Oct. 29, 1935. G. J. SCHROEPFER 2,018,926

METHOD AND APPARATUS FOR EXCAVATING TUNNELS

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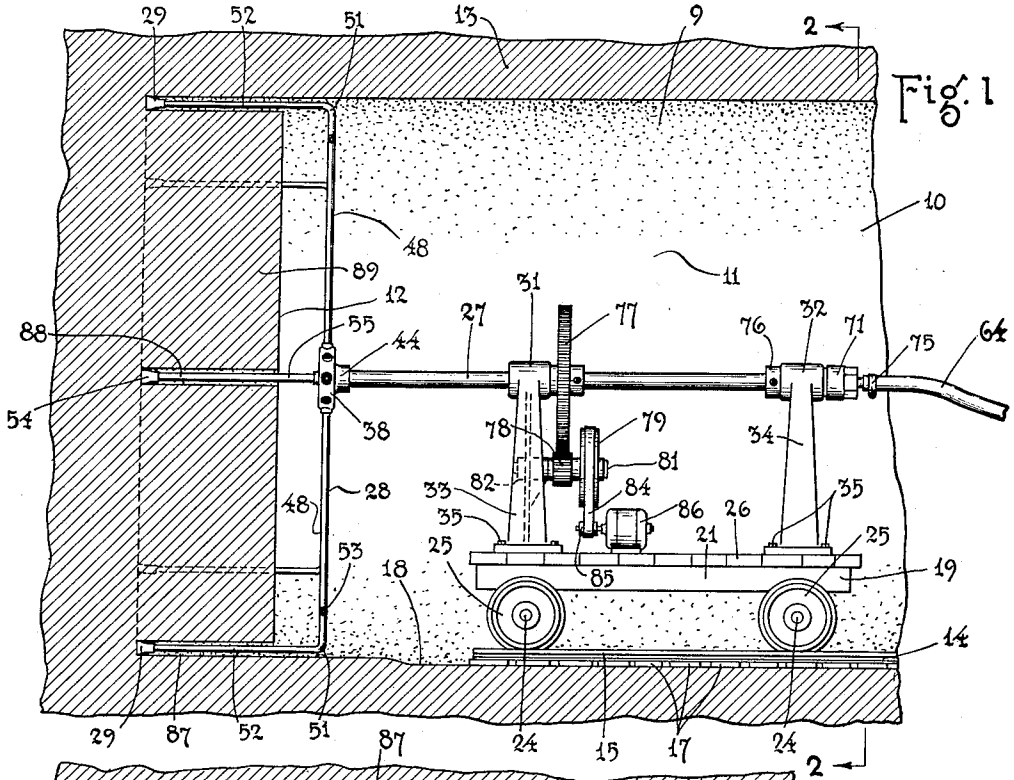


Fig. 1

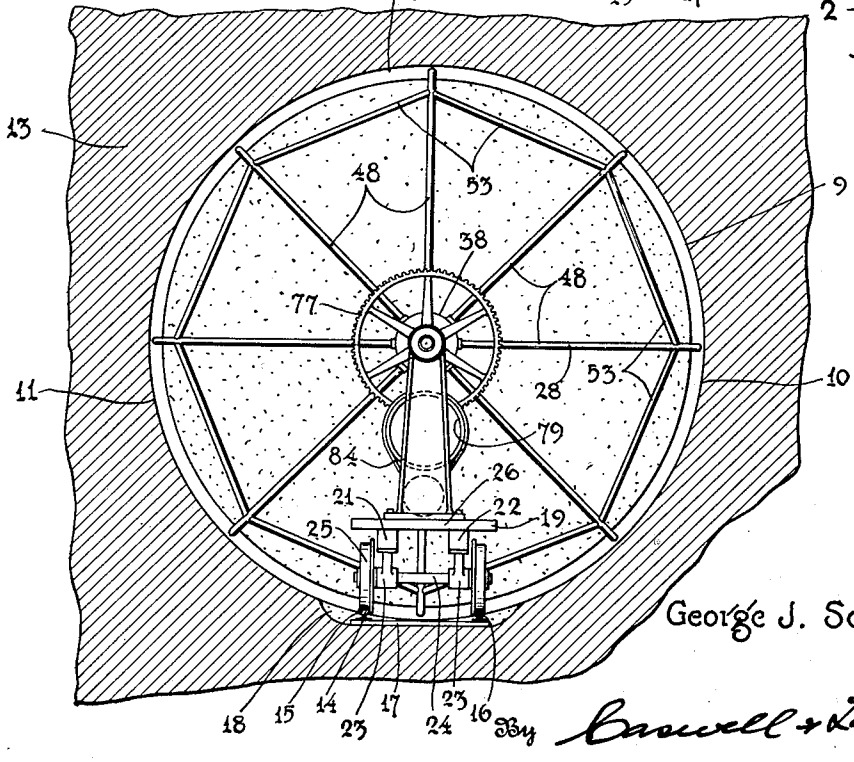


Fig. 2

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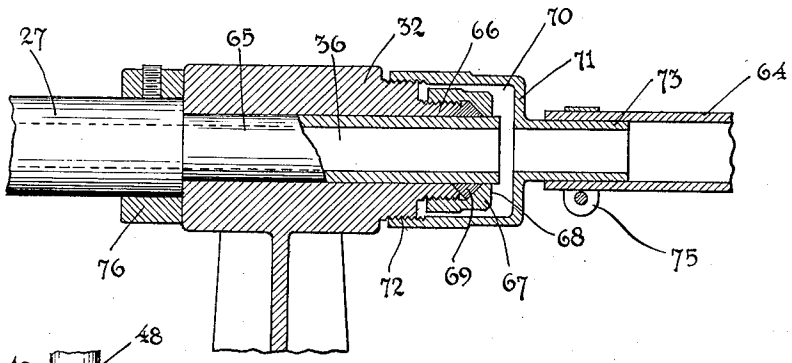
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Fig. 3



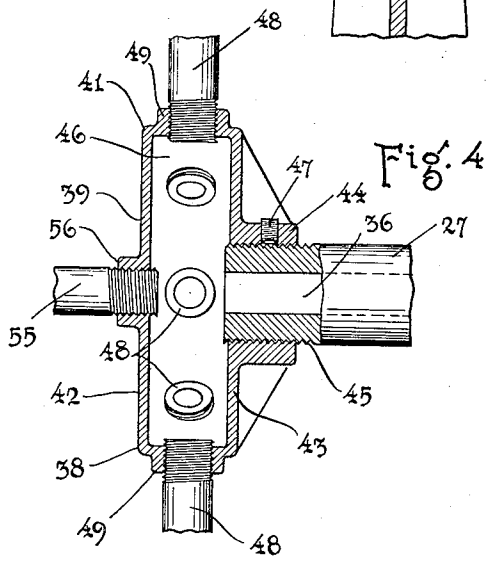
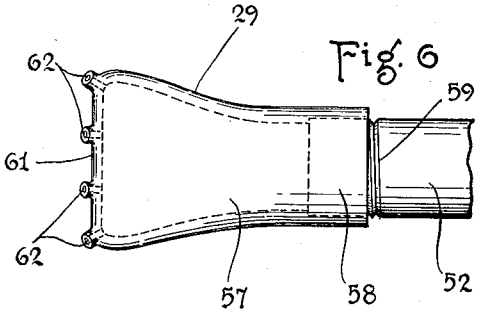


Fig. 4

Fig. 6



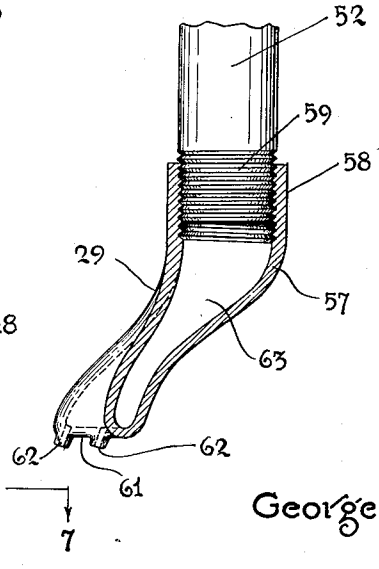
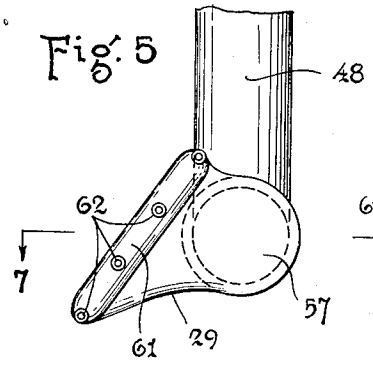


Fig. 7

Fig. 5



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2,018,926

METHOD AND APPARATUS FOR EXCAVATING TUNNELS

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Application April 23, 1934, Serial No. 721,906

2 Claims. (Cl. 262—7)

My invention relates to a method and apparatus for use in excavating tunnels in formations such as St. Peter sandstone and the like and particularly to a method and apparatus utilizing the principle of abrasion for cutting into the sandstone.

An object of the invention resides in providing a method and apparatus by means of which excavation is accomplished through the action of air jets impinging upon the face of the tunnel.

Another object of the invention resides in providing an apparatus in which air is directed over an annular area at the periphery of the face of the tunnel to provide an annular groove forming a core of stone at the center of the tunnel separated from the wall of the tunnel.

A still further object of the invention resides in providing an apparatus having a support carrying one or more nozzles and adapted to be rotated or held stationary, depending upon the number of nozzles employed to cause the air jets to cut the annular groove.

An object of the invention resides in providing means for guiding said support for movement in a direction parallel to the axis of the tunnel for giving depth to the annular groove.

A feature of the invention resides in providing a pipe having a reach extending in a direction parallel to the axis of the tunnel and to which the nozzle is attached, said reach being capable of being advanced into the annular groove as the cutting progresses.

An object of the invention resides in installing within the tunnel a track and in providing a truck traveling thereon and carrying the support for the nozzles, said truck serving to guide the nozzles toward the face of the tunnel.

Other objects of the invention reside in the novel combination and arrangement of parts and in the details of construction hereinafter illustrated and/or described.

In the drawings:

Fig. 1 is a longitudinal sectional view of the end of a tunnel showing an embodiment of my invention installed therein.

Fig. 2 is a cross sectional view taken on line 2—2 of Fig. 1.

Fig. 3 is a longitudinal sectional view taken through the hose connection in one of the standards of the invention.

Fig. 4 is a longitudinal sectional view taken through the manifold of the invention.

Fig. 5 is a front elevational view of one of the nozzles of the invention.

Fig. 6 is a side elevational view of the structure shown in Fig. 5.

Fig. 7 is a plan sectional view taken on line 7—7 of Fig. 5.

In tunnels built in sandstone and similar earth formations, it is usually necessary in order to render such tunnels absolutely safe and permanent to line the tunnel with reinforced concrete capable of resisting the stresses to which the structure may be subjected. Where a tunnel is excavated in the customary manner and especially when blasting is resorted to, a considerable overbreak in excavation occurs necessitating an undesirable overrun in concrete, both of which unnecessarily increase the cost of the operation. The present invention provides an apparatus by means of which the tunnel may be accurately formed so as to require a minimum amount of excavation and a minimum amount of concrete and also provides an apparatus by means of which the excavation may progress rapidly and with a relatively small amount of labor.

For the purpose of illustrating the application of my invention, I have shown in Figs. 1 and 2 the end of a tunnel 9 having a bore or passageway 10 therein. This tunnel is of circular cross section and the circular wall of the tunnel is indicated at 11, while the face or the end of the tunnel is indicated at 12. The earth in which the tunnel is formed is represented by the reference numeral 13 and for the purpose of illustration is assumed to be sandstone or other similar earth formation which is readily disintegrated by abrasion through the application of a jet of air thereto.

In the tunnel 10 is provided a track 14 which consists of two rails 15 and 16 spiked to ties 17. This track is laid on a roadway 18 formed in the bottom of the tunnel by cutting the lowermost portion of the circular wall 11 of the tunnel down to a level and for a width sufficient to receive said track. Upon the track 14 are run ordinary cars by means of which materials may be brought to and from the face of the tunnel and by means of which the excavated stone is removed from the tunnel.

My invention utilizes the track 14 and further utilizes a truck 19 which is carried by said track. This truck consists of two longitudinal frame members 21 and 22 which have attached to the undersides thereof bearings 23. The bearings 23 journal axles 24 which have attached to them flanged wheels 25 riding on the rails 15 and 16 of the track 14. The two longitudinal frame

members 21 have attached to them a floor 26 on which the invention proper is mounted.

My invention further includes a shaft 27 which serves as a support for a head 28 carrying a number of nozzles 29. The shaft 27 is rotatably mounted in bearings 31 and 32 formed on two standards 33 and 34. The standards 33 and 34 are attached to the floor 26 of truck 19 through bolts 35. The shaft 27 is hollow, being formed with a bore 36 into which air under pressure is directed and by means of which the various nozzles 29 are fed with air.

The head 28 comprises a manifold 38 which is shown in detail in Fig. 4. This manifold consists of a casting 39 cylindrical in form having a peripheral wall 41 and radial walls 42 and 43. A boss 44 issues centrally from the radial wall 43 and is threaded to screw upon the threaded end 45 of the shaft 27. A set screw 47 threaded into the boss 44 holds the manifold 38 from movement on the shaft 27. The manifold 38 is formed with a chamber 46 within the same, which chamber communicates with the bore 36 in shaft 27.

The head 28 further includes a number of arms 48 which are constructed from pipe and which are screwed into bosses 49 equally spaced about the periphery of the wall 41. These arms extend outwardly toward the wall 11 of the tunnel 10 and are formed with bends 51 providing longitudinal reaches 52 arranged in the form of a circle or cylinder having a diameter slightly less than the diameter of the tunnel proper. The shaft 27 is arranged with its axis coincident with the axis of the tunnel so that the head 28 may rotate freely within the bore of the tunnel. The various nozzles 29 are attached to the reaches 52. For the purpose of reinforcing the arms 48, braces 53 are employed, which braces may be constructed of pipe or any other suitable material and are welded to the arms 48. The manner of arranging these braces is clearly shown in Fig. 2.

In addition to the nozzles 29 which are arranged about the periphery of the head 28 a centrally located nozzle 54 is employed which is attached to a pipe 55 coaxially disposed relative to shaft 27. This pipe is screwed into a boss 56 formed on the manifold 38 and also communicates with the chamber 46 within said manifold.

The various nozzles 29 are similarly constructed and are shown in detail in Figs. 5, 6 and 7. These nozzles are each provided with a body 57 having a boss 58 formed thereon and threaded upon the threaded ends 59 of the various reaches 52 of arms 48. These nozzles are further constructed with a tip 61 angularly disposed with respect to the boss 58. This tip is elongated in form and is provided with a row of orifices 62 which extend through said tip and communicate with a chamber 63 within the nozzle proper. By means of the particular arrangement of orifices and the inclination of the nozzle as shown, propulsion of the shaft 28 through the force of the air leaving the nozzle is partly procured. In addition a progressive application of air to the area to be cut or abraded is procured.

Air under pressure is directed into the bore 36 of shaft 27 through a hose 64 shown in Fig. 1. The manner of connecting this hose is illustrated in detail in Fig. 3. The end 65 of the shaft 27 is slightly reduced in diameter and is journaled in the bearing 32 previously referred to. This shaft projects outwardly beyond the end of the said bearing. At such locality the bearing is reduced in diameter as designated at 66 and is threaded to receive a cap 67 forming part of a stuffing box indicated in its entirety by the reference numeral 68. The cap 67 is so constructed that a packing 69 encircling shaft 27 is forced against the protruding portion of the end 65 of said shaft and a fluid tight connection afforded between the bearing 32 and said shaft. Attached to the bearing 32 is a housing 71 which is threaded at 72 to screw upon said bearing. This housing is formed with a chamber 70 which receives the stuffing box 68 and the end 65 of shaft 27, and which communicates with the bore 36 in shaft 27. This housing is constructed with a nipple 73 over which the hose 64 is applied and which also communicates with chamber 70. An ordinary hose clamp 75 is used for holding the said hose applied to the nipple. It will be readily comprehended that air under pressure may be directed into chamber 70 within the housing 71 through the hose 64, and from said chamber directed into the bore 36 of shaft 27. Leakage along the bearing 32 is prevented by the stuffing box 68.

Through the angularity of the nozzles 29 propulsion of the shaft 27 may be procured by the air impinging upon the face 12 of the tunnel proper. However, if desired, positive means may be employed for rotating said shaft. In Figs. 1 and 2 such construction has been shown. Upon shaft 27 and in close proximity to the bearing 31 is mounted a spur gear 77. This gear rides against the bearing 31 and restrains the shaft 27 from axial movement in one direction. A collar 76 at the other end of the shaft engages bearing 32 and restrains said shaft from axial movement in the other direction. The spur gear 77 meshes with a pinion 78 which is secured to a pulley 79. Both the pinion 78 and pulley 79 are rotatably mounted on a stub shaft 81 which is secured to a boss 82 formed on standard 33. A belt 84 passes over the pulley 79 and over another pulley 85 on the end of the armature shaft of a motor 86. Motor 86 rests upon the floor 26 of truck 19 and is secured thereto in the ordinary manner. By means of this construction, shaft 27 may be rotated at a greatly reduced rate of speed.

The operation of my invention is as follows: The truck 19 is run along the track 14 until the nozzles 29 and 54 are in close proximity to the face 12 of the tunnel. Motor 86 is then turned on which starts rotation of the shaft 27. Air is then directed into the bore 36 of shaft 27 through hose 74, which causes air jets from the orifices 62 of said nozzles. These air jets strike the surface of the sandstone and abrade and disintegrate the same, reducing the earth formation to a granular form. The grains so formed impinge upon the uncut structure and thereby further reduce and cut the rock formation. If the shaft 27 rotates an annular groove 87 is cut by the nozzles 29 at the periphery of the tunnel, one wall of which groove forms the wall 11 of the tunnel proper. In addition, a bore 88 is also cut by the nozzle 54 which is disposed at the center of the face. By means of the groove 87 a core 89 is formed which is separated from the wall 11 of the tunnel. As the cutting progresses the truck 19 is moved along the track 14 either through a pinch bar or through any other suitable mechanism which may be connected to the wheels of the truck 19. The head 28 is thus advanced toward the face 12 and as the cutting continues reaches 52 travel into the groove 87 until the arms 48 are within a short distance of the face of the tunnel. At such time the apparatus is shut down and moved back along the track 14. The core 89 is then blasted by means of dynamite

which is applied to the central bore in the core and to such other bores as may be required. The blast breaks down the core, the broken stone or muck falling to the floor of the tunnel. Suitable trucks or cars may then be run upon the track 14 and the muck carried away. After the muck has been cleared away, the roadway 18 is extended and a further length of track added to extend the track up to the face of the tunnel a distance sufficient to permit of repeating the operation. The truck 19 is then brought back and the procedure repeated.

In the use of my invention overbreak in excavation is effectively minimized and any undesirable overrun in concrete thereby avoided. The apparatus is simple and inexpensive in construction and is inexpensive in operation. Thus, with my invention, tunneling operations in sandstone and similar formations are readily and economically accomplished.

Changes in the specific form of my invention, as herein disclosed, may be made within the scope of what is claimed without departing from the spirit of my invention.

Having described my invention, what I claim as new and desire to protect by Letters Patent is:

1. The method of cutting a channel in sandstone or the like, which comprises directing against the material a plurality of jets of air in closely spaced relationship and arranged successively lengthwise of said channel, and causing said jets to move as a unit lengthwise of said channel, whereby sand particles loosened by a leading jet are, immediately upon being loosened, caught by a trailing jet and caused thereby to effect an abrading action upon unloosened sand particles in said channel.

2. In apparatus of the character described for cutting a tunnel outlining channel in sandstone, an air nozzle supported to move along an area of the tunnel face defining the longitudinal and lateral extent of the channel to be formed, means for moving the nozzle, said nozzle having a plurality of air passageways therein extending in the direction of said area for directing jets of air against the same, said passageways being arranged successively lengthwise of said area and in closely spaced relationship, a trailing jet of air from one of said passageways being adapted to catch sand particles loosened by a leading jet of air from a preceding passageway and force such particles with abrading effect against unloosened sand particles in said area.

GEORGE J. SCHROEPFER.