(19) Canadian Intellectual Property Office | Office de la Propriété Intellectuelle du Canada

An Agency of Industry Canada | Un organisme d'industrie Canada

(11) **CA 526190** (13) **A**

(40) **12.06.1956**

(12)

(21) Application number: **526190D**

(22) Date of filing: **..**

(51) Int. Cl:

(71) Applicant: **WILLIAM DOXFORD AND SONS LTD.**

(72) Inventor: **PURDIE WILLIAM H ().**
**JACKSON PERCY ().**

(54) **OPPOSED PISTON TWO-STROKE CYCLE INTERNAL COMBUSTION ENGINES**

(54) **MOTEURS A COMBUSTION INTERNE A CYCLE A DEUX TEMPS ET PISTONS OPPOSES**

(57) **Abstract:**

The invention relates to opposed piston two-stroke cycle internal combustion engines of the kind in which the pistons are operatively connected to separate cranks on a crank-shaft and in which air for scavenging and combustion is admitted to the engine cylinder through ports in the cylinder wall at or near one end thereof (usually the lower end, i.e. the end nearer to the crank-shaft) and the exhaust takes place through ports in the cylinder wall at or near the other end thereof. In such engines the air ports are exposed and covered by one of the pistons during the movements thereof and the admission of air to the cylinder is controlled thereby and the exhaust ports are exposed and covered by the other piston which controls the escape of the exhaust gases.

According to the present invention an engine of the above kind is characterised by the feature that for the purpose of enabling some degree of super-charge of the engine cylinder to be obtained the air ports remain open on the inward stroke of the pistons (i.e. remain exposed by the air-controlling piston) substantially until, or after, the exhaust ports have been closed (i.e. covered) by the exhaust-controlling piston and that in order to prevent exhaust gases passing from the cylinder into the air inlet when the air inlet ports are uncovered by the air-controlling piston on its outward stroke, valve means are provided for shutting off the air inlet ports or at least the portion of them which is uncovered before the pressure in the cylinder has fallen to the air supply pressure. The valve means may be mechanically controlled in timed relationship with the engine but preferably they are in the form of an automatic non-return valve or valves.

With a view to reducing the time during which the air-inlet ports are uncovered before the cylinder pressure has fallen due to escape of exhaust gases, it is preferred that the crank (or cranks) operating the exhaust-controlling piston leads by a few degrees the crank operating the air-controlling piston.

In one form of the invention there are two sets of air ports, one set being valve-controlled as aforesaid and exposed before the other set which are nearer to the end of the cylinder and are without valve control. The latter ports may extend to the end of the piston stroke.

In cases where it is desirable to minimise the flow of air through the exhaust ports it is preferable that the exhaust ports are restricted in length axially of the cylinder (i.e. stop short of the end of the piston stroke) and when two sets of air ports as just described are employed the exhaust ports may be fully exposed when the valve-controlled air ports are fully exposed, or when the uncontrolled or lower ports are just opening.

The exhaust ports may be exposed for example about 50° of crank movement before the end of the stroke of the exhaust-controlling piston and covered about 50° after the end of the stroke. The air ports without valve control may be exposed about 30° after the exhaust ports have been exposed and be covered before the exhaust ports are covered. The valve-controlled air ports may remain open until, or for a few degrees after, the exhaust ports are covered. The exhaust ports may have a length corresponding to about 30° of crank-shaft angle so that they are substantially fully opened when the air ports without valve control are exposed. The crank operating the exhaust-controlling piston may have a lead over the crank operating the air-controlling piston of up to about $4^{\circ}$ to $8^{\circ}$ in a reversing engine or more in a non-reversing engine.

In other cases where it is desirable that a proportion of cool air be mixed with the exhaust gases, for example to reduce the temperature of the gases when an exhaust driven tubo-blower is used for super-charging, it is preferable that the exhaust ports extend to the end of the piston stroke.

When an automatic non-return valve is employed, as above described, to prevent back flow of exhaust through the air ports the valve may be of the multi-disc type or a flap valve or valves for example in the form of a series of thin cantilever plates fixed at one end and free to bend to permit air to flow between them and a seating when the pressure in the air inlet duct exceeds the pressure in the engine cylinder. When a mechanically operated valve is employed it may for example consist of a sleeve around the cylinder oscillated, rotated and/or reciprocated by means operated from the engine crank-shaft or cam-shaft. The sleeve may be timed to open the air-ports about $25^{\circ}$ before the piston reaches the end of its outward stroke and to close the ports after they have been covered by the piston on its inward stroke. If the engine is designed to reverse then mechanical means for changing the timing of the sleeve must be provided.

Some specific examples of engines according to the invention will now be described with reference to the drawings which are largely diagrammatic and in which:-

Figure 1 represents a longitudinal section through an opposed piston two-stroke cycle super-charged reversing marine engine,

Figure 2 represents a cross-section of the engine shown in Figure 1,

Figure 3 is a view, similar to Figure 1 of a second form of engine,

Figure 4 is a timing diagram applicable to both engines and showing the sequence and approximate timings in one revolution of the engine, of the openings and closings of the various air and exhaust ports, and

Figure 5 is a detailed view of the non-return valve used in the engine shown in Figures 1 and 2.

The engine shown in Figures 1 and 2 has a lower piston 1 connected to a centre crank 2 through a crosshead 3 and connecting rod 4. There is also an upper piston 5 connected to two side cranks 6 and 7 through connecting rods 8 and 9. Near the lower end of the cylinder 18 there is an upper row of air ports 10 which are controlled by automatic non-return valves 11 and 12. Below these ports there is a second row of air ports 13 which open direct into the air supply chamber 14 of the engine. At the upper end of the cylinder there is a row of exhaust ports 15, which in the present example, extend to the top of the cylinder.

The side cranks 6 and 7, to which the upper piston 5 is connected, are given a lead relative to the centre crank 2 of about 4° to 8° in the ahead direction of rotation. This lead of the exhaust crank and piston enables the exhaust ports to be opened earlier and quicker than if there were no lead so that the large quantity of gas in the cylinder due to the super-charge may be exhausted through the exhaust passages 16 and 17 as quickly as possible.

In the operation of the engine, as the crankshaft rotates downward motion of the lower piston 1 after the exhaust ports have opened uncovers the controlled air ports 10 but air will flow through them into the cylinder 18 only after the pressure in the cylinder has fallen below the pressure in the air chamber 14 and flow of exhaust gases from the cylinder back through the ports is prevented by the non-return valves 11 and 12. After the pressure in the cylinder 18 has fallen air will flow from the air chamber 14 through the non-return valves 11 and 12 into the cylinder 18 and will flow through it and out through the exhaust ports 15 and will thus scavenge the cylinder 18 of any remaining products of combustion. Further movement of the crank 2 and hence of the lower piston 1 uncovers the lower set of air ports 13 and air then flows through these and into the cylinder 18 without restriction by valves thus assisting the scavenging of the cylinder and the supply of air for combustion. Continued rotation of the cranks 2 and 6 and 7 results in the pistons 1 and 5 passing their outer dead centres and first the uncontrolled air ports are covered by piston 1 and then the exhaust ports are covered by piston 5 but air still continues to flow into the cylinder 18 through the non-return valves 11 and 12 and ports 10 until the ports 10 are covered by the lower piston thus giving extra air, and super-charging the cylinder 18.

Figure 3 shows an opposed piston engine in which a lower piston 19 is connected to a centre crank 20 through a connecting rod 21 and in which an upper piston 22 is connected to two side cranks 23 and 24 through a connecting rod 25. As in the previous example the upper piston 22 controls exhaust ports 26 and the lower piston 19 uncovers firstly controlled air ports 27 and afterwards uncontrolled air ports 28. In this example, the airports 27 are controlled by a rotary oscillating sleeve 29 which is actuated from a cam 30 on the camshaft 31 of the engine and is operated through rod 32 and bell crank lever 33. To permit of running in either direction there are two cams 30 and 34 on the camshaft, the former being for operating the sleeve 29 in the "ahead" direction and the latter for operating it in the "astern" direction and the manoeuvring shaft 35 determines which cam shall be in operation through the lever 36 and ahead roller 37 or astern cam roller 38. The sequence of operations is as in the previous example, the side cranks 23 and 24 are given a lead of up to 6° relative to the centre crank 20 and this permits the piston 22 to open the exhaust ports 26 earlier and quicker than normal. After the exhaust ports have been uncovered by piston 22 the piston 19 uncovers the upper row of air ports 27 which, however, do not permit the passage of air from the air chamber 39 into the cylinder 40 until the ports 27 have been uncovered by the operation of the sleeve 29. Further rotation of the engine causes the piston 19 to uncover the row of uncontrolled air ports 28 which permit the free passage of air from the air chamber 39 into the cylinder 40 and through this to the exhaust ports 26, thus scavenging out the cylinder. On further motion of the engine the piston 19 on its upward stroke, first covers the ports 28 and then the upper piston 22 covers the exhaust ports 26 but air still continues to flow into the cylinder and super-charge it until the ports 27 are covered by the piston 19. The ports 27 are not covered by the oscillating sleeve 29 until later in the motion of the engine.

Figure 4 shows the approximate valve timings in one revolution of the above-described engines in which the side cranks have a lead of about 6° relative to the centre crank in theahead direction. In the diagram all the timings indicated are referred to the centre crank and lower piston. The full lines relate to the lower piston and the dash lines to the upper piston. The sequence of events is as follows:-

A. The exhaust ports are uncovered by the upper piston at 56° before outer dead centre,

B. The valve controlled air ports are uncovered by the lower piston at 50° before outer dead centre, the valves remaining closed until the cylinder pressure has fallen to the pressure of the air,

C. The lower, scavenge, air ports are uncovered by the lower piston at 25° before outer dead centre,

D. The upper piston reaches outer dead centre at 6° before the lower piston reaches dead centre,

E. The lower piston reaches dead centre,

F. The lower air ports are covered by the lower piston at 25° after outer dead centre,

G. The exhaust ports are covered by the upper piston at 44° after outer dead centre, and

H. The valve controlled air ports are covered by the lower piston at 50° after dead centre.

Figure 5 shows the form of automatic non-return valve used in the engine shown in Figures 1 and 2. The upper row of air ports 10 in the cylinder 18 are controlled by a number of plate valves 43 which rest on seats 44 formed by the edges of trough-shaped members 45. When the pressure inside the cylinder 18 exceeds that in the air chamber 14 the plate valves 43 are held on their seats 44 by the pressure but when the pressure inside the cylinder 18 falls below the air pressure in the chamber 14 then the thin plate valves 43 are opened and each is deflected round the curved surface 46 of the underside of the member 45 above it. Air then flows through the troughs and into the cylinder 18 as shown by the arrows.

The air for super-charging may be provided by the means described in either of Canadian patent applications No. 625864 and 625865 or by an extra large reciprocating blower or blowers or by Roots, vane or centrifugal blowers. In the above examples the air is supplied to the chambers 14 and 39.

The arrangement according to the present invention and embodied in the above examples has the advantages that the exhaust ports have a substantial lead over the opening of the air ports, that the exhaust ports have a large initial area of opening permitting escape of a substantial amount of the exhaust gases before the air port opens, that the escape of air through the exhaust ports is restricted by the early closing of the exhaust ports, and that the valve-controlled air ports may be of large area permitting a large amount of air for super-charging to be admitted until after the exhaust ports are closed. Further, the large initial opening of the exhaust ports permits the length of the ports to be reduced and so the escape of air through the exhaust ports to be further reduced if so desired.

The above examples relate to reversing engines for marine use and it will be appreciated that, owing to the lead of the outer cranks over the centre crank the efficiency of the engine will be greater in the ahead direction than in the astern direction, thus providing a limit on the amount of lead which may be given. In the case of a non-reversing engine the lead may be increased with advantage.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A reversing opposed piston two-stroke cycle internal combustion engine having a working cylinder with at least one air-inlet port adjacent one end thereof and at least one exhaust-outlet port adjacent the other end thereof, an air-controlling working piston reciprocable within the end of the cylinder having the air port to cover and uncover the air port, an exhaust-controlling working piston reciprocable within the other end of the cylinder to cover and uncover the exhaust port, a crank-shaft with at least two throws and means operatively connecting the two pistons to the two throws respectively whereby the pistons are constrained to reciprocate in timed relation characterised by the features that the air-inlet port extends into the cylinder for a greater distance, measured in terms of angular displacement from its outer dead centre of the crank throw connected to the air-controlling piston when the top of the piston coincides with the inner edge of the air port, than does the exhaust port measured likewise in terms of angular displacement of the crank throw connected to the exhaust-controlling piston, that in the "ahead" direction of rotation the throw connected to the exhaust-controlling piston leads the throw connected to the air-controlling piston by between $4^{\circ}$ and $8^{\circ}$ and that there is provided valve means preventing flow of exhaust gases from the cylinder through the air-inlet port when the latter is uncovered by the air -controlling piston in its outward stroke during both ahead and astern running.

2. An engine as claimed in claim 1 in which the valve means are constituted by an automatic non-return valve.

A

3. An engine as claimed in claim 1 in which the air-inlet port aforesaid stops short of the outer end of the stroke of the air-controlling piston and there is a second port between the first port and the end of the piston stroke, the second port being without valve means.

4. An engine as claimed in claim 1 in which the crank throw connected to the exhaust-controlling piston leads the crank throw connected to the air-controlling piston by $6^{\circ}$, in which the top of the exhaust-controlling piston coincides with the inner end of the exhaust port during the outward stroke of the piston when the crank throw connected to the air-controlling piston is $56^{\circ}$ before its outer dead centre, the top of the air-controlling piston coincides with the inner end of the air port during the outward stroke of the piston when the crank throw connected to this piston is at $50^{\circ}$ before outer dead centre, the top of the exhaust-controlling piston coincides with the inner end of the exhaust port during the inward stroke of the piston when the throw connected to the air-controlling piston is $44^{\circ}$ past its outer dead centre and the top of the air-controlling piston coincides with the inner end of the air port when the crank throw connected to that piston is $50^{\circ}$ past its outer dead centre.

5. An engine as claimed in claim 1 in which the throw connected to the exhaust-controlling piston leads the throw connected to the air-controlling piston by at least $6^{\circ}$.

A

*Fig.1.*

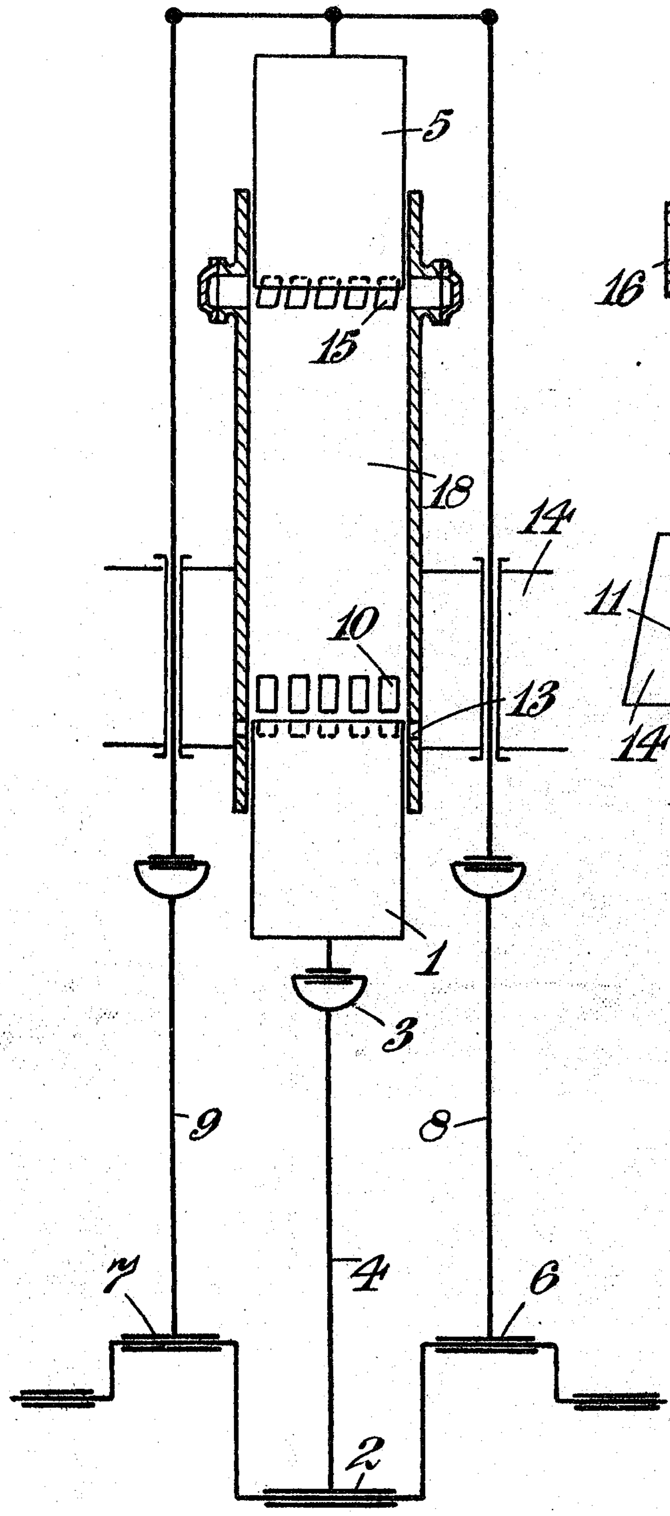
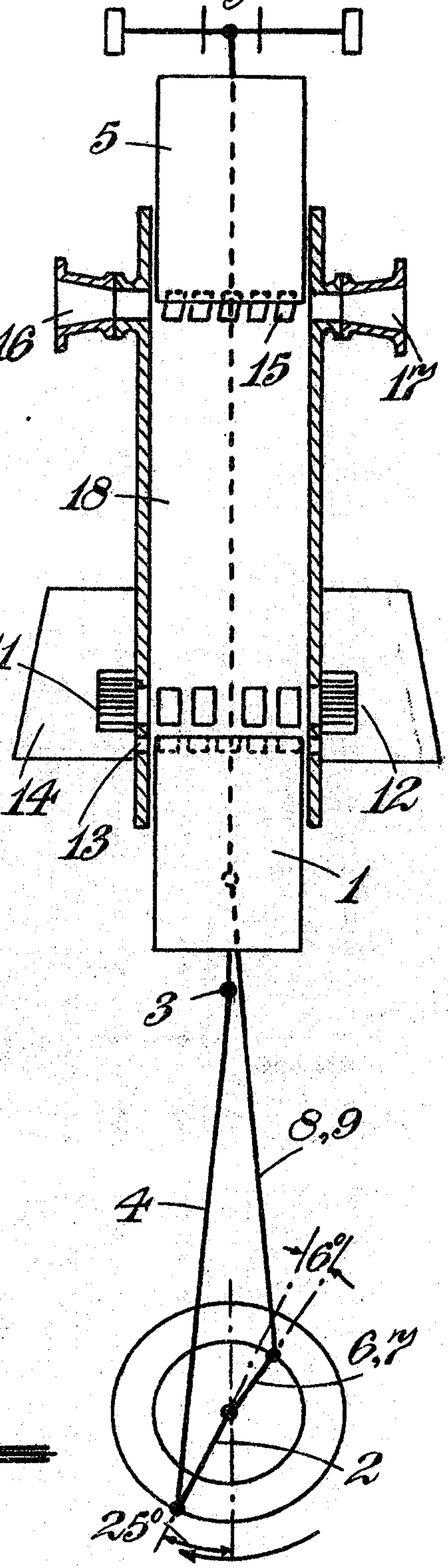



*Fig.2.*




INVENTOR

W. H. Purdie + P. Jackson

PATENT ATTORNEYS

Ridout & Maybee

Fig.3.

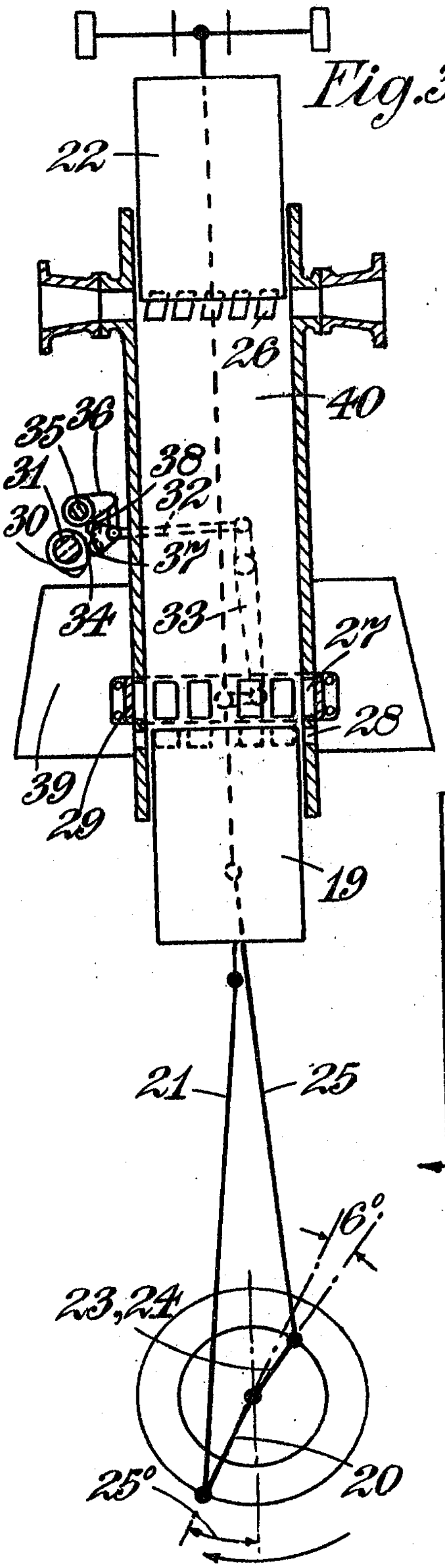



Fig.4.

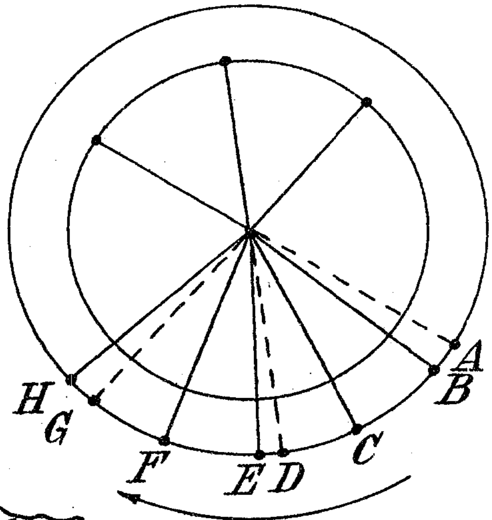
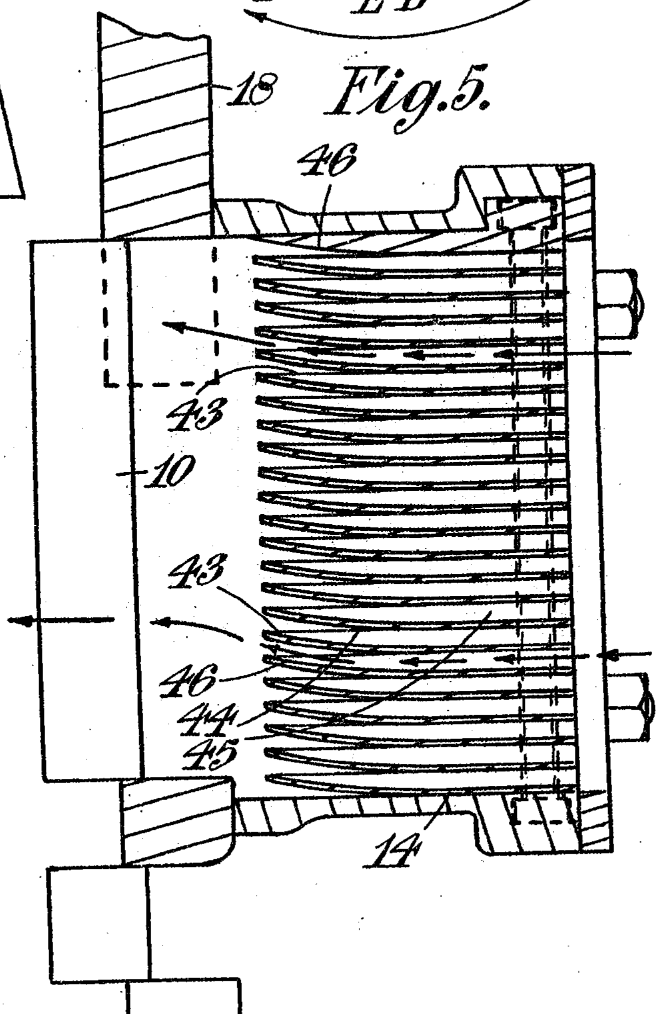



Fig.5.




**INVENTOR**

W. H. Purdie & P. Jackson

PATENT ATTORNEYS

Ridout & Maybee