

# PATENT SPECIFICATION



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183,501

Complete Left: Nov. 1, 1921.

Complete Accepted: Aug. 1, 1922.

## PROVISIONAL SPECIFICATION.

### Improvements relating to Internal Combustion Engines.

I, GEORGE HENRY ENDERBY, of St. Mabyn House, Newlyn, Penzance, in the County of Cornwall, a subject of the King of Great Britain and Ireland, do hereby declare the nature of this invention to be as follows:—

This invention has for its object to construct improved internal combustion engines of the opposed piston type operating on either two- or four-stroke cycles.

The invention comprises the employment of two pairs of opposed pistons, the pistons of each pair being oppositely movable and coaxially arranged, and the two pairs being arranged with their axes parallel, a pair of rocking levers each connecting a piston in one pair to the adjacent piston in the other pair, and a pair of connecting rods respectively connecting one end of one of the levers to a common crank pin or its equivalent which is rotatable about an axis at the centre of the engine.

The invention also comprises the utilisation of the unequal movements obtained in each pair of pistons due to the disposition of the connecting rods for opening and closing the exhaust and air inlet ports at different intervals.

In one manner of constructing a two-stroke engine in accordance with this invention for operating on the Diesel or semi-Diesel principle, two cylinders are used and these are arranged with their axes parallel. In each cylinder are provided a pair of oppositely movable pistons, the space for the working fluid being provided between the adjacent ends of the pistons. At the outer ends of the cylinders centrally pivoted rocking levers are mounted, the pistons at one end of the cylinders being connected to one lever and

the others at the opposite end of the cylinder being connected to the other lever. At a central position between the cylinders is arranged a crank shaft, which by means of a common crank pin is connected by a pair of connecting rods to diagonally opposite ends of the rocking levers. For balancing purposes another pair of connecting rods may be arranged in conjunction with the first pair at the opposite side of the engine.

At positions near the outer limits of the piston movements, each cylinder is provided with an exhaust port and an air inlet port, one piston serving to control one port and the other piston in the same pair the other port. When these ports are uncovered exhaust gas escapes through one and fresh air is admitted through the other. Due to the arrangement above described the pistons in each pair move with a certain inequality, one reaching the end of its stroke a little before the other, and this enables an important advantage to be obtained in the control of the said ports. The exhaust port is opened before the air inlet port and can if desired be closed before the air inlet port. By this device a thorough scavenging of each working space can be insured, an adequate supply of fresh air for the next working stroke can be introduced, and if desired the air can be forced into the cylinders at the commencement of each compression stroke under an initial pressure.

The scavenging air may be supplied from a separate pump or pump delivering air into a receiver or directly into the cylinders, but preferably a pump piston is arranged in the form of an annular enlargement on each piston, the

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pump piston operating in an annular cylinder formed coaxially with the main cylinder.

When operating on the Diesel or semi-Diesel principle any suitable means may be employed for introducing the fuel oil at the end of the compression stroke.

If desired the engine may be operated with carburetted air, like an ordinary petrol or other oil vapour engine, any

suitable means being then provided for igniting the charge after compression.

Obviously the invention is not limited to four cylinder engines as any multiple of four cylinders may be used. Also the invention is not limited to any particular mechanical details as these may be varied to meet different arrangements.

Dated this 1st day of February, 1921.

MARKS & CLERK.

## COMPLETE SPECIFICATION.

### Improvements relating to Internal Combustion Engines.

I, GEORGE HENRY ENDERBY, formerly of St. Mabyn House, Newlyn, Penzance, in the County of Cornwall, now of Mulfia, Orchard Terrace, Newlyn, Penzance, in the County of Cornwall, a subject of the King of Great Britain and Ireland, 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 internal combustion engines of the type comprising one or more pairs of opposed pistons, the pistons of the (or each) pair being oppositely movable and co-axially arranged and being connected by rocking levers and connecting rods pivoted at one extremity of each of the rocking levers in such a manner as to operate upon a common crank shaft.

The object of the present invention is to improve the construction and arrangement of internal combustion engines of the above type in such a manner as to improve their efficiency in operation by providing means for adequately scavenging the working space or spaces and enabling an adequate supply of fresh air to be introduced for the next working stroke.

In connection with such engines it has hitherto been proposed to arrange for the exhaust ports to be opened before the inlet ports and closed after the inlet ports but in contradistinction to this arrangement the present invention consists in an internal combustion engine of the type referred to in which the exhaust ports are both opened and closed before the inlet ports. This arrangement enables a thorough scavenging of the working spaces to take place and at the same time enables a charge of air to be forced into the cylinder before the compression commences so

that the air in the cylinders will already be under an initial pressure at the commencement of each compression stroke.

The invention also consists in the forms of internal combustion engine hereinafter described and illustrated.

The accompanying drawings illustrate two forms of internal combustion engine in accordance with the invention.

Figure 1 is a longitudinal sectional elevation showing a two-cylinder engine with two pairs of opposed pistons constructed and arranged in accordance with the invention.

Figure 2 is a diagram illustrating the port operation of the engine shewn in Figure 1.

Figure 3 is a similar view to Figure 1 showing an engine with one pair of opposed pistons constructed and arranged in accordance with the invention and

Figure 4 is a diagram of the port operation of the engine shewn in Figure 3.

In carrying my invention into effect in one convenient manner as shewn, for example, in Figures 1 and 2, I provide two cylinders *a b* with their axes parallel to one another and within the respective cylinders I provide a pair of oppositely movable pistons *a<sup>1</sup>, a<sup>2</sup>, b<sup>1</sup>, b<sup>2</sup>*, the space for the working fluid being provided between the adjacent ends of the pistons.

At the outer ends of the cylinders centrally pivoted rocking levers *c d* are mounted, the pistons at one end of the cylinder being connected to one lever and those at the opposite end to the other lever as shewn.

At a central position between the cylinders is arranged a crank shaft *e* which by means of a common crank pin *f* is connected by a pair of connecting rods *g* of equal length to diagonally opposite ends of the rocking levers, it being understood that a further pair of connecting rods

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may, if desired for balancing purposes, be arranged in connection with the first pair at the opposite side of the engine.

At positions near the outer limits of the piston movements each cylinder is provided with an exhaust port or ring of exhaust ports *h* and inlet port or ring of inlet ports *i*, one piston serving to control one series of ports and the other piston of the same pair the other series of ports.

On account of the arrangement of the ports and of the connection of the equal length connecting rods to a common crank pin the movements of the pistons are non-symmetrical in that one reaches the end of its stroke a little before the other and this enables the exhaust ports to be opened and closed before the inlet ports whereby a thorough scavenging of each working space can be ensured, an adequate supply of fresh air for the next working stroke can be introduced and such air can be forced into the cylinders at the commencement of each compression stroke under an initial pressure.

The diagram in Figure 2 shows the relative positions of the various parts at different positions in the stroke, the respective ports being shewn at *h* and *i* while the arcs *k* represent the paths of the ends of the rocking levers *c* *d*, the circle *l* represents the path of the crank pin centre and the arrows *m* *n* represent the inward and outward movements respectively of the pistons in the two cylinders.

The diagram has been plotted to show the positions of the respective pistons with the crank pins in the positions 1, 2, 3, 4, 5, 6 and 7 respectively, the corresponding positions of the points representing the connection between the left-hand piston rods and rocking levers and the positions of the left-hand pistons being similarly indicated while on the right-hand side of the diagrams these various positions are indicated by the references 1<sup>1</sup>, 2<sup>1</sup>, 3<sup>1</sup>, 4<sup>1</sup>, 5<sup>1</sup>, 6<sup>1</sup> and 7<sup>1</sup> respectively. Reference to this diagram will show that in the working of the engine the exhaust ports both open and close before the inlet ports. For example, considering the upper part of the diagram the left-hand piston travels from the point 1 to the point 2, completely closing the exhaust port, while the right hand piston travels from the point 1<sup>1</sup> to the point 2<sup>1</sup> showing that the inlet port is not yet closed. Similarly on the return stroke the left-hand piston *a*<sup>1</sup> reaches from the point 7 when the right hand piston arrives at the point 7<sup>1</sup> so that the exhaust port is also opened before the inlet port.

The scavenging air may be supplied from a separate pump or pump delivering air into a receiver or directly into the cylinders, but preferably a pump piston is arranged in the form of an annular enlargement *m* on each piston as shewn, the pump piston operating in an annular cylinder formed co-axially with the main cylinder.

When operating on the Diesel or semi-Diesel principle any suitable means may be employed for introducing the fuel oil during the compression stroke.

If desired, the invention may be operated with carburetted air as an ordinary petrol, or other oil vapour engine, any suitable means being then provided for igniting the charge after compression.

Figure 3 is a similar view to Figure 1 illustrating the application of our invention to an engine of the type referred to having a single cylinder and a single pair of pistons only or a plurality of cylinders all on one side only of the crank shaft. Similar letters of reference are used in this figure to denote the parts which are similar to those shown in Figure 1, and it is thought that further description is unnecessary except to point out that when applying the invention to a single cylinder engine it is necessary in order to provide for the opening and closing of the exhaust ports before the inlet ports, to connect the connecting rods *g* to the separate crank pins *f* and *f*<sup>1</sup>, while the centre line of the crank shaft *e* is located a suitable distance (shown by the reference letter *s* in Figure 4) above the line tangential to the arcs in which the lower or outer extremities of the rocking levers move.

Reference to the diagram in Figure 4 shows that in this form also the same sequence of port opening is obtained.

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

1. An internal combustion engine of the type referred to in which the exhaust port is both opened and closed before the inlet port, substantially as described.

2. An internal combustion engine as claimed in Claim 1, having two pairs of pistons with rocking levers connected thereto and two connecting rods of equal length connecting opposite extremities of the rocking levers to a common crank pin upon a crank shaft, substantially as described.

3. An internal combustion engine according to Claim 1, having a single cylinder with a single pair of pistons therein or a plurality of such cylinders all on one side of the crank shaft, the pistons being connected respectively to one end of a pair of rocking levers, the other ends of which are connected to two crank pins upon a crank shaft, substantially as described. 10
- 5 4. Improved internal combustion engine of the type referred to, substantially as described and as illustrated by the accompanying drawings. 15
- Dated this 1st day of November, 1921. 15  
MARKS & CLERK.

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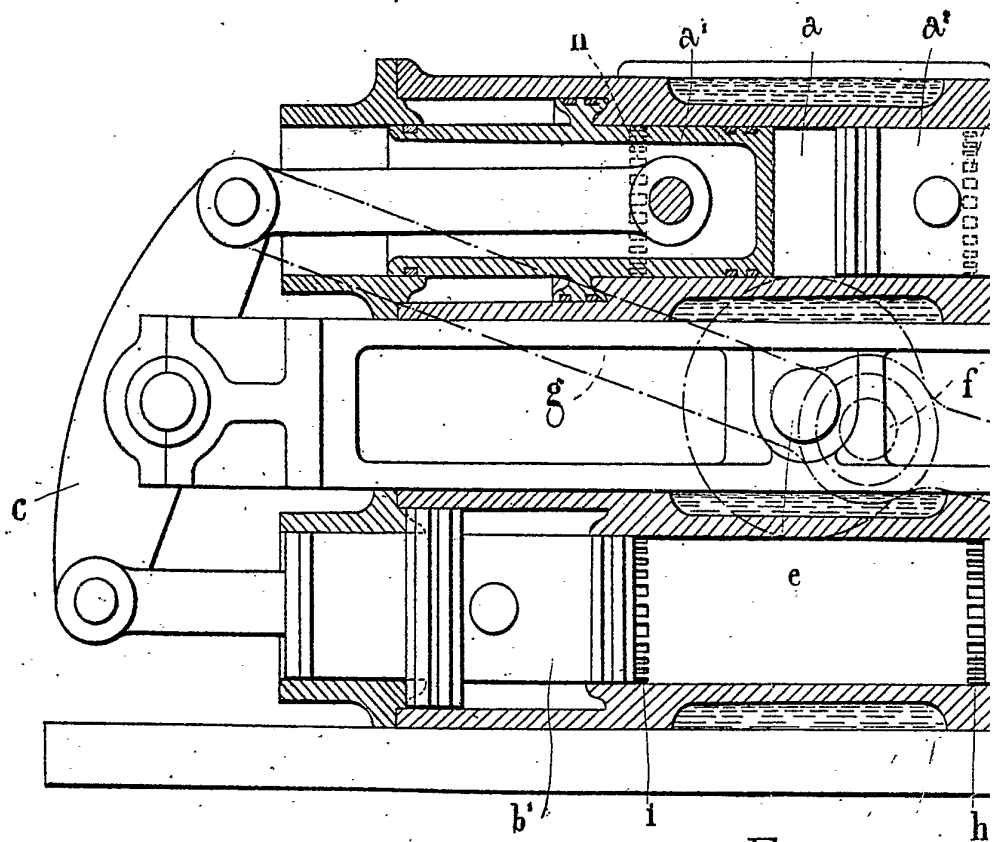


Fig. 1.

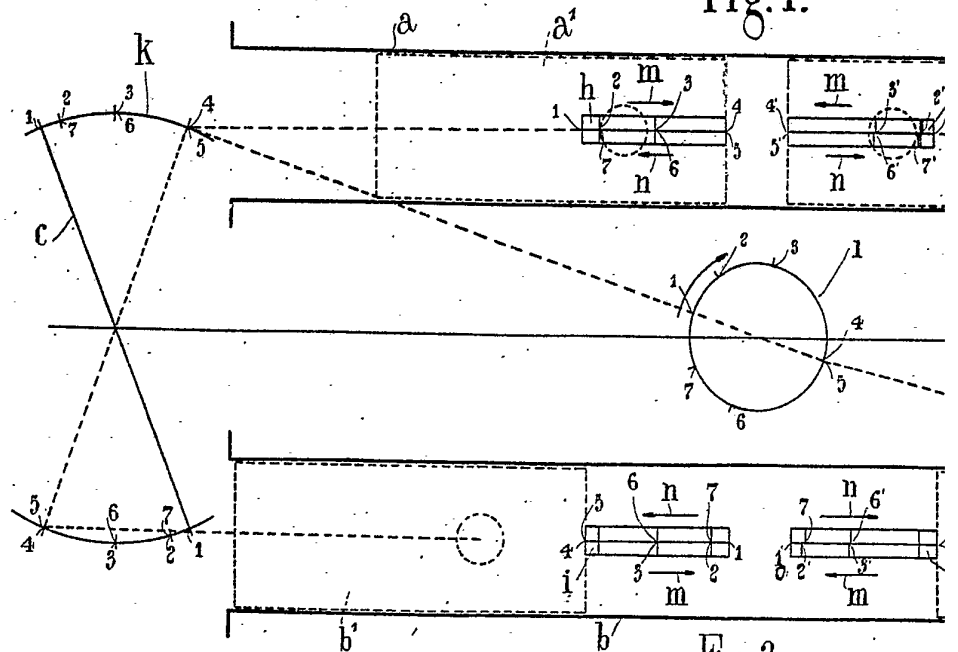


Fig. 2.

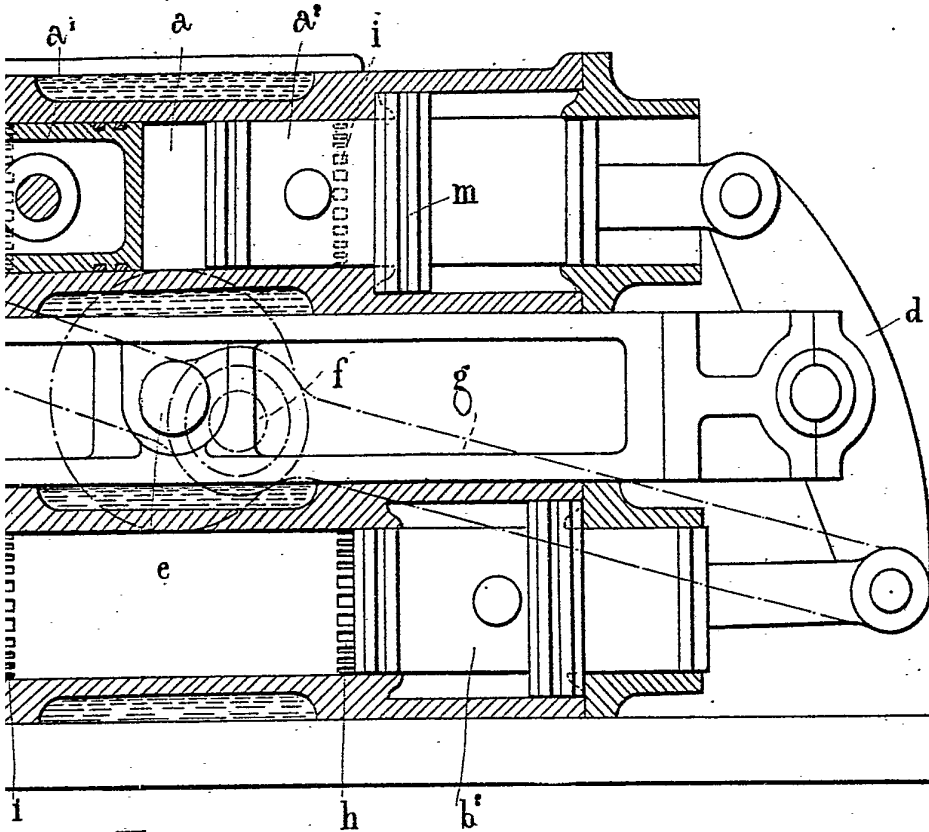


Fig. 1.

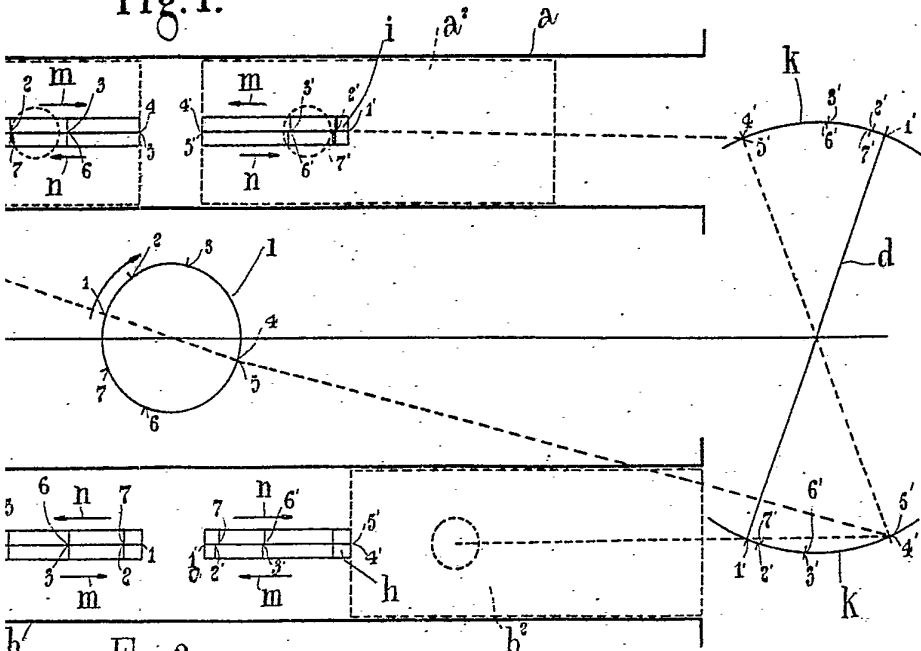


Fig. 2.

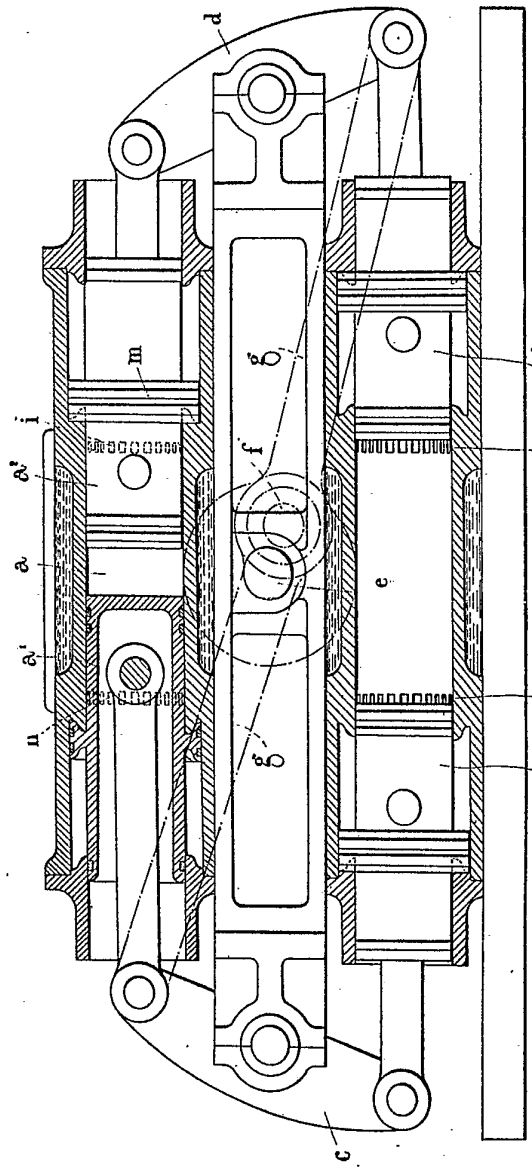


Fig. 1.

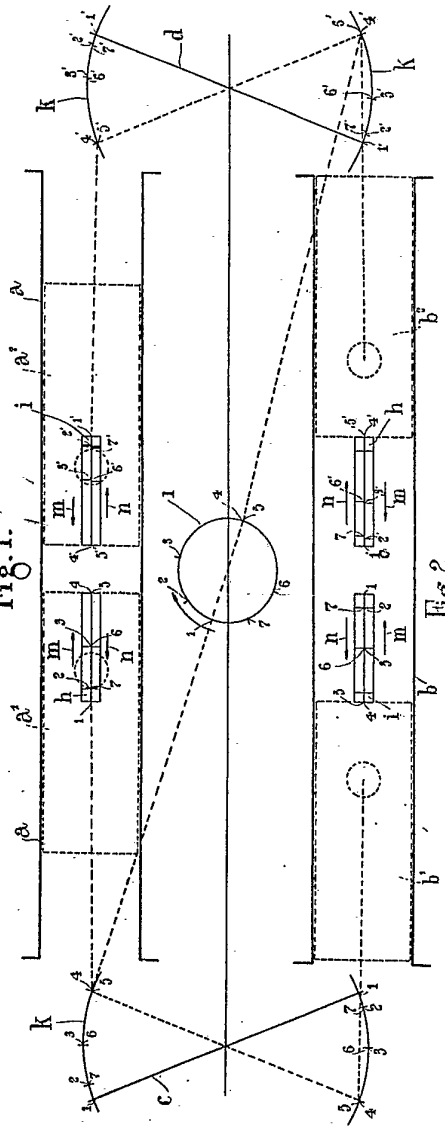
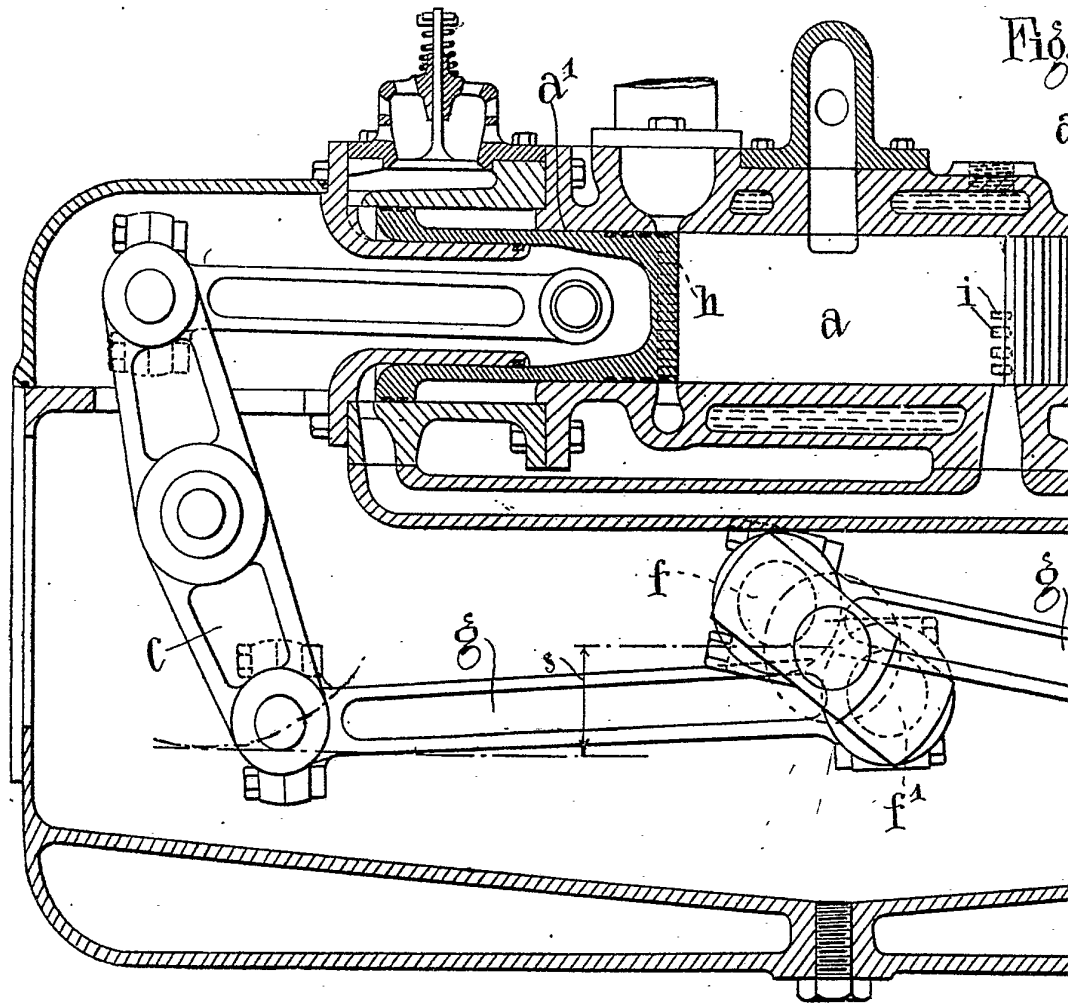


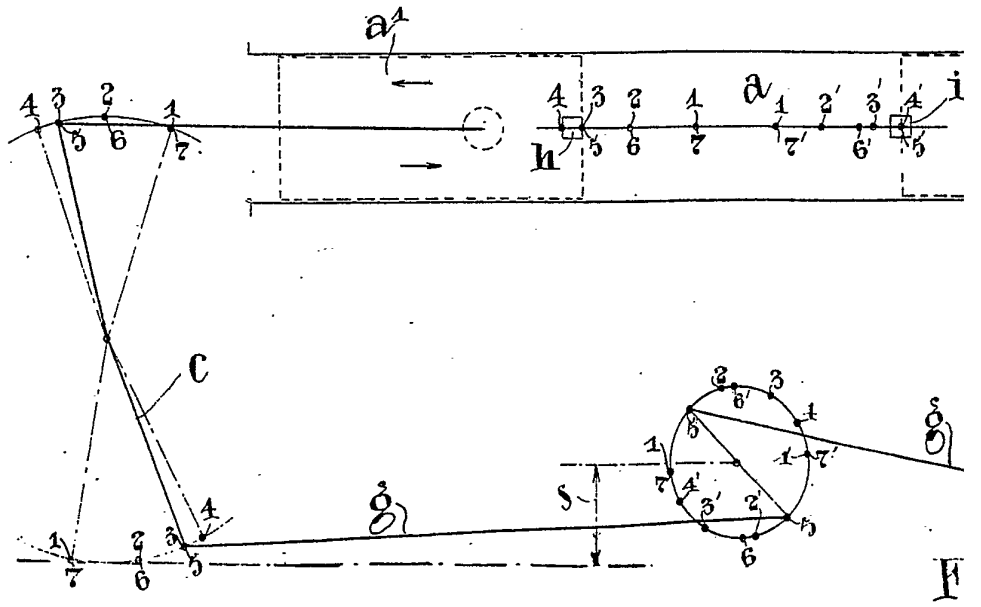
Fig. 2.

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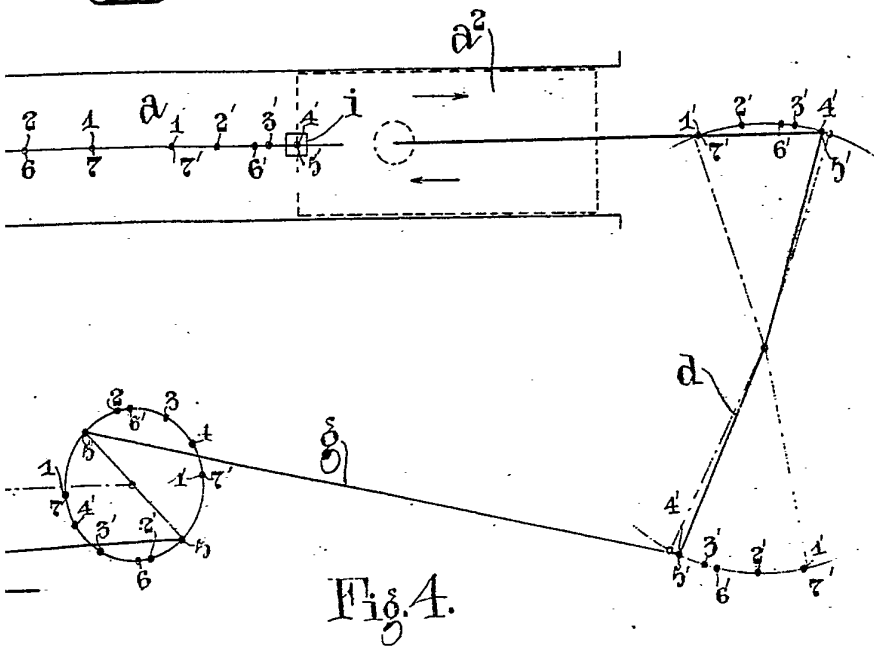
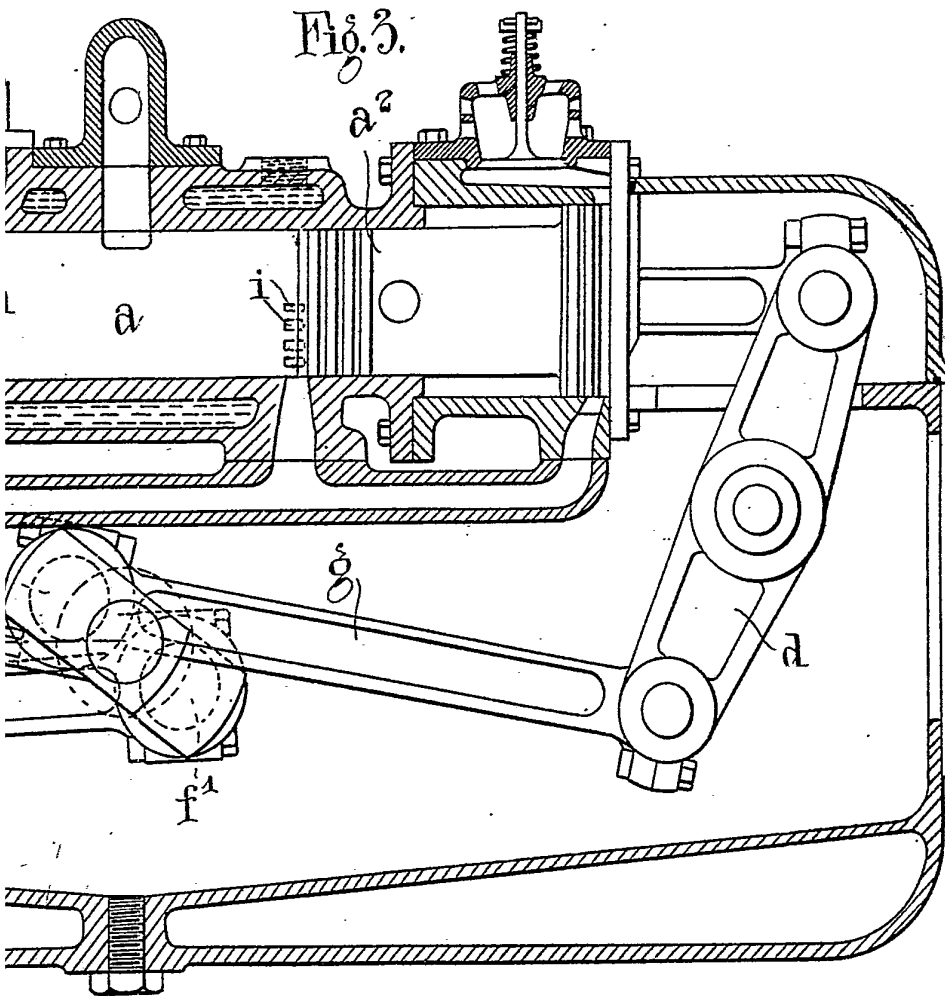
Fig 5



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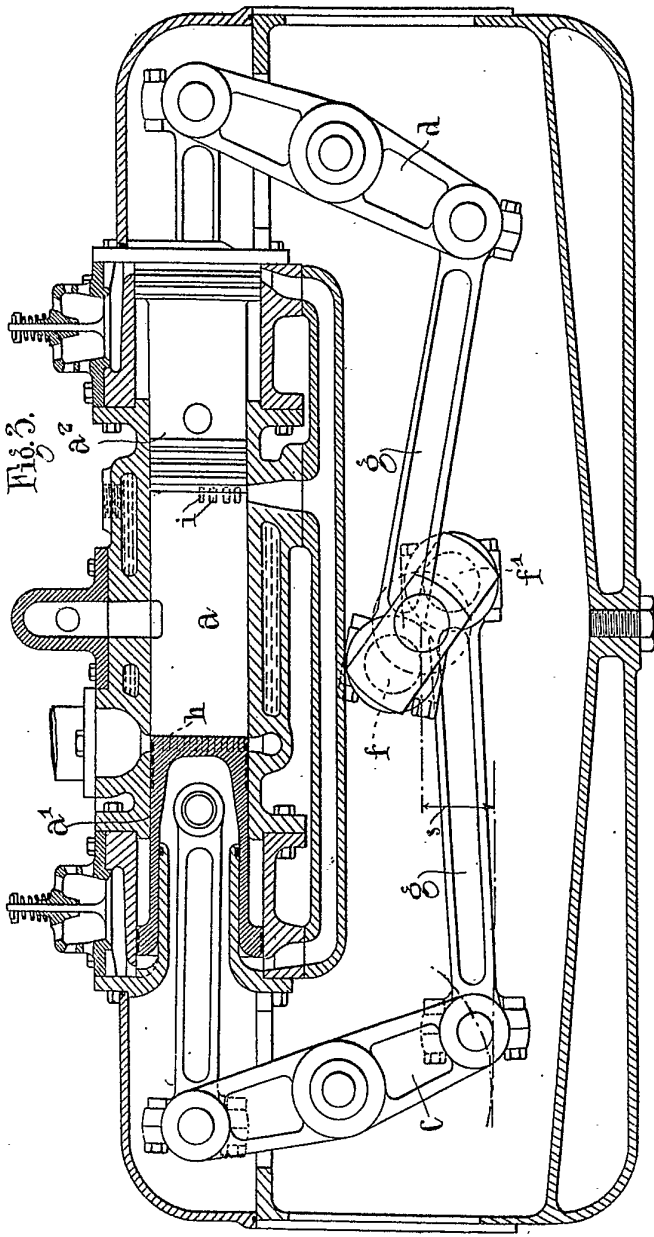


Fig. 3.

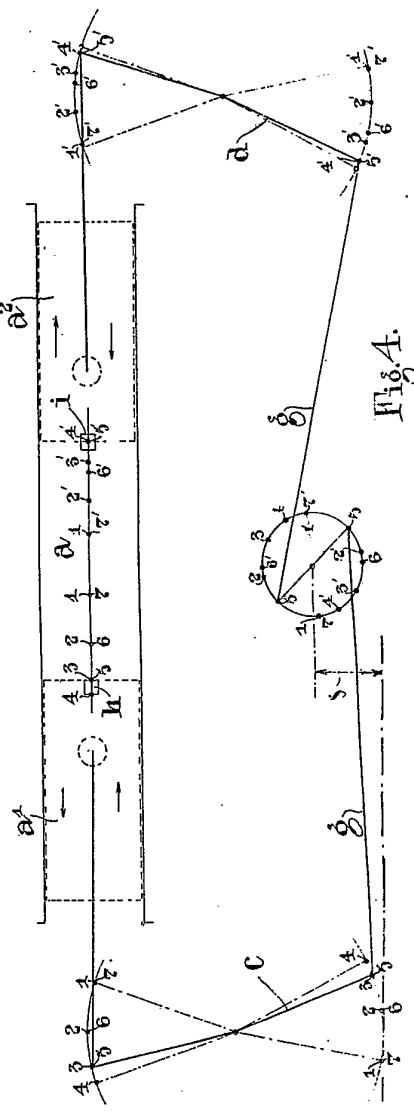


Fig. 4.

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