

Sept. 22, 1925.

1,554,723

W. E. HAMILTON

TUNNELING MACHINE

Filed March 11, 1924

5 Sheets-Sheet 1

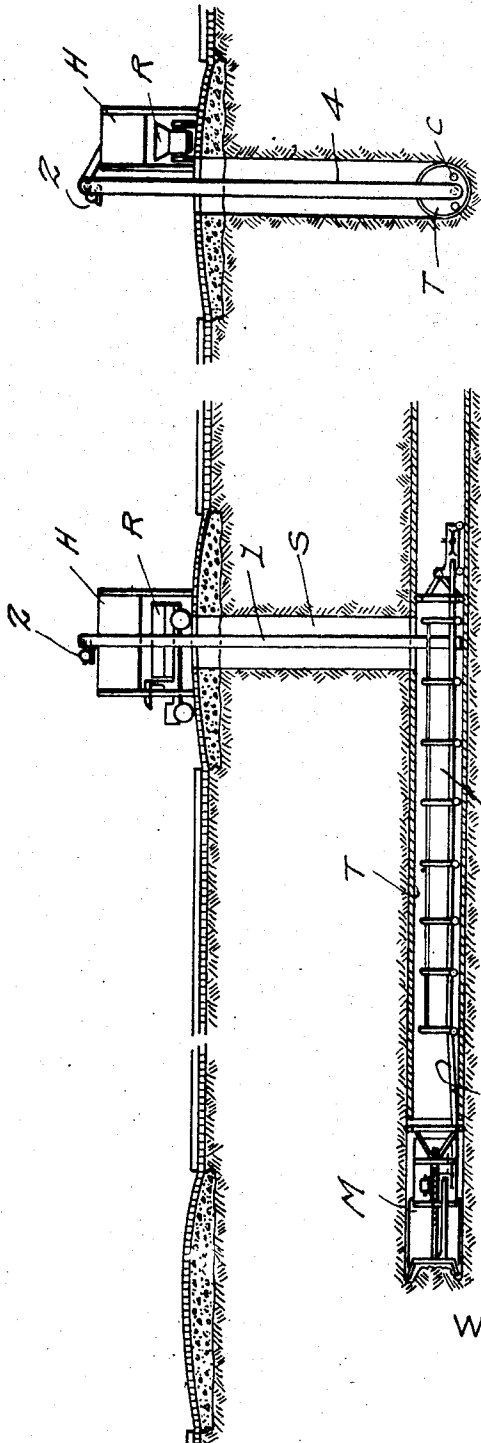


FIG. 1

FIG. 2

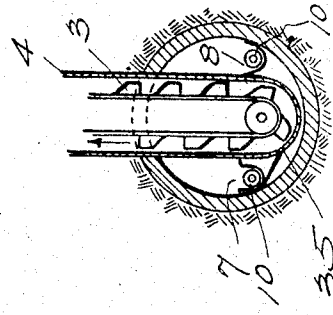


FIG. 4

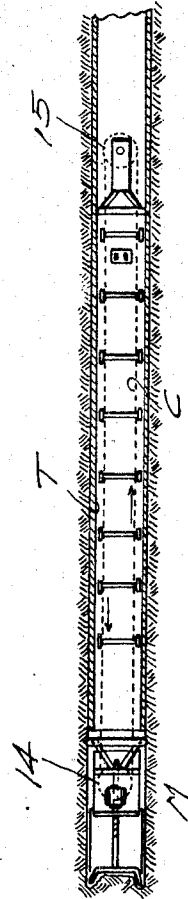


FIG. 3

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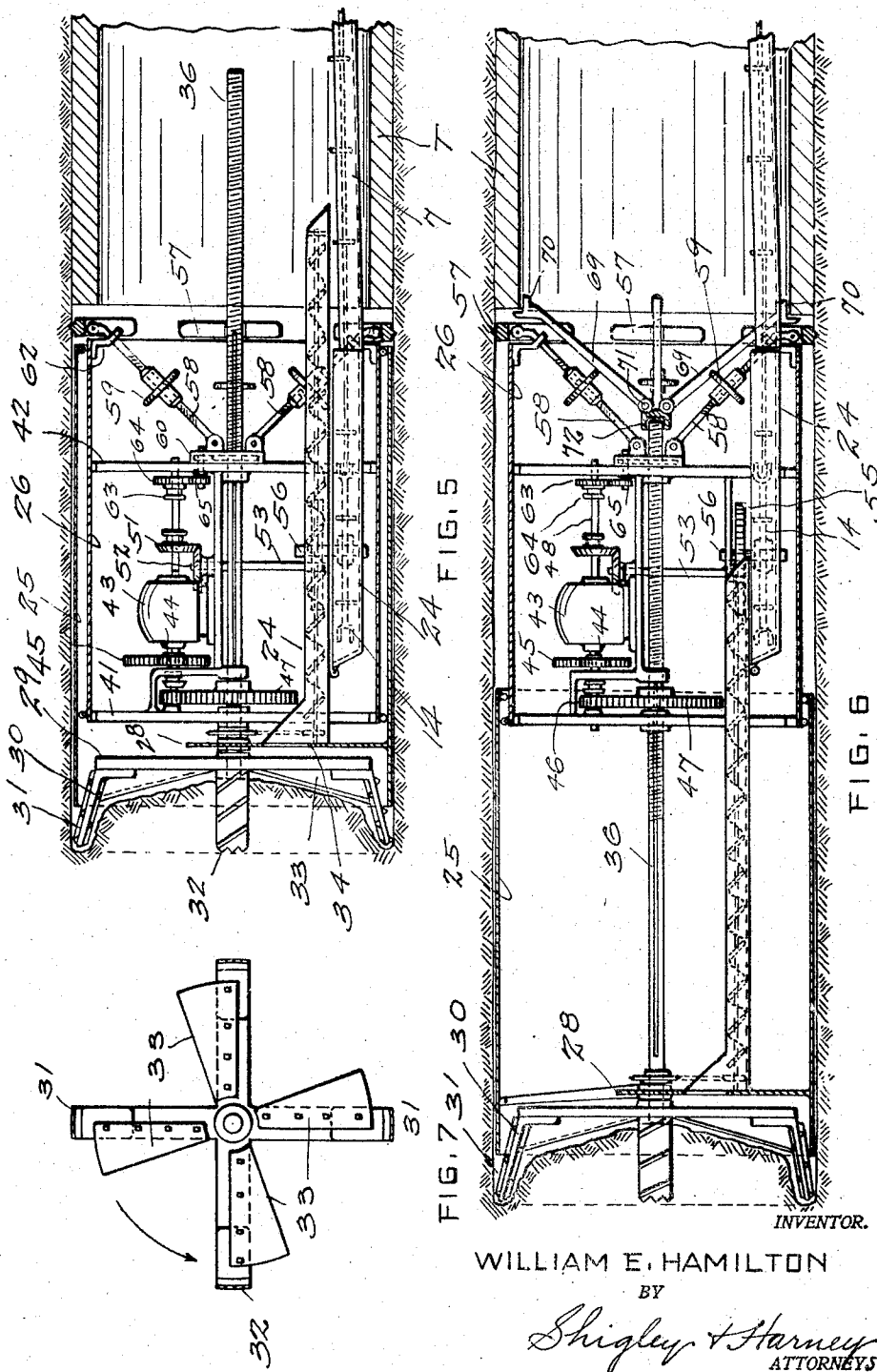
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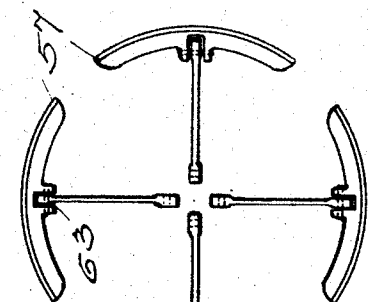
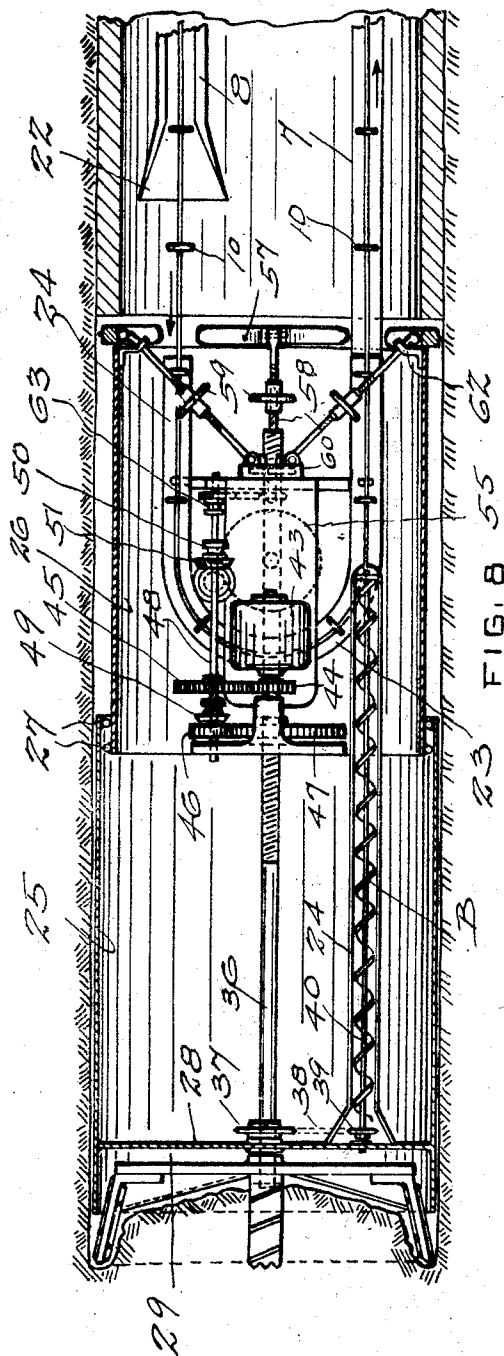


FIG. 9

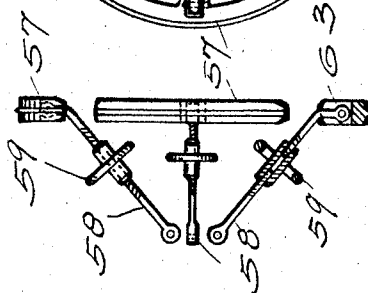


FIG. 10

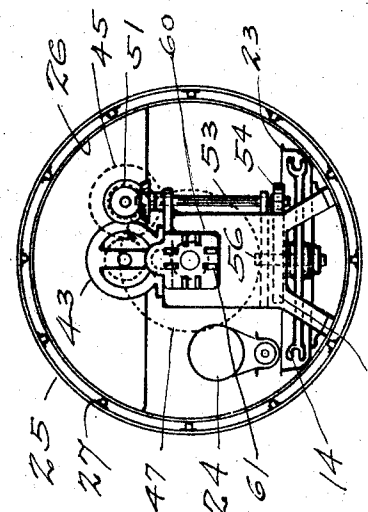


FIG. 11

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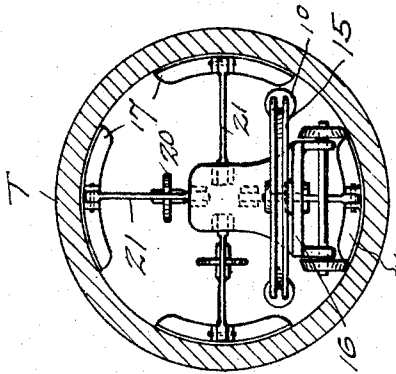


FIG. 12

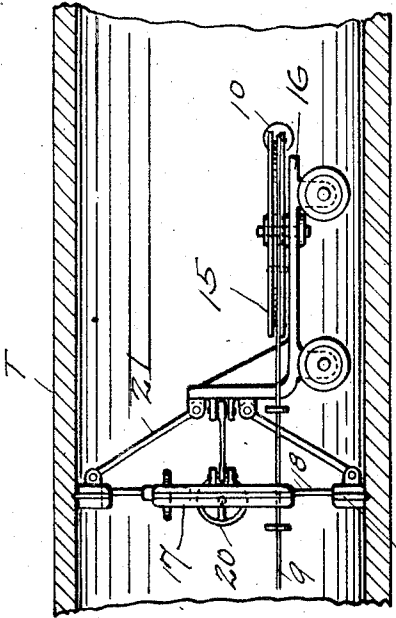


FIG. 13

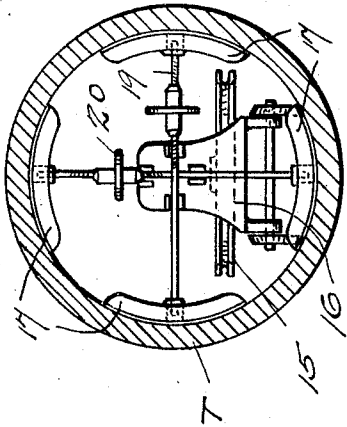


FIG. 14

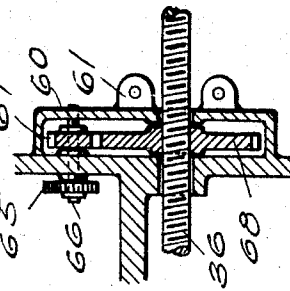


FIG. 15

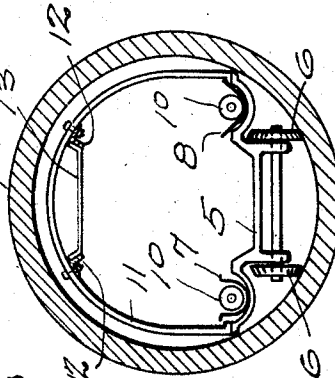


FIG. 16

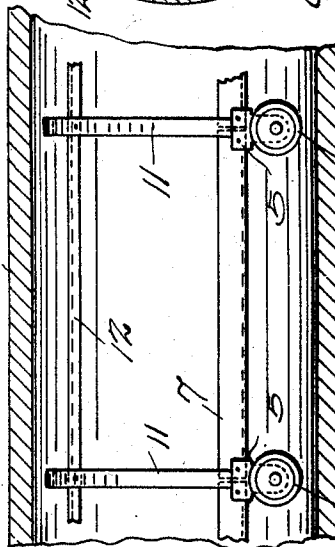


FIG. 17

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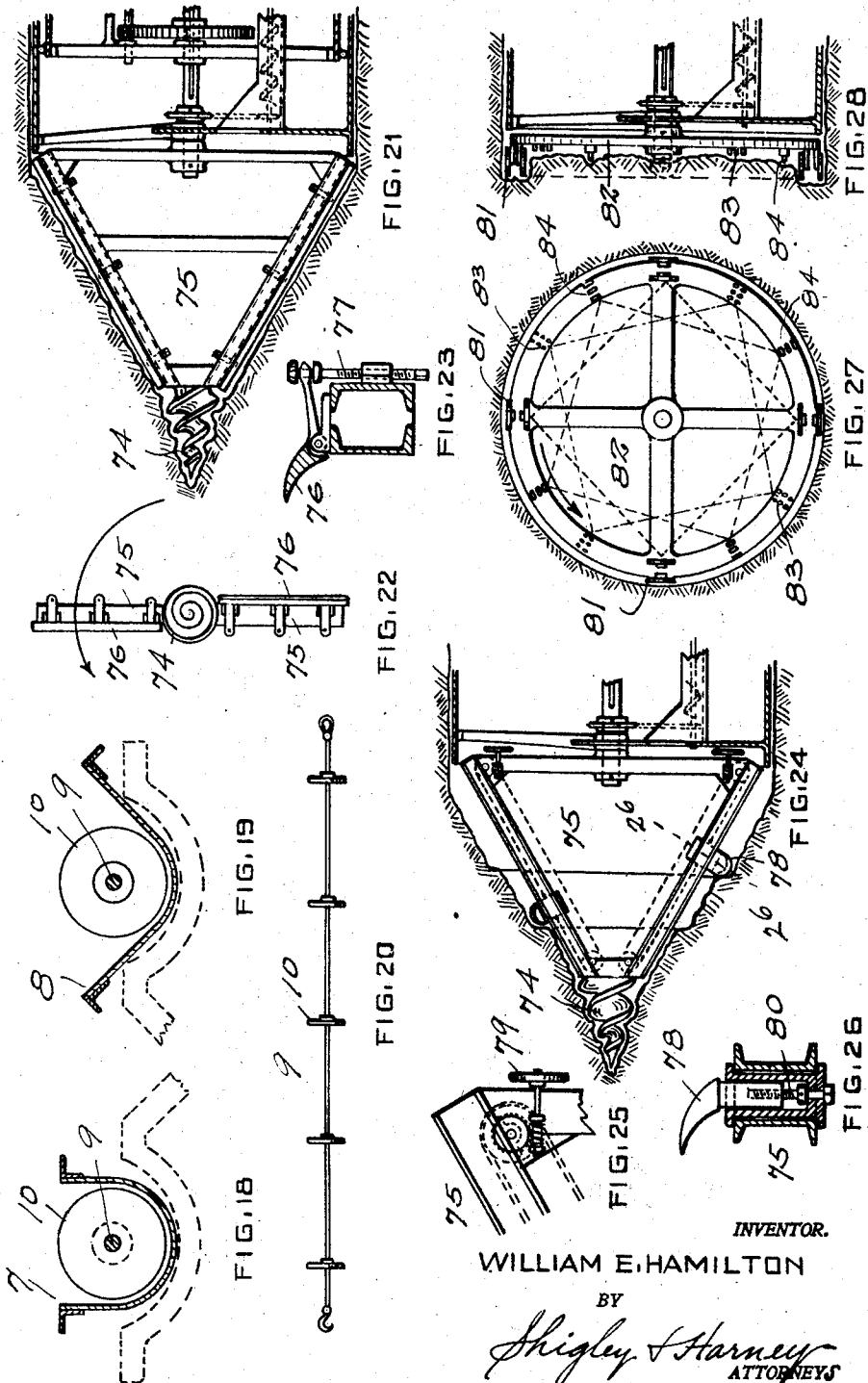
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UNITED STATES PATENT OFFICE.

WILLIAM E. HAMILTON, OF COLUMBUS, OHIO.

TUNNELING MACHINE.

Application filed March 11, 1924. Serial No. 698,551.

To all whom it may concern:

Be it known that I, WILLIAM E. HAMILTON, a citizen of the United States of America, residing at Columbus, in the county of Franklin and State of Ohio, have invented certain new and useful Improvements in Tunneling Machines, of which the following is a specification.

The present invention relates to improvements in tunneling machines for boring tunnels, sewers, and other subterranean excavations, and the machine of the invention is adapted for boring in different kinds of materials, may be adapted for boring different diameters of tunnels, and provides means for removing the spoil, and also for furnishing the building material to be used in the construction of the walls of the tunnel. In boring the tunnel underground, a vertical shaft is used, and the device embodies means for extending the operations forward from the vertical shaft, and for returning the spoil or excavated material to the bottom of the shaft. The building material is carried forward from the bottom of the vertical shaft to the tunneling machine by the same conveyor that is employed to carry away the spoil.

In the preferred embodiment of the invention, a vertically disposed rotary cutter is employed to cut into the face of the tunnel head, and a spiral or screw conveyor is utilized to convey the spoil from the cutter head to an endless conveyor which extends back to the vertical shaft.

The vertical shaft is equipped with an endless elevator by which the material excavated is lifted to the surface of the ground and emptied into a hopper from which it is carried away by suitable vehicles.

The invention consists in certain novel constructions and arrangements of parts as will be hereinafter more specifically pointed out and claimed.

In the accompanying drawings, I have illustrated one complete example of the physical embodiment of my invention, together with several modified forms of the horizontal rotary cutter, and the parts are combined and arranged according to the best mode I have so far devised for the practical application of my invention.

Figure 1 is a sketch showing the tunnel-

ing machine and connections in use, and illustrating the tunnel in the course of building, together with a vertical shaft or outlet.

Fig. 2 is a view at right angles to Fig. 1, showing the elevator in the vertical shaft for lifting the spoil to the hopper on the surface of the ground.

Fig. 3 is a top plan view of the tunneling machine and the conveyor apparatus used in connection therewith.

Fig. 4 is an enlarged detail view, showing the tunnel in section, and illustrating the boot of the elevator, together with the outgoing and the incoming members of the horizontal conveyor.

Fig. 5 is an enlarged detail view of the tunneling machine in telescoped position, the cutter being retracted, and ready to be fed forward as it cuts into the face of the tunnel.

Fig. 6 is a view similar to Fig. 5, but here the cutter has bored into the tunnel head and is in extended position.

Fig. 7 is a view in end elevation of a cutter head that is used in clay or soft material.

Fig. 8 is a plan view of the machine in the position of Fig. 6.

Fig. 9 is an end elevation of the machine of Figs. 5 and 6, the view being taken from the right end.

Fig. 10 is a side elevation, partly in section, of the expanding ring that is used as a base for guiding the direction of bore of the cutter.

Fig. 11 is an end elevation, showing the segmental arms of the guiding ring of Fig. 10.

Fig. 12 is a side elevation showing the truck which supports the idler sprocket or tail wheel of the conveyor, and also showing in side elevation an anchor ring fitted against the walls of the completed tunnel.

Fig. 13 is a view in elevation, from the left of Fig. 12, showing the anchor ring, which is similar to the ring in Fig. 10.

Fig. 14 is a view in elevation from the right end in Fig. 12.

Fig. 15 is a side elevation of a part of the horizontal endless conveyor trough, and carriers.

Fig. 16 is a view from the right end of Fig. 15.

Fig. 17 is an enlarged detail sectional

view of the screw-drive mechanism of the rotary cutter, by means of which the tunneling machine is contracted or telescoped after each boring operation of the machine.

5 Fig. 18 is an enlarged detail sectional view through one of the conveyor troughs, this trough being for the outgoing excavated spoil.

10 Fig. 19 is a similar view showing the trough for the incoming building material.

Fig. 20 is a view showing one of the standard sections of the conveyor cable, which passes through the troughs of Figs. 18 and 19.

15 Fig. 21 is a modified form showing a tapered or conical cutter head.

Fig. 22 is an end view showing the tapered cutter head of Fig. 21.

20 Fig. 23 is an enlarged transverse sectional view through the framework and the cutter blade of the cutter in Fig. 21.

Fig. 24 is a side view of a modified form of tapered cutter head, especially adapted for hard spoil.

25 Fig. 25 is an enlarged detail of the framing of the head in Fig. 24, showing the means for adjusting the cutter blade.

Fig. 26 is a sectional view at line 26—26, showing the framework and a cutter.

30 Fig. 27 is a further modified form of cutter head, which uses an electrically heated device for softening the material to be excavated.

35 Fig. 28 is a side view of the cutter head in Fig. 26.

40 In Figures 1 to 4, the parts are shown diagrammatically, and the different features of the entire apparatus may be here described, in order to give a clear understanding of the invention.

45 The partly completed tunnel is indicated by the letter T, and the intersecting vertical shaft is lettered S, there being a hopper H at the mouth of the shaft to receive the excavated spoil from the vertical endless conveyor 1 operated by the motor 2, and equipped with buckets 3. The conveyor travels in a housing 4, and elevates the spoil to the hopper H from which it is emptied into the waiting truck R.

50 The tunneling machine, or cutting machine is designated M, and the horizontal conveyor C receives the spoil from a screw conveyor B, which latter conveyor receives the spoil direct from the cutting device of the tunneling machine.

55 The horizontal conveyor C is made up of transverse bolsters 5, in which are supported the two-wheeled trucks 6, the wheels being beveled so that they may readily travel, and rest solidly on the curved bottom of the completed tunnel. These bolsters 5 are connected by a pair of troughs as 7 and 8, the former being for outgoing material, and
60 the latter for incoming building material.

The cable conveyor sections 9 (see Fig. 20) are provided with disks 10 that slide along in the troughs, and the outgoing trough 7 conforms to the circular disk, so that the material may be conveyed efficiently through the trough. The incoming trough which forms a channel for the brick, stone, and other material, has flattened side walls, adapting them to the material that is carried from the shaft to the tunneling machine. The section of cable 9 in Fig. 20, in actual use, is twice the length of the section of the conveyor illustrated in Fig. 15. That is, the distance from one truck 6 to the adjoining truck 6 is half the distance of the cable section 9. Thus, as the boring progresses, the conveyor may be elongated by adding the sections to the tail end of the conveyor and pushing the entire conveyor forward on its wheels 6. The troughs 7 and 8 are suitably fastened to the bolsters 5, and arch bars 11 are erected transversely of the bolsters to brace the structure. Longitudinal angle bars 12 are bolted near the top of the arch bars, and transverse brackets 13 are fastened between these angle bars. The transverse bars 13 are adapted to support wires, pipes, tubes, etc., which form part of the equipment of the apparatus.

75 The horizontal conveyor cable is stretched between the horizontal head sprocket wheel 14, and the tail sprocket wheel 15. The wheel 15 is an idler supported on the truck 16 at the rear of the conveyor, and this truck is anchored by and at the rear of the anchoring ring which is made up of four segments 17 that impinge against the inner wall of the cylindrical tunnel. These segments are arranged in pairs that are connected by screw bars 18, 19, and the screw bars, which are threaded in opposite directions, are provided with hand-wheels 20, by means of which the bars may be protracted to anchor the ring in the collar, or contracted to withdraw the ring from engagement with the wall of the tunnel. The truck 16 is held out from the anchor ring by diagonal braces 21, pivoted to the ring segments and to the truck, as best seen in Fig. 12.

80 In Fig. 8, it will be seen that the trough 8 terminates in a wide mouth 22 just back of the tunneling machine, and the cable conveyor passes therefrom and around the head wheel 14. The trough 7 (the outgoing trough) has a rounded end 23 and a short leg 24 (Fig. 8) for guiding the cable conveyor around the head of the conveyor and through the short leg, and the disks 10 of the conveyor successively carry away the spoil as it is deposited in the trough 7 by the spiral or screw conveyor B, operating in its trough 24.

85 The tunneling machine proper is encased within a telescopic housing or shield made

up of the two cylindrical, metallic sections 25 and 26, rollers 27 being employed on the outer and inner sides of the respective sections, as anti-friction means, and for guiding the telescopic members during the extension, and contraction of the machine. The rear end of the shield is open, but the head end is closed by a partition 28, although in some of the views of the drawings this partition is broken away. In front of the partition is a space 29 for the rotary cutter head. The cutter head in Figures 5, 6 and 8 includes the cross-head 29 from the ends of which project the oblique arms 30, upon which are mounted the diametrically arranged two pairs of cutting blades, 31 and 32, and the material is broken down between the diametrically opposite cutting blades and the radial blades 33, of the cross-head and force the dirt or spoil through the opening 34 in the partition 28, and into the spiral conveyor trough 24, and from thence the spoil is carried to the outgoing side of the cable conveyor and through its trough to the boot 35 of the elevator.

The cutter head is carried on the end of the screw bar 36 of the tunneling machine, and power is transmitted from this screw bar to the spiral conveyor through the medium of the sprocket 37 on the screw bar, sprocket chain 38, and sprocket wheel 39 on the shaft 40 of the spiral conveyor.

The screw bar is supported between the frame members 41 and 42 that are rigidly fixed in the section 26 of the shield, and is revolved from the electric motor 43 by the train of gears 44, 45, 46 and 47 the last gear being keyed to the screw bar which is grooved to permit longitudinal movement of the bar through the gear (see Figs. 6 and 8). The gear 45 is fixed on the counter-shaft 48, and the clutch device 49 is adapted to control and operate the cutter head.

A clutch device 50 on the shaft 48 controls the driving mechanism for the cable conveyor, which mechanism comprises the bevel gear 51, horizontal bevel gear 52, upright shaft 53, small gear 54, at the lower end of this shaft, and the large gear 55, on the stub shaft 56 of the gathering wheel or head wheel 14 of the conveyor.

The smaller shield section 26 has at its rear end an anchoring wheel, or segmental annular brace similar to the anchoring rim for the spiral conveyor. This anchoring ring or brace at the rear of the shield section is for the screw bar 36, and is made up of four spaced segments 57 that are designed to impinge outwardly against the cut walls of the tunnel, as shown in Fig. 8, and each of these segments has a sectional screw bar 58, of which the threads are turned in opposite directions for the hand wheels 59. The diagonal braces 58 are pivoted at one end to a segment and at the other end to a

stationary housing 60, by means of the perforated ears 61 thereon. Hooks 62 (see Figs. 5, 6 and 8) are employed to guide the screw bars or braces 58 at the periphery of the housing section 26, and the screw bars are pivoted to the segments at 63. The rotary cutter is operated from the motor through the screw bar 36, and as the cutting progresses, the rotary cutter with the outer shield section 25, is projected ahead of and away from the shield section 26, and the machinery therein, the extended position of the machine being shown in Fig. 8. After each cutting operation, whereby the sections are moved with relation to each other, i. e., after the section 25 is projected from the section 26, and the cutter head is projected from its driving machinery, the section 26 is pushed forward, together with the driving machinery, inside the section 25 to the position shown in Fig. 5.

For directing the bore of the tunnel in either a straight line or for deflecting the direction of the tunnel in a curved line, the diagonal or radial braces 58 and hand wheels 59 are used in conjunction with the segments 57, to set the screw bar 36 in the desired direction.

The forward feed drive for the cutter head utilizes the clutch 63, on shaft 48, which when thrown in, transmits power from the shaft 48 through the large gear wheel 64 to the smaller wheel 65, the latter on the stub shaft 66, in the housing 60. This shaft 66 has thereon a pinion 67 that engages the gear 68 threaded on the screw bar 36. The gear 68 is retained in the housing against movement, laterally, and therefore when the clutch 63 is thrown in, the screw drive is operated, and in this position the rotary cutter is again ready to operate, and the boring continues. Each time that the machine is moved forward, the conveyor cable is elongated a corresponding distance, and the work thus proceeds step by step until the destination is reached.

After the end of each forward operation of the cutter head and consequent advance of the screw with relation to its machine, the machine is advanced and with it the cylinder 26 is telescoped in the larger cylinder shield 25. In Fig. 6, where the cutter head is advanced, rear braces 69 with feet 70 to engage the end of the completed tunnel, are employed. These braces are pivoted at 71 to a bearing cup 72, which fits over the rear end of the screw bar. The expanded ring brace is now loosened and only the clutch 63 is thrown in with the result that the section 26 and its machinery, are carried forward and telescoped within section 25 to the position of Fig. 5.

Figures 21, 22 and 23 show views of a modified form of cutter head which has a centering auger 74, and this auger together

with the conical form of the cutter head 75 maintains the cutter head in a central position and at the same time reduces the strain on the head shaft. The protruding movement of the cutter blades 76 is controlled by a screw 77 as shown in Figures 22 and 23.

Figures 24, 25 and 26 show a variation of the different described cutter heads in which the long blade on each side is omitted and replaced by a more narrow cutting blade 78 to be used in excavating hard shale and formations in which boulders may occur. In this structure the cutter can be manipulated to operative position by means of the hand wheel 79 shown in Fig. 25, and thus cut around the boulder and allow it to be dislodged by hand without damage to the machine.

In Figure 26 a method of adjusting the cutter head laterally is illustrated by means of the bolt 80, and in Figure 25 means for adjusting it longitudinally comprises a hand wheel 79.

When excavating very hard or vitreous rocks I utilize an electrical cutter head as illustrated in Figure 27 and alternately heat and cool the rock to be excavated in a circular or annular path which is the diameter of the tunnel bore. This method of excavating is accomplished as indicated in Figures 27 and 28 by passing a low voltage electric current between the two electrodes shown as the four sets of wheels 81 on the cutter head or ring 82. As the cutter head slowly revolves the electric current passing from one electrode wheel to the other goes through the stone having a high resistance, and by this means the stone is brought to a high heat. If necessary the face of the rock may be sprayed with bicarbonate of soda or other material to make it fusible. Immediately following the electrode wheels is a multiple of jet sprays 83 spraying cold water on the face of the rock while it is still hot from the passage of electric heat. By this means of suddenly cooling the rock it may be caused to crack and chip thus readily enabling the chisel cutters 84 immediately following the water jets to dislodge the broken pieces. The heating spraying and chipping mechanism are shown in multiples of four (Figs. 27 and 28) all mounted on the frame work of spider-ring 82 which would be mounted on the end of the screw feeder and become a part of the tunneling machine.

What I claim is:

1. The combination with a tunneling machine including a rotary cutter head, a spiral screw conveyor to receive the material therefrom, a conveyor adapted to convey material to and from the machine comprising spaced troughs, an endless cable made up of sections traveling in said troughs and car-

riers on said sections, and an endless elevator co-acting with said conveyor.

2. The combination with a tunneling machine of a conveyor to receive spoil therefrom, a trough for outgoing spoil and a trough for incoming building material, an endless conveyor traveling in said troughs, and an endless vertical elevator at the rear of the endless conveyor.

3. The combination in a tunneling machine including a rotating cutter head and a transporting conveyor comprising parallel troughs, an endless cable traveling through said troughs and provided with spaced carrier disks whereby one trough and one branch of the conveyor bring in construction material, an initial feeding device for the conveyor, and an elevator at the rear of the transporting conveyor.

4. The combination with a tunneling machine, of a transporting conveyor including an endless cable, of an anchoring truck and a tail wheel thereon for the conveyor, a segmental expanding ring forward of the truck adapted to engage the walls of the tunnel, and a bracer between said ring and the truck.

5. The combination with a tunneling machine of a transporting conveyor including an endless conveyor cable and head and tail wheels therefor, an anchoring truck for the tail wheel, an anchoring ring forward of the truck to engage the walls of the tunnel, means for expanding the anchoring ring and means connecting the ring with the truck.

6. The combination with an endless conveyor of an anchoring truck, an anchoring ring, and operating means for the conveyor including a tail wheel on the truck, said ring comprising curved segments to engage the wall of a tunnel, sectional screw bars engaging the segments in pairs and a hand wheel for each pair of bars, and pivotal connections between said ring and truck.

7. The combination in a tunneling machine of a sectional, telescoping housing and a rotary screw bar supported in the inner member of the housing, a rotary cutter on the screw bar and operating means therefor, and means co-operating with the screw bar for advancing the inner member and contained machinery after a period of operation by the cutter.

8. The combination in a tunneling machine including a rotary cutter head and screw bar, and operating machinery for the screw bar, supporting means for the end of the bar, an anchoring ring for the machinery including curved segments, and adjustable means connecting said segments with the screw bar co-operating with said supporting means for governing the direction of the travel of the cutter head.

9. The combination in a tunneling ma-

chine including a rotary cutter head and screw bar, and operating machinery for the screw bar, supporting means for the end of the bar, an anchoring ring for the machinery including curved segments, radiating sectional screw bars connecting said screw bar with the anchoring ring, and hand wheels for operating the sectional screw bars co-operating with said supporting means to guide the direction of the travel of the cutter head. 10

In testimony whereof I have affixed my signature.

WILLIAM E. HAMILTON.