

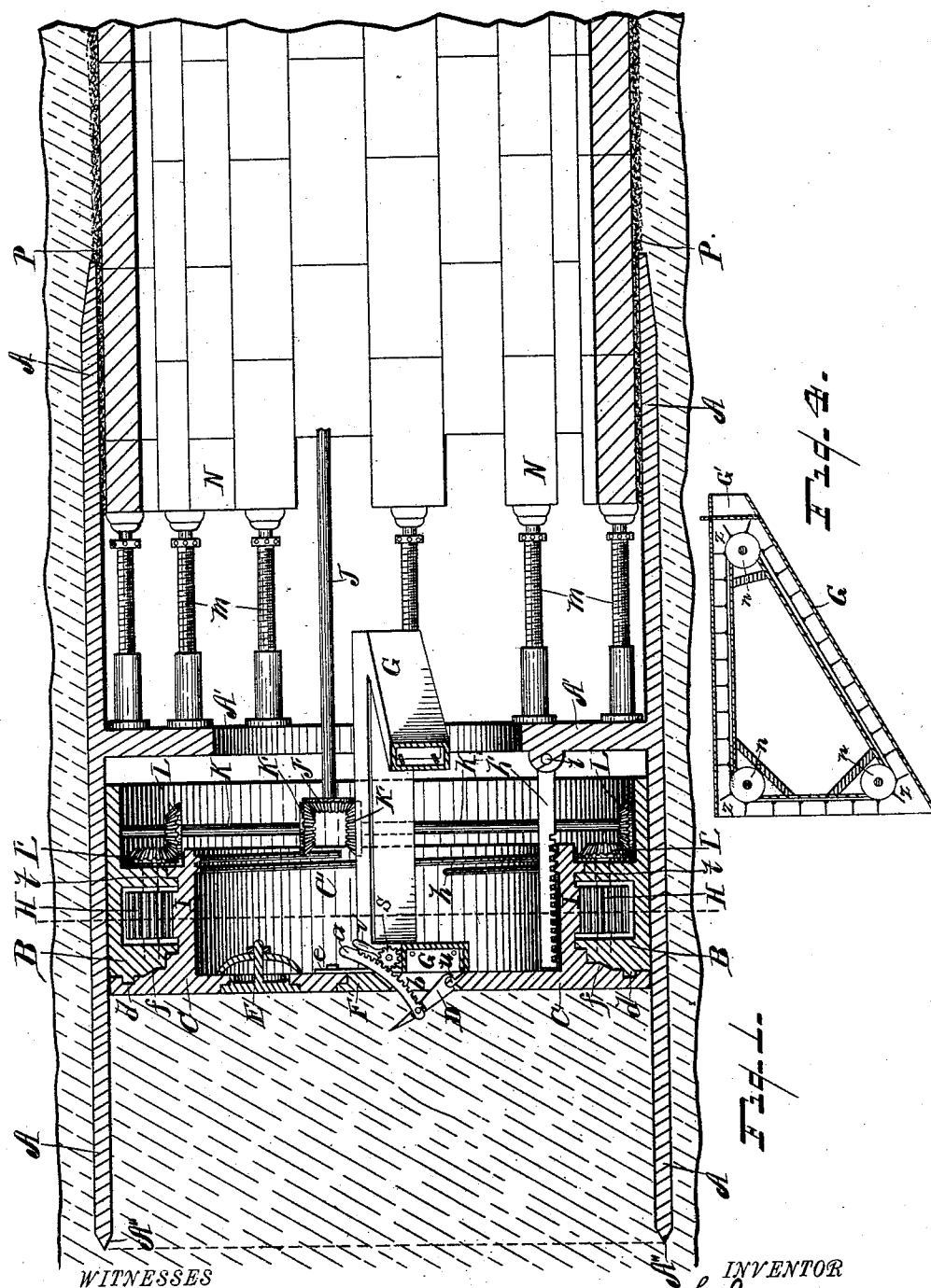
(No Model.)

2 Sheets—Sheet 1.

L. GROVER.
SUBAQUEOUS TUNNELING MACHINE.

No. 444,244.

Patented Jan. 6, 1891.



WITNESSES

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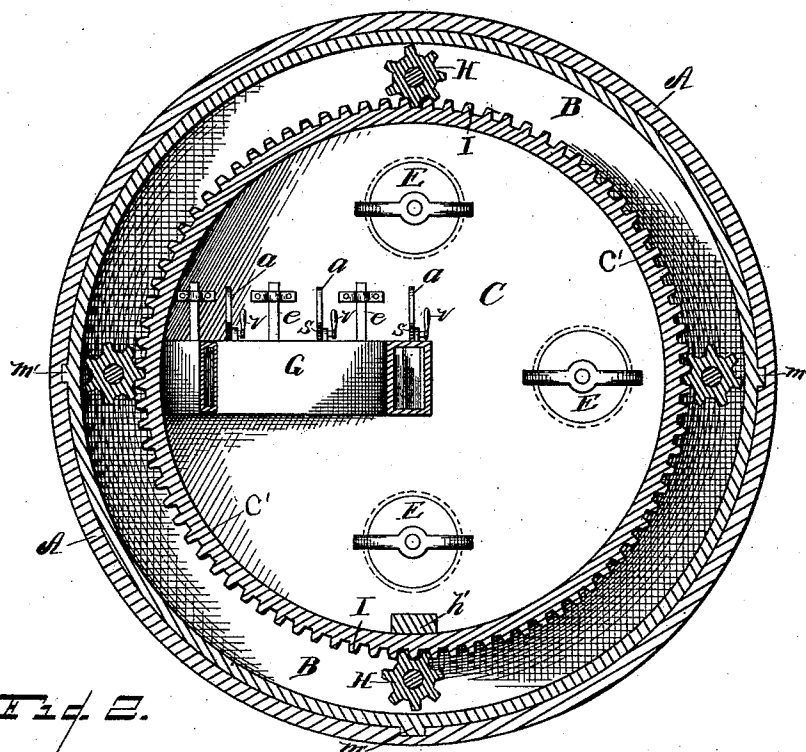


Fig. 2.

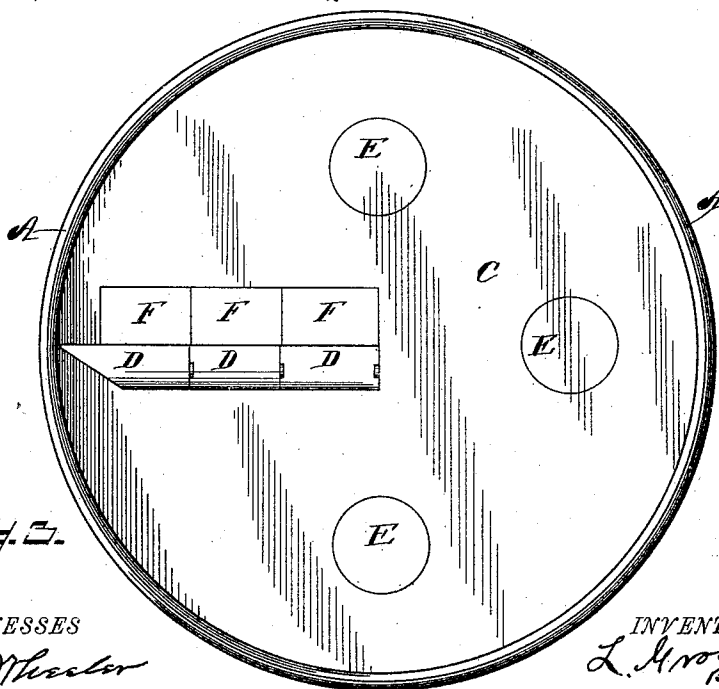


Fig. 3.

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UNITED STATES PATENT OFFICE.

LEONARD GROVER, OF HOMER, MICHIGAN.

SUBAQUEOUS TUNNELING-MACHINE.

SPECIFICATION forming part of Letters Patent No. 444,244, dated January 6, 1891.

Application filed June 16, 1890. Serial No. 355,536. (No model.)

To all whom it may concern:

Be it known that I, LEONARD GROVER, a citizen of the United States, residing at Homer, in the county of Calhoun and State of Michigan, have invented certain new and useful Improvements in Subaqueous Tunneling-Machines; and I do declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same, reference being had to the accompanying drawings, and to the letters of reference marked thereon, which form a part of this specification.

15 This invention relates to new and useful improvements in the construction of subaqueous and subterranean tunnels; and it consists in employing at the construction end of the tunnel a traveling caisson cylindrical in form and open at each end, the diameter of said caisson being slightly greater than the diameter of the tunnel. In the forward end of said caisson and adapted to travel horizontally therein is a revolving disk or head that snugly fills the inner diameter of the caisson, said revolving head being provided with a sectional excavating-knife projecting from its outer face and extending from the center of said head to its periphery, said knife being adapted to remove the earth from in front of the tunnel as the caisson is forced ahead, the tunnel being constructed within the walls of the rear end of the caisson.

The objects of the invention are to provide 35 a traveling caisson or shield that may be forced into the heading of earth in advance of the tunnel and the earth removed therefrom, as the tunnel is constructed within said caisson, the arrangement of parts being such as to prevent any possible cave-in and to exclude all water from the interior of the tunnel, and a further arrangement of parts whereby the earth may be excavated in advance of the traveling caisson, if desired, as said caisson is forced ahead in the construction of the tunnel. These objects are attained by the mechanism illustrated in the accompanying drawings, in which—

Figure 1 is a vertical longitudinal section 50 through the caisson or shield, the excavating machinery located therein, and a portion of the construction end of the tunnel. Fig. 2 is

a cross-section through the caisson and excavating machinery, taken on dotted line of Fig. 1. Fig. 3 is an end elevation of the caisson and the revolving head or disk located therein, showing the sectional knife secured in the outer face of said head and the man-holes therein. Fig. 4 is a central horizontal section through the conveyer.

Referring to the letters of reference, A indicates the traveling caisson or shield, which is made preferably of steel and is in the form of a hollow cylinder, the diameter of which is somewhat larger than that of the tunnel, so as to permit of the construction of the tunnel within the circumference of the rear end of the caisson-wall. The caisson is provided at or near its longitudinnal center with the diametrically-extending rib or flange A', that strengthens the caisson against collapsing and forms a bearing or base against which the jacks *m* rest, that afford the means by which the caisson is forced ahead. The forward end of the caisson is sharpened or beveled, as shown at A'' in Fig. 1, to facilitate its passage into the earth.

B indicates a broad metal ring that snugly fills the interior of the caisson, and is splined in the forward end thereof, as shown at *m'* in Fig. 2, whereby said ring is held from rotating, but is permitted to travel longitudinally within the caisson, said ring having mounted therein a series of pinions H H, as shown in Figs. 1 and 2.

C indicates a revolving metal disk or head that fills the inner diameter of the caisson, said head being provided with the annular horizontally-extending flange C', that extends within the ring B, said flange having on its periphery a series of cog-teeth I, that are adapted to engage with the pinions H, mounted in the ring B. The head C is secured to the ring B by means of the annular flange that extends from the periphery of the flange C' of said head and engages with a corresponding shoulder on said ring, as shown at *t* in Fig. 1.

To exclude the water and mud from the bearing-faces between the head C and ring B, the outer face of the ring B is provided with an annular tenon *d*, that is received in a corresponding groove in the inner face of the head C, which construction acts as a sand-

band to exclude the dirt from between said head and ring. The remaining portions of said bearing-faces meet on the angular line *f*, which forms so indirect a passage that but little, if any, water will find its way through, thus obviating the use of packing and producing a comparatively tight joint that offers but little friction between said parts.

The head C is revolved by power furnished through the drive-shaft J, which may be driven by compressed air or any suitable power found adaptable. On the end of the shaft J is a beveled gear J', that meshes with the gear K' K' on the ends of the counter-shafts K K, said counter-shafts carrying on their opposite ends the beveled gears L L, that mesh with the gears L' L' on the end of the shaft journaled in the ring B and carrying the pinions H H, that mesh with the cog-teeth I I on the periphery of the flange C' of the head C, as clearly shown in Figs. 1 and 2, whereby the head C is revolved through the medium of the pinions H H, the counter-shafts and their gearing driven by the main or driveshaft J, the requisite power and speed being secured by the relative sizes of the gearing, which will be readily understood. It will also be apparent that the manner of transmitting the motion to the head C through the shafts and gearing may be changed or varied, as is found most expedient and effective.

In the outer face of the revolving head is located a sectional knife D, of which there are three sections shown at D D D in Fig. 3. Each section of the knife is hinged at *u* (see Fig. 1) in the face of said head, and the cutting-angle of each section of the knife is regulated by the circular rack *a* (which is pivoted at its outer end to the knife) and the pinion *s*, that meshes with said rack, said pinions being rotated by the lever *v*. By this arrangement it will be apparent that the edge of the knife may be thrown out or in, as desired, by rotating the pinion *s*.

b indicates an opening through the head C just back of the knife D, through which the earth passes that is removed by the knife as the head revolves. Communicating with said opening is a conveyer G, that receives the earth from the opening *b*. Said conveyer is in the form of a right-angled triangle, one of its right-angled sides being secured to the inner face of the head C, so that the conveyer revolves therewith, the other right-angled portion of the conveyer extending horizontally rearward on a line with the axis of said head. At the three points of angle within the conveyer is located a friction-roller *n*, (shown in Fig. 4,) over which passes an endless belt provided with rake-teeth *z*, that engage and convey the earth deposited in the conveyer from the knife to the discharge-port G' in the end of the conveyer, from whence it may be carted to the tunnel-shaft or removed in any desired manner.

On the inner face of the flange C' of the head C is a worm-thread *h*, that engages with the teeth of the rack *h'*, pivoted at *i* to the

flange A' of the caisson. If it is desired to carry the head C forward in the caisson to the outer end A'' thereof, as said head is revolved the rack *h'* is thrown down to the position shown in Fig. 1, when the worm-thread *h*, revolving in the teeth of said rack, will carry said head forward to the desired point. It will also be observed that a reverse motion of the head C will carry said head backward in the same manner. When it is desired that the head C shall remain at a certain point within the caisson, the rack *h'* is raised from contact with the worm-thread *h*, when the head will revolve, but will not travel horizontally in the caisson.

In constructing a subaqueous tunnel with this improved caisson and excavator a shaft is first sunk at the side of the stream or body of water to be tunneled under to the required depth at which the tunnel is to be laid. In the excavation at the bottom of said shaft the caisson A, with its excavating machinery, is placed, the forward end A'' of the caisson heading in the direction of the course of the tunnel. The construction of the tunnel is then commenced within the rear end of the caisson, the shell of the tunnel being constructed of rectangular metal plates N, bolted together, with lead or other suitable packing between the joints to render it water-tight. The tunnel having been constructed a sufficient distance within the caisson, the jacks *m*, which may be either screw or hydraulic jacks, are placed between the ends of the plates N of the tunnel and the flange A' of the caisson, by means of which the caisson is forced ahead into the earth, as shown in Fig. 1. The head C is then revolved, when the knife D therein will remove the earth within the caisson from in front of said head as the caisson advances, the earth being carried away by the conveyer G, as before described. As the plates N of the tunnel are set in place the jacks *m* are shifted so as to bear against the ends of the plates last set and that extend farthest into the tunnel, as shown in Fig. 1. By this arrangement the forward motion of the caisson may be made almost continuous.

Between the inner wall of the caisson and the periphery of the tunnel as said tunnel is constructed and the caisson is forced ahead is placed a filling P of any suitable packing or cement that prevents the water from entering the tunnel between the wall of the caisson and the periphery of the tunnel, and also forms a protective coating around the tunnel-casing.

When tunneling in soft or treacherous ground it is desirable to operate the revolving head some distance within the caisson, as shown in Fig. 1. The extending rim of the caisson acts as a shield to prevent the earth from caving in, and is steadily advanced in that position as the earth is removed by the knife of the revolving head.

Should the earth become too soft or the caisson encounter sufficient water to cause it

to flow through the opening *b* behind the knife, said opening may be closed by drawing the edge of the knife upward against the face of the head *C* by means of the rack *a*, rendering the revolving disk water-tight. The caisson is then forced ahead without revolving said disk until solid ground is again encountered, when the excavating will proceed as before.

When operating in hard ground, into which it would require a great amount of power to force the caisson, it is desirable to operate the revolving head at the forward end of the caisson, so that by extending the knife *D* the earth may be excavated from in front of the caisson-wall, which will permit of the easy and rapid advancement of said caisson. Should the earth be so hard as to offer too great a resistance to the entire length of the knife, said knife being in sections, but one section at a time may be used until it has cut its way, when another section of the knife may be thrown out, and so on until the excavation extends across the entire diameter of the tunnel, when the caisson may be forced ahead and the operation repeated.

F F indicate gates or doors opening through the head *C* above the knife *D*, said gates being held closed by the metal bars *ee*. The purpose of said doors is to permit of the removal of bowlders or obstructions from in front of the knife.

E E are man-holes in the head *C* through which the earth or rock in front of said head may be blasted, if desired. Said man-holes also afford sight-openings through which to view the nature of the earth in advance of the revolving head and the operation of the knife.

It will now be evident that in the employment of this improved tunneling device the operators are entirely free from danger, as the revolving disk *D* forms a bulk-head behind which they work, and which affords a perfect protection against the caving in of the earth or a sudden inflow of water, and by the employment of this device it is not necessary to construct what is called a "deep tunnel," there being no danger of a cave-in. The tunnel may be constructed just below the river-bottom, thus enabling the maintenance of the same grade as that of a deep tunnel, with much shorter approaches, effecting a great saving in the cost of construction.

Having thus fully set forth my invention, what I claim as new, and desire to secure by Letters Patent, is—

1. In a subaqueous tunneling-machine, the combination of the hollow caisson open at both ends and having an annular flange *A'*, means located between said flange and the construction end of the tunnel for moving

the caisson horizontally, a ring slidably fitted within the caisson, and a revolving head located within said ring and adapted to revolve therein, substantially as specified.

2. In a subaqueous tunneling-machine, the hollow caisson open at both ends and having means for advancing it from the construction end of the tunnel, combined with the ring slidably located within the caisson and the revolving head located within said ring, said head carrying a knife adjustably mounted therein and having an opening through said head adjacent to said knife, substantially as specified.

3. A subaqueous tunneling device comprising the following combined elements: the hollow circular caisson open at both ends and having means for advancing it horizontally, a revolving head within the caisson, said head carrying a knife and having an opening there-through adjacent to the knife, a conveyor mounted on said revolving head and adapted to revolve therewith, means for moving said head horizontally within the caisson, and means for revolving said head and its conveyor, substantially as specified.

4. A subaqueous tunneling-machine comprising the following combined elements: the caisson open at both ends and means for advancing said caisson, the ring slidably mounted within the caisson, the knife-carrying head located in said ring and having the knife adjustably mounted thereon, the openings adjacent to said knife, the man-hole in said head, and means for moving said head horizontally within the caisson.

5. In combination with the caisson, the revolving head located therein, said head carrying a series of knives, each knife having an adjustment with the revolving head, the series of knives arranged so as to extend from the center of the revolving head to its periphery, the openings through said revolving head adjacent to said knives, the series of man-holes through said head, means for revolving said head, and means for moving it horizontally within said caisson, as set forth.

6. In combination with the caisson, the revolving head located therein, the series of knives in said head, each knife having an independent adjustment, said knives extending from the center of the revolving head to the periphery thereof, the opening through said revolving head adjacent to said knives, means for revolving said head, and means for advancing it horizontally within the caisson, substantially as specified.

In testimony whereof I affix my signature in presence of two witnesses.

LEONARD GROVER.

Witnesses:

E. S. WHEELER,
R. B. WHEELER.