March 14, 1967 N. D. BECKER 3,308,897

EARTH CORING PUNCH AND DRIVE APPARATUS THEREFOR

Filed April 6, 1964 3 Sheets-Sheet 1

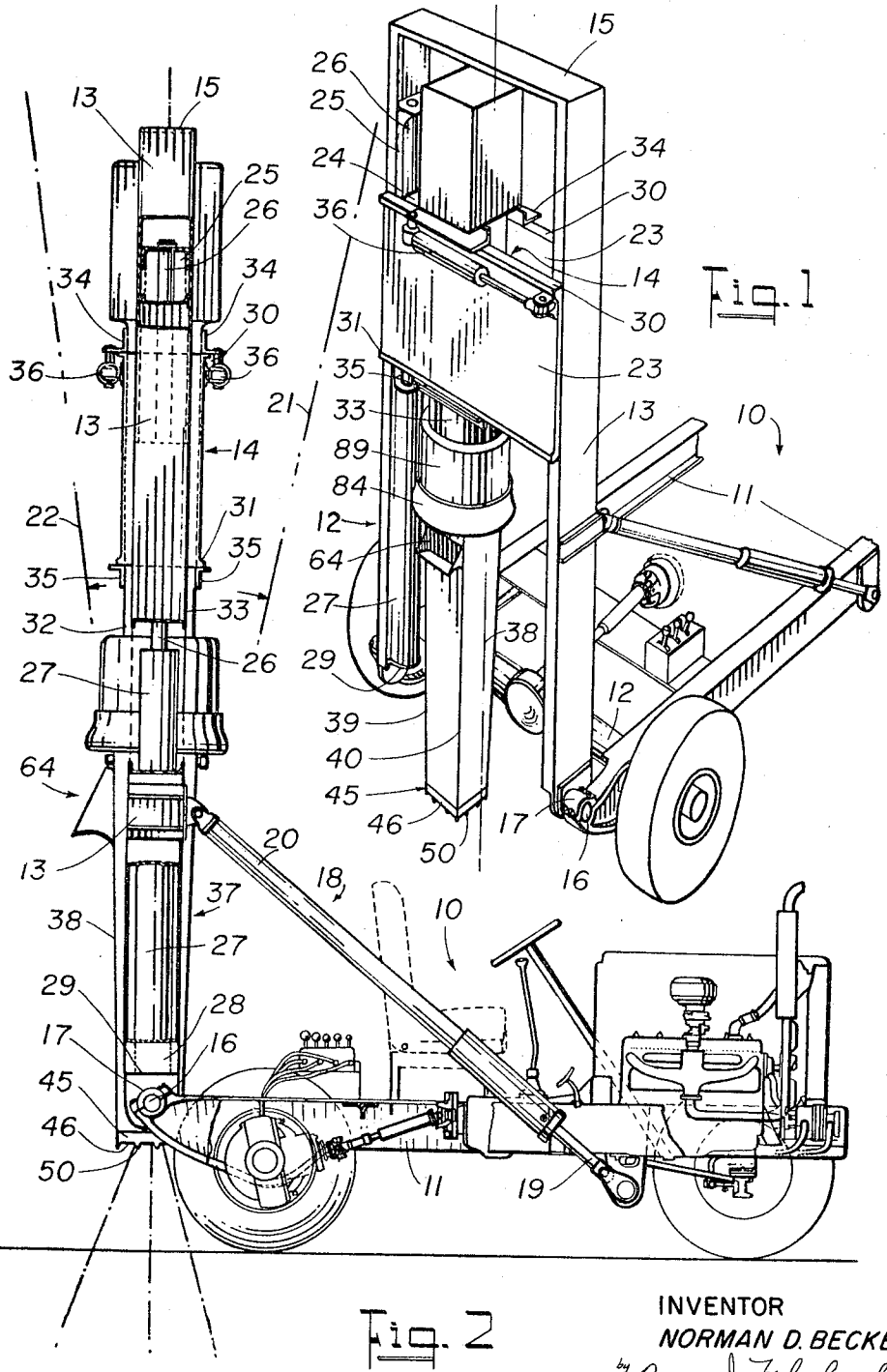



Fig. 1

Fig. 2

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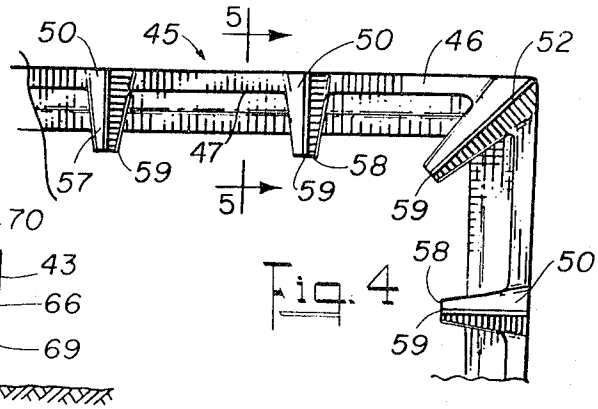



Fig. 4

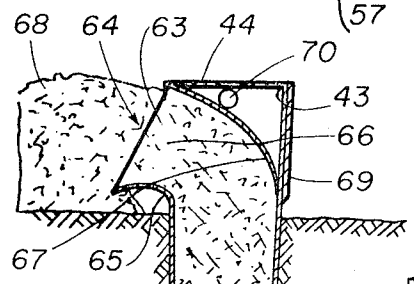
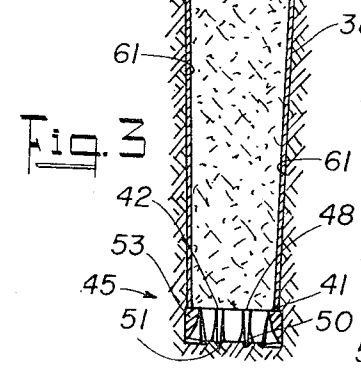



Fig. 3



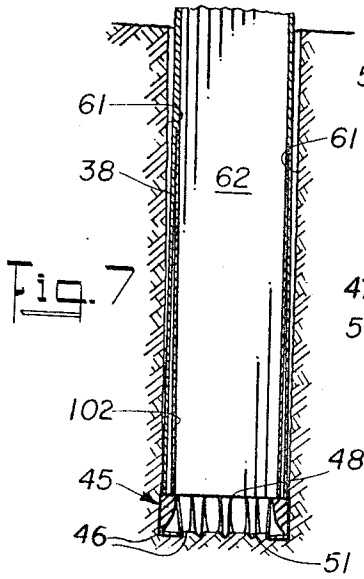




Fig. 7

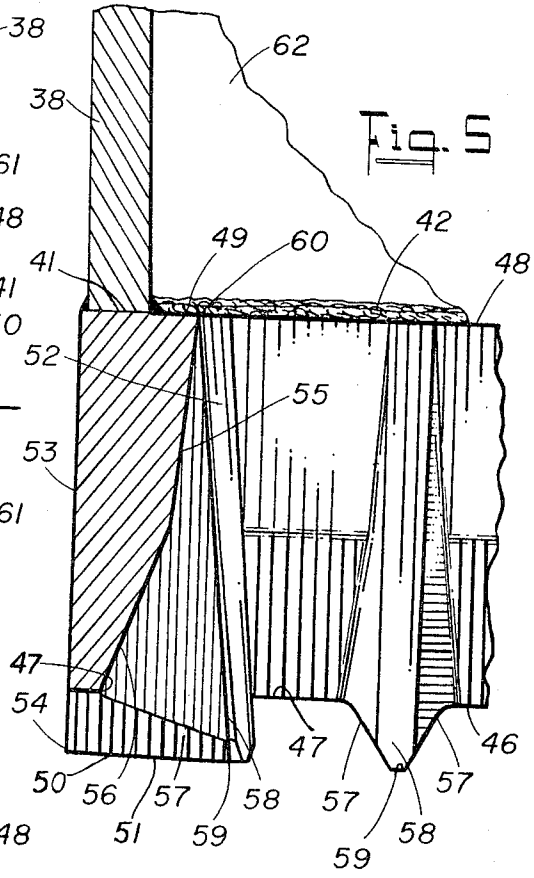



Fig. 5

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EARTH CORING PUNCH AND DRIVE APPARATUS THEREFOR

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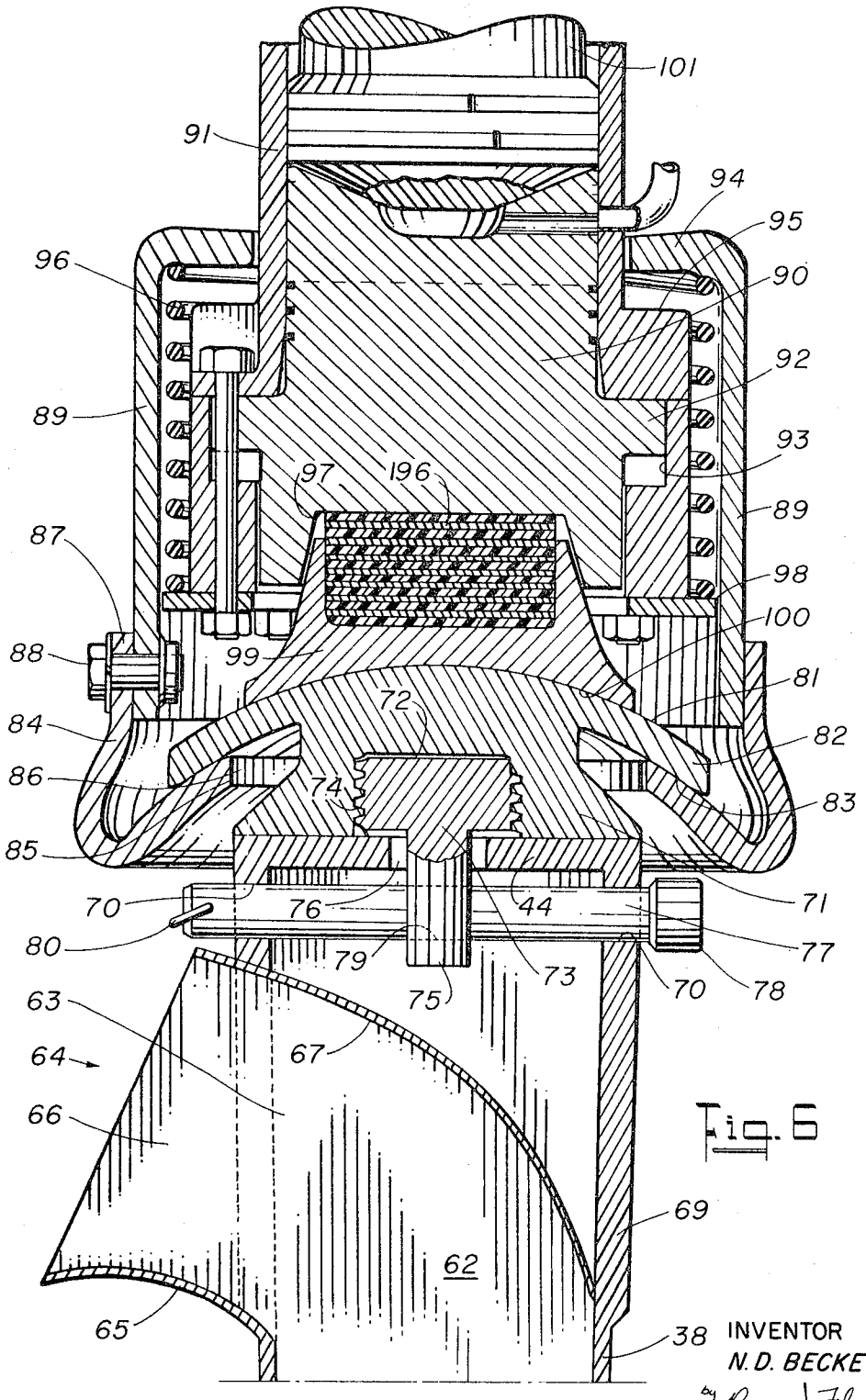



Fig. 6

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United States Patent Office 3,308,897 Patented Mar. 14, 1967



3,308,897

# EARTH CORING PUNCH AND DRIVE APPARATUS THEREFOR

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5 Claims. (Cl. 175—405)

This invention relates to earth excavating tools, and specifically concerns a tubular earth coring punch for penetrating the earth and its associated impact drive apparatus for positioning and driving the punch, as well as apparatus for raising it from the ground.

Heretofore the excavation of holes for setting guard posts or piles in earth or fill which contains coarse gravel or boulders has been costly and slow, requiring rock drills, explosives, and considerable manual labour. While tubular earth corers are known which may be driven by impact means for sampling soils free from stones, these tools are incapable of being driven into stony ground, particularly into rock fill materials used for highway roadbads. The use of rotary or churn drills to sink bore holes in such rock fill, or in any stony ground, wears out bits at relatively high rates, and it is difficult to produce satisfactory holes by such tools. Consequently the placing of support posts for highway guard rails and the like has been an expensive operation.

I have devised a simple yet robust tubular earth coring punch which carries an integral toothed annular shoe secured on the lower margin of a strong tubular casing, and which may have any desired cross-sectional configuration, whether round, oval, rectangular, or polygonal, the punch being carried by a suspension enabling it to be positioned accurately and to be driven into rock fill or even consolidated formations by high energy percussion engine means to the depth required for setting even the largest posts or piles. The earth coring punch of my invention has its internal cross-section so shaped as to retain within the casing substantially the entire volume of rock and earth which passes upward through the shoe opening as it is driven down. Once the punch has been driven to the desired depth, it is pulled up by the suspension means and raised clear of the hole, leaving a clean-walled borehole closely conforming in cross-section to the form of the punch casing, while substantially all of the hole contents are retained inside the punch as a "core." In the digging of a succession of holes by use of the novel tool and method of my invention, the "core" volume held in the punch as a result of a previous hole-sinking operation is discharged from a side opening of the punch at a point above the ground level during its descent while the operation of punching the next hole proceeds.

Such coring punches when designed for unconsolidated ground preferably have a small taper in their side walls, which widen upwardly, so that as the shoe is driven down, the walls of the hole are progressively compacted by the sides of the punch. The resulting bore is smooth-walled and provides rigid support for a post, pillar, pile or column which may be set and tamped in the hole thereafter, using the earth or rock which has been discharged from the side opening and which falls conveniently close to the hole.

It is therefore my principal object in devising the earth perforating tool and support apparatus of my invention, to provide an impact-driven coring punch carrying a toothed annular shoe fixed on its lower end having a cutting edge and transverse spaced teeth, the punch being



adapted to be positioned in depending support relation from and disposed for impact drive by a percussion engine of high power for driving thereby into ground or fill, shattering and occluding stones or boulders encountered in its descent. It is my further and important object to provide a punch casing so shaped as to retain within the casing substantially the entire contents of the hole made by the shoe while the tool is raised.

Essentially my invention consists in a transportable earth-perforating hollow punch having any desired cross-section and any length suitable for the depth of hole to be sunk, detachably carried suspended by its upper end from a high energy percussion engine, and disposed for impact drive thereby, the engine and punch being carried by an adjustable framework mounted in the carrying vehicle and being jointly adjustable in position laterally and vertically, the punch being also independently pivotable about a horizontal axis adjacent its upper end and having its lower end fitted with an integral shoe of annular form carrying integral teeth aligned with the axis of the punch and spaced about the periphery of the shoe. The cutting edge of the shoe lies substantially along the outer margin of the shoe, which thickens upwardly to provide a constricted opening whose cross-sectional area is significantly less than the cross-section at the cutting edge. A series of rock-breaker chisel-like teeth extend inwardly as well as below the cutting edge and project into the opening of the shoe to shatter or otherwise displace rocks in order that the fragments will move up through the shoe.

Among the advantages to be derived from the use of the earth perforating tool and apparatus hereinafter to be described are the ease of accurately positioning the cutting edge with respect to a desired hole position, and the precision of adjustment of tool inclination to the vertical prior to the driving operation. A hole for placing utility poles may be sunk to a typical depth in the range from four to five feet in less than a minute in yielding ground or fine gravels, while in typical roadbed material or rock fill the time required may be as short as two to three minutes. In contrast to these elapsed time intervals, the sinking of a hole in the shoulder of a highway by conventional methods and tools may require upwards of one hour. A succession of holes may each be driven on the average more rapidly than it is possible to move the carrying vehicle into position. There is no loss of time in disposing of the hole contents.

It is an important aspect of my invention that the work of sinking a hole by driving an annular shoe of the shape which I have found to be most efficient and as will be described hereinafter, is a small fraction of the amount of work required to sink a hole by conventional drilling tools. This saving apparently is due to the fact that the work of driving the relatively small cross-section of the cutting edge of the annular shoe to penetrate the undisturbed ground or rock is far less than the work required to grind or reduce to fragments the entire volume of material which is to be removed. It has been found that the total work expended in sinking a square hole of cross-section area one square foot is considerably less than the work which would be required to drill a hole whose cross-sectional area is equal to the projected area of the shoe, which for the embodiment referred to was thirty-five square inches. Economies in fuel consumption are therefore realized.

It is also an advantage of the present invention that holes may be sunk rapidly at substantial inclinations to the vertical, as for example beneath a curb or wall, to provide access to underground service lines and the like.

The foregoing and further advantages and features characterizing my invention will become more directly apparent from a study of the following description of its

preferred embodiments which are described in conjunction with the accompanying drawings, wherein:

FIGURE 1 is a perspective view showing a punch coring tool according to the invention as mounted on a carrying vehicle, suspended from a percussion drive engine;

FIGURE 2 is a side elevation view of the apparatus of FIGURE 1 showing the tool in raised position in relation to tilt ranges, the support columns being partly cut away for clarity;

FIGURE 3 shows a punch coring tool in vertical axial cross-section, as driven into the ground, excluding drive or support apparatus for clarity;

FIGURE 4 shows the punch shoe in bottom plan view;

FIGURE 5 is an enlarged scale cross-section of the shoe of FIGURE 4 taken on line 5—5 thereof;

FIGURE 6 is a vertical diametral sectional view through the upper end of the punch coring tool and the coupling by which it is adjustably supported from the drive engine; and,

FIGURE 7 shows an alternative form of punch corer having interior and exterior cross-sectional areas of its shank of opposite taper.

Referring to the drawings, FIGURES 1 and 2, a transportable coring punch according to the invention comprises a wheeled, self-propelled carrying vehicle generally designated **10**, having horizontal frame beams **11** carrying a punch tool assembly generally designated **12**, together with associated operating elements and conventional engine, transmission, and steering means, for powering the apparatus and moving it about from one location to another. An elongate punch-suspending framework comprising spaced upright side columns **13** and transverse upper bracing element **15** is pivotably supported by its lower ends upon pivot axles **16**. The latter are short stub shafts projecting outwardly from the side columns and are journalled in bearings **17** fixed on the rearwardly-extending ends of the vehicle frame beams **11**.

As may best be understood by reference to FIGURE 2 the inclination of the framework about a pivot axis in bearings **17** may be adjusted by actuation of a linear hydraulic motor **18** whose rod extension **19** is pivotably connected by one end in the forward part of the vehicle frame member and whose cylinder extension **20** is pivotably connected by a remote end with a column. It will be seen that the center line of the support framework may be varied between a forward position indicated by dashed line **21** and a rearward position indicated by dashed line **22**, affording a range of fore-and-aft angular positions of at least twenty degrees arc.

The adjustably positionable upright framework supports a vertically movable open-ended box-like slide structure designated **14**, comprising front and back vertical cover panels **23**, and integral vertical joining end members **24**. The latter are suspended from upwardly extending tension struts **25** slidably received within the side columns **13**, which preferably are of channel form. The upper ends of tension struts **25** are in turn carried by the upper ends of movable piston rods **26**. Each of the pair of cylinders **27** from which piston rods **26** are reciprocably extensible has its base **28** supported in a bracket **29** secured in the lower end of a respective side column. The tension members **25** accordingly may be controllably reciprocated by operating the pistons by means of conventional valve means under suitable applied fluid pressure, to cause the entire box slide to move guidedly up and down. Cover panels **23** closely fit in freely sliding relation against the channel flanges of the side columns which serve as guides or ways to restrain the slide in the fore-and-aft direction while the tension struts provide restraint in the lateral motion.

The fluid-operated linear motors which raise and lower the box slide are preferably of substantial lifting capacity and of long stroke, for example in excess of six feet in a machine designed to set utility poles.

The upper and lower margins of cover panels **23** are thickened outwardly to provide upper and lower pairs of flange ways **30** and **31** projecting to the front and to the rear from the top and bottom margins of the box slide. A percussion engine generally designated **32** having a casing **33** is carried within the box slide which requires to have inner dimensions sufficiently large to permit lateral movement of the casing within it. The engine casing carries upper and lower pairs of projecting bracket members **34** and **35** fixed on the forward and rearward sides which engage flanged ways **30** and **31** of the box slide and which are laterally movable to permit positioning of the engine. Such positioning may be effected by controllably energizing a further hydraulic motor comprising cylinder **36** supported by an end on the box slide and having its piston rod secured by an end to the engine casing, suitable operating means being provided (not shown) to actuate the motor for movement of the engine in either direction.

The percussion engine **32** may be of any form, provided that it have adequate energy output, and may comprise an air- or steam-operated hammer or an internal combustion hammer suitable for a mobile punch. Such hammers may desirably be conventional two-cycle diesel free-piston engines and such type is generally illustrated in the drawing. The energy delivered per blow to the punch tool next to be described should be upwards of 3,000 foot pounds, and preferably should be as much as 8,000 foot pounds or more for punch corers designed to produce a hole of one square foot cross-section in coarse gravels and rock fill.

Referring additionally to FIGURE 3, the earth coring punch generally designated **37** comprises an elongate steel casing **38** illustrated as having a square cross-section. Each side wall is of quadrilateral shape, widening upwardly and having its longer side edges **39**, **40** inclined equally to a center line at a small angle, for example in the range 0 to about 7 degrees. The four side walls are integrally joined together at their meeting edges, forming a tube of truncated pyramidal form having bottom edges **41** disposed in the plane of the lower opening **42** and their upper edges **43** integrally joined with a closing end wall **44**. The latter is parallel with the plane of lower opening **42** and at right angles to a longitudinal axis of the tube. The lower margins **41** are integrally joined with an open, annular shoe generally designated **45** having a depending cutting edge **46** disposed in a plane spaced below and parallel with the plane of opening **42**.

Turning now to FIGURE 4 and FIGURE 5 it will be seen that the shoe thickens upwardly in cross-section, and that the dimensions of the aperture **47** which is bounded by the cutting edge **46** exceed the dimensions of upper aperture **42**. The upper face **48** of the shoe projects inwardly beyond the inner surfaces of the casing to provide a ledge or shelf **49**, upon which the casing is rigidly secured as by welding. In one successful embodiment the casing **38** had a thickness of one-half inch while the face **48**, whose outer periphery was substantially flush with the exterior of the casing, had a breadth of 1.08 inches.

A series of chisel-shaped rock-breaker teeth **50** extend below the cutting edge **46**, being spaced uniformly along the periphery of the shoe, and terminating in chisel edges **51** which extend perpendicularly to the cutting edge **46**. The tooth layout is such that one tooth occupies each corner position, with its edge lying along a diagonal of the shoe. The corner teeth **52** have wider edges than the others and the spacing between such corner teeth and their neighbours, as measured between the centers of chisel edges, is about the same as the spacing betwen the other teeth. In oval or round punches, the chisel edges would be disposed along radii from a common center.

The exterior side walls **53** of the shoe are planar, and are inclined slightly to the longitudinal axis of the punch so that the outer ends **54** of the chisel edges **51** lie outwardly of the lower marginal edges **41** of the casing. The inner side wall of the shoe comprises upper bevelled faces

55 and lower bevelled faces 56, the inclination of the former to the vertical being less than the latter's. In one successful embodiment the contained angle between faces 53 and 56 was in the range 19 to 23 degrees, while the contained angle between the faces 53 and 55 was in the range 8 to 10 degrees.

The chisel-edge teeth 50 and 52 narrow downwardly and are formed with bevelled side faces 57 forming a wedge with included apical angle of about 65 degrees as measured in a vertical plane, and an included angle of about 18 degrees as measured in a horizontal plane. The inwardly-facing flat sides 58 of each tooth are inclined at a rake angle of about 7 degrees with respect to the longitudinal axis of the punch. The inward ends 59 of chisel edges 51 will be seen to lie inwardly of the inner margins 60 of the upper face of the shoe, and in a typical design will be over three inches in length.

The tooth form described above has been found to provide a highly effective rock-breaking action when a sufficiently energetic blow is repeatedly directed to drive the casing and shoe downwardly through mixed soil and rock, or through mixed fill including rock fragments whose cross-sectional dimensions may exceed the largest dimensions of the shoe. The rock-breaker teeth 50 and 52 primarily serve to shatter and/or deflect stones encountered, while annular cutting edges 46 serve to a lesser degree to produce similar effects while roughly shaping the inner walls 61 of the resulting hole. Rock fragments and earth passing upward between the side faces 57 of adjacent teeth 50 or 52 are forced inwards by the bevelled faces 55 and 56 of the shoe which tend to compress the core material within the zone of constriction as the shoe descends. Matherial which passes into the chamber or space 62 above the shoe within the casing is therefore in a somewhat worked condition but by no means entirely disintegrated.

The chamber 62 has a cross-sectional area increasing abruptly immediately above the aperture 42 and thereafter increases gradually and uniformly upwards, so that the casing offers little resistance to its filling by the core material which is in a loosened state within the chamber. Moreover, as will become more directly apparent hereinafter from a description of the drive action, each downward increment of punch displacement is effected at a relatively high velocity and occurs in a very short time interval of a few microseconds. There is conquently negligible packing or sticking of the core to the casing.

The outer surface of the casing, which as described is preferably slightly tapered in punches intended for setting piles or poles in rock fill, displaces the surrounding rock and earth outwards and compacts the material in the immediate vicinity of the hole wall 61 to provide a relatively smooth, dense surface, capable of standing without caving in for long periods of time and which does not tend to spall off and fall into the bottom particularly during the setting of the pole or post.

In earth materials of the character glacial till or moraine deposits comprised of mixed clays, sands and fine gravels, a punch corer as described will drive the shoe at a rate of as much as two to three inches per blow; in shaly ground the punch may descend up to about one inch per blow. River bed gravels in which the stones are rounded and average three inches and upward in maximum transverse dimension, have logged rates of drive in the range one-half to one inch per blow. In rock fill comprised mainly of large irregular fragments with a sand or clay matrix as in highway base fill, the same punch may penetrate a fraction of an inch per blow with an irregular rate of progress depending on the configuration of the obstacles confronting the shoe. Such large stones produce astonishingly little offsetting or deflection of the punch so that straight holes may be sunk.

On completion of a hole, the punch is raised out of the ground, and with it are lifted the contents of the hole, which are firmly held in the punch. In almost every instance, the break boundary between the bottom of the hole and the retained core will lie in a plane roughly coincident with the plane of opening 47. The core material appears to be blocked against falling out of the shoe by the zone of compacted material within the zone between apertures 42 and 47.

As the punch is driven into the ground to make a subsequent hole the retained core material from the previous hole is forced upward in the casing and is discharged intermittently through the side opening 63 surrounded by a spout 64 to deflect the issuing material laterally. The spout comprises an upper margin formed by end wall 44, a lower curved wall 65, casing side wall extensions 66, and a curved upper wall 67 within the casing. The issuing material 68 piles up and is pushed outwards by following material so that it accumulates relatively close to but clear of the hole. The lower lip of the spout serves to deflect the loose material away from the hole as the punch is lifted.

The punch is provided with a head-reinforcement 69, as by doubling of the casing thickness, to transmit the impact energy uniformly. Opposed apertures 70 are formed in the side walls adjacent end wall 44, to receive hoisting means to be described hereinafter. Referring particularly to FIGURE 6, apparatus for the holding, driving, and adjusting of the punch are shown, comprising a cap member 71 covering the upper end wall 44 of the casing. The cap member has an axial cylindrical recess 72 in its under side in which a boss 73 is received and threadedly engaged with threading 74 formed in the recess. The wall 44 is apertured centrally at 76, to pass a depending integral rod-like extension 75, which projects below wall 44. A thick pin 77 having an enlarged head 78 is received in the apertures 70, and passes through an aperture 79 in the extension 75. The pin is retained engaged with the casing and the extension by a detachable keeper 80. It will be seen that the cap and the boss 73 may be rotated relatively to each other and to the casing, to secure the cap firmly upon the end of the casing and to take up any play or looseness due to wear.

The upper side 81 of the cap is spherically formed, having a center of curvature lying in the longitudinal axis of the punch at a point below the cap and generally in the upper half of the length of the punch. The cap has an integral radial flange or skirt 82 of constant radial thickness, having a spherical underside 83. A support member 84 surrounding the skirt comprises a thick-walled formed steel body having an inwardly extending flange 85 bounded by a central aperture 86 of a diameter intermediate the inner and outer margins of the skirt 82, and being like it also of spherical shell form, so that when the skirt and flange are in contacting relation the centers of curvature of their meeting faces are substantially coincident.

The support member 84 has a cylindrical upwardly extending portion 87 to which is secured, as by fasteners 88, a cylindrical casing 89 surrounding an anvil 90. The latter is captive within a casing 91, which may be a lower extension of engine casing 33 or may be a separate casing secured detachably thereto. Anvil 90 is free to move guidedly a limited distance inside casing 91, as determined by a thick radial flange 92 reciprocably movable in a cylindrically walled groove 93 in the casing. An inwardly projecting flange 94 extending from the upper end of casing 89 is spaced above a radial shoulder 95 of the lower portion of casing 91, and is spring-pressed by coil spring 96 to be normally out of contact with the shoulder. When the anvil casing 91 is moved upward by the actuation of the vertical elevators for the box slide assembly 14, a disc 98 secured to the base of casing 91 lifts the lower end of the spring and tends to urge the casing 89 upward thereby. Because of the weight of the punch and contents, the spring will compress until shoulder 95 seats under flange 94, and further lifting of casing 91 causes flange 85 to engage the cap 71 and to raise the punch.

In the setting of the punch to sink a hole, the vehicle **10** will rarely be found to be level, so that in order to sink a vertical hole the punch must be capable of freely swivelling in any direction. It will therefore be understood that the provision of a spherical captive cap **71** and of the lifting provisions for engaging the cap with the attendant application of pressure distributed uniformly about the periphery thereof, makes possible the precise setting and raising of the punch regardless of the initial attitude of the vehicle.

Assuming now that the box slide **14** and the side columns **13** have been oriented properly with the punch suspended to hang vertically, the elevators are operated to cause the punch to descend and to press the shoe **45** on the ground. It will be seen that the casing **91** will press against the anvil flange **92**, compressing impact-transfer discs **196** which are seated in a recess **97** in the underside of the anvil, against the striker **99**. The latter has a concavely spherical under face **100** corresponding to the convex curvature of impact face **81** of the punch cap. The entire weight of the percussion engine, punch support, punch and punch contents, and that of the box slide, may therefore be rested on the shoe, serving to aid in its penetration of the ground. Whatever the form of impact means used, a piston or hammer **101** which preferably has a weight between 1000 and 2000 pounds or more is repeatedly caused to descend swiftly from a raised or rebound position to strike the anvil **90**, and to drive the coupling and impact-transfer elements together with the punch.

When the direction of fall of the hammer **101** is inclined to the longitudinal axis of the punch, which usually will be vertical, the freely swivelling contact of striker **99** and cap **71** will cause the blow to be directed into the punch axis. Provided the angle is not so great that the intersection of the hammer thrust line does not lie appreciably outside cutting edge **46**, the punch may be effectively driven, particularly in clay, sand, and fine gravel.

The inclination of the side columns as well as the lateral positioning of the box slide may be adjusted by the operator at will as the driving operation proceeds, to minimize the angular difference.

Referring now to FIGURE 7, an alternative design of punch is shown having casing **38** formed with a double wall, the upper end of inner wall **102** meeting the casing **38** on a transverse section below the spout **64**, the lower margin of the inner wall being only slightly larger than the margin of aperture **42** of the shoe in face **48**. The outer wall may have a zero taper, i.e., it may be straight-sided with parallel walls, or, as shown, may taper slightly inwardly upwardly, while the inner wall is tapered to increase the cross-sectional area progressively upwardly to prevent packing of the core material. Such punch form is useful wherever the compaction of the borehole **61** is unnecessary, as in certain consolidated materials such as hard shales or clays, and in cherty sand and frozen soils. The provision of zero taper leaves a narrow space between the hole sides and the casing, since the outer margin or cutting edge **46** of the shoe will be slightly greater in cross-section than any part of the casing exterior. Such tool form lessens the work of driving by omitting the bore wall compaction, while the loosened core material may pass freely upward in space **62**. In frozen soil a shoe of the same form as shown in FIGURES 3 to 5 would be employed, differing slightly only in that the inside faces **55**, **56** are less inclined so that the cross-section is narrower and the chisel edges are kept sharper.



While the invention has been described with particular reference to short punch casings, it is to be understood that the punch may be of considerable length permitting it to be driven to depths of as much as twenty feet or more without departing from the principles and methods described. Moreover, the apparatus may be used to excavate trenches of any configuration, by sinking a succession of closely spaced holes. The laying of utility pipes in such trenches is feasible, by knocking out the partition walls between holes at their bases, and leaving the upper portions for protection against caving.

I claim:

1. An earth perforating punch for sinking compacted wall boreholes in rock fill and recovering the contents of said boreholes, comprising an upwardly elongate tubular casing having a closing upper end wall, an open shoe in the form of an annulus integrally joined with and depending from the periphery of the lower end of said casing, said shoe having a peripheral depending cutting edge and having inner side walls bevelled to provide an aperture of which the cross sectional area decreases upwardly from said cutting edge, the smallest cross-sectional dimensions of said aperture being significantly smaller than any internal cross-sectional dimensions of said casing, said shoe also having a plurality of wedge-shaped teeth uniformly spaced apart along the peripheral cutting edge and disposed at right angles thereto, said teeth having extension portions tapering in thickness downwardly to chisel edges depending below said cutting edge, said chisel edges having a length spanning the widest lateral dimension of said annulus and extending inwardly of the plan projection of said annulus, a side opening in said casing adjacent said end wall, and a curved duct connecting said opening with the interior of said casing.

2. A punch as set forth in claim **1** wherein the chisel edges form a vertical included angle of about 65 degrees and said teeth have vertical shank side faces converging laterally inwardly and having a contained angle as measured in the horizontal plane of about 18 degrees.

3. A punch as set forth in claim **2** wherein said casing is thickened adjacent said upper end wall and is apertured on opposite sides through said thickened portion to receive a lifting bar therethrough, and wherein said lifting bar passes between said spout and said end wall.

4. A punch as set forth in claim **3** wherein said casing and said shoe have a rectangular cross section, and one tooth is disposed in each corner of said shoe having its chisel edge aligned with the diagonal extended to an opposite corner.

5. A punch as set forth in claim **4** wherein the tooth shanks extend upwardly outwardly from the inner ends of said chisel edges to the upper face of said shoe.


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