

April 7, 1959

D. E. STRAITIFF
WELL DIGGING MACHINE

2,880,964

Filed Aug. 17, 1953

4 Sheets-Sheet 1

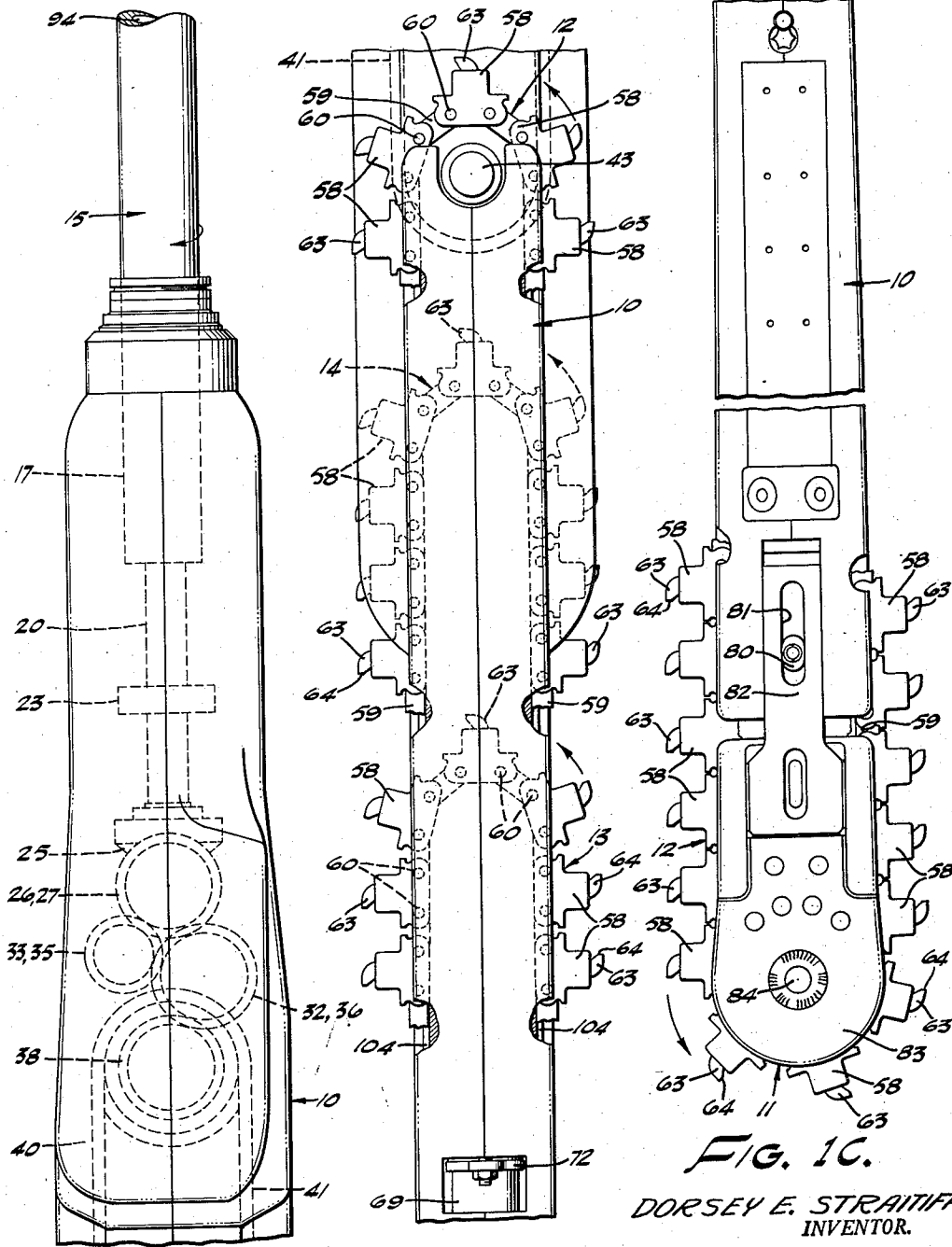


FIG. 1a.

FIG. 1b.

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4 Sheets-Sheet 2

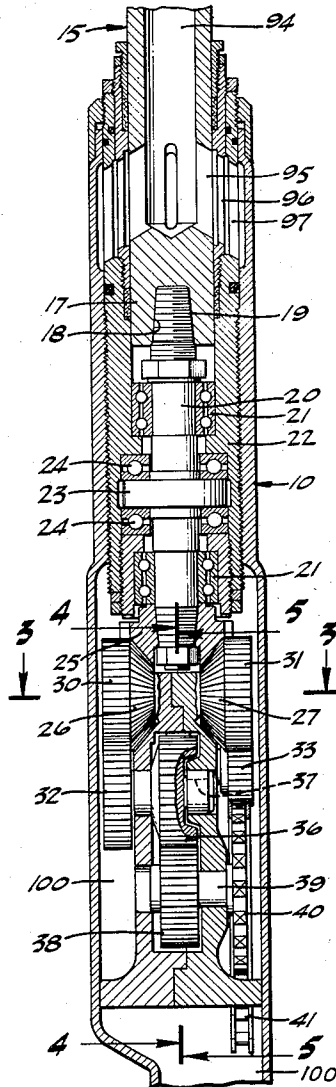


FIG. 2a.

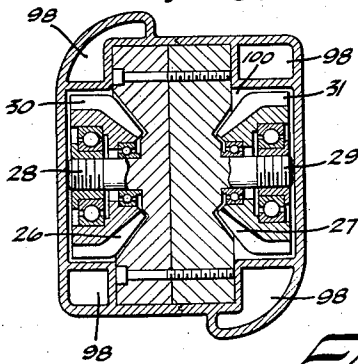


FIG. 3.

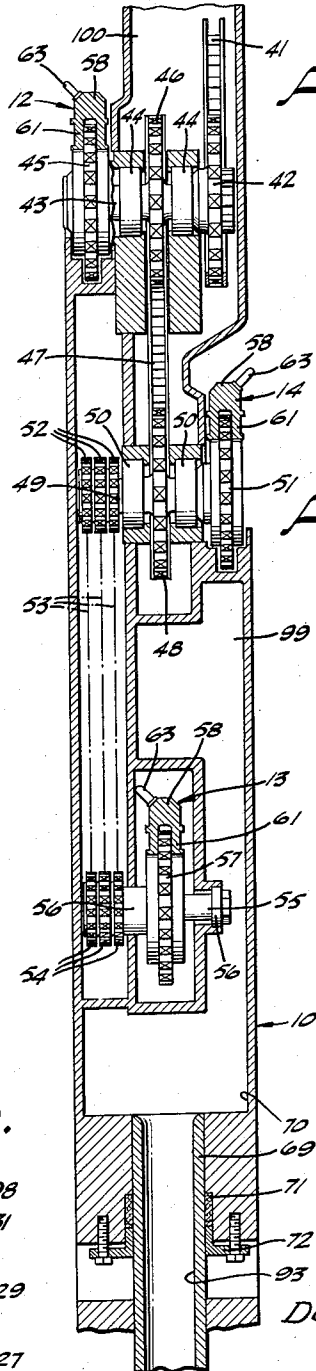


FIG. 2b.

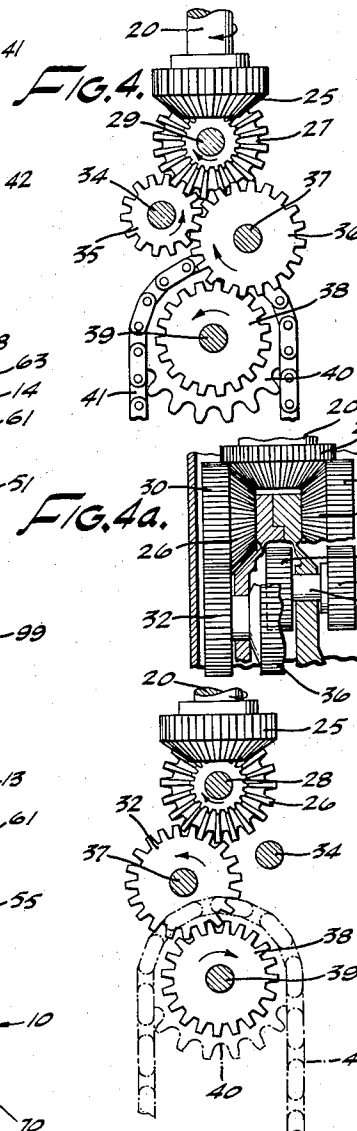


FIG. 4.

FIG. 4a.

FIG. 5.

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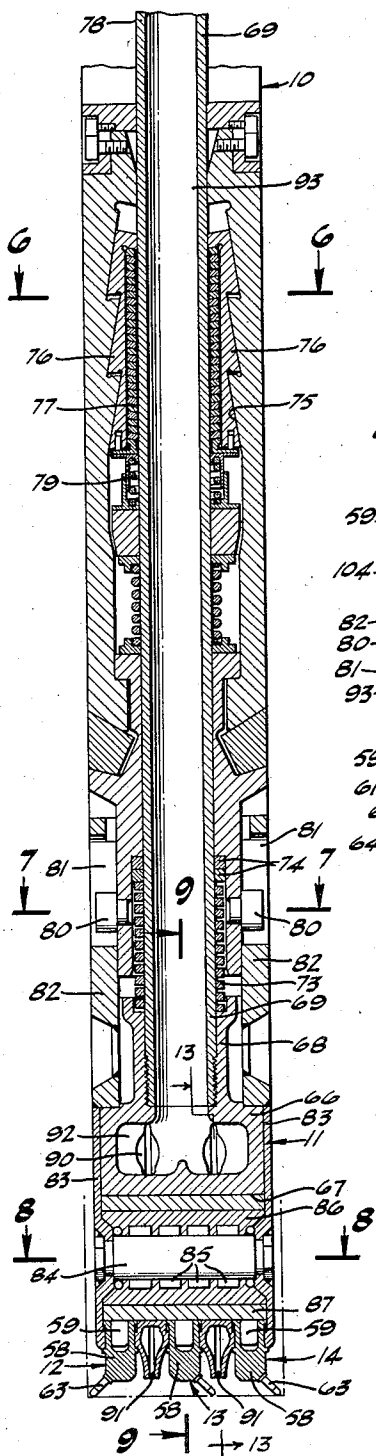


FIG. 2C.

FIG. 6.

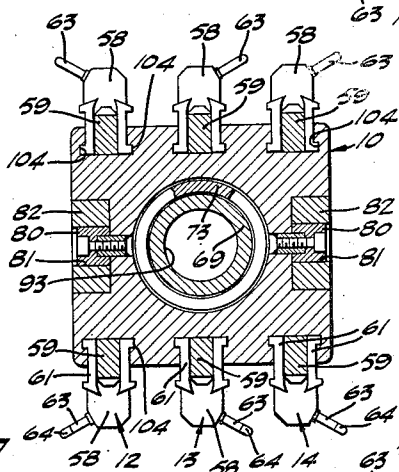
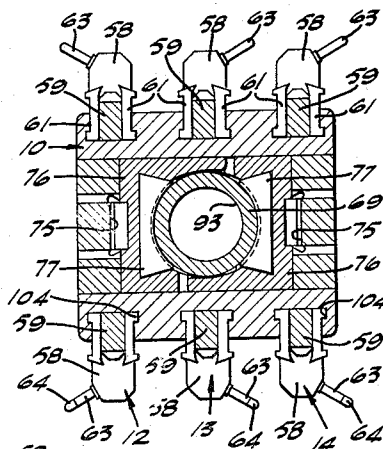
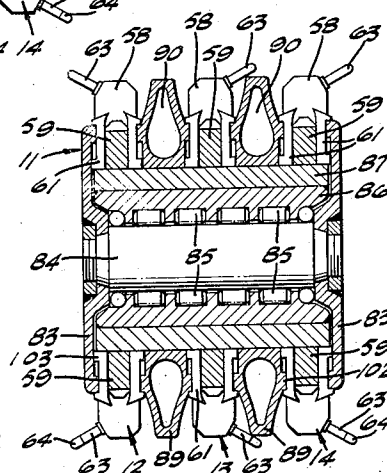


FIG. 7.

FIG. 8.



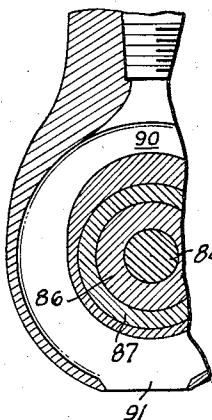
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FIG. 13.



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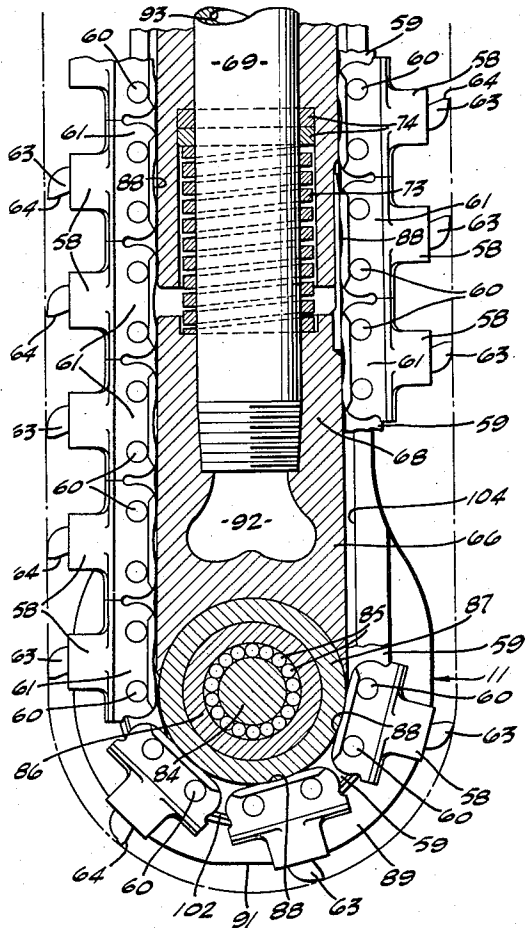


FIG. 9.

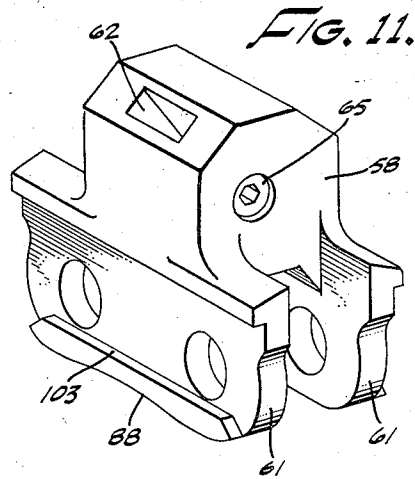


FIG. 11.

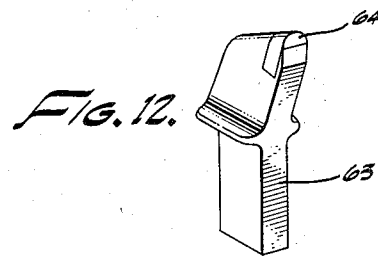


FIG. 12.

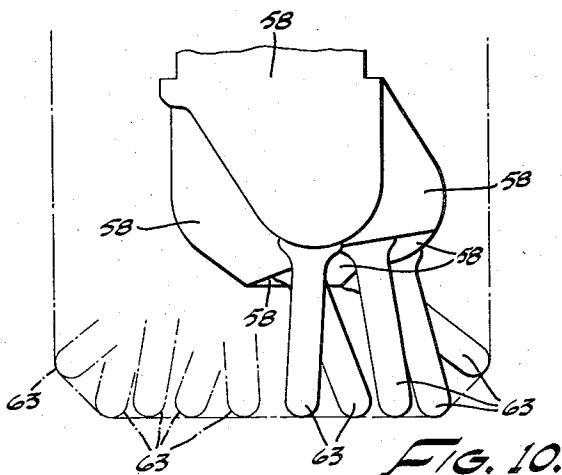


FIG. 10.

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2,880,964

WELL DIGGING MACHINE

Dorsey E. Straitiff, Beverly Hills, Calif.

Application August 17, 1953, Serial No. 374,755

10 Claims. (Cl. 255—1)

This invention relates to well digging apparatus of the type shown in my copending application Serial No. 89,507, filed April 25, 1949, and entitled "Well Digging Apparatus," now Patent No. 2,653,794, issued September 29, 1953. This invention concerns certain improvements over the form of apparatus shown in that application.

Among the objects of the present invention are to provide a well digging apparatus having longitudinally extending parallel cutting chains and having an improved digger head construction which prevents binding of the longitudinal flights of the chains within the hole dug by the cutter teeth mounted on the chain links. A related object is to provide a digger head construction which has greater lateral dimensions than other parts of the apparatus to assure clearance of the longitudinal flights of the digging chains within the well. Another object is to provide a stationary trackway for the individual cutter links in order to prevent undesirable lateral movement of the links. Another object is to provide such a trackway on a member employed for jetting mud fluid against the formation adjacent the active cutter teeth, in a manner to conserve space.

Another general object of my invention is to provide a novel form of tooth pattern for the individual links of the cutter chains which is effective to restrict torque imparted to the digging tool by the drill string.

Another object of this invention is to provide an improved form of drive gearing for transmitting torque from the rotary drill string to the longitudinally moving cutter chains. A related object is to provide drive gearing of this type in which the power drive to one of the cutter chains is located between the flights of another of the cutter chains.

Another object is to provide an improved form of automatic take-up for maintaining the cutter chains in tension.

Other and more detailed objects and advantages will appear hereinafter.

Referring to the drawings:

Figures 1a, 1b and 1c are side elevations showing a preferred form of my invention; Figure 1b constitutes an extension of the lower end of Figure 1a and Figure 1c constitutes an extension of the lower end of Figure 1b.

Figures 2a, 2b and 2c constitute longitudinal sectional views of the apparatus shown in Figures 1a, 1b and 1c, respectively.

Figure 3 is a sectional plan view taken substantially on the lines 3—3 as shown in Figure 2a.

Figure 4 is a schematic diagram taken substantially on the lines 4—4 of Figure 2a in side elevation showing the gear train for driving the digging chains from the rotary drill string.

Figure 4a is a fragmentary sectional view similar to Figure 2a with certain parts broken away to show additional structure.

Figure 5 is a similar view taken substantially on the lines 5—5 as shown in Figure 2a.

Figures 6, 7 and 8 are sectional plan views taken

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substantially on the line 6—6, 7—7 and 8—8, respectively, as shown in Figure 2c.

Figure 9 is a sectional elevation taken substantially on the lines 9—9 as shown in Figure 2c.

5 Figure 10 is a schematic diagram showing the various locations of the cutter teeth with respect to the well formation.

Figure 11 is a perspective view showing one of the links of the cutter chains.

10 Figure 12 is a perspective view showing one of the cutter teeth which is mounted on the chain links.

Figure 13 is a sectional view taken along line 13—13 of Figure 2c.

Referring to the drawings:

15 In brief, my improved well digging device comprises a longitudinally extending body or frame 10 having a digging head 11 at its lower end. A series of longitudinal digging chains 12, 13 and 14 (Fig. 6) are trained over the digging head 11 and are power driven from sprockets mounted near the upper end of the body 10. Power for moving the digging chains relative to the body 10 is supplied from the rotary drill string 15 which extends down into the hole from the ground surface. This rotary drill string is similar to that employed in the rotary system of drilling wells and is familiar to those skilled in this art. Turning movement of the drill string 15 causes the parallel digging chains to move relative to the body 10 and thereby bring the cutter teeth into digging engagement with the formation at the bottom of the hole. While I have chosen to show and describe a device having three digging chains, it is to be understood that a larger or smaller number may be employed if desired.

25 The lowermost section 17 of the drill string 15 is provided with an internal thread 18 for reception of a threaded end 19 on the vertical shaft 20. This shaft 20 is mounted in radial bearings 21 carried in a stationary sleeve 22 fixed to the upper portion of the body 10. The shaft 20 is provided with an integral flange 23 positioned between thrust bearings 24.

40 A bevel pinion 25 is fixed to the lower end of the vertical shaft 20 and meshes with a pair of bevel gears 26 and 27. These bevel gears are mounted to turn on coaxial trunnions 28 and 29 (see Figure 3). Each of the gears has a spur gear portion 30, 31 formed integrally therewith. The spur gear portion 30 meshes with the driven spur gear 32, and the spur gear portion 31 meshes with the idler gear 33. This idler gear is mounted on a transverse shaft 34, and also fixed upon this shaft 34 is the driving spur gear 35. This gear 35 meshes with the spur gear 36 which has a wider face. The gear 36 is fixed to the shaft 37, and the gear 32 is also fixed to this shaft 37. From this description it will be understood that rotary movement of the pinion 25 drives the bevel gears 26 and 27 in opposite directions and thereby causes the spur gears 30 and 31 to drive the gears 32 and 33 in opposite directions. The power carried by both gear trains is accumulated on the gear 36 since the gear 36 is directly connected to the gear 32 and since it is in mesh with the driving gear 35. This arrangement forms and completes a mechanical couple at this point in the gear train. The stress on the individual parts is therefore less than if only a single-power path were provided. The gear 36 then transmits the total power to the driven spur gear 38 which is mounted on shaft 39. The driving sprocket 40 is also carried on the shaft 39 and serves to drive the power chain 41.

70 The lower end of the power chain 41 passes (as shown in Fig. 2b) around driven sprocket 42 which is fixed on transverse shaft 43. This shaft is carried in suitable bearings 44 mounted on the frame 10. The driving sprocket 45 is also mounted on the transverse shaft 43 and the upper end of the digging chain 12 passes over

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this driving sprocket 45. The turning of the shaft 43 by power supplied into power chain 41 therefore serves to drive the digging chain 12.

A power sprocket 46 is fixed on the shaft 43 between the bearings 44 and drives power chain 47. The driven sprocket 48 mounted on transverse shaft 49 is driven by the chain 47. The shaft 49 is mounted on spaced bearings 50 positioned on the frame 10. The driving sprocket 51 is also fixed on the shaft 49 and serves to drive the digging chain 14. It will therefore be understood that turning movement of the transverse shaft 49 by means of the power chain 47 serves to drive the digging chain 14.

A multiple width sprocket 52 is carried on one end of the transverse shaft 49 and this sprocket 52 projects into the space between the flights of the digging chain 12. A power chain 53 connects the driving sprocket 52 with the driven sprocket 54 mounted on transverse shaft 55. This shaft is carried in suitable bearings 56 mounted on the frame 10. Power sprocket 57 is also fixed on this shaft 55 and serves to drive the upper end of the digging chain 13.

The power delivered by chains 41, 47 and 53 is therefore effective to turn the digging chains 12, 14 and 13, respectively, simultaneously and in the same direction. The digging chains are each composed of links 58 of the general type shown clearly in Figure 11. The links 58 are connected to each other by means of intermediate links 59 (Fig. 1b) and link pins 60. The intermediate links are received between the ears 61 of each of the links 58. Each link 58 is provided with a socket 62 for reception of a removable cutter 63. Each cutter is preferably provided with a formation-engaging tip 64 which is formed of tungsten carbide or other hard facing material. A set screw 65 is provided on each link 58 for clamping the cutter 63 in position. As set forth hereinafter, the locations of the sockets 62 are not the same on each link 58 but assume various positions so that the cutter teeth engage the entire area of the formation at the bottom of the hole.

Since the chain links and pins are subject to wear in service, means are provided for taking up the slack which develops in the digging chains after a period of use. This slack take-up device preferably operates automatically so that the digging chains are always maintained at the proper tension and so that undesirable looseness on the slack flight of each digging chain does not develop. As shown in the drawings, the digging head 11 includes a support member 66 (Fig. 2c) which is provided with a central transverse bore 67 and an upstanding threaded socket 68. A pipe 69 is threaded into this socket and functions as an integral part of the support member. The upper end of this pipe 69 is slidably received within the bore 70 of the body 10. The joint is sealed off by means of packing 71 and packing gland 72. A heavy coil spring 73 bears on the support member 66 at one end and on the thrust rings 74 at the other end. The force of the spring tends to move the support member 66 away from the body member 10. The lower portion of the body member 10 includes a multiple slip seat 75 for the inverted wedge slips 76. Each of these wedge slips 76 carries a large number of small gripping dogs 77 which have serrated faces adapted to engage the outer surface 78 of the pipe 69. A coil spring 79 serves to maintain the individual dogs 77 in engagement with each other.

When looseness or slack develops in the digging chains after a period of use, the force of the spring 73 moves the support member 66 downward with respect to the body member 10 for a distance sufficient to take up the slack it has developed. Reverse relative movement is prevented by engagement of the dogs 77 with the pipe 69. The arrangement just described is in effect a one-way clutch which permits movement of the support member 66 downward with respect to the body 10 but prevents relative movement in the other direction.

Lugs 80 are fixed to the body 10 and travel in longi-

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tudinal slots 81 provided in the side plates 82. These side plates 82 are fixed to the support member 66 and to the face plates 83. The lugs 80 thus serve to limit the total travel of the digging head 11 with respect to the body 10 and also prevent rotation of the head 11 relative to the body 10.

The face plates 83 which form a part of the digging head 11 support a nonrotary transverse pintle 84 in a central position with respect to the bore 67. Roller bearings 85 on the pintle 84 carry a rotary hub 86 which is confined endwise between the face plates 83. A sleeve 87 is fixed on this hub, as by a press fit, and this sleeve is preferably formed of work hardening material such as Hadfield manganese. The sleeve 87 and hub 86 are intended to rotate freely within the bore 67.

The digging chains 12, 13 and 14 are trained over the sleeve 87 so that the frictional contact of the chain links with the sleeve causes it to turn on the pintle 84. It will be understood that separate sprockets on the digging head 11 are not provided but instead all three digging chains are trained over the sleeve 87 which has a cylindrical outer surface. The links 58 are preferably formed with curved concave recesses 88 for surface contact with the sleeve 87.

The support member 66 is provided with a pair of arcuate ribs 89 which are positioned on opposite sides of the digging chain 13. These ribs 89 are hollow as shown at 90 to provide passageways for delivery of mud fluid through the jet nozzles 91. The passageways 90 are supplied with mud fluid from the reservoir 92 and this reservoir is in communication with the interior 93 of the pipe 69. Mud fluid reaches the upper end of the pipe 69 from the interior 94 of the drill string 15 by way of the ports 95, 96 and 97, vertical passages 98 and body cavity 99.

The arcuate ribs 89 on the support member 66 are also provided with oppositely directed shoulders 102 which form the lower ends of trackways in order to confine the links 58 against the outer surface of the sleeve 87. As clearly shown in Figure 11, each of the links 58 is provided with a laterally extending lip 103 on each side and these lips are engaged by the shoulders 102. The links 58 are thus prevented from "riding-off" the sleeve 87 by a build up of detritus between the links and the sleeve 87. The curved trackways provided by the shoulders 102 merge with longitudinal trackways 104 provided on the support member 66 and body member 10. The links 58 are thus confined against movement toward and away from the axis of the tool. The outer diameter of the sleeve 87 is preferably larger than the effective outer diameter of each of the driving sprockets 45, 51 and 57 and the trackways are correspondingly tapered so that the two flights of each digging chain are not precisely parallel. In this way the chains are prevented from sticking within the hole since greater clearance is provided adjacent their upper ends.

The mud fluid delivered to the digging head 11 from the drill string 15 by way of the passages, ports, cavities, etc., described above does not contact the bearings for the shaft 20 nor any of the gears or sprockets furnishing power to drive the digging chains 12, 13 and 14. The bearings, gears and power chains operate within an oil bath enclosure 100 which is sealed off from the mud passages.

The torque of the rotary drill string 15 tends to turn the entire device within the well hole. This tendency to turn as a result of applied torque is resisted by the cutter teeth 63 or, as shown in my Patent No. 2,653,794, may be resisted by torque shoes carried on the body. I have found that by employing a given sequence of positions of the cutters 63 this torque may be absorbed by the individual cutter teeth as they engage the formation at the bottom of the hole. Considering Figure 10 of the drawings, if each cutter tooth follows a cutter tooth in exact alignment with it, the cutters would gouge grooves in the formation but would not cut over the full area. If

each succeeding cutter tooth in a given series cuts slightly to the left of each preceding tooth, there will be a tendency for each to follow in the groove cut by the preceding cutter and thereby apply a twisting force to the digging head. By properly choosing the locations of each cutter tooth on its respective link 58, therefore, it is possible to absorb at least a portion of the torque applied by the rotary drill string 15 directly against the teeth acting on the bottom of the hole. The locations of the sockets 62 on the links 58 vary through a considerable range and the shape of the cutter carrying part of the links 58 also varies so that each cutting chain is capable of cutting a considerable area of the formation, as shown in Figure 10.

Having fully described my invention, it is to be understood that I do not wish to be limited to the details herein set forth, but my invention is of the full scope of the appended claims.

I claim:

1. Digging apparatus of the class described comprising in combination: a frame, a plurality of longitudinally and laterally spaced driving sprockets each rotatably mounted on the frame, common support means rotatably mounted at the lower end of the frame, a plurality of endless chains of different lengths trained over said driving sprockets and said common support means, the chains having formation-engaging teeth, a rotary driving element extending axially of the frame, bearing means supporting the driving element with respect to the frame, a bevel pinion on said driving element, a pair of coaxial bevel gears meshing with said pinion, a driven spur gear rotatably mounted on the frame, gear means whereby the combined power of both bevel gears is applied to said spur gear, and power transmission means whereby said spur gear may drive each of said sprockets and chains in the same direction.

2. Digging apparatus of the class described comprising in combination: a frame, a plurality of longitudinally and laterally spaced driving sprockets each rotatably mounted on the frame, common support means rotatably mounted at the lower end of the frame, a plurality of endless chains of different lengths trained over said driving sprockets and said common support means, the chains having formation-engaging teeth, a rotary driving element extending axially of the frame, bearing means supporting the driving element with respect to the frame, a bevel pinion on said driving element, a pair of coaxial bevel gears meshing with said pinion, a driven spur gear rotatably mounted on the frame, gear means whereby the combined power of both bevel gears is applied to said spur gear, and power transmission means whereby said spur gear may drive each of said sprockets and chains in the same direction, said driving element and gear being confined within the outline of the hole produced in the formation by said teeth of the chains.

3. Digging apparatus of the class described comprising in combination: a frame, a plurality of longitudinally and laterally spaced driving sprockets each rotatably mounted on the frame, common support means rotatably mounted at the lower end of the frame, a plurality of endless chains of different lengths trained over said driving sprockets and said common support means, the chains having formation-engaging teeth, a rotary driving element extending axially of the frame, bearing means supporting the driving element with respect to the frame, a bevel pinion on said driving element, a pair of coaxial bevel gears meshing with said pinion, a spur gear fixed upon a rotary transverse shaft, gear means whereby one of the bevel gears drives said spur gear, gear means whereby the other bevel gear drives said rotary transverse shaft, and power transmission means whereby said spur gear may drive each of said sprockets and chains in the same direction.

4. Digging apparatus of the class described comprising in combination: a frame, a plurality of longitudinally and laterally spaced driving sprockets each rotatably mounted

on the frame, common support means rotatably mounted at the lower end of the frame, a plurality of endless chains of different lengths trained over said driving sprockets and said common support means, the chains having formation-engaging teeth, a rotary driving element extending axially of the frame, a bevel pinion on said driving element, a pair of coaxial bevel gears meshing with said pinion, a spur gear fixed upon a rotary transverse shaft, a relatively narrow idler gear meshing with said spur gear, a relatively wide driven gear meshing with said spur gear, means whereby one of the bevel gears may drive the rotary transverse shaft and the other bevel gear may drive the idler gear, whereby the combined power of both bevel gears is applied to said spur gear, and power transmission means whereby said spur gear may drive each of said sprockets and chains in the same direction.

5. Digging apparatus of the class described, comprising in combination: a frame, a driving sprocket rotatably mounted on one side of the frame, another driving sprocket rotatably mounted on the frame and spaced axially below and laterally offset from said first driving sprocket, chain support means mounted at the lower end of the frame, parallel endless digging chains of different lengths trained over said driving sprockets and said support means, the chains having formation-engaging teeth, means for driving the first driving sprocket, and means including a power chain located between the flights of the digging chain trained over the first-mentioned driving sprocket for driving the second-mentioned driving sprocket.

6. Digging apparatus of the class described, comprising in combination: a frame, a first driving sprocket rotatably mounted on one side of the frame, a second driving sprocket rotatably mounted on the other side of the frame and spaced axially below said first driving sprocket, a third driving sprocket positioned laterally between and below both the first and second driving sprockets, chain support means mounted at the lower end of the frame, three parallel endless digging chains of different lengths trained over said driving sprockets and said support means, the chains having formation-engaging teeth, means for driving said first and second driving sprockets, and means including a power chain located between the flight of the digging chain trained over the first driving sprocket for driving said third driving sprocket.

7. Digging apparatus of the class described, comprising in combination: a frame, a plurality of driving sprockets rotatably mounted on the frame, a digging head having an upwardly extending pipe fixed thereto, means mounted at the lower end of the frame and slidably receiving the pipe for relative longitudinal movement with respect to the frame, means whereby the pipe may convey drilling fluid from the frame to the digging head, a chain-engaging member rotatably mounted on the support member, a plurality of parallel endless chains of different length trained over said sprockets and rotary member, the chains having formation-engaging teeth, resilient means acting to effect relative movement between the frame and the digging head in a direction to remove slack from the chains, means engaging the pipe to prevent relative movement in the other direction, a rotary driving element extending axially of the frame, bearing means supporting the driving element with respect to the frame, and means including gear means whereby said driving element may drive said driving sprockets.

8. Digging apparatus of the class described, comprising in combination: a frame having a passageway for drilling fluid, a plurality of driving sprockets rotatably mounted on the frame, a digging head mounted at the lower end of the frame, a nonrotary transverse pintle supported within the digging head, bearing means on the pintle, a rotary hub carried by said bearing means, a sleeve fixed to said hub, a plurality of parallel endless chains of different lengths trained over said sprockets and

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sleeve, the chains having links provided with formation-engaging teeth, the digging head having arcuate ribs partially encircling the sleeve and positioned between the chains, the ribs having cavities, means connecting the cavities to receive drilling fluid from said passageway and nozzle openings in the ribs communicating with said cavities for jetting streams of drilling fluid against the formation.

9. Digging apparatus of the class described, comprising in combination: a frame, a first driving sprocket rotatably mounted on one side of the frame, a second driving sprocket rotatably mounted on the other side of the frame and spaced axially below said first driving sprocket, a third driving sprocket positioned laterally between and below both the first and second driving sprockets, chain support means on the frame at the lower end thereof, three parallel endless chains of different lengths trained over said driving sprockets and said support means, the chains having formation-engaging teeth, a rotary driving element extending axially of the frame, bearing means supporting the driving element with respect to the frame, and means including gear means whereby said driving element may drive all three driving sprockets, the latter said means including portions thereof located between the flights of one of the digging chains.

10. Digging apparatus of the class described, comprising in combination: a frame, a first driving sprocket rotatably mounted on one side of the frame, a second driving sprocket rotatably mounted on the other side of

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the frame and spaced axially below said first driving sprocket, a third driving sprocket positioned laterally between and below both the first and second driving sprockets, chain support means rotatably mounted on the frame at the lower end thereof, three parallel endless chains of different lengths trained over said driving sprockets and said support means, the chains having formation-engaging teeth, a rotary driving element extending axially of the frame, bearing means supporting the driving element with respect to the frame, and means including gear means whereby said driving element may drive all three driving sprockets in the same direction, the latter said means including portions thereof located between the flights of one of the digging chains.

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