This invention relates to a device adapted to be connected into a string of drill pipe or the like for use in a well bore to center, guide and stabilize the pipe in the bore and which may also be used when desired as a reamer, or milling tool.

In the drilling of wells, and especially in the drilling of and production of oil from oil wells, it is customary to make use of a tubular drill stem or string of drill pipe which is of relatively heavy walled structure and substantially smaller in external diameter than the diameter of the well bore. By this arrangement an annulus is provided about the exterior of the drill pipe between the pipe and the surrounding wall of the well bore, through which drilling fluids may circulate through the drill pipe to lubricate the bit and carry away the cuttings.

The drilling string is customarily provided with one or more drill collars connected to the lower end of the drill pipe for the purpose of adding weight to the lower end of the string, such drill collars being attached to the drill bit and having an external diameter somewhat smaller than that of the bit but larger than that of the drill pipe above.

It is often desirable, particularly when the drilling string is relatively long, to provide stabilizer means connected into the string at suitable, longitudinally spaced intervals, which are constructed for engagement with the surrounding wall of the bore to hold the string in a centralized position and guide the string in the well bore.

For convenience and efficiency the stabilizer means employed for this purpose should be constructed for easy replacement, should provide substantially full circular contour throughout the length of the stabilizer blades and should offer a minimum resistance to flow of fluid through the annulus. It is also desirable that such stabilizing equipment be capable of use when needed as a reamer or milling tool for the reaming or cutting away of obstructions or irregularities in the bore.

The invention has for an important object the provision of a combined reamer and drill string stabilizer adapted to be connected into a drilling string and having parts which are easily replaceable for purposes of maintenance and repair.

Another object of the invention is to provide a reamer and stabilizer of the kind referred to having a tubular body adapted to be connected into a drilling string and embodying external replaceable cutter blades which are arranged for engagement with the surrounding wall of the bore to guide and centralize the string in the bore and to offer little resistance to the flow of fluid through the annulus about the string.

A further object of the invention is the provision in a tool of the character mentioned of means for detachably securing the blades to the body to yieldingly hold the blades against radial, angular and axial movement relative to the body of the tool in response to forces exerted on the blades during manipulation of the tool in the bore.

Another object of the invention is to provide in a tool of the kind referred to elastic means for connecting the blades to the body to resist movement of the blades relative to the body of the tool under the action of forces exerted on the blades during rotation and manipulation of the tool in the bore.

A further object of the invention is the provision of a combined reamer and drill string stabilizer having a tubular body adapted to be connected into a drill string and formed with elongated, external, peripherally spaced slots positioned at an angle with the axis of the body about the body and whose ends are rounded, radially outwardly extending blades positioned in the slots and elastic means positioned for coaction with the body and blades in the slots to hold the blades in pressure engagement with the bottom walls of the slots.

Another object of the invention is the provision of a tool of the character referred to combining a drill collar section as the body of the tool, with the blades in stabilizing assembly therewith to reduce the number of connections in the string and to provide external protuberances on the string to aid in handling the string.

Another object of the invention is to provide a reamer and stabilizer for drilling strings including a tubular body having an elongated, external slot formed with an internal, longitudinal groove in one of the side walls, and a radially outwardly extending blade positioned in the slot and formed with an external, longitudinal groove in one of its side faces positioned in a radially offset, parallel relation to said internal groove, and elastic means in the slot extending into said grooves for coaction with the body and blade to hold the blade in pressure contact with the bottom of the slot.

Another object of the invention is to provide a tool of the character mentioned having a tubular body formed with an external, elongated slot whose ends are closed and an internal longitudinal groove in each side wall of the slot and which is open at its opposite ends to the exterior of the body, a radially outwardly extending blade positioned in and substantially filling the slot and having an external longitudinal groove in each of its side faces which opens toward the interior groove in the adjacent side wall of the slot, and means adapted to be inserted into said grooves through one end of each of said internal grooves and which is shaped for coaction with the body and blade in the grooves to hold the blade in the slot.

A further object of the invention is the provision of a combination of fastening elements in the form of fastened bodies of generally tubular shape formed of sheet metal rolled into a spiral, some having a central core of resilient material, and solid, square end cylinders limiting possible movement under elastic deflection of other elements.

Another object of the invention is to provide a combined reamer and drill string stabilizer which is of simple design and rugged construction, in which the parts are easily replaceable for the purpose of repair, or to adapt the tool for use in well bores of different diameters or for other purposes.

A further object of the invention is the provision of a tool of the type mentioned wherein the blade slots of the body are arranged to be connected into the string with either end up to suit the requirements of the string.

Another object of the invention is to provide a tool of the kind referred to in which the blades are held in the blade slots of the body by retaining means embodying an elastic material which forms a seal to prevent the depositing of sand between the parts.

A further object of the invention is the provision in a tool of the character mentioned of elastic assembly means which is easily inserted in position, tightened or removed.

The above and other important objects and advantages of the invention may best be understood from the following detailed description, constituting a specification of the same when considered in conjunction with the annexed drawings, wherein—

FIGURE 1 is a perspective view of a preferred em-
bodiment of the invention, the device being shown in an upright position such as that it will usually occupy when in use;

FIGURE 2 is a fragmentary, transverse cross-sectional view on a somewhat enlarged scale, showing a portion of the body of the tool with one of the cutter blades mounted and illustrating the manner in which the blades are fitted in place and secured to the body;

FIGURE 3 is a fragmentary cross-sectional view on a greatly enlarged scale, similar to that of FIGURE 2, showing details of construction of one form of fastening means by which the blades are replaceably attached to the body;

FIGURE 4 is a perspective view, on a somewhat enlarged scale, illustrating a preferred construction of the spiral-pin fastening element used in the invention;

FIGURE 5 is a fragmentary view, on an enlarged scale, looking into the open side of one of the retainers receiving grooves in the body of the tool, and showing a preferred arrangement of the fastening means of the invention positioned therein;

FIGURE 6 is a longitudinal, central cross-sectional view, on an enlarged scale of a somewhat different form of the fastening means of the invention, showing the same in a retracted condition preparatory to insertion in the tool;

FIGURE 7 is a view similar to that of FIGURE 6, showing the fastening means in the expanded condition which it assumes when in retaining position in the tool;

FIGURE 8 is a view similar to that of FIGURE 3, showing the relationship of the parts during the insertion of the fastening element of FIGURE 6 in the tool; and

FIGURE 9 is a view similar to that of FIGURE 8 showing the fastening element in its retaining position in the tool.

Referring now to the drawings in greater detail, the invention comprises an elongated, tubular body 10, which is provided at its end with threaded portion 12 for connection to the lower end of an upper section of a tubular drilling string, and having at its lower end a threaded portion 14 to which the upper threaded end of a lower section of the tubular drilling string is connected, in the usual manner. The body 10 is preferably of relatively thick walled construction and is provided with longitudinally extending, peripherally spaced, external slots 16, which are preferably spirally or helically arranged, and positioned in angular relationship to the longitudinal axis of the body, and whose bottom walls are in planes disposed parallel to such axis. The slots 16 are preferably arranged so that each end of each slot is located at a point substantially in longitudinal alignment on the body with the opposite end of each of the adjacent slots. The slots are preferably rounded at their ends, as seen at 17 in FIGURE 1, and formed with substantially parallel side walls and a bottom wall 18 located in a plane substantially at right angles to the planes of the side walls.

The body 10 is also provided with substantially chordal passageways 20 opening at their opposite ends to the exterior of the body, and which extend parallel to the side and bottom walls of each slot to form internal semi-circular grooves 22 opening into the slots in radially outwardly spaced relation to the bottom wall 18 throughout the lengths of the slots. Each of the passageways 20 may be formed at one end with an enlarged counterbore 21 extending for a portion of its length, for a purpose hereafter to be explained.

A radially outwardly extending blade or cutter element 24 is positioned in each slot, which blade conforms generally to the shape of and is dimensioned to closely fit the slot. In the present illustration, the slots 16 and the blades 24 are of rectangular shape in cross-section, each blade having an inner face 26 which seats against the bottom wall 18 and side faces 28 facing the side walls of the slots and which are formed with external longitudinal grooves 30, opening toward the internal grooves 22, and which are spaced radially outwardly from the inner face 26, a distance somewhat greater than the space of the groove 22 from the bottom wall 18, so that the grooves 22 and 30 are in a definite radially offset relationship. The external grooves 30 preferably have the same radius as the internal grooves 22.

The blades 24 extend radially beyond the external surface of the body the same distance and are provided with shaped ends such as those shown at 32 externally of the slots, and with matching end faces which are seated against the ends of the slots.

The blades are removably retained in the slots by suitable fastening means extending into the grooves 22 and 30, which fastening means preferably takes the form of a spiral pin 34, shown in detail in FIGURE 3. The spiral pin 34 may be of conventional type formed of sheet material, such as sheet steel rolled into a spiral to form an elongated tubular pin, which may be provided with a core 36 of rubber or other suitable resilient material filling the interior of the pin. The pin may be provided with bevelled ends 35 to facilitate the insertion of the pin in the passageways 20. The pins are of somewhat larger radius than that of the grooves 22 and 30, so that the pin may be inserted into the bores 20 to form a tight fit in the grooves. Solid, flat ended pins, such as those shown at 39 may be positioned between the roll pins 34 to prevent unintentional end faces for transmitting end forces to the roll pins during insertion position in the tool.

In assembling the tool, the blades are positioned in the slots and a series of roll pins, or roll pins with solid pins between them, are inserted in the passageways 20 and are driven into the grooves to compress the pins in the grooves. Due to the radially offset relationship of the grooves 22 and 30, the pins will be distorted to exert a force on the blades tending to urge the blades inwardly of the slots so that the blades will be tightly held in contact with the bottoms of the slots. Moreover, by this arrangement, any tendency of the blades to tilt in the slots during rotation of the body will be resisted by the pins, whereby shock due to forces exerted on the blades during the operation of the tool will be absorbed by the pin to effectively prevent loosening or dislodgement of the blades.

Each of the passageways may be provided at one end with a somewhat enlarged counterbore 21, extending for a portion of the length of the passageway through which the pins 34 and 39 may be inserted into the passageway and an additional roll-pin 37 of smaller diameter may then be inserted into the counterbore to close the same, and to prevent backing out of the roll pins 34 and pins 39. The blade may also be peened at the other end of the passageway 20 to prevent dislodgement of the roll-pin 34 in a direction away from the counterbore 21.

The blades 24 may be arranged in left hand spiral arrangement, as viewed from the upper end of the tool, so that there will be no tendency for the tool to feed downwardly in the well bore upon right hand or clock-wise rotation of the drilling string. In making use of the tool of the invention, the body 10 is connected to the drilling string in the usual manner and lowered theretofore into the well bore, the outer faces of the blades 24 being then in position for engagement with the surrounding wall of the well bore to guide and centralize the drilling string in the bore. Should any obstructions or irregularities be encountered in the bore, it will be apparent that the blade 24 may act as a reamer to enlarge any restriction in the bore and also may act in an endwise direction in the manner of a milling tool to cut away obstructions. Due to the peripheral spacing of the blades, it will also be seen that the free circulation of well fluid may take place about the tool between the blades so that there will be no obstruction to the circu-
lation of fluid in the annulus surrounding the drilling string. In the event that it should be necessary to remove the blades for purposes of replacement or repair, the roll-pins may be removed by driving the same out of the passageways 20 to release the blades, whereupon new blades may be inserted and the pins replaced.

A somewhat different form of the fastening means of the invention is illustrated in FIGURES 6 to 9, inclusive, of the drawings, wherein the fastening means 34' takes the form of a helical coil of suitable material, such as steel wire, which may be of any desired size and diameters, commensurate with the holding strength which is required. The coil 34' is constructed to be extended or otherwise manipulated, as shown in FIGURE 6, to reduce the external diameter of the coil sufficiently to permit the coil to be readily inserted into the passageway formed by the facing grooves 22 and 30 of the parts when the parts are assembled, as shown in FIGURE 7. Upon insertion of the coil in the passageway the coil will be compressed and expanded, as shown in FIGURE 7, to tightly fit in the passageway, as seen in FIGURE 9, to securely hold the parts together. The extending and insertion of the coil 34' into the passageway may be accomplished in any convenient way, as by pulling the coil into the passageway by means of a wire extended through the passageway and hooked onto an end turn of the coil, or by the use of a rod inserted endwise into the coil into engagement with an end turn of the coil to push the coil into the passageway in an obvious manner. It will also be apparent that the coil 34' when in position between the parts will exert an expansive force tending to urge the blade 24 inwardly of the slot in the body, due to the eccentric arrangement of the grooves 22 and 30 forming the passageway.

The fastening device 34 may also be used with the solid pins or spacers 39 and 41 to permit the coils 34' to be easily driven into a removed from the passageway. The coils 34' also possess the advantage that they may be released and removed by applying a force tending to reduce the external diameters of the turns to release the coils from the internal walls of the passageways to permit the withdrawal of the coils therefrom.

In place of the body 10, drill collars may be adapted for use as the body of the tool by providing such collars with external slots, such as the slots 16, whereby the drill collars may be employed in the usual way without blades, or may be used with blades such as the blades 24 to function as stabilizers or reamers. In this manner the utility of the drill collars may be greatly extended and the number of different types and sizes of tools which must be kept on hand may be substantially reduced.

It will thus be seen that the invention constructed and arranged as described above provides a combined reamer and stabilizer guide of simple design and rugged construction, which may also be used, when necessary, as a milling tool for cutting away obstructions, and in which the parts are easily replaceable.

The invention is disclosed herein in connection with a certain specific embodiment of the same, but it will be understood that this is intended by way of illustration only and that various changes can be made in the construction and arrangement of the parts within the spirit of the invention and that the scope of the appended claims.

Having thus clearly shown and described the invention, what is claimed as new and desired to secure by Letters Patent is:

1. A well tool comprising a tubular body adapted to be connected into a drilling string and formed with an external, longitudinally extending slot closed at its ends positioned in angular relation to the axis of the body, and having an internal longitudinal groove in one side wall whose ends are open to the exterior of the body, a radially outwardly extending blade in the slot having an external groove extending longitudinal throughout the length of the blade and disposed in parallel, radially outwardly offset relation to said internal groove, said body having a counterbore disposed in longitudinal alignment with and whose inner end is in communication with said grooves, said grooves and said counterbore being positioned to form a continuous passageway whose ends are open to the exterior of the body, and means in the passageway positioned for coaction with the body and blade in said grooves to hold the blade against radial outward movement.

2. A well tool comprising a tubular body adapted to be connected into a drilling string and formed with an external, longitudinally extending slot closed at its ends, positioned in angular relation to the axis of the body and having an internal longitudinal groove in one side wall whose ends are open to the exterior of the body, a radially outwardly extending blade in the slot in contact with the bottom of the slot and having an external groove extending longitudinally throughout the length of the blade and disposed in parallel radially outwardly offset relation to said internal groove said body having a counterbore disposed in longitudinal alignment with and whose inner end is in communication with said grooves, said grooves and said counterbore being positioned to form a continuous passageway whose ends are open to the exterior of the body, and means in the passageway positioned for coaction with the body and blade in the grooves to urge the blade toward the bottom of the slot.

3. A well tool comprising a tubular body adapted to be connected with a drilling string and formed with external, longitudinally extending, peripherally spaced slots positioned in angular relation to the axis of the body and whose ends are closed, each of said slots having an internal, longitudinal groove in one side wall disposed in parallel, radially outwardly spaced relation to the bottom of the slot and whose ends are open to the exterior of the body, a radially outwardly extending blade in each slot in contact with the bottom of the slot and having an external groove extending throughout the length of the blade, disposed in parallel, radially outwardly offset relation to said internal groove, said body having a counterbore disposed in longitudinal alignment with and whose inner end is in communication with said grooves, said grooves and said counterbore being positioned to form a passageway whose ends are open to the exterior of the body and in means in the passageway positioned for coaction with the body and blade in the grooves to urge the blade toward the bottom of the slot.

4. A well tool comprising a tubular body adapted to be connected into a drilling string and formed with external, longitudinally extending, peripherally spaced slots positioned in angular relation to the axis of the body and whose ends are closed, each of said slots having an internal, longitudinal groove in one side wall disposed in parallel, radially outwardly spaced relation to the bottom of the slot and whose ends are open to the exterior of the body, a radially outwardly extending blade in each slot in contact with the bottom of the slot and having an external groove extending throughout the length of the blade, disposed in parallel, radially outwardly offset relation to said internal groove said body having counterbores disposed in longitudinal alignment with and whose inner ends are in communication with said grooves, said grooves and counterbores being positioned to form continuous passageways whose ends are open to the exterior of the body, and yieldable means in each passageway positioned for coaction with the body and blade in said internal groove and with the blade on the side of said external groove opposite said one side of said internal groove to hold the blade against radial movement in the slot away from the bottom of the slot.

5. A well tool comprising a tubular body adapted to be connected into a drilling string and formed with an
external, longitudinally extending slot positioned in angular relation to the axis of the body and whose ends are open to the exterior of the body, and having an internal, longitudinal groove in each of its side walls disposed in parallel, radially outwardly spaced relation to the bottom of the slot and whose opposite ends are open to the exterior of the body, having an external groove in each side extending throughout the length of the blade and disposed in parallel, radially outwardly offset relation to the adjacent one of said internal grooves, said body having counterbores disposed in longitudinal alignment with and whose inner ends are in communication with said grooves, said grooves and counterbores being positioned to form passageways whose ends are open to the exterior of the body and means in the passageway positioned in adjacent ones of the grooves and shaped for coaction with the body and blade in the grooves to hold the blade in the slot.

6. A well tool comprising a tubular body adapted to be connected into a drilling string and formed with external, longitudinally extending, peripherally spaced slots positioned in angular relation to the axis of the body and whose ends are closed, each of said slots having an internal longitudinal groove in one side wall disposed in parallel, radially outwardly spaced relation to the bottom of the slot and whose opposite ends are open to the exterior of the body, a radially outwardly extending blade in each slot having an external groove extending throughout the length of the blade, disposed in parallel, radially offset relation to said internal groove and whose ends are open to the exterior of the body, each of said blades having at each end a portion disposed in overlapping relation to the opposite end portion of an adjacent blade peripherally of the body, said body having counterbores disposed in longitudinal alignment with and whose inner ends are in communication with said grooves, said grooves and counterbores being positioned to form passageways whose ends are open to the exterior of the body, and means in the passageway positioned for coaction with the body and blades in the grooves to hold the blades in the slots.

7. A well tool comprising a tubular body adapted to be connected into a drilling string and formed with an external, longitudinally extending slot closed at its ends positioned in angular relationship to the axis of said body, and having an internal longitudinal groove in one side wall whose opposite ends are open to the exterior of the body, a radially outwardly extending blade in the slot having an external groove extending throughout the length of the blade, disposed in parallel, radially outwardly spaced relation to the opening toward said internal groove, said body having a counterbore disposed in longitudinal alignment with and whose inner end is in communication with said grooves, said grooves and counterbore being positioned to form a passageway whose ends are open to the exterior of the body, and means adapted to be inserted into the grooves through said counterbore and shaped for coaction with the body and blade in the grooves to hold the blade in the slot.

8. A well tool comprising a tubular body adapted to be connected into a drilling string and formed with an external, longitudinally extending slot closed at its ends positioned in angular relation to the axis of the body, and having an internal groove in one of its side walls disposed in parallel, radially outwardly spaced relation to the bottom of the slot and whose ends open outwardly to the exterior of the body, a radially outwardly extending blade in the slot having an external groove extending throughout the length of the blade, disposed in parallel, radially outwardly offset relation to and opening toward said internal groove, said body having a counterbore disposed in longitudinal alignment with and whose inner end is in communication with said grooves, said grooves and counterbore being positioned to form a passageway whose ends are open to the exterior of the body, and expansible means adapted to be inserted into the grooves through said counterbore and shaped for coaction with the body and blade in the grooves when inserted therein to cause the element to coact with the body and blade to urge the blade radially inwardly of the slot.

9. A well tool comprising a tubular body adapted to be connected into a drilling string and formed with an external, longitudinally extending slot closed at its ends, positioned in angular relation to the axis of the body, and having an internal groove in one of its side walls disposed in parallel, radially outwardly spaced relation to the bottom of the slot and whose ends open outwardly to the exterior of the body, a radially outwardly extending blade in the slot having an external groove disposed in parallel, radially outwardly offset relation to and opening toward said internal groove said body having a counterbore disposed in longitudinal alignment with and whose inner end is in communication with said grooves, said grooves and counterbore being positioned to form a passageway whose ends are open to the exterior of the body, and means in the passageway positioned in adjacent ones of the grooves and shaped for coaction with the body and blade in the grooves to hold the blade in the slot.

10. A well tool comprising a tubular body adapted to be connected into a drilling string and formed with external longitudinally extending, peripherally spaced slots disposed in angular relation to the axis of the body and whose ends are closed, each of said slots having an internal, longitudinal groove in one side wall disposed in parallel, radially outwardly spaced relation to the bottom of the slot and whose ends are in communication with the exterior of the body, a radially outwardly extending blade in each slot in contact with the bottom of the slot and having an external, longitudinal groove in planes parallel to the axis of the element throughout substantially the entire length of the element to yieldingly hold the blade in contact with the bottom of the slot.

11. In a well tool, the combination with a tubular body adapted to be connected into a drilling string and formed with an external, longitudinally extending slot closed at its ends positioned in angular relation to the axis of the body, and having an internal longitudinal groove in one side wall whose opposite ends are open to the exterior of the body and a radially outwardly extending blade in the slot having an external groove extending throughout the length of the blade disposed in parallel relation to and opening toward said internal groove, said body having a counterbore disposed in longitudinal alignment with and whose inner end is in communication with said grooves, said grooves, said counterbore and grooves being positioned to form a passageway opening at one end to the exterior of the body, of means for holding the blade in the groove comprising an elongated, expansible tubular element formed of sheet metal rolled into a cylindrical shape and formed with bevelled end portions of a size to be inserted into the passageway in an expanded condition of said element to cause the element to be contracted upon insertion of the element in the passageway into engagement with the body and blade in the grooves and a solid mem-
9 ber shaped to be inserted in the passageway into the grooves into endwise engagement with said element.

12. In a well tool, the combination with a tubular body adapted to be connected into a drilling string and formed with an external, longitudinally extending slot closed at its ends positioned in angular relation to the axis of the body, and having an internal longitudinal groove in one side wall whose opposite ends are open to the exterior of the body and a radially outwardly extending blade in the slot having an external groove extending throughout the length of the blade disposed in parallel relation to and opening toward said internal groove, said body having a counterbore disposed in longitudinal alignment with and whose inner end is in communication with said grooves, said counterbore and grooves being positioned to form a passageway opening at one end to the exterior of the body, of means for holding the blade in the groove comprising a generally cylindrically shaped expandable element of a size to be inserted in the passageway into engagement with the body and blade in the grooves to yieldingly hold the blade against outward movement in the slot and a solid member shaped to be inserted in the passageway into the grooves into endwise engagement with said element.

13. In a well tool, the combination with a tubular body adapted to be connected into a drilling string and formed with an external, longitudinally extending slot closed at its ends positioned in angular relation to the axis of the body, and having an internal longitudinal groove in one side wall whose opposite ends are open to the exterior of the body and a radially outwardly extending blade in the slot having an external groove extending throughout the length of the blade disposed in parallel relation to and opening toward said internal groove, said body having a counterbore disposed in longitudinal alignment with and whose inner end is in communication with said grooves, said counterbore and grooves being positioned to form a passageway opening at one end to the exterior of the body, of means for holding the blade in the groove comprising a generally cylindrically shaped, hollow, expandable element of a size to be inserted in the passageway into engagement with the body and block in the grooves to yieldingly hold the blade against outward movement in the slot, a core of resilient material in said element in position to yieldingly resist radial contraction of the element and a solid member shaped to be inserted in the passageway into the grooves into endwise engagement with said element.

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