United States Patent

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[54] **INTERNAL COMBUSTION ENGINE**
17 Claims, 13 Drawing Figs.

[52] **U.S. Cl.** ..... **123/44 D,** 123/44 C
[51] **Int. Cl.** **F02b 57/00**
[50] **Field of Search** ..... 123/44 C, 44 D, 44

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ABSTRACT: This application discloses a novel internal combustion engine incorporating the advantageous features of two-cycle and four-cycle engines in a single simplified engine, and also discloses the novel engine in combination with a drive assembly for utilization of the engine in an automobile. A stationary vertical crankshaft and a cylinder block disposed for rotation about the crankshaft are disclosed. Cylinder sleeves disposed in the rotatable block assembly include intake and exhaust ports which are substantially diametrically opposed with the valve action being controlled by the position of the piston within the cylinder sleeve in combination with nonrotative upper and lower intake and exhaust control casings. Fuel as well as air for combustion and scavenging of the combustion chamber is provided through the use of a blower system cooperating with a rotating blower ring attached to the block assembly. The engine includes not only a combustion chamber associated with each piston but also a secondary burning chamber which is opened at a predetermined point in the travel of each piston so that an additional charge of oxygen is applied to the combustion chamber after the main combustion has taken place. Construction details of the complete engine, the novel power transfer assembly for driving a vehicle, and a fuel injection system are disclosed.

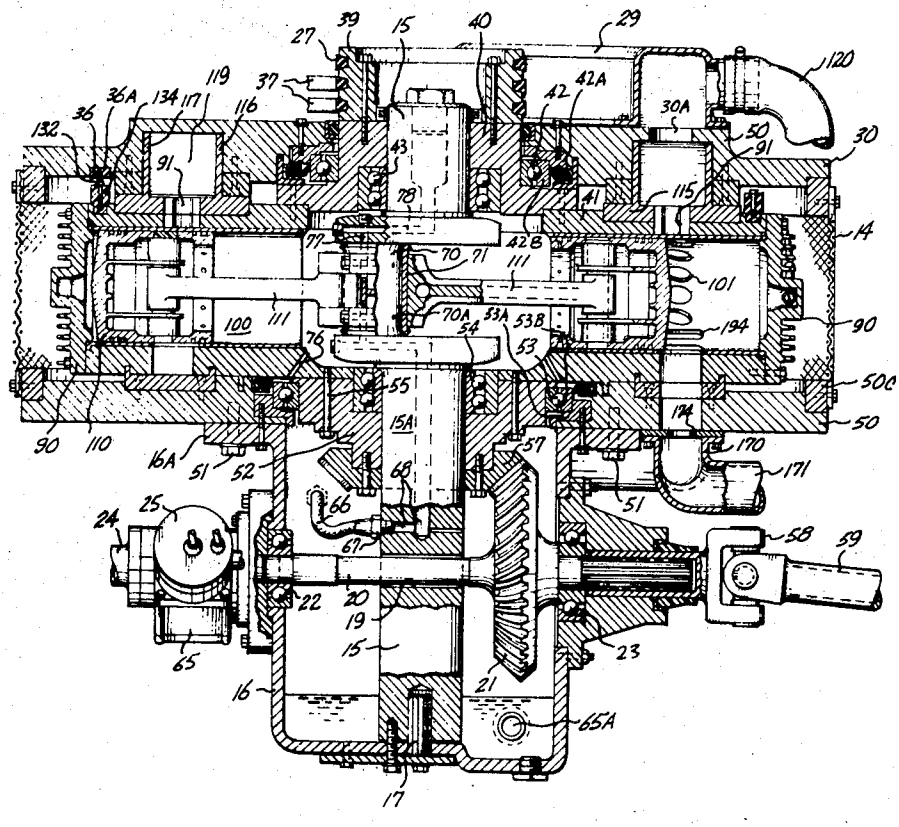


Fig. 1.

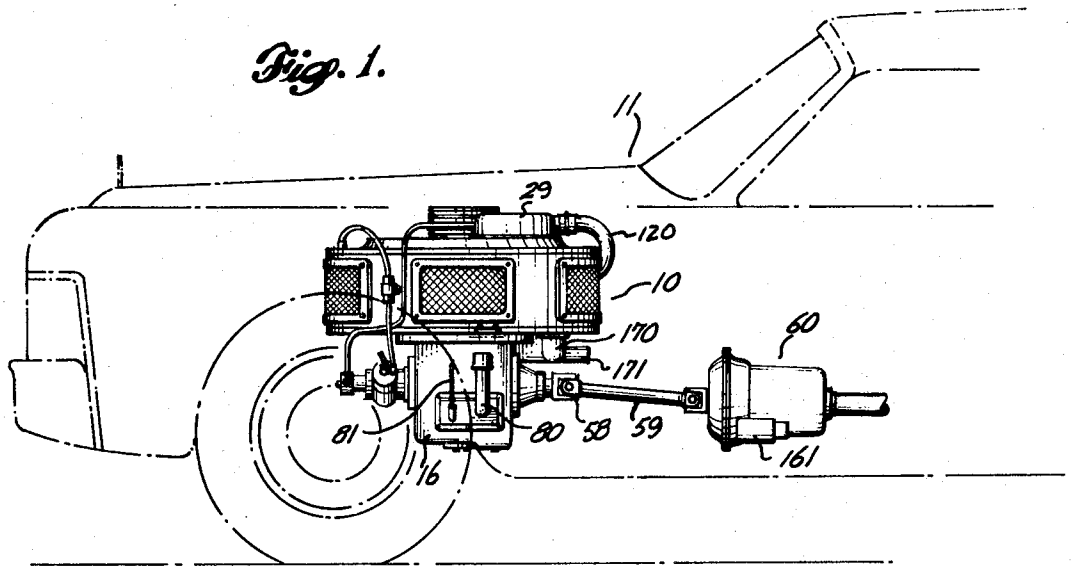
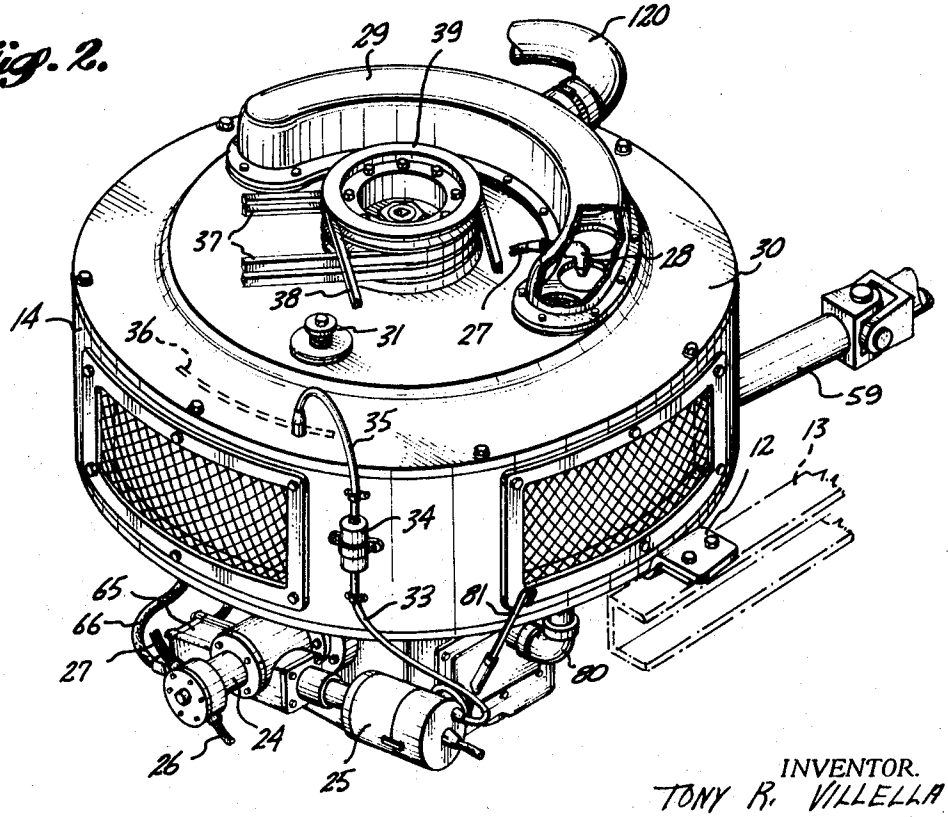


Fig. 2.



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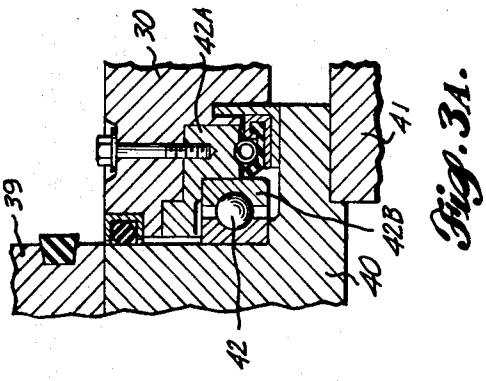


Fig. 3A.

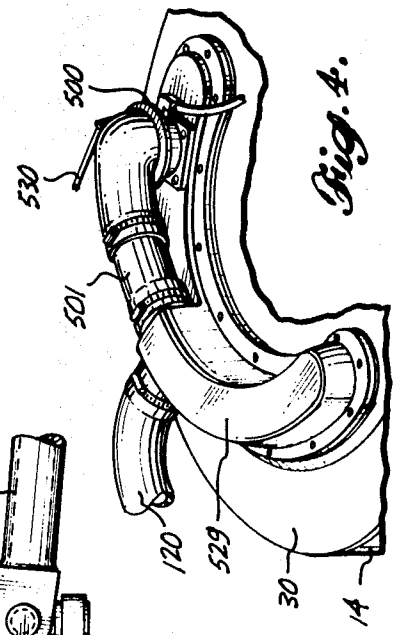


Fig. 4.

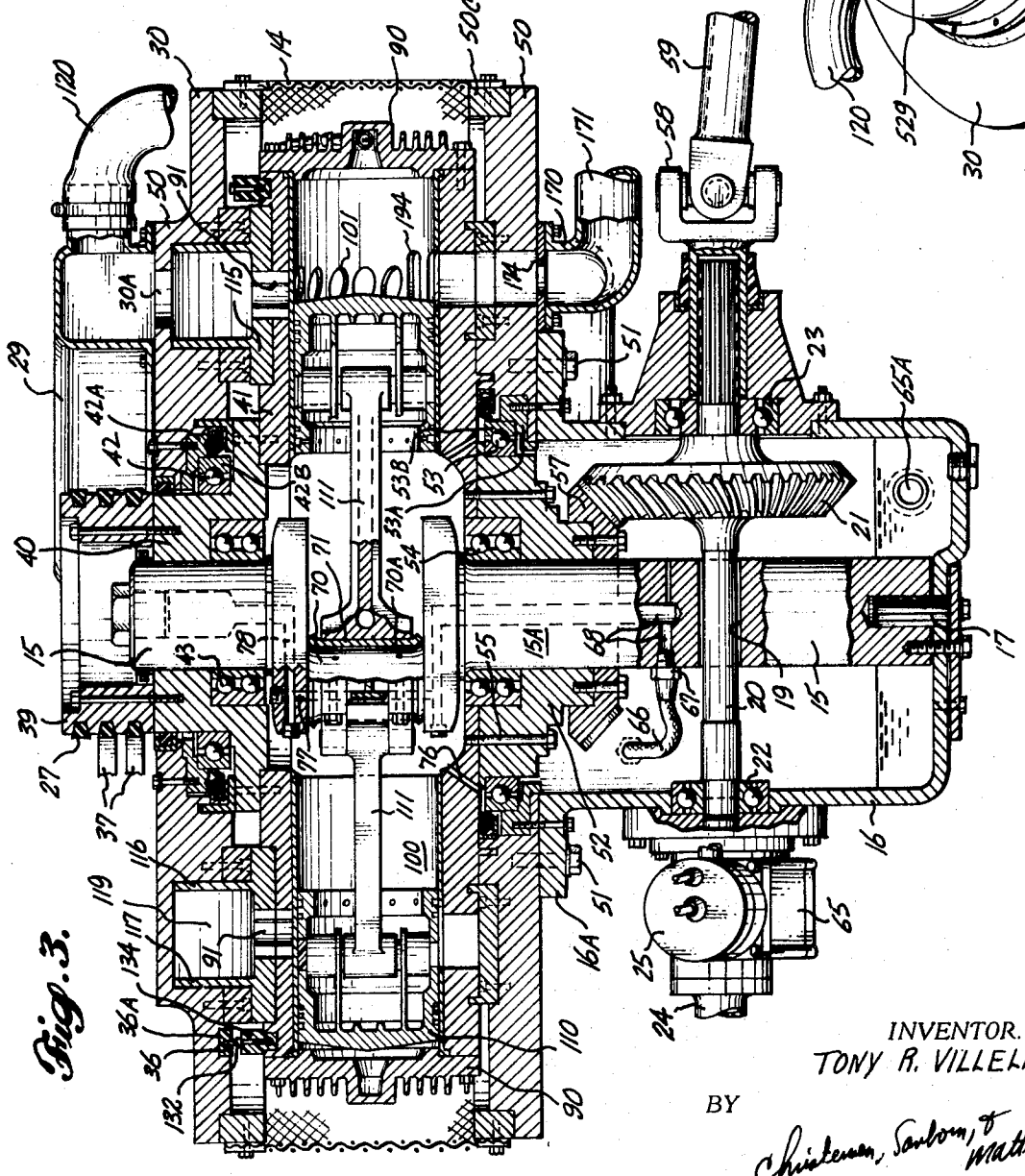


Fig. 3.

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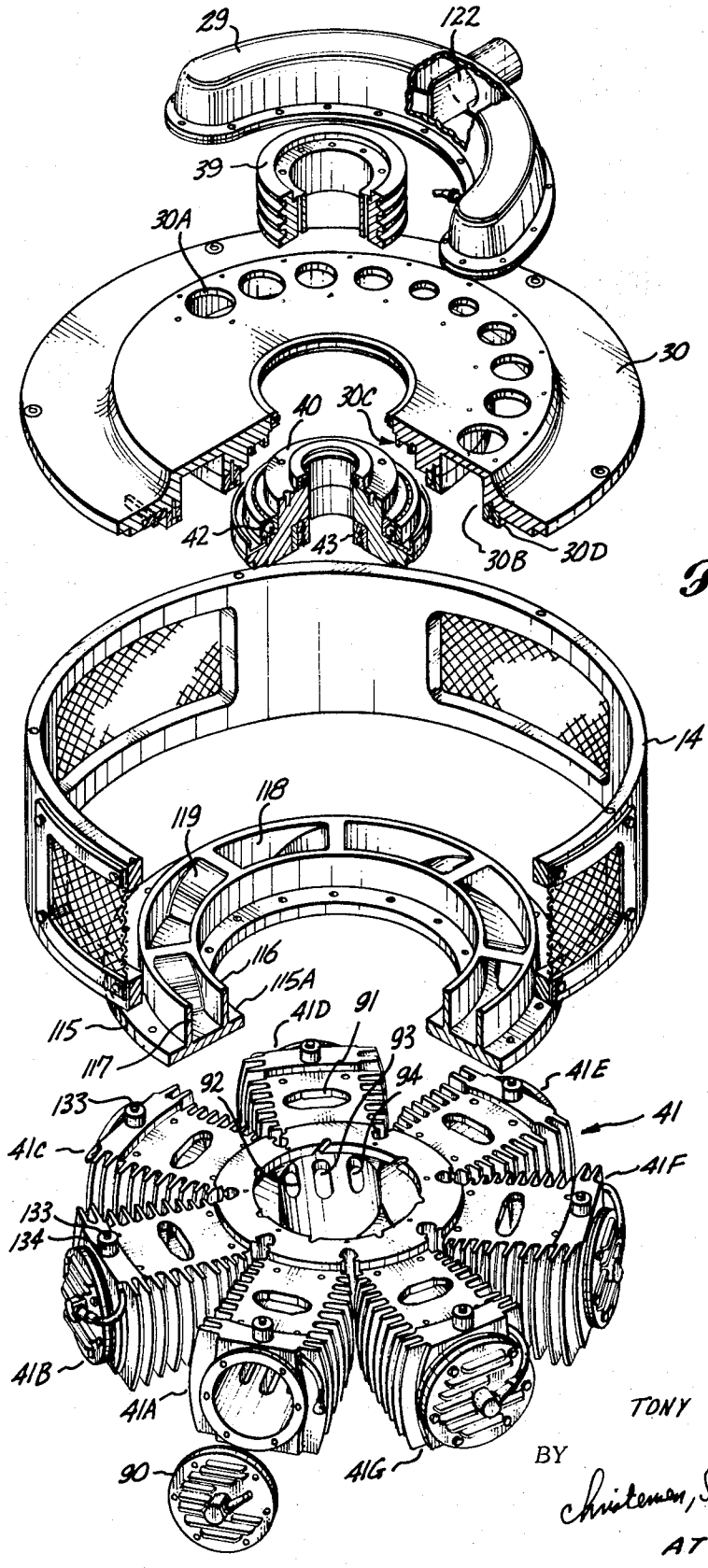


Fig. 5.

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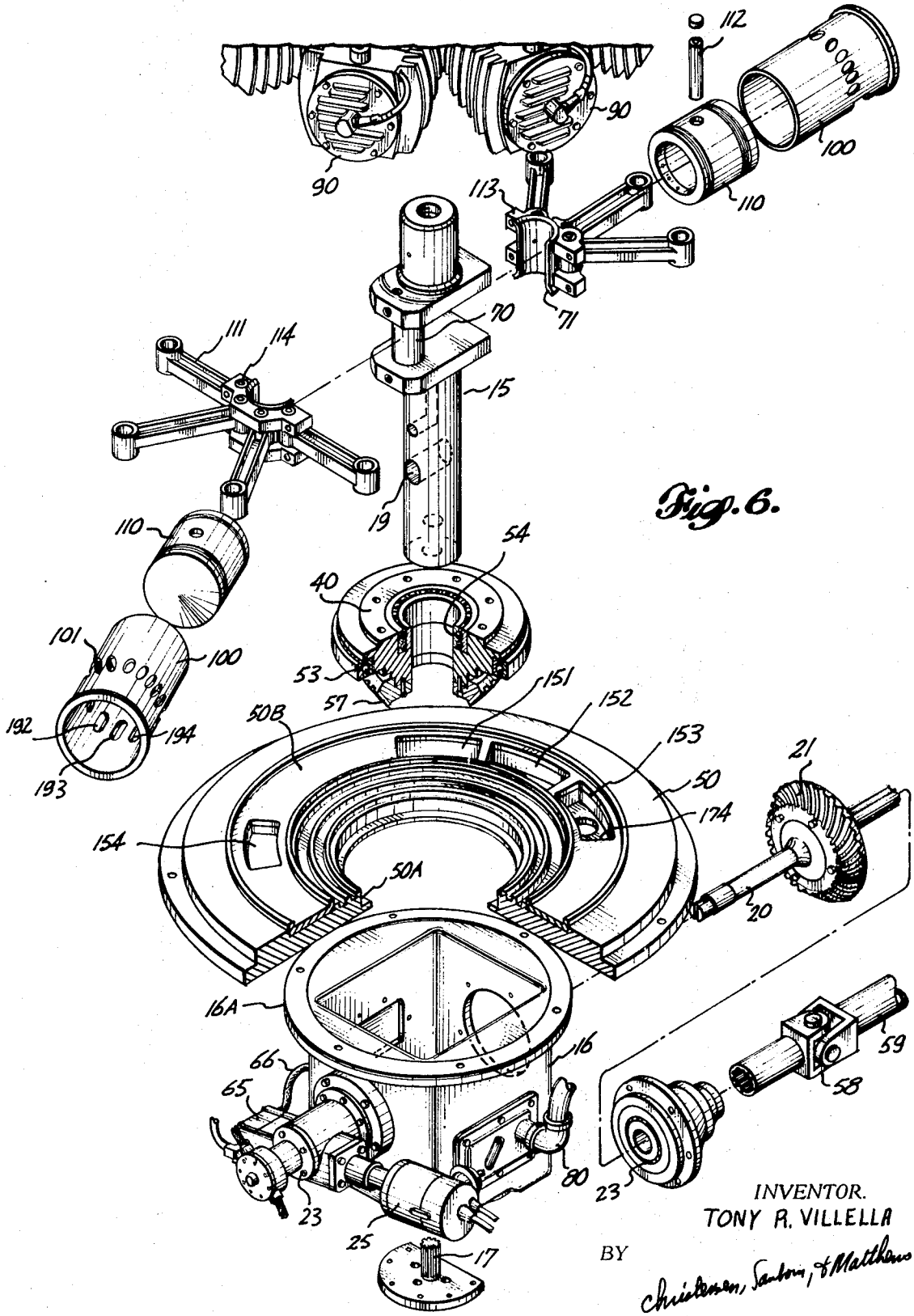


Fig. 6.

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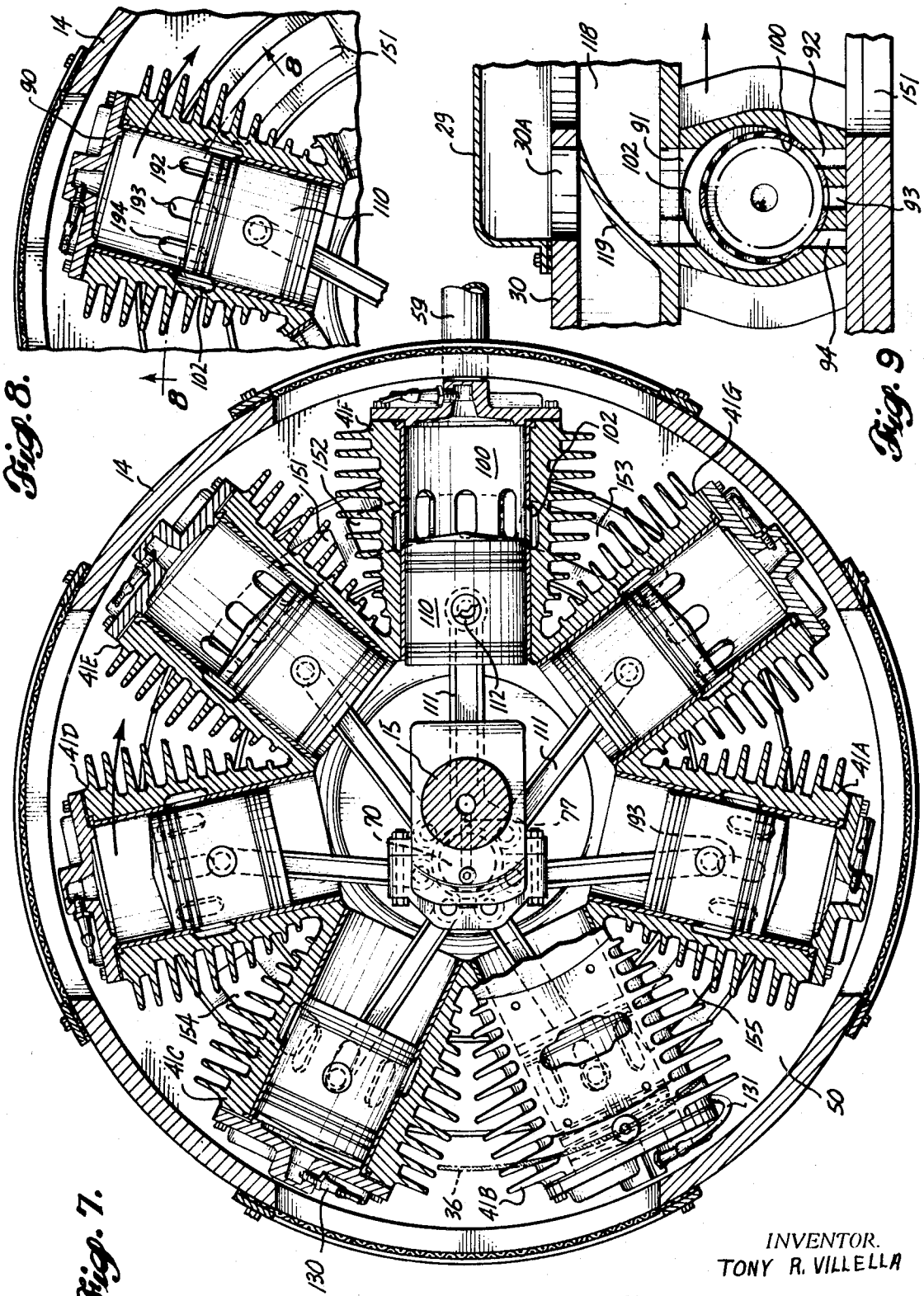


Fig. 8.

Fig. 9

Fig. 7.

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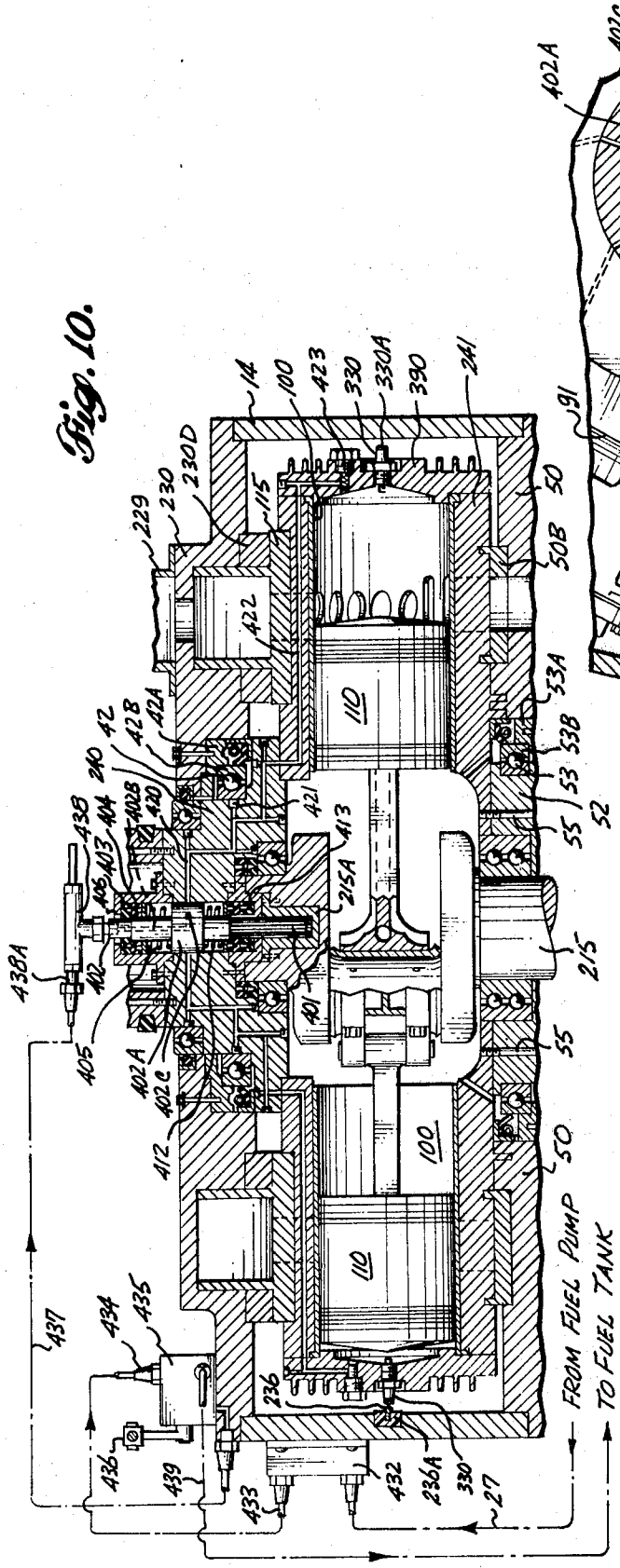


Fig. 10.

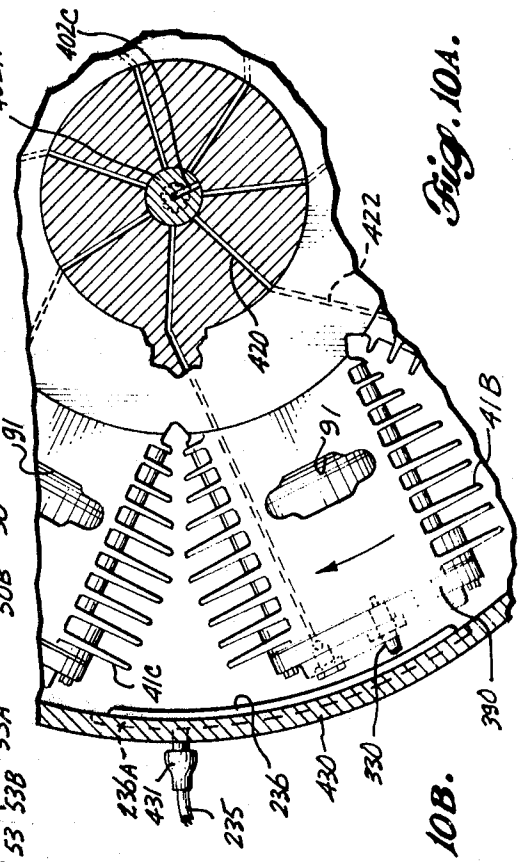


Fig. 10A.

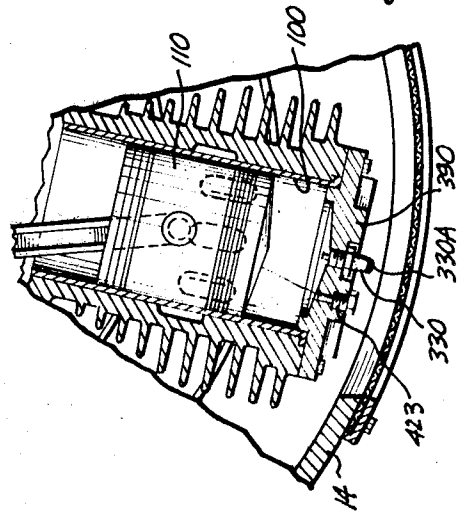


Fig. 10B.

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INTERNAL COMBUSTION ENGINE

Since the advent of internal combustion engines a great deal of time, effort and money has been devoted to simplifying such engines and to improving the efficiency thereof while reducing the weight for a given power output. Two-cycle engines of the stationary crankshaft type are well known in the art with most such engines utilizing oil carried by the combustion mixture for lubricating the bearing assemblies through the use of an arrangement wherein the fuel traverses the crankcase before entering the combustion chambers. The wasteful nature of prior art two-cycle engines based on blower arrangements for clearing the combustion chamber following each power cycle as well as the problems associated with fouling of spark plugs are so well known as to require no further elaboration herein.

Four-cycle engines have met with far greater success in most applications, and particularly in the automotive industry, but have the inherent disadvantage of requiring two complete cycles of piston travel to obtain a single power stroke. The comparative advantages of the four-cycle engine as contrasted to prior art two-cycle engines are also well known. Both types of engines are known to produce substantial volumes of air contaminants as a result of the inefficient and incomplete burning of the initial fuel as well as through the production of undesirable combustion by-products such as carbon monoxide. The increased concern about such air contamination and the desire of engine manufacturers to provide engines having a high horsepower-to-weight ratio has resulted in many engines being more complex. This is particularly true in the area of carburetion and valve assemblies for these engines together with the crankcase venting systems for burning the combustion by-products which previously entered the engine crankcase and then were permitted to escape to the atmosphere.

It is an object of the present invention to provide a simplified internal combustion engine incorporating many of the advantageous features of both two-cycle and four-cycle engines while simultaneously avoiding and eliminating some of the deficiencies of each of these two types of engines encountered in the prior art. Another object of the present invention is to provide a compact and greatly simplified internal combustion engine.

Another object of the present invention is to provide a highly efficient internal combustion engine whose combustion by-products include a greater proportion of carbon dioxide and a smaller proportion of carbon monoxide than has been provided by prior art engines.

An additional object of the present invention is to provide a drive assembly for an automobile which utilizes a stationary vertical crankshaft and having a rotating block assembly coupled with an output transmission arrangement for coupling power to the vehicle wheels.

Additional objects of the invention relate to specific improved components within the overall engine assembly which permit the fabrication and assembly of the engine using a relatively small number of components which can be assembled or disassembled in a short time.

The above as well as additional objects and advantages of the invention will be more clearly understood from the following description when read with reference to the accompanying drawings wherein,

FIG. 1 is an elevation view of the novel engine disposed within an automobile and having a power transfer case and transmission assembly illustrated in combination with the engine.

FIG. 2 is a perspective view of a preferred embodiment of the engine of the present invention.

FIG. 3 is a vertical sectional view of the novel engine.

FIG. 3A is an enlarged sectional view of one of the bearing and seal assemblies of FIG. 3.

FIG. 4 is an enlarged perspective view of a further embodiment of the intake manifold for the engine and including a carburetor housed therein.

FIG. 5 is an enlarged isometric view showing major engine components separated and partially cut away to illustrate construction details of the engine.

FIG. 6 is a further exploded isometric view of the lower components of the engine located beneath the apparatus illustrated in FIG. 5 together with the power transfer case and drive shaft.

FIG. 7 is a horizontal sectional view looking down on the engine and illustrating various operating positions of the seven pistons.

FIG. 8 is a horizontal sectional view of one of the piston assemblies illustrating the location of the piston when intermediate two of the positions illustrated in FIG. 7.

FIG. 9 is an enlarged vertical section through one of the piston assemblies illustrating the reburning chamber associated with each of the combustion chambers.

FIG. 10 is a vertical cross section of another embodiment of the invention using a novel fuel injection system.

FIG. 10A is a horizontal section of a part of the apparatus of FIG. 10.

FIG. 10B is a horizontal section through one of the cylinders of the embodiment of FIG. 10 at the time when fuel injection is taking place.

Turning now to the drawings and in particular to FIGS. 1 and 2, the assembled engine 10 is illustrated as being mounted in the front end of a vehicle 11 by means of the support brackets 12 bolted to the vehicle frame 13. The engine has a stationary crankshaft 15 (FIG. 3) which is rigidly bolted to the crankcase 16 and is further held against rotation by means of the splined shaft 17 which fits into a mating opening in the lower end of the crankshaft (FIGS. 3 and 6). The crankshaft has a horizontal bore 19 therein (FIG. 6) through which the power output drive shaft 20 extends. The shaft 20 has a gear 21 secured thereto, the front end of shaft 20 being supported for rotation by the bearing 22 in the front wall of the crankcase 16 (FIG. 3) and the rear portion of the shaft is similarly supported by the bearing 23 in the rear wall of the crankcase.

The front end of the shaft 22 is coupled with and drives the fuel pump 24 and is geared to the distributor 25. Fuel line 26 (FIG. 2) carries fuel to the pump 24 with line 27 extending from the high pressure side of the pump to the injection nozzle 28 located inside the lower manifold 29. The blower manifold 29 is bolted to the top plate 30 of the engine housing 14, said top plate of the engine housing having a blowback valve assembly 31 located therein. The holes 30A in the plate 30 are the entrance openings for fuel and air to the cylinders, as will be described hereinafter.

Electrical lead 33 extends from the distributor 25 to the high voltage coil 34 supported on the side of the housing 30 with the output lead 35 from the coil 34 extending to the ignition ring 36 shown in dashed lines in FIG. 2 and explained in greater detail hereinafter. A plurality of conventional drive belts 37 and 38 are shown in FIG. 2 as being engaged with the drive pulley 39 which as seen in FIG. 5 and in FIG. 3 is bolted to the upper main bearing member 40. The upper main bearing support member 40 is bolted to the engine block assembly 41 and carries the roller bearing 42 on the outside thereof (see FIG. 3A) as well as the ball bearing and race assembly 43 which is disposed around the crankshaft (FIG. 3). As seen in FIGS. 3, 3A, and 5, the top plate 30 is bolted to the cylindrical housing member 14 with the member 14 in turn being bolted to the lower support plate 50 (FIGS. 3 and 6). The lower support plate 50 is in turn secured by bolts 51 to the upper flange 16A of the crankcase 16.

The lower main bearing support member 52 is supported for rotation relative to the lower main plate 50 by the lower ball bearing 53 and is adapted to rotate about the crankshaft 15 by means of the lower ball bearing assembly 54. Bolts 55 (FIG. 3) hold the lower main bearing support member 52 to the cylinder block 41 and thus it will be seen that the cylinder block 41 and all of the components rigidly secured thereto are free to rotate about the crankshaft 15 with the major weight of the cylinder block and associated components being borne by the bearings 53 and 54. A pinion gear 57 bolted to the lower

end of the lower main bearing support member **52** is engaged with the gear **21** carried by the output shaft **20**. Thus rotation of the cylinder block about the vertical axis of the stationary crankshaft **15** provides output torque via the universal joint **58** and drive shaft **59** to the transmission shown generally at **60** in FIG. **1**. A starter motor **61** is shown in FIG. **1** as being positioned on the bottom of the transmission **60** for selectively applying starting torque to the engine. It will be obvious that various types of starting arrangements can be provided for starting the engine by imparting initial rotational energy to the block assembly.

The preferred embodiment of the present invention makes use of a pressurized oil system for lifting oil from the crankcase and applying the same to the various components of the engine and thus in FIGS. **2** and **6** an oil pump **65** is shown as being coupled with the front end of the power output shaft **20**. Oil line **66** extends from the pump to a fitting **67** (FIG. **3**) on the lower portion of the crankshaft **15**. The crankshaft **15** is provided with a main central bore **15A** which communicates via the bore **68** with the fitting **67** so that pressurized oil is forced up through the center of the crankshaft for application to the bearing assemblies and other surfaces requiring lubrication. Thus it will be seen in FIG. **3** that the single main journal **70** on the crankshaft has a central bore therethrough communicating with the central bore **15A** so that oil is provided via the openings **70A** to the main bearing **71** disposed about the journal **70**. Various additional oil lines are provided, such as lines **76**, **77** and **78**, for lubricating the main ball bearings, wrist pins, and cylinder walls. Many of the oil lines are formed by bores in the various parts. A filler pipe **80** and dipstick **81** (FIG. **1**) are provided on the side of the crankcase **16**. The oil pump intake **65A** will be seen in FIG. **3** inside the crankcase.

In the preferred embodiment of the invention illustrated herein a seven-cylinder engine is disclosed. Thus it will be seen in FIG. **5** that the cylinder block **41** includes seven individual radial cylinder assemblies **41A**—**41G**. Individual cylinder heads **90** are bolted to the ends of the cylinder assemblies with the head members **90** and the individual cylinder assemblies **41A**—**41G** being provided with a plurality of cooling fins. While the block assembly **41** could be made from a plurality of individual components, the main block **41** of one engine constructed in accordance with the teachings of the present invention was a single-piece aluminum casting machined in the manner indicated in FIG. **5**. Each cylinder assembly includes a single intake port opening **91** (see assembly **41D** of FIG. **5**) on the upper surface thereof and three elongated exhaust ports **92**, **93** and **94** in the lower portion thereof.

Each of the radial bores in the cylinder block has a ported cylinder sleeve **100** disposed therein (FIG. **6**). Each cylinder sleeve **100** has three exhaust ports **192**, **193** and **194** disposed in the lower surface thereof for alignment with exhaust ports **92**, **93** and **94** in the cylinder block. In approximate circumferential alignment with the exhaust ports **192**, **193** and **194** the cylinder sleeves **100** are provided with a plurality of elliptical intake ports **101**. While the number of intake ports or openings **101** is not critical it will be seen in FIG. **9** that the cylinder block is provided with an enlarged circumferential groove **102** in each of the cylinder walls with the enlarged groove **102** being aligned with the intake and exhaust openings **101** and **192**—**194** in the cylinder sleeve **100**. Thus when fuel is being applied to the cylinder, as well as during the application of air from the blower in the manner described hereinafter, it will be seen from FIGS. **7** and **9** that the air and the fuel mixture is applied to the cylinder throughout the major portion of the circumference thereof and hence charging and scavenging of the cylinders is greatly enhanced. To further enhance charging and scavenging of the cylinders it will be seen that the intake and exhaust openings **101** and **192**—**194** in sleeves **100** are cut at an angle through the wall of the sleeve. As a result the fuel mixture as well as the purging air is directed toward the head end of the cylinders for a more thorough filling and cleansing of the cylinders.

Each cylinder sleeve **100** has a piston **110** disposed therein (see FIG. **6**). Connecting rods **111** and wrist pins **112** connect the pistons with the single journal **70** on the crankshaft via the main bearing hub **113**. Wrist pins **114** will be seen in FIG. **6** for connecting the central ends of connecting rods **111** with the hub **113**. The pistons **110** are provided with the usual sealing and scraping ring assemblies.

A blower ring assembly **115** (FIG. **5**) is bolted to the cylinder block on the upper surface thereof and serves to ram the air available from the intake manifold housing **29** through opening **30A** into the individual cylinders at the appropriate time. It will be seen that the blower ring includes a horizontal ring section **115A** having upstanding walls **116** and **117** formed integrally therewith. Seven separate compartments **118** are provided in the blower assembly with the separating walls **119** between adjacent compartments being angled in the manner shown in FIG. **5** so that when the blower ring is rotated in a clockwise direction air will be scooped from within the manifold housing **29** and forced downwardly against the cylinder block and hence into the cylinders. As seen in FIG. **5**, the holes **30A** in top plate **30** (which remains stationary) extend around approximately one half of the circumference of the top plate and are of decreasing area from each end of the line of holes to the center. By having the indicated graduation in the area of holes **30A** it is found that better fuel distribution is obtained. The plate **30** is also provided with a rectangular groove **30B** which mates with the upstanding walls **116** and **117** of the blower ring **115**. A plurality of additional slots indicated generally at **30C** are provided in the lower surface of the top plate **30** for sealing rings to be inserted therein between the top plate **30** and the upper main bearing support **40** as shown in FIG. **3**.

The interior of the manifold **29** is constantly maintained under positive air pressure from a blower which is coupled to the manifold housing **29** via the air tube **120**. As described hereinafter, the cylinder block rotates in a clockwise direction with the fuel injection nozzle **28** being positioned generally above the last two holes **30A** at the most clockwise end of the series of holes **30A**. Since the interior of the intake manifold housing **29** is constantly under positive pressure, it will be seen that there is little likelihood of any of the fuel from the injector nozzle **28** flowing counterclockwise within the intake manifold. However, to avoid such a possibility an intake manifold divider **122** is disposed in alignment with the intake tube **120** to effectively separate the two halves of the intake manifold.

Each cylinder is provided with a spark plug **130** with the plug wire extending from the plug through a bore in the cylinder head and terminating via the conductive pickup pin **132** (FIGS. **3** and **5**) which extends above the insulating ring **134** mounted on the top of each cylinder. The seven conductive pins **133** are disposed at the same circumferential position so that they will successively come into alignment with the conductive ignition ring **36** mounted by the insulating member **36A** within the top plate **30**. It will be seen that as the cylinder block rotates the pins **136** and associated spark plug wires **131** will, together with the ignition ring **36**, successively couple the spark plugs with the distributor **25**. The actual timing of the energization of the spark plugs is under control of the distributor **25** and is adjustable in accordance with techniques common in the art.

The bottom plate **50** (FIGS. **3** and **6**) is provided with a plurality of sealing grooves **50A** which mate with the cylinder block to act as oil seals. A sealing ring assembly **50B** is secured to the lower plate **50** to further seal the opening between the cylinder block and the lower plate **50**. The sealing ring **50B** is made of a metal bearing material so that it acts as a seal and as a bearing. An outer cylindrical seal **50C** (FIG. **3**) is also secured to the outer edge of the plate **50**. For reasons explained hereinafter, the plate **50** is provided with three exhaust openings **151**, **152** and **153**. While not necessary for proper engine operation, the plate **50** and associated sealing ring **50B** can advantageously include the openings **154** and

155 (FIG. 7). As seen in FIGS. 1 and 3 an exhaust manifold 170 is bolted to the bottom of the plate 50 with the exhaust pipe 171 extending therefrom. The exhaust manifold 170 covers the exhaust ports 151, 152 and 153. As seen in FIG. 3 an adjustment plate 174 can be placed between the plate 50 and the exhaust manifold, the plate 174 having an opening of reduced area by comparison to the area of holes 151, 152 and 153. This permits an actual tuning of the exhaust cycle and control over the volume of gas dumped during exhaust.

The manner of operation of the engine will be most clearly understood by reference to FIGS. 7, 8 and 9. As seen in FIG. 7, the piston in cylinder 41A is moving outwardly and has just passed a position of alignment with the fuel nozzle 38 in the intake manifold 29. The exhaust ports 192, 193 and 194 associated with cylinder 41A are shown in dotted lines in FIG. 7, and it will be seen that the piston has just passed beyond the outer ends of the exhaust ports. Since as seen in FIG. 3 the intake ports are somewhat shorter in the axial direction than the exhaust ports, the piston will also have passed beyond the ends of the intake ports. Just prior to the arrival of cylinder 41A to the position indicated in FIG. 7 the chamber will have been charged with an air-fuel mixture. When the cylinder reaches the position corresponding to cylinder 41B in FIG. 7 the spark plug associated with cylinder 41B is in electrical contact with the ignition ring 36 via spark plug wire 131 and hence when the piston reaches its position of outermost travel, corresponding to maximum compression, the distributor will provide energy to the spark plug causing the explosion to occur at the proper time. This occurs near the end of the time when the conductive pin 133 is engaged with the spark ring 36.

The piston in cylinder 41D is shown as approaching alignment with the outer ends of the exhaust ports as the piston moves inwardly due to the expanding gases. The piston in cylinder 41E is shown as having arrived at a position of alignment with the approximate midpoint of the exhaust ports 192, 193, 194. It will be seen that cylinder 41E is also aligned with the exhaust opening 151 in the lower engine plate 50 and thus is in the exhaust cycle. At this time the air intake openings 30A beneath the intake manifold 29 are aligned with cylinder 41E and hence fresh air is applied to the cylinders in positions 41E and 41F. The blower ring 115 serves to ram the air under positive pressure into the cylinder. The exhaust cycle and purging of the cylinder with fresh air continues as the cylinder is aligned with exhaust openings 151, 152 and 153.

Cylinder 41G is shown in the position of having just completed the exhaust cycle since the last exhaust opening 153 in the lower plate 50 has just been passed by the cylinder 41G. It will be seen that even though the piston in cylinder 41G is aligned with the exhaust ports in the sleeve 100 the sleeve is not aligned with an exhaust opening in the plate 50 and hence the exhaust cycle has ended and the cylinder is approaching the point of being charged with a fresh fuel supply. This occurs as the cylinder is moving between the positions shown for cylinders 41G and 41A.

It is of particular significance to note that as the cylinder block is traversing the angle between the positions of cylinders 41D and 41E the piston comes into a position of alignment with the exhaust ports 191, 192 and 193 in the sleeve 100 and the associated exhaust ports 92, 93 and 94 in the cylinder block before the exhaust ports 92, 93 and 94 become aligned with the exhaust opening 151 in the lower plate 50. This position of a piston and cylinder is illustrated in FIG. 8 wherein it will be seen that the cylinder has not arrived at a position of alignment with the exhaust opening 151 even though the piston has moved inwardly by an extent sufficient to bring the outermost end of the piston in alignment with the exhaust ports 92, 93 and 94. As seen in FIG. 9, the cylinder wall is of a substantial thickness so that the exhaust ports 92, 93 and 94 in the cylinder wall define a secondary burning and expansion chamber having a substantial volume. This volume is charged with fresh air as the exhaust cycle takes place and fresh air purges the cylinders. Then as the piston achieves the position illustrated in FIG. 8 and while the combustion products are at the elevated temperature associated with the explosion, the exhaust ports are opened by the piston moving inwardly. The trapped air in the ports is then applied to the chamber. As a result a second combustion occurs at a time when the major volume of expanding gases is confined within the cylinder and without being exposed to the exhaust opening 151. This second burning tends to oxidize the carbon monoxide resulting from the initial combustion so that a higher percentage of carbon dioxide and lower percentage of carbon monoxide results. A further result achieved when the piston reaches the position shown in FIG. 8 is that the increased volume provided by the exhaust ports 92, 93 and 94 permits the expansion of the exhaust gases to a very low pressure condition so that when the exhaust ports become aligned with the exhaust opening 151 little or not further expansion occurs. Since the engine utilizes a blower system for removing the exhaust gases it will be seen that the exhaust gases are not discharged via a compression cycle of the piston as is common in four cycle engines, and thus the engine runs very quietly.

An additional factor to be observed regarding the secondary burning cycle is that the intake ports 101 in sleeve 100 are opened when the piston is in the position shown in FIG. 8, which is prior to alignment of exhaust ports 92, 93 and 94 with the exhaust opening 151 but after the piston has opened the exhaust ports 92, 93 and 94. Therefore the external blower in combination with the blower ring 115 rams additional air into the now expanded combustion chamber (due to ports 92, 93 and 94 being part of the combustion chamber at this time). As a result it is found that the secondary burning cycle burns a major portion of the air contaminants exhausted by prior art engines.

It will be seen that as the block rotates relative to the plate 50 from the position of cylinder 41A to position 41D the exhaust ports 92, 93 and 94 pass over the openings 155 and 154 in plate 50. These openings 155 and 154 are not essential but can be used as oil scavenging openings.

Referring now to FIGS. 10 and 10A, a modified form of the engine of the present invention will be described, which embodiment utilizes a novel fuel injection system. Those components which are the same as those previously described bear the same reference numeral. In the embodiment of FIG. 10 the stationary camshaft 215 differs from the previous embodiment in that the central opening 215A in the upper end thereof is splined for receipt of the splined shaft 401 which forms the lower end of a main fuel injector 402. The fuel injector 402 has upper seals 403 and 404 disposed thereabout with the coil spring 405 exerting upward pressure on the seals 403 and 404 so that the upper seal 403 engages the seal cover 406 which is bolted to the upper bearing support 240. The lower end of the coil spring 405 rests on the enlarged collar 402A of the main fuel injector.

The lower end of the main fuel injector adjacent the midpoint of the splined section 401 is similarly provided with seals 410 and 411. Seals 410 and 411 are urged downwardly by the coil spring 412 into engagement with the lower seal cover 413 bolted to the bottom of the upper bearing support 240.

The fuel injector 402 has a vertical bore 402B which undergoes a 90° turn and exits from the periphery of the central collar 402A. The outer end 402C of the fuel channel 402B is aligned with the fuel channel 420 formed in the upper bearing support 240. This fuel channel 420 is shown as being formed by the drilling of a plurality of straight bores having the outer ends of the bores capped by cap plugs 421 so that the channel 420 communicates with the channel 422 in the cylinder block 421. The channel 422 then extends to the fuel injector 423 positioned in the cylinder cap 390 adjacent the spark plug 330. As seen most clearly in the sectional view of FIG. 10A, rotation of the cylinder block and bearing support 240 secured thereto causes the fuel channels 420 to be sequentially aligned with the opening 402C of the fuel channel in the main fuel injector 402. Thus the fuel injectors 423 associated with the individual cylinders of the engine will be sequentially provided with fuel under sufficient pressure and at the right

time to cause the fuel injectors **423** to be momentarily opened for spraying the fuel into the cylinder for the combustion cycle. As seen in FIGS. **10A** and **10B** the injection of the fuel takes place at the same point in the engine cycle as described in connection with FIG. **7** so that the combustion can then occur at a later time as the piston is approaching its outermost position corresponding to maximum compression of the air-fuel mixture. By having the injector **402** held in the end of the crankshaft by a spline arrangement the relative position of the injector in the shaft can be easily and accurately adjusted simply by removing the injector and reinserting it in the desired angular position.

In the embodiment of FIG. **10** the spark plug **330** is provided with a hemispherical cap **330A** which is aligned with the spark commutator ring **236**. The conductive ring **236** is mounted by the insulating member **236A** in the front wall **430** of the engine housing. It will be seen in the embodiment of FIG. **10** that the front portion of the engine housing includes the solid wall **43** in the forward position for holding the conductive commutator ring **236**, the housing further including the screen assemblies in the sidewalls thereof as shown in FIGS. **1** and **2**. The coil wire **235** is connected to the commutator ring **236** for applying the necessary high voltage thereto at the appropriate time during the cycle as determined by the distributor **25**. It has been found in practice that it is not necessary for the head **330A** of the spark plug **330** to physically contact the commutator ring **236** since the voltages involved are sufficiently high to jump a small gap. Hence lubrication is not required and yet efficient engine operation is assured by having the cap **330A** in close proximity to the ring **236** as the cylinder block rotates.

The fuel line **27** in FIG. **10** communicates with the fuel distributor **432** which has an exit line **433** which goes to the connector **434** on the throttle control valve assembly **435**. A throttle control linkage **436** controls the fuel flow through the valve assembly **435** to the line **437** leading to the injector coupling member **438** screwed in the top of the main fuel injector **402**. An adjustment member **438A** is provided in the member **438** for adjusting the fuel flow. A line **439** leads from the valve assembly to the fuel tank. Thus fuel is continuously supplied by the fuel pump to the valve **435** and from there goes to the fuel injectors or is returned to the fuel tank. The system thus maintains a constant supply of high pressure fuel to the main fuel injector **402** so that each of the individual fuel injectors **423** will be sequentially operated for the injection of fuel into the cylinders.

The structural details of the embodiment of the invention shown in FIG. **10**, such as the pistons, sleeves, bearings, gears, supports, etc. will be seen to correspond to the first embodiment of FIGS. **1—9**. While tapered roller bearings work well as the main bearings it has been found that the arrangement using ball bearing assemblies **53** and **42** works well. The plates **53A** and **42A** are pressed onto the outer race assemblies **53B** and **42B**. There plates **42A** and **53A** are bolted respectively to the top plate **30** and to the bottom plate **50**. The main bearing hubs **40** and **52** are held to the cylinder block **41** by bolts **55**. The inner races **54A** and **43A** of the bearings **54** and **43** are preferably heated prior to being placed on the main shaft so that they then seize onto the shaft. The seal and bearing member **230D** in FIG. **10** will be seen to be secured to the top plate **230** with the blower manifold **229** being secured to the top plate **230**.

There has been disclosed an improved internal combustion engine which consists of a small number of parts as compared to prior art engines and which can be assembled and disassembled in a relatively short time. It is of significance to note that the engine consists essentially of a top layer which is stationary (i.e. top plate **30**), a central layer which rotates (i.e. the cylinder block **41** and blower ring **115**), and a lower layer comprising the bottom plate **50**. The entire assembly is easily mounted on the stationary camshaft and coupled with any suitable transmission assembly for providing power to an output drive shaft. Not only does the engine operate economically while avoiding the discharge of the volume of noxious combustion by-products typically discharged by prior art engines, but also it is found that with the engine mounted in the manner indicated the gyroscopic action associated with the large mass rotating in a horizontal plane provides increased stability for the vehicle. In one embodiment of the invention major components such as the cylinder block **41** were made from aluminum resulting in an engine having an extremely high horsepower to weight ratio.

The embodiment of the invention shown in FIGS. **10**, **10A** and **10B** has been found to work particularly well since the point of fuel injection during the engine cycle is easily adjusted simply by removal of the splined shaft **401** from the upper end of the stationary camshaft **215** and then reinserted after being rotated by one or more splines.

I have also found that a conventional carburetor can be utilized with the engine and thus it will be seen in FIG. **4** that a small carburetor **500** is mounted on the top plate **30** with the hose **501** communicating with the air blower hose **120**. In the embodiment of FIG. **4** the manifold cover **529** is somewhat shortened due to the use of the carburetor assembly **500**. A throttle linkage **530** serves to control the speed of the engine via the usual carburetor control.

What I claim is:

1. An internal combustion engine comprising in combination: a first plate having air-intake opening means therein; a second plate having at least one exhaust opening therein; a crankshaft; means interconnecting said plates and said crankshaft and holding the same against relative movement; cylinder block means having means defining a plurality of combustion chambers extending radially outward from a common point, each of said combustion chambers having means defining at least one air-intake opening in the circumference thereof aligned radially with the said air-intake opening means of said first plate and at least one exhaust opening in the circumference thereof aligned radially with the said exhaust opening in said second plate; means supporting said block means between said plates for rotation relative to said crankshaft; and a plurality of pistons each disposed in one of said combustion chambers and each having connecting rod means associated therewith and connected to said crankshaft, each of said pistons in moving from one end of the associated combustion chamber to the other during rotation of the block covering and uncovering the intake and exhaust openings in the chamber wall, said second plate being positioned relative to said block such that each piston uncovers the associated exhaust opening in the cylinder block before the cylinder block exhaust opening becomes aligned with an exhaust opening in said second plate.

2. The apparatus defined in claim **1** including blower means secured to said block means and aligned for rotation adjacent said first plate and radially aligned with said air intake openings of said first plate and of said combustion chambers.

3. Apparatus as defined in claim **1** wherein said second plate includes a plurality of exhaust openings therein.

4. The apparatus defined in claim **1** wherein said block means has a circumferential groove disposed around at least a portion of the circumference of each of said combustion chambers starting from an area of radial alignment with the said air intake opening means of said first plate means, and each of said combustion chambers includes a sleeve member having a plurality of air intake openings disposed in alignment with said groove.

5. The apparatus of claim **1** wherein the said intake and exhaust openings of each of said chambers are at least partially disposed in opposite sidewalls of the chamber and radially aligned to permit through-flow of air during the exhaust cycle.

6. The apparatus of claim **1** wherein said means defining said combustion chambers comprises a cast block portion having diametrically opposed intake and exhaust openings therein, and a sleeve member secured in each said portion with each sleeve member having diametrically opposed intake and exhaust openings.

7. The apparatus of claim 1 including a main beveled drive gear disposed about said crankshaft, means holding said gear to said block for rotation therewith and a second beveled gear meshed with said first gear and lying in a plane substantially parallel to the axis of said crankshaft.

8. The apparatus of claim 1 including fuel input means for providing a mixture of air and fuel to said chambers through at least one opening in said first plate.

9. The apparatus of claim 8 including an intake cover secured to said first plate and disposed over the said intake openings thereof, and means supplying air under pressure to the interior of said cover.

10. The apparatus of claim 1 including fuel injection means coupled with each of said cylinders and operative to supply pressurized fuel to the interior of each chamber at a selected time during rotation of said block means, said fuel injection means including individual control valve assemblies associated with each of said chambers and each having a fuel line connected thereto and extending to a point adjacent said crankshaft, and fuel distributor means secured to said crankshaft and having an opening therein which is sequentially aligned with said fuel lines as said block means rotates, said fuel distributor means including an elongated member having a splined end, a fuel line extending longitudinally to an interior point of the member, and a radial fuel line terminating in an open end which is sequentially aligned with the ends of the said fuel lines connected to said control valves; and wherein one end of said crankshaft has a splined opening for receiving the splined end of said elongated member.

11. The apparatus of claim 1 including a plurality of electrically actuated ignition devices each having a portion extending inside one of said chambers and including conductive terminal means for receiving an electric signal, and means defining a conductive ignition ring maintained stationary relative to said first plate near the outer edge thereof and sequentially engageable with said terminal means as said block means rotates relative to said first plate.

12. The apparatus of claim 11 wherein said ignition devices comprise spark plugs having an end member extending radially outward from said block means, and said conductive ignition ring is secured to means interconnecting said plates.

13. The apparatus of claim 11 wherein said conductive ring is secured to said first plate.

14. The apparatus of claim 1 including a thin walled substantially flat bearing and sealing member secured to said bottom plate, said bearing and sealing member and said block means having mated upstanding and depressed portions which are mutually reentrant to form a seal extending around a circumference on said plate.

15. The apparatus of claim 1 including a blower ring secured to said block means below said first plate, said blower ring including a plurality of individual compartments each having open tops and bottoms and angled leading and trailing end walls.

16. The apparatus of claim 15 wherein said blower ring has a number of said compartments corresponding to the number of combustion chambers in the engine.

17. An internal combustion engine comprising in combination: a first plate having air-intake opening means therein; a second plate having at least one exhaust opening therein; a crankshaft; means interconnecting said plates and said crankshaft and holding the same against relative movement; cylinder block means having means defining a plurality of combustion chambers extending radially outward from a common point, each of said combustion chambers having means defining at least one air-intake opening in the circumference thereof aligned radially with the said air-intake opening means of said first plate and at least one exhaust opening in the circumference thereof aligned radially with the said exhaust opening in said second plate; means supporting said block means between said plates for rotation relative to said crankshaft; blower means secured to said block means and aligned for rotation adjacent said first plate and radially aligned with said air-intake openings of said first plate and of said combustion chambers; and a plurality of pistons each disposed in one of said combustion chambers and each having connecting rod means associated therewith and connected to said crankshaft.