

[54] INSERT CUTTER FOR CUTTING KERFS
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75232

3,666,029 5/1972 Dixon 175/374
3,679,009 7/1972 Goodfellow 175/374
3,786,879 1/1974 Murdoch 175/374
3,791,465 2/1974 Metge 175/373

[22] Filed: Aug. 20, 1973

Primary Examiner—David H. Brown
Attorney, Agent, or Firm—Eddie E. Scott

[21] Appl. No.: 389,742

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 251,607, May 8, 1972, abandoned.

[52] U.S. Cl. 175/374, 175/410

[51] Int. Cl. E21b 9/10, E21b 9/36, E21c 13/01,
E21c 13/02

[58] Field of Search 175/371-374,
175/351, 354, 410

[56] References Cited

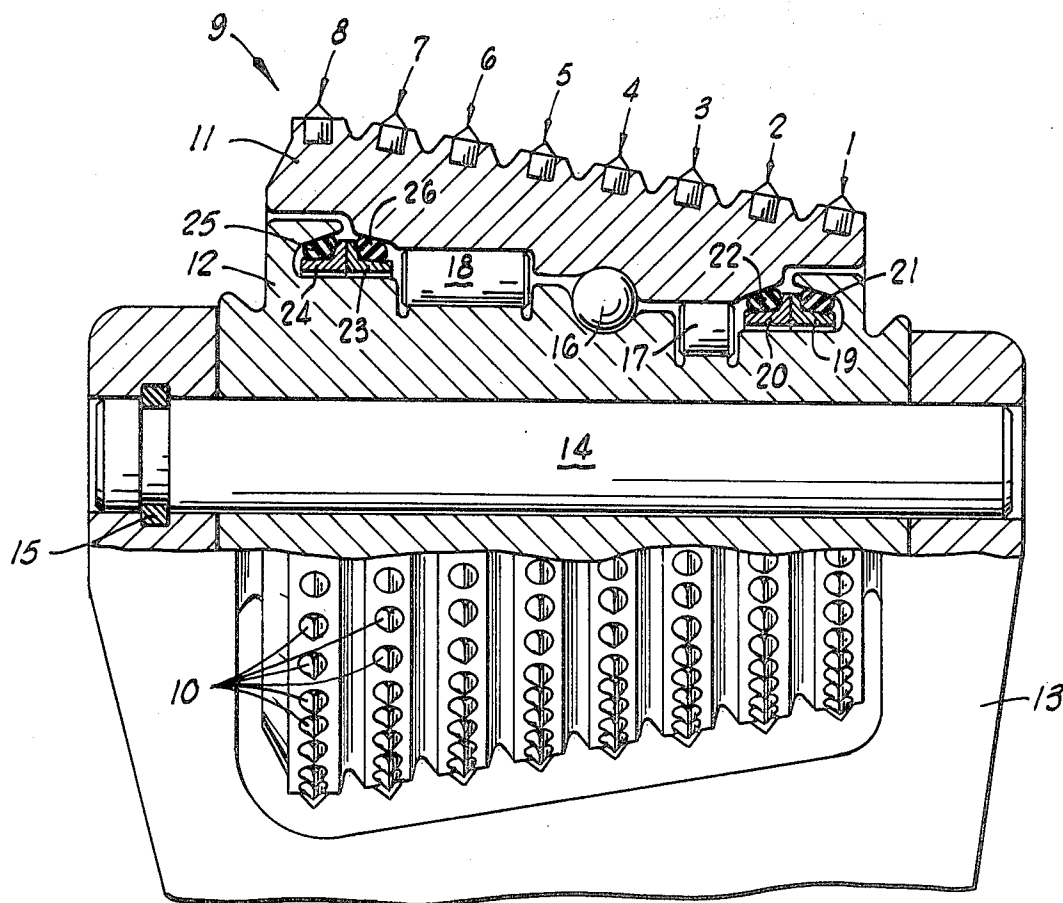
UNITED STATES PATENTS

2,121,202	6/1938	Killgore	175/410 X
2,687,875	8/1954	Morlan et al.	175/410 X
3,216,513	11/1965	Robbins et al.	175/227
3,570,613	3/1971	Coski	175/374
3,572,452	3/1971	Winberg	175/371
3,593,812	7/1971	Peterson	175/354
3,596,724	8/1971	Bechem	175/410 X

[57] ABSTRACT

An insert cutter for an earth boring machine that functions to form a plurality of circular kerfs in the earth formations being bored thereby fracturing the portion of the formations between a proximate pair of kerfs and causing fragments of the formations to be separated from the formations being bored. A multiplicity of annular rows of tungsten carbide inserts are positioned in the cutter body thereby simulating the formation loading of a disk cutter. Each insert has an elongated formation contacting head and all of the heads of the inserts in an annular row are aligned. An annular row of inserts functions to form a circular kerf in the earth formation being bored as the cutter is moved along the formation. The cutting structure interruption (C.S.R.) in an annular row of inserts is less than the pitch cord (P.C.) of the annular row.

15 Claims, 7 Drawing Figures



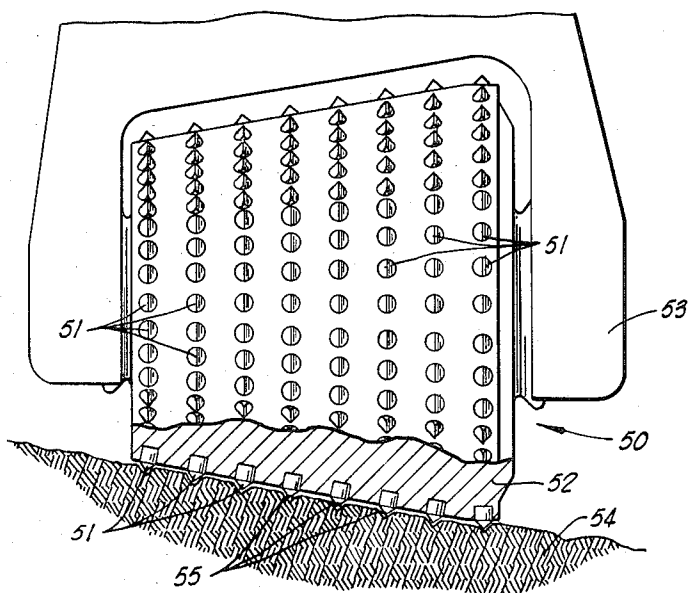


FIG. 1

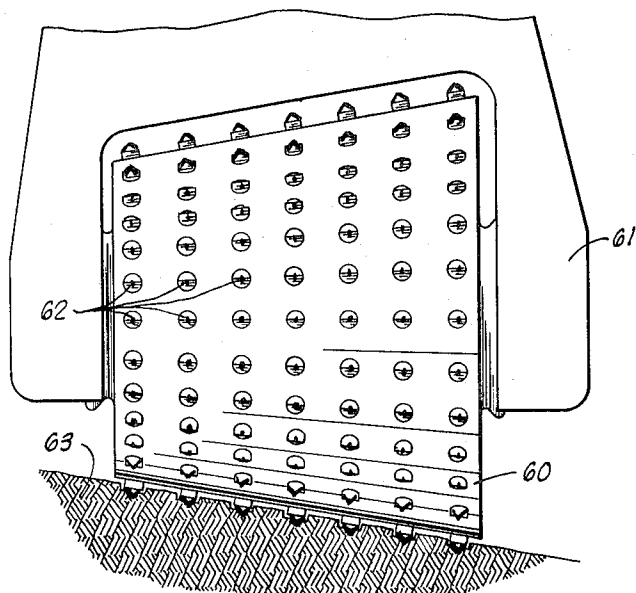


FIG. 3
PRIOR ART

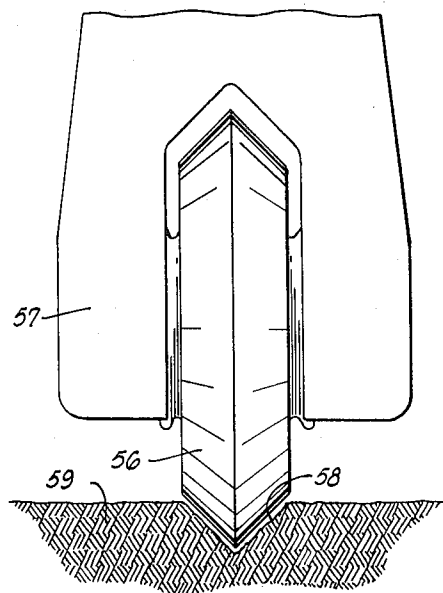


FIG. 2
PRIOR ART

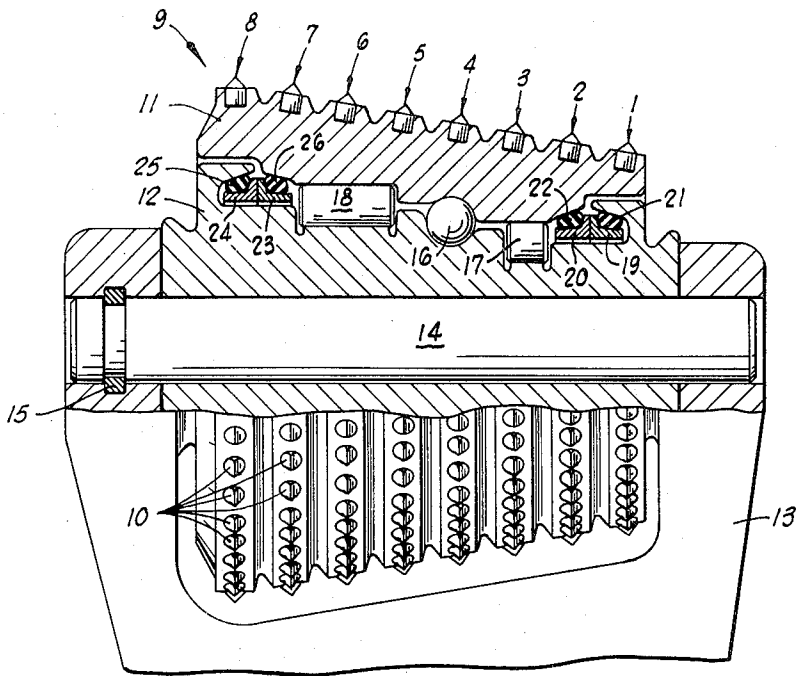


FIG. 4

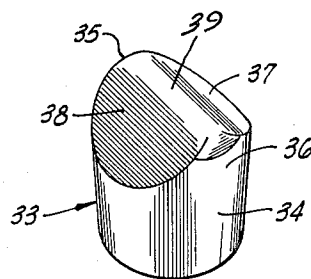
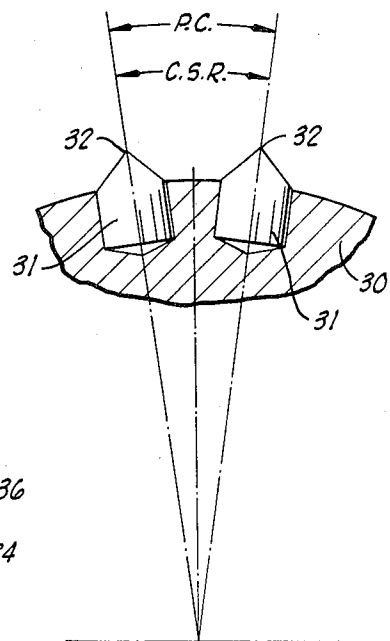
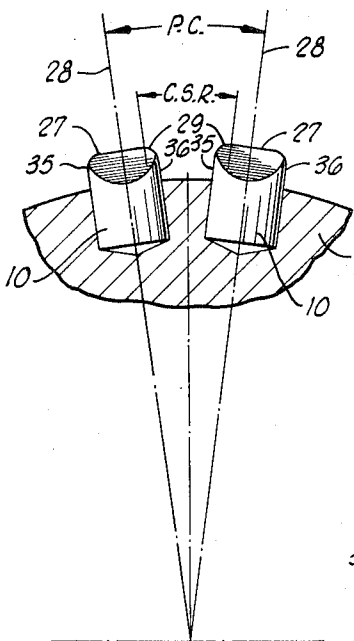


FIG. 5

FIG. 7

FIG. 6

PRIOR ART

INSERT CUTTER FOR CUTTING KERFS

BACKGROUND OF THE INVENTION

This is a continuation-in-part of application Ser. No. 251,607, filed May 8, 1972 now abandoned. The present invention relates to the art of earth boring and, more particularly, to an insert cutter for cutting kerfs in the formations being bored.

Conventionally, rotary drilling apparatus and, particularly rotary drilling apparatus for boring large diameter holes and tunnels, includes a multiplicity of roller cutters. These roller cutters are formed of either conical, cylindrical or disk configuration. A number of the roller cutters together with their bearings and the saddles or arms in which the cutters and bearings are supported are mounted on a rotary head or bit and used to form holes in the formations being bored. The roller cutters may be conveniently mounted on the rotary cutting head of a tunneling machine or on the body of a raise bit and are adapted to be easily and quickly interchanged.

A tooth-type or insert roller cutter generally ranges from a cylindrical configuration to a somewhat conical configuration and includes milled steel teeth or carbide inserts on the cutting surface. This type of cutter is adapted for cutting formations ranging all of the way from very soft to extremely hard. The tooth-type roller cutter is usually a full face cutter, i.e., it is paired with another cutter to insure that the bottom is well covered by the cutter teeth which will tear out, scrape out or crush out individual areas of the formation to be bored. As a formation becomes very hard and abrasive, the cutting structure usually employs sintered tungsten carbide buttons or tooth-shaped inserts. The formation being bored sees the cutting structure as a multiplicity of point load contacts each one spalling out a relatively small circle of bottom. The bottom does not completely break out between rows, and it is necessary to run a paired cutter with compacts spaced to cut the spaces (or uncut bottom) between the rows on the previous cutter. This type of cutter arrangement requires a pair of cutters to completely destroy bottom in one revolution.

A disk-type cutter is effective in very soft to medium formations. The disk is usually a heat treated alloy steel cutter with an inclined angle between about 60° and 90°. The disk cutters are usually indexed 2 or 3 inches apart. In effect, the disk cutters plow concentric circles around the face of the formation being bored. The cutting disks are indexed so that the formation between disks will break out completely under a given load and RPM. This is a very efficient way to cut formations because the cuttings come off the face in relatively large pieces instead of the small cuttings obtained from tooth-type cutters with the full face cutting principal. Disk cutters have not been economical in hard formations because the alloy steel disk dulls out quickly in the harder abrasive formations. This is especially detrimental in a shaft drilling or raise drilling operation where trip time is costly. It is not practical to make the disks completely of carbide and the brazing on of continuous sintered carbide tips or wedges is also of questionable feasibility from an economical and operational standpoint.

The present invention may be advantageously used on tunneling machines, continuous mining machines, raise drills, rock bits, and other types of earth boring

bits and machines. The cutter of the present invention is rotatably connected to the bit or the rotary head of the earth boring machine and serves to cut a series of kerfs in the formations being bored.

DESCRIPTION OF THE PRIOR ART

A general understanding of the prior art relating to tooth-type or insert cutters may be obtained from a consideration of the disclosures of the following U.S. Patents in U.S. Pat. No. 3,389,760 to W. V. Morris, patented June 25, 1968, a toothtype rolling cutter is shown. This cutter may include either inserts or steel teeth on the cutting surface. In U.S. Pat. No. 3,570,613 to W. D. Coski, patented March 16, 1971, a gage cutter for an earth boring machine is shown. The cutter includes a plurality of rows of cutter elements about the periphery thereof with the rows being of such size and position so as to define an oblate cylinder cutting envelope or plane to equalize the load on the cutting elements. In U.S. Pat. No. 3,593,812 C. R. Peterson, patented July 20, 1971, a rock cutter is shown. The cutter is formed of a stack of juxtapositioned cutter disks with said disks each having projecting carbide bits.

A representative indication of the prior art relating to disk-type cutters is obtainable from a consideration of the disclosures of the following U.S. Patents. In U.S. Pat. No. 2,766,977 to J. S. Robbins patented Oct. 16, 1956, a rotary cutter head for boring type continuous mining machines is shown. A multiplicity of disk-type cutters are mounted on the rotary head of the mining machine for contacting and disintegrating the formations. In U.S. Pat. No. 3,216,513 to R. J. Robbins et al., patented Nov. 9, 1965, a disk-type cutter assembly for rock drilling is shown. The disk cutter includes a plurality of relatively hard tooth members embedded in the disk cutting edge which facilitates the kerf forming action of the cutter and improves the cutter edge life. In U.S. Pat. No. 3,139,148 to J. S. Robbins, patented June 30, 1964, a rotary boring head having roller cutter disks is shown. The disks are adapted to contact and disintegrate the formations. In U.S. Pat. No. 3,596,724 to K. G. Beecham patented Aug. 3, 1971, a cutting roller for use in rock boring equipment and having two circumferentially extending parallel ribs is shown. Each of the ribs is provided with a series of wear resistant exchangeable inserts which protect the crown and flank surfaces of the rib against wear. In U.S. Pat. No. 3,430,718 to J. C. Lawrence, patented Mar. 4, 1969, a roller cutter for rotary drilling apparatus is shown. The roller cutter includes a circumferential cutting edge located in a plane which intersects the axis of the cutter at an oblique or acute angle. A plurality of cutting points, preferably formed from embedded carbide inserts, are positioned in the rim of the cutter body. In U.S. Pat. No. 3,572,452 to D. F. Winberg, patented Mar. 30, 1971, a roller cutter is shown with a bit in the form of a ring or disk, encircling the roller cutter. The cutting edge of the bits are formed by two flat surfaces that may be considered to be planes which rise to an edge.

SUMMARY OF THE INVENTION

The present invention provides an insert cutter that will serve to cut kerfs in the formations being bored. At least one annular row of inserts is positioned in the cutter body and the annular row of inserts simulates the formation loading of a continuous disk. The inserts

have an elongated formation contacting head portion and the elongated head portions of the inserts in the annular row are aligned. The cutting structure interruption in said annular row of inserts is less than the pitch cord of said annular row of inserts. The cutter of the present invention will entirely disintegrate a swath of formation in a single rotation of the cutter head and therefore will operate effectively without being paired with another cutter.

The aforementioned advantages of the present invention and other features and advantages will become apparent from a consideration of the following detailed description of the invention when taken in conjunction with the drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 illustrates a cutter of the present invention contacting a formation.

FIG. 2 illustrates a prior art disk cutter contacting a formation.

FIG. 3 illustrates a prior art insert cutter contacting a formation.

FIG. 4 is an illustrative view of an insert cutter constructed in accordance with the present invention positioned in a saddle that is adapted to be connected to the rotary head of an earth boring machine.

FIG. 5 is an end view of a portion of the cutter of FIG. 4 showing the cutting structure interruption of the inserts.

FIG. 6 is an illustrative end view of a portion of a cutter of the prior art showing structure interruption of the inserts.

FIG. 7 is a perspective view illustrating one of the inserts of the cutter shown in FIG. 4.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to FIG. 1, the operation of a cutter constructed in accordance with the present invention is illustrated. The cutter, generally designated by the reference number 50, includes a multiplicity of tungsten carbide inserts 51 arranged to form a series of annular rows. The individual inserts 51 are mounted in a cutter shell 52. The cutter shell 52 is rotatably mounted in a saddle 53. The saddle 53 may be connected to the rotary head of an earth boring machine or to the body of an earth boring drill. The annular rows of inserts act upon the formation 54 to form a multiplicity of kerfs 55. The desired hole is formed by continually cutting a multiplicity of circular kerfs in the earth formations being bored, thereby fracturing the portion of the formations between a proximate pair of kerfs and causing fragments of the formations to be separated from the formations being bored.

Referring now to FIG. 2, a prior art disk cutter is shown. The cutting action of a disk cutter has been described by Frank F. Roxborough and Alan Rispin in the article, "The Mechanical Cutting Characteristics of the Lower Chalk" in *Tunnels and Tunneling*, Jan. 1973 as follows:

"A solid steel disc with a pointed circumferential edge. The disc operates as a free rolling wheel in which a high thrust forces the sharpened circumference to penetrate the rock face. A superimposed translatory motion causes the disc to roll, gouging a furrow in the rock in much the same way as a heavily loaded wheel rolling over yielding ground."

The disk 56 shown in FIG. 2 is rotatably mounted in a saddle 57. The saddle 57 may be connected to the rotary head of an earth boring machine or to the body of an earth boring drill. The disk 56 forms a kerf 58 in the formation 59.

Referring now to FIG. 3, a prior art insert cutter is illustrated. The cutting action of an "insert cutter" or "button cutter" has been described by Frank F. Roxborough and Alan Rispin in the article, "The Mechanical Cutting Characteristics of the Lower Chalk" in *Tunnels and Tunneling*, Jan. 1973 as follows:

"This is very much a grinding tool. It usually takes the form of a free rolling cylinder or cone frustum, the surface of which is studded with tungsten carbide buttons. It is operated in a similar fashion to the disc and roller cutter. A high penetrating force into the rock surface, supplemented by a translatory motion to the tool, causes rock degradation by grinding and pulverisation."

The insert cutter 60 is rotatably mounted in a saddle 61. The saddle 61 may be connected to the rotary head of an earth boring machine or to the body of an earth boring bit. A multiplicity of inserts 62 project from the surface of the cutter 60. The inserts 62 act upon the formation 63 to crush out individual areas of the formation to be bored thereby forming the desired hole.

Referring now to FIG. 4, a cutter constructed in accordance with the present invention is illustrated. The cutter includes a multiplicity of carbide inserts arranged to form a series of annular rows 1 through 8. The cutter, generally designated by the reference numeral 9, includes 350 individual sintered tungsten carbide inserts, each designated by the reference numeral 10, mounted in a cutter shell 11. The cutter shell 11 is positioned around a bearing shell 12 and bearing shell 12 is securely locked in a saddle 13. The saddle 13 may be connected to the rotary head of an earth boring machine or to the body of an earth boring bit. It is to be understood that the cutter 9 could also be in the form of a conical cutter adapted to be journaled on one of the arms of a rotary rock bit. It is also to be understood that the cutter 9 could be constructed to include a single annular row of inserts for forming a single kerf in the formations and that the cutter 9 could cooperate with another cutter to fracture the formations between a pair of kerfs.

The bearing shell 12 is locked in position in the saddle 13 by a main pin 14 and a retainer nail or roll pin 15. The bearing shell 12 remains firmly locked in place throughout the drilling operation due to a tenon and groove arrangement disclosed in U.S. Pat. No. 3,203,492 to C. L. Lichte, patented Aug. 31, 1965. A multiplicity of bearing systems including a series of ball bearings 16, a series of inner roller bearings 17 and a series of outer roller bearings 18 promote rotation of the cutter shell 11 about the bearing shell 12. Lubricant is retained in the bearing area by two sets of seal elements. The inner set of seal elements includes a pair of annular metal seal rings 19 and 20 that are positioned near the inner end of the cutter 9. A flexible rubber O-ring 21 is positioned between seal ring 19 and the bearing shell 12 to retain the seal ring 19 in the desired position and resiliently urge seal ring 19 against seal ring 20. A flexible rubber O-ring 22 is positioned between the cutter shell 11 and the seal ring 20 to retain the seal ring 20 in the desired position and resiliently urge the seal ring 20 against seal ring 19. The outer set of seal

elements includes a pair of annular metal seal rings 23 and 24 that are positioned near the outer end of the cutter 9. A flexible rubber O-ring 25 is positioned between the seal ring 24 and bearing shell 12 to retain the seal ring 24 in the desired position and resiliently urge seal ring 24 against seal ring 23. A flexible rubber O-ring 26 is positioned between the cutter shell 11 and the seal ring 23 to retain seal ring 23 in the desired position and resiliently urge seal ring 23 against seal ring 24.

Referring now to FIG. 5, an end view of a portion of the cutter shell 11 is shown in partial section. Two adjacent inserts 10 are shown positioned in the cutter shell 11. Each of the inserts 10 have an elongated head portion 27 that is adapted to contact the formations. The distance between each of the central axes 28 of the two adjacent inserts 10 measured at the respective heads 27 is defined as the pitch cord (P.C.). The P.C. of inserts 10 is eight-tenths of an inch. The distance between the nearest points 29 of adjacent head portions 27 of the inserts 10 is defined as the cutting structure interruption (C.S.R.). The C.S.R. of inserts 10 is one-half of an inch. The C.S.R. of cutter shell 11 is therefore less than the P.C. of the cutter shell 11. The elongated head portions 27 of the inserts 10 are aligned to simulate the formation loading of a disk cutter. To insure the proper formation loading, the C.S.R. of inserts 10 should be within the range of from three-eighths of an inch to five-eighths of an inch. It will therefore be appreciated that the C.S.R. of the inserts 10 should be less than 78% of the P.C. to obtain the proper formation loading. When the C.S.R. is a maximum (five-eighths inch) it will be approximately 78% of the P.C. (eight-tenths inch). As shown in FIG. 5, the C.S.R. is approximately 62.5%. Cutters within the aforementioned range have been found to obtain faster penetration rates than prior art insert cutters and to have a longer lifetime than prior art disk cutters.

Referring now to FIG. 6, an end view of a portion of prior art cutter 30 is shown in partial section. Two adjacent inserts 31 are shown positioned in the cutter 30. The head portion 32 of each of the inserts 31 are relatively pointed and are clearly distinct from the elongated head portion of the inserts shown in FIG. 2. In general the head portions of prior art inserts have been pointed or rounded; however, in some instances, the head portions have been in the form of a chisel-shaped head. The chisel-shaped head inserts of the prior art have not been arranged to have the heads in each annular row aligned and the specific shape of the prior art chisel-shaped head inserts has been distinct from the shape of inserts 10. It should be noted that the C.S.R. and P.C. of the prior art cutter 30 are substantially equal.

Referring now to FIG. 7, a single insert 33 constructed in accordance with the present is illustrated. The insert 33 has a cylindrical body 34 adapted to be secured in a cutter such as the cutter 9 shown in FIG. 4. The upper end of the insert 33 forms a chisel-shaped formation contacting head. The leading flank 35 and the trailing flank 36 are substantially parallel whereas the inner flank 37 and the outer flank 38 tend to converge. The prior art chisel-shaped head inserts include leading flanks and trailing flanks that are inclined compared to the substantially parallel leading and trailing flanks of insert 33. This provides the head portion of the insert 33 with an elongated formation contacting surface 39. The elongated formation contacting surface

39 of the inserts in each annular row are aligned to simulate the formation loading of a disk cutter.

The structural details of a cutter constructed in accordance with the present invention having been described, the operation of the cutter 9 will now be considered. The saddle 13 is connected to a rotary drilling head or bit and the head or bit is rotated and moved through the formations. The inserts 10 contact the formations and form a plurality of circular kerfs therein. The portions of the formations between adjacent kerfs tend to fracture out and the fragments are separated from the formations being bored to form the desired hole or tunnel. The elongated heads 27 of the inserts 10 in each annular row (1 through 8) simulate a continuous line contact with the formations rather than the point contacts known in the prior art. The continuous line contact serves to form individual kerfs in the formations being bored. The cutter 13 will therefore disintegrate a complete swath of formation with a single rotation of the rotary head or bit thereby eliminating the need for a training or paired cutter.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. An earth boring cutter that functions to form at least one kerf in the formations being bored, comprising:

a cutter body, said cutter body having an annular cutter body surface; and

at least one annular row of insert means projecting from said cutter body for forming a kerf in the formation being bored, said at least one annular row of insert means including a multiplicity of individual non-hollow inserts which said inserts having cylindrical body portions extending into said cutter body below said annular cutter body surface and head portions extending substantially above said annular cutter body surface with said head portions having elongated formation contacting surfaces with said elongated formation contacting surfaces being aligned to form a kerf in the formations being bored.

2. The earth boring cutter of claim 1 where said inserts have a cutting structure interruption that is less than five-eighths inch.

3. The earth boring cutter of claim 2 wherein said inserts have a cutting structure interruption that is less than 75% of the pitch cord.

4. The earth boring cutter of claim 3 wherein said inserts have a cutting structure interruption that is less than 70% of the pitch cord.

5. The earth boring cutter of claim 4 where said inserts have a cutting structure interruption that is approximately 62.5% of the pitch cord.

6. An earth boring cutter that functions to form at least one kerf in the formations being bored, comprising:

a cutter body, said cutter body having an annular cutter body surface; and

at least one annular row of solid inserts projecting from said cutter body for forming a kerf in the formation being bored, said inserts having a cylindrical body portion extending into said cutter body below said annular cutter body surface, a head portion extending substantially above said annular cutter body surface, a leading flank, a trailing flank, an inner flank and an outer flank, with said leading

flank and trailing flank being substantially parallel and said inner and outer flanks substantially meeting to form a formation contacting surface with said formation contacting surfaces being in a common plane.

7. The earth boring cutter of claim 6 where said inserts have a cutting structure interruption of less than one-half inch.

8. The earth boring cutter of claim 7 wherein said inserts have a cutting structure interruption of less than three-eighths inch.

9. A cutter for an earth boring machine wherein said cutter is adapted to be mounted upon a rotary unit of the earth boring machine with said rotary unit functioning to form a multiplicity of circular kerfs in the earth formation being bored to fracture the portion of the formations between a proximate pair of said kerfs in a manner to cause fragments of the formations to be separated from the formations being bored, comprising:

a cutter body, said cutter body having an annular surface; and

at least two annular rows of insert means connected to said cutter body and projecting from said annular surface for forming at least two circular kerfs in the earth formations being bored, said at least two annular rows of insert means including a multiplicity of individual solid inserts with said inserts having a cylindrical body portion embedded in said cutter body below said annular surface, a head portion projecting outward substantially above said annular surface, and an elongated formation contacting surface with the elongated formation contacting surfaces of all the inserts in annular row being aligned to form a circular kerf in the earth formations being bored.

10. The cutter of claim 9 wherein said inserts have a cutting structure interruption that is less than 75% of the pitch cord.

11. The cutter of claim 10 wherein said inserts have

a cutting structure interruption that is less than 70% of the pitch cord.

12. The cutter of claim 11 wherein said inserts have a cutting structure interruption that is approximately 62.5% of the pitch cord.

13. A cutter for an earth boring machine wherein said cutter is adapted to be mounted upon a rotary unit of the earth boring machine with said rotary unit functioning to form a multiplicity of circular kerfs in the earth formations being bored to fracture the portion of the formations between a proximate pair of said kerfs in a manner to cause fragments of the formations to be separated from the formations being bored, comprising:

a cutter body, said cutter body having an annular plane surface; and

at least two annular rows of solid inserts connected to said cutter body and projecting from said annular plane surface for forming at least two circular kerfs in the earth formations being bored, said inserts having cylindrical body portions extending into said cutter body below said annular plane surface and head portions extending substantially above said annular plane surface with said head portions having elongated contacting surfaces with said elongated formations contacting surfaces in an annular row being aligned to form circular kerfs in the formations being bored to fracture the portion of the formations between proximate kerfs, said inserts having a cutting structure interruption that is less than five-eighths inch.

14. The cutter of claim 13 wherein said inserts have a cutting structure interruption that is less than one-half inch.

15. The cutter of claim 14 wherein said inserts have a cutting structure interruption that is less than three-eighths inch.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,858,670 Dated Jan. 7, 1975

Inventor(s) Eugene Gray Ott & William Michael Conn

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

On the first page of the patent, after "Inventors:", addresses should be as follow:

--Eugene Gray Ott, 918 Glen Oaks Blvd;
--William Michael Conn, 916 Greencastle,
both of Dallas, Tex. 75232--

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,858,670 Dated Jan. 7, 1975

Inventor(s) Eugene Gray Ott & William Michael Conn

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

- Column 1, line 9: "appartus" should read --apparatus--
- Column 1, line 63: "feasilbity" should read --feasibility--
- Column 2, line 10: Line should read --Patents. In U.S. Pat. No. 3,389,760 to W. V. Mor--
- Column 2, line 20: After "3,593,812" insert --to--
- Column 3, line 32: After "showing" insert --the cutting--
- Column 4, line 11: "Tunnels and Tunneling" should be printed in italics
- Column 4, line 55: "outr" should read --outer--
- Column 5, line 5: "reiliently" should read --resiliently--
- Column 5, line 6: "sal" should read --seal--
- Column 5, line 9: "sal" should read --seal--
- Column 5, line 52: "substantially" should read --substantially--
- Column 5, line 55: After "present" insert --invention--
- Column 6, line 21: "training" should read --trailing--
- Column 7, Claim 7, line 6: "where" should be --wherein--
- Column 8, Claim 13, line 25: After "elongated", insert --formation--
- Column 8, Claim 13, line 26: "formations" should be --formation--

Signed and Sealed this

nineteenth Day of August 1975

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks