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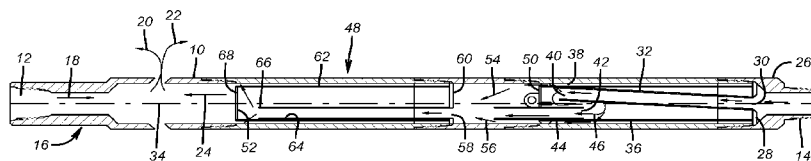


FIG. 1

(57) Abstract: A debris catcher uses induced circulation from a venturi to urge debris laden flow into the lower end of a housing. An inlet tube maintains velocity so as to keep the debris moving with the fluid stream as it goes up the inlet tube. A screen fits over the open end of the inlet tube and runs down around the inlet tube toward the entrance of the debris laden fluid into the lower end of the housing. There is a clearance around the cylindrical portion of the screen so some flow can exit that way. There is also an open exit through the top of the screen that can be reached after the fluid stream makes two hairpin turns. Many modules can be stacked. Each module has a large screen area for flow to exit and progressive modules can have smaller screen openings in an uphole flow direction.



DEBRIS CATCHER WITH RETENTION WITHIN SCREEN

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FIELD OF THE INVENTION

[0001] The field of this invention is debris catchers for subterranean use and more particularly those types that use eductors to induce flow into a lower end of the debris catcher.

BACKGROUND OF THE INVENTION

[0002] For a variety of reasons debris can accumulate in a wellbore and needs to be removed. This can happen when something is milled out or simply from scale and other foreign material that is normally found on the interior wall of casing.

[0003] There are various designs including some that are mounted to a tubular string and employ scrapers for dislodging the debris when the string moves in one direction and a flow diverter into a chamber where the debris is left behind and the fluid continues on a path that eventually bypasses the diverter so that the string is allowed to move up. One example of this design is USP 7,562,703. Other examples of debris catchers that rely on string movement are USP 7,040,395. Other designs use an eductor to induce circulation which sucks debris into an inlet tube that is centrally located in a housing. The velocity is allowed to slow to let the debris drop into a collection chamber and the flow continues up the housing through a screen and into the eductor inlet for recirculation. Some examples of this design are USP 6,276,452 and US Publication 2009/0200010.

[0004] A few other examples of debris catchers are in USP 7,497,260; 7,472,745; 6,227,291 and 6,607,031. There are issues with some of the past designs. The type of catchers that depend on flow diversion with cup seal sometimes use check valves that are in the debris path that can clog or the screens can plug and result in pulling a wet string or triggering a bypass to open so that no debris can be collected. In the circulating type of debris catchers the flow had to go through one or a series of inlet tubes that ultimately led to a single screen near the exit. The debris was supposed to have mostly dropped out before the screen was reached but if the debris was

particularly fine it could be carried with the circulation flow to the screen that could clog and all circulation through the tool would stop.

[0005] The present invention addresses this issue in a debris catcher that can be in modular form to increase capacity. Each module has an inlet tube that emerges in a preferably cylindrically shaped screen. The debris that enters with a fluid stream has to negotiate two hairpin turns inside a screened space before any debris can either exit or go to the next module. In the negotiation of such turns the debris can drop out. The fluid flow can get through a module by using the cylindrical portion of the screen or the top of the screen since there is a clearance volume around the cylindrical portion of the screen. The top of the screen has an open exit so that the flow with any still entrained debris can exit to the next module or out of the housing, depending on the application. Those skilled in the art will more readily appreciate the present invention from a review of the detailed description of the preferred embodiment and the associated drawing while appreciating that the full scope of the invention is determined by the appended claims.

SUMMARY OF THE INVENTION

[0006] A debris catcher uses induced circulation from a venturi to urge debris laden flow into the lower end of a housing. An inlet tube maintains velocity so as to keep the debris moving with the fluid stream as it goes up the inlet tube. A screen fits over the open end of the inlet tube and runs down around the inlet tube toward the entrance of the debris laden fluid into the lower end of the housing. There is a clearance around the cylindrical portion of the screen so some flow can exit that way. There is also an open exit through the top of the screen that can be reached after the fluid stream makes two hairpin turns. Many modules can be stacked. Each module has a large screen area for flow to exit and progressive modules can have smaller screen openings in an uphole flow direction.

BRIEF DESCRIPTION OF THE DRAWING

[0007] The FIG. 1 is a section view of a two module assembly for the debris catcher showing the large available screen areas in each module;

[0008] FIG. 2 is an alternative and the preferred embodiment to the FIG. 1 embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

[0009] Those skilled in the art will appreciate that parts of the FIG. 1 are schematic and that details of how such a debris catcher generates a circulation flow using an eductor are described in the patents mentioned above and most particularly USP 6,276,452. Briefly, flow comes into housing **10** through an inlet **12** which is connected to a tubular string (not shown) that is connected at the surface to pumping equipment (also not shown). Threads **14** at the lower end of the housing **10** are connected to a mill (not shown) that generates cuttings and passes them internally of the mill to connection **14** via one or more connecting tubulars that are also not shown. The jet bushing or eductor assembly **16** uses flow from the surface represented by arrow **18** as the motive fluid. The eductor exit stream diverges and goes back uphole as represented by arrow **20** or downhole as represented by arrow **22**. The flow going downhole is smaller than the flow going back to the surface. The flow going downhole represented by arrow **20** reaches the mill and takes away the cuttings through the inside of the mill and into the housing **10**. The eductor assembly **16** reduces pressure in the housing **10** and induces the flow represented by arrow **24**. That induced flow is what creates the recirculation that starts as arrow **22** and ends as arrow **24**. The other circulation path with the surface is represented by arrows **18** and **20**.

[0010] Looking now toward the lower end **26** of housing **10** there is an inlet plate **28** with an opening **30** that leads to inlet tube **32**. The tube **32** can be aligned with the axis **34** or skewed, as shown. A cylindrically shaped screen **36** has an annular clearance space **38** around it so that filtered flow that exits the top **40** of tube **32** can either go through the screen **36** or it can reverse direction and make a hairpin turn to get to the bottom **42** of exit tube **44** and then make a second hairpin turn represented by arrow **46** to get out unscreened through tube **44** with entrained debris that did not fall down onto plate **28** carried to the next stage **48**. Note that the top **50** of the screen **36** can preferably be a solid plate to aid in redirecting flow toward the bottom **42** of tube **44**. However in the uppermost module such as **48** in the FIG. 1 the top **52** can be screen material. Arrows **54** and **56** represent flow that has gone around

the solid top **50** and into the annular space **38** to reach the inlet **58** in plate **60** from which screen **62** extends.

[0011] Module **48** can be one of many depending on the volume of debris storage required from the particular ongoing milling operation. It has an inlet tube **64** that has an open top **66**. Screen **62** has a screen top **68** because screen **62** is the final and smallest size of debris removal and what gets through screen **62** can just become part of the inlet flow to the eductor represented by arrow **24**.

[0012] It should be note that the screen opening size when there a multiple modules gets smaller as the flow continues uphole through housing **10** back to the eductor assembly **16**. Preferably, tube **44** is aligned with the inlet **58** to the next stage so that if circulation is stopped debris in tube **64** can fall into tube **44** and be trapped further down in housing **10** without accumulating in the space between the modules.

[0013] Those skilled in the art will appreciate that in each stage there is a very large screen area that extends more than the length of the inlet tube so that the flow can keep moving with a reduced likelihood that the solids will foul the screen completely. Even if the screen such as **36** becomes clogged, the debris can still be captured within it as the flow continues to the open tube **44** to the next stage, if any, or back to the eductor assembly **16**. Since the flow will go to those portions of the screen such as **36** that are open to flow, the possibility of continuing to capture debris is there as long as the debris exits a particular inlet tube and the debris size is larger than the screen opening size. If the debris is smaller than the screen size in a particular stage then it simply passes through to get caught in later stages. The clearance around each screen in any stage such as **38** insures that the screen area for screen **36** is available and that any debris that does get through that screen will not get caught in the annular space because the width of the annular space is larger than the screen opening size that is used to form the annular space.

[0014] FIG. 2 shows a stack of three screen assemblies **100**, **102** and **104**. The remainder of the assembly beyond what is described in this paragraph is the same as the FIG. 1 embodiment. Screen **100** is the lowermost and takes induced flow into inlet **106** that has entrained debris and carries it up

flow tube **108**. Flow into tube **108** flips the pivoting cover **110** as the path of least resistance as compared to flow through the screen **112** that sits just below the pivoting cover **110**. An annular space **114** exists about all three screens **100**, **102** and **104** with stabilizers **116** in the annular space **114** to keep the screens **100**, **102** and **104** centered. Flow out of tube **108** slows down to drop solids in a surrounding annular space **118**. Flow with any remaining solids goes through the plate **120** through tube **122** which continues to become the next flow tube **124**. At the end of tube **124** the solids drop into annular space **126** and further flow with any remaining solids goes through exit tube **128** and into its continuation which is flow tube **130**. This pattern repeats depending on how many screen stages are present. In this design it is preferred that all the stages have the same opening size so that any solids that get through anywhere in any of the stages will be of a small enough size as to not present an operational concern for the eductor assembly **16** and that the velocity in the annular space can stay high enough to keep any solids moving up the space **114** moving out of such annular space rather than accumulating in it. In this embodiment, the flow tubes are aligned between stages and any number of stages can be used depending on the expected debris loading. When circulation is shut off the pivoting cover **110** closes to keep debris from falling back into inlet **106**. Screen **112** allows fluid to move through the assembly when pulled out of the hole to avoid pulling a wet string.

[0015] The above description is illustrative of the preferred embodiment and various alternatives and is not intended to embody the broadest scope of the invention, which is determined from the claims appended below, and properly given their full scope literally and equivalently.

We claim:

1. A debris catcher for subterranean use, comprising:
 - a housing having a first inlet to provide pressurized fluid to an eductor assembly mounted in a passage therein for inducing flow through said passage;
 - a second inlet to receive debris laden fluid induced to flow into said passage by said eductor assembly;
 - at least one screen in fluid communication with said second inlet and disposed in said passage, said screen defining at least one debris collection settling volume.
2. The debris catcher of claim **1**, further comprising:
 - an inlet tube extending from a bottom on said screen and into said screen, said bottom located adjacent said second inlet.
3. The debris catcher of claim **2**, wherein:
 - said inlet tube is aligned with a longitudinal axis of said passage.
4. The debris catcher of claim **2**, wherein:
 - said inlet tube is misaligned with a longitudinal axis of said passage.
5. The debris catcher of claim **2**, wherein:
 - said screen has a solid top and said inlet tube has a longitudinal axis intersecting said solid top causing flow exiting said inlet tube to make a turn.
6. The debris catcher of claim **5**, wherein:
 - said solid top has an outlet opening with an exit tube extending through it.
7. The debris catcher of claim **6**, wherein:
 - said exit tube forces flow through said inlet tube to reverse direction twice to get into said outlet tube.
8. The debris catcher of claim **7**, wherein:
 - said at least one screen comprises a plurality of screens stacked in said passage.
9. The debris catcher of claim **8**, wherein:
 - said exit tube in a first of said screens is aligned with said inlet tube of an adjacent second screen located between said first screen and said eductor assembly.

10. The debris catcher of claim **8**, wherein:
said screens have openings that vary in size as between screens.
11. The debris catcher of claim **10**, wherein:
the opening size of screens gets smaller the closer a screen is mounted to said eductor assembly.
12. The debris catcher of claim **8**, wherein:
said screen mounted closest to said eductor assembly has a top fully made of screen material.
13. The debris catcher of claim **2**, wherein:
said at least one screen comprises a plurality of screens stacked in said passage.
14. The debris catcher of claim **13**, wherein:
said screens have openings that vary in size as between screens.
15. The debris catcher of claim **14**, wherein:
the opening size of screens gets smaller the closer a screen is mounted to said eductor assembly.
16. The debris catcher of claim **15**, wherein:
said screen mounted closest to said eductor assembly has a top fully made of screen material.
17. The debris catcher of claim **15**, wherein:
a lowermost screen has an inlet tube extending from a bottom and into said screen, said bottom located adjacent said second inlet.
18. The debris catcher of claim **17**, wherein:
all said screens except the screen closest to said eductor assembly have a solid top and said inlet tube has a longitudinal axis intersecting said solid top causing flow exiting said inlet tube to make a turn.
19. The debris catcher of claim **18**, wherein:
said solid top has an outlet opening with an exit tube extending through it;
said exit tube forces flow through said inlet tube to reverse direction twice to get into said outlet tube.

20. The debris catcher of claim **19**, wherein:
said exit tube in a first of said screens is aligned with said inlet tube of an adjacent second screen located between said first screen and said eductor assembly.
21. The debris catcher of claim **13**, wherein:
said plurality of screens comprises a lowermost screen having a bottom located adjacent said second inlet and an inlet tube extending into said bottom screen and at least one additional screen with its inlet tube extending into said additional screen so that said inlet tubes are substantially aligned with each other for flow through said passage.
22. The debris catcher of claim **13**, wherein:
the opening size for all screens is substantially the same.
23. The debris catcher of claim **13**, wherein:
said screens define a surrounding annular space to allow use of screen area defining said annular space progressively as a screen clogs with debris.
24. The debris catcher of claim **23**, wherein:
said annular space outside one screen communicates in said passage with an annular space outside another screen.

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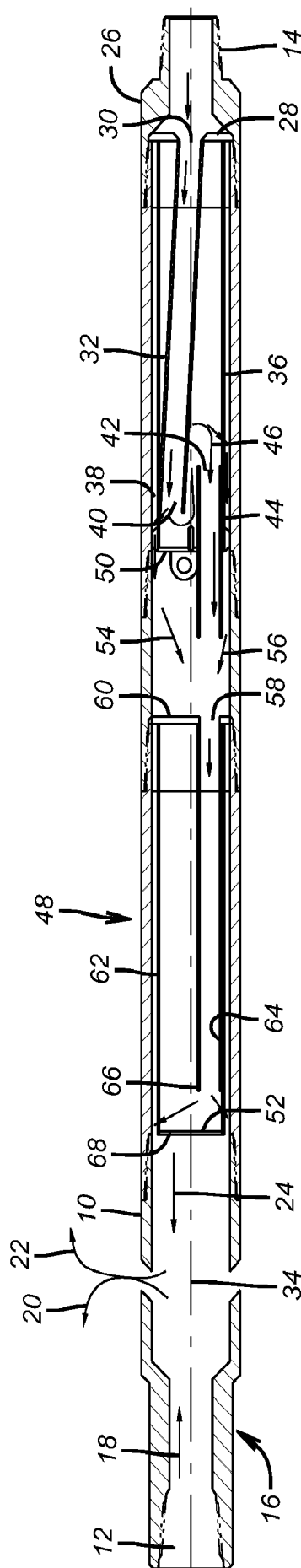


FIG. 1

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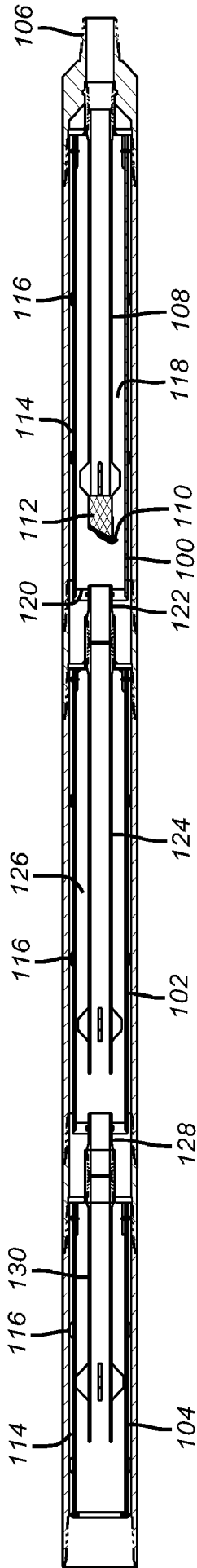


FIG. 2

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