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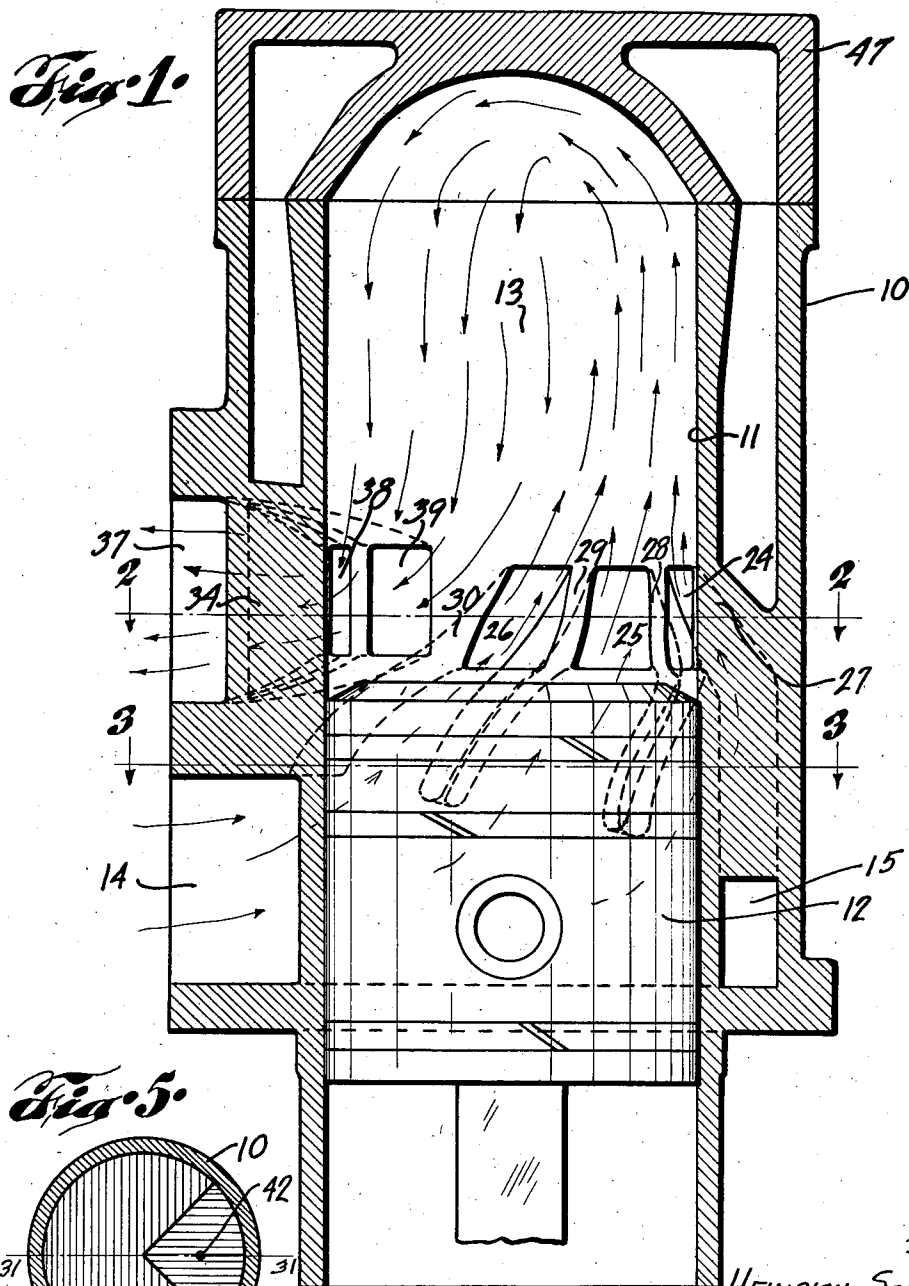
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METHOD AND MEANS FOR SCAVENGING

Filed Oct. 24, 1932

3 Sheets-Sheet 1



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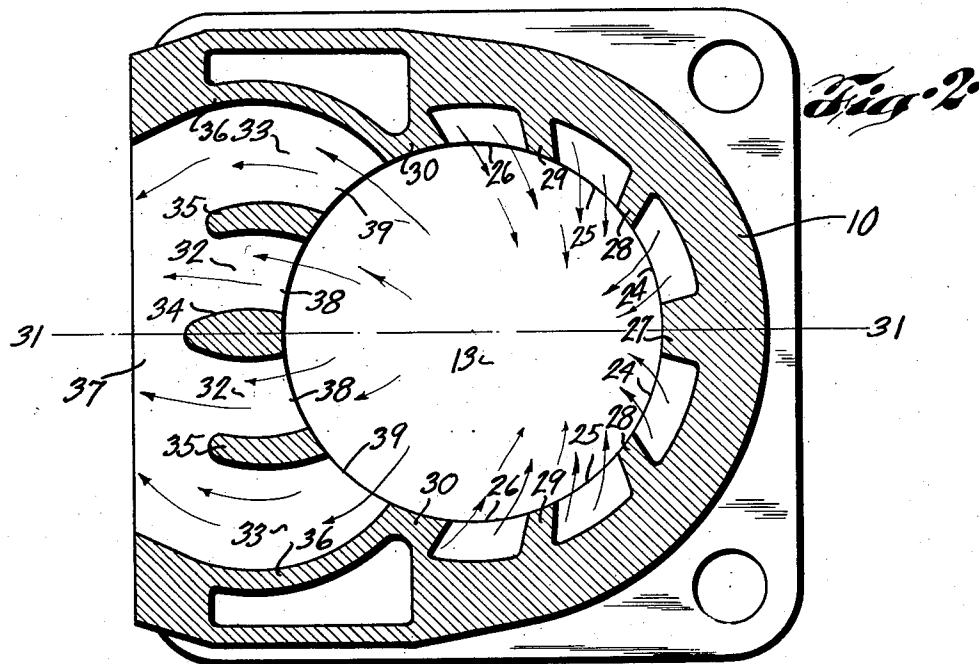
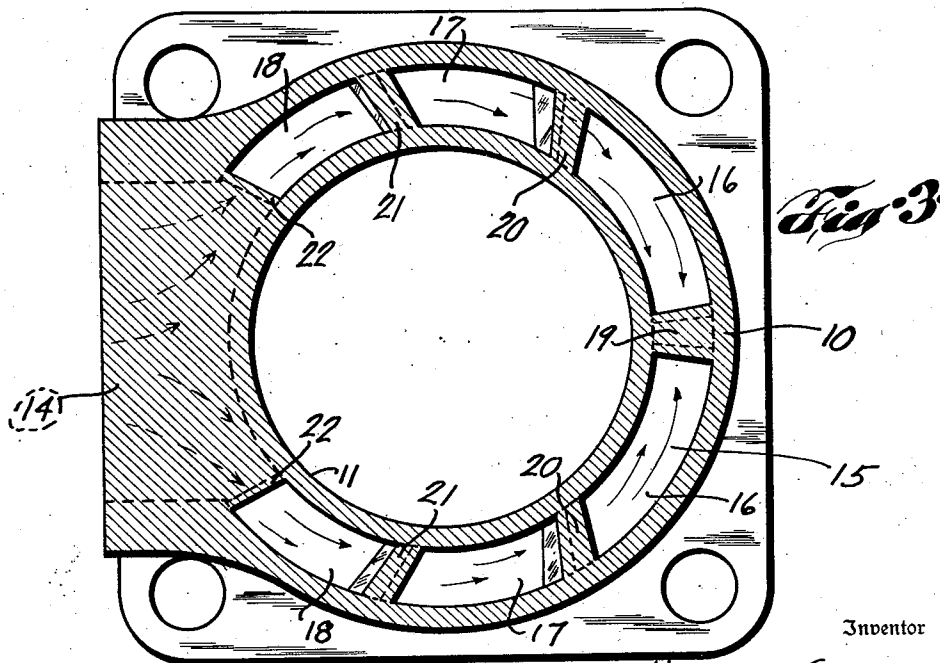
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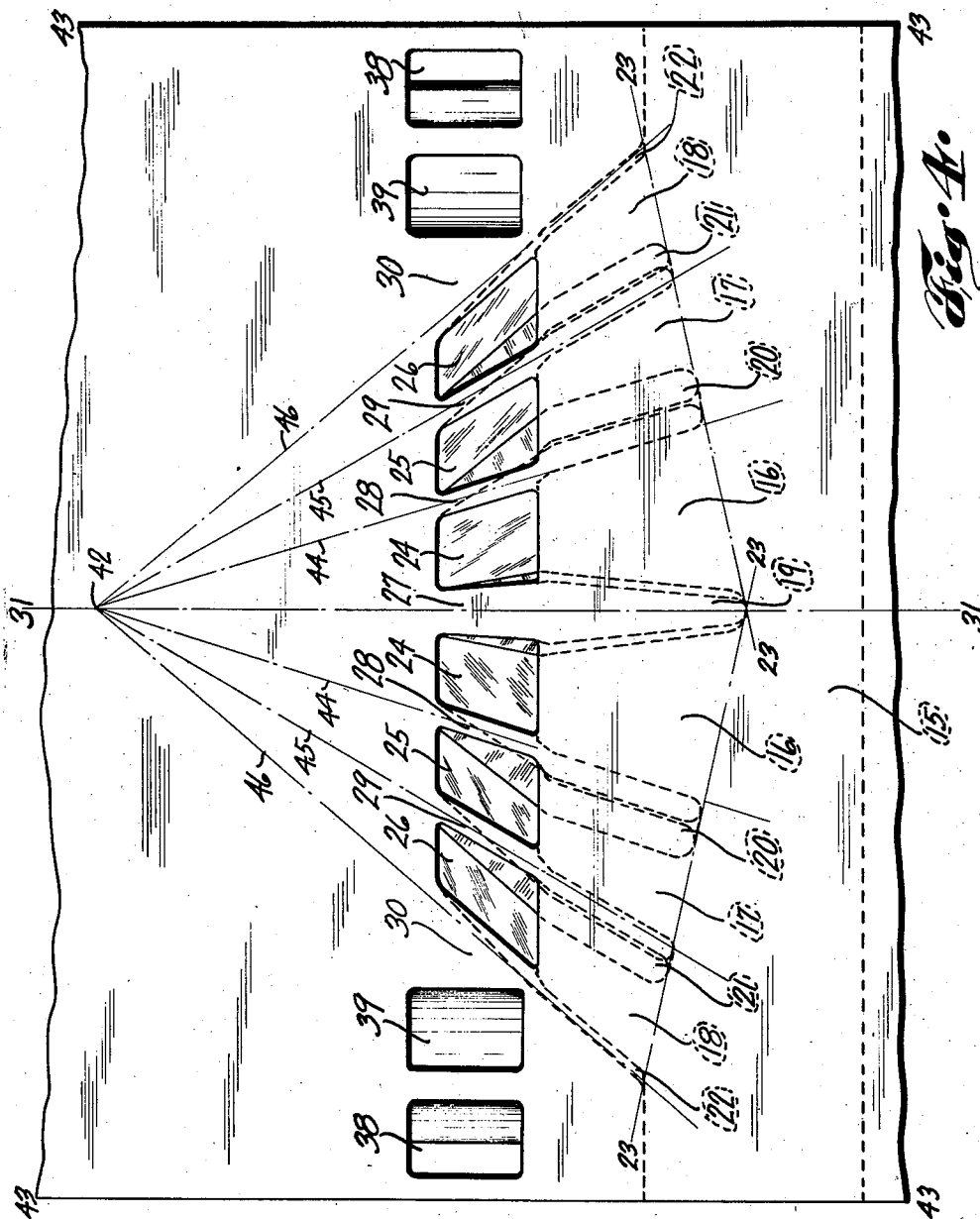
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UNITED STATES PATENT OFFICE

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METHOD AND MEANS FOR SCAVENGING

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In older prevailing forms of scavenging systems for two-cycle internal combustion engines, it is usual to arrange the scavenging ports in such a manner that an air stream issuing from any one port, clears the products of combustion, or exhaust gases, from only a single portion of the cylinder chamber, and similarly, the scavenging air streams issuing from the remaining ports, each clears only an indefinite, fragmentary portion of the chamber. With such older arrangements, it is difficult to obtain a thorough coalescence of the individual scavenging air streams, with a resulting poor coaction of such streams, since, as generally occurs, the individual streams tend to interfere with each other, and to produce a turbulent condition within the cylinder chamber, resulting in an undesirable admixture of the exhaust gases with the incoming scavenging streams, thus rendering the scavenging process imperfect and only partially effective. In the older, prevailing scavenging systems, a venturi or throat of the scavenging stream, has usually been located at some point outside of the port, and outside of the cylinder chamber. Therefore, the air stream expanded immediately upon being directed into the cylinder chamber, resulting in an immediate decrease in velocity and, consequently, an increase in pressure. Thus, a high pressure region is usually formed in the inner or lower portion of the cylinder chamber in a zone immediately adjacent the scavenging air intake ports, preventing an orderly upward movement, either of the individual air streams, or of any resultant stream, thus causing a partial loss of the incoming scavenging air through the exhaust ports, an objectionable mixing of the incoming air with the exhaust gases in the cylinder, and hence an incomplete scavenging process.

In the older forms of scavenging systems, the ports themselves usually constitute the only stream-forming or -shaping means outside of the cylinder, being in communication with a common scavenging air supply chamber or manifold, and in the usual constructions, the length of any supply conduit is merely the thickness of the cylinder wall. Such types of scavenging port supply passages or nozzles are entirely ineffective as stream-forming and -directing means, since an air stream cannot be properly shaped and directed within such relatively short length of passage or nozzle. Furthermore, the port passages or nozzles of many of the older types of engines, besides being objectionably short, are of uniform cross-sectional area throughout their

length, and it is evident that with such a construction it is practically impossible to alter the velocity of the air stream passing therethrough, as a result of which, the velocity of the air stream is substantially reduced immediately upon its entrance into the cylinder. Thus, with the older forms of port nozzles it will be apparent that the individual streams entered the cylinder chamber in a more or less haphazard manner, resulting in turbulence within the chamber, incomplete clearing of exhaust gases therefrom, and mixture of a portion of the exhaust gases with the incoming scavenging air. Such mixing continues throughout the scavenging stroke of the engine, serving to contaminate the scavenging air remaining in the cylinder at the end of the scavenging stroke for subsequent compression. Such a condition causes inefficient combustion and consequently a substantial reduction in power developed per stroke of the engine.

It has been found from experience that in order to obtain a positive and effective cylinder scavenging action, it is essential to unite the individual air streams proceeding from each of the ports, so as to form a coalescent body of positive and evenly rising layers of air, along and adjacent a wall portion of the cylinder on the side opposite the exhaust ports. Furthermore, such an upstream within the cylinder must remain substantially stable and uniform, irrespective of fluctuation in air supply pressures, such as may normally occur due to varying speed of the engine. Since it is intended to have the upstream thus formed, control all other air currents within the cylinder, it is essential that this stream be more positive in its action and movement than any other stream in the chamber. It is, therefore, an object of the present invention to provide an improved scavenging system which will attain the above noted advantages.

A further object is to provide an improved method of scavenging engine cylinders, which consists in uniting the individual scavenging air streams from the various ports, into an upstream constituting a stable, columnar body of air having a comparatively high velocity, and which is of a relatively small cross-sectional area on the scavenging port side of the cylinder, the cross-sectional area of the body of air being substantially maintained until it attains a zone near the outer or head end of the cylinder, where it is permitted to dissipate a substantial part of its velocity into pressure, to form a relatively high pressure, low velocity downstream along the ex-

haust port side of the cylinder chamber. The latter stream is of comparatively larger cross-sectional area, and occupies substantially all of the remaining cross-sectional area of the cylinder chamber not filled by the upstream. The two opposite streams, together filling the cylinder, thus insure thorough sweeping and complete displacement of the exhaust gases from the cylinder chamber.

A still further object is attained by an improved arrangement of port passages or nozzles, in which each port nozzle is formed of gradually, uniformly decreasing cross-sectional area, the maximum sectional area of the nozzle being located at the intake end of the nozzle, and the minimum cross-sectional area being substantially the area of the port. By this provision, the air stream passing through the port nozzle, gradually increases its velocity as it approaches the port, and as a result a relatively high velocity air stream is projected a considerable distance into the cylinder chamber before its velocity is dissipated.

Another object is attained by an improved arrangement of port nozzles in which the margins of each nozzle, or the dividing walls between adjacent nozzles, consist of plane portions, the planes and axes of which are directed toward, and intersect at or near a point lying in an axial plane of symmetry of the cylinder, such point of intersection being disposed adjacent the wall of the cylinder opposite the exhaust ports, and about midway of the dead center positions of the piston. The arrangement is further such that the streamlines of the several port nozzles or passages, being lines each connecting the centers of the various cross sections of a port nozzle, are so directed as to approach, closely, the point of intersection of the port wall planes. By this provision, the air streams passing through the several nozzles, are directed positively toward a common point, and it is thus evident that there will result at this point, a coalescence of the various individual scavenging streams.

An additional object is attained by an improved arrangement of port nozzles in which the side or dividing walls of each port nozzle are each inclined with respect to a longitudinal plane of symmetry of the cylinder, the angle of inclination being different for each dividing wall on one side of the plane of symmetry. Since the lateral port margins are formed by the intersection of the dividing walls with the cylinder bore, each port is shaped substantially in the form of an irregular four-sided polygon, or rectangle.

A still further object is attained in an improved arrangement of intake and exhaust ports for an internal combustion engine, in which the neighboring margins of the adjacent exhaust and scavenging ports are increasingly spaced from each other, from the inner end toward the head end of each port. By this provision, the tendency of air leakage from each end scavenging port, over to the adjacent exhaust ports, is minimized.

Further objects and advantages will appear from the following detailed description of parts and the accompanying drawings, in which:

Fig. 1 is a longitudinal sectional elevation of a preferred form of engine cylinder of the two-cycle type, to which the present improvements are applied; Fig. 2 is a section taken along line 2-2 of Fig. 1; Fig. 3 is a section taken along line 3-3 in Fig. 1; Fig. 4 is a development of the improved form of cylinder illustrated in Fig. 1, and Fig. 5 is a diagrammatic transverse section through the

cylinder, showing, on a greatly reduced scale, the relative sectional areas, or fronts, of the high velocity and low velocity scavenging streams characterizing the present scavenging method.

Referring to the drawings by characters of reference, the numeral 10 designates, generally, a preferred form of engine cylinder, of port scavenging type, which is, by preference, provided with a bore 11 forming the internal cylindrical surface of the cylinder, and in which is operable a piston 12. Air for scavenging the cylinder chamber 13 of exhaust gases is, by preference, supplied under pressure through a conduit 14, from any suitable source (not shown), to an air reservoir or supply manifold 15, which is, by preference, extended circumferentially about the inner end of the cylinder structure. Scavenging port nozzles or conduits 16, 17 and 18 are, by preference, formed by side or dividing walls 19, 20, 21 and 22, respectively, in the cylinder body, each port nozzle including the entire conduit or passage which extends from the cylinder bore 11 to a line which is indicated at 23-23 (Figs. 1 and 4), or to a point where the nozzle joins the common air supply chamber or manifold 15. The intersection of each of the port nozzles 16, 17 and 18 with the cylinder bore forms scavenging ports 24, 25 and 26 respectively, and in like manner the intersection of the port nozzle dividing walls with the cylinder bore, forms port sides or bridging portions 27, 28, 29 and 30. It will be readily seen that the port nozzles, ports, dividing walls and port sides are arranged symmetrically on each side of a plane indicated at 31-31 in broken lines (Figs. 2 and 4), such plane extending longitudinally of the cylinder, and preferably including the cylinder axis. While the symmetrical arrangement of ports is preferable, the number thereof may be greater or less than the number shown.

Exhaust port nozzles 32 and 33 are, by preference, formed, in part, by side walls 34, 35 and 36, respectively, the exhaust port nozzles serving to connect the cylinder with a common exhaust chamber or conduit 37. The intersection of the exhaust port nozzles 32 and 33 with the cylinder bore, forms exhaust ports 38 and 39, respectively. It will be noted that the exhaust port nozzles, ports and side walls are shown as arranged symmetrically on opposite sides of the plane 31-31 of cylinder symmetry.

For best results, it is necessary that the individual scavenging streams issuing from the air port nozzles, unite within an area indicated at 41 (Fig. 5), in a transverse plane which is preferably located substantially midway of the dead center positions of the piston. It is evident, therefore, that the streamlines of the several port nozzles, each of which may be regarded as an imaginary line connecting the centers of all the various cross sections of the nozzle, and produced into the cylinder chamber, most desirably intersect in a point indicated at 42, which lies within the zone or area 41, and in or near the plane of symmetry 31-31. Furthermore, the streamlines must each be angularly positioned with respect to the plane of symmetry, the streamline of the port nozzle 16 being inclined to a greater extent than either the streamline of the port nozzle 17, or that of the port nozzle 18, (see Fig. 4).

In Fig. 4, the cylinder bore 11 is shown developed in a plane indicated at 43-43, in which the scavenging ports, exhaust ports, and associated port nozzles are symmetrically arranged on each side of the plane 31-31. The position of

the port nozzle walls 19, 20 and 21 are determined by planes 31, 44, 45 and 46, respectively, the plane 31—31 bisecting the dividing wall 19, with the streamline plane of the port nozzle 16 lying midway between planes 31 and 44, and similarly with the streamline planes of the port nozzles 17 and 18. It will be evident that the planes 44, 45 and 46 intersect substantially at the point 42 within the zone 41. From Fig. 4 it will be apparent that the side walls of each port nozzle are increasingly spaced from each other as the nozzle approaches the common supply chamber or manifold 14, and consequently a gradually decreasing cross sectional area of nozzle is presented to the stream moving therethrough, for a purpose hereinafter appearing.

In constructing the cylinder, the port nozzles are, by preference, so formed that each is of a spiral trend about the cylinder bore, and as a result the streamline determined by the shape of each port nozzle is constantly but gradually varying in a direction tangential of the cylinder, and substantially maintains the same curved course, toward the area 41 within the cylinder chamber. The end port nozzles 18 are, by preference, formed with a greater spiral trend, than the inner port nozzles, and as shown in the figures, the outer port nozzles are extended under the exhaust ports. Therefore, since the scavenging air supply is introduced through the conduit 14, which is immediately adjacent the exhaust ports, it will be seen that the scavenging air streams are continually being directed to the area or zone of coalescence 41 in the chamber. As above noted, the intersection of the dividing walls with the cylinder bore forms the bridging portions of the ports, and since the port nozzle walls vary in inclination with respect to an axial cylinder plane, the intake ports 24, 25 and 26 are each of an irregular four sided polygonal or trapezoidal form, and further, no two intake ports on one side of the plane of symmetry 31—31 are alike. Such an arrangement is of particular advantage in minimizing loss of scavenging air issuing from the scavenging ports 26 by "short-circuiting" through the adjacent exhaust ports 38, since it is apparent that the adjacent sides of these ports, are increasingly spaced from each other in a direction extending from the bottom of the port to the top thereof. The arrangement of the inlet ports 26 with respect to the adjacent exhaust ports 38 is of particular importance near the beginning of the scavenging stroke at which time, the piston 12 is about to uncover these ports. Further movement of the piston, in its downward stroke uncovers a portion of the scavenging ports, and at such time, the issuing air streams have not assumed a definite path of movement within the cylinder chamber. Also at the same time, the adjacent sides of these ports are in their maximum spaced relation, such that a minimum loss of the scavenging air occurs. Further piston movement gradually decreases the distance between the adjacent side walls of these ports, but as the inlet ports are thus uncovered, the air streams issuing therefrom assume a definite form and path of movement within the cylinder, and since the streamlines of the port nozzles 18 are directed toward the area 41 which is within the cylinder on the side opposite the exhaust ports, it is evident that loss of scavenging air is minimized.

It has been found from experience and through the use of stream-visualizing devices, that by the

described arrangement of ports and port nozzles, the individual streams issuing from the various ports coalesce within the area 41 in the cylinder chamber. A smooth and non-turbulent uniting of the air streams is effected by directing all the port nozzle streamlines so as to intersect along the plane of symmetry and within the zone 41. It has been found that the area 41 is approximately equal to the combined areas of the scavenging ports 24, 25 and 26, and since this area is formed substantially within the outermost half or two thirds of the cylinder chamber length, it is evident that the individual scavenging air streams entering the cylinder chamber, do not expand before reaching this area. Such a condition is produced, in part, by the particular formation of the port nozzles, in that each port nozzle is constructed with a gradually decreasing cross-sectional area, in the direction of the port and so the air stream passing therethrough, gradually increases in velocity until a comparatively high velocity is obtained at the port. This velocity of introduction is such that the stream continues to be compacted, and so does not attain its minimum cross section until attaining the zone 41. It is evident that this high velocity stream thus continues beyond the ports, in unbroken form, into the cylinder chamber, since practically no expansion of the individual streams is apparent at the time of coalescence. The union of the individual streams within the area 41, results in the formation of an unbroken upstream or column of scavenging air, all parts of which are moving at the same, comparatively high velocity, which is evidenced by the fact that the cross sectional area of this upstream, at a point adjacent the cylinder head 47, is substantially equal to the area indicated at 41, thus negating any substantial expansion until the columnar stream reaches a zone close to the cylinder head.

It is apparent that in order to unite air streams of high velocity without causing appreciable turbulence or loss in velocity, the direction of movement, and the velocity of the individual streams must be practically the same. In the present disclosure, the velocities of the uniting streams are practically uniform, since the ports are all of substantially the same area. Also, due to the slight convergence of the streamlines, the direction of movement of any one stream is practically the same as the direction of movement of its neighboring stream, at the point where such streams unite or blend. Therefore, an orderly blending of the various individual air streams will result in a stable and comparatively high velocity upstream, the sectional area of the upstream being practically equal to the combined area of the scavenging ports, it being noted that the venturi throat of each individual stream is located at some point along the path of this upstream within the cylinder, and not at the ports. This upstream, once formed, practically maintains its velocity until the stream reaches the cylinder head 47. The head is formed, by preference, of substantially dome shape, avoiding preferably all sharp bends, edges, and abruptly angulate surfaces. This construction results in a minimum upsetting effect on the upstream as the head is deflectingly engaged thereby.

The upstream, upon reaching a zone adjacent the cylinder head, expands and forms a high pressure region under the head, which causes a

downward movement of the air toward the exhaust ports.

As this expansion takes place, the downstream, as a consequence, occupies the remaining cross sectional area of the cylinder, and since the area of the downstream is substantially larger than the area 41 of the upstream, it is evident that the velocity of the downstream is considerably less than that of the upstream. By this arrangement, a high pressure region is formed substantially under the cylinder head, and not, as in older prevailing scavenging systems, in the vicinity of the intake ports. Such a condition aids in forming a downstream of relatively high pressure, which pressure is, however, not sufficient to interfere with the movement of the upstream, which because of its high velocity and columnar characteristics, exhibits little tendency toward leakage into the downstream. The downstream thus being of integral aspect, presents a solid front, and causes an orderly movement of the exhaust gases through the exhaust ports. The combined cross sectional area of the upstream and downstream substantially equals the cross-sectional area of the cylinder chamber, and therefore thorough scavenging results, leaving no gas filled pockets or voids, unswept by the fresh air streams.

With the described improved arrangement of ports and port nozzles, it will be apparent that the various streamlines may be arranged to intersect along any point or restricted area along the plane of symmetry other than the point 42, the desirable condition being that they intersect in some defined, restricted area. It will further be apparent that in order to insure the intended path of movement of the individual air stream within the cylinder it is essential that the streamlines contain as few bends or curves as possible. It may be noted that the port nozzles or passages are each importantly characterized by an absence of internal corners or abruptly angularly related surfaces. The curvature of streamlines defined by the nozzles is, desirably, on as great a radius or radii as space conditions will permit. In constructing the cylinder in the form of a casting, the cores resulting in the nozzles or passages are carefully prepared and carefully removed so as to avoid any internal projections or protuberances of any nature. This structural caution precludes any turbulence which might otherwise result in an upsetting effect on the air stream, either within the nozzle or beyond the port. It results, therefore, that the energy of each air stream is entirely reflected in a distinctly linear velocity characterized by an almost complete absence of eddies within the stream. The course of each stream is thus definite, even though the air pressure of the source, within the manifold, may vary within wide limits.

It will also be noted, as a structural feature of importance, that each of the port passages or nozzles is of substantial length. Particularly is this of advantage, as in the preferred practice, where high air pressures and velocities are employed, since in such case only a minimum period of time is available for shaping the air stream in its course through the passage or nozzle. It appears as a minimum requirement that the length of the passage be considerably in excess of the greatest dimension of the port. A much more dependable shaping of the individual air streams has been found to result from the improved form of ports herein described, as well as the increased

length and novel trend of the several port passages or nozzles.

While the foregoing description of a specific embodiment of the invention is based on a structure in which the parts are cast as an integral unit, the assembly may be formed as a part of a cylinder liner, which includes, integrally with the cylinder wall structure, the air nozzles or passages cast exteriorly thereon.

The foregoing description has been predicated primarily on a description of an engine cylinder of vertical type. Obviously, it is immaterial to the structure and practice of the invention what angle the cylinder axis may form with the vertical or horizontal. It is therefore to be understood that terminology of superposition is to be taken only in a relative sense, the designation, for example, of the inner end of the cylinder having reference to the lower end of a vertical cylinder on the crank end thereof, while references to the outer or upper end refer to the head end of the cylinder. The terms of description are therefore not to be understood as restrictive in a directional sense.

It will, of course, be understood that the present detailed description of parts and the accompanying drawings relate to only a single preferred executional embodiment and practice of the invention, and that substantial alterations and modifications may be made without departing from the spirit and full intended scope of the invention, as defined by the claims.

I claim:

1. The herein described method of scavenging a two cycle internal combustion engine, which consists in introducing a plurality of non-intersecting jets of air near one end of the cylinder, in causing said jets gradually to converge to result in a unified stream of scavenging air at a point somewhat beyond one end of the cylinder, increasing the velocity of the jets, at least to the zone of their convergence and causing a movement of said stream toward the opposite end of the cylinder and in a direction substantially parallel to the cylinder axis; in so defining and shaping the stream externally of the cylinder so as to restrict the expansion of such stream during its movement to the opposite end, so that it presents a front of substantially less than one-half the sectional area of the cylinder until the stream attains a zone adjacent the opposite end of the cylinder; in reducing the velocity of the stream within the said zone, and in moving said stream at a reduced velocity from said zone toward and adjacent to the first said end of the cylinder.

2. The herein described method of scavenging a two cycle internal combustion engine, which consists in introducing a plurality of streams of scavenging air, causing convergence of said streams in a zone located substantially away from and between the inner and outer ends of the cylinder; directing said streams externally of the cylinder, so that each stream meets the others directly encountered by it, at only a slight angle, in shaping such streams entirely prior to and at the time of their introduction to the cylinder, to prevent substantial expansion of the resultant stream in proceeding from said zone; in confining the resultant stream to a region of substantially segmental form, and of a transverse area less than half that of the cylinder, in causing said resultant stream to expand in a zone adjacent the outer end of the cylinder, and in deflecting the expanding resultant stream to

a point adjacent the inner end of the cylinder, at a pressure substantially greater than that of the said resultant stream.

3. The herein described method of scavenging a two cycle internal combustion engine which consists in forming a columnar stream of air at a substantial pressure, in a zone somewhat inwardly of the outer end of the cylinder; in preventing any substantial reduction of the linear velocity of all parts of said stream between the zone of its introduction, and the outer end of the cylinder, confining said stream to a front of substantially less than one-half the sectional area of the cylinder, and to a segmental region at one side of the cylinder axis, in thereafter reducing the velocity of said stream by deflection and expansion thereof near the outer end of the cylinder, and in directing the said stream in an opposite direction, after expansion, parallel to the cylinder axis, and so that said expanded stream presents a front of an area substantially greater than one-half the sectional area of the cylinder.

4. A step in the described method of scavenging a two cycle internal combustion engine, which consists in introducing a plurality of streams of scavenging air, each at a point close to one end of the cylinder, in increasing the linear velocity of said streams as they are impelled internally of the cylinder and beyond the points of introduction, and in causing coalescence of said streams within the cylinder at a point substantially remote from the points of introduction, and without diminution of velocity.

5. In combination with the cylinder and piston of a two cycle internal combustion engine, a plurality of scavenging air inlet ports and port nozzles connected thereto, and extending therefrom beyond the cylinder wall and beyond the zone of the ports, in a direction toward the crank end of the cylinder, the ports being disposed near the inner end of the cylinder, said nozzles being formed to direct streams of air within and toward the outer end of the cylinder, the ports and nozzles each being constructed to constrict the stream of air after issue from said port; and the ports and nozzles being of such shape and trend as to effect their smooth and gradual convergence and produce within the cylinder, a single resultant outwardly moving column of air resulting from coalescence of the streams from said ports, and to restrict said air column to a sectional area not substantially greater than the combined areas of said ports, and substantially less than one-half the transverse sectional area of the cylinder.

6. In a two cycle internal combustion engine including a cylinder and piston, a band of scavenging air ports located near the inner end of the cylinder, each port being defined by lateral rectilinear margins, the planes of said margins of the intake ports outermost of the band, being inclined with respect to the axis of the cylinder, such angle of inclination being less as to the ports lying inwardly of the ends of said band, a port nozzle or passage for each of said ports, the passages extending from a point outside the cylinder wall to the connected port, and sloped or inclined proportionately to the margins of the associated port, each nozzle or passage being of gradually reduced sectional area from its intake to the associated port, the slope of nozzles and ports being such that the streams therefrom substantially agree in direction throughout the length of the cylinder between the port band and the cylinder head.

7. In an internal combustion engine of two

cycle type including a cylinder and piston, a band of scavenging air ports disposed about the inner end of the cylinder, symmetrically with respect to an axial plane, a plurality of said ports being defined by rectilinear lateral margins of differing inclination with respect to such plane, the margins of the ports, of greater inclination, being progressively more remote from said plane of symmetry, and port nozzles communicating with the ports, said nozzles extending through and beyond the cylinder wall, and the axes of the nozzles differing in slope conformably to the inclinations of the said port margins.

8. The herein described method of scavenging a two cycle internal combustion engine, which consists in introducing a plurality of streams of scavenging air to a cylinder, and so directing the streams that they meet within the cylinder, each stream at substantially less than a right angle to each of the others encountered thereby, so that the streams coalesce in non-bucking relation, in so shaping and directing said streams as to confine them to a region substantially at one side of the cylinder axis, and to cause their coalescence into a substantially unified homogeneous resultant stream, in a zone substantially inwardly of the ends of the cylinder, and in increasing the velocity of said streams, within said region, and at least until attaining the said zone of coalescence.

9. The described method of scavenging a two cycle internal combustion engine, which consists in introducing a plurality of individual air streams, and forming therefrom in a zone nearer the inner end of the cylinder, a columnar air stream of substantially solid front, and of a sectional area substantially less than one-half that of a cylinder section, in increasing the velocity of the individual air streams between the points of their introduction and said zone of formation of the columnar air stream, and so restricting their diffusion and expansion, in confining said columnar stream to a segmental space at one side of the cylinder axis, in moving both said individual streams and the resulting columnar stream in directions substantially parallel to the cylinder axis and out of contact with stream-deflecting or baffling agencies over the greater part of the length of the cylinder, and in maintaining a substantially uniform velocity and generally corresponding direction of all parts of said stream, until contact thereof with the cylinder head structure.

10. In an internal combustion engine of two cycle type including a cylinder and piston, a band of scavenging air ports arranged about the inner end of the cylinder and symmetrically with respect to an axial plane through the cylinder, each of said ports being of irregular polygonal shape, and sloped, in the plane of the cylinder wall, toward said axial plane, and each of said ports on a given side of said plane of symmetry, being of a shape and slope different from each other port on the same side of said plane, the ports being of progressively greater slope at greater distances from said plane.

11. In an internal combustion engine of two cycle type including a piston and cylinder, a plurality of port nozzles and communicating ports for scavenging air, each directed into the cylinder near the inner end thereof, a source of air under pressure communicating with the inlet ends of the nozzles, each nozzle being of differing sectional area between its inlet end and the port, and the associated port being of smaller sectional

area than other parts of the nozzle, the nozzles being located and shaped to define streams which agree substantially in direction and substantially avoid deflected relation to the cylinder wall while traversing the length of the cylinder.

12. In a two cycle internal combustion engine including a cylinder and piston, a source of air under pressure adjacent the cylinder, a plurality of air conduits directed from said source and terminating in said ports, said conduits each being of gradually reduced sectional area between the receiving end and said port, the port end of each conduit being formed to constrict the air stream after emergence and at points substantially within the cylinder and each conduit being formed to define a stream whose center line is curved about and along the cylinder.

13. In an internal combustion engine of two cycle type including a cylinder and piston adapted to operate therein, a plurality of inlet ports arranged in a band along a transverse plane near the inner end of the cylinder, a conduit for each of said ports directed thereto from a source of scavenging air, each of said conduits characterized by gradual changes in trends and being so formed that the major portion of the streamline therethrough lies in a plane curved on a substantial radius and intersecting the cylinder chamber at only a slight angle at the corresponding port, the slope of the streamlines varying only slightly, each from the others, whereby to avoid crossing until the streams are substantially beyond the port band.

14. In an internal combustion engine of two cycle type including a cylinder and piston, a plurality of scavenging air passages directed from a source of air under pressure and terminating in a band of ports near the inner end of the cylinder, said ports being symmetrically arranged about the cylinder with respect to an axial plane therethrough, said passages being arranged with their axes sloped along the cylinder wall, and the slope of the axes of said passages, being progressively less, in proceeding from the endmost ports toward said plane of symmetry.

15. In an internal combustion engine of two cycle type including a cylinder and piston, a plurality of scavenging air ports arranged about the cylinder in a zone near its inner end, an air supply passage communicating with each of said ports, a plurality of said passages each being formed to define a stream therein, and gradually to alter the course of said stream between the inlet of the passage, and its discharge through the associated port, said passages being relatively convergent to only a degree so slight that their produced axes cannot intersect near the port zone, and each passage being so shaped that the trend of streamline therethrough, varies, substantially uniformly, in radial, axial and tangential directions, between the inlet of the passage and its associated port.

16. In an internal combustion engine of two cycle type including a cylinder and piston, a group of scavenging air inlet and exhaust ports disposed near the inner end of the cylinder, a port passage for each inlet port, extending exteriorly of the port in a direction further toward the inner end of the cylinder, each of said passages being of spiral trend and directed about the cylinder toward the exhaust side thereof, the said passages being of such slope that no two of their produced axes can intersect in the region of said port group.

17. In an internal combustion engine of two

cycle type including a cylinder and piston, a band of scavenging air ports disposed about a portion of the inner end of the cylinder, exhaust ports spaced from the intake ports and located on one side of the cylinder, a nozzle terminating in each of said intake ports and each being of a substantially spiral trend, directed around the cylinder and toward the side thereof occupied by said exhaust ports, the adjacent nozzles being slightly out of parallelism, and all thereof being located with their produced axes out of intersecting relation in the vicinity of the air port band.

18. In an internal combustion engine of two cycle type including a cylinder and piston, a band of intake ports disposed near the inner end of the cylinder, port nozzles extending downwardly and divergently away from said ports and a plurality of plane elements formed integrally with the cylinder structure and constituting partitions between adjacent port nozzles, said partitions being divergently disposed in a direction longitudinally of the cylinder, and their produced axes being out of intersecting relation in the vicinity of the port band.

19. In an internal combustion engine of two cycle type including a cylinder and piston, a group of scavenging air ports arranged adjacent a transverse cylinder plane, a group of exhaust ports intersected by said plane, passages communicating with said ports, all of those leading to the air ports being characterized by streamlines which are out of intersecting relation in the vicinity of said cylinder plane, the adjacent air inlet and exhaust passages being of such trend that the streamlines thereof, diverge both longitudinally and transversely of the cylinder.

20. In an internal combustion engine of two cycle type including a cylinder and piston, a row of scavenging air intake ports, a port nozzle for each of said air ports, a plurality of exhaust ports, the intake and exhaust ports being disposed near a common plane transverse of the cylinder, the nozzles of those intake ports adjacent the exhaust ports being sloped to underlie the adjacent exhaust ports, and all of the port nozzles having inlet openings distributed at substantially equal intervals about the cylinder, in a zone remote from the said plane of the ports.

21. In an internal combustion engine of two cycle type, a scavenging air manifold of substantially annular form, extending about an inner portion of the cylinder, exhaust passages from the cylinder, disposed outwardly of the said manifold, an intake or supply connection to said manifold on the exhaust side of the cylinder, an exhaust connection adjacent the intake connection, air ports in the cylinder beyond said manifold, and a passage from the manifold to each of said ports.

22. In an internal combustion engine including a cylinder and piston, a source of scavenging air, a plurality of conduits leading from said source to the cylinder, and each terminating in a port in the cylinder wall near the inner end of the cylinder, said conduits and ports each being so shaped that the center lines of the streams therethrough lie, in greater part, in a curved plane extending along the cylinder wall and such that each said center line intersects the wall at the port at an angle sufficiently slight with respect to the plane of the cylinder wall that the streams substantially agree in direction, and none thereof is appreciably altered in course by the cylinder wall.

23. In an internal combustion engine of two

cycle type, a cylinder, a piston operable therein, a plurality of scavenging air intake ports arranged in a group near the inner end of the cylinder, and adapted to be controlled by the piston, air passages each communicating with one of said ports, and extending divergently beyond the port zone toward the crank end of the cylinder, the passages and ports being arranged to consolidate a plurality of streams of scavenging air in a zone intermediate the length of the cylinder, but to maintain all of such streams out of intersecting relation prior to reaching the said zone of consolidation, and to direct the resultant stream toward the outer end of the cylinder, and a head structure presenting a domed air deflecting surface toward the interior of the cylinder, and adapted to contact with said air stream, said surface being characterized by a regular and substantial curvature.

24. In an internal combustion engine of two cycle type including a cylinder and piston, a group of scavenging air inlet ports disposed near the inner end of the cylinder, tubular passages opening into the said ports, the adjacent passages being of divergent trend away from said ports, said passages having their inlet openings distributed substantially about the circumference

of the cylinder, and located substantially beyond the zone of said ports, the tubular passages being angularly so related that their stream lines are in non-intersecting relation in the zone of the ports, and a manifold adapted to contain a supply of air under pressure, and communicating with the inlets of the several air passages.

25. In an internal combustion engine of two cycle type including a cylinder and piston adapted to operate therein, a plurality of inlet ports arranged in a group near the inner end of the cylinder, a conduit for each of said ports directed thereto from a source of scavenging air, each of said conduits, both of itself and as produced interiorly of the cylinder, being characterized by a curvature of uniform direction with all parts of the conduit curved on substantial radii, and each conduit further being so formed that the streamline therethrough lies in a curved plane substantially in wrapped relation to the cylinder, but intersecting the cylinder chamber at only a slight angle to the plane of the cylinder wall at the corresponding port, the curved planes of said stream lines being non-coincident.

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