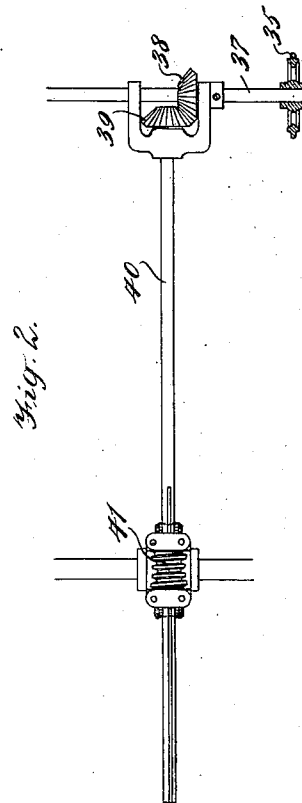
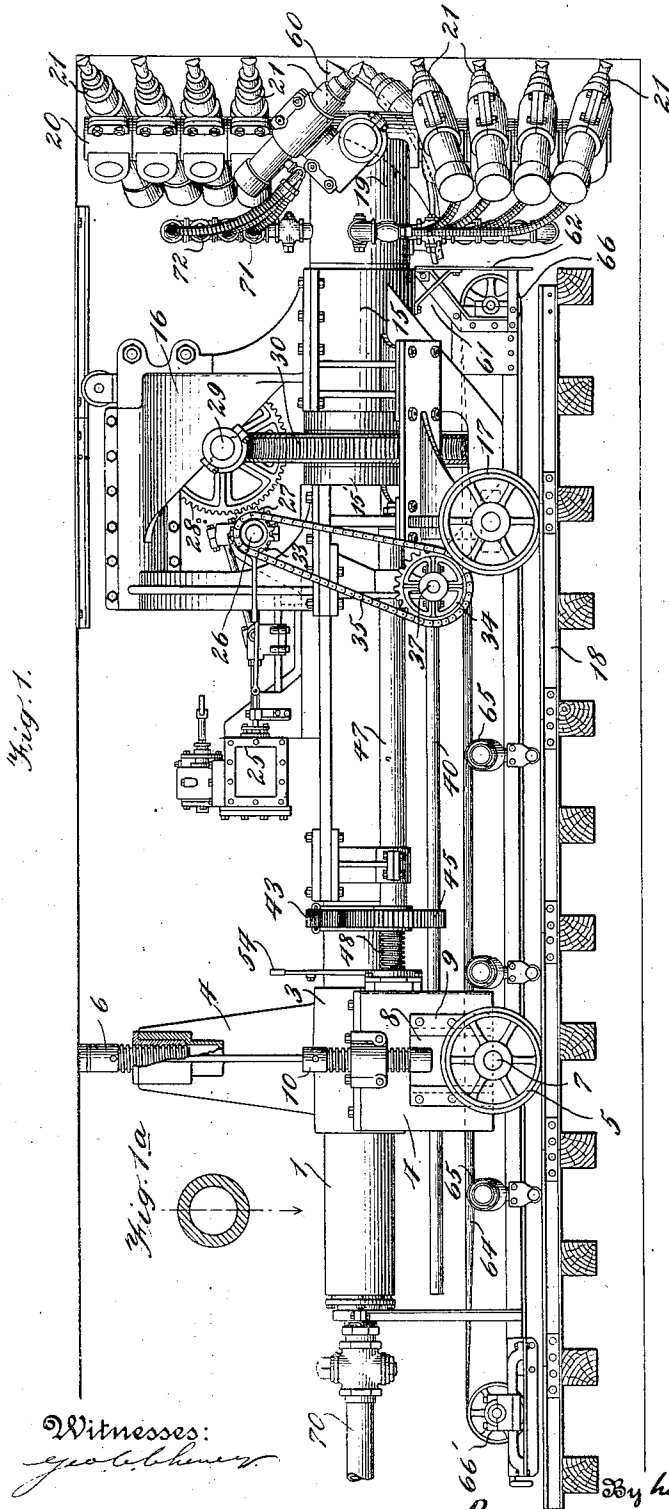


O. O. APP.
EXCAVATING MACHINE.
APPLICATION FILED MAR. 15, 1917.

1,283,618.

Patented Nov. 5, 1918.

5 SHEETS—SHEET 1.



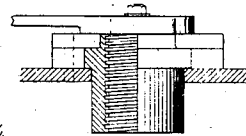
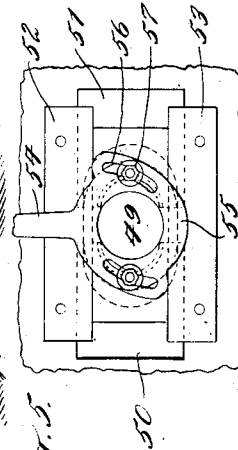
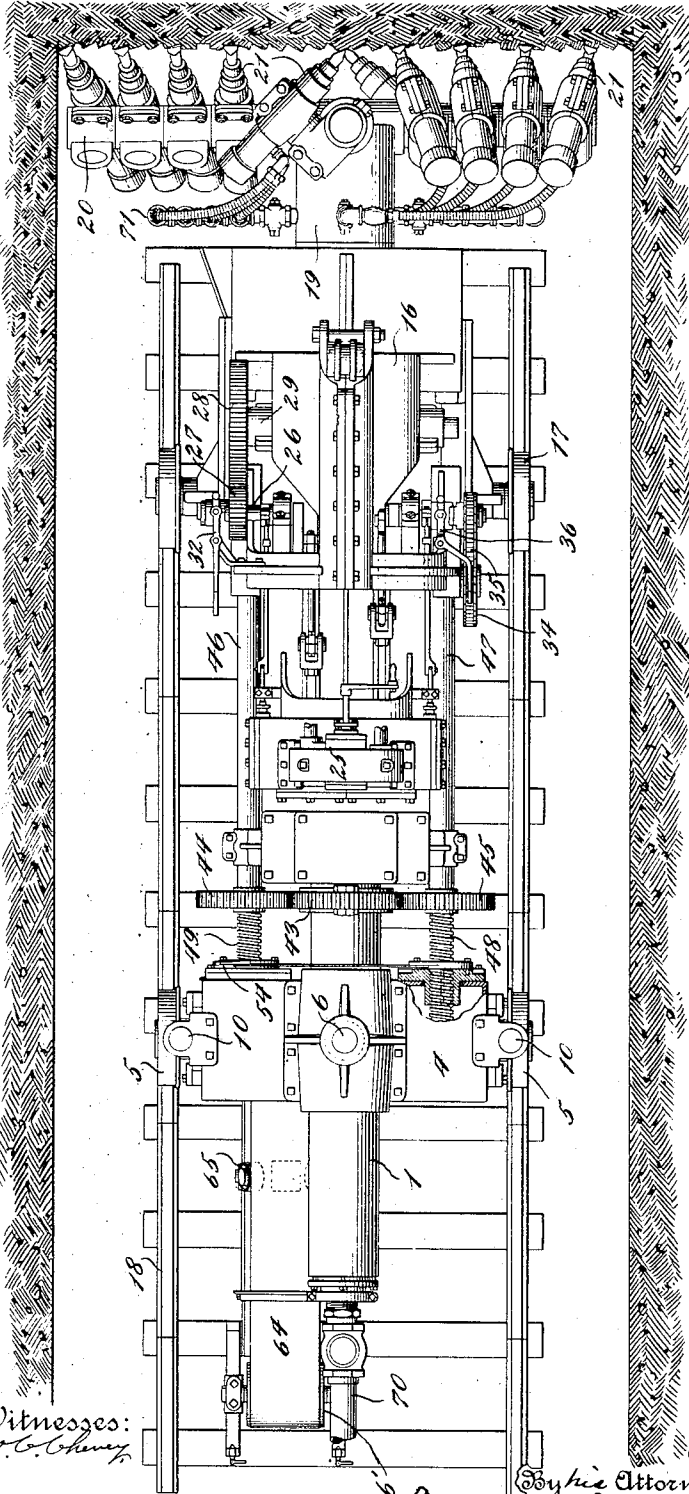
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5 SHEETS—SHEET 2.



Witnesses:
Geo. C. Chumey

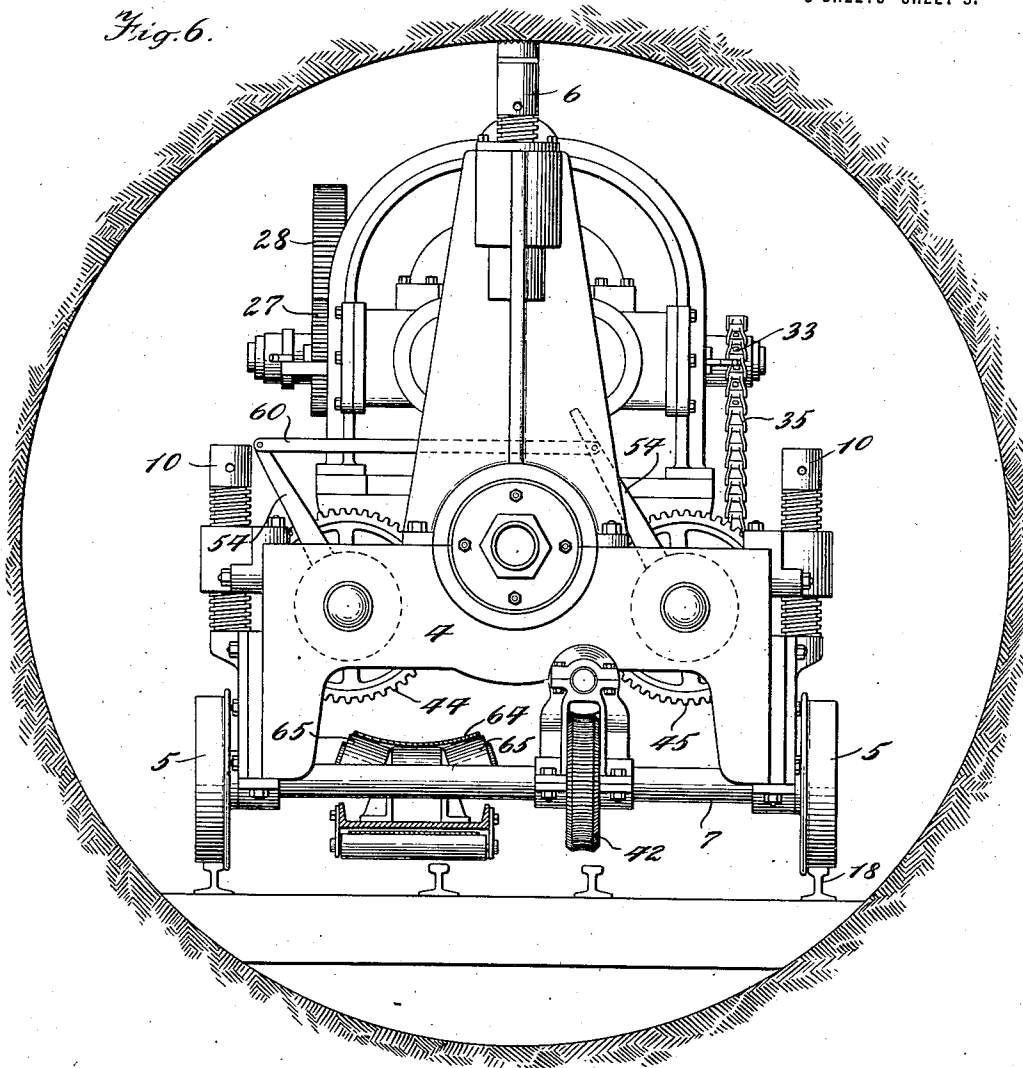
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Patented Nov. 5, 1918.
5 SHEETS—SHEET 3.

Fig. 6.



Witnesses:
J. C. Cheney

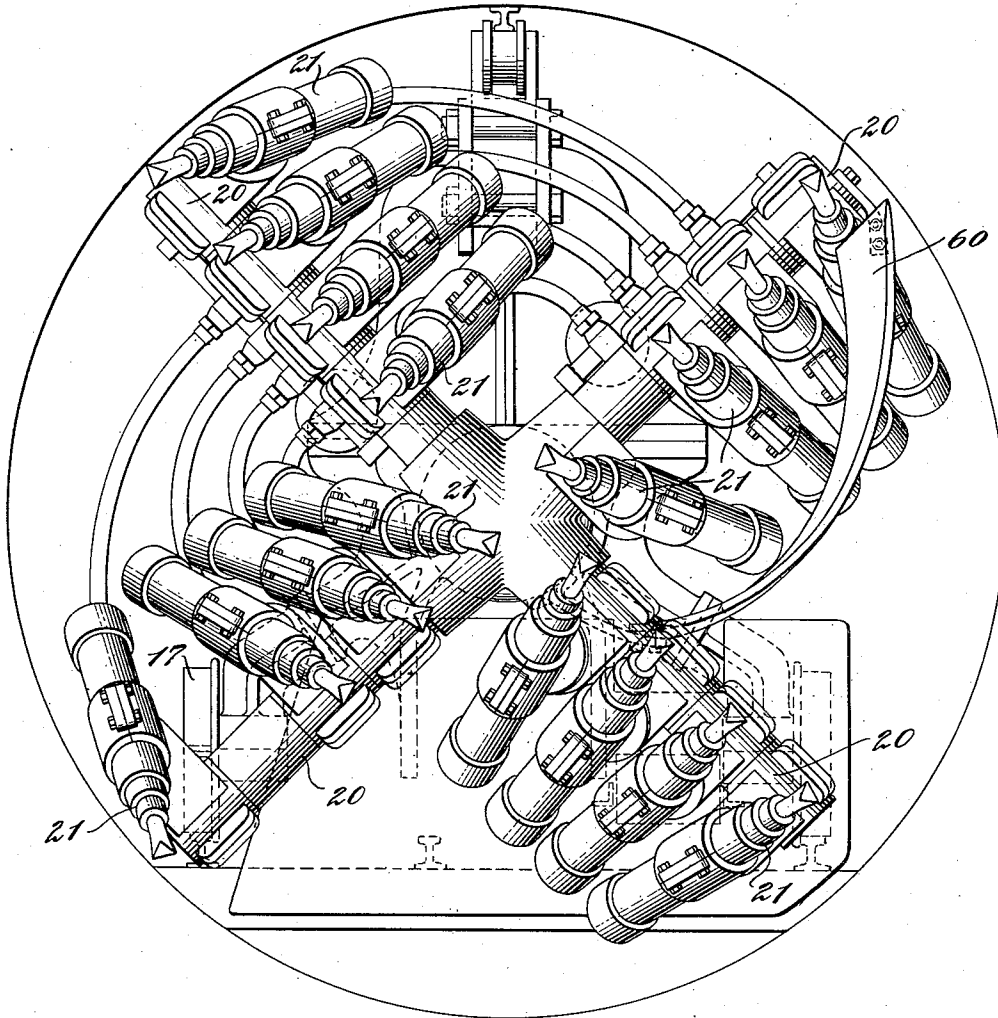
Oliver O. App. Inventor
By his Attorneys
Rosenbaum, Stockbridge & Rose

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1,283,618.

Patented Nov. 5, 1918.
5 SHEETS—SHEET 4.

Fig. 7.



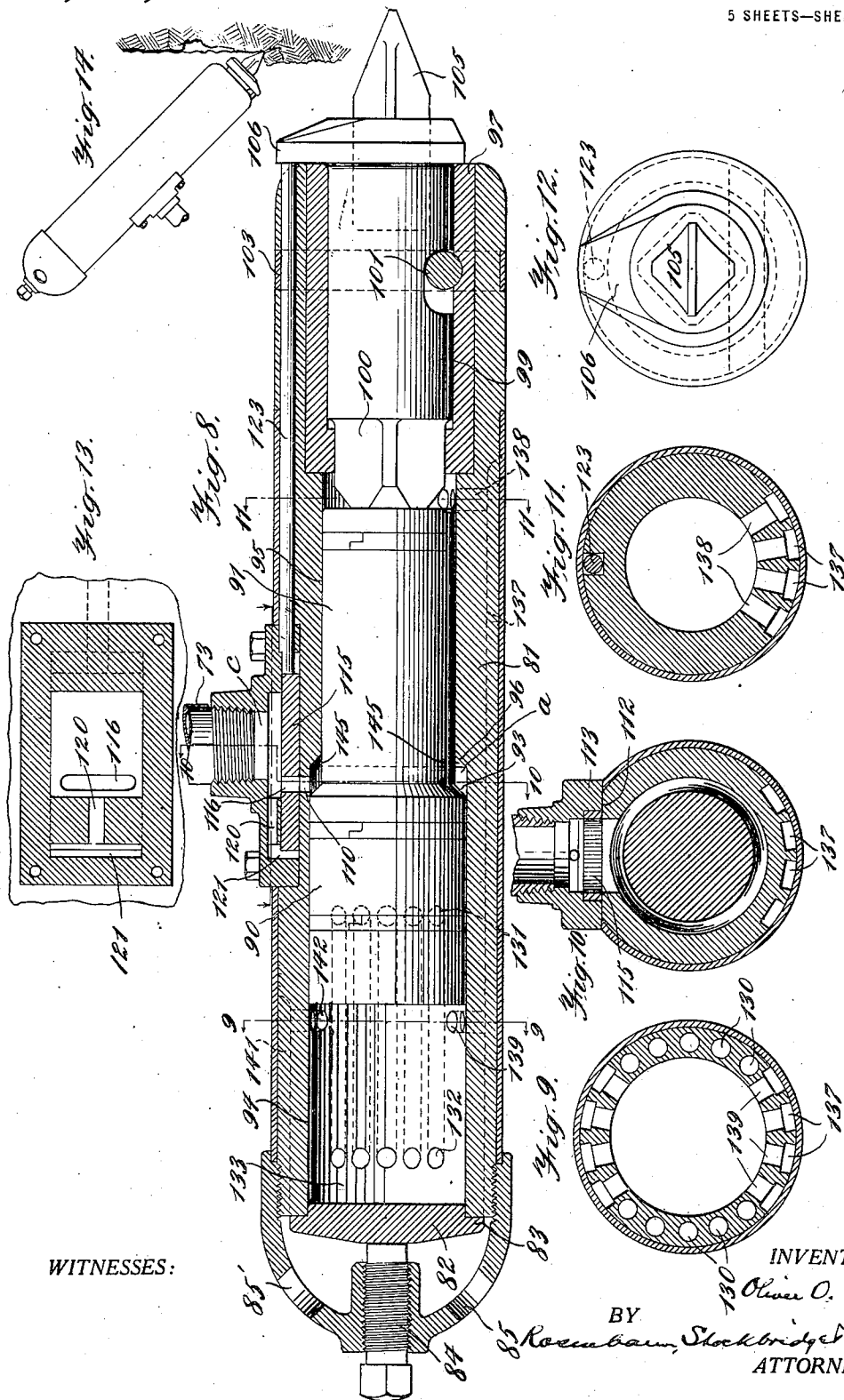
Witnesses:
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1,283,618.

Patented Nov. 5, 1918.

5 SHEETS—SHEET 5.



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UNITED STATES PATENT OFFICE.

OLIVER OSCAR APP, OF NEW YORK, N. Y.

EXCAVATING-MACHINE.

1,283,618.

Specification of Letters Patent.

Patented Nov. 5, 1918.

Application filed March 15, 1917. Serial No. 154,969.

To all whom it may concern:

Be it known that I, OLIVER O. APP, a citizen of the United States, residing at the city of New York, in the borough of Manhattan and State of New York, have invented certain new and useful Improvements in Excavating-Machines, of which the following is a full, clear, and exact description.

10 This invention relates to machines for excavating rock, coal, metalliferous ores and like hard substances, and more particularly to machines having a head which carries a plurality of power actuated implements, each consisting of a cutting tool and a power driven hammer for striking the tool. The tools are mounted upon the head, which may either be rotatable, oscillatory or fixed to the frame, and are in each instance arranged so that each tool is at an angle to the work, and when struck by the hammer the impact of the blow will chip away the material.

25 The primary object of the invention is to provide a machine of this character in which there is a definite relation between each hammer and its cutting tool, *i. e.*, the cutting tool of each implement will be in firm contact with the rock before it is struck by the power driven hammer.

30 It has been found that when a cutting tool is utilized, which is not in firm contact with the work before it is struck by the hammer, the force of the blow delivered to the tool by the hammer will be partially dissipated in the tool itself instead of being entirely transmitted through the tool to the material to be cut, thereby lessening to a material extent the effective force of the blow. Moreover, when the tool is struck without being in firm engagement with the work, it rapidly crystallizes and is destroyed under the tremendous strains to which it is subjected. Furthermore, the hammer is then liable to drive the tool from its holder, strike against the hammer case and irreparably destroy the parts of the implement.

50 The failure of a cutting tool of a power driven implement of the hammer type, to seat firmly against the work before a blow of the hammer can be delivered has been found to be due to several causes. If the cutting tools are fixedly mounted upon the

head, then as the head advances, each of the tools will have a corresponding advance, but the amount of cutting done by each tool is irregular, due to the varying hardness of material encountered, and other conditions. Paths of varying thickness will therefore be cut in the work, and the tools which chip away large pieces of the material will be prevented from seating by the tools which cut a lesser amount of the material.

It has therefore been proposed to movably mount the tool upon the head to overcome this objection. Such a construction is disclosed in the patent to Proctor, No. 1,201,097, granted October 16, 1916. Here again, however, it has been found that merely mounting the tool for movement, is not sufficient since it need not be in firm contact with the rock when the tool is struck by the hammer. The result has been that the tools have been rapidly destroyed and the force of the blow dissipated. One reason why the movable tool will not seat firmly against the rock before the hammer strikes it is due to the rebound of the tool after being struck by the hammer. It has also been found, when the tool is mounted upon a rotating head whose axis is longitudinal to the machine, that upon the up revolution of such a head or hammer the cutting tool drops by gravity away from the work and when the hammer strikes the same the force of the blow is, as before, dissipated in the cutting tool rather than being imparted directly to the rock itself.

It is the fundamental purpose of this invention to overcome these objections and to produce in a rock tunneling machine, a relation between the cutting tool and the hammer, which will permit the cutting tool to be in firm contact with the material to be cut each time the hammer strikes a blow, so that the entire force of the blow will be imparted directly to the operation of chipping or cutting the rock and not be dissipated in any sense in the cutting tool itself. The result has been that the tools do not crystallize and will cut many feet of rock without resharpening.

It is also the object of the invention to provide a relation between the action of the hammer and the cutting tool so that if the cutting tool is out of firm contact with the

rock, then the hammer will be stopped from operating before it can deliver a blow against the cutting tool or its holder. In this manner, any danger of the parts of the machine becoming broken is substantially eliminated.

It is also the object of the invention to provide a construction which will permit the tool to rebound under the blow which it receives from the hammer and yet firmly seat before another blow can be struck by the hammer.

It is a further object of the invention to provide a construction in which the strength of the blow delivered by the hammer upon the cutting tool will be entirely dependent upon the character and quality of rock to be chipped; in other words, to provide a tool which, if the material is soft, will strike a relatively light blow, and if the material is hard, will strike a blow of full force, blows of other strengths being struck by the hammer under intermediate conditions.

Still another object of the invention is to provide a construction which will eliminate to an appreciable degree the grinding action which would occur between the cutting edge of the tool and the material to be cut.

A further object of the invention is to provide a rock excavating machine in which each of the objects previously set forth is obtained for each individual hammer, acting independently of all of the other hammers and performing its functions in accordance with the particular character of material which it is to cut.

Other objects of the invention will be apparent from the detailed description hereinafter to follow, and with these and such objects in view, the invention consists of the constructions and combinations which will be hereinafter set forth and particularly pointed out in the appended claims.

In the accompanying drawings, one embodiment of the invention is shown, which comprises a head for the power actuated cutting tools, which head rotates upon a horizontal axis parallel to the longitudinal axis of the machine, but it is not the intention to limit the invention to this particular type of head, since it is equally applicable to excavating machines rotatable upon the horizontal axis transverse to the longitudinal axis of the machine, to a machine having an oscillating head or to one in which the head is fixedly mounted upon the frame.

In the accompanying drawings

Figure 1 shows a side elevation of a machine constructed in accordance with the principles of the invention;

Fig. 1^a is a transverse section through the main shaft;

Fig. 2 is a detail of the gearing for advancing the frame which carries the head;

Fig. 3, a top plan view of the machine;

Figs. 4 and 5, details of a split-box construction utilized in advancing the rear carriage of the frame;

Fig. 6, a rear end elevation of the machine;

Fig. 7, a front end elevation of the machine;

Fig. 8, a sectional view through one of the power actuated implements.

Figs. 9, 10 and 11, transverse sections through such an implement, upon the lines 9-9, 10-10 and 11-11, respectively;

Fig. 12, a front end elevation of the implement;

Fig. 13, a sectional view showing a detail of the control valve for the implement; and

Fig. 14, a conventional showing of one of the tools and to illustrate the angle at which the material is attacked.

The machine illustrated consists of a hollow, rotary main shaft 1, a cross section of which is shown in Fig. 1^a. This main shaft is supported adjacent its rear end in a bearing 3 carried by a carriage 4 mounted upon wheels 5. The carriage 4 is adapted to be locked to the walls of the tunnel by means of a screw jack 6 positioned at the top thereof. The wheels 5 are mounted upon axles 7, which are carried by plates 8 slidably mounted in guides 9 secured to the sides of the carriage 4. A screw 10 carried by the carriage at each side thereof bears against the plates 8. By turning these screws the height of the carriage, and hence the main shaft 1, may be adjusted. In this manner the angle at which the tunnel is cut may be varied, for by changing the angular position of the shaft 1, the angle of the head, which will be hereafter described, will also be varied. The front end of the shaft 1 is supported in bearings 15 and 15', which are carried by the front carriage 16. This carriage is also movably mounted upon wheels 17, which wheels, with the wheels 5, preferably move upon rails 18.

Attached to the front end of the main shaft is a head 19, which head carries four arms 20, arranged at right angles to each other, the arms being rigidly connected to the main shaft so that a head of great strength is obtained. These arms 20 carry power driven implements for cutting or chipping the rock, which, in the present instance, comprise pneumatic rock drills of the hammer type. These rock drills are designated 21 and their specific construction will be hereinafter set forth.

Mounted upon the front carriage 16 is an engine, which, in the form disclosed, is a compressed air engine 25, which drives a main shaft 26. This main shaft is through gears 27 and 28 connected to a shaft 29 which carries a worm driving a worm wheel 30

mounted upon the main shaft 1. The driving relation between the gears 27 and 28 is controlled by a clutch 32.

The other end of the main shaft 26 of the air engine carries a sprocket wheel 33 which drives a sprocket wheel 34 by means of a chain 35, the connection between the sprocket wheel 33 and the shaft 26 being controlled by a clutch 36. The sprocket wheel 34 is mounted upon a shaft 37, which is shown in detail in Fig. 2. This shaft carries a beveled gear 38 meshing with a corresponding gear 39 mounted upon a shaft 40 extending longitudinally to the rear of the machine, which shaft carries a worm 41 mounted in suitable bearings in the rear carriage 4 of the frame. This worm 41 drives a worm wheel 42 which is mounted upon the axle 7 in the rear wheels 5 of the machine (see Fig. 6). Therefore, by the throwing in and out of the clutch 36, the rear carriage when free may be advanced along the rails 18.

The main shaft 1 carries at a point positioned just in front of the rear carriage 4, an annular gear 43 which meshes with the gears 44 and 45 carried by shafts 46 and 47, respectively. The shafts 46 and 47 are parallel to the main shaft 1 and are mounted at their front ends in suitable bearings in the front carriage 16 of the frame. The rear ends of these two shafts are threaded, as at 48, and 49, and each shaft fits into an interiorly threaded split box carried by the rear carriage 4, consisting of two parts 50 and 51, which are mounted against rotary movement in slides 52 and 53 (see Fig. 5). The parts 50 and 51 are moved toward and away from each other by means of an arm 54 which has a head or ring 55 loosely surrounding the threaded shaft 49, which ring has cam slots 56 formed therein. Bolts or pins carried by the sliding pieces 50 and 51 fit into these cam slots and are held in position by nuts 57, so that upon movement of the arm 54, the pieces 50 and 51 of the box may be brought together or moved apart. When brought together they engage the threaded shafts 48 and 49 and when forced apart, permit these shafts to pass freely.

The front ends of the shafts 46 and 47 abut against parts of the front carriage 16, so that when the main shaft 1 is rotated, imparting rotation to the shafts 46 and 47, the threaded portions of these shafts 48 and 49 rotate in the split boxes 50 and 51 carried by the rear carriage 4, which is locked to the walls of the tunnel. The shafts 46 and 47, therefore, move forwardly, which movement is imparted to the front carriage 16 and to the head 19 of the machine to advance the power driven implements into engagement with the face of the rock to be cut.

After the front carriage and head have been advanced a predetermined distance, de-

pending upon the length of the threaded portions 48 and 49 of the shafts, the arms 54 which are connected together by a link 60 are then moved to open the split boxes. The rear carriage 4 is then released from locking engagement with the walls of the tunnel by unscrewing the jack 6. The clutch 36 can then be thrown in to rotate the shaft 37, which, through the shaft 40 and worm wheel 42, will cause a rotation of the wheels 5 to carry the rear carriage 4 forwardly until the rear carriage is adjacent the gears 43, 44 and 45. The arms 54 are then moved to close the split boxes against the threaded ends 48 and 49 and the rear carriage locked to the walls of the casing so that on further rotation of the main shaft 1, the front carriage 16 and the head 19, will be advanced, as has been previously described.

To remove the muck or fragments of rock which are cut or chipped from the face of the rock, shovels 60 are provided, only one of which shovels is shown in Fig. 7 of the drawings. These shovels are carried by the head of the machine and scoop up the muck or chippings which drop to the bottom of the tunnel and deposit them in a hopper 61 positioned beneath the front carriage 16. This hopper is provided at its front end with a face plate 62, against which the rear edge of the shovel rests, so that the muck will not be dropped from the shovel but will be carried upwardly and deposited into the hopper. The material deposited in the hopper is fed to a conveyer belt 64, which is suitably supported by idlers 65 at intermediate positions, and at its ends by wheels 66 and 66'. This conveyer may be driven by attaching a motor to the rear wheel 66', or in any other desired manner.

From the description of the machine as so far explained, it is apparent that by suitably operating the clutches 32, 36, and the arm 54, the head of the machine may be rotated and advanced forwardly continuously for a predetermined distance, after which the rear carriage 4 is brought forwardly and the operation is continued. This simultaneous forward and rotary movement of the head is imparted to the rock cutting implements 21, which are carried thereby and as the machine operates these implements cut concentric paths in the face of the rock, as will be later described, which paths are of increasing diameter and hence, upon each rotation of the head the tunnel is advanced a determined amount, depending upon the pitch of the screws 48 and 49.

Referring now more particularly to the rock cutting implements which are mounted upon the rotating head, in the embodiment shown, 16 of these implements are provided which are of the same construction, four being mounted upon each arm, the outer im-

plements on the arms being preferably slanted, as shown, to cut a clearance for the machine and the ends of the arms of the head. The specific construction of these implements is clearly shown in Figs. 8 to 13, inclusive. These power actuated implements are pneumatically operated rock drills of the hammer type, the compressed air for the same being admitted through a pipe 70 which connects to the rear end of the hollow main shaft 1, air being supplied to the separate implements through pipes 71 carried by the head. Flexible pipes 72 distribute the air from the pipes 71 to each of the implements, the flexible pipes being connected to a pipe 73 which conducts the air to the implement (see Fig. 8).

The casing or cylinder 81 of the implement is open at both ends and has its rear end closed by a head 82, which is provided with a flange 83 which fits against the rear annular end face of the casing and is maintained in place by a set screw 84, which is threaded into a cap 85. This cap 85 has suitable exhaust openings 85' therein and is threaded over the rear end of the casing 81. Slidably mounted within the open casing 81 is a solid differential piston or hammer, which is cylindrical in form and comprises two heads 90 and 91 of different diameters, which are joined together by a shoulder 93. The interior of the casing 81 comprises two cylindrical interior surfaces 94 and 95 which are of a suitable diameter to permit the heads 90 and 91 to have a sliding fit therein, these surfaces being joined together by an annular shoulder 96.

Mounted in the front end of the casing or cylinder 81 is a bushing 97 and slidably mounted within this bushing is a tool holder 99, which is preferably cylindrical for the major portion of its length, but is squared at its rear end 100, which squared end passes through an aperture in the bushing 97. A pin 101 prevents the sliding tool holder from being inadvertently displaced from the bushing, which pin is held in position by a resilient band 102 surrounding the casing 81. The front end of the tool holder is provided with a square recess, into which the cutting tool or chisel 105 is adapted to fit.

Air is admitted to the chamber which is designated *a*, and which is formed to the front of the shoulder 93 of the hammer through a port 110, which port is controlled by a valve mechanism, which will now be described. The curved peripheral surface of the casing above the port 110 is cut away, as at 112, to provide a flat seat upon which a valve chest 113 is mounted. The main reservoir chamber of the valve chest is shown at *c* and positioned below this chamber is a slide valve 115, which rests directly upon the seat 112. A port 116 is provided in this

valve, which is adapted to register with the port 110 when the valve is in open position. The fluid pressure is admitted to the chamber *c* of the valve chest through the pipe 73, which, as before described, is connected to one of the flexible conduits 72. Leading rearwardly from the chamber *c* is a conduit 120, which is enlarged at its rear end, as at 121, and extends downwardly to expose the rear end of the slide valve.

A rod 123, which slides loosely in a passage formed in the top wall of the casing 81, abuts at its front end against an annular flange 106 carried by the tool holder and at its rear end against the front face of the slide valve. The front face of this valve, contrary to the rear face, is in this manner connected to the atmosphere through the passage provided for the rod 123, so that at all times while the air pressure is being admitted through the pipe 73, the valve 115 is unbalanced and is urged forwardly by the pressure against its rear face.

Longitudinally disposed inlet conduits 130 are drilled in the side walls of the casing. These conduits have inlet openings 131 and outlet openings 132, the outlet openings 132 being spaced from the head 82 a sufficient distance to provide a trapping chamber 133 in which the compressed air admitted through the outlets 132 is compressed upon the rear movement of the hammer. Also formed in the walls of the casing are exhaust conduits, one set of which is designated 137, which conduits lead into the cylinder through ports 138, which are positioned adjacent the rear end of the tool holder. Other ports 139 also connect these conduits to the rear chamber of the cylinder, and in Fig. 8 these ports are positioned just to the rear end of the hammer. The exhaust ports 137 extend to the rear end of the casing where the exhaust air escapes into the cap 85 and is exhausted through the openings 85'. Another set of exhaust conduits 141 may be utilized, which are arranged adjacent the top of the casing at the rear end thereof, which conduits have ports 142 arranged in radial alinement with the ports 139. The conduits 141 also lead to the rear end of the casing and the air therein escapes through the exhaust ports 85' in the cap 85. A trapping or cushioning chamber 145 may also be formed by extending the walls of the chamber to the front of the port 110. The operation of the machine is as follows: Assuming that the air engine has been supplied with air and the machine brought into close proximity to the face of the material to be cut, and that the line pressure has been turned on so that it passes through the main shaft 1 to the chamber *c* of each of the power driven implements, and assuming that the tools 105 of each of these implements is free from

the face of the work, the fluid pressure behind the slide valve 115 of each of the implements will force the slide valve 121 forwardly, which forward movement of the slide valve will, through the rod 123, be imparted to the tool holder and tool 105. The forward movement of the slide valve will also close the port 110 and the hammer within the cylinder or casing of each of the implements will remain inactive, with each of the tools 105 held in its outermost position, which is limited by the pin 101. Assuming now that the head is rotated and simultaneously advances, the action of each of the tools as it comes in contact with the rock, is similar but independent of each of the others, so that the action of one of these tools alone will be described.

As the head is further advanced the tool 105 will engage the rock and it will, together with the tool holder 99, be forced rearwardly, pressing the valve 115 also rearwardly to open the port 110, which will admit fluid pressure to the chamber *a*. In the position of the hammer shown in Fig. 8, the chamber formed to the rear thereof is open to the atmosphere so that the pressure of the air in the space or chamber *a* against the shoulder 93, will force the hammer rearwardly at a considerable speed, as the hammer approaches its rearmost position, the shoulder 13 passes beyond the inlet ports 131 of the inlet conduits 130, which will admit fluid pressure to the space behind the rear end of the piston, a portion of which fluid pressure, due to the momentum of the hammer will be trapped within the compressing chamber 133 and compressed to a pressure above the normal line pressure. The hammer then starts forwardly and as the end of the piston uncovers the ports 132 line pressure is admitted to the cylinder behind the hammer, which will drive the hammer forwardly at high speed, since the space in front of the front end of the cylinder is open to exhaust. The line pressure is continued to be admitted to the hammer until the shoulder 93 covers the inlet ports 131 of the inlet conduits 130, after which time the hammer will continue its forward stroke, under its own momentum and the expansive force of the air, until it strikes the end of the tool holder, with great force, which blow will be conducted through the tool holder and tool 105 to the rock, resulting in chipping off a piece of the same. During this forward movement of the piston the pressure exerted upon the tool holder and tool 105 to move it forwardly as described, will cause the tool to remain in firm contact with the work so that at the instant the hammer strikes the tool holder the tool 105 is in firm contact with the rock and the entire force of this blow is imparted to the rock and the

cutting edge of the tool will be driven with great force against the work, the impact of the blow being sufficient to chip away a portion of the work in front of the tool.

Assuming that only a small piece of rock has been chipped away, the tool will first rebound under the force of the blow imparted to it and will then move forwardly by virtue of the pressure exerted by the unbalanced slide valve through the rod 123, until it again seats against the rock. And assuming that this forward movement of the tool is compensated for by the simultaneous advance of the head, due to both its rotary and longitudinal advancement, the valve will then remain wide open, and since the chamber to the rear of the hammer is at exhaust, the pressure of the air against the annular shoulder 93 of the hammer will move the same rearwardly and its forward movement will result, as previously described, to strike the tool holder and tool another blow. This action is continuous as long as the advancement of the head equals the amount of material cut and each of the hammers continues to operate, rapidly striking blows of full strength against the tool. Such an action would occur where the excavating machine is operating in hard material of uniform quality. It should be noted that the contact between the cutting tool and the rock is continuous, due to the rebound of the tool when struck by the hammer, and for this reason the grinding action upon the edge of the tool, due to its being moved over the rough surface of the material cut, will be eliminated to an appreciable extent. This is true because the pressure urging the tool forwardly is so controlled by a proper design of the slide valve, that it is not equal to the force tending to cause the tool to rebound from the hard material when struck by the hammer. On the other hand, if the parts were so designed that this outward pressure on the tool was greater than the force causing a rebound to the tool, the tool would then remain in constant contact with the hard material, and upon rotation of the head the cutting edge of the tool would be ground upon the rough surface so that in a comparatively short time the effectiveness of the tool would be destroyed, requiring its replacement with a new tool.

Assuming that the character of rock in which the tool is cutting a path is not of uniform hardness, and that the tool at a point in its travel chips off a relatively large piece of material, and the pressure on the point of the tool is released. As before described, as soon as this pressure is released the unbalanced pressure upon the valve and tool will cause the latter to move forwardly and if it does not again come in contact with the material it will move to the limit of

its forward movement, which is controlled by the pin 101. Simultaneously with the forward movement of the tool, the slide valve will close the port 110. As soon as this valve closes, the hammer is prevented from striking another blow against the tool holder until the valve is again opened, since with the closing of this valve a cushion chamber is formed to the front of the annular shoulder 93 of the hammer. The chamber *a* forms a part of this cushioning chamber, and as the hammer moves forwardly the air within this chamber will be compressed to a degree much higher than the line pressure, which compression increases until it equals the pressure urging the hammer forwardly, at which time the forward movement of the hammer will stop and the balanced forces upon the hammer will prevent its further movement until the slide valve is again opened. It might here be stated that during the normal operation of the hammer, the air in the chamber *a* is forced back into the line through the open slide valve. This action will to a certain extent retard the forward movement of the hammer. However, the retardation is not sufficient to impair the effectiveness of the blow delivered by the hammer, since the area of the rear face of the hammer is much greater than that of the annular shoulder 93. As the head continues to advance, the tool will remain in its outermost position until it again comes in contact with the work and any further advancement of the head will force the tool 105 rearwardly. Initially this rearward movement of the tool is slight but will be sufficient to partially open the slide valve and the hammer will commence to operate as before described. However, if the slide valve is only partially opened the volume of air which is admitted to the rear of the piston to drive it forwardly, is less than in a full open position of the valve and a blow of full force will not be delivered by the hammer since the air pressure tending to drive the hammer forwardly is less. Moreover, since the velocity of the hammer depends upon the pressure of the air, the rapidity with which the hammer will strike the tool is lessened. As for example, it has been found that when the slide valve is only partially open the number of blows which will be delivered by the hammer is reduced to 100 per minute, whereas with the valve in its full open position, as many as from 700 to 800 blows are struck within the same period of time. If the material in front of the tool is relatively hard, this light blow may not be sufficient to chip off a piece and the continued advancement of the head will cause a further rearward movement of the tool, thereby increasing the opening of the slide valve. This will continue if the material does not give away under the blows of

the hammer until the tool is moved rearwardly to a position in which the slide valve is in its fully open position, when blows of full strength will be rapidly imparted to the cutting tool to chip away the rock or other material. It will therefore be seen that the action of the tool is dependent upon the character of the material to be cut, that is, if the material is relatively soft only light blows are delivered against the cutting tool at a relatively low rate, but if the material is hard these blows increase both in strength and rapidity until the material is chipped away. There is, therefore, a particular coöperation between the advancing head and the tool controlled valve mechanism described, since these parts coöperate to determine the character of blow which will be struck to chip away the material.

The action of each of the tools upon the rotating head is similar, and while each of the tools is independent in its operation of each of the other tools, nevertheless each of the tools controls the quantity of the material cut by the other tools within limits. To explain, let us assume that the face of the material to be cut is of a non-uniform character and that some of the tools are encountering hard material while other of the tools are encountering soft material, the tools which encounter the soft material will cut away the material in relatively large pieces and after a piece of the material has been chipped away the tool will then cease to operate until it is again firmly seated against the rock. The other tools which are encountering the hard material will act continuously to cut away the material in relatively small pieces and will continue to act with their full strength. These tools govern the advance of the head and the tools which are doing the lighter work can not seat and again operate until the tools which are encountering the harder material will have cut the amount of material required to keep the face of the work substantially uniform. It will therefore be seen that since each of the tools has a determined amount of material to cut in order to advance the head, these tools can either cut this material by a continuous operation or by an intermittent operation, but all of the tools will nevertheless keep pace with each other.

Various ramifications and modifications of the illustrative embodiment of the invention shown may be made without departing from the spirit of the invention, the scope of which is particularly pointed out in the appended claims.

I claim:

1. In an excavating machine, a head, a plurality of tools and power actuated hammers for striking said tools carried by said head, means for moving said head to advance

said tools across the face of the material to be cut, each of said tools having a limited movement independent of said head toward and away from the material to be cut, and means for urging each of said tools toward its outward limit.

2. In an excavating machine, a head, a plurality of tools and power actuated hammers for striking said tools carried by said head, each of said tools having a limited movement independent of said head toward and away from the material to be cut, said tools being mounted on said head inclined to the face of the material to be cut, means for moving said head to advance the tools across the face of the material to be cut, and means for urging each of said tools toward the limit of its outward movement.

3. In an excavating machine, a head, a plurality of tools and power actuated hammers for striking said tools carried by said head, means for moving said head to advance said tools across the face of the material to be cut, each of said tools having a limited movement independent of said head toward and away from the material to be cut, and fluid pressure actuated means for urging each of said tools toward its outward limit.

4. In an excavating machine, a head, a plurality of tools and power actuated hammers for striking said tools carried by said head, each of said tools having a limited movement independent of said head toward and away from the material to be cut, said tools being mounted on said head inclined to the face of the material to be cut, means for moving said head in advance of the tools across the face of the material to be cut, and fluid pressure actuated means for urging each of said tools toward the limit of its outward movement.

5. In an excavating machine, a head, a plurality of tools and fluid pressure actuated hammers for striking said tools carried by said head, means for moving said head to advance said tools across the face of the material to be cut, each of said tools having a limited movement independent of said head toward and away from the material to be cut, and means for urging each of said tools toward its outward limit.

6. In an excavating machine, a head, a plurality of tools and fluid pressure actuated hammers for striking said tools carried by said head, each of said tools having a limited movement independent of said head toward and away from the material to be cut, said tools being mounted on said head inclined to the face of the material to be cut, means for moving said head in advance of the tools across the face of the material to be cut, and means for urging each of said tools toward the limit of its outward movement.

7. In an excavating machine, a head, a

plurality of tools and fluid pressure actuated hammers for striking said tools carried by said head, means for moving said head to advance said tools across the face of the material to be cut, each of said tools having a limited movement independent of said head toward and away from the material to be cut, and fluid pressure actuated means for urging each of said tools toward its outward limit.

8. In an excavating machine, a head, a plurality of tools and fluid pressure actuated hammers for striking said tools carried by said head, each of said tools having a limited movement independent of said head toward and away from the material to be cut, said tools being mounted on said head inclined to the face of the material to be cut, means for moving said head in advance of the tools across the face of the material to be cut, and fluid pressure actuated means for urging each of said tools toward the limit of its outward movement.

9. In an excavating machine, a head, a plurality of tools and power actuated hammers for striking said tools carried by said head, said tools being inclined to the face of the material to be cut, means for moving said head to advance said tools across the face of the material to be cut, and means for automatically varying the strength of the blows delivered by each of the hammers in accordance with the resistance which it encounters.

10. In an excavating machine, a head, a plurality of tools and power actuated hammers for striking said tools carried by said head, said tools being inclined to the face of the material to be cut, means for moving said head to advance said tools across the face of the material to be cut, and means controlled by the tool for automatically varying the blows delivered by each of the hammers in accordance with the resistance which it encounters.

11. In an excavating machine, a head, a plurality of tools and power actuated hammers for striking said tools carried by said head, said tools being inclined to the face of the material to be cut, means for moving said head to advance said tools across the face of the material to be cut, each of said tools having a limited movement independent of said head toward and away from the material to be cut, and means controlled by the resistance encountered by each of said tools for automatically varying the blows of the hammer against its respective tool.

12. In an excavating machine, a head, a plurality of tools and power actuated hammers for striking said tools carried by said head, said tools being inclined to the face of the material to be cut, means for moving said head to advance said tools across the face of the material to be cut,

each of said tools having a limited movement independent of said head toward and away from the material to be cut, and means controlled by the movement of each of said tools for automatically varying the strength and rapidity of the strokes of each hammer and the blow delivered by each hammer.

13. In an excavating machine, a head, a plurality of tools and fluid pressure actuated hammers carried by said head, said tools being inclined to the face of the material to be cut, and means for moving said head to advance said tools across the face of the material to be cut, each of said tools having a limited movement independent of said head toward and away from the material to be cut, means for urging said tools outwardly, and means controlled by the inward movement of said tools for controlling the supply of fluid pressure to each of the hammers.

14. In an excavating machine, a head, a plurality of tools and fluid pressure actuated hammers for striking said tools, means

for moving said head to advance said head across the face of the material to be cut, each of said tools having a limited movement independent of said head toward and away from the face of the material to be cut, and means controlled by the movement of said tool to maintain the depth of the paths cut by each of the tools uniform within the limit of the independent outward movement of each of the tools.

15. In an excavating machine, a head, a plurality of tools and power actuated hammers for striking said tools carried by said head, each of said tools having a limited movement toward and away from the material to be cut independent of said head, and means for urging said tools toward the limit of the outward movement, said means being of insufficient force to prevent the rebound of the tools when struck by the hammer.

In witness whereof I subscribe my signature.

OLIVER OSCAR APP.