# United States Patent [19]

**Coski**

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[54] **EARTH CUTTER ASSEMBLY**


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[52] **U.S. Cl.** ..... **175/53,** 175/331, 175/344, 175/374

[51] **Int. Cl.** ..... **E21b 9/22**

[58] **Field of Search** ..... 175/53, 329, 330, 336, 175/374, 344, 334, 335, 345–347, 331



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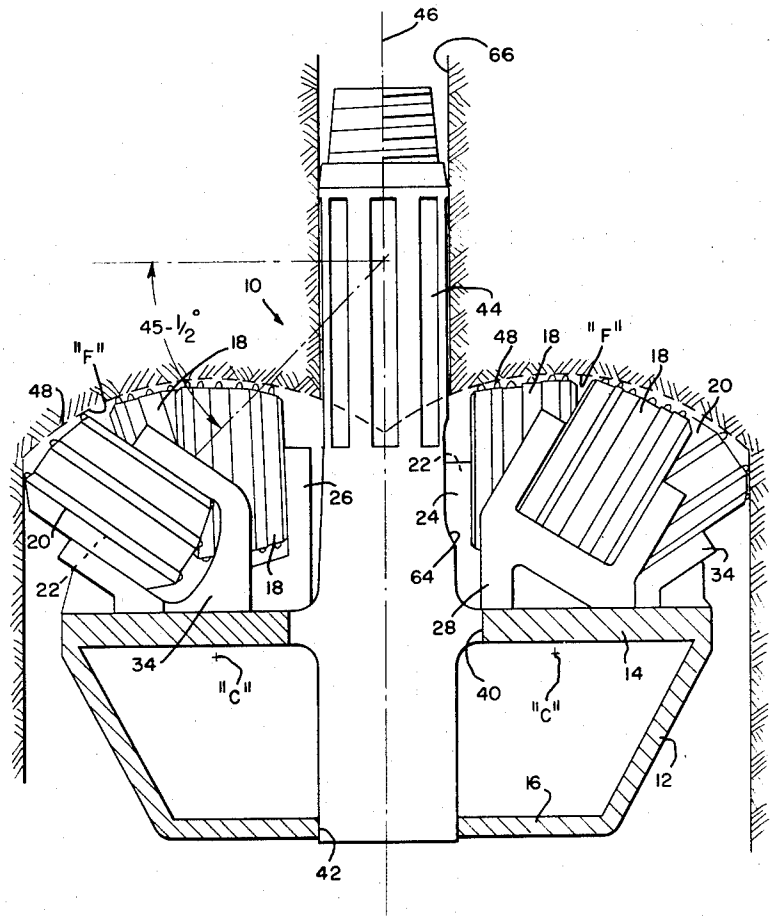
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[57] **ABSTRACT**

The assembly comprises a rotatable body for supporting roller-type earth cutters, and means for mounting the earth cutters to the body, in which the cutters are so configured and mounted as to cooperate, upon rotation of the body, to define at least one, overall circular and convex cutting surface of the assembly.


**21 Claims, 8 Drawing Figures**



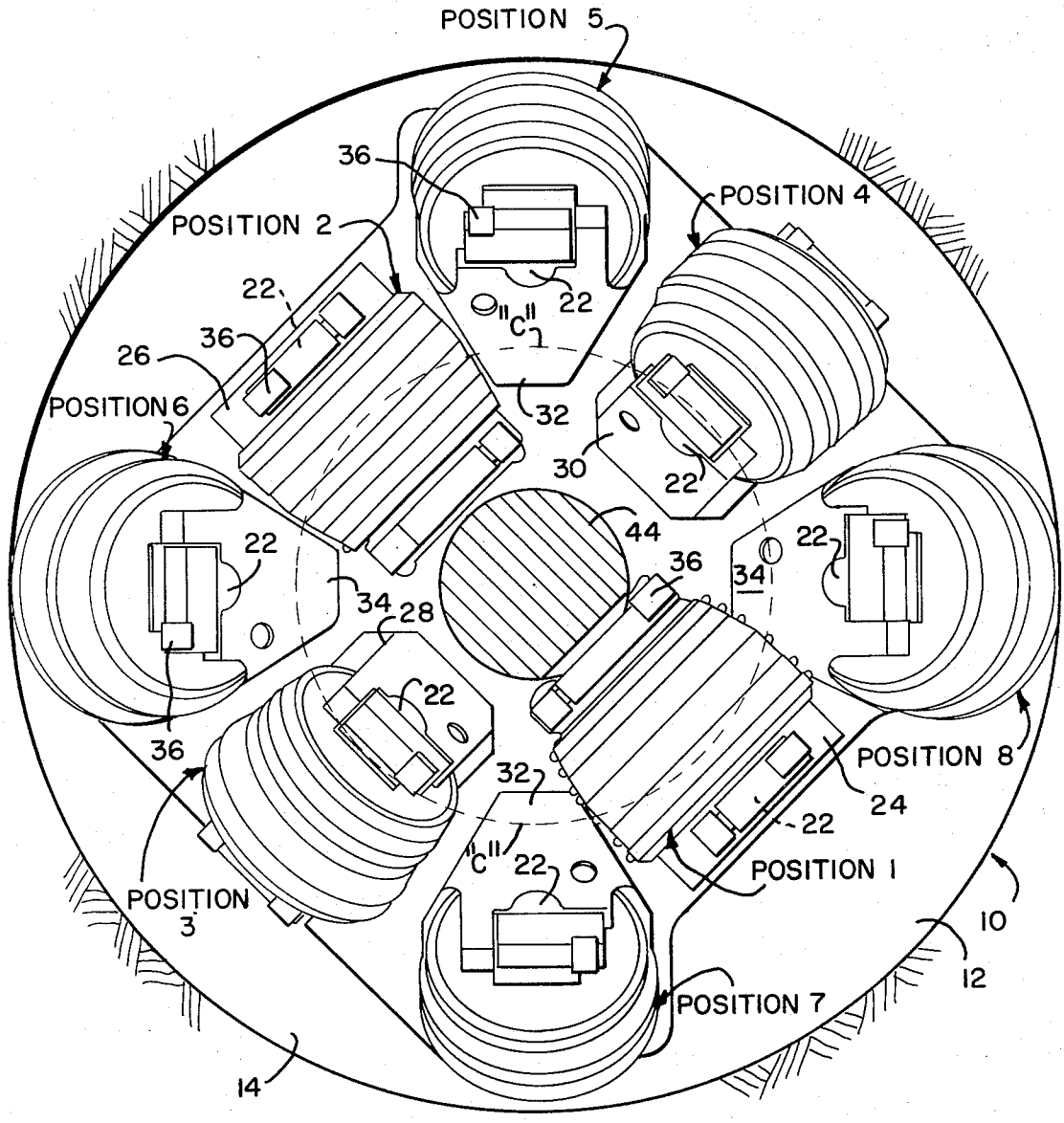

POSITION 5
36
POSITION 4
POSITION 2
22
22
36
26
POSITION 6
32
30
22
44
22
36
34
34
28
22
36
POSITION 8
32
24
22
22
POSITION 1
POSITION 3
10
12
POSITION 7
14

FIG. 1

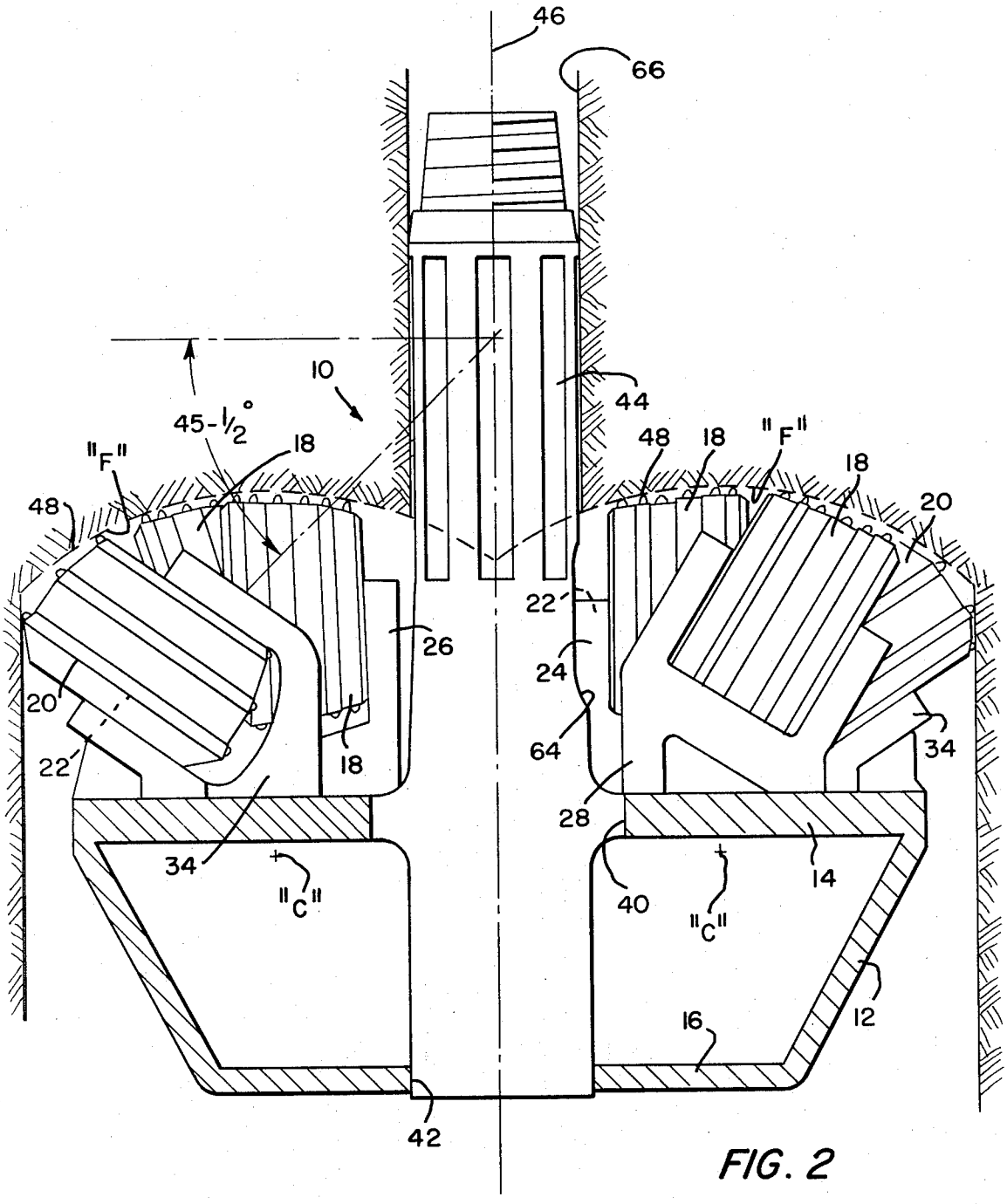
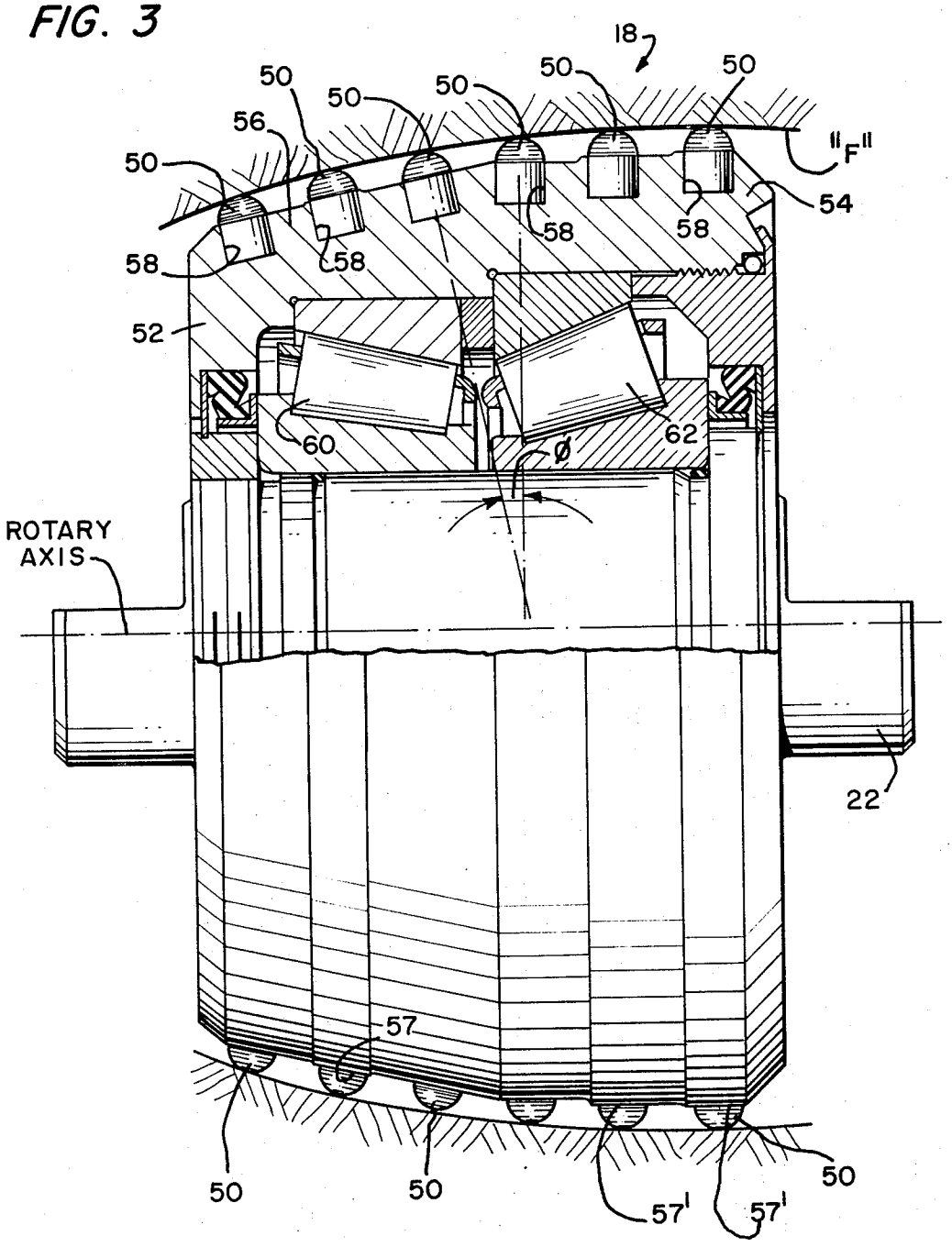

46
66
10
44
45-½°
18
"F"
48
18
"F"
18
20
48
22
26
24
20
64
34
22
18
28
34
"C"
14
40
"C"
16
12
42

FIG. 2

FIG. 3


18
50
50
50
50
50
56
50
58
58
58
58
54
"F"
52
60
62
ø
ROTARY AXIS
22
57
50
50
57'
57'
50

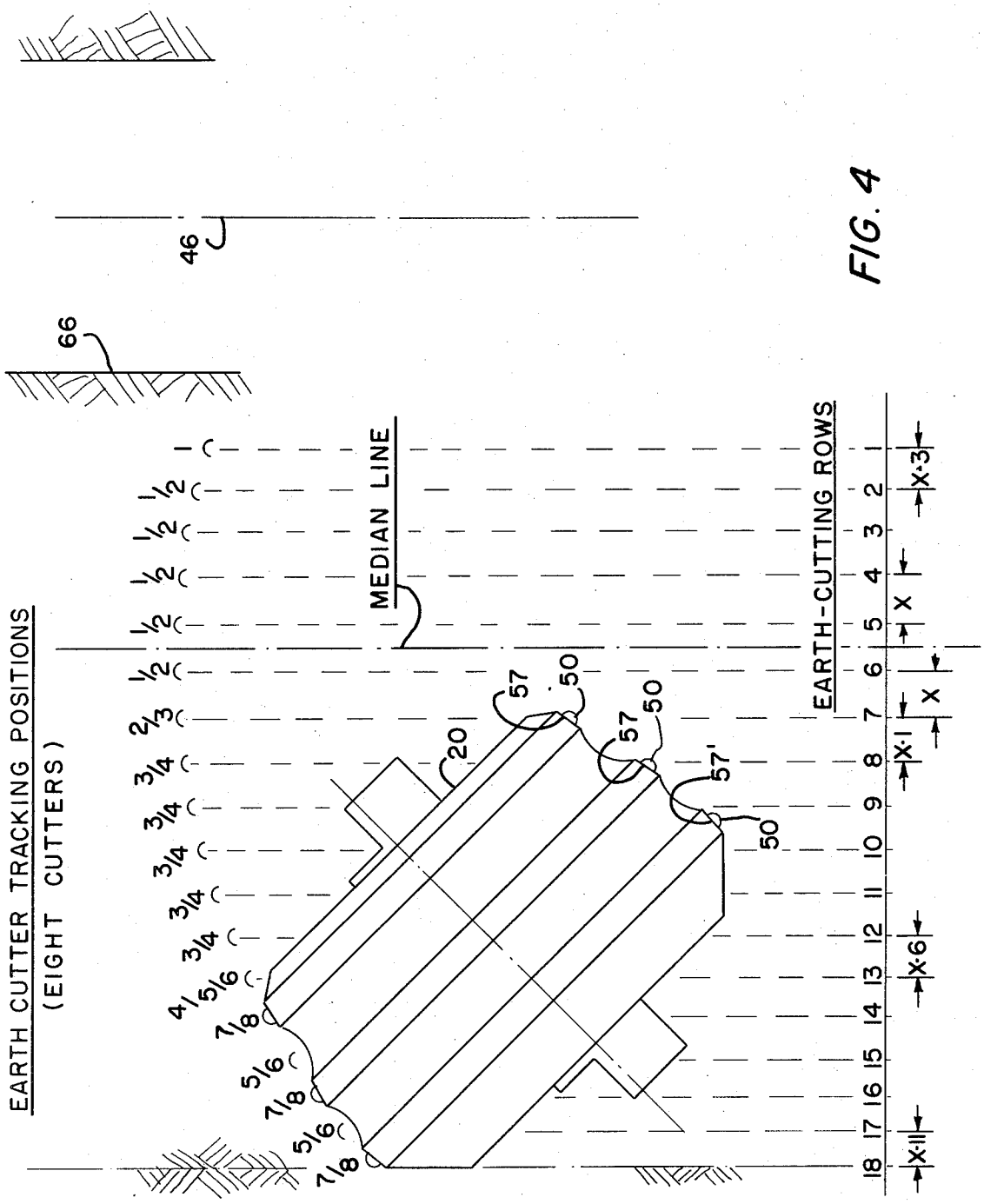
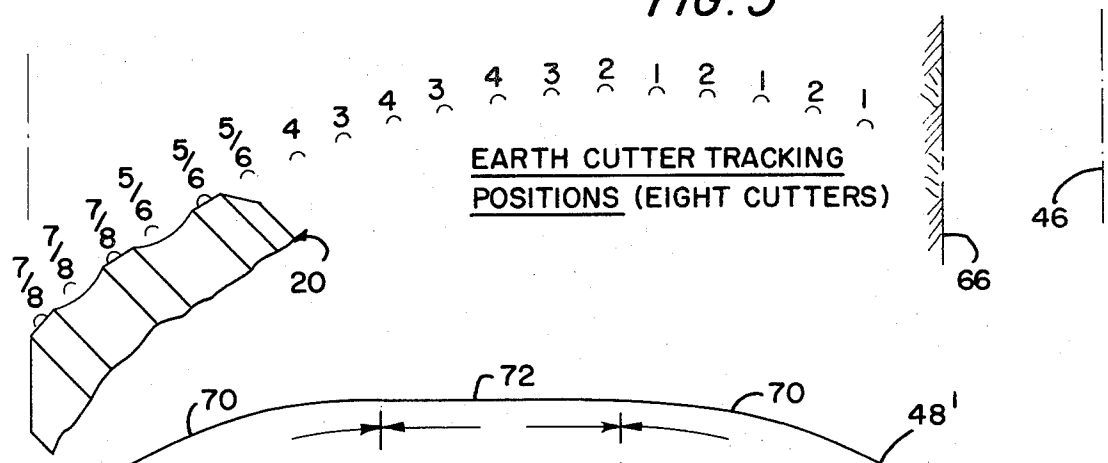

46
66
MEDIAN LINE
EARTH-CUTTING ROWS
EARTH CUTTER TRACKING POSITIONS
(EIGHT CUTTERS)
1
1½
1½
1½
1½
1½
2⅓
¾
¾
¾
¾
¾
¾
4 1/5/16
7/8
5/16
7/8
5/16
7/8
20
57
50
57
50
57'
50
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
X·3
X
X
X·1
X·6
X·11

FIG. 4

FIG. 5



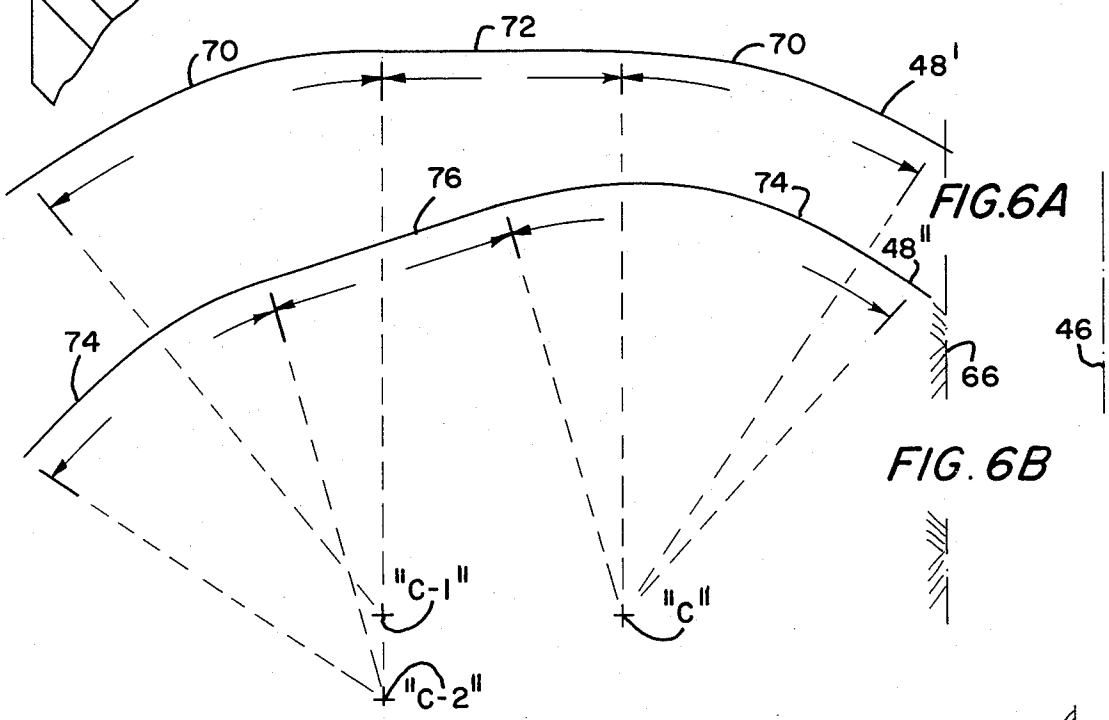




FIG. 6A

FIG. 6B

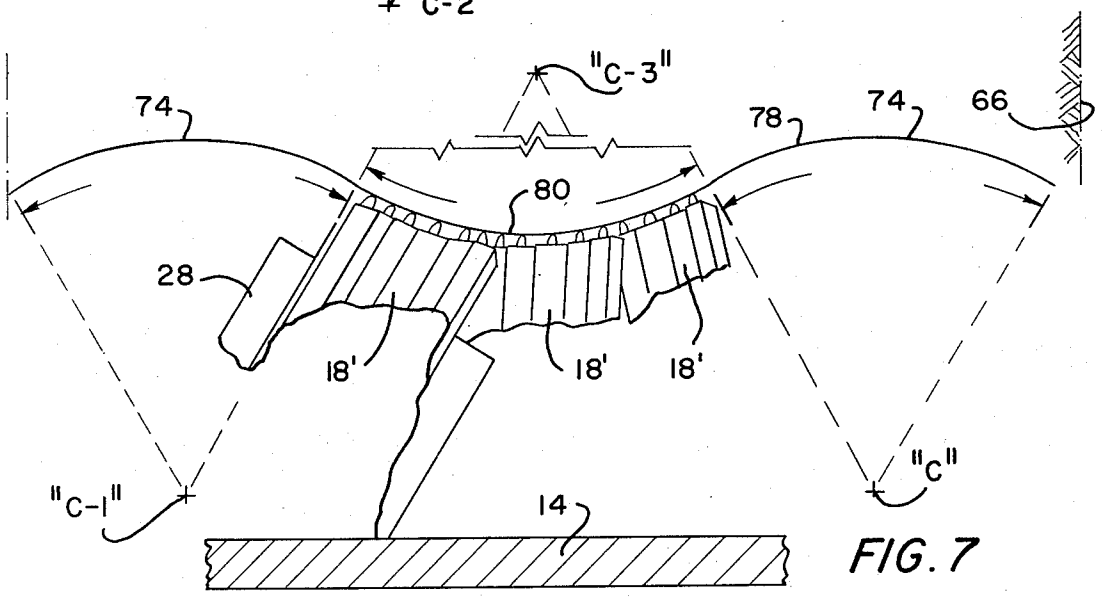



FIG. 7

# EARTH CUTTER ASSEMBLY

This invention pertains to earth cutter assemblies having earth cutting means for disintegrating the face of an earth formation and in particular to an earth cutter assembly which is so arranged as to prevent an excessive loading of any one earth cutter means in that it avoids creating face prominences or discontinuities in the earth face.

Earth cutter means, typically, are of the roller type, and customarily they have a straight cylindrical or conical configuration which defines a linear cutting surface. A plurality of such cutter means, in the prior art, are arranged in a predetermined pattern on a rotatable body in order that all of the cutter means address the face of the earth formation. Thus, different cutter means are arranged to "track" in adjacency to prior cutter means, whereby all the patterned cutter means share the face-cutting burden. However, it has been the practice to have the outermost cutter means linear cutting surface angularly inclined to engage both the face and a portion of the wall of the bore being cut, with the innermost cutter means linear cutting surface also angularly inclined. As a result, the axial ends of such innermost and outermost cutter means, as well as these cutter means arranged therebetween, must negotiate angular prominences in the earth face in attempting to accommodate for the disparate cutting angles to sides adjacent thereto and, for this reason, are subject to high loading.

It is an object of this invention to disclose an improved earth cutter assembly for boring the face of an earth formation which avoids the cited limitations of known assemblies.

It is a particular object of this invention to set forth an earth cutter assembly for rotary boring of the face of earth formations, comprising earth cutter means, for disintegrating the earth formation face; a rotatable body, having a rotary axis, for supporting said earth cutter means; said body having means for couplingly receiving a drive stem for imparting rotary drive to said body; and means mounting said earth cutter means only to said body for rotation therewith; wherein said mounting means is cooperative with said earth cutter means to cause said earth cutter means effectively to define at least one, overall circular and convex cutting surface, about said axis, upon rotation of said body.

It is another object of the invention to set forth an earth face cutter, for use with others thereof in a patterned array on a rotatable member for cooperative rotary boring of the face of an earth formation to form at least one, overall circular and concave cut in said face; comprising a body having a rotary axis and an earth face engaging surface; said body further having relieved areas formed therewithin for receiving supporting means, for mounting said body on a rotatable member together with other earth face cutters; and said body further having earth cutting means disposed about its earth-face-engaging surface; wherein said earth cutting means comprise means effective for cutting an arcuate kerf, in the face of the formation, which kerf defines a complementary portion of said one overall circular and concave cut.

A feature of this invention comprises a rotatable body for supporting roller-type earth cutters and means for mounting the earth cutters to the rotary body in which each cutter cooperates with others thereof to define at least one, overall circular and convex cutting surface.



Further objects and features of this invention will become apparent by reference to the following description, taken in conjunction with the accompanying figures, in which:

FIG. 1 is a plan view of an embodiment of the earth cutter assembly, according to the invention, showing a plurality of individual roller-type earth cutters set out upon a rotatable body in a patterned array;

FIG. 2 is an elevational view, partially in cross-section, which has been contrived; i.e., several of the earth cutters are rotated from their positions in the array (of FIG. 1) and superimposed upon (behind) one another to illustrate the face-engaging position each assumes upon rotation of the body;

FIG. 3 is an axial and partial cross-sectional view of a typical roller-type earth cutter, according to the invention, used with the rotary body and taught by this invention;

FIG. 4 is a combined pictorial and outline depiction of the roller cutter positionings and earth-cutting rows, in one embodiment of the invention;

FIG. 5 corresponds to FIG. 4 insofar as it outlines the roller cutter positionings in an alternate embodiment of the invention;

FIGS. 6A and 6B illustrate alternative configurations of cutting surfaces which may be derived from this disclosure; and

FIG. 7 illustrates still another cutting surface configuration proceeding from my teaching.

As shown in FIGS. 1 and 2 the novel earth cutter assembly **10** comprises a cutterhead or body **12** having a pair of bored mounting plates **14** and **16.** Roller-type earth cutters **18** and **20** are mounted to plate **14.** Each roller type cutter accommodates a shaft **22** (FIG. 3) which is received in a mounting saddle **24** (or **26** or **28,** etc) the latter being replaceably secured to plate **14** of the rotatable body **12.** Both plates **14** and **16** of the body **12** have apertures **40** and **42,** respectively, for receiving a rotary drive stem **44** by means of which the earth cutter assembly **10** is rotated and forced against the face F of the earth formation.

The innermost roller cutter **18,** the same occupying "position number 1" has its mounting shaft **22** lying perpendicular to the rotary axis **46** of the drive stem **44,** whereas the outermost roller cutter **20** occupying "position number **8,**" has its rotary shaft located in its saddle inclined at an angle of 45½° relative to horizontal.

As can be seen clearly in the elevation view of FIG. **2,** the cutter **18** and **20** mounted to the body **12** cooperate with the rotation of the body **12** to define one circular, convex cutting surface **48** about the axis of the rotary drive stem **44.** Accordingly, no one cutter is ever met with a bi-angular-formed prominence or face discontinuity. The transformation of cutter attack from the outermost roller cutter to the innermost roller cutter defines a smooth-radius curve. Successive roller cutters track in overlapping follow, or in endwise adjacency to preceeding cutters, with rotation of the body **12,** and each of the cutters **18** and **20** defining the cutting surface **48** smoothly blend and form a symmetrically convex surface across a radius of the earth face cutter assembly **10.**

As shown in FIG. **3,** cutter **18** comprises a body **52** having a substantially straight portion **54** and a substan-

tially conical portion **56.** Each of these portions **54** and **56** have at least one row of drill holes **58** formed in the outer surface thereof for receiving the cutter inserts **50.** In order that the cutter inserts might define, about the surface of the cutter **18,** an arcuate-kerf-cutting profile, portion **52** is formed with an intermediate, conical land **57,** and portion **54** with terminal, horizontal lands **57'.** Thus, while all of the inserts **50** are of one common length, and each is bottomed in its respective common-depth drill hole, the inserts, between rows thereof, are caused to project diverse radial distances from the rotary axis of body **52.**

As shown in FIG. **4,** cutter **20** also has lands from which the inserts **50** project —from row to row— diverse radial distances from the rotary axis of the body; cutter **20** has a pair of conical lands **57** and one horizontal land **57'.** Lands **57',** then, define first portions of the roller cutter bodies which are of uniform outside diameter, and lands **57** define second portions of conical configuration.

The symmetrical and convex cutting surface **48,** (FIG. **2**), which encircles the axis **46,** is formed through the cooperation of the arrayed cutters **18** and **20.**

Each of the cutters, the cutter **18** shown in FIG. **3** being typical, cooperates with the others thereof on body **12** to form one, overall circular and concave cut in the earth face. Each cutter **18** and **20** carries earth cutting inserts **50** in a disposition which causes said cutter to form an arcuate kerf in the face "F" of the earth formation which comprises a complementary portion of the overall concave cut.

The cutting surface **48** defines a symmetrical arc; the radius of the arc, taken at any place along the circular disposition of the surface **48,** originates at a point located along an imaginary circle "C" which lies concentric with the axis **46.** Thus, the radius of the arc of surface **48,** at any cross-section thereof, proceeds from a point which is spaced radially from axis **46.**

While the cutters **18** and **20** occupy eight positions on the body **12,** this embodiment of cutter array requires only six saddles **24, 26, 28, 30, 32** and **34** of differing cutter-carrying configuration. Saddles **24, 26, 28, 30** support cutters **18** in positions number **1** through number **4** and carry the cutter-mounting shafts **22** at 0°, 3-½°, 21°, and 24-½° of inclination from horizontal, respectively. Saddles **32** support cutters **20** in positions number **5** and number **7** at 42° of inclination, and saddles **34** support further, cutters **20** in positions number **6** and number **8** at 45-½° of inclination.

Both types of cutters **18** and **20,** the former having six rows of inserts **50,** and the latter having three rows of inserts **50,** have common axial lengths and radii, and accommodate common shafts **22.** Thus, for instance, six-row cutters **18** in positions number **1** through number **4** can be replaced with three-row cutters **20,** without affecting the overall shape of surface **48.** Also, to further this facility of interchangeability of cutters, the inserts **50** are carried on the cutters **18** and **20** at slightly diverse angles —between a given row thereof on a straight portion **54** and an adjacent row thereof on a conical portion **56.** This is done to optimize the attack efficiency of the inserts **50,** in all cutters, regardless of cutter positioning in the selected patterned array on body **12.** Thus, as FIG. **3** illustrates, there is an angular disparity "$\phi$" between the rows of inserts **50** on body portions **54** and **56.**

The cutters, such as cutter **18** of FIG. **3,** carry the body **52** thereof on bearings **60** and **62** which are borne by shaft **22.** The shafts **22** are received, at opposite ends thereof, in saddle recesses (not shown) and are secured thereto by fasteners **36.**

The rotary drive stem **44** is secured in apertures **40** and **42** by any convenient means —such as welding, or by fasteners, etc. as is well known and practiced in the art. In this embodiment, the stem **44** has a relieved portion **64,** adjacent to saddle **24** to accommodate a proximate positioning of cutter **18** (position number **1**) to a bore-hole or pilot hole **66** which receives the stem **44.**

FIG. **5** represents the derived earth cutter tracking position, with eight cutters **20.** Cutters **20** in positions number **1** through number **4** track independently, whereas cutters **20** in positions number **5** through number **8** follow paired or re-trace tracks. In this, given inserts **50** of these latter positions follow rows which are also followed by other inserts **50.**

The embodiment shown in FIGS. **1** and **2** comprises an arrangement of cutters **18** in positions number **1** through number **4** and cutters **20** in positions number **5** through number **8.** Here then is derived the tracking pattern set out in FIG. **4** —where the cutters **18** in positions number **1** through number **4** have inserts **50** followed by other inserts.

In FIG. **4** is shown a "median line," the same being parallel with axis **46** and drawn from a point along circle "C" (FIG. **2**). Adjacent earth cutting rows to each side of the "median line" are spaced-apart —outwardly to row 18, and inwardly to row one— in progressively and exponentially diminishing distances. Typically, rows six and seven are a distance of "X" therebetween, relative to axis **46.** Rows 12 and 13 are a distance of "X-6" apart, and rows one and two are a distance of "X-3" apart.

The diminishing spacing distances outward to row eighteen provide a proper complement for the greater circumferential distances the outermost rows must traverse with rotation of the body **12.**

In FIGS. **6A** and **6B** are shown alternate arrangements of an earth cutting surface **48'** (and **48''**) which can be derived from my teaching. Surface **48'** comprises a pair of convex cutting surface segments **70** drawn by radii originating at point "C" and another outboard point "C-**1.**" In this embodiment, points "C" and "C-**1**" are perpendicularly in line relative to axis **46.** Further, a smoothly blended-in, flat, cutting surface section **72** is interposed between segments **70.**

Surface **48''** in FIG. **6B** also comprises a pair of convex cutting surface segments **74** with an intervening flat section **76.** Yet, in this embodiment the outboard segment **74** is defined by a radius originating at a point "C-**2**"; here, derivation points "C-**2**" and "C" are obliquely in line relative to axis **46.**

FIG. **7** sets forth a still further embodiment of the novel earth cutter assembly cutting surface. As shown in FIG. **7,** the cutting surface **78** is undulated; it has a pair of convex segments **74** with a concave segment **80** therebetween; the latter is drawn on a radius taken from a point "C-**3.**" To define segment **80,** it is my teaching to use earth cutters **18'** (or **20'**) which are inverse images of cutters **18** (or **20**); that is, instead of presenting roller surfaces with inserts **50** in a convex profile, they would comprise bodies **52** with inserts in a concave profile.

In all of the disclosed embodiments I present arcuate segments of the cutting surfaces as being symmetrical. Now clearly this is a matter of choice. Such segments could just as well be unsymmetrical. Also, the variations in cutting surface profiles (FIGS. 2, 6A, 6B, 7) are exemplary only. Other profiles will suggest themselves to those skilled in the art, by taking teaching from my instant disclosure.

While I have described my invention in connection with specific embodiments thereof, then, it is to be clearly understood that this is done only by way of example, and not as a limitation to the scope of my invention as set forth in the objects thereof and in the appended claims.

I claim:

**1.** An earth cutter assembly, for rotary boring of the face of earth formations, comprising:
- roller earth cutters, for distintegrating the earth formation face;
- a rotatable cutterhead having a rotary axis, for supporting said roller earth cutters;
- said cutterhead having means for couplingly receiving a drive stem for imparting rotary drive to said cutterhead; and
- means mounting said roller earth cutters only to said cutterhead for rotation therewith; wherein
- said mounting means is cooperative with said roller earth cutters to cause said roller earth cutters effectively to define at least one, overall circular and convex cutting surface, about said axis, upon rotation of said cutterhead.

**2.** An earth cutter assembly, according to claim **1**, wherein:
- said mounting means is cooperative with said roller earth cutters to cause said earth cutters effectively to define said cutting surface with at least one, overall circular and flat cutting portion about said axis, upon rotation of said cutterhead.

**3.** An earth cutter assembly, according to claim **1**, wherein:
- said convex cutting surface has a convexity which defines a symmetrical arc; and
- said arc of said surface, taken at any given place along the circular disposition of said surface, has a radius originating at a given point spaced radially from said axis.

**4.** An earth cutter assembly, according to claim **3**, wherein:
- said given point occupies a location along an imaginary circle lying concentric with said axis.

**5.** An earth cutter assembly, according to claim **3**, wherein:
- said earth cutters comprise a plurality of earth face cutters; and
- each earth face cutter of said plurality has a cutting surface which defines a complement of said symmetrical arc.

**6.** An earth cutter assembly, according to claim **1**, wherein:
- said mounting means comprises means which replaceably fixes said earth cutters of said plurality upon a surface of said cutterhead in a predetermined pattern which insures an engagement of substantially all of said earth formation face by said earth cutters upon rotation of said cutterhead.

**7.** An earth cutter assembly, according to claim **6**, wherein:
- said plurality of earth cutters comprises a first set of earth cutters and a second set of earth cutters; and
- all earth cutters of one of said first and second sets are of common overall dimensions, are selectively interchangeable, any one thereof with any other thereof with respect to said pattern, and are cooperative, with the earth cutters of the other of said first and second sets, in any selectively interchanged position, to maintain definition of said overall circular and convex cutting surface.

**8.** An earth cutter assembly, according to claim **6**, wherein:
- said pattern defines a space in the axial center of said cutterhead which is devoid of earth cutters; and
- said drive stem receiving means is located in said axial center for fixedly engaging a drive stem.

**9.** An earth cutter assembly, according to claim **8**, wherein:
- said drive stem receiving means comprises a borehole formed in said cutterhead for receiving a drive stem therewithin.

**10.** An earth cutter assembly, according to claim **6**, wherein:
- said earth cutters of said plurality comprise roller cutters having rotary axes;
- said roller cutters are all replaceably fixed upon said cutterhead surface by said mounting means only.

**11.** An earth cutter assembly, according to claim **10**, wherein:
- said mounting means comprise shaft members each of which carries one of said roller cutters rotatable thereon;
- said shaft members for respective roller cutters, are variously longitudinally disposed, relative to said axis, from a plane perpendicular to said axis to a plane inclined at least 45½° to the horizontal.

**12.** An earth cutter assembly, according to claim **10**, wherein:
- said roller cutters each have a plurality of earth-cutter elements circumferentially carried thereabout;
- said elements being effective, with rotation of said body, to define concentric rows of earth cutters about said rotary axis of said body; and
- given ones of said elements of certain roller cutters track in, and cooperate to define rows in which other said elements of other roller cutters track.

**13.** A roller earth face cutter, for use with others thereof in a patterned array on a rotatable cutterhead for cooperative, rotary boring of the face of an earth formation to form at least one, overall circular and concave cut in said face; comprising:
- a roller cutter body having a rotary axis and an earth face engaging surface;
- said body further having relieved areas formed therewithin for receiving supporting means, for mounting said body on a rotatable cutterhead together with other roller earth face cutters; and
- said body further having earth cutting means disposed about its earth-face-engaging surface;
- said earth cutting means comprise means effective for cutting an arcuate kerf, in the face of the formation, which kerf defines a complementary portion of said one overall circular and concave cut.

**14.** A roller earth face cutter, for use with others thereof in a patterned array on a rotatable cutterhead for cooperative, rotary boring of the face of an earth

formation to form at least one, overall circular and concave cut in said face; comprising:

a roller cutter body having a rotary axis and an earth face engaging surface;

said body further having relieved areas formed therewithin for receiving supporting means, for mounting said body on a rotatable cutterhead together with other roller earth face cutters; and

said body further having earth cutting means disposed about its earth-face-engaging surface;

said earth cutting means comprise means effective for cutting an arcuate kerf, in the face of the formation, which kerf defines a complementary portion of said one overall circular and concave cut; wherein

said body has a plurality of rows of drill holes formed in said earth face engaging surface;

said body further has a first portion of uniform outside diameter extending from one axial end of said body to an intermediate area of said body, and at least a second, substantially conical portion, extending from the opposite axial end of said body to an intermediate area of said body;

at least one row of drill holes of said plurality thereof is formed in said first portion;

at least one other row of drill holes of said plurality thereof is formed in said second portion;

said earth cutting means comprise earth cutter inserts fixed in said drill holes;

said inserts are all of uniform length, and have earth-cutting working ends and non-working ends opposite thereto; and

said non-working ends of all said inserts are bottomed in said drill holes, and said working ends, from row to row, project diverse radial distances from said axis.

**15.** An earth face cutter, according to claim **14**, wherein:

said body has at least three rows of drill holes formed in said outer surface;

all drill holes of at least one row of said three rows thereof are perpendicular to said axis; and

all drill holes of at least another row of said three rows thereof are obliquely disposed relative to said axis.

**16.** An earth cutter assembly, for rotary boring of the face of earth formations, comprising:

roller earth cutters, for distintegrating the earth formation face:

a rotatable cutterhead having a rotary axis, for supporting said roller earth cutters;

said cutterhead having means for couplingly receiving a drive stem for imparting rotary drive to said cutterhead; and

means mounting said roller earth cutters only to said cutterhead for rotation therewith; wherein

said mounting means is cooperative with said roller earth cutters to cause said roller earth cutters effectively to define a cutting surface, about said axis, upon rotation of said cutterhead, which surface has two, overall circular and convex portions.

**17.** An earth cutter assembly, according to claim **16**, wherein:

said two convex portions each have a convexity which defines a symmetrical arc; and

said arcs, taken at any given place along the circular disposition of said portions, have a radius originating at given points spaced radially from said axis.

**18.** An earth cutter assembly, according to claim **17**, wherein:

said given points are spaced apart and are perpendicularly in line relative to said axis.

**19.** An earth cutter assembly, according to claim **17**, wherein:

said given points are spaced apart and are obliquely in line relative to said axis.

**20.** An earth cutter assembly, for rotary boring of the face of earth formations, comprising:

roller earth cutters, for distintegrating the earth formation face;

a rotatable cutterhead having a rotary axis, for supporting said roller earth cutters;

said cutterhead having means for couplingly receiving a drive stem for imparting rotary drive to said cutterhead; and

means mounting said roller earth cutters only to said cutterhead for rotation therewith; wherein

said mounting means is cooperative with said roller earth cutters to cause said roller earth cutters effectively to define a cutting surface about said axis, upon rotation of said cutterhead, which surface has at least one, overall circular and convex portion, and at least one, overall circular and concave portion.

**21.** An earth cutter assembly, according to claim **18**, wherein:

said mounting means is cooperative with said roller earth cutters to cause said roller earth cutters effectively to define said cutting surface with at least one, overall circular and flat cutting portion, contiguous with at least one of said two convex portions and concentric with said axis, upon rotation of said cutterhead.

* * * * *