Aug. 6, 1968 R. M. RILEY 3,395,690

INTERNAL COMBUSTION ENGINE

Original Filed Oct. 20, 1965 3 Sheets-Sheet 1

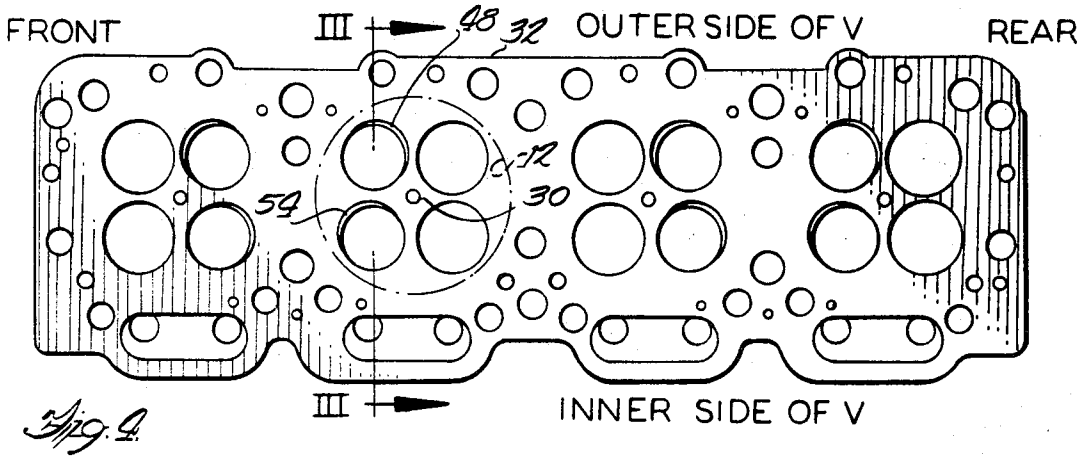


Fig. 2.

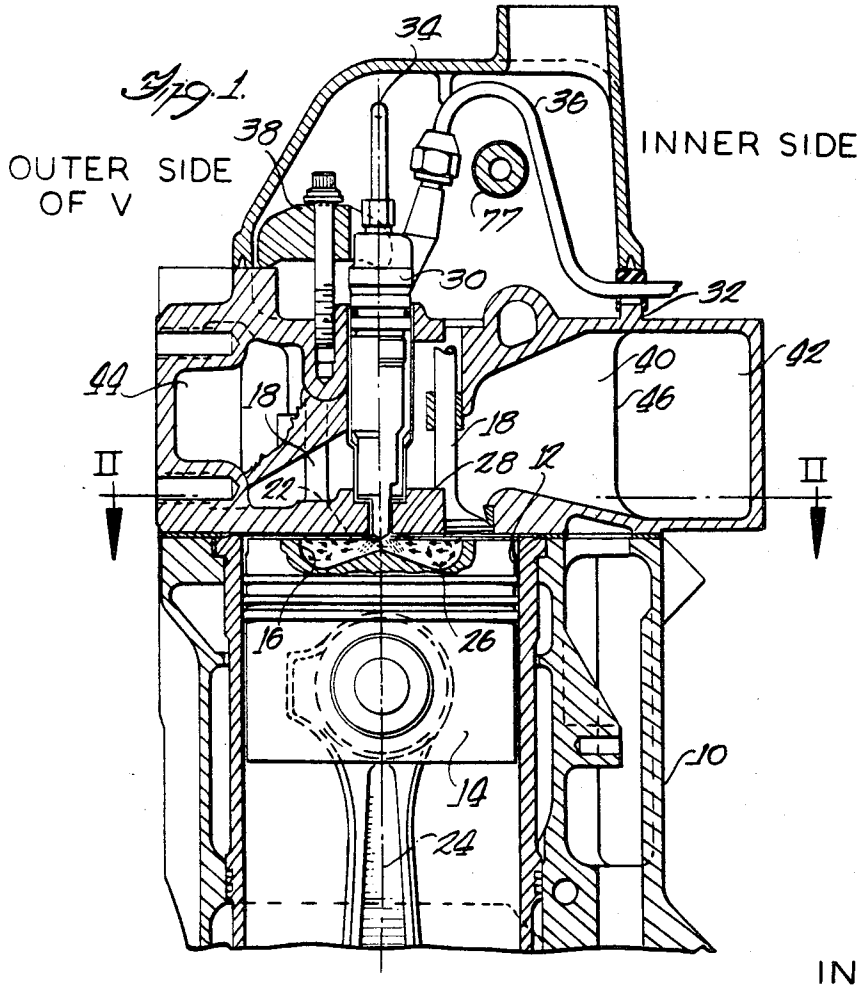


Fig. 1.

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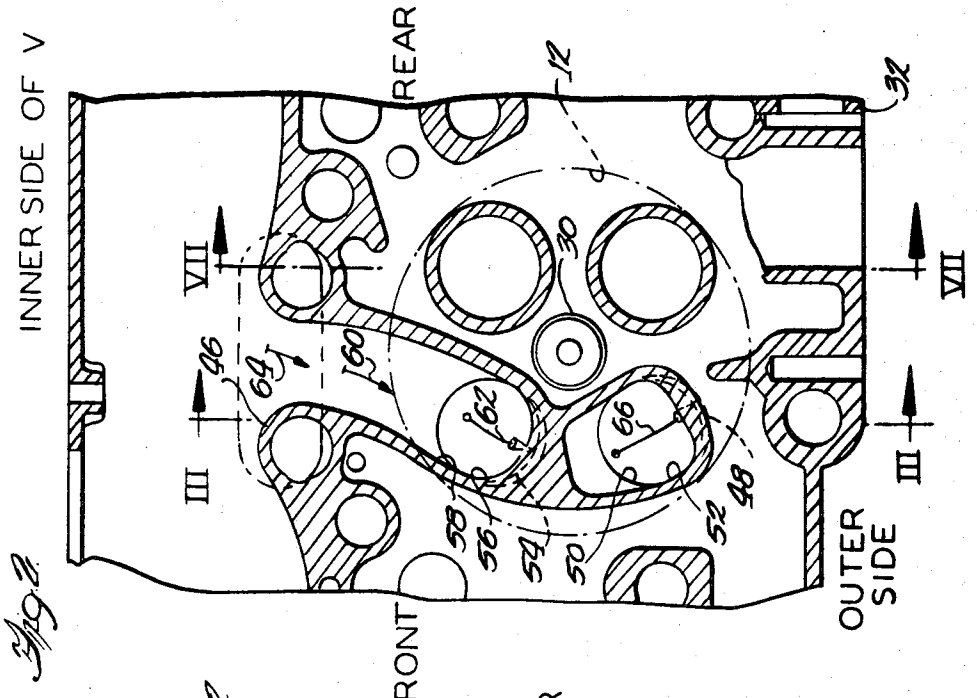


Fig. 2

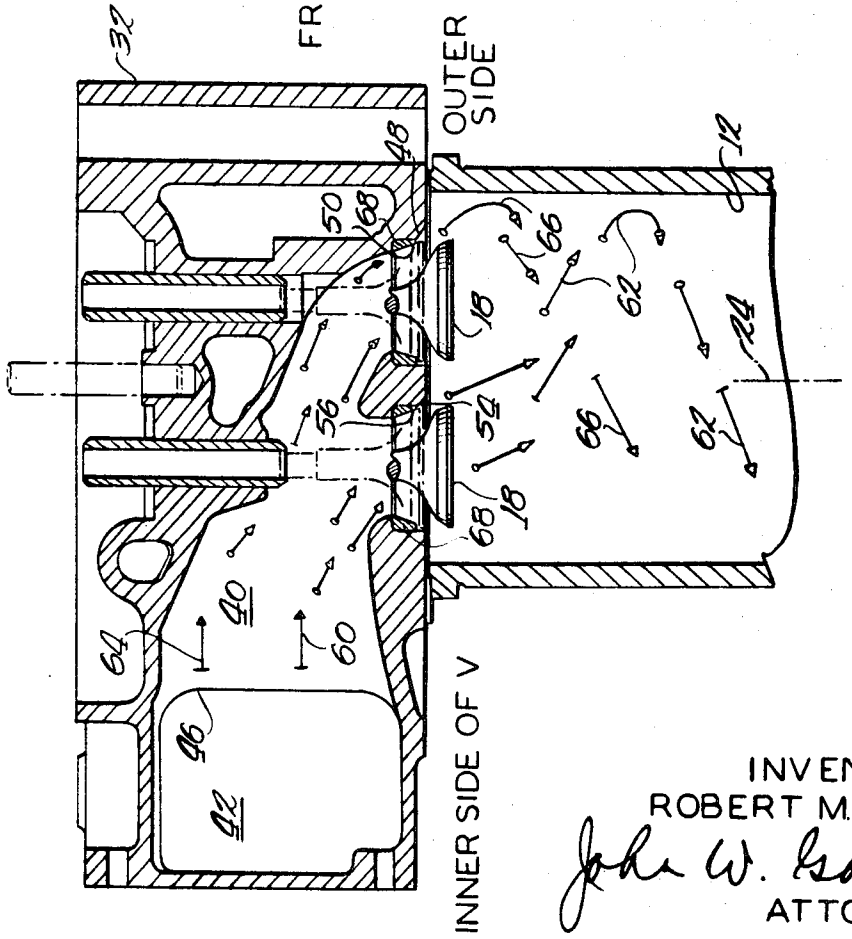


Fig. 3

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Fig. 5

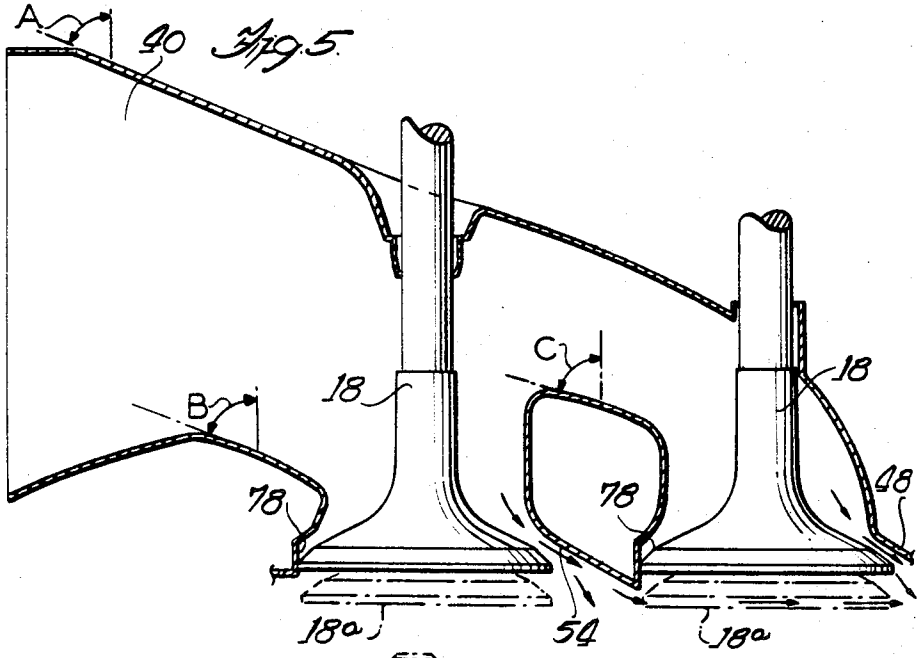


Fig. 7

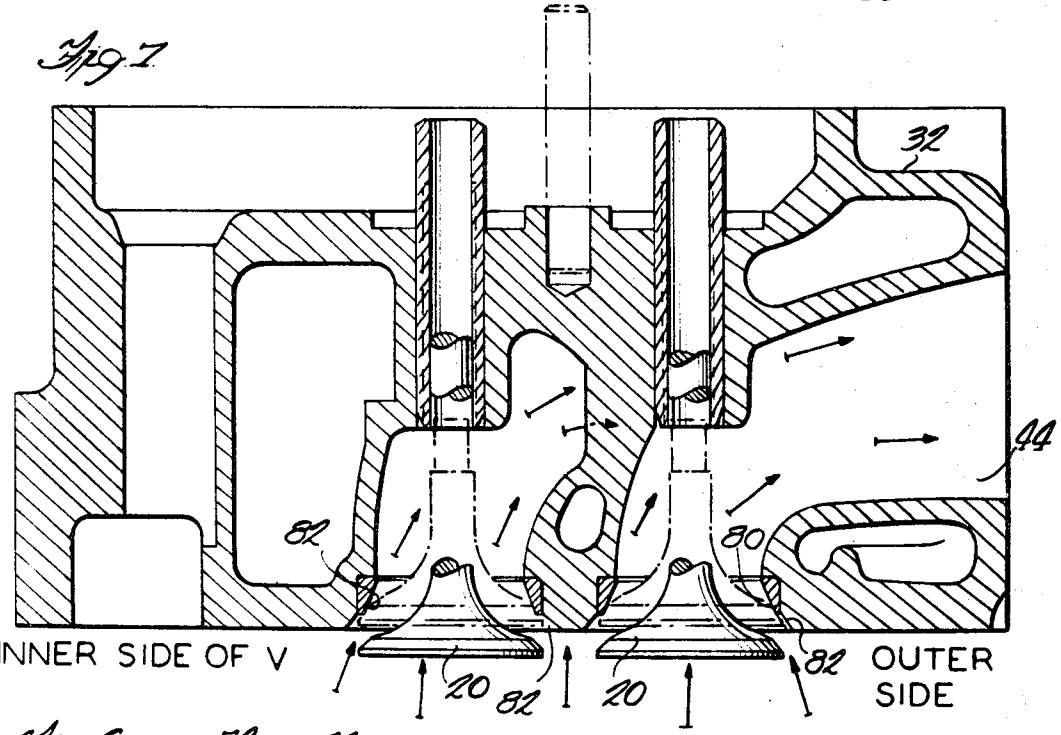
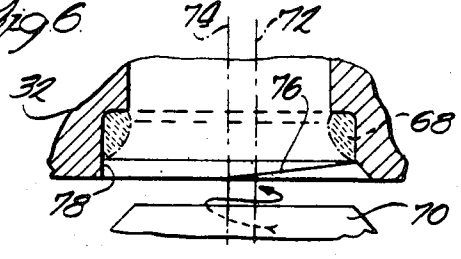


Fig. 6



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3,395,690

INTERNAL COMBUSTION ENGINE

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Continuation of application Ser. No. 498,559, Oct. 20, 1965. This application May 5, 1967, Ser. No. 636,548
10 Claims. (Cl. 123—191)

ABSTRACT OF THE DISCLOSURE

Method and cylinder-head passage structure for dual induction of swirling intake fluid into an engine cylinder in two stages. Initially fluid in the passage is emitted from dual, back-masked, flow directing ports which contribute in the proportions of about 50%–50% to the swirl producing component of the slow moving intake fluid. Then during main induction the fluid is emitted faster, and so that about 70% of the swirl component comes from that one of the dual ports which is at the extreme end of their tangentially disposed, common, single inlet passage, and only about 30% from the other port, which is at an intermediate location.

This application is a continuation of my application 498,559 filed Oct. 20, 1965, now abandoned.

The present invention related to an internal combustion engine, and particularly to a cylinder head for a compression ignition, fuel injection type engine I seek, with certain simplifications of structure and an improvement in performance, the results detailed in U.S. Patent No. 2,001,358, the entire disclosure of which is incorporated herein by reference.

An object of my invention is to provide a cylinder head by which induction air is introduced through two inlet valve ports into an engine cylinder, by an improved manner of inwardly directed swirling of the air. The swirl rate which is created is sufficiently high that air swirl is residual throughout the suction and compression strokes of the piston in the engine, and a biaxial rotation of the air occurring throughout the period of fuel injection causes practically all of the compressed, swirling air to be presented to the incoming fuel sprays or jets. Normally, injection occurs during, for example, the last 25° of crankshaft rotation on the compression stroke, and continues to a point such as 10° past the top dead center position of the piston.

Further objects, in line with my objective of a cylinder construction which has two inlet valve ports, and which thus requires two poppet valves, are first, provision of two directed inlet ports at spaced apart points at which the included angle between the centers of the two directed ports and the longitudinal axis of the cylinder is approximately 90° and second, provision of inlet port valves which open the ports in unison so that inducted air enters as two mutually reinforcing swirls of air flow, inducing unidirectional air rotation around the longitudinal axis of the engine cylinder, from two spaced points all at once and functioning in parallel-assist relation.

Another object of the invention is to provide a squish piston in such a cylinder as the foregoing one, which piston, as it advances toward the cylinder head, defines therewith a small annular chamber having a circular axis which is substantially in the plane of the head of the piston. The highly compressed air, in conforming to the annulus, proceeds circumferentially around the chamber along the direction of the circular axis and at the same time travels in a transverse orbit so as to proceed in helical fashion along the circular axis. The result is biaxial rotation, of which the circumferential movement is about the longitudinal axis of the cylinder as a center.

Other objects of my invention are to provide intake valves of recessed valve construction, and to provide on the respective inlet ports controlled thereby, back masking to aid in directionalizing initial swirl within the cylinder.

Another object is to provide, on the inlet ports, beveled mouth portions oriented with respect to one another so that these mouths function as directed passages to air in directionalizing initial swirl within the cylinder.

My invention provides, for use in controlling and directing induction air to an engine as above, the improved method including the steps of starting swirl, by a back masking feature of the two directed ports, in the low flow condition during predetermined initial opening movement of the simultaneously operated intake valves, before air in two directed intake ducts leading to the respective ports has acquired directional momentum therein, and sustaining and augmenting the swirl by the inertia of fast moving air from the air directing intake ducts, at a time during the balance of the open phase of the valve operating cycle wherein the back masking feature declines to inconsequential effectiveness.

It is preferred that the two intake ducts be divisions of a common inlet duct or passage which, as viewed in longitudinal cross section, has considerable height compared to the two intake ducts. There is no longitudinal dividing wall as such. The lower portion of the common passage in general feeds the air to the shorter intake duct which leads to the near port in order of communication with the cylinder; the upper portion feeds the air to the succeeding or second port communicating with the cylinder. The arrangement affords, in the first stage of induction into the cylinder, an approximately 50–50 contribution to swirl by the respective two ports and, acting in concert as they do, the ports produce a sudden, high initial kick to the admitted air charge.

A second stage follows when the valves have been lifted about 20% open, and the inlet passage takes over the direction of the air due to the momentum that the flow acquires therein; during transition, the back masking effect is reduced to being barely perceptible. At this second stage, the succeeding port is admitting about 70% of the swirl-sustaining air, and the volume of air flow through the near port has a swirl component contributing less than half that amount, specifically, only about 30% of the swirl. The reason for, and the advantage of, having the second stage takeover of air direction by means of a directed passage and ports, is that the recessed valves clear the back masking of the intake valve recesses fairly soon after they start opening, and hence the back masking does not appreciably throttle or otherwise interfere with the free, passage-directed, air flow through the valves. Such benefit is fairly impossible of achievement with use of masked valve structures of prior engines, such structures having an even more conspicuous disadvantage of shortness of valve life because the intake valve structures are non-rotatable. The disadvantage is in general contributed to because of using a single passage for two inlets, but the present invention overcomes that general disadvantage.

Further features, objects, and advantages will either be specifically pointed out or become apparent when, for a better understanding of the invention, reference is made to the following description, taken in conjunction with the accompanying drawings which show a preferred embodiment thereof and in which:

FIGURE 1 is a cross-sectional view, in rear elevation, through the No. 3 cylinder (left bank) of a valve-in-head, V8 engine embodying the present invention;

FIGURE 2 is a top plan, sectional view of the cylinder taken along section lines II—II in FIGURE 1;

FIGURE 3 is a sectional, front elevation view of the cylinder, taken along the section lines III—III of FIGURE 4 for more clearly showing the intake valves;

FIGURE 4 is a bottom plan view of the cylinder head for the left bank of the engine, the section lines III—III thereon appearing across the No. 3 cylinder;

FIGURE 5 is a view showing the intake valves generally similarly to the FIGURE 3 showing, but being a developed view;

FIGURE 6 is a schematic view of a detail in FIGURE 3, schematically illustrating a machining step during manufacture; and

FIGURE 7 is a front elevational view taken along the section lines VII—VII of FIGURE 2 and showing the exhaust valves in the head of the cylinder.

More particularly, in FIGURE 1 of the drawings, a multi-cylinder, V-type engine cylinder block **10** is shown in section through one of the cylinders **12**, typical of the cylinders in the engine. A piston **14** slides in the cylinder between a retracted, bottom dead center position and an advanced, top dead center position shown in solid lines in FIGURE 1.

The piston **14** is centrally recessed so as to define with the cylinder head **32** an annular squish chamber **17**. The air is inducted into the cylinder in a manner hereinafter described so as to have swirl in the direction of the arrows **22** in the portion of a chamber **16**, being from right to left as viewed in FIGURE 1. The advancing piston **14** not only compresses the trapped swirling air, but by the time the piston reaches the top dead center position it will have displaced the air radially and tangentially inwardly into the recess so as to proportionally increase its circumferential angular velocity along the circular axis of the annular chamber. A resulting, intensified helical motion, as indicated by the arrows **26**, results whereby the air orbits about the circular axis of the annular chamber and at the same time revolves about the longitudinal axis of the chamber, which latter axis coincides with the longitudinal axis **24** of the cylinder.

For purposes of four valve, four stroke cycle operation of each cylinder, the head carries two intake valves **18** for the cylinder **12** and two exhaust valves, not shown. A lateral exhaust passage **44** in the head receives discharged exhaust gases and delivers them to a longitudinally disposed exhaust manifold, not shown, which is bolted to the outer side of the V.

Multiple jets **28** of fuel are sprayed, by an injector nozzle **30** in the head, from a path generally along but diverging from a central axis, into the chamber **16** as the piston **12** makes final approach and then begins receding at top dead center on the firing stroke. The nozzle **30** has a drain line **34** to drain return fuel from the nozzle back to a fuel tank, not shown, and the nozzle is supplied through a fuel delivery line **36**. The fluid is delivered in timed and metered quantities to all nozzles by a common fuel pump, not shown. The nozzle **30** is held in place by a bolted down clamp **38**.

A single air inlet passage **40** for the cylinder has an open back end **46** communicating with a common intake manifold **42** located on the inner side of that cylinder bank of the engine. The passage **40** is curved, extending at an angle downwardly and across the cylinder at one side thereof and the flow is controlled by the intake valves **18** therein.

In FIGURES 2 and 3, the inlet passage **40** as shown terminates at the anterior end in an open recess providing a first directed inlet port **50**. The valves **18** are recessed in the head **32**, the recessing providing additional end clearance volume whereby the piston can advance to a point closely approaching the metal of the cylinder head. The recess for the port **50** has a bevel **48** formed on the swirl side of the discharging mouth of the port **50**.

The inlet passage **40** has an open recess intermediate its ends providing a second directed port **56** for inlet air to the cylinder, and the valve recess has a bevel **54** on the swirl side of the discharging mouth of the port **56**.

As best seen in FIGURE 2, an outer side wall portion **50** of the passage **40** and a corresponding outer side point of the port **50** are substantially tangent to the cylinder **12**, and a similarly arranged side wall portion **58** of the passage **40** and a side point of the second port **56** are substantially tangent to the cylinder at the same side with the first port. As will be understood by those skilled in the art, the port **50** is not a so-called high swirl port, but is a directed port which requires the cylinder wall **12** in addition to the directed passage **40** to produce proper swirl about the axis **24** of the cylinder. On the other hand, the portion of the passage **40** intermediate its ends is preferably formed with its lower portion in a modified cork screw design so that the second directed port **56** is self-sufficient and delivers an air flow already spiralling about the axis of its valve **18** before discharging through the second port **56**.

Air follows the path of the arrow **64** upstream of the port **50** and has the swirling motion indicated by the arrows **66** upon being emitted from the port. Air has the flow indicated by the arrows **60** upstream of the second port **56** and follows the swirling direction indicated by the arrows **62** upon being emitted from the port. The first and second ports **50** and **56** are defined by hardened valve seat inserts **68** received in the valve recesses so as to be offset inwardly from the mouth.

In the underside view of the cylinder head **32** as shown in FIGURE 4, the bevels **48** and **54** of the respective first and second ports define the swirl sides and are oriented at right angles each to the tangent point of the associated port to the cylinder **12** and to one another, so as to impart unidirectional flow following the cylinder wall about the central cylinder axis **24**.

In FIGURE 5, the helical passage **40**, as schematically shown in developed view, has substantially constant downward angularity for stabilizing the directed flow. The inner surface of the top portion of the passage wall is diagonally related to the piston motion, i.e., making helical angle A with respect to a line parallel to the axis of the helix. The inner surface of the bottom wall portion leading to the second port makes a helical angle B and the inner surface of the bottom wall portion of the passage leading to the first port makes a helical angle C. These angles are about the same, and cannot be excessive or else the directed ports will fail to yield optimum results.

The valves **18** are operated in unison by intake cams on a cam shaft **77** appearing in FIGURE 1. They have valve rotators which are conventional and are not shown. During predetermined initial intake valve actuation, at a time when the air in the passage **40** is at manifold pressure but is comparatively static, suction in the cylinder **12** causes the air nearest the valves **18** to be inducted from the passage **40** in a swirling fashion according to the direction indicated by arrows in FIGURE 5. The respective bevels **48** and **54** allow the air to be introduced only from the swirl side of the inlet ports and so the air, as soon as it begins entering, has a common direction of revolution about the cylinder axis. Such preferential guiding of the air from the recessed side of the ports is necessary only until air in the passage **40** develops flow momentum, and after the valves have advanced from the solid line position into the broken line position **18***a* so as to clear the recess, the air is being flow-directed through the directed ports.

In FIGURE 6, after the final machining operation the valve seat insert **68**, adapted to occupy the position indicated in phantom lines, is pressed into that position in the cylinder head **32**. Theretofore, final machining is accomplished by bringing in a beveling tool **70** along an axis **72** eccentric to the valve axis **74** so as to be on the swirl side thereof. Thus, the generally cylindrical recessing **76** acquires a bevel shape on its anterior side only, leaving back

masking **78** on the anti-swirl side and on the intervening portions adjoining the anterior side.

In FIGURE 7, the exhaust valves **20** are shown lifted from the exhaust valve ports **80**. The valves **20** likewise operate from a recessed position, and the recesses are seen to be beveled at **82** at all points around the mouth of the port **80**. Uninterrupted beveling in this manner is accomplished by causing the tool **70**, not shown, to be applied directly concentric to the valve guide axis and is the conventional way of forming the mouth of an exhaust valve seat. In the general case, the formation facilitates the handling of gases, the exhaust gas following the path indicated by the arrows in FIGURE 7.

A range found satisfactory for the helical angles of the various inner surfaces of the intake duct **40** is from about 45° to about 75°, but each angle preferably is at least approximately 65°.

Following is an example of specifications for the foregoing engine induction system:

First port **50**—directed port	Requires cylinder wall **12** for proper function. Contributes 70% of swirl during full lift valve.
Second Port **56**—directed port of modified corkscrew design	Produces 30% swirl during full valve lift. Self sufficient to produce swirl.
Valve lift	0.4 inch.
Helix angle A	71°.
Helix angle B	67°.
Helix angle C	71½°.
Cylinder head	Grey iron casting.
Recess bevels	Angle of 40½° to plane of port.
Offset of cutting tool axis	0.150 inch.
Axial depth of bevel	0.136–0.144 inch.
Cylinder bore	5⅝.
Angle of cylinder block	90° v.

Variations within the spirit and scope of the inventions described are equally comprehended by the foregoing description.

What is claimed is:

1. In an engine having a swirl-fed cylinder:

a cylinder head therefor having a single air inlet passage for said cylinder, said passage having an open back end spaced apart laterally from said cylinder and extending at an angle downwardly and across said cyinder at one side thereof, and terminating at the anterior end in an open recess providing a first directed port for said cylinder, said passage and said port being adjacent the side wall of said cylinder, and arranged with an outer side wall of the passage and an outer side point of the port being substantially tangent to the cylinder;

said passage having an open recess intermediate its ends providing a second directed port for said cylinder and similarly arranged with a side wall of the passage and a side point of the second port being substantially tangent to the cylinder; and

simultaneously actuated, recessed valves associated with the respective recess for controlling the first and second ports in unison;

each recess having a beveled anterior portion and a back-masked portion and cooperating with the associated valve whereby during the progress of the intake valve actuation, the main stage of air induction, as a result of flow momentum through the passage and directed ports in a swirl producing direction, is preceded by a first stage of air entering through the valves and expanding into the cylinder, likewise in said direction but solely as guided by the anterior beveled and back-masked portions of the recesses.

2. In an engine having a swirl-fed cylinder:

a cylinder head therefor having a single air inlet passage for said cylinder, said passage having an open back end spaced apart laterally from said cylinder and extending at an angle downwardly and across said cylinder at one side thereof, and terminating at the anterior end in an open recess providing a first directed port for said cylinder, said passage and said port being adjacent the side wall of said cylinder, and arranged with an outer side wall of the passage and an outer side point of the port being substantially tangent to the cylinder;

said angle comprising a helix angle of at least approximately 65°; said passage having an open recess intermediate its ends providing a second directed port for said cylinder, and similarly arranged with a side wall of the passage and a side point of the second port being substantially tangent to the cylinder at the same side with the first port; and

simultaneously actuated valves associated with the respective recesses for controlling the first and second ports in unison;

each recess having a beveled anterior portion and a back-masked portion and coperating with the associated valve whereby, during the progress of the intake valve actuation, the main stage of air induction, as a result of flow momentum through the passage and directed ports in a swirl producing direction, is preceded by a first stage of air entering through the valves and expanding into the cylinder, likewise in said direction but solely as guided by the anterior beveled and back-masked portions of the respective recesses.

3. The invention of claim **2**, wherein said first stage terminates when the valves are lifted clear of the recesses.

4. The invention of claim **3**, characterized by said recesses being arranged such that the valves lift clear and the main induction stage commences when about 20% of the total valve lift is reached.

5. The invention of claim **3**, characterized by said ports contributing about equally in producing swirl in the cylinder during the first induction stage.

6. The invention of claim **5**, further characterized by said passage and ports being of a size, angularity, and arrangement, such that the respective first and second ports contribute on an approximately 70–30% basis in sustaining swirl in the cylinder during the main induction stage.

7. The invention of claim **3**, characterized by each recess initially being fully masked, and the beveled portion being formed by discreet relief of only the anterior portion of each recess.

8. The invention of claim **2**, characterized by the angle between the recesses and the center line of the cylinder being approximately a right angle, each of the beveled anterior portions being oriented with respect to its associated recess so as to lie at approximately right angles to the aforesaid side point of the associated port, and extending at approximately right angles to the orientation of the other beveled anterior portion.

9. In a swirl aspirated engine, the combination with the cylinder, of

a movable piston therein having a recess in the head, and advanceable to a point compressing the inducted air in the cylinder into a biaxially rotating mass in a squish chamber defined by the piston head recess and a confronting cylinder head;

said cylinder head being secured to, and having a single air inlet passage for, said cylinder, said passage having an open back end spaced apart laterally from said cylinder and extending at an angle downwardly and across said cylinder at one side thereof, and terminating at the anterior end in an open recess providing a first directed port for said cylinder, said passage and said port being adjacent

the side wall of said cylinder, and arranged with an outer side wall of the passage and an outer side point of the port being substantially tanget to the cylinder;

the downward angle of said passage, as viewed in developed side elevation, being substantially constant throughout the length of the passage and being on at least a 65° diagonal to the piston motion; said passage having an open recess intermediate its ends providing a second directed port for said cylinder, and similarly arranged with a side wall of the passage and a side point of the second port being substantially tangent to the cylinder at the same side with the first port; and

simultaneously actuated valves associated with the respective recesses for controlling the first and second ports in unison;

each recess having a beveled anterior portion and a back-masked portion and cooperating with the associated valve whereby, during the progress of the intake valve actuation, the main stage of air induction, as a result of flow momentum through the passage and directed ports in a swirl producing direction, is preceded by a first stage of air entering past said valves and expanding into the cylinder, likewise in said direction but solely as guided by the anterior beveled and back-masked portions of the respective recesses.

10. In the introduction of swirl fed fluid from two separate points defined by two intake-valve-controlled ports of a single head passage, into a chamber contained by a mechanism, said mechanism including an element in the chamber which, when the mechanism is turned, recedes with respect to the head passage to enlarge the chamber,

improved two-stage operation of conducting fluid through the single passage and intake valves, so as to feed the enlarging chamber simultaneously from both of the ports, all while turning the mechanism so as to cause said element to recede, which operation accomplishes the successive stage of:

first simultaneous induction of the fluid through the valved ports and into the chamber, by emitting the fluids so as to direct approximately 50% of the swirl sustaining component of the flow of the passage fluid, from a first one of the two ports and by emitting so as to direct the balance of the swirl sustaining component from the immediately next successive, terminal one of the ports, solely during predetermined initial intake valve actuation; and

final simultaneous induction of the fluid by emitting so as to direct aproximately 30% of the swirl sustaining component of the flow of the passage fluid from said first port, and by emitting so as to direct the balance of the swirl sustaining component from said immediately next successive terminal port, as caused solely due to fluid momentum resulting from flow in the single passage, and solely during the final intake valve actuation providing main induction.

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