G. A. FOWLER.

PNEUMATICALLY OPERATED ROCK DRILLING ENGINE.

APPLICATION FILED MAY 19, 1910.

1,001,012. **Patented Aug. 22, 1911.**

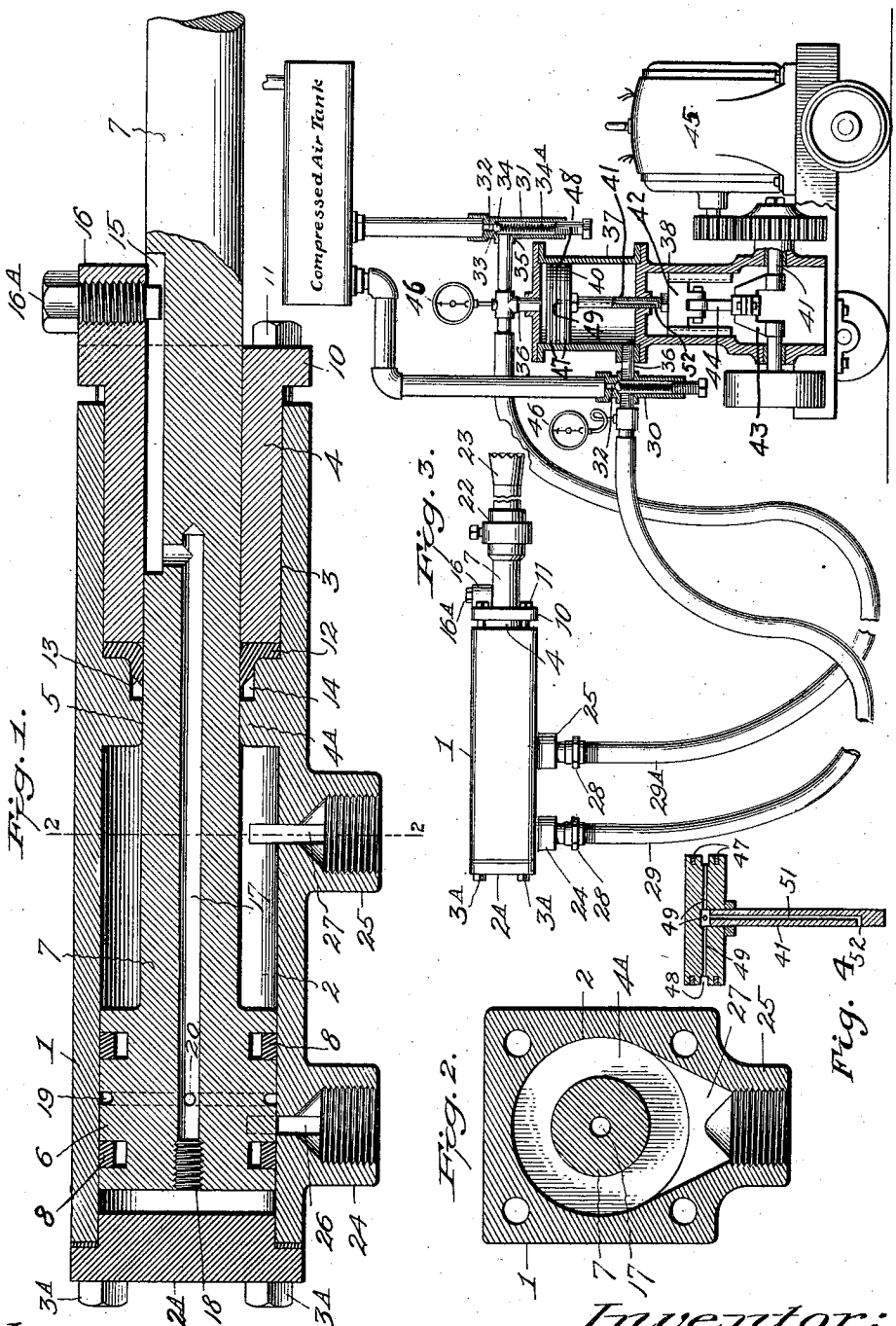

Fig. 1.

Fig. 3.

Fig. 2.

Fig. 4.

Witnesses:

G. Sargent Elliott

Adella M. Fowler

Inventor:

George A. Fowler

By H. S. Bailey Attorney.

COLUMBIA PLANOGRAPH CO., WASHINGTON, D. C.

UNITED STATES PATENT OFFICE.

GEORGE A. FOWLER, OF DENVER, COLORADO.

PNEUMATICALLY-OPERATED ROCK-DRILLING ENGINE.

1,001,012. Specification of Letters Patent. **Patented Aug. 22, 1911.**

Application filed May 19, 1910. Serial No. 562,151.

To all whom it may concern:

Be it known that I, GEORGE A. FOWLER, a citizen of the United States of America, residing in the city and county of Denver and State of Colorado, have invented a new and useful Pneumatically-Operated Rock-Drilling Engine, of which the following is a specification.

My invention relates to improvements in pneumatically operating rock drilling engines; and the objects of my invention are: First, to provide a pulsating compressed air actuated rock drilling engine having a combined automatically operating compressed air pressure regulating and pulsating apparatus. Second, to provide a pulsating compressed air actuated rock drilling engine in which means is provided for preventing the equalizing of the pulsating pressure within its cylinder. Third, to provide an air pulsating actuating rock drilling engine and cooperating apparatus in which means is provided for feeding to the drilling apparatus an excess of air pressure, and for automatically reducing and adjustably controlling the reduced pressure to any predetermined pressure desired, and for automatically maintaining the predetermined pressure at the desired pressure, for preventing the equalization of the pressures in the cylinders of the drilling apparatus. And fourth, to provide a rock drilling engine that is free of operative valve mechanism and that is provided with a combined front cylinder head, stuffing box gland, and piston plunger support, and with means for holding the piston plunger in a non-rotative but reciprocal position, and that is simple and inexpensive to construct and is extremely economical in the use of air and that is especially adapted to be used in connection with the driving heads of tunnel drilling machines, such as the tunneling machine patented to me on the 23rd day of June, 1908, numbered 891,473, in which in Figure 19 a feature of this invention is disclosed, and in my pending application Serial No. 148,644, filed Decemoer 21st, 1909. I attain these objects by the mechanism illustrated in the accompanying drawings, in which:

Fig. 1, is a central longitudinal sectional view of a rock drilling engine embodying my invention. Fig. 2, is a transverse sectional view thereof on the line 2—2 of Fig. 1. And Fig. 3, is a side view of the drill, showing the same connected by pipes with the opposite ends of a power-driven pulsating cylinder. Fig. 4 is a sectional view of the piston head and piston rod of the air compressor, showing the air passages leading from the center of the piston head to the atmosphere.

Similar letters of reference refer to similar parts throughout the several views.

Referring to the drawings, the numeral 1 designates a casing preferably of square form, which is provided with two cylindrical bores 2 and 3, which may be if desired of different diameters, but which I preferably make of the same diameter. The cylinder bore 2 is provided with a cylinder head 2^A, which I term the rear cylinder head, which is secured to the end of the casing by any suitable means, preferably by bolts or cap screws 3^A. The cylinder bore 3 is also provided with a cylinder head member 4, in the form of a sleeve, which projects into its end. This cylinder head forms a combined cylinder head packing washer gland and a support for the outer end portion of the piston plunger, as will be more fully described hereinafter. These two bores are separated by a partition 4^A, which is provided with an axial aperture 5. The cylindrical bore 2 is provided with a reciprocating piston head 6, and a piston rod 7, which forms an integral part of or is secured to the piston head and extends reciprocally through the axial aperture 5 in the partition 4^A. This piston head and piston rod I term the piston plunger, as the piston rod forms the drill bit supporting and driving rod, as will be explained more fully hereinafter. The piston head is provided with spring cylinder packing rings 8, at its opposite end portions, which prevent any excessive leakage of the compressed air piston-plunger actuating fluid from one end of the piston head to its opposite end.

The bore 3 of the casing is provided with the front cylinder head or sleeve 4, which fits closely within the bore and is provided with an enlarged flange portion 10, which is adapted to be adjustably secured to the cylinder by any suitable means, but preferably by cap screws 11, or bolts if desired, which latter may be extended entirely through this head and apertures formed in the cylinder and the rear head, and these three parts be bolted together. This sleeve extends into the bore close to the partition 4^A and against the flange portion 12 of a

cupped leather or other suitable washer 13, which is placed between the inner end of the sleeve and the adjacent side wall of the partition 4A. This cupped washer is provided with a large collar portion which is arranged to fit snugly over the piston plunger, and its end is preferably tapered on its outer surface to the edge of its axial aperture, and the axial aperture on the adjacent side of the partition 4A is counterbored to provide an enlarged aperture 14, which is arranged and adapted to receive it and form a clearance space for it that will tend to press it down onto the plunger when the sleeve is clamped against it by the clamping screws. This sleeve may be provided with an inwardly projecting key, which may extend through its shell into its axial aperture, and is adapted to fit into a keyway 15 that is formed in the top of the piston plunger rod. This key may be positioned in any part of the sleeve, but I preferably provide the sleeve at its upper outer end with a projecting lug 16, through which a key is extended in the form of a cap screw 16A, that is threaded through the lug against its head and its lower end is reduced in diameter enough below the diameter of the threads to be round and smooth and is flattened if desired to fit loosely into the keyway of the piston plunger, which is made of a length to extend out beyond the key holding lug of the sleeve to the atmosphere at the end of the full rearward stroke of the piston head. This keyway in the piston plunger is a little longer than the full reciprocal stroke of the piston head and plunger, and the sleeve is made to extend inwardly a short distance beyond the inward end of the keyway on its rearward stroke. This keyway connects with an axial passage 17, that is formed through the axial center of the piston head and its piston plunger. The entrance to this aperture in the piston head is closed by a plug 18. A circumferential groove 19 is formed in the center of the width of the piston head, and a plurality of radial apertures 20 are formed from this groove 19 diametrically through the head into the axial aperture 17. This circumferential groove 19 is arranged and adapted to collect any air that leaks from either side of the piston head past either packing ring, and allow it to escape to the atmosphere, and thus prevents air from working past the piston's cylinder rings to the opposite sides of the piston head and equalizing the pressure to such a degree as to weaken the effective movements of the piston head and its plunger rod or to bring it to a stand-still between the two equalized pressures.

The outer end of the piston plunger is provided with a drill bit holding chuck 22, which may be of any suitable kind or character that is adapted to operatively support a rock cutting or crushing or drilling drill bit 23. The drill bit 23 may also be of any kind or character used for drilling, surfacing, or crushing rock.

My improved rock drilling engine is devoid of valve mechanism, and also of exhaust ports for leading the exhaust air to the atmosphere, and its piston plunger is arranged and adapted to be reciprocated by the direct application of two independent volumes of compressed air of different predetermined and adjustable pressures, which are used over and over again, each volume being used intermittently and in alternate order in the opposite ends of the cylinder. These two independent volumes of air are replenished from a supply of compressed air automatically as they lose their volume and pressure from the cylinder, and its cooperating air manipulating mechanism by leakage. It is necessary however in order to provide suitable independent volumes of compressed air at a suitably regulated and variable pressure, to meet the requirements of working different characters of rock, that apparatus be provided for regulating the pressure of the compressed air automatically and for controlling and forcing or driving each volume of air into the opposite ends of the cylinder after each stroke of the piston head.

My invention contemplates the use of any suitable apparatus for manipulating and controlling compressed air or any other suitable piston head actuating fluid. I preferably however carry out this feature of my invention in the following manner: On the casing of the cylinder I form two projecting hub portions 24 and 25, which are provided with air inlet apertures from which air inlet ports 26 and 27 extend into the cylinder at the opposite end portions of the cylinder. These inlet ports are positioned to permit the piston head to make its operative stroke without uncovering the circumferential groove port of the piston head to them. The cylindrical inlet apertures in the hubs are interiorly threaded to receive hose connecting fittings 28, to which pieces of hose 29 and 29A are connected, and extend to a pair of pressure regulators or equalizers 30 and 31. These pressure regulators may be of any suitable type, but I preferably use a spring controlled ball type of a pressure regulator, which as illustrated comprises a casing, provided with an air inlet aperture 32 and a valve seat 33, and a ball valve 34, which is positioned to control the inlet aperture, and an adjustable spring 34A arranged to control the pressure of the ball valve against its seat, and an inlet port 35 that extends through it and to which is connected one of the pieces of hose that extend from the cylinder. The inlet aperture 32 of the pressure regulator is connected by suitable

piping to a suitable supply of compressed air, and the aperture 35 of each regulator is connected by suitable piping 36 to the opposite ends of a cylinder 37, that forms a part of an air compressor. This air compressor comprises a supporting frame 38, the cylinder 37 mounted thereon, a piston head 40, and a piston rod 41, which are reciprocally mounted in said cylinder, a cross head 42, a crank shaft 43 rotatably mounted in the frame, and a connecting rod 44. This air compressor may be driven by any suitable motor but an electric motor 45 is preferably illustrated connected by gearing with the crank shaft to drive the same to reciprocate the piston 40 in the cylinder, to compress and drive or force from the cylinder the two independent volumes of air that are drawn into its opposite ends through the two hose connections from the cylinder to the two pressure regulators, and through their ports 35 and the piping that connects them with the opposite ends of the cylinder. The pressure regulators are preferably each supplied with a pressure gage 46. It is just as essential however that means be provided within the cylinder of the air-compressor to prevent the equalization of the air pressures therein on opposite sides of its piston head, due to leakage of air past its piston head from either one or the other or both sides of it within the cylinder of the drilling engine, and my invention contemplates the use of any means within or forming a part of either or both the cylinder or its piston head and piston rod. I preferably however carry out this feature of my invention in the following manner: The piston head 40 is provided with cylinder packing rings 47, which may be of any suitable type. These packing rings are preferably arranged at the opposite end portions of the piston head and between these packing rings a circumferential groove 48 is formed around the piston head, and from this groove a plurality of radial apertures 49 extend to an axial aperture 50 formed in the center of the head. The piston rod is also provided with an axial aperture 51, which may extend either wholly or partially through it, but which extends from its piston head end where it is arranged to connect with the axial aperture 50 in the head to a point outside of the cylinder's lower cylinder head, and between the cylinder head and the piston rod's connection with the cross head 42, where the piston rod is provided with a radial aperture 53, which connects its axial aperture as well as the radial apertures and the circumferential groove in the piston head with the atmosphere at all times during the reciprocative strokes of the piston head within the cylinder. The unequal pressures on the opposite sides of the piston head are thus prevented from becoming equalized by leakage from either side to the other, as any air leaking past either cylinder ring will flow into the circumferential groove 47 and through the radial apertures 49 and the apertures 51 and 53 to the atmosphere.

The operation of my improved drilling engine is as follows: These pressure regulating valves are arranged and adapted to automatically maintain two independent volumes of compressed air of different pressures in the drill cylinder and in the two pieces of hose and in the opposite ends of the air compressor cylinder, and they perform this function in the following manner: Assuming that a piston plunger driving pressure of sixty pounds gage is required to satisfactorily drive the drill bit to drill rock, it is necessary to bring to the compressed air inlet of each air pressure regulator, compressed air of somewhat higher pressure, say for example at a pressure of 100 pounds, the adjustable spring of the regulator 30 that is connected to the hose that extends from the rear end of the drill cylinder is set to allow the valve of the regulator to open sufficiently to admit air into the lower end of the air compressor cylinder until a pressure of 60 pounds is obtained, when the said 60 pound pressure plus the tension of the spring which is set at 40 pounds, when the air supply is 100 pounds, will close the valve against further admission from the supply of 100 pounds. And if the pressure in the lower end of the cylinder should be reduced by leakage of air past the piston, the pressure in the supply pipe again opens the ball valve of the regulator 30, to restore the normal pressure in the end of the cylinder to 60 pounds. But inasmuch as the area of the piston plunger or front end of the drill cylinder's piston head is of smaller area than its rear end, compressed air of sufficiently greater pressure should be used in it to equalize the speed of the reciprocative strokes of the piston head and its piston plunger in both directions. Consequently in adjusting the spring of the regulator 31 that is connected to the hose that leads from the front or piston plunger end of the drill cylinder, it is set to hold the valve of this regulator to admit a greater pressure of air, say for example a pressure of air of seventy pounds to the upper end of the air compressor cylinder, and to the hose 29^A and the front end of the drill cylinder, while the spring 34^A of the regulator 31 is set at 30, which plus the pressure of 70 admitted will close it against the 100 pounds pressure from the source of supply. Thus the springs of both regulators hold back the air pressures of 100 pounds that flow to them and admit only the 60 and 70 pounds respectively. The 70 pound air pressure volume of air used on the front side of the drill cylinder's pis-

ton head is completely separated from and can not in any way mingle with the 60 pound pressure volume of air that is used against the rear end of the drill cylinder's piston head except a portion of one or of both volumes of air leak past the piston packing rings of the piston head of the drill cylinder or past the cylinder packing rings of the piston head, which is impossible, as any leakage in the drill cylinder or in the compressor cylinder would flow into their circumferential grooves and radial and axial apertures through their pistons to the atmosphere. Consequently these two independent different pressures are prevented from becoming equalized in any part of the drilling apparatus, and they work constantly under their different predetermined and automatically controlled set pressures, and are forced in and out of the opposite ends of the drill cylinder by the reciprocative action of the piston of the air compressor, which is driven by the motor. The volume of air that is driven out of the upper end of the compressor cylinder by the upward stroke of its piston, flows to the front or piston plunger end of the drill cylinder, and after pushing the piston head of the piston plunger on its rearward stroke is driven out of the drill cylinder by the forward stroke of the piston head, which is driven forward by the down stroke of the piston of the air compressor, which has driven the 60 pounds of air from it into the rear end of the drill cylinder and against the rear end of the piston head, while at the same time the same downward stroke of the piston of the air compressor that forced the air into the rear end of the drill cylinder permits the piston head to force the air that forced it on its rearward stroke out of the drill cylinder into the hose and aperture 35 of its pressure regulator, and into the top of the air compressor cylinder, and to follow the piston of the air compressor cylinder down on its downward stroke that is driving the piston head of the drill cylinder forward. Consequently the piston head of the piston plunger is substantially held between two reciprocally pulsating volumes of compressed air of variable and adjustable pressures of sufficient piston plunger and driving force to cause the drill bit to operatively drill rock, and in case there is any leakage of the air from either one of these independent pulsating volumes of drill operating air, that lowers its pressure, the valve of the pressure regulator will automatically open under the constant higher pressure of the air supply and restore the weakened volume to its regular set working pressure without any attention or manipulation on the part of the operator. During the operation of the engine, a sufficient quantity of air will always remain in the opposite ends of the drill cylinder to cushion the reciprocal movements of its piston head.

My invention is extremely simple in construction, thoroughly practical and highly efficient in operation, and while I have illustrated and described the preferred construction and arrangement of the drilling engine and its coöperating pressure regulating and compressed air actuating apparatus, I do not wish to be limited to the construction and arrangement shown, as many changes might be made without departing from the spirit of my invention.

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

1. In a pulsating air pressure actuated rock drilling engine, the combination of an operative cylinder, a piston head and a piston rod adapted to operatively support a rock drilling drill bit, said piston head being provided with an atmospheric vent surrounding the central portion of its width and extending through said piston head and said piston rod to the atmosphere, said atmospheric vent being arranged to prevent the neutralization of pressure at the opposite end portions of said piston head in said cylinder and having air inlet ports at the opposite end portions of its cylinder, with a motor driven compressor comprising a cylinder having air ports at its opposite end portions and provided with a reciprocating piston operatively arranged to be reciprocated in said air compressor cylinder between its ports by said motor, an adjustable pressure reducer provided with a central valve controlled air inlet port provided with oppositely arranged tube connecting apertures, one of which of each pressure reducer is connected by tubing to each of the air ports of said compressor cylinder and the other of which of each pressure reducer is connected by tubing to the air ports of said drill cylinder, said central valve controlled air inlet port of each of said pressure reducers being arranged to be connected to a supply of compressed air of greater pressure than the pressure of the air required to operate said drilling engine, said air inlet port being arranged to connect with the port of each reducer leading into said air compressor, a valve seated in said air inlet port to control the entrance port to said compressor cylinder, and an adjustable tension spring arranged and adapted to control automatically and to admit any predetermined part of said compressed air supply pressure flowing to said pressure reducer to said cylinder at which said adjustable tension controlled valve is adjustably set.

2. In a rock drilling engine adapted to be driven by two independent volumes of constant pressure pulsating volumes of compressed air, the combination of a casing pro-

vided with a reciprocating piston receiving cylinder, said cylinder being provided with a removable rear cylinder head and a fixed front head portion provided with an axial bore of two diameters, a cylindrical bore in the opposite end of said casing from said rear cylinder head, a cylinder head gland extending into said bore close to said fixed front cylinder head, a piston head reciprocally mounted in said cylinder provided with a piston plunger rod extending slidably through said fixed front head, and a cupped washer mounted on said piston plunger rod between said cylinder head gland and the adjacent side of said fixed front cylinder head and having a collar portion adapted to extend into and engage the walls of the larger bore of said fixed front head, means including clamping bolts or screws for adjusting the pressure of said front cylinder head gland against said cupped washer to force it around said piston plunger, a depending key removably secured to said cylinder gland, a keyway on the peripheral surface of said piston plunger registering partially within and partially outside of said cylinder head gland into the atmosphere on the reciprocal strokes of said piston head and its piston plunger rod, a radial aperture extending from the end of said keyway within said gland to the axial center of said piston plunger rod, an aperture in the said piston plunger rod extending from the radial aperture to the central portion of said piston head, a circumferential groove around said piston head in the central portion of its length, and radial apertures extending from said circumferential groove to and arranged to connect with the aperture in the piston plunger rod, piston packing cylinder rings encircling said piston head on opposite sides of said circumferential groove, and means including compressed air inlet ports and pressure regulators connected to said inlet apertures in the opposite end portions of said piston head cylinder arranged to receive in each inlet an independent pulsating volume of automatically regulated adjustable variable pressure compressed air.

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

GEORGE A. FOWLER.

Witnesses:

G. SARGENT ELLIOTT,

ADELLA M. FOWLE.