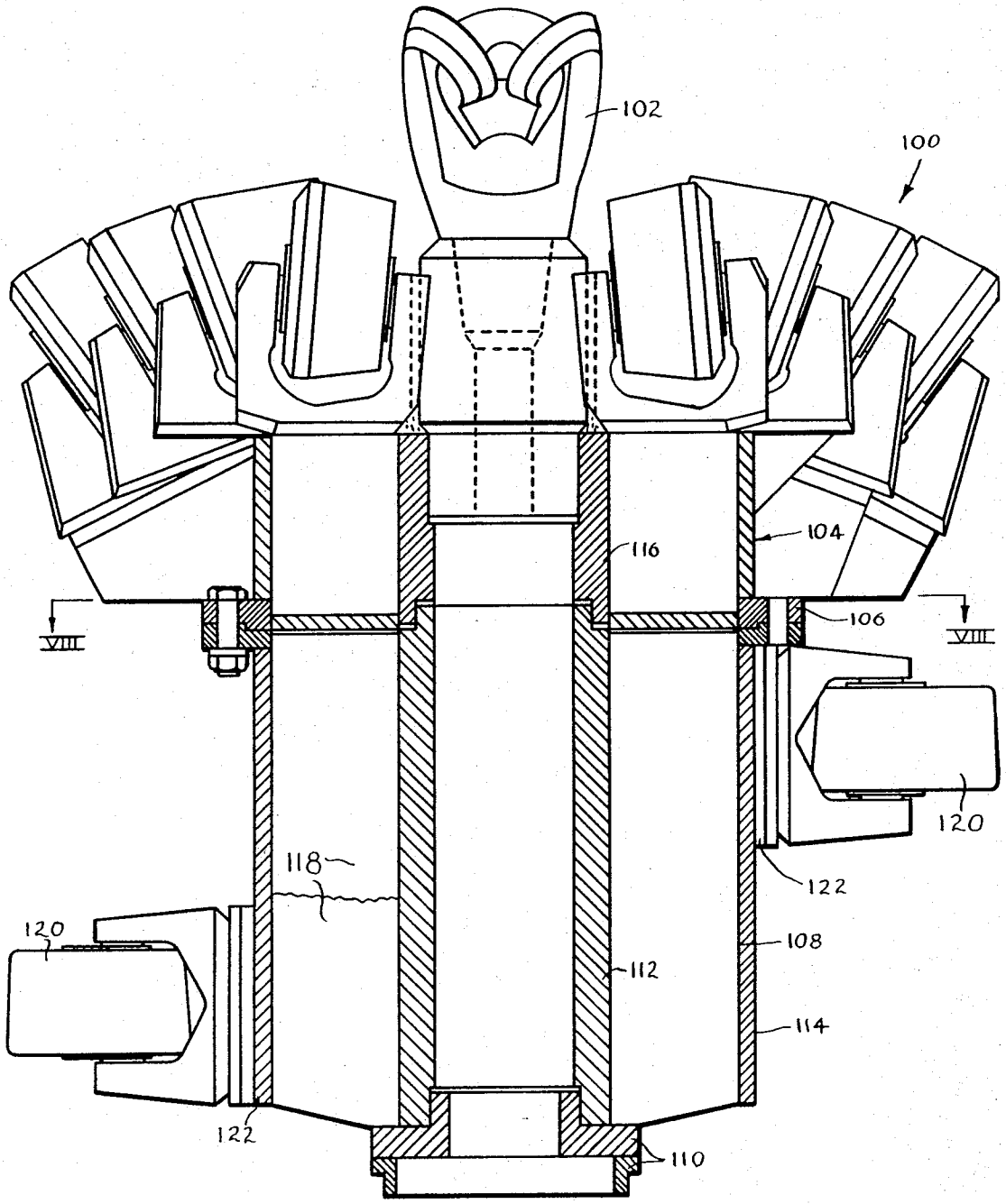
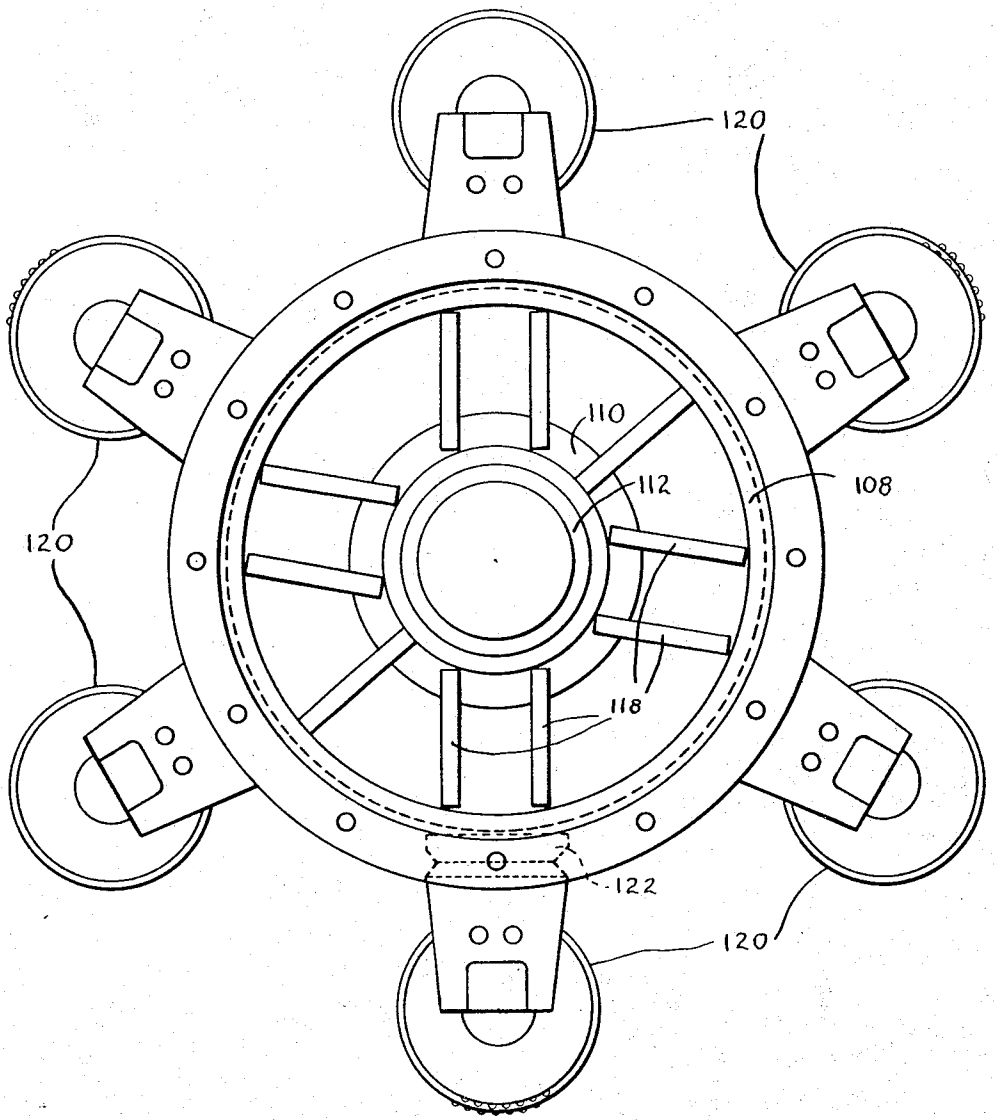

102
100
104
116
106
VIII
VIII
120
118
122
120
108
112
114
122
110

FIG. 8



BIG HOLE CUTTER

The present invention relates to big hole cutters such as are employed in connection with raise drilling machines and box hole drilling machines and is particularly concerned with the construction of the frame which supports the individual rolling cutters of the big hole cutter.

Big hole cutters of the type with which the present invention is concerned are well known and comprise frame structures which are circular when viewed in plan and which have distributed over one side thereof rolling cutters having their axes extending substantially radially of the frame. The rolling cutters are distributed radially and circumferentially on the frame and when the frame is moved in the axial direction while being rotated, the rolling cutters engage the formation and reduce the formation principally by crushing and cutting the formation.

Inasmuch as the big hole cutter is advancing into the formation, there is a tendency for the material, or muck, taken from the formation by the rotary cutters to become entrapped between the face of the formation and the frame of the cutter. This causes complications and prevents the rolling cutters from working efficiently because they do not have clean contact with the formation being reduced.

With the foregoing in mind, a particular object of the present invention is the provision of a big hole cutter of the nature referred to so constructed and arranged that no problems occur on account of debris, or muck, being entrapped between the frame of the big hole cutter and the face of the formation being reduced.

Another object of the present invention is the provision of a frame or base plate assembly for a big hole cutter including openings extending axially therethrough for the passage of debris taken from a formation by rolling cutters mounted on the base plate.

A still further object is the provision of a frame or base plate for a big hole cutter according to the preceding object in which the strength of the frame or base plate is extremely high and is in no way diminished by the passages extending axially therethrough for the debris.

BRIEF SUMMARY OF THE INVENTION

According to the present invention, a construction is provided for a big hole cutter for cutting holes on the order of from 5 feet in diameter upwardly in which the big hole cutter is made up of a base plate structure or frame structure on which is mounted in circumferentially and radially distributed relation a plurality of rolling cutters. The big hole cutter is moved in the axial direction to bring the rolling cutters into pressure engagement with the face of a formation to be reduced and by rotating the big hole cutter while maintaining the pressure the formation is reduced.

It is usually the case that big hole cutters rotate on a generally vertical axis and move in the upward direction. Because of this, debris, or muck, taken from the formation tends to accumulate on the upper side of the frame structure and to interfere with the engagement of the rolling cutters witn the formation.

The present invention arranges the base structure from concentric rings interconnected by spoke-like structures and support plates so that between the inner and outer rings there are provided axial spaces through which the debris taken by the rolling cutters can fall.

The rolling cutters are mounted on the spoke-like structures and on other support arrangements provided on the outer ring of the frame structure. The spoke-like structures are made in the form of hollow beams which are reinforced so that the large torques that are encountered for rotating the big hole cutters can be transmitted through the frame structure from a drill string connected to the frame structure on the axis to the rolling cutters which are mounted on the frame structure in distributed relation.

The nature of the present invention and the various objectives and advantages thereof will become more clearly apparent upon reference to the following detailed specification taken in connection with the accompanying drawings in which:

FIG. **1** is a plan view looking down on top of a big hole cutter according to the present invention and especially adapted for use with a raise boring machine.

FIG. **2** is a sectional view of the big hole cutter of FIG. **1** and is indicated by section line II—II on FIG. **1**.

FIG. **3** is a plan view of the frame structure of the big hole cutter of FIGS. **1** and **2** showing the arrangement thereon of the support areas for the rolling cutters to be mounted on the frame structure.

FIG. **4** is an irregular sectional view indicated by line IV—IV on FIG. **3** and showing more in detail two of the regions for receiving rolling cutters and also showing one of the passages extending axially completely through the frame structure.

FIG. **5** is a fragmentary sectional view indicated by line V—V on FIG. **3** and showing another of the rolling cutter supports of the frame structure.

FIG. **6** is a fragmentary side elevational view of the frame structure showing a typical support for a rolling cutter and the manner in which it is braced on the frame structure.

FIG. **7** is a view similar to FIG. **2** and is a vertical section through a big hole cutter according to the present invention especially constructed and arranged for use with a box hole drilling machine.

FIG. **8** is a plan sectional view indicated by line VIII—VIII on FIG. **7** and illustrating somewhat more in detail the placement on the frame structure of the stabilizing rollers forming a part thereof.

DETAILED DESCRIPTION OF THE INVENTION

Referring to the drawings more in detail and, in particular, to FIGS. **1**, **2** and **3**, the big hole cutter according to the present invention is made up of a base frame or base structure generally indicated at **10** and formed of a tubular inner part **12** and a tubular outer part **14** concentric with the inner part.

Inner part **12** may consist, for example, of steel tubing with a wall thickness of about one and ½ inch and with about 12½ inches outside diameter. Outer tubular member **14** may be a steel tube having a wall thickness of about 1¾ inches and about 33 inches outside diameter. The sizes given are those for about a 5 foot cutter. In length, the tubular members could be on the order of about 12 inches.

Mounted in the inner tubular member **12** is a member **16** which extends upwardly from the base frame on the axis thereof and which has a threaded upper end **18** for connection to the lower end of drill string by means

of which the big hole cutter is rotated while being pulled upwardly in the axial direction.

Mounted in distributed relation on the upper side of the base frame are rolling cutters. The rolling cutters are substantially identical except for length and the angle of inclination to the axis of the big hole cutter. Each rolling cutter has a saddle portion fixed to the base structure of the big hole cutter and a body part rotatably supported in the saddle.

The rolling cutters consist of a first pair of rolling cutters **20** and **22** nearest the axis of rotation of the big hole cutter and having their axes of rotation substantially perpendicular to the axis of the big hole cutter. Each rolling cutter has a respective saddle portion **24, 26** and rotatably mounted on a shaft fixed to the saddle structure is a respective rotatable body part **28, 30.** Each body part tapers inwardly toward the axis of rotation of the big hole cutter and is preferably studded with hard wear resistant inserts such as rods of cemented tungsten carbide having rounded outer ends.

Outwardly from rolling cutters **20** and **22** is a further pair of rolling cutters **32, 34** which are supported with the axes of rotation at such an angle that the outer surfaces of the respective rotatable bodies thereof incline downwardly in a direction away from the axis of rotation of the big hole cutter at an angle of about 10°.

Still further outwardly from cutters **32** and **34** is a further pair of cutters **36, 38** having their axes of rotation so inclined that the peripheries of the rotatable body parts thereof incline outwardly from the axis of rotation of the big hole cutter at angles of about **21** degrees. The aforementioned cutters are arranged in diametrally opposed pairs as will be seen from FIG. **1.**

Still further outwardly on the base structure of the big hole cutter is a group of rolling cutters identified at **40, 42, 44** and **46,** each of which has the axis of rotation inclined outwardly so that the peripheral surface of the rolling body of each cutter, on the side facing the formation, inclines outwardly from the axis of rotation of the big hole cutter at an angle of about 27°.

The rotating bodies of the respective rolling cutters substantially overlap as will be seen in FIG. **2** so that, when the big hole cutter is viewed from the side, a substantially continuous cutting surface is provided which is somewhat concave upwardly and the outermost limit of which cutting surface is disposed radially outwardly from the radial outer limits of the base structure.

By way of example, the diameter on which rolling cutters **20** and **22** are disposed may be displaced about 80° from the diameter on which rolling cutters **32** and **34** are disposed and about **38** degrees from the diameter on which rolling cutters **36** and **38** are disposed. The diameter on which rolling cutters **40** and **42** are disposed may be displaced about 20° from the diameter of rolling cutters **20** and **22** and 90° from the diameter on which rolling cutters **44** and **46** are disposed.

The manner in which the base structure is made will be clearly seen from FIGS. **3** through **6.** In FIGS. **3** to **6,** it will be noted that the inner portion **12** is connected to the outer tubular portion **14** by spoke-like elements and which spoke-like elements may consist of a pair of diametrally opposed axially extending plates **50** and **52** welded in place between the tubular portions and a plurality of beam-like structures **54** distributed in the space between the tubular members and provided for supporting rolling cutters **20, 22, 32** and **34.**

Each of the beam-like structures **54** comprises a pair of parallel plates **56** and **58** extending axially between members **12** and **14** and welded thereto and a further plate **60** extending diagonally between members **12** and **14** in the space between plates **56** and **58** and also welded in position.

A top plate **62** and a bottom plate **64** is provided for each beam-like structure and is welded in place in the top and bottom thereof. The beam-like structures impart great rigidity to the connection established thereby between inner tubular member **12** and outer tubular member **14** and, likewise, provides solid supports for the saddles of the rolling cutter assemblies which are mounted thereon.

For further increasing the strength of the structure, triangular gusset plates **65** are welded in place between the beam-like structures **54** and the inside of tubular member **14** near the upper and lower ends of the beam-like structures.

For supporting the saddles pertaining to rolling cutters **36** and **38** which are disposed outwardly of the outer periphery of outer tubular member **14,** support arrangements such as is illustrated in FIG. **5** are employed. FIG. **5** shows that there is an inclined support plate **66** extending through a notch **68** formed in the upper edge of outer tubular member **14** and with the adjacent radial plate **52** also notched as at **70** to accommodate support plate **66.**

Depending from opposite sides of support plate **66** and extending along the periphery of outer tubular member **14** and welded in place are bracing plates **72** and a further plate **74** extends along the outer edges of plates **72** perpendicularly to support plate **66** and also welded in place. Further to reinforce the support arrangement, gusset plates indicated at **76** can be provided, one near the top of the support arrangement, and one near the bottom and extending inwardly to the outer tubular member **14** and welded in place.

The support arrangement for supporting the outermost rolling cutters **40** to **46** is illustrated in section in FIG. **4** and in side elevation in FIG. **6.** This support structure also comprises an upper support plate **80** on which the saddle of the respective rolling cutter rests, spaced side plates **82** interposed between support plate **80** and the outer periphery of outer tubular member **14** and an outer plate **84** at the outer edges of plates **82** and perpendicular to support plate **80** and welded in place. Bracing gussets as indicated at **86** in FIG. **6** are also provided between the sides of the support members and the outer periphery of tubular member **14.**

In respect of the support regions for the second group of rolling cutters, represented by cutters **32** and **34,** the saddles thereof extend outwardly beyond the outer periphery of outer tubular member **14** at least a short distance and support is provided for the overhanging portions of the saddle members by gusset-like support plates **88** welded to the outer periphery of support member **14** and forming substantial continuations of the plates **56** and **58** on the inside of the tubular member **14** in the same circumferential region.

It will be appreciated that the base on frame structure described above provides extremely rigid and strong support for the rolling cutters mounted thereon and is so constructed and arranged by virtue of the box-like beams extending radially between the inner and outer tubular portions to transmit extremely high torques

from the drill stem connected to the big hole cutter through the base structure to the rolling cutters.

In respect of the conveying of torque, the base frame generally turns in the clockwise direction when viewed from above during working operations and the inclined plates **60** on the inside of the box beam structures become particularly effective during working operations for insuring transmission of torque from the inner tubular member **12** to the rolling cutters and also to the outer tubular member **14.**

It has been mentioned that the base structure provides openings for debris to fall therethrough, and it will be seen, particularly in FIGS. **3** and **4,** that, when viewed in plan, the base structure has a plurality of large openings extending axially therethrough, one such opening being identified by reference numeral **90** while in the circumferential region between adjacent ones of those rolling cutters which are disposed at least partly outwardly from the outer periphery of the outer tubular member **14,** there is substantial clearance that will permit debris readily to fall therethrough.

The big hole cutter of the present invention is, thus, free of accumulation of debris on the top that would interfere with the proper action of the rolling cutters upon the formation being reduced. The big hole cutter, thus, operates more efficiently and at lower torque than would be the case if the construction of the big hole cutter were such that debris could accumulate on top thereof. At the same time, the axial passages for the debris to fall through have been obtained at no sacrifice in strength of the base structure of the big hole cutter.

It will be evident that, while the big hole cutter shown has a nominal size of, say, 5 feet, the same principles of construction could be utilized in extending the diameter of the big hole cutter to substantially any desired size while the base structure thereof would always have axial passages to permit the passage of debris therethrough.

FIGS. **7** and **8** show a modification of the arrangement of the present invention especially adapted for a box hole machine in which the big hole cutter is mounted on the upper end of a drill string and is pushed upwardly into a formation to be reduced. In FIGS. **7** and **8,** the tool shown comprises an upper portion generally indicated at **100** which is substantially the same as the structure previously described with the exception that, instead of the drill string adaptor at the upper end, there is provided a known pilot cutter arrangement **102.**

Bolted to the bottom of base structure **104** of the upper part **100** of the tool of FIGS. **7** and **8,** by virtue of a ring **106** fixed to the base structure, is a stabilizer frame **108.** At the extreme bottom of the stabilizer frame, there is ring means **110** for connection of the frame to the drill string which will support and drive the big hole cutter.

The stabilizer frame also comprises an inner tubular member **112** and an outer tubular member **114.** Inasmuch as inner tubular member **112** is that member which is principally loaded in torsion and compression, it is formed to a greater thickness than outer member **114.**

Furthermore, at the upper end member **112** is formed with a tenon which telescopes with the lower end of inner member **116** of the base structure **104** of the upper part **100.** Inner member **112** and outer member **114** are interconnected by circumferentially spaced axially extending plates **118** which are welded in place to form spoke-like elements and which support outer member **114** in concentric relation to member **112.**

Outer member **114** is adapted for receiving stabilizer rollers **120** which are similar to rolling cutters except that the bodies thereof are preferably substantially cylindrical while also being studded with cemented hard carbide inserts. The purpose of the stabilizers is to support the big hole cutter against lateral deflection. This is important because the drill string is advanced by a drill string extending downwardly therefrom and which drill string is in compression and can, therefore, deflect laterally.

With the first described big hole cutter, the drill string was connected to the upper end thereof and was in tension and tended to deflect laterally a smaller amount while, furthermore, the drill string was substantially confined within a relatively small pilot hole through which the drill string extends downwardly to the big hole cutter.

With the modification of FIGS. **7** and **8,** the drill string does not have the benefit of lateral support and for that reason the provision of stabilizer rollers **120** is of advantage.

As will be seen in FIGS. **7** and **8,** the stabilizer rollers are preferably connected to outer member **114** on suitable pad areas such as the plates **122** welded to the outside of outer member **114** and to which the saddles of the stabilizer rollers are connected. The stabilizer rollers are, in the modification illustrated, arranged in groups of three and at two levels, with the rollers in each group being uniformly circumferentially spaced and with one group being circumferentially offset from the other group as illustrated in FIG. **8.**

The stabilizer roller arrangement of FIGS. **7** and **8** can be employed with the big hole raise cutter of FIGS. **1** to **6,** but as explained, is not as critical a component of the big hole cutter as in connection with the box hole cutter of FIGS. **7** and **8.**

In the case of either of the big hole cutter arrangements illustrated, any debris taken thereby as a cutting operation proceeds can readily fall through or around the base structure thereby maintaining the working area free of debris and thereby permitting the best possible cutting conditions to exist for efficient high speed operation of the big hole cutter under the smallest power requirement conditions.

Modifications may be made within the scope of the appended claims.

What is claimed is:

1. In a big hole cutter, especially for raise drilling and box hole drilling operations; a base structure adapted for rotation on a central axis, supports for rolling cutter devices mounted on the side of said base structure which faces the formation to be reduced and extending generally radially outwardly from said axis, and means on the axis of said base structure for connection of drill string means thereto for rotating said base structure while thrusting said base structure axially toward the side on which said rolling cutter supports are mounted, said base structure comprising inner and outer tubular members coaxial with the axis of rotation of said base structure, and substantially radial spoke elements disposed between and connected to said tubular members and circumferentially spaced to define axial channels through said base structure for the passage of debris taken by said rolling cutters, said spoke elements hav-

ing the uppermost surfaces coplanar with the upper ends of the tubular members, at least some of said spoke elements being in the form of box beams made up of top and bottom and side plates and forming supports for rolling cutters.

2. A big hole cutter according to claim 1 which includes a reinforcing plate in each box beam extending from the axial corner on one side of the beam at one end to the axial corner on the other side of the beam at the other end.

3. A big hole cutter according to claim 1 in which said box beams comprise one pair of beams on a first diameter of the base structure and a second pair of beams on a second diameter of the base structure which makes an angle different from a right angle with the first diameter, said spoke elements including radially extending axial plates between the most widely spaced ones of said box beams and connected at the radial ends to said tubular members.

4. A big hole cutter according to claim 1 which includes a stem for connection to drill pipe fixed in said inner tubular member and extending axially from said base structure on the side toward said rolling cutter supports.

5. A big hole cutter according to claim 1 which includes a plurality of rolling cutters in radially and circumferentially distributed relation mounted on said supports therefor.

6. A big hole cutter according to claim 1 in which said box beams comprise a plurality of beams distributed circumferentially in the space between said tubular members, each box beam adapted for supporting a respective said rolling cutter.

7. A big hole cutter according to claim 6 in which one diametral pair of said box beams is adapted for supporting a first pir of rolling cutters adjacent the axis of the base structure and another diametral pair of the beams is adapted for supporting a second pair of rolling cutters spaced radially outwardly from said first pair of rolling cutters, and means fixed to the outer periphery of said outer tubular member forming extensions of the upper surfaces of said other diametral pair of box beams.

8. A big hole cutter according to claim 1 in which said supports for rolling cutters include upwardly facing support plates, notches in the upper end of said outer tubular member through which said plates extend in a generally radial direction so as to protrude outwardly beyond the outer periphery of said outer member, and support bracket means beneath said plates connected thereto and to the outer periphery of said outer tubular member for supporting the said plates.

9. A big hole cutter according to claim 8 which includes lateral gusset plate means extending laterally between said support bracket means and the outer periphery of said outer member to support said bracket means laterally.

10. A big hole cutter according to claim 8 in which said support plates are arranged respective radial distances from the axis of said base structure.

11. A big hole cutter according to claim 1 in which said tubular structure comprises a central tube and an outer tube and substantially radial circumferentially spaced axial plate elements extending therebetween and fixed thereto.

12. A big hole cutter according to claim 11 which includes means at the bottom of said tubular structure for connection thereof to drill pipe.

13. A big hole cutter according to claim 12 which includes means to mount a pilot cutter on the axis of said base structure on the side opposite said tubular structure.

14. In a big hole cutter, especially for raise drilling and box hole drilling operations; a base structure adapted for rotation on a central axis, supports for rolling cutter devices mounted on the side of said base structure which faces the formation to be reduced and extending generally radially outwardly from said axis, and means on the axis of said base structure for connection of drill string means thereto for rotating said base structure while thrusting said base structure axially toward the side on which said rolling cutter supports are mounted, said base structure having axial channels there-through for the passage of debris taken by cutters on said supports, a tubular structure connected to the side of said base structure opposite said rolling cutter supports and coaxial with the base structure, and circumferentially and axially distributed support means on the outside of said tubular structure for receiving stabilizer rollers having the radially outermost regions in substantial axial alignment with the radially outermost regions of the rolling cutters mounted in the radially outer positions on said base structure.

15. A big hole cutter according to claim 1 in which said base structure is in the form of a weldment.

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