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MINATURE COMBUSTION-IGNITION ENGINE HAVING MEANS FOR VARYING THE COMPRESSION RATIO

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Fig.1

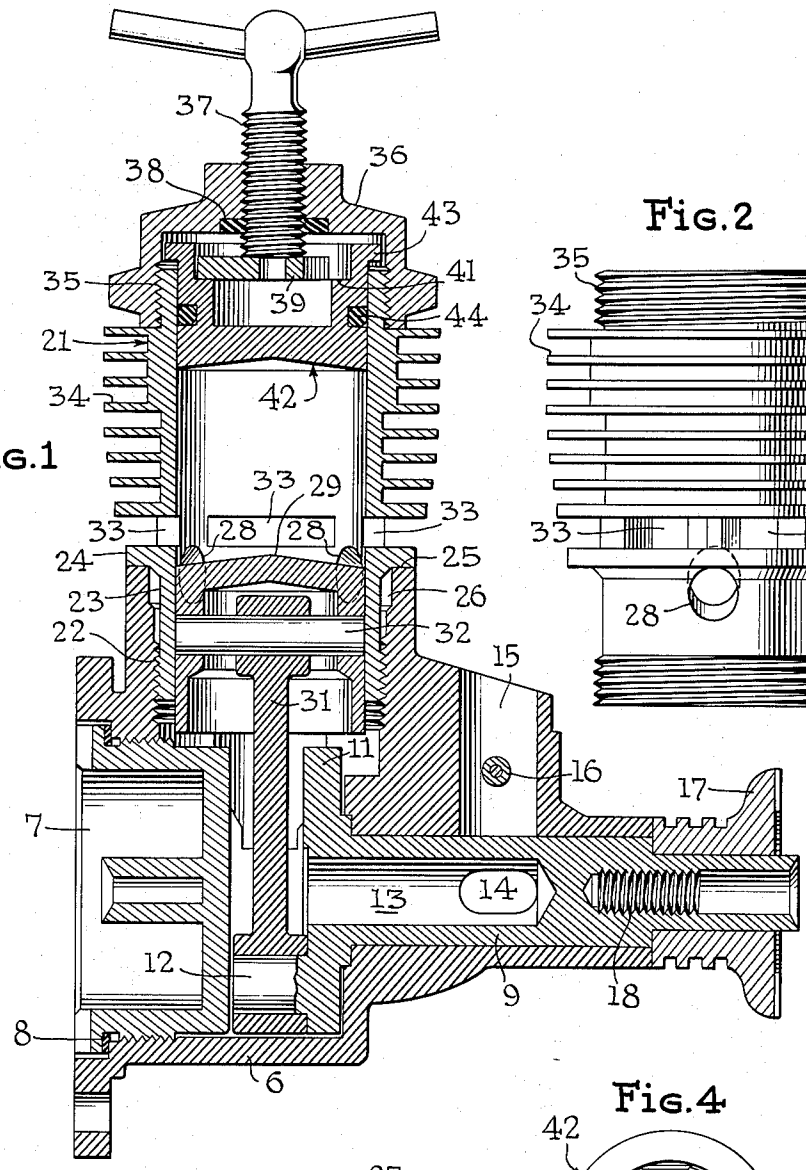


Fig.2

Fig.3

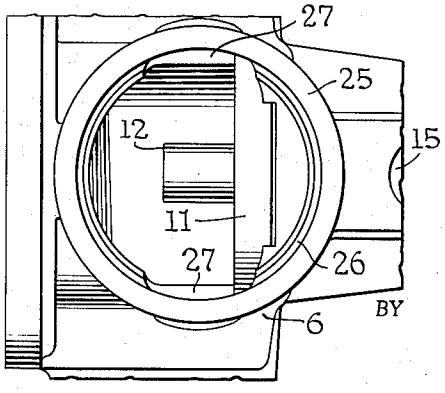
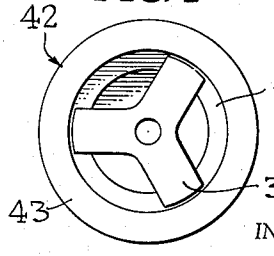


Fig.4



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MINIATURE COMBUSTION-IGNITION ENGINE HAVING MEANS FOR VARYING THE COMPRESSION RATIO

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1 Claim. (Cl. 123—48)

This invention relates to miniature two stroke cycle internal combustion engines. In miniature engines the conditions of use impose some restrictions that have no parallel in full sized engines, and relax some others so that constructions not usable in a full sized engine are desirable.

Before describing applicant's improved engine, and as a basis for evaluating what applicant has done, a brief statement of significant special considerations will be given.

The chief field of use for miniature internal combustion engines is as power plants for miniature airplanes. These airplanes are used extensively for amusement and to a considerable extent as training targets.

This use imposes requirements as to lightness so insistent as to stimulate new demands, whenever an improvement is made. First the planes carried small batteries for ignition. The advent of glow plug ignition made it possible to use batteries only for starting, so the batteries could be left on the ground. Today the glow plus is obsolete and a true compression-ignition miniature is available. Because of the tremendous rotary speeds at which these engines run, and the high compression ratios necessary for running, and even for starting, the shock loads on the crank shafts and particularly on crank pins tend to be destructive and cause fatigue failures. These failures have been frequent enough to retard the adoption of compression-ignition miniature engines, but applicant has now discovered that fatigue failures can be eliminated, or at any rate reduced to a tolerable risk, by introducing elasticity, not in the crank or piston, but in the cylinder head.

As a practical matter the compression ratio of a miniature compression-ignition engine must be adjustable. The simple solution is to use a piston-like cylinder head sustained by an adjustable thrust screw, start the engine at a compression ratio determined by trail and then set it to a higher compression ratio to secure the best available performance. The optimum compression ratio for starting is lower than that for running but each is affected by load and by other variables, and neither can be treated as a fixed quantity.

In the prior art the cylinder head was a close fit. The head was required to move only when the adjusting screw was turned. Applicant uses a free fit, and relies on an O-ring of rubber-like material for a seal. Other have used O-rings but with tight fits. Applicant provides a stop, conveniently a shoulder, to limit the adjustment toward higher compression, the limitation being such as will preclude contact of the cylinder head with the piston. An incidental advantage of such a stop is that it prevents the freely fitted cylinder head from being sucked inward too far during starting. Between the adjustable cylinder head and the adjusting screw applicant interposes yielding means, desirably a Y-shaped plate spring of quite heavy stock, and called a "shock-pad."

Free fit and yielding mounting afford sufficient shock

relief to multify the probable life of a crank shaft by a factor of 5.

The fit of the cylinder head, though free, is close enough to give protection to the O-ring which is of a heat resisting synthetic rubber-substitute. In applicant's engine the life of the O-ring has been found to approximate that of the engine. This is accounted for, by the facts that the cooling of the cylinder is good, and the running periods of most miniature engines are short, commonly two to four minutes, though much longer periods are practicable and occasionally occur.

It has been proposed to use in miniature engines a cylinder head which is adjustable to vary the compression ratio. It has also been proposed in a patent to use in large engines (i. e., not miniature engines) a yieldingly mounted plunger smaller than the cylinder, subject to pressure in the working space, and intended to relieve shocks. Such a plunger, as proposed, required the use of elaborate piston packing rings which inherently develop considerable friction.

These broad ideas are factors in applicant's problem, but the prior art does not solve the problem presented by a miniature engine. In such an engine the structure must be light, the cylinder head must shift with reasonable freedom (and at the same time must be sealed), and shocks must be absorbed.

Thus a piston-like cylinder-head or contra-piston as it is called in the miniature engine art, freely fitted in the cylinder bore gives free action, the O-ring used as hereinafter described gives a good seal and has an acceptable life despite the free fit, and the shock-pad can be proportioned to give the desired shock absorption.

As a consequence crank shaft failures have ceased to be a problem. Shafts used to last two to three hours. Fifteen is now considered a minimum life and some have lasted fifty hours. Similarly a close but free fit of the cylinder head increases the life of an O-ring from about three hours to fifteen. An extended life in a ratio of five to one was certainly beyond prediction. The figures given are based on tests conducted on actual miniature engines, many of which have been built and run to destruction.

The invention will now be described by reference to the accompanying drawing which as filed in the Patent Office shows a commercial engine magnified about three diameters.

Fig. 1 is a section on the plane defined by the axes of the cylinder and crank shaft.

Fig. 2 is an elevation of the cylinder.

Fig. 3 is a fragmentary plan view of the crank case as it appears after removal of the rear plug, cylinder, piston and connecting rod, the crank-shaft remaining in place, so that the crank disc and crank pin are visible.

Fig. 4 is a plan view of the adjustable cylinder head or contra-piston with the shock-pad in place.

Statements of direction refer to the engine positioned as in Fig. 1, in which position the right hand end of the shaft carries the propeller (not shown). Tractor mounting being usual this will be called the forward end.

The crank case 6 is a die casting and is of familiar form, and quite clearly illustrated in Figs. 1 and 3. A cup-like plug 7 is threaded into the rear and seals against a gasket 8. Its removal permits the insertion of crank-shaft 9 with its integral crank-disk 11 and crank-pin 12.

Shaft 9 is bored axially from its inner end at 13, and has a side port 14 located to time properly in-flow of air from the atmosphere to the crank case through port 15. In port 15 is the fuel feeder 16 of conventional form.

A hub 17 makes a pressed fit on a reduced portion of shaft 9, limits axial motion of the shaft and offers a seat for the propeller (not shown). This is retained by a

screw, which may engage the threads 18 provided for that purpose.

A cylinder generally indicated by the numeral 21 has at its lower end threads 22 which stand proud of the sleeve 23 on which they are formed. At the upper end of the sleeve is a flange 24 which engages a seat 25 formed around an opening in the top of the crank case 6. The effect is to afford an annular chamber 26 which encircles the sleeve 23 below the flange 24 and to which grooved passages 27 lead. The passages 27 are best shown in Fig. 3. Their effect is to maintain constant communication between the interior of the crank case and the annular chamber 26 from which inlet ports 28 lead to the cylinder bore. These are so located as to be exposed by the piston 29 when the latter is at its crank-end dead point.

A connecting rod 31 engages the crank pin 12 and the wrist-pin 32 fixed in the piston 29. The exhaust ports are slots 33 cut through the cylinder walls above the flange 24. They are so located as to be exposed by the piston 29 on the down stroke immediately before the inlet ports 28 are exposed. This is a well known transfer port arrangement for which no novelty is here claimed.

For cooling purposes, the cylinder is encircled by fins 34. Above the topmost fin 34 the cylinder barrel is externally threaded at 35 to receive what may be described as a cover 36. This cover is not the true cylinder head. It is primarily a support for the cylinder head. It carries, threaded through it, a screw 37 which may readily be turned by a cross bar clearly shown in the drawings. The screw 37 is frictionally retained by the insert 38 and bears at its lower end on a resilient steel member 39 which will be termed the shock-pad.

The shock-pad is a stiff spring made of heat treated steel. As viewed in Figs. 1 and 4, it might be described as a Y-shaped member having a central hole, but functional considerations will be better stated if it be described as an annular member with radial fingers. Such a description would include a number of minor variants which can be evolved without changing the functional aspects of the shock-pad. It is basically a stiff spring designed for good fatigue characteristics.

The ends of the arms of the shock-pad 39 seat on a shoulder 41 formed in the upper portion of a movable contra-piston 42. This contra-piston head makes a free fit in the upper end of the bore of cylinder 21 and its downward motion is limited by stop means which, in the example illustrated, take the form of a peripheral flange 43 designed to engage the upper end of the cylinder.

When the contra-piston 42 is in its lowermost position the clearance space above the piston, at its head-end dead-point, is approximately 2% of the stroke.

The contra-piston 42 makes a free fit in the cylinder, one comparable with the fit of piston 29, which produces a satisfactory running seal without packing rings or even grooves. Such a piston is commonly called a plug piston, and the term will be used in that sense. The limits on the fit of a plug piston are close, say a diametric clearance of 0.0002" to 0.0003", when new. Because plug pistons are lapped in the cylinders the final dimensions are not precisely determined. They are the closest working fit that can be produced by commercial methods. The fit of the contra-pistons, which are ground to size and not lapped can be somewhat more free, say a diametric clearance of 0.0005" to 0.0010". Thus the contra-piston can be slightly more freely fitted than a plug piston for the same cylinder. Too free a fit shortens the life of the O-ring.

One might assume on first impression that the ring 44 would be destroyed rather quickly by heat. This, however, is not the case. The life of the ring, when used according to the invention, is comparable to the life of the engine as a whole. This is so because two conditions are met, neither of which conditions should be relaxed. The first condition is that the cylinder is adequately finned and consequently resists undue rise in temperature. The second condition is that the fit of the contra-piston 42, although free enough to permit the contra-piston to yield, is close enough to resist the penetration of combustion gases to the ring 44.

The adjustment of the clearance by turning screw 37 is quite critical both for starting and for running. The optimum adjustments, for these two conditions, differ.

In the claim the term "close working fit" will be used to define a close fit permitting motion under the pressures at which the miniature engine cylinder operates, say 0.0005" to 0.0010" diametric clearance. The term "high scale" as applied to a spring means a steep rise of resistance with deflection.

The fuel mixture is customarily a petroleum base such as kerosene or gasoline with lubricating oil of proper grade and a highly volatile combustible such as ether.

What is claimed is:

The combination of a miniature internal combustion engine having an open ended cylinder; a contra-piston making a close working fit in the bore of said cylinder and closing said open end, said contra-piston being recessed in its outer face and having marginal stop means which engage the outer end of the cylinder to limit inward motion of the contra-piston; supporting means carried by said cylinder and including a thrust member adjustable in the direction of the cylinder axis toward and from the contra-piston; and a spider-shaped spring overlying said recess, engaged at its center by said thrust member and having at least three substantially radial spring-arms which engage said contra-piston at points approximately uniformly spaced around the periphery thereof.

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