H. F. FULLAGAR.

INTERNAL COMBUSTION ENGINE.

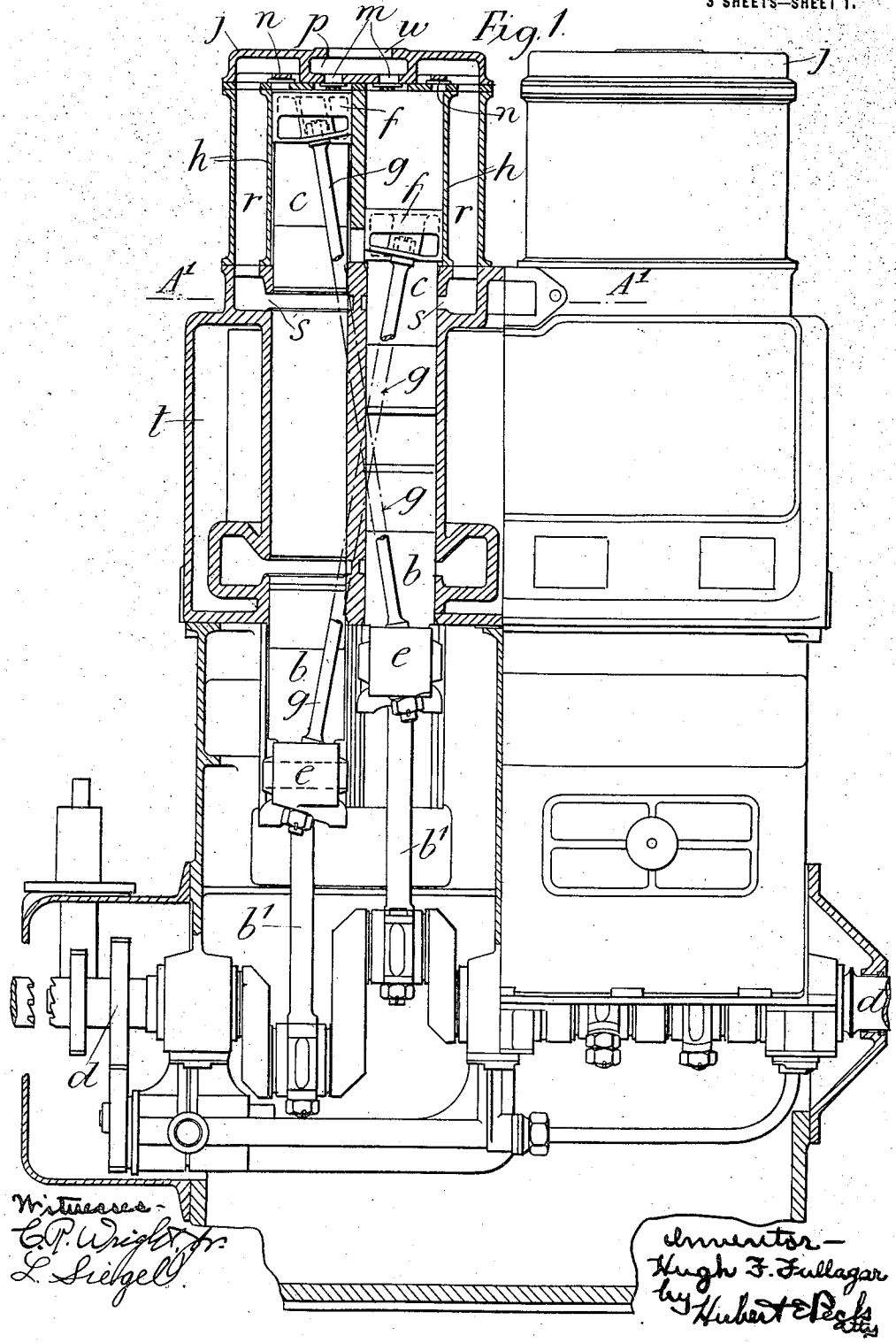
APPLICATION FILED AUG. 19, 1913.

1,174,560.

Patented Mar. 7, 1916.

3 SHEETS—SHEET 1.

Fig. 1.



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3 SHEETS—SHEET 2.

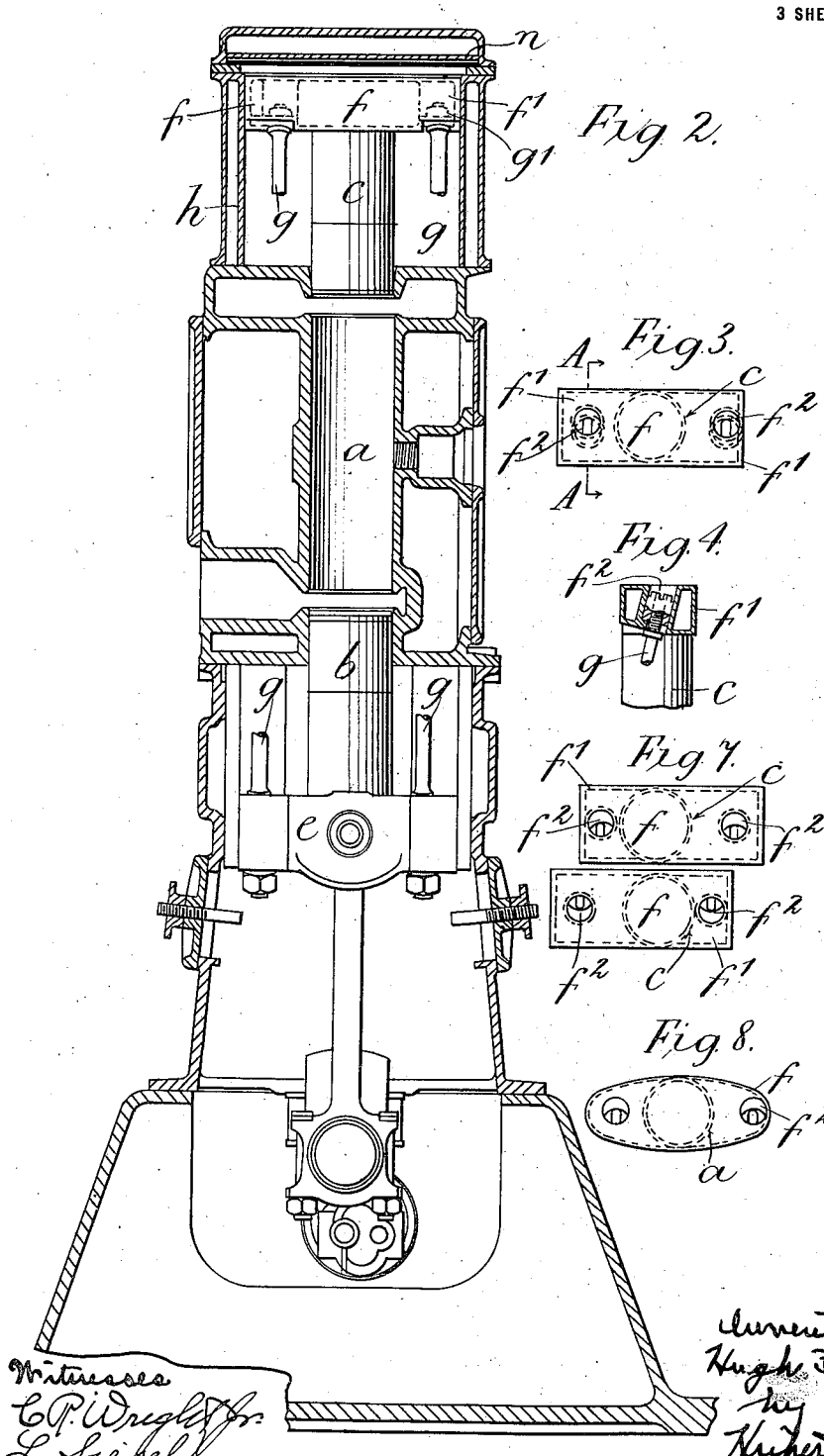


Fig 2.

Fig 3.

Fig 4.

Fig 7.

Fig 8.

Witnesses
C. P. Wright Jr.
L. Siegel

Inventor —
Hugh F. Fullagar
by
Hubert E. Peck
atty

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3 SHEETS—SHEET 3.

Fig. 5.

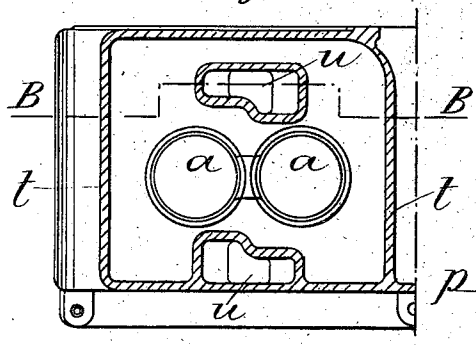


Fig. 9.

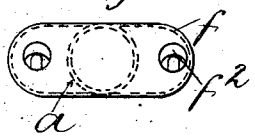


Fig. 11.

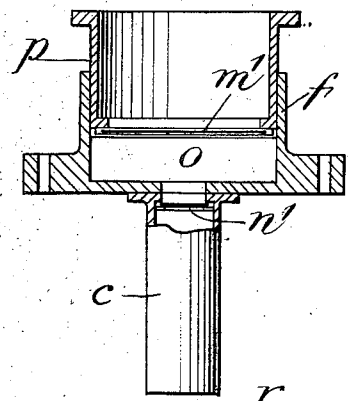


Fig. 6.

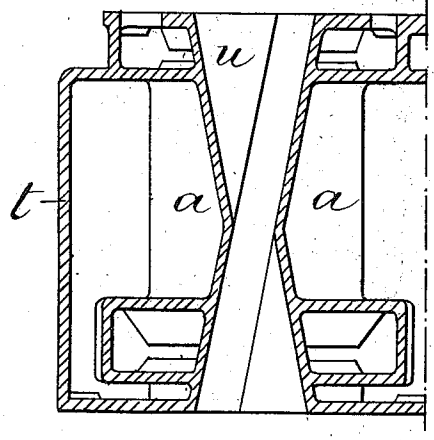
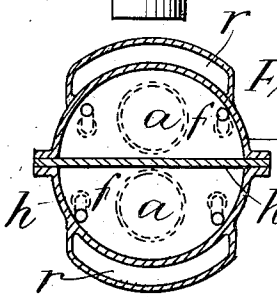


Fig. 10.



Witnesses
C. P. Wright Jr.
L. Siegel

Inventor
Hugh F. Fullagar
by Hubert & Peck
Atty

UNITED STATES PATENT OFFICE.

HUGH FRANCIS FULLAGAR, OF GATESHEAD-UPON-TYNE, ENGLAND.

INTERNAL-COMBUSTION ENGINE.

1,174,560. Specification of Letters Patent. Patented Mar. 7, 1916.

Application filed August 19, 1913. Serial No. 785,539.

To all whom it may concern:

Be it known that I, HUGH FRANCIS FULLAGAR, a subject of the King of Great Britain and Ireland, residing at Gateshead-upon-Tyne, in the county of Durham, England, have invented Improvements in Internal-Combustion Engines, of which the following is a specification.

This invention refers principally to internal combustion engines of the types described in the specification of former Letters Patent Nos. 995,857 and 995,858 granted to me, in which the engine comprises, as a unit, two cylinders open at either end, placed closely side by side and each containing two oppositely moving pistons, the pistons at one end of the cylinders being connected to a crank shaft in the unusual manner, while each of the pistons at the other end is directly connected, by means of a crosshead and external rods, to the piston at the opposite end of the adjacent cylinder. When such engines are operated upon the two-stroke cycle, it is desirable that air pumps to supply the cylinders with air for the combustible charge should be driven by the engine itself, but it is difficult to attach such pumps, without considerable complication, if they are driven by means of levers or cranks, while if they are attached directly, tandem-wise, to the pistons remote from the crank-shaft, the length or height of the engine will be considerably increased, and the very accurate balance, of which the engines of the types described are capable, will be partially destroyed. Furthermore, if the pumps are equal in number to the cylinders, the area of the pump pistons must, if each have the same stroke, be considerably greater than that of the main pistons, in order to supply sufficient air for the double cylinders, and it is, therefore, not possible in practice to mount such cylinders, if of the ordinary cylindrical type, concentric with the main pistons.

Now, according to this invention, the crossheads attached to those pistons remote from the crankshaft, and by which the said pistons are cross-connected to the oppositely moving pistons, are themselves formed into single acting air pistons the width or dimensions of each of which in the direction of the crank shaft approximates to that of the diameter of the main piston to which it is connected and the requisite area of air piston is obtained by extending the surface of the pistons transversely to the plane of the crankshaft.

In the accompanying illustrative drawings, Figure 1 shows partly in front elevation and partly in vertical section, a two-stroke cycle internal combustion engine of the kind referred to comprising two units and embodying an air pump construction according to this invention. Fig. 2 shows the engine partly in vertical section in a plane at right angles to that of Fig. 1 and partly in side elevation. Fig. 3 shows in plan one of the crossheads forming an air pump piston, and Fig. 4 is a section corresponding to the line A A of Fig. 3. Fig. 5 is a horizontal section on the line A^1 A^1 of Fig. 1 and Fig. 6 is a vertical section on the line B B of Fig. 5. Figs. 7 to 11 are more or less diagrammatic views showing modifications.

In each unit of the engine shown in Figs. 1 to 4 inclusive, *a*, *a* indicate the two engine cylinders each open at both ends and provided with the oppositely moving pistons *b* and *c*; *d* the crank shaft to which the pistons *b* are directly connected by rods b^1; *e* and *f* the crossheads respectively of the pistons *b* and *c*, and *g*, *g* the external rods each directly connecting the piston *b* of one cylinder to the piston *c* of the adjacent cylinder through the corresponding crossheads *e* and *f*. The upper crossheads *f* constitute, according to the present invention, the movable member of a single acting air pump the other member of which is stationary.

In the example illustrated in Figs. 1, 2, 3 and 4, each crosshead is made rectangular in plan, the width being equal to, or slightly greater than, the bore of the cylinder *a*, and the length taken transversely to the crank shaft, such as to afford the requisite piston area, on the one hand, and constitute the requisite lateral extensions f^1 for the attachment of the external rods *g*, on the other. The upper ends of the external rods *g* are connected to the extensions f^1 of the crossheads *f* by means of turret nuts g^1 located in recesses f^2 formed therefor in the said crosshead extensions (see Fig. 4). In this case, each rectangular crosshead *f* moves in a tubular guide *h* of rectangular cross section, closed at the end remote from the crankshaft by a cover *j* and forming an air pump chamber, whose cross-sectional area may be twice, or more times, that of the main piston *c* to which it is attached, the stroke of both being,

of course, the same. Each such crosshead *f* and its guide chamber *h* thus form an air pump capable of supplying one engine cylinder *a* with the desired quantity of air, while the original accurate balance of the engine is not disturbed.

The air pumps are provided with the necessary inlet and outlet valves *m* an *n* respectively which may be automatic in action, as in the example shown, or be mechanically operated.

In the engine illustrated, the valves *m* and *n* are automatic spring valves and are constituted by rectangular flat steel blades or plates, the inlet valves *m* controlling the inlet of air from an air inlet chamber *p* formed in the cover *j*, and the outlet valves *n* controlling the delivery of air to the engine cylinders *a* through passages *r* in the walls of the guide or pump chambers *h* and ports *s* formed in the walls of the cylinders *a* between the inner ends of the pistons in such cylinders.

The casing *t* surrounding and carrying each pair of engine cylinders *a* is, as shown in Figs. 5 and 6, provided at opposite sides with inclined passages *u* through which and the guide casings *h*, the pairs of cross diagonally arranged connecting rods *g* pass from the upper crossheads *f* to the lower ones *e*.

Each air pump piston *f* may, if desired, extend more to one side than the other of the axis of the corresponding cylinder, as indicated in Fig. 7, but usually it will be preferred to arrange it to extend to equal amounts from such center as shown in Figs. 2 and 3. It will be evident that each air pump piston *f* may, if desired, be made in other shapes, in plan, than rectangular, so as to afford the necessary area and transverse extensions, for example, in the form of an ellipse as shown in Fig. 8, or in the form of a flat sided figure with semicircular ends as shown in Fig. 9, or of plano-convex shape, for example of substantially semicircular shape, as shown in Fig. 10. In the latter example the two pistons *f* work in air pump chambers of corresponding shape in plan formed by and between semicircular casings *h* and an interposed plate h^1, each air pump piston having, as in the examples hereinbefore described, except Fig. 7, its two side portions, as seen in plan, arranged symmetrically, or substantially so, with respect to the engine piston to which it is connected. It will further be evident that instead of using the transversely extended crossheads *f* as air pistons working in conjugation with fixed air pump chambers, as hereinbefore described, they may be used as air pump chambers, as shown diagrammatically in Fig. 11, where *o* is the pump chamber formed by the crosshead *f* and *p* a fixed piston, m^1 being an air inlet valve and n^1 a compressed air outlet valve. Also, the air inlet and outlet passages and controlling valves therefor can be arranged otherwise than as in the example shown.

The engine illustrated in the accompanying drawings is suitable for motor cars, the four cylinders being cast in one piece.

An engine embodying the present invention can of course be variously modified in construction from that shown to suit requirement. Thus, in larger engines suitable for stationary or marine work, the cylinder liners would be in the form of separate tubes fixed in a water jacketed casing as well understood and arranged between a supporting exhaust chamber and an air chamber which would preferably consist of a separate casting. In large engines moreover the crossheads would usually be made separate from the pistons, say of steel with cast iron rubbing slippers. In all cases, however the principle of using the crosshead members of air pumps for supplying air to the working cylinders is the same for all sizes and constructions of engines. In small engines, such as the engine illustrated, the air will usually be carbureted before it enters the air pump chamber, but in larger engines it may be deisrable to inject the fuel separately either into the center of the cylinder, in the case of liquid fuel, or through the air inlet ports *s*, or through separate suitably controlled gas ports.

Combined engine pistons and air pump pistons such as hereinbefore described can be used in multiple cylinder two-stroke internal combustions having cylinders in close proximity, other than those described in my said former specifications.

What I claim:—

1. In a multiple cylinder two stroke cycle internal combustion engine having cylinders arranged in close proximity to each other and each provided with a pair of oppositely working pistons of circular cross section, the combination with one of the pistons in each cylinder of an air pump piston and a tubular casing forming an air pump chamber, one of these two pump parts being connected to the aforesaid engine piston and the dimensions of the said air pump piston and casing in the direction of the engine crank shaft approximating to the diameter of the said engine piston but whose dimensions at right angles thereto are extended to provide the requisite air pump piston area, substantially as described for the purposes described.

2. In a multiple cylinder two-stroke cycle internal combustion engine, the combination with a working piston of the engine of a crosshead connected only to the one piston, said crosshead forming an air pump piston, and a tubular crosshead guide forming with the crosshead an air pump, said crosshead and guide being of greater dimensions meas-

ured through the center of said working piston and in a direction transverse to the axis of the engine crank shaft than in the direction of said axis for the purpose described.

3. In a two stroke cycle internal combustion engine, the combination with an engine piston of a crosshead to which said piston is connected, and a tubular guide for said crosshead, said crosshead and guide being adapted to form an air pump and said crosshead having its two side portions, as seen in plan, arranged symmetrically with respect to a plane extending through the diameter of said engine piston in the direction of the axis of the crank shaft and of greater dimensions in a transverse direction measured through the axis of the said piston, than in the direction of the axis of said engine crank shaft, substantially as described for the purpose specified.

4. In a two stroke cycle multiple cylinder internal combustion engine having cylinders in close proximity to each other, the combination with engine pistons of circular cross section of crossheads connected to said engine pistons and each of plano-convex shape in plan and arranged with its greater dimension at right angles to the engine crank shaft and tubular guides fitting said crossheads, arranged adjacent to each other and adapted to form with said crossheads, air pump chambers, as set forth.

5. In a two stroke cycle multiple cylinder internal combustion engine having cylinders in close proximity to each other, the combination with engine pistons of circular cross section of crossheads connected to said engine pistons and each of semicircular or substantially semicircular shape in plan and arranged with its greater dimensions at right angles to the engine crank shaft and tubular guides fitting said crossheads, arranged adjacent to each other and adapted to form with said crossheads, air pump chambers, as set forth.

6. In a multiple cylinder internal combustion engine, the combination with engine pistons of circular cross section of separate crossheads connected to said pistons and each made of greater dimension in a direction transverse to the axis of the engine crankshaft than in the direction of such axis, guides for said crossheads adapted to form therewith air pump chambers, a cover at the outer end of each guide, said cover having ports and chambers for the passage of air to and from the corresponding air pump chamber, and valves for controlling said ports.

7. An internal combustion engine comprising, as a unit, two cylinders arranged side by side, two oppositely movable pistons in each cylinder, cross-heads and a pair of coupling rods arranged at opposite sides of the cylinders, connecting one piston in one cylinder to the oppositely situated piston in the other cylinder, guides for said cross heads, a crank shaft, connecting rods separately connecting the coupled pairs of pistons and cross heads to said crank shaft, the guides and cross heads for the pistons at one end of the cylinders being adapted to form air pumps for supplying compressed air to the engine cylinders.

8. An internal combustion engine comprising, as a unit, two cylinders arranged side by side, two oppositely movable pistons in each cylinder, crossheads connected to the outer ends of said pistons and arranged transversely to the plane of the engine crank shaft, a pair of inclined coupling rods directly connecting the crosshead of each piston to the crosshead of the oppositely situated piston of the other cylinder, the two pairs of inclined coupling rods crossing each other, and guides for said crossheads, the cross head guides at the outer ends of the pistons remote from the crank shaft being made tubular and adapted in conjunction with the corresponding crossheads to form air pumps for supplying compressed air to the said cylinders.

9. An internal combustion engine comprising, as a unit two cylinders arranged side by side, two oppositely movable pistons in each cylinder, a cross-head and a pair of inclined rods connecting each piston in one cylinder to the oppositely situated piston in the other cylinder, the two pairs of rods being inclined in opposite directions and crossing one another, a crank shaft having oppositely arranged cranks, connecting rods separately connecting the connected pairs of pistons and cross heads to the cranks, and guides for the cross heads, the cross heads for the pistons remote from the crank shaft and the corresponding guides therefor being arranged to work one in the other in a fluid tight manner and form air pumps the dimensions of which are greater in a direction transverse to the axis of the crank shaft than in the direction of such axis.

10. An internal combustion engine comprising as a unit, two cylinders arranged side by side, two oppositely moving pistons in each cylinder, a crosshead and rods connecting each piston to the oppositely situated piston in the other cylinder, a crank shaft to which the connected pistons are coupled and guides for the crossheads, the guides for the crossheads remote from the crank shaft being tubular and closed at their outer ends and made of greater dimensions in a direction at right angles to the axis of the crank shaft than in the direction of said axis, and the corresponding crossheads being fitted to slide fluid tight in said casings and form therewith air pumps hav-

ing valve controlled fluid inlet ports and valve controlled fluid delivery outlets arranged to be placed in communication with inlet ports to said cylinders.

11. An internal combustion engine comprising, as a unit, two cylinders arranged vertically side by side, two oppositely movable pistons in each cylinder, a cross head and coupling rods connecting each piston in one cylinder to the oppositely situated piston in the other cylinder, a crank shaft to which the connected pistons are coupled, a tubular guide of semicircular shape in cross section fixed over the outer end of each cylinder that is remote from the crank shaft in which the corresponding crosshead, of similar shape, works in a fluid tight manner to form a single acting air pump and through which the coupling rods connected to the corresponding cross head work, each tubular guide being of greater cross sectional area than the corresponding piston, and a cover fixed to the outer end of each tubular guide and provided with valve controlled air inlet openings to the pump chamber and valve controlled air delivery outlet openings in communication with air inlet openings to the engine cylinder.

12. An internal combustion engine comprising as a unit, two cylinders arranged vertically side by side, a casing surrounding said cylinders and provided at opposite sides thereof with two vertically arranged passages, two oppositely movable pistons in each cylinder, a crank shaft to which the pistons are coupled, a tubular guide fixed over the outer end of each cylinder that is remote from the crank shaft and over the said vertically arranged passages, and made of greater cross sectional area than the corresponding piston and of greater dimension in a direction at right angles to the said axis of the crank shaft than in the direction of such axis, said tubular guides being each provided at its outer end with a cover having valve controlled air inlet and delivery ports, a crosshead carried by the outer piston of each cylinder and arranged to work in a fluid tight manner in the corresponding tubular guide and form an air pump therewith, coupling rods extending from the under side of each of said cross heads through the corresponding tubular guide and the vertical passages to the oppositely situated crosshead and piston of the other cylinder, and coupling rods directly connecting the latter pistons to the crank shaft.

13. In an internal combustion engine, a crank shaft, two cylinders arranged side by side with their axes in the same plane as the axis of said shaft and each provided with two oppositely moving pistons, a separate cross head for each piston, those of the outer pistons being of substantially semi-circular shape as seen in plan, a circular casing made in two parts and having a diametrically arranged plate or division fixed between them to form two air pump chambers in which the said outer cross heads of substantially semi-circular shape separately work in a fluid tight manner, a cover plate fixed to the outer end of said casing and provided with air inlet and outlet passages to and from each air pump chamber to the corresponding engine cylinder and valves controlling said inlet and outlet passages, a pair of rods extending through the lower or inner portions of each chamber from the outer cross head and thence to the cross head of the inner piston of the adjacent cylinder and coupling rods connecting the inner pistons to separate cranks on the crank shaft.

Signed at Newcastle-on-Tyne, England, this thirtieth day of July 1913.

HUGH FRANCIS FULLAGAR.

Witnesses:

H. NIXON,

H. D. WERTIGAN.