Dec. 9, 1952 A. A. MATHESON 2,620,779

AIR ACCELERATING ENGINE AND COMPRESSOR

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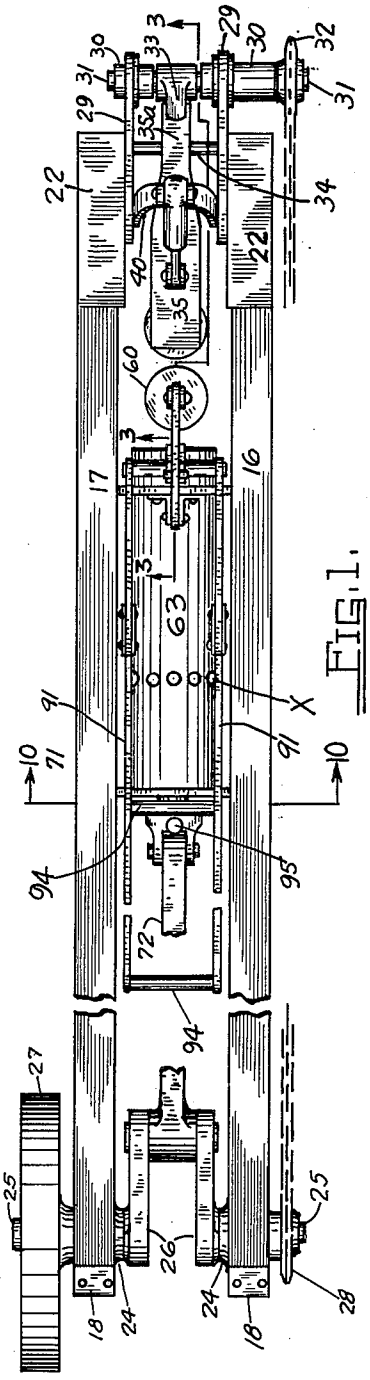


FIG. 1.

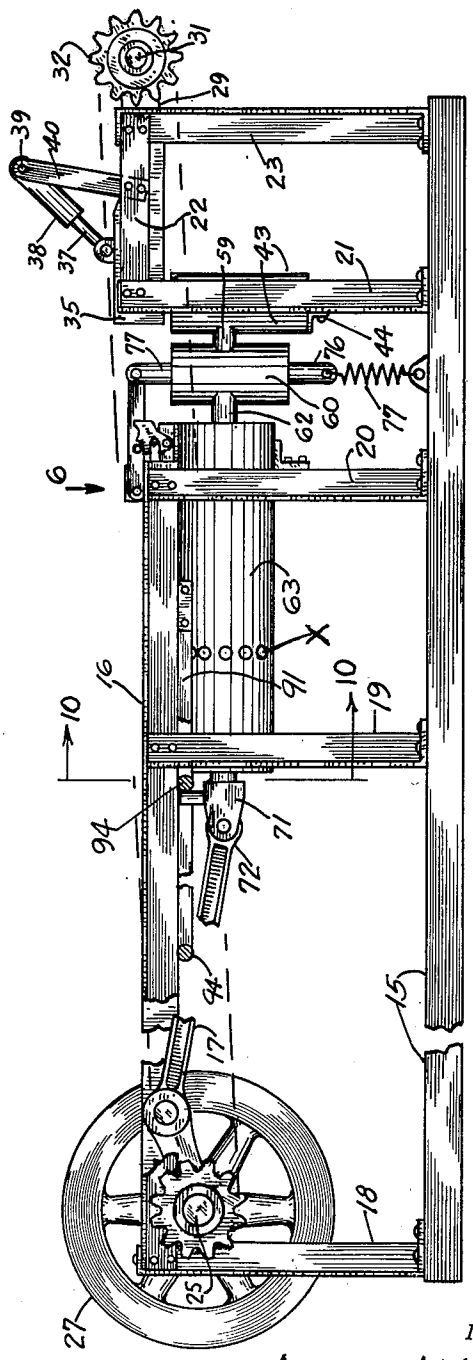


FIG. 2.

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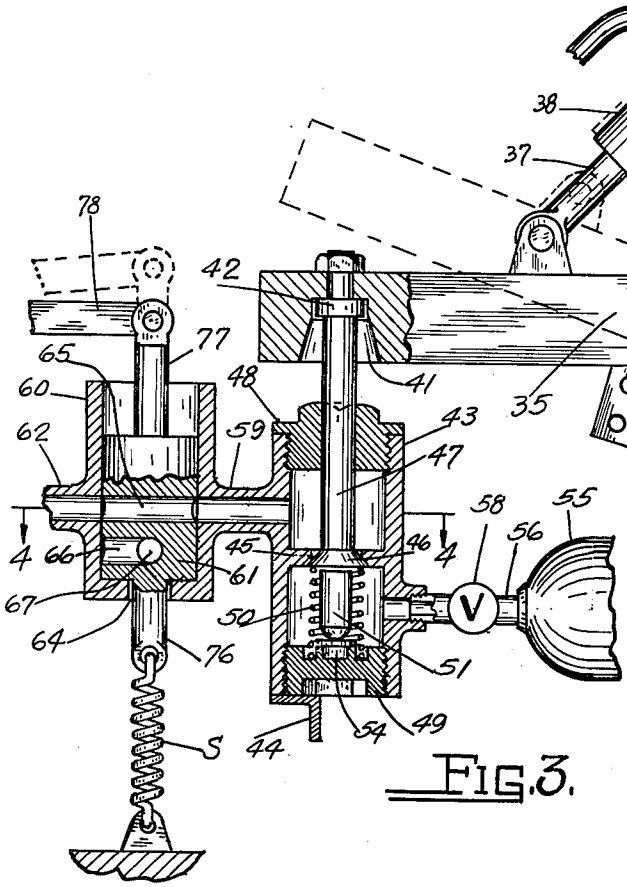



FIG. 3.

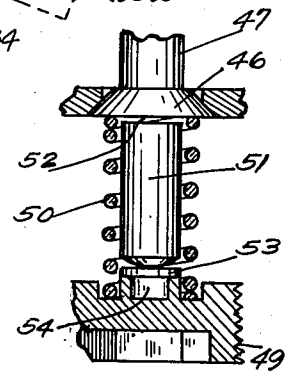



FIG. 5.

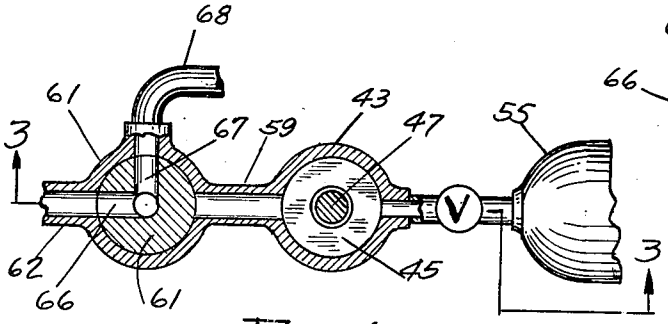



FIG. 4.

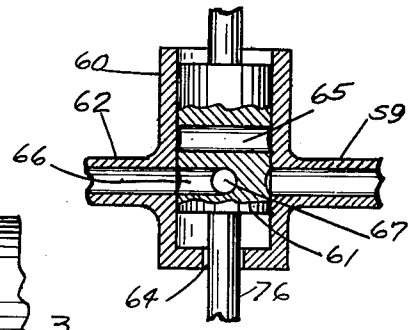



FIG. 3A.

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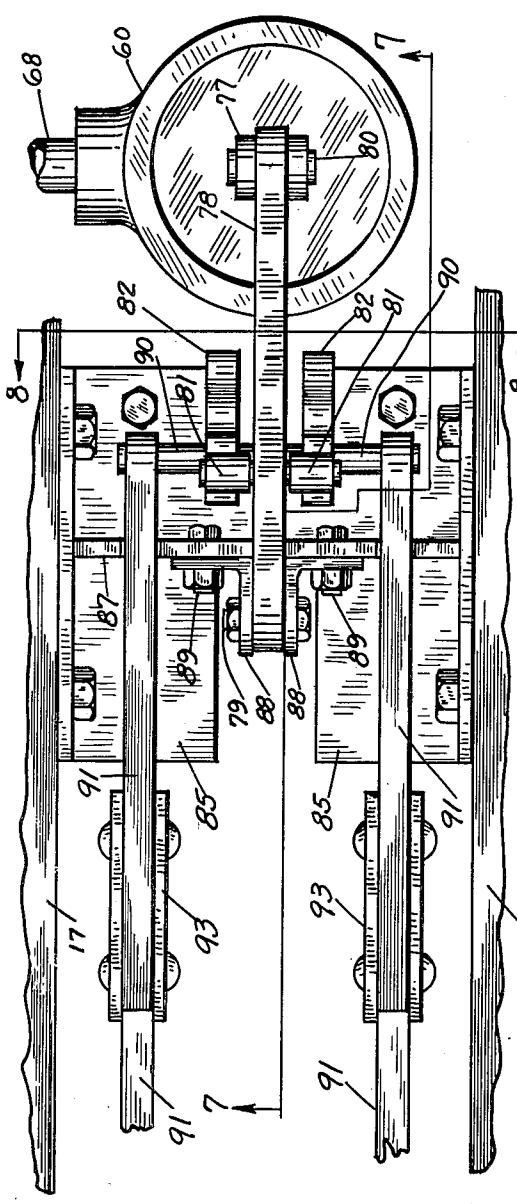


FIG. 6.

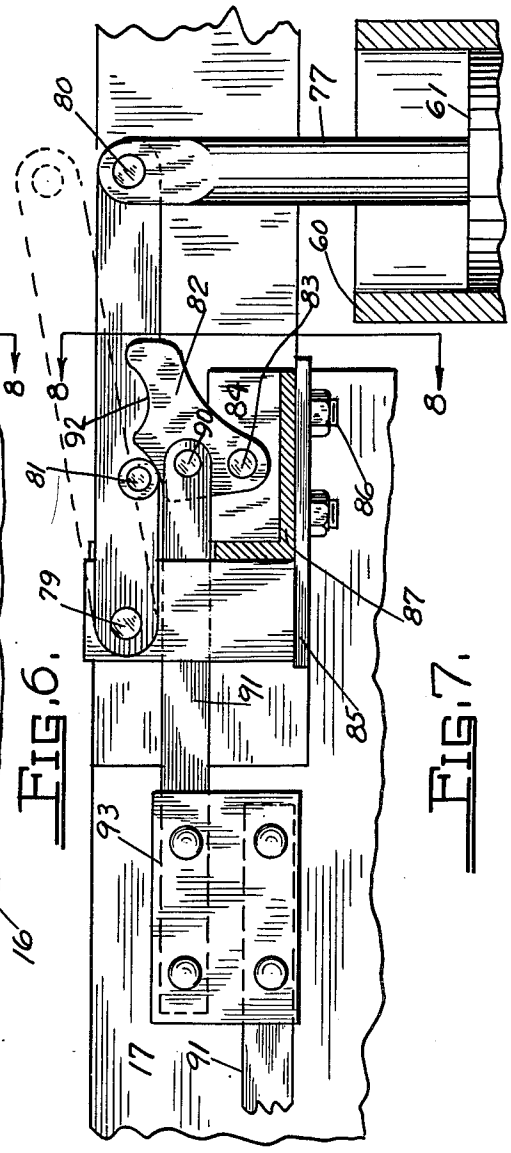


FIG. 7.

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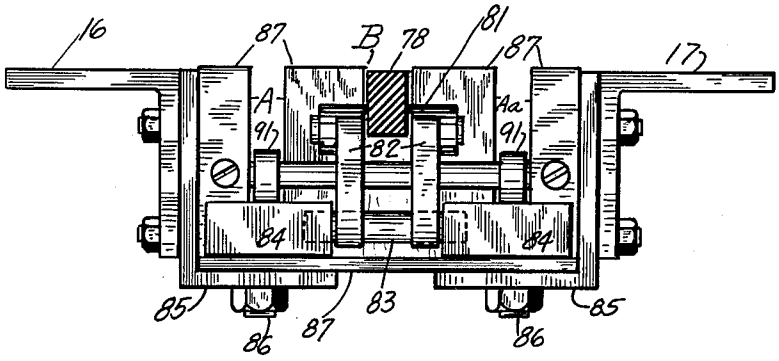



FIG. 8.

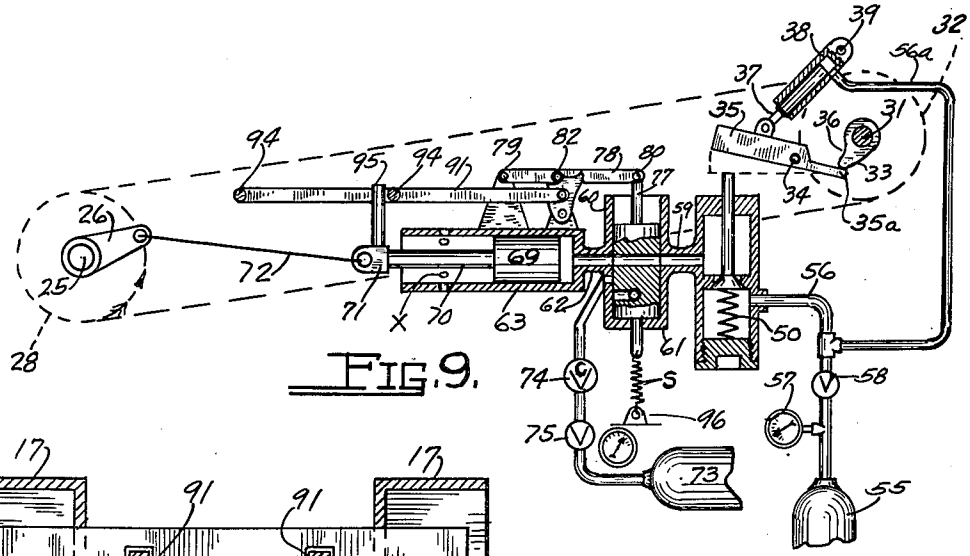



FIG. 9.

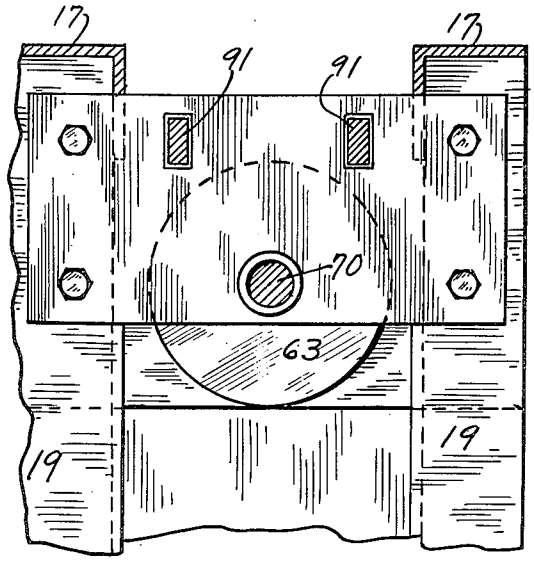



FIG. 10.

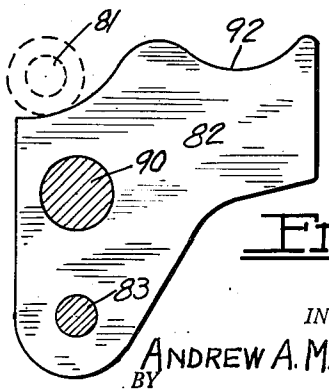



FIG. 11.

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# UNITED STATES PATENT OFFICE

2,620,779

## AIR ACCELERATING ENGINE AND COMPRESSOR

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Application August 6, 1951, Serial No. 240,462

8 Claims. (Cl. 121—167)

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This invention relates to improvements in compressed air engines and relates more particularly to an improved valve gear for such engines.

This invention is an improvement to the engine shown and described in U. S. Letters Patent No. 2,304,839 granted December 15, 1942.

It is the object of this invention to produce an engine that is operated by highly compressed air and which in addition to delivering power for operating machinery, will also serve to compress air that can be stored for effecting work or operating other air-driven devices.

The mechanism that forms the subject of this invention, briefly described, comprises a frame on which is mounted for rotation a crank shaft and a single engine cylinder containing a piston. The piston and the crank are connected by means of a connecting rod. The cylinder has one end closed and the other open. A high-pressure air supply tank is connected with the cylinder by conduit means having two valve mechanisms, connected in series, the valve nearest the air supply is of the poppet type and closes with the pressure, and the other is a slide valve that connects the cylinder alternately with the discharge side of the poppet valve and with an air chamber to be charged. A valve mechanism operates to maintain a connection with the discharge side of the poppet valve at all times except during the return stroke of the piston when the other or "slide valve" is in position to direct the exhaust into the cylinder to be charged. Means is provided for effecting an instantaneous opening of the poppet valve at the beginning of each piston stroke.

Having thus explained the objects of the invention, and briefly described the invention itself, the invention will now be described in detail, and for this purpose reference will be had to the accompanying drawings in which the present embodiment of the invention has been illustrated and in which:

Figure 1 is a top plan view of the invention showing one embodiment thereof, a portion having been broken away to save space;

Figure 2 is a side elevation of the device shown in Figure 1;

Figure 3 is a view partly in section and partly in elevation, taken on line 3—3, Figure 1;

Figure 3a is a section showing the slide valve of Figure 3 in the other of its two operative positions;

Figure 4 is a section taken on line 4—4, Figure 3;

Figure 5 is a fragmentary sectional view showing a portion of Figure 3 to an enlarged scale;

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Figure 6 is a top plan view, looking downwardly in Figure 2, and shows the parts that operate the slide valve, in their normal relations;

Figure 7 is a view, partly in section and partly in elevation, taken on line 7—7, Figure 6;

Figure 8 is a view, partly in section and partly in elevation, taken on line 8—8, Figures 6 and 7;

Figure 9 is a view, partly in section, showing the several elements in their operative relation, the figure being a diagrammatic representation;

Figure 10 is a section taken on line 10—10, Figures 1 and 2, and

Figure 11 is a side elevation of one of the cams, showing the same to substantially full size.

Referring now to the drawings, reference numeral 15 designates a base which, in the actual commercial installations, will be of reenforced concrete, but which has been illustrated as comprised of two wood beams. Supported on the base by suitable vertical posts to which reference will shortly be made, is a frame comprising two angle iron bars 16 and 17 that are attached to the upper ends of posts 18, 19, 20 and 21, which are arranged in pairs. It will be observed that posts 21 are somewhat higher than the others and from the upper ends of this pair, angle irons 22 project and are attached to the upper ends of posts 23. Bearing blocks 24 are attached to the frame in the angles between posts 18 and bars 16 and 17, and a crank shaft 25 is mounted for rotation in the bearings. Shaft 25 is formed with a crank arm 26 positioned between the bearing blocks and carries a fly wheel 27 at one end and a sprocket wheel 28 at the other end.

Extension plates 29 are riveted or bolted or otherwise attached to the vertical flanges of angle irons 22. Each plate 29 carries a bearing block 30 near its outer end and a cam shaft 31 is journaled in these bearings. One end of shaft 31 carries a sprocket wheel 32 and is provided with a cam 33 positioned between bearings 30. A shaft 34 extends across the space between angle irons 22 and is secured to the vertical flanges of the latter. A heavy impact bar 35 is pivoted on shaft 34 for limited angular movement and has its end 35a projecting underneath cam 33 as shown most clearly in Figure 3. Cam 33 has one cam surface that terminates on radial line 36 and since it turns in a counter clockwise direction, when viewed as in Figure 3, it moves member 35 slowly up to the dotted line position and then permits it to drop in response to gravity and to the pressure exerted on piston 37 which is acted on by the air pressure in cylinder 38 in a manner to which attention will be called as the description proceeds. It will be observed that the

upper end of cylinder 33 is mounted to move about pivot 39 at the upper ends of bars 40 which have their lower ends riveted or bolted to the vertical flanges of angle irons 22. From Figure 3 it will be seen that impact member 35 has a downwardly flaring depression 41 in its lower surface in which is positioned head 42 of a high carbon steel bolt. Head 42 is subjected to repeated blows of great intensity and must be made of material that is best suited to withstand such treatment.

Referring now more particularly to Figures 2, 3, 3a and 4, it will be seen that a cylindrical valve casing 43 is supported from posts 21 on an angle iron bar 44. In Figure 3, valve casing 43 has been shown in diametrical section from which it will be seen that it is provided intermediate its ends with a transverse wall 45 that has a downwardly flaring valve seat for the frustoconical surface on valve 46 whose stem 47 extends through a central opening in the threaded plug 48 that closes the upper end of the cylinder. The lower end of the valve casing or cylinder is closed by a removable plug 49. A compression spring 50 is positioned between valve 46 and plug 49 and is under compression. The force exerted on valve 46 by spring 50 must be sufficient to move it to closed position against the weight of impact member 35 whose hammer blows serve to move the valve to open position against the force exerted by the spring and the air pressure acting on its under surface. Since the hammer blows must be quite severe in order to move the valve to open position, the spring by itself is not sufficient to limit the extent to which the valve opens and, therefore, a steel bar 51 is positioned in the spring to serve as a stop. In Figure 5, the normal clearance space or movement of the valve has been designated by 52. Since bar 51 is required to stop some severe blows, it is necessary to mount it on a support that will yield sufficiently to prevent destructive action from taking place. In Figure 5, the resilient support for bar 51 has been shown to an enlarged scale from which it will be seen that a resilient steel plate 53 is supported adjacent its outer edge by the thin wall of the hollow central plug 54. The lower end of bar 51 is rounded and, therefore, when the upper end of the bar receives a blow, it will cause washer 53 to flex sufficiently to prevent destruction of the parts.

Air under high pressure, between 400 and 500 pounds per square inch, is applied from cylinder 55 that is connected with the poppet valve below partition 45 by means of a tube 56. The usual pressure gage 57, and valve 58, are provided in the tubular connection, as shown in Figure 9.

The chamber on the delivery side of the poppet valve is connected by means of a tubular member 59 with the slide valve 60 which will now be described. The slide valve comprises a body having a cylindrical opening in which piston 61 is slidably mounted. Tubular member 59 communicates with the interior of cylinder 60 at a point that has been shown as substantially midway between its ends. Cylinder 60 has a tubular member 62 that communicates with the interior of the power cylinder 63 to which reference will presently be made. The lower end of cylinder 60 is closed but has a central opening 64. Piston 61 has a diametrical opening 65 and two right angularly related openings 66 and 67, the latter communicating with the tubular outlet opening 68 when opening 66 is in alignment with the opening in 62.

We will now direct our attention to Figure 9 from which it will be seen that piston 69 is mounted for reciprocation in cylinder 63 and that it has a piston rod 70 whose outer end carries a crosshead 71 that is connected with crank arm 26 by means of a connecting rod 72. Let us now assume that the poppet valve is moved to open position by a blow from impact member 35; air under high pressure will immediately pass the poppet valve and, after filling the passages, will enter cylinder 63 between its closed end and piston 69, which will, therefore, move towards the left producing a turning of the crank shaft to which the heavy balance or fly wheel is attached. The action of spring 50 and the pressure of the air will effect a closing of the poppet valve as soon as the inertia of member 35 can be overcome. At the end of the outward or power stroke of piston 69, a valve gear mechanism, which will presently be described, moves piston 61 from the position shown in Figures 3 and 9 to that shown in Figures 3a and 4, and the exhaust from cylinder 63 will, therefore, be directed to container 73 by way of a conduit having a check valve 74 and a manual valve 75, as shown in Figure 9. When piston 69 returns to the position corresponding to Figures 1, 2 and 9, piston 61 must return to the position shown in Figures 3 and 9.

The mechanism for moving piston 61 will now be described. From Figure 3, it will be seen that piston 61 is provided with a downwardly projecting rod 76 that is connected with the base by a tension spring S which normally retains the piston in its lowermost position, as shown in Figure 3. At the end of the outward or power stroke of piston 69, piston 61 must be raised to the position shown in Figure 3a and returned to the position shown in Figure 1 when piston 69 completes its exhaust stroke.

Referring now more particularly to Figures 1, 6 and 7, it will be seen that a rod 77 extends upwardly from piston 61 and is forked at its upper end. Lever 78 that has one end rockably connected to the stationary pivot 79, has its free end positioned in the fork at the upper end of rod 77 and is connected thereto by pivot 80. Lever 78 is provided on opposite sides with rollers 81 that are in axial alignment. Positioned on opposite sides of lever 78 are cams 82 that turn about the axes of the stationary pin or shaft 83 whose ends are positioned in openings in blocks 84 that are secured to angle brackets 85 by means of bolts 86 which also serve to fasten the transversely extending angle iron 87. The horizontal flange of angle iron 87 is positioned between the under surfaces of blocks 84 and the upper surfaces of angle brackets 85, as shown most clearly in Figures 7 and 8. The vertical flange of angle iron 87 is provided with three notches which have been designated by reference characters A, Aa, and B. Angle brackets 88 which carry the pivot 79 are attached to the vertical flange of angle iron 87 by bolts 89.

Cams 82 are provided with openings through which a steel bar 90 extends and which constrains them to simultaneous rocking movement about pivot 83. Rods 91 extend forwardly through notches A and Aa and have openings for the reception of the ends of bar 90. When rods 91 are moved towards the left, when viewed as in Figures 6 and 7, cams 82 will turn in a counterclockwise direction. When the cams are in the position shown in Figure 7, piston 61 is in the position shown in Figures 3 and 9, but when the cams have been turned until rollers 81 are on the

concave surfaces 92, piston 61 will occupy the positions shown in Figs. 3a and 4. In Figure 11, a side plan view of the cams to full size has been shown. The cams are so designed and the parts so proportioned that when rollers 81 rest on surfaces 92, the parts will remain in that position until the cams are forcefully moved in the opposite direction. In the present construction rods 91 are made in two parts and connected by plates 93, as shown in Figures 6 and 7; this offset is a matter of convenience in the present embodiment only. Rods 91 have been shown as connected by bars 94, as shown in Figure 9. Cross head 71 has a vertical pin 95 that moves freely between bars 94 and contacts them for a short distance at the end of each stroke so as to shift the cams to effect a movement of piston 61. Any other mechanically equivalent movement for effecting movement of piston 61 may be substituted for the one shown.

*Operation*

The operation can be most clearly explained when reference is had to Figure 9 which is a diagrammatic representation. Let us assume that the parts occupy the position shown and that the interior of conduit 56 is in communication with the interior of cylinder 33 by a conduit 56a.

Shaft 31 is rotated until cam 35 releases impact member 35 which then moves at high speed in response to the large pressure acting on piston 37. When head 42 strikes the upper end of valve stem 47, the latter moves the valve to open position and permits a quantity of air at high pressure to flow into cylinder 63, thereby forcing piston 69 to move outwardly and turn crank shaft 25 to which the heavy fly wheel is attached. As piston 69 approaches the outer end of its power stroke, pin 95 engages the outer bar 94 and turns cams 82 into the position where roller 81 rests on surface 92, thereby shifting piston 61 to the position shown in Figures 3a and 4. It will be observed that cylinder 63 is provided with a number of openings X at a point beyond which the piston passes before it starts on the return stroke. Openings X, after the piston passes beyond them, serve to communicate the interior of the cylinder with the circumambient air and allows any air of higher than atmospheric pressure to discharge. If the air pressure at the end of the power stroke has expanded to a point where the pressure is lower than atmospheric, air will flow into the cylinder when openings X are uncovered.

The fly wheel is heavy and stores a large amount of energy during the power stroke and shaft 25 therefore continues to rotate whereby piston 69 moves towards the position shown in Figure 9 and the air contained in cylinder 63 is compressed and forced into tank 73 where it is retained by check valve 74. As soon as the crank shaft has completed one revolution, a new cycle begins and the operation described will be repeated.

It will be observed that crank shaft 25 carries a sprocket wheel 28 and that an identical sprocket wheel 32 is carried by shaft 31. Since the two sprocket wheels are operatively interconnected by a sprocket chain, shafts 25 and 31 will rotate at the same speed and impact member 35 will be released at the same time in each cycle relative to the rotation of shaft 25.

Since the source of the power is highly compressed air and since this expands during its passage through the engine, the parts will remain cool during the operation. When air is compressed during the return stroke of the power piston, some heat will be developed by this compression but not sufficient to overcome the cooling effect of the expanding air.

Having described this invention what is claimed as new is:

1. In an air operated single acting engine comprising a power cylinder having one end closed and the other end open, a piston mounted for reciprocation in the cylinder, a crank shaft provided with a crank pin and a fly wheel, and means comprising a connecting rod for converting reciprocating motion of the piston into rotary motion of the crank shaft, in combination with the above of a source of air under high pressure, conduit means communicating the high pressure air source with the power cylinder between the piston and the closed end thereof, a closed poppet valve housing in said conduit means, a partition dividing the interior of the housing into a high pressure air compartment and an air discharge compartment, the partition having an opening provided with a valve seat on the side of the high pressure, a valve positioned in the high pressure compartment in position to be urged to closing position by the air pressure, the valve having a stem extending through the air discharge chamber and through the wall of the housing, a slide valve of the piston-type positioned in the conduit means between the poppet valve and the power cylinder, said slide valve having two positions, and two separate openings spaced along its axis, one opening forming a passage for air to the power cylinder and the other opening forming a passage for air discharged from the power cylinder, means for positioning the first-mentioned opening to communicate the power cylinder with the discharge compartment of the poppet valve housing when the piston in the power cylinder is at the beginning of the power stroke, means comprising an impact member operatively connected with the power piston for effecting an instantaneous opening of the poppet valve at the beginning of the power stroke, and means operated at the end of the power stroke connecting the power cylinder with the exhaust opening, said means functioning in cycles.

2. A device in accordance with claim 1 in which means comprising a coil spring is positioned in the high-pressure compartment of the poppet valve housing for urging the valve to closed position and in which means comprising a rigid abutment is positioned in the spring to limit the extent to which the valve opens.

3. A device in accordance with claim 2 in which the abutment is supported from the end wall of the housing by a yieldable means that permits a limited movement of the abutment in response to force exerted thereon by the valve as it moves to open position.

4. A device in accordance with claim 3 in which the yieldable support for the abutment consists of a resilient disk supported adjacent its edges only and in which the end of the abutment resting on the disk is convex.

5. In a single acting air pressure operated engine having a high-pressure air supply, a power cylinder, a piston mounted in said cylinder, a crank shaft, means for converting reciprocation of the piston to rotary motion of the crank shaft and conduit means communicating the air supply with the power cylinder, a poppet valve in the conduit, the valve being arranged to close in the direction of air flow, means for instantane-

ously opening said valve at the beginning of the power stroke of the power piston, a two-way slide valve mechanism in that portion of the conduit between the delivery compartment of the poppet valve and the power cylinder for conducting high-pressure air to the power cylinder at the beginning of the power stroke, and means responsive to the movement of the power piston as it reaches the end of the power stroke for shifting the slide valve to connect the interior of the power cylinder with a discharge port and maintain said connection during substantially the entire discharge stroke.

6. A device in accordance with claim 5 in which the slide valve is normally held in the first-mentioned position by means of a spring.

7. In combination with a single acting air-pressure operated engine having a power cylinder, a power piston slidable therein a crank shaft having a crank and crank pin and a connecting rod operatively connecting the power piston with the crank pins, an air supply and discharge conduit in communication with the power cylinder, a slide valve means in said conduit having a piston provided with two openings spaced along the axis thereof, one of which is a diametrical opening, resilient means and a stop for normally



holding the piston in a position in which the diametrical opening is in communication with the power cylinder during the major part of the power stroke, and means responsive to the movement of the power piston as it approaches the end of the power stroke for moving the slide valve piston into a position in which the other opening communicates with the power cylinder and for retaining it in that position until the end of the discharge stroke.

8. A device in accordance with claim 7 in which the last-mentioned means comprises at least one cam operatively associated with the slide valve piston operating means for moving said piston to discharge position.

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