# PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION.

## Improvements in or relating to Admission Apparatus for Internal Combustion Engines of the Liquid Fuel Injection Type.

We, D. NAPIER & SON LIMITED, a Company registered under the Laws of Great Britain, and RONALD WHITEHAIR VIGERS, British Subject, both of 211, Acton Vale, Acton, London, W.3, do hereby declare the nature of this invention to be as follows:—

This invention relates to admission apparatus for internal combustion engines of the liquid fuel injection type wherein inlet and exhaust ports in each cylinder are controlled by a sleeve valve to which is imparted a combined oscillating and reciprocating motion.

When such sleeve valves are employed the movement of the sleeve is mainly rotary during the initial opening period of the inlet ports with the result that the charge tends to flow into the cylinder during the initial part of the induction stroke in a tangential direction which causes the whole charge to be in a state of rotation about the cylinder axis at the end of the induction period. This rotation persists during the compression stroke and is utilised to bring the different parts of the air charge progressively into the path of one or more fuel jets during the injection period so as to assist in the distribution of the fuel throughout the air charge.

Whereas a considerable degree of rotation is desirable during normal running of the engine however the transference of heat from the rotating air charge to the relatively cool cylinder walls is promoted by and increases with the rate of rotation. In order to prevent excessive cooling of the charge during starting or during idling or at both such times therefore, it is desirable that the rotational movement of the air charge should be reduced or eliminated at such times while enabling the desired degree of rotation still to be obtained, however, during normal running of the engine and it is the object of the present invention to provide a convenient arrangement whereby this variation in the rate of rotation can be effected.

To this end according to the present invention, the cylinder or each cylinder of an internal combustion engine of the kind referred to has associated therewith an induction chamber into which one or more of the inlet ports in the cylinder open and means are provided whereby the point of entry of the air into the induction chamber can be varied in relation to the inlet port or ports so as to vary the mean direction of flow of the air towards each port. Since on the direction of flow of air towards the inlet ports, particularly during the middle and later parts of the induction period, depends to some extent the direction of entry of the air into the cylinder and hence the degree of rotation of the charge within the cylinder at the end of the induction period, it will be seen that the above arrangement enables the degree of rotation to be varied.

Preferably the induction chamber has two inlet openings therein so spaced apart that the mean direction of air flow from one opening towards each inlet port in the cylinder wall will be substantially different from that in which air will flow from the other opening to each inlet port. The two inlet openings are valve-controlled, the arrangement preferably being such that when one air inlet opening is fully open the other is fully closed and vice versa. It will be seen that in this way when one inlet opening is fully open one definite degree of rotation will be produced in the cylinder, this rotation being, for example, that required for normal running, whereas, when the other inlet opening is fully open, the rotation is reduced to the extent desired for starting or idling purposes. Alternatively three inlet openings might be provided in the induction chamber any one of which can be fully open while the other two are closed, the inlet openings being so positioned as to provide the desired degree of rotation respectively for normal running, for idling and for starting where, for example, it is desirable that the rotation shall be reduced to a greater extent for starting purposes than for idling.

The invention is particularly applicable to multi-cylinder internal combustion engines and, when applied to such

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engines, a series of separate induction chambers are conveniently provided, each having two or more spaced inlet openings capable of being controlled by a valve or valves in the manner described above. In this way not only can the degree of rotation in the several cylinders be controlled but it is possible to ensure that for any given setting of the valve or valves the degree of rotation in all the cylinders is substantially the same. Thus the difficulty of obtaining equal rotation in all the cylinders experienced with prior constructions in which the inlet ports of all the cylinders communicated directly with a common induction chamber can be overcome.

Moreover, although when the invention is applied to a multi-cylinder engine each induction chamber may be associated with the inlet ports of one cylinder, preferably each induction chamber has opening into it one or more ports of one cylinder and one or more ports of the adjacent cylinder. In this way the provision of a partition wall between adjacent cylinders which unless the cylinders were widely spaced would restrict the flow of air to the ports in the cylinders which lie adjacent to this wall is obviated.

Thus in a multi-cylinder engine having, as is usual in engines of the kind in question, three circumferentially spaced inlet ports in each cylinder, these ports may open into a gallery which extends along the cylinder block at right angles to the lengths of the cylinders. A partition extends from each cylinder across the gallery at a point on the cylinder on that side of the central inlet port which first opens during the induction period so as to divide the gallery into a series of induction chambers which in the case of each adjacent pair of cylinders each contains two inlet ports of one cylinder and the adjacent port of the next cylinder.

Whether the induction chambers are arranged as above described or otherwise, the inlet openings through which air flows into them conveniently all lead to a common induction passage and are controlled by a single valve member so that the inlet openings in the various induction chambers are simultaneously correspondingly controlled.

The invention may be carried into practice in various ways but the following is a description by way of example of one construction according to this invention.

The engine comprises one or more blocks of cylinders each containing, for example, four or more cylinders. Each cylinder is provided with three circumferentially spaced inlet ports and two circumferentially spaced exhaust ports, the centre inlet port in each cylinder being formed in the part of the cylinder wall approximately farthest from the plane which is common to all the cylinder axes, while the remaining two inlet ports in each cylinder are equally circumferentially spaced from the centre inlet port. Thus it will be seen that each of such remaining inlet ports in each cylinder is formed in a part of the cylinder wall where it approaches the adjacent cylinder wall so that such inlet port lies opposite to one of the side inlet ports in the adjacent cylinder.

Disposed in each cylinder is a sleeve valve controlling the inlet and exhaust ports therein, this sleeve valve having imparted to it in known manner a combined oscillating and reciprocating motion such that this motion is mainly oscillating during the initial opening period of the inlet ports, whereby rotation of the air charge tends to be produced about the axis of each cylinder.

Closing the outer end of each cylinder is a plug-like cylinder head between the outer circumferential wall of which and the inner circumferential wall of the cylinder the outer end of the sleeve valve lies and moves. Formed in this plug-like cylinder head is a substantially cylindrical combustion chamber of smaller diameter than the cylinder bore having mounted in its end wall adjacent to the circumference thereof a fuel injection device adapted to deliver a spray the mean direction of which is approximately parallel to or has a large component in a direction parallel to the axis of the cylinder.

Formed integral with the cylinder block and extending along the side thereof through which the inlet ports open is a gallery with which such inlet ports communicate and this gallery is divided into a series of induction chambers by partitions. Each partition extends across the gallery from the outer wall of the gallery to that part of the wall of a cylinder which lies adjacent to the side of the centre inlet port which opens first during the induction period. Thus, except in the case of the end cylinders, each induction chamber contains two inlet ports of one cylinder and the adjacent inlet port of the next cylinder, this inlet port being that to which air is caused to flow in a manner tending to assist rotation of the charge in the cylinder by reason of the port opening into the space between the two cylinders to which air can only flow in a direction generally tangential to the cylinder walls. In the case of one cylinder at the end of the cylinder block,

however, the end induction chamber will contain only two ports of such end cylinder while, in the case of the other cylinder at the end of the cylinder block, the end induction chamber will contain only one port of such cylinder. The arrangement is preferably such, however, that the end induction chamber containing the two ports is of substantially the same shape as each of the intermediate induction chambers. The formation of the other end induction chamber containing a single inlet port is not, however, of such importance since such port opens into the space between two cylinder walls which thus guide the air to the port in a manner which is not affected to any great extent by the point from which the air initially flows into the induction chamber.

Formed in the outer wall or the upper or lower wall of the part of the gallery constituting each induction chamber are two inlet openings one of which lies adjacent to the partition wall constituting one end wall of the induction chamber while the other lies adjacent to the other end wall of the induction chamber. The inlet openings throughout the gallery open into a common induction manifold and a valve, for example, a slide valve, is arranged to control the flow of air from the manifold through the inlet opening into the induction chambers, this valve being so constructed and arranged as to control similarly the two inlet openings in each induction chamber in such a manner that when one of the inlet openings is fully open the other is fully closed and vice versa. It will thus be seen that by suitable adjustment of the valve air can be caused to enter each induction chamber through the inlet opening at one end thereof or through the inlet opening at the other end thereof. Further, when one inlet opening is open, the direction of flow from this inlet opening to and through the inlet ports in such induction chamber and more particularly to and through the centre inlet port in each cylinder will be different from that in which the air flows to and through such inlet ports when the other inlet opening is open.

As stated above, the direction in which the air approaches the inlet ports in engines of the kind in question has an appreciable effect on the degree of rotation of the charge within the cylinders at the end of the induction period and, with the construction above described, it will therefore be seen that by suitably positioning and controlling the two inlet openings in each induction chamber the degree of rotation imparted to the air charge drawn into each cylinder can be varied. Thus one inlet opening in each induction chamber can be positioned so that when open air flows therethrough to the inlet ports in a direction tending as far as possible to assist the rotation of the charge within each cylinder caused by the manner of opening of the inlet ports, whereas the other inlet opening is positioned so that when open air flows therethrough to the inlet ports in a direction tending to check or reduce the rotation of the charge within each cylinder caused by the manner of opening of the inlet ports.

Moreover, when air is flowing through either one or the other of the inlet openings the direction of flow to each inlet port of each of the cylinders will be substantially the same as that to the corresponding inlet port in each of the remaining cylinders so that the conditions of air rotation within each individual cylinder will tend to be exactly the same as within each of the remaining cylinders. It will be appreciated in this connection that the formation of the induction chamber containing two inlet ports of one cylinder at one end of the gallery of similar shape to the intermediate induction chambers as described above will tend to ensure that the conditions of rotation in this end cylinder is the same as for the intermediate cylinders.

It will also be seen that with the arrangement above described with the valve in a position in which one inlet opening in each induction chamber is fully open and the other fully closed one definite degree of rotation can be obtained in all the cylinders such, for example, in relation to the other characteristics of the engine as to be suitable for normal running while with the valve in a position to close the first inlet opening and fully open the second, a definite check can be imposed on the rotation so as substantially to eliminate it or so as to obtain a definite smaller degree of rotation suitable for example for idling or starting purposes. Again, intermediate degrees of rotation can be obtained by placing the valve in intermediate positions in which each inlet opening is partly open.

In a modified arrangement similar in other respects to the above each induction chamber may have formed in one wall thereof a long slot-like aperture extending substantially throughout its length and leading into the induction manifold and each of these apertures may have extending over it a plate mounted to slide longitudinally of the gallery constituting the induction chambers and having a single inlet opening formed in the part thereof

lying over each aperture. Thus, by moving the plate longitudinally, the position of the inlet opening into each induction chamber and hence the direction of air flow from such opening to and through the inlet ports can be varied.

It is to be understood that the constructions more particularly described above are given by way of example only and that the form of the induction chamber or chambers, the manner in which the point of entry of the air into such chamber or chambers is varied or controlled and other details of construction may be modified without departing from this invention.

Dated this 24th day of January, 1933.
KILBURN & STRODE,
Agents for the Applicants.

COMPLETE SPECIFICATION.

## Improvements in or relating to Admission Apparatus for Internal Combustion Engines.

We, D. NAPIER & SON LIMITED, a Company registered under the Laws of Great Britain, and RONALD WHITEHAIR VIGERS, British Subject, both of 211, Acton Vale, Acton, London, W.3, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to admission apparatus for internal combustion engines of the sleeve valve type and is particularly but not exclusively applicable to engines in which each cylinder contains a single sleeve valve to which is imparted a combined oscillating and reciprocating motion.

In sleeve valve engines in order to obtain adequate inlet port area, it is usual to provide in each cylinder two or more circumferentially spaced inlet ports. Further the direction in which the charge flows to these ports affects the movement of the charge in the cylinder. It is one object of the present invention to provide an arrangement which will enable adjacent cylinders to lie close to one another while offering little obstruction to the flow of the charge to the inlet ports and at the same time will be such that the direction of flow to the inlet ports in each cylinder can be determined with a view to obtaining substantially the same conditions in each cylinder and making these conditions satisfactory for efficient combustion.

To this end in a multi-cylinder internal combustion engine of the sleeve valve type according to the present invention there is combined with two or more adjacent cylinders each provided with two or more inlet ports, an inlet gallery into which the ports open extending at right angles to the length of the cylinders and divided into two or more separate induction chambers by one or more partitions each extending from a part of a cylinder lying between two inlet ports therein.

The invention is particularly applicable to sleeve valve engines in which each cylinder is provided with three circumferentially spaced inlet ports as is usual in engines wherein the ports in each cylinder are controlled by a single sleeve valve having a combined oscillating and reciprocating motion. In this case in order to provide adequate inlet port area, one inlet port in each of two adjacent cylinders conveniently opens into the space between such cylinders and it will be seen that, by dividing the inlet gallery into separate induction chambers by partitions disposed according to this invention so as each to extend from the outer wall of the gallery to a part of a cylinder lying between the central inlet port and one of the other inlet ports in a cylinder, the space between two cylinders into which inlet ports open is left unobstructed by a partition.

It will also be seen that with an arrangement according to the present invention, by providing each induction chamber with an inlet opening disposed in a position therein which corresponds to that of the inlet opening in each of the other induction chambers, the direction of flow from each inlet opening to the cylinder ports supplied thereby can be caused to be substantially the same for all the induction chambers whereby the movement of the charge in all the cylinders will also be substantially the same.

Moreover the arrangement provides for control of the movement of the charge within each cylinder since this is determined to some extent by the direction in which the charge flows towards the inlet ports which in turn is determined by the position of the inlet opening in the induction chamber.

For example, with sleeve valve engines

of the kind in which a single sleeve valve having a combined oscillating and reciprocating motion controls the ports in each cylinder, the movement of the sleeve is usually mainly rotary during the initial part of the inlet period and this results in the charge rotating in the cylinder about the axis thereof. This rotation of the charge is usually undesirable in vaporised charge spark ignition engines and in an arrangement according to the present invention the inlet opening in each induction chamber may be so placed as to cause air to flow therefrom towards the inlet ports in such a manner as to check this rotation.

Again in liquid fuel injection compression ignition engines with sleeve valves of the type referred to having a combined oscillating and reciprocating motion, the rotation of the charge is required and is utilised to cause distribution of the fuel throughout the air charge. When the present invention is applied to such engines therefore the inlet opening in each induction chamber may be so disposed as to cause flow of air towards the inlet ports in a direction which will tend to assist the rotation of the air charge within the cylinder. Further, in such liquid fuel injection compression ignition engines, whereas a considerable degree of rotation is desirable during normal running of the engine, the transference of heat from the rotating air charge to the relatively cool cylinder walls is promoted by and increases with the rate of rotation and, in order to prevent excessive cooling of the charge during starting or during idling or both such times, it is therefore sometimes desirable that the rotational movement of the air charge at such times should be reduced or eliminated while enabling the desired degree of rotation still to be obtained during normal running of the engine. If desired, therefore, according to a further feature of the present invention, means may be provided for varying the point of entry of the air charge into each induction chamber so as to vary the direction of flow of the air charge towards the inlet ports and hence the degree of rotation imparted to the air charge within the cylinder. For example, each induction chamber may have two inlet openings displaced from one another longitudinally of the induction gallery and a valve or valves may be provided whereby these inlet openings can be controlled, preferably so that when one inlet opening is fully open the other is fully closed, and vice versa. Preferably a single valve member or a common actuating member for the valves controlling the inlet openings in all the induction chambers is provided so that these valves are operated similarly and simultaneously. With such an arrangement, it will be seen that two definite degrees of rotation can be obtained according to whether air is permitted to enter through one inlet opening or the other in each induction chamber and these degrees of rotation can be determined, one to suit normal running conditions and the other to suit idling or starting conditions.

In a still further proposal three inlet openings might be provided in each induction chamber, any one of which could be fully open while the other two were closed, the inlet openings being so positioned as to provide the desired degree of rotation respectively for normal running, for idling and for starting, where, for example, it is desirable that the rotation shall be reduced to a greater extent for starting purposes than for idling.

The invention may be carried into practice in various ways but one construction according to this invention as applied to a liquid fuel injection compression ignition engine is illustrated somewhat diagrammatically by way of example in the accompanying drawings, in which

Figure 1 is a transverse section through the cylinder block in a plane traversing the inlet and exhaust ports, and

Figure 2 is a section on the line 2—2 of Figure 1.

In the construction illustrated the engine comprises a cylinder block A having four or more cylinders B each of which is provided with three circumferentially spaced inlet ports C and two circumferentially spaced exhaust ports D arranged as shown.

Disposed in each cylinder is a sleeve valve E controlling the inlet and exhaust ports therein, this sleeve valve having imparted to it in known manner a combined oscillating and reciprocating motion such that this motion is mainly oscillating during the initial opening period of the inlet ports C whereby rotation of the air charge tends to be produced about the axis of each cylinder, as indicated by the arrows in the left-hand cylinder shown in Figure 1, wherein inlet ports $E^1$ in the sleeve valve E are shown as just beginning to uncover the inlet ports C in the cylinder.

Closing the outer end of each cylinder is a plug-like cylinder head $A^1$, as shown in Figure 2, between the outer circumferential wall of which and the inner circumferential wall of the cylinder the outer end of the sleeve valve E lies and moves. Formed in this plug-like cylinder head $A^1$ is a substantially cylindrical combustion chamber $A^2$ of smaller

diameter than the cylinder bore having mounted in its end wall adjacent to the circumference thereof a fuel injection device $A^3$ adapted to deliver a spray the mean direction of which is approximately parallel to or has a large component in a direction approximately parallel to the axis of the cylinder.

Formed integral with the cylinder block A and extending along the side thereof through which the inlet ports C open is a gallery F with which such inlet ports communicate and this gallery is divided into a series of induction chambers as shown by partitions $F^1$. Each partition $F^1$ extends across the gallery from the outer wall of the gallery to that part of the wall of a cylinder which lies adjacent to the side of the centre inlet port C in that cylinder which opens first during the induction period. Thus, except in the case of the end cylinders, each induction chamber contains two inlet ports of one cylinder and the adjacent inlet port of the next cylinder, this latter inlet port being that to which air is caused to flow in a manner tending to assist rotation of the charge in the cylinder by reason of the port opening into the space between two cylinders to which space air tends to flow in a direction generally tangential to the cylinder walls.

In the case of the induction chamber at the left hand end of the cylinder block, this contains only two ports of the end cylinder while in the case of the induction chamber at the other end of the cylinder block this contains three ports of the adjacent end cylinder in addition to one port of the next cylinder.

Formed in the lower wall of the part of the gallery F constituting each induction chamber are two inlet openings G, $G^1$ one of which lies adjacent to one end of the induction chamber wall while the other lies adjacent to the other end thereof. The inlet openings G, $G^1$ throughout the gallery F open into a common induction manifold H and a valve, for example as shown a slide valve $H^1$, having ports $H^2$, is arranged to control the flow of air from the manifold H through the inlet openings G, $G^1$ into the induction chambers. This valve is so constructed and arranged as to control similarly the two inlet openings G, $G^1$ in each induction chamber in such a manner that when one of the inlet openings is fully open the other is fully closed, and vice versa.

It will thus be seen that by suitable adjustment of the valve $H^1$ air can be caused to enter each induction chamber through the inlet opening G at one end thereof or through the inlet opening $G^1$ at the other end thereof. Further, when in the construction shown the inlet opening $G^1$ at the left hand end of each induction chamber is open the air flowing to the inlet ports C in the cylinders will approach two of the ports in each cylinder in such a direction that it will tend to flow through such ports in a direction to assist the rotation of the charge within the cylinder which tends to be set up by reason of the manner in which the ports are controlled by the sleeve valve E. When the inlet port G at the right hand end of each induction chamber is open, however, the air will tend to approach two of the inlet ports C in each cylinder in a direction such that this air will tend to flow through these ports in a direction tending to reduce or eliminate the rotation of the charge within the cylinder which tends to be set up by reason of the manner in which these ports are controlled by the sleeve valve E.

Instead of the induction manifold H and the ports G, $G^1$ and valve $H^1$ being arranged in conjunction with the lower wall of the gallery F they may be arranged in association with the side or upper wall thereof as shown in chain line in Figure 2.

As stated above, the direction in which the air approaches the inlet ports in engines of the kind in question has an appreciable effect on the degree of rotation of the charge within the cylinder at the end of the induction period and with the construction above described it will therefore be seen that the degree of rotation imparted to the air charge drawn into each cylinder can be varied. Thus the arrangement can be such that when air is permitted to flow through the inlet openings $G^1$ the degree of rotation obtained in all the cylinders tends to be the same and can be such in relation to the other characteristics of the engine as to be suitable for normal running while, when air is permitted to flow instead through the inlet openings G, a definite check can be imposed on the rotation of the charge set up in each cylinder so as substantially to eliminate it and so as to obtain a definite smaller degree of rotation suitable, for example, for idling or starting purposes. Again intermediate degrees of rotation can be obtained by placing the valve $H^1$ in intermediate positions in which each inlet opening G, $G^1$ is partly open.

In a modified arrangement similar in other respects to the above, each induction chamber might have formed in one wall thereof a long slot-like inlet opening extending substantially throughout its length and leading into the induction

manifold H and each of these apertures might have extending over it a plate similar to the plate $H^1$ mounted to slide longitudinally of the gallery constituting the induction chambers and having one inlet opening formed in the part thereof lying over each aperture. Thus by moving the plate longitudinally the position of the inlet opening into each induction chamber and hence the direction of air flow from such opening to and through the inlet ports C could be varied.

It is to be understood that the construction more particularly described above is given by way of example only and that the form of the induction chambers, the manner in which the point of entry of the air into such chamber or chambers is varied or controlled where means are provided for this purpose, and other details of construction may be modified without departing from this invention.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is :—

1. In a multi-cylinder internal combustion engine of the kind referred to, the combination with two or more adjacent cylinders each provided with two or more inlet ports, of an inlet gallery into which the ports open, extending at right angles to the length of the cylinders and divided into two or more separate induction chambers by one or more partitions each of which extends across it from a part of a cylinder lying between two inlet ports therein.

2. A multi-cylinder internal combustion engine of the kind referred to in which each cylinder is provided with two or more inlet ports, and an induction gallery extends along the cylinders and is divided into a plurality of separate induction chambers by one or more partitions each extending between the outer wall of the gallery and a part of a cylinder lying between two inlet ports in that cylinder.

3. In a multi-cylinder internal combustion engine of the kind referred to, the combination with two or more cylinders each having three circumferentially spaced inlet ports therein, one inlet port in each of two adjacent cylinders opening into the space between such cylinders, of an induction gallery which extends along the cylinders and is divided into separate induction chambers by partitions each of which extends from the outer wall of the gallery to a part of a cylinder lying between the central inlet port and one of the other inlet ports in such cylinder.

4. A multi-cylinder internal combustion engine of the kind referred to as claimed in any one of the preceding claims wherein each induction chamber is provided with an inlet opening disposed in a position therein which corresponds to that of the inlet opening in each of the other induction chambers so that the direction of flow from each inlet opening to the cylinder ports supplied thereby is substantially the same, whereby the movement imparted to the charge in each cylinder tends to be the same.

5. A multi-cylinder internal combustion engine of the liquid fuel injection type as claimed in Claim 3 or Claim 4 wherein the ports in each cylinder are controlled by a single sleeve valve having a combined oscillating and reciprocating motion and each partition extends from the outer wall of the gallery to a part of the cylinder lying on the side of the central inlet port which opens first during the induction period.

6. In a multi-cylinder internal combustion engine of the liquid fuel injection type as claimed in Claim 1, Claim 2, Claim 3 or Claim 5 wherein the ports in each cylinder are controlled by a single sleeve valve having a combined oscillating and reciprocating motion, the combination with each induction chamber, of means whereby the effective point of entry of air into the induction chamber can be varied so as to vary the direction of flow of this air towards the cylinder ports and hence the degree of rotation of the charge within each cylinder.

7. In a multi-cylinder internal combustion engine of the liquid fuel injection type as claimed in Claim 6, the combination with induction chambers each of which is provided with two inlet openings displaced from one another longitudinally of the induction gallery, of a valve or valves for controlling these inlet openings, preferably in such a manner that when one inlet opening is fully open the other is fully closed, and vice versa.

8. A multi-cylinder internal combustion engine of the kind referred to having its cylinders and associated parts constructed and arranged substantially as described with reference to the accompanying drawings.

Dated this 15th day of January, 1934.

KILBURN & STRODE,
Agents for the Applicants.

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Fig. 1.

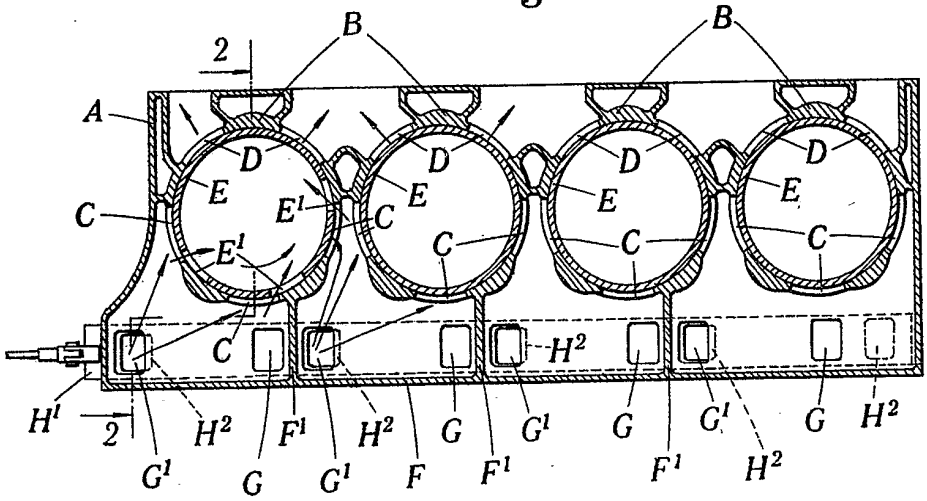
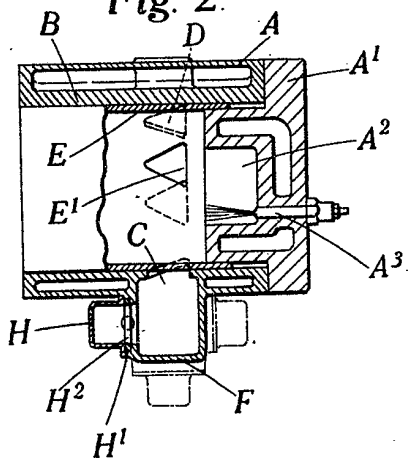



Fig. 2.

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