This invention relates to well drilling tools and relates more particularly to well reamers for use in the rotary method of well drilling. A general object of this invention is to provide a practical and particularly efficient well reamer having self-cleaning cutters.

The rotary well reamers now in general use generally have three roller cutters mounted at circumferentially spaced points to have 3-point contact with the wall of the well. The typical 3-point reamer has a decided tendency to bind or stick in the well bore, probably because it maintains the well bit truly centralized and prevents any play or wobbling of the bit. Another undesirable feature of rotary well reamers having roller cutters is the tendency for the cutters to become “bailed up” or to accumulate mud that interferes with the cutting or reaming action of the cutters.

Another object of this invention is to provide a rotary well reamer in which the cutters are related and arranged to have 4-point contact with the wall of the well bore, that is, the cutters are spaced about the axis of the reamer shank to engage the well wall at four circumferentially spaced points.

Another object of this invention is to provide a rotary well reamer in which the roller cutters are arranged in substantially diametrically opposite cutters of each pair being in close relation, whereby the reamer may remain free in the well and does not drag or retard the drilling speed.

Another object of this invention is to provide a well reamer of the character mentioned in which the shank is formed and the cutters are related to leave substantial spaces about the reamer when the same is in the well, thereby facilitating fishing operations in the event that the reamer or the drilling string becomes lost or caught in the well.

Another important object of this invention is to provide a well reamer embodying rotatable cutters that are self-cleaning in operation and that do not become “bailed up” with accumulations of mud, etc.

Another object of this invention is to provide a rotary well reamer in which the teeth or cutting parts of the adjacent cutters clear themselves of mud, etc. by meshing with the other without direct or actual contact.

Another object of this invention is to provide a self-cleaning reamer of the character mentioned in which the cutters may be identical or alike, thereby reducing the cost of manufacture and maintenance.

Another object of this invention is to provide a well reamer of the character mentioned embodying simple, effective means for mounting the pairs of identical cutters so that the cutting parts of adjacent cutters mesh to clear the cutters of mud and the like.

A further object of this invention is to provide a well reamer of the character mentioned that is simple and inexpensive to manufacture and that embodies cutters whose teeth may be cut in a lathe.

The various objects and features of my invention will be fully understood from the following detailed description of a typical preferred form and application of the invention, throughout which description reference is made to the accompanying drawings, in which:

Fig. 1 is a side elevation of the reamer provided by this invention. Fig. 2 is an enlarged fragmentary side elevation of the reamer provided by this invention illustrating one pair of cutters and the adjacent parts. Fig. 3 is a horizontal detailed sectional view taken as indicated by line 3—3 on Fig. 1. Fig. 4 is an enlarged fragmentary vertical detailed sectional view taken as indicated by line 4—4 on Fig. 3 illustrating the mounting of one of the cutters. Fig. 5 is a horizontal detailed sectional view taken as indicated by line 5—5 on Fig. 2 and Fig. 6 is an enlarged fragmentary vertical detailed sectional view taken substantially as indicated by line 6—6 on Fig. 3.

The improved well reamer provided by this invention includes, generally, a body or shank, four roller cutters, and means for facilitating its connection in the string. In the particular case illustrated in the drawings a tapered threaded pin is provided on the upper end of the shank and a tapered threaded socket is provided in the lower end of the shank to facilitate the connection of the shank in the drilling string. The opposite end portions of the shank may be cylindrical and may have wickers to facilitate the fishing of the reamer from the well in the event that it becomes caught.
or lost. In accordance with the invention the intermediate portion of the Shank 10 which carries the cutters 11 is flat sided or substantially rectangular in transverse cross section. In the preferred construction illustrated this intermediate portion of the Shank 10 has two flat parallel side surfaces 17 substantially tangential to the peripheries of the end portions 15 and two side surfaces 18 curved concentric with the longitudinal axis of the Shank 10 and having a greater radius of curvature than the end portions 16. The opposite ends 15 of the flattened intermediate portion of the Shank 10 are preferably inclined or tapered. Recesses or pockets 20 are provided in the intermediate portion of the Shank 10 for receiving the cutters 11. The recesses or pockets 20 have their mouths or other ends at side surfaces 18 and extend axially or vertically of the Shank 10. There are two diametrically opposite pockets 20 and the sides of the pockets are open at the surfaces 17. The upper and lower walls 21 of the pockets 20 are preferably flat and at right angles to the axis of the Shank 10 and the inner wall of each pocket 20 may have two vertically extending concave surfaces or walls, as best illustrated in Fig. 5 of the drawings. The Shank 10 is provided with the usual longitudinally extending passage 21 for conducting the circulating fluid.

The cutters 11 are in the nature of roller reaming cutters and in accordance with the invention the four cutters 11 may be identical. The cutters 11 are generally cylindrical and have flat upper and lower ends. The lower portions of the cutters 11 may be frusto-conical or tapered. A central longitudinal opening 22 extends through each cutter 11 from one end to the other. Peripheral cutting parts are provided on the cutters 11. The cutting parts may be in the nature of teeth 23 formed by making a plurality of spaced V-shaped circumferential grooves 24 in the peripheries of the cutters and interrupting or intersecting the circumferential grooves 24 with axially extending grooves 25. The grooves 25 may be partially or totally blanked in transverse cross section. When the teeth 23 are formed in this manner they occur in circumferential series separated by the V-shaped grooves 24 and the several teeth of each series 23 are separated by the vertical grooves 25.

The means 22 for mounting or supporting the cutters 11 on the Shank 10 support two cutters 11 in each pocket 20, the cutters in each pocket being in adjacent parallel relation. The mounting means for the cutters 11 may be varied considerably without departing from the broader principles of the invention, that is, mounting means of various natures may be employed to support the cutters in the relationship contemplated by the invention. The cutter mounting or supporting means 22 removably or detachably support the cutters 11 on the Shank 10 and include supporting pins 26 passed through the cutter openings 11. The protruding portions of the pins 26 are supported by parts removably secured to the Shank 10. The projecting portions of the cutter pins 26 are carried by blocks 27 inserted in sockets or bores 28 in the Shank 10. The cutters 11 are rotatable on their pins 26 and the blocks 27 are supported by the blocks 27 so that the cutters 11 project beyond the surfaces 10 to have reaming contact with the wall of the well bore. The blocks 27 are cylindrical in transverse cross section and each has a flat side surface 29. The opposite ends of the blocks 27 may be flat. The sockets or bores 28 are shaped to accurately or closely receive the blocks 27. The bores 28 are cylindrical and extend transversely into the intermediate portion of the Shank 10 from its sides 18. In the particular construction illustrated in the drawings there are two bores 28 adjacent each end 21 of each pocket 20, the bores 28 adjacent the ends of the sockets being in parallel relation.

In the preferred form of the invention the cutter supporting means 22 are such that the cutters 11 of the adjacent block 27 are in slightly staggered or vertically offset relation so that the teeth 23 of the adjacent identical cutters are in meshing relation. The adjacent bores 28 at the ends of the pockets 20 are slightly vertically offset, that is, the longitudinal axes of the adjacent bores 28 are slightly offset vertically. The bores 28 at the ends of a pocket 20 are correspondingly offset so that the distance between the centers of the vertically aligned bores 28 at the opposite ends of the pockets is equal. The blocks 27 are introduced into their pockets 20 from their outer ends and the inner ends of the blocks may bear against the inner walls of the bores and the outer ends of the blocks may be flush with the sides 18 of the Shank 10. Each block 27 is provided with a transverse or diametric opening 30. The openings 30 receive the projecting portions of the cutter supporting pins 26. The blocks 27 are ranged in the sockets 28 to have their flat side surfaces 29 face inwardly toward the pockets 20. The bores 28 are spaced from the ends 21 of the pockets 20 and flat walled notches 31 connect the ends of the pockets 20 to the bores 28. The side surfaces 29 of the blocks 27 form side or bottom walls of the notches 31. Flat sided thrust washers 32 are provided on the pins 26 and are received in the notches 31. The thrust washers 32 are held against turning through cooperation with the walls of the notches 31 and bear against the surfaces 29 of the blocks 27. The thrust washers 32 are engaged by the ends of the cutters 11. The washers 32 at the corresponding ends of the cutters 11 are of the same thickness. For this reason the washers 32 cooperating with the surfaces 29 of the vertically offset blocks 27 support the cutters 11 against endwise movement in the relationship where one cutter of each pair is slightly higher than the adjacent cutter 11.

The extent of vertical offsetting of the adjacent cutters 11 is substantially equal to one half of the thickness or vertical extent of the teeth 23. The sets or pairs of bores 28 are related so that the pins 26 supported by the blocks 27 in the bores carry the cutters so that the adjacent cutters 11 are in the relation where their teeth 23 mate or mesh. Due to the vertical offsetting of the cutters 11 described above, the cutters 11 of the pairs may be supported in such close relation that their teeth 23 mesh throughout the major portions of their depths. It is to be understood, however, that the cutting teeth 23 of the blocks 27 for preventing rotation cutters 11 need not come into direct or actual contact. Fig. 2 of the drawings best illustrates the meshing relation of two adjacent cutters 11 and the vertical offsetting of the cutters that permits the desired meshing of the cutting teeth 23.

The means 22 include means 60 for clamping or preventing rotation of the cutter supporting pins 26 and for locking the blocks 27 in place. A notch 34 is provided in one end of each pin 26 and keys 35 are welded or otherwise fixed in the openings 30 of the blocks 27 receiving the end portions of the pins 26 to cooperate with the notches 34. The
keys 35 cooperating with the notches 34 dependably prevent rotation of the pins 26. Openings 36 extend axially in the bore 16 from its opposite ends 19 and intersect or join the bores 28 at substantially diametrically opposite points. The blocks 27 have notches 37 for registering with the openings 36. Tapered pins 38 are arranged in the openings 36, cooperating with the notches 37 positively preventing displacement of the blocks 27. The blocks 27 fitting the cylindrical bores 28 have no tendency to move vertically or inwardly and their outward movement is positively prevented by the pins 38. Screws 39 are threaded in the outer portions of the openings 36 to hold the pins 38 in place. It is to be understood that the pairs of adjacent blocks 27 of the cutter supporting means 12, described above, may be made integral in which case an adjacent bore 28 may be in communication or there may be a single bore for receiving the joined or integral double blocks.

In assembling a cutter 11 on the shank 10 the pin 26 is first passed through the cutter and the washers 32 are placed on the projecting end portions of the pin. The assembly is then moved laterally or radially toward the shank 10 and the blocks 27 are introduced in the bores 28. With the introduction of the blocks 27 in the bores 28 the washers 32 are engaged in the notches 31. When the blocks 27 have been properly positioned in the bores 28 the pins 38 are arranged in place to secure the blocks 27 against displacement. It will be understood how the cutters 11 may be easily removed from the shank 10 when it is desired to repair or condition the reamer. When the pins 38 are withdrawn from the openings 36 the blocks 27 may be easily withdrawn from the bores 28 to disconnect the cutters 11 from the shank 10.

In the operation of the reamer provided by this invention the cutters 11 projecting from the mouths of the pockets 26 engage or act on the wall of the well bore. The cutter is usually rotated in a right-hand direction as indicated by the arrow A in Fig. 5 in which case the adjacent cutters 11 rotate on their individual axes in the direction indicated by the arrows B. From an inspection of Fig. 5 of the drawings it will be apparent that the meshing or mating teeth of the adjacent cutters 11 pass between one another while moving in opposite directions. The teeth 23 thus moving one past the other effectively clear the cutters 11 of mud, etc. The longitudinal grooves 25 assure the better clearing of the mud from the cutters 11. The engagement of the cutters 11 with the earth formation during the rotation of the reamer assures the independent rotation of the cutters 11 and as the teeth 23 of the adjacent cutters mesh the cutters are at all times maintained free and clear of accumulations of mud, etc.

The cutters 11 are provided on the shank 10 in diametrically opposite pairs to have contact with the side walls of the well bore at four spaced points. This four point engagement of the cutters with the earth formation is such that the reamer remains free in the well and does not bind or materially resist rotation of the drilling string. Further, the cutters 11 being arranged in diametrically opposite pairs and the shank 10 being provided with the flat side surfaces 17 provides or leaves substantial spaces at opposite sides of the shank giving the reamer greater movement and freedom in the well. Further these spaces about the shank 10 may greatly facilitate the fishing or removal of the reamer from the well in the event that it becomes lost or stuck. Although the cutters 11 are formed and mounted to mesh for the purpose described above, they may be identical to materially reduce the cost of manufacture of the reamer. The cutters 11 and the wear resisting elements of the cutter supporting means 12 are easily replaceable so that the reamer may be reconditioned when worn.

Having described a typical preferred form and application of my invention, I do not wish to be limited or restricted to the specific details herein set forth, but wish to reserve to myself any variations or modifications that may appear to those skilled in the art or fall within the scope of the following claims.

Having described my invention, I claim:

1. A well reamer comprising a shank, and two substantially diametrically opposite pairs of roller reaming cutters on the shank, the cutters of each pair being in adjacent relation and the said pairs being spaced substantial distances apart circumferentially of the shank.

2. A well reamer comprising a shank, and two pairs of adjacent roller reamer cutters rotatably supported on diametrically opposite sides of the shank to rotate about substantially vertical axes, said pairs of adjacent cutters being spaced substantial distances apart circumferentially of the shank.

3. A well reamer comprising a shank, and two substantially diametrically opposite pairs of roller reaming cutters on the shank, the cutters including cutting teeth, the teeth of the cutters of each pair being in meshing relation.

4. A well reamer comprising a shank to be connected in a well drilling string, a pair of roller reaming cutters having longitudinally spaced cutting teeth, and means supporting the cutters for rotation about substantially parallel axes with their teeth in intermeshing relation, the teeth of one cutter passing above the teeth of the other cutter.

5. A rotary well reamer comprising a shank having a portion of generally rectangular transverse cross section, and pairs of cutters supported on the shank to project from two opposite sides of said portion.

6. A well reamer comprising a shank to be connected in a well drilling string, roller cutters having cutting teeth, and means rotatably supporting the cutters in longitudinally offset relation with the teeth in intermeshing relation.

7. A well reamer comprising a shank to be connected in a well drilling string, two roller cutters each having peripheral longitudinally spaced cutting teeth, and means rotatably supporting the cutters on the shank for rotation about axes extending longitudinally of the shank and in adjacent longitudinally offset relation so that the teeth of one cutter are in intermeshing relation to the teeth of the other cutter.

8. A well reamer comprising a shank to be connected in a rotary well drilling string and having two diametrically opposite pockets, two roller cutters in each pocket, and supports supporting the cutters in the pockets for rotation about spaced axes whereby the cutters provide four point engagement with the wall of the well bore.

9. A well reamer comprising a shank to be connected in a rotary well drilling string and having two diametrically opposite pockets, two roller cutters in each pocket, and two spaced pins passing through each pocket each rotatably sup-
porting a cutter whereby the cutters have four-point engagement with the wall of the well bore.

10. A well reamer comprising a shank to be connected in a rotary well drilling string and having two diametrically opposite pockets, the sides of the shank between the pockets being flattened, two roller cutters in each pocket, and supports supporting the cutters in the pockets for rotation about spaced axes whereby the cutters provide four-point engagement with the wall of the well bore.

11. A well reamer comprising a shank to be connected in a rotary well drilling string and having an external pocket, pairs of substantially vertically aligned supports at the upper and lower ends of the pocket, the distance between the aligned supports being equal, the said pairs of supports being in vertically offset relation, pins extending between and carried by the supports, and a cutter rotatable on each pin and having cutting parts, the cutters being identical and in adjacent vertically offset relation with their cutting parts in meshing relation.

12. A well reamer comprising a shank to be connected in a rotary well drilling string and having an external pocket, pairs of substantially vertically aligned supports at the upper and lower ends of the pocket, the distance between the aligned supports being equal, the said pairs of supports being in vertically offset relation, pins extending between and carried by the supports, and a cutter rotatable on each pin and having cutting parts, the cutters being vertically offset and with their cutting parts in meshing relation.

13. A well reamer comprising a shank to be connected in a rotary well drilling string and having two diametrically opposite pockets, two spaced supporting pins passing vertically through each pocket, means supporting the end portions of the pins, and cutters rotatable on the pins in adjacent relation and having cutting parts, the cutting parts of the adjacent cutters being in meshing relation.

14. A well reamer comprising a shank to be connected in a rotary well drilling string and having two diametrically opposite pockets, two spaced supporting pins passing vertically through each pocket, means supporting the end portions of the pins, said means including members removably secured to the body and carrying the opposite end portions of the pins, and cutters rotatable on the pins in adjacent relation and having cutting parts, the cutting parts of the adjacent cutters being in meshing relation.

WALTER A. ABEGG.