PATENT SPECIFICATION

147,730

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COMPLETE SPECIFICATION.

Improvements in Two-stroke Cycle Internal Combustion Engines and in Methods of Working Same.

I, HUGO JUNKERS, a citizen of the Republic of Germany, formerly of 68, Bismarckstrasse, Aachen-Frankenburg, Germany, and now of 47, Albrechtstrasse, Dessau, Germany, 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:—

My invention relates to a process for working two-stroke explosion engines operating with liquid fuel, in the case of which the fuel is introduced, in a liquid state, directly into the working cylinder proper, being finely divided and mixed with the air serving for combustion, whereupon the mixture is artificially ignited during the compression.

In the case of two-stroke explosion engines, operating with liquid fuel, there exists, as is quite generally known, great difficulties relatively to the formation of the mixture, which essentially are one of the causes why the two-stroke cycle process, which from the engine builder's viewpoint is so very advantageous, is much less used in connection with engines of this kind than the four-stroke cycle process.

Moreover, the customary method in the case of two-stroke engines of arranging a carburettor between the charging pump and the working cylinder embodies a variety of drawbacks. Above all, it causes a loss of fuel during the scavenging operation. On the other hand again, when introducing the fuel directly in the working cylinder, it will be found that the time available for the evaporation and mixing of the fuel with the air serving for the combustion is comparatively short, so that the inflammability of the mixture, notably in the case of a very variable load, will be rendered questionable. For this reason the attempt has already been made to facilitate the formation of an inflammable mixture in the case of engines of the kind indicated, by arranging hot glowing baffle walls in the cylinder. Engines so modified, however, possess a series of peculiarities which prevent their being generally used, so that as a rule, they will only prove practicable in cases where an accurate governing, and reduced fuel consumption, are esteemed as factors of minor importance compared with the fact that such engines run with less attention and have a wider choice of possible fuels.

In accordance with my present invention the drawbacks due to the arrangement of carburettors in connection with two-stroke cycle engines are successfully obviated by the fuel being directly introduced into the working cylinder. However, in order to secure an inflammable mixture without rendering the use of hot glowing surfaces necessary, it will prove requisite to effect an intense mixing of the fuel and the air serving for combustion within the brief interval of time available between the moment when the injection commences and the ignition proper. Now this object is attained by the fuel being injected into the mass of air rotating within the working cylinder. The rotation of the air is secured by the scavenging air being caused to enter through ports, formed around the circumference of the cylinder, not in a radial but in a subtense (approximately, tangential) direction. Experiments have shown that scavenging air introduced in

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the said manner will retain its circulating property even after the said ports are closed during the compressing action, and, what is more, even during the combustion process following. This fact is accordingly made use of, in this invention, in order to bring about an intense mixing of the fuel with the air of combustion despite the extremely brief space of time available for the purpose. At the same time great advantages are obtained in that no special devices nor any particular expenditure of energy, are required to produce the rotatory movement of the air of combustion, since as experience has shown, the scavenging resistances do not increase in the case of air entering in the subtense direction as when entering radially, while the quality of the scavenging process itself is probably enhanced.

The present invention embodies the decided advantage over and above the arrangement of the known kind in which the fuel is injected in a subtense direction into a motionless quantity of air, said air being thereby put into rotation, in that the whole of the air is already in a condition of most powerful rotation when the injection commences, and need not therefore be accelerated by the fuel. And while, in the previous arrangement, fuel and air are caused to flow in the like direction and only at a varying speed, the quality of the mixing process may according to the present invention be still further increased in that, for example, the fuel is injected in a direction opposed to that in which the air flows, or in that the jet of fuel is injected in such a manner that the small particles thereof will move approximately perpendicularly to those of the air with the view to distributing the fuel uniformly across the entire air of combustion.

The improved method in addition renders it possible by suitably changing the direction of the fuel injection, the shape of the fuel jet, the force of the injection *etc.*, to secure the most favourable mixing and ignition conditions for fuel of the most diverse kind. Two-stroke counter piston engines will be found to be the most suitable for carrying this new mixture forming process into practical effect, both by reason of the good scavenging possible in connection with such engines, and also on account of the smooth nature of the wall surfaces of their combustion chambers, which facilitates maintaining the air in rotation for a long period. However, the process may also be employed in connection with single piston engines, provided these possess scavenging rings of ports, and in the case of which the air may be introduced in a subtense direction.

Various arrangements for carrying out my invention are shown by way of example in the accompanying drawings, in which

Figs. 1 and 5 to 7 are longitudinal sections through two-stroke counter piston engines constructed in accordance with this invention.

Fig. 2 is a section through the scavenging ring of ports.

Figs. 3 and 4 are cross sections of the cylinder at the place of injection.

Fig. 8 is a partial longitudinal section through a counter piston engine, taken in the proximity of the scavenging ring,

Fig. 9 is a cross section through the scavenging ring,

Figs. 10 and 11 are pressure-volume diagrams of engines working in accordance with the improved process.

Referring to these drawings, 1 is the working cylinder traversed along helical lines by the scavenging air, 2 the scavenging ports disposed in the subtense direction, 3 the scavenging air chamber, 4 the injector, 5 the fuel inlet, 6 the sparking plug, 7 the exhaust ports, 8 the exhaust tank, 9 and 10 the two working pistons, of which piston 9 controls the scavenging ports, and piston 10 the exhaust ports.

The direction in which the air flows is indicated by curved arrows, and that of the exhaust gases by intersecting lines.

Fig. 1 shows a suitable form of construction of the improved engine. The nozzle 4 for the fuel and the sparking plug 6 are arranged in the wall of the dead centre chamber in the middle portion of the cylinder 1.

The scavenging ring of this engine, as shown in Fig. 2, is so constructed in a manner well-known (in connection with Diesel engines) that the scavenging air conduits 2 terminate in the cylinder along a subtense direction, so that the air entering into the cylinder is put in rotation.

In the arrangement shown in Fig. 3 the fuel is injected in the form of a conical spray for the main part at right angles to the rotating masses of air, so that the entire rotating quantity of air will be enabled to completely saturate itself with the fuel.

In the arrangement shown in Fig. 4 the fuel is introduced in a subtense direction counter to the direction of rotation pursued by the air, which likewise ensures

the obtaining of a uniform mixture of fuel and air.

According to Fig. 5, the fuel is injected in a direction substantially parallel to the longitudinal axis of the cylinder and counter to the inflowing air. This arrangement will be of notable advantage in cases in which the injection of the fuel is to take place very early, that is to say possibly directly the scavenging ports have been opened by piston 9, since there is small possibility of fuel being taken along into the exhaust chamber by the excess portion of scavenging air.

In the arrangement disclosed in Fig. 6, the fuel is injected toward the opposite side, that is toward piston 10 governing the exhaust, the hot bottom surface of said piston accelerating the evaporation. In this case, the injection of the fuel must only be commenced just after the exhaust ports have been closed, as otherwise a loss of fuel would be liable to arise. The arrows denote the continuance of the rotation of the air confined between pistons 9 and 10 after ports 2 and 7 have been closed.

In the arrangement illustrated in Fig. 7 the injector 4 is no longer arranged in the dead centre, but is shifted toward the inlet ports. In this case, the injection of the fuel may take place earlier than where the injector is disposed in the dead centre; however, the injection cannot be continued for the entire period of compression.

In the arrangements shown in Figs. 8 and 9, the arrangement laid down in Fig. 7 is still further developed, in that the fuel is introduced directly into the scavenging ring 2. To this end, the injector nozzles 4 terminate in the conduits 2 of the scavenging ring. They may be disposed either in the direction of these said conduits, or else in any desired angle whatsoever thereto.

The period for the introduction of the fuel is, in this arrangement, naturally restricted to the time during which the ports are open.

Figs. 10 and 11 show diagrams of explosion motors of the kind specified, in which A denotes the commencement of the exhaust action, B that of the scavenging process, C the termination of this latter, D the termination of the exhaust action (the closing of the exhaust ports), E the beginning of the fuel admission, F the termination thereof. (The hatched portion of the diagram denotes the period during which the fuel is admitted). Z denotes the period of ignition, H the termination of the combustion process.

Fig. 10 is a view of the average diagram obtained in connection with two such forms of constructions as shown in Figs. 1 or 5.

The admission of the fuel commences, as a rule, soon after the scavenging ports are opened, that is, after the excess of scavenging air required for a complete scavenging action has passed the injector (point E) and continues for a part of the compression action until point F is reached.

Fig. 1 is a diagrammatic view of a working process in which the injection of the fuel is only begun during the compression action and continued beyond the ignition point Z, into the period of combustion.

My invention will notably be found to be of special importance where the conditions for the satisfactory formation of a mixture are rendered peculiarly difficult, hence, particularly in the case of motors having a high number of revolutions, moreover, however, in cases where a simple and reliable motor is required, where a good control is required relatively to speed and load, and where finally importance is attached to the fact of the engine being immediately ready for service, that is of its being readily and quickly thrown into gear without necessitating any delay on account of pre-heating and the like. These conditions are of special importance in connection with motors serving for driving vehicles. Now although the two-stroke process would in and for itself be the most suitable for automobile motors and the like, owing to the possibility it affords of utilizing the machine to a far greater advantage, the four-stroke motor has in this connection been hitherto almost exclusively employed because the aforementioned conditions could only be realized with extreme difficulty in connection with a two-stroke motor.

The present invention affords the possibility of obviating or at least of substantially minimizing these difficulties, and thereby of rendering the two-stroke explosion motor operating with liquid fuel, available, not only for all general purposes, but particularly for automobile motors.

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. A method of working two-stroke cycle internal combustion engines which consists in injecting liquid fuel into a

mass of air rotating within the cylinder of the engine.

2. A method of working two-stroke cycle internal combustion engines which consists in causing the scavenging air entering the cylinder of the engine to rotate within said cylinder and injecting liquid fuel into said rotating mass of air.

3. In a method according to any of the preceding claims causing air to enter the cylinder of the engine in a tangential direction.

4. In a method according to any of the preceding claims causing air to enter the cylinder of an explosion engine in a subtense (substantially tangential direction) and immediately thereafter injecting liquid fuel into said air.

5. In a method according to any of the preceding claims causing scavenging air to enter the cylinder of an explosion engine in a subtense direction and injecting liquid fuel into said cylinder during the scavenging period.

6. In a method according to any of the preceding claims causing scavenging air to enter the cylinder of an explosion engine in a subtense direction and injecting liquid fuel into said cylinder during the scavenging period and beyond the point of ignition.

7. A method of working two-stroke cycle internal combustion engines which consists in causing scavenging air to enter the cylinder of the engine in a subtense direction, injecting liquid fuel into said scavenging air, causing the rotating mixture then formed to be ignited and continuing the injection of fuel even after ignition has been effected.

8. In a two-stroke cycle internal combustion engine the provision in a working cylinder of slots for the introduction of scavenging air disposed in the wall of said cylinder in such a manner as to cause the air to enter the interior of said cylinder in a subtense direction, and means for injecting liquid fuel directly into said cylinder.

9. In a two-stroke cycle internal combustion engine according to Claim 8 the provision in a working cylinder of slots for the introduction of scavenging air disposed in the wall of said cylinder in such a manner as to cause the air to enter the interior of said cylinder in a tangential direction.

10. In a two-stroke cycle internal combustion engine according to Claim 8 an arrangement in which means are provided for injecting liquid fuel into the cylinder in a subtense direction, but counter to the direction of rotation of said air.

11. In a two-stroke cycle internal combustion engine of the kind described an arrangement in which slots for the introduction of scavenging air are disposed in the wall of the cylinder in such a manner as to cause the air to enter the interior of said cylinder in a subtense or tangential direction means also being provided for injecting liquid fuel into the air passing through said slots.

12. In a two-stroke cycle internal combustion engine, in combination, a working cylinder, two pistons adapted to reciprocate in said cylinder in opposite directions, slots for the introduction of scavenging air disposed in the wall of said cylinder for causing the air to enter in a subtense direction and means for injecting liquid fuel disposed between the dead centre and said slots.

13. Two-stroke cycle internal combustion engines constructed and arranged substantially as hereinbefore described and illustrated in the accompanying drawings.

Dated the 8th day of July, 1920.

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Agents for the Applicant.

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147,730 COMPLETE SPECIFICATION

3 SHEETS

SHEET 1

Fig. 1

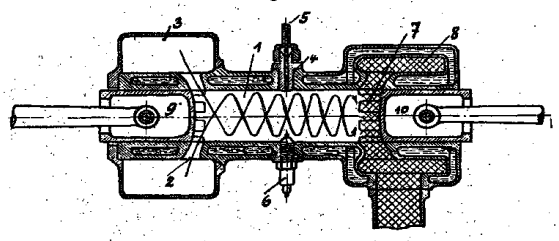
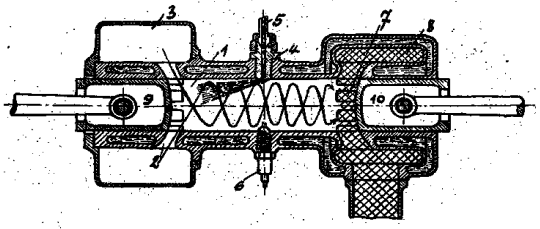


Fig. 2

Fig. 3

Fig. 4

Fig. 5



SHEET 2

Fig. 6

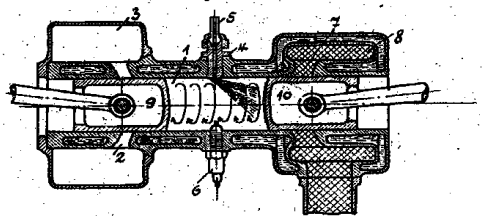


Fig. 7

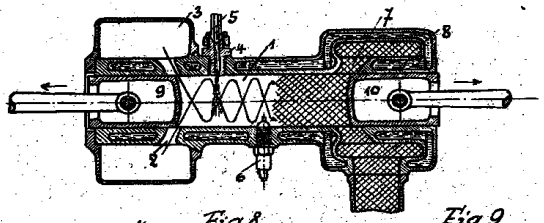


Fig. 8

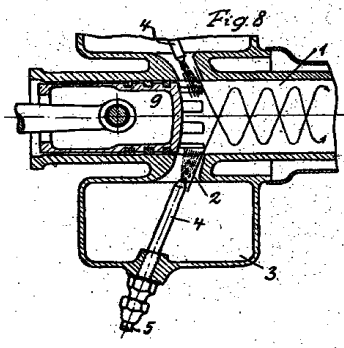


Fig. 9

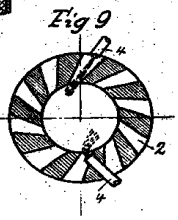


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Fig. 1

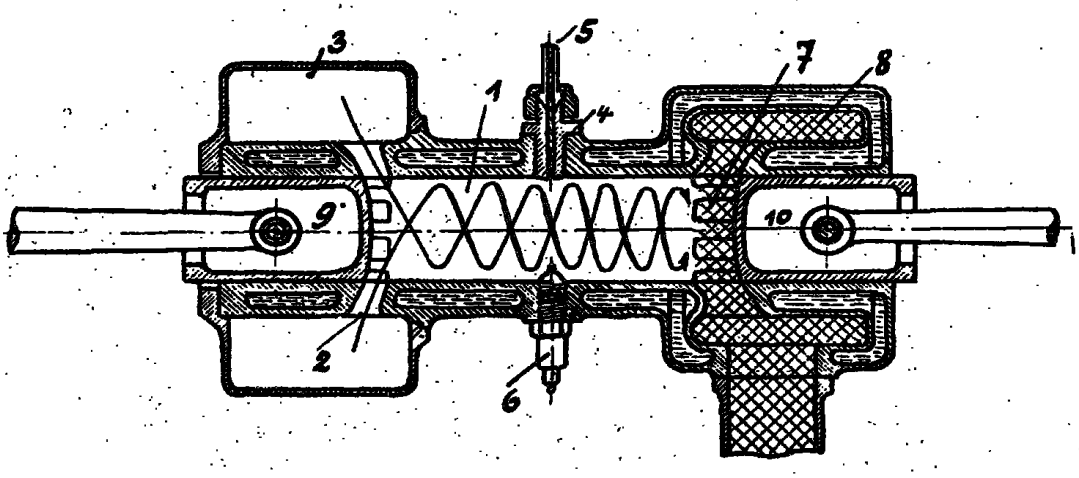

Fig. 2

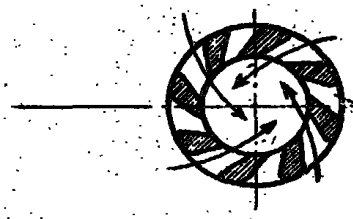

Fig. 3

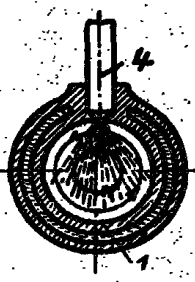

Fig. 4

Fig. 5

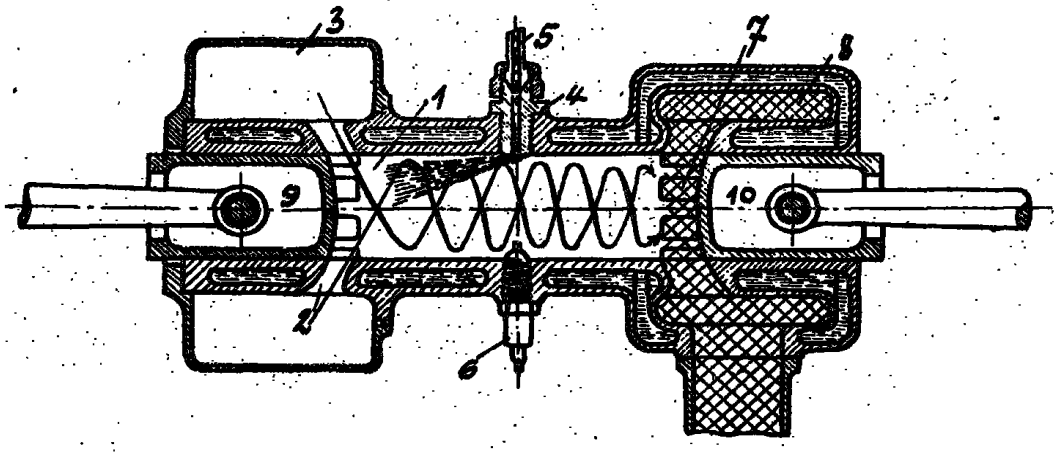

Fig. 6.

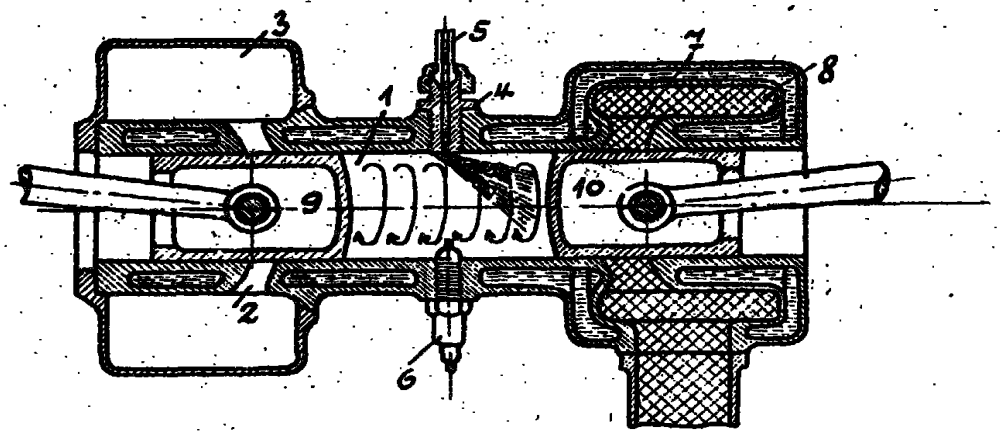

Fig. 7.

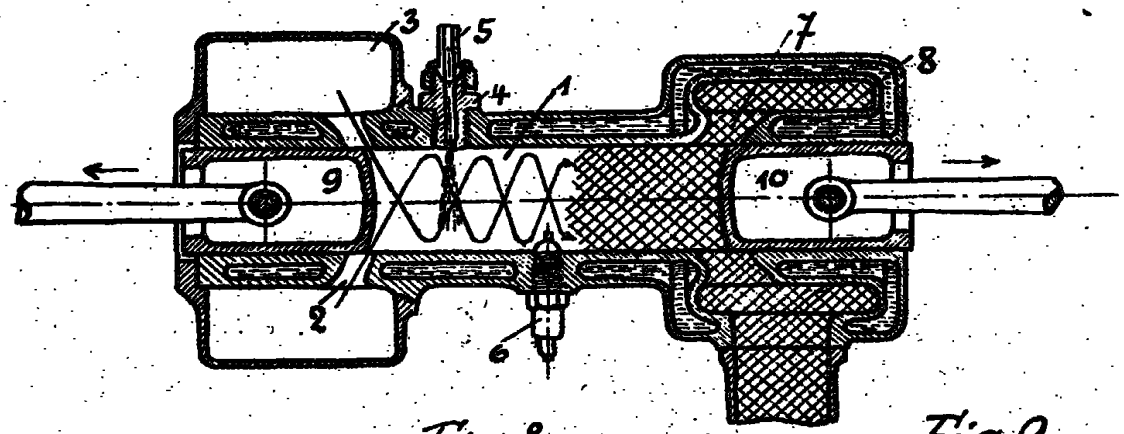

Fig. 8

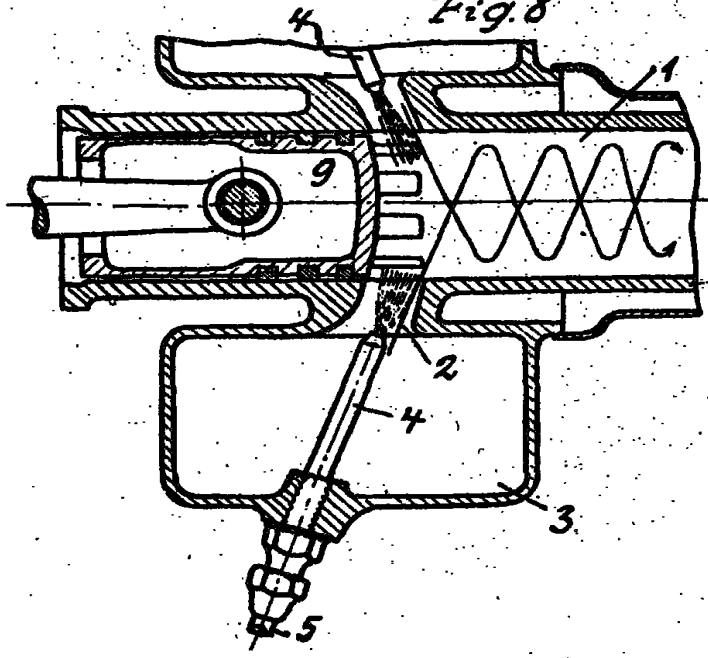

Fig 9

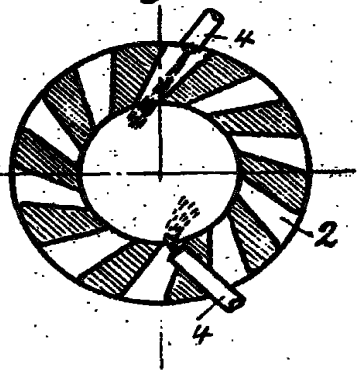

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Fig. 10

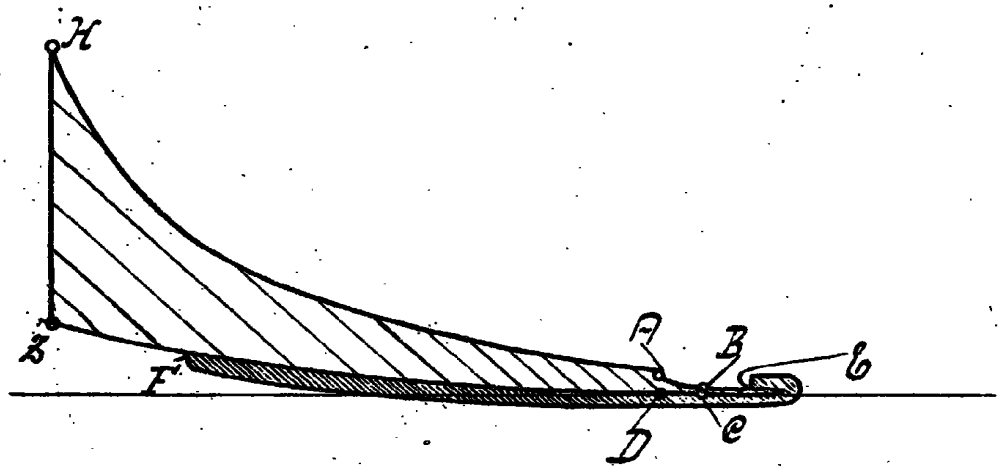
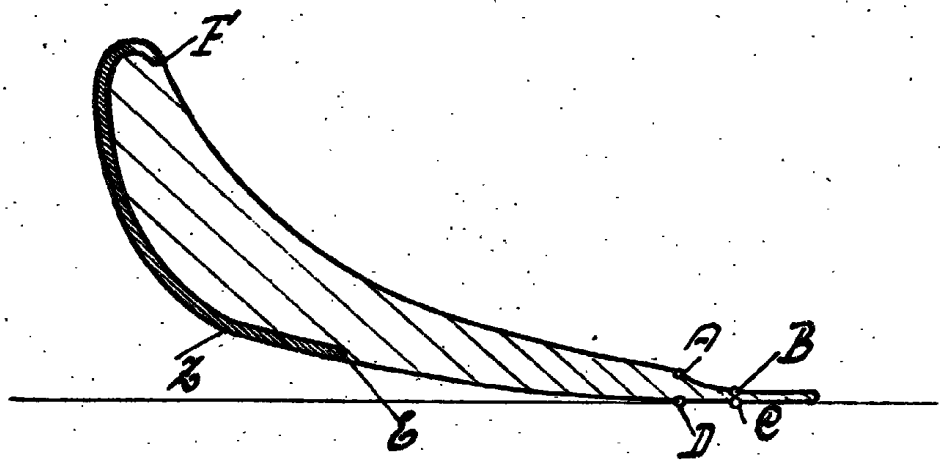


Fig. 11.



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