

June 10, 1930.

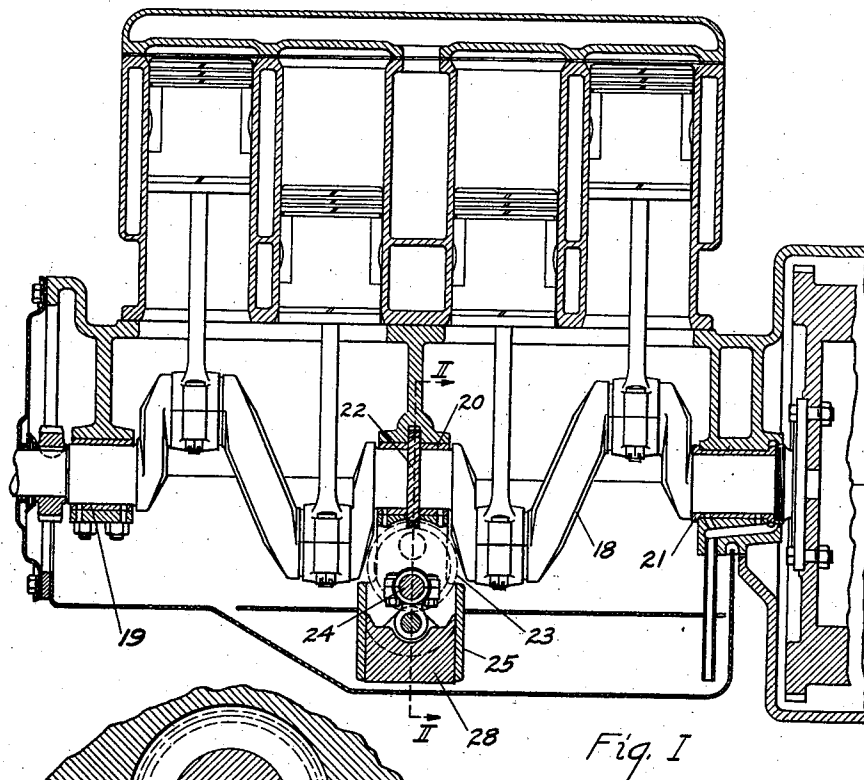
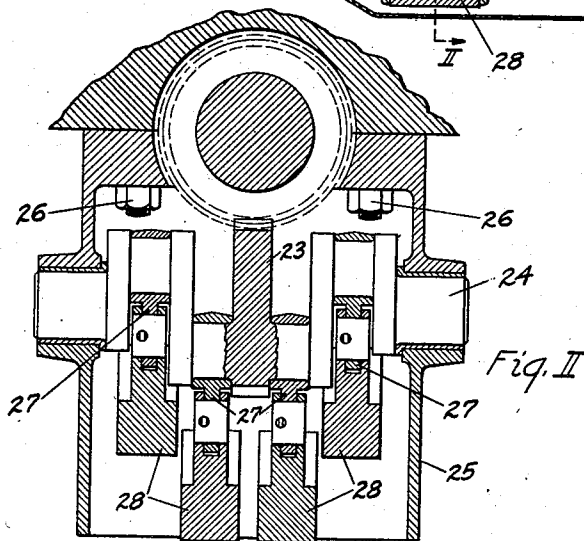
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1,762,860

BALANCER FOR RECIPROCATING ENGINES

Filed April 12, 1924

4 Sheets-Sheet 1



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4 Sheets-Sheet 2

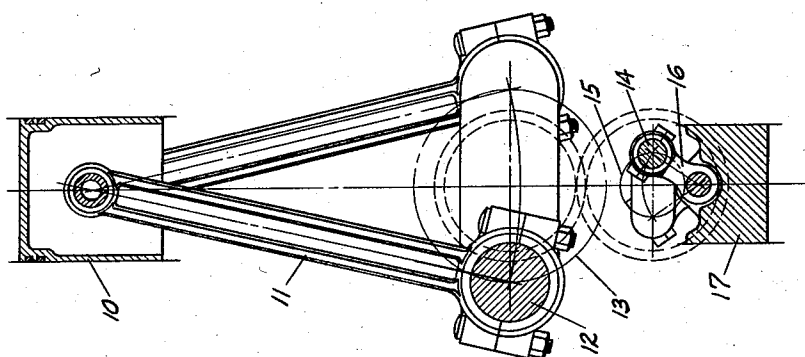


Fig. III

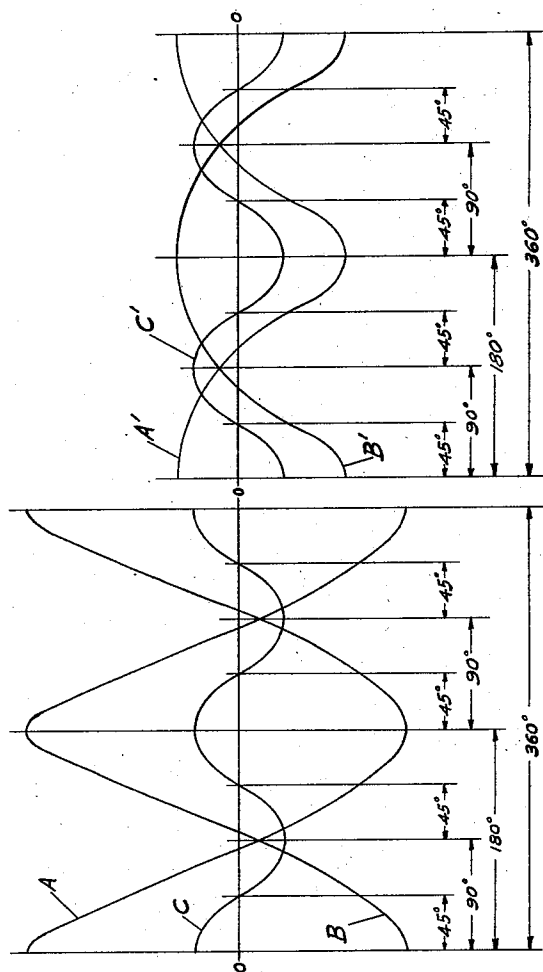


Fig. I

Fig. II

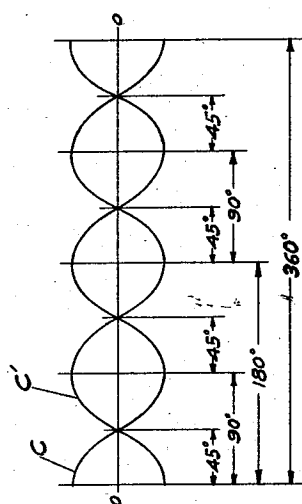


Fig. III

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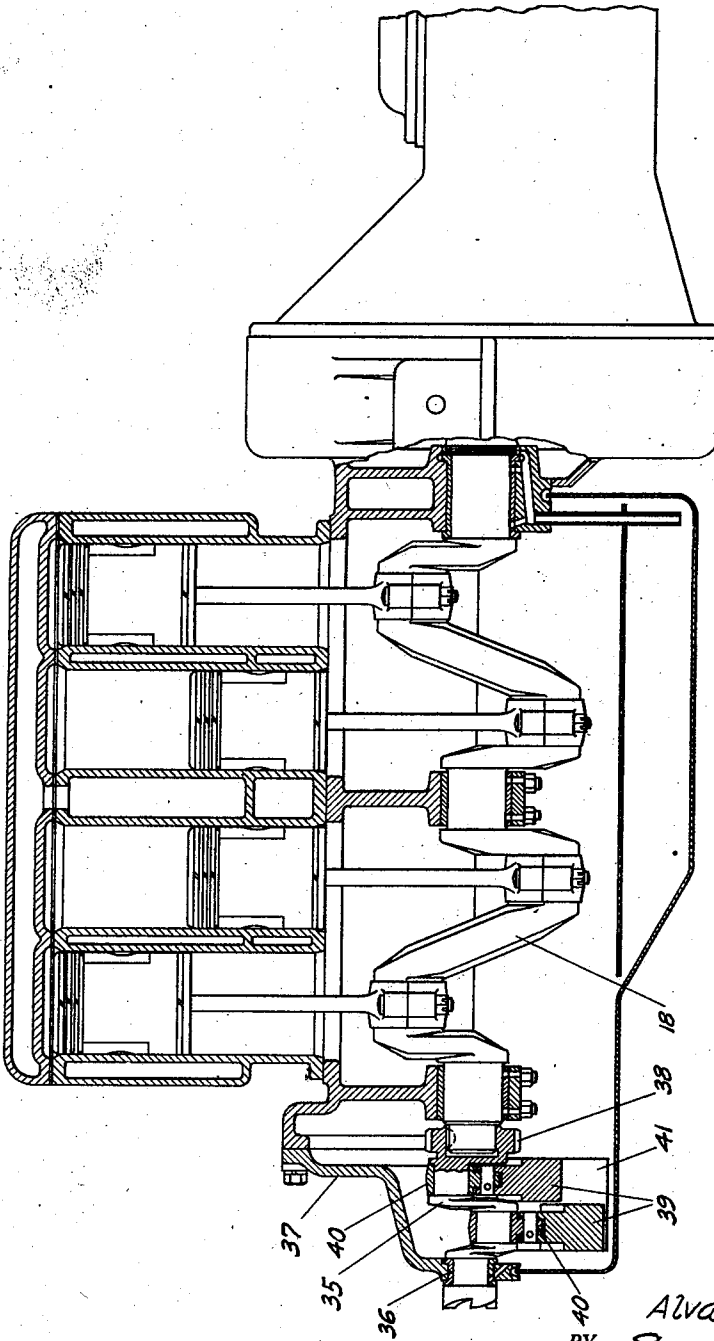


Fig. VII

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4 Sheets-Sheet 4

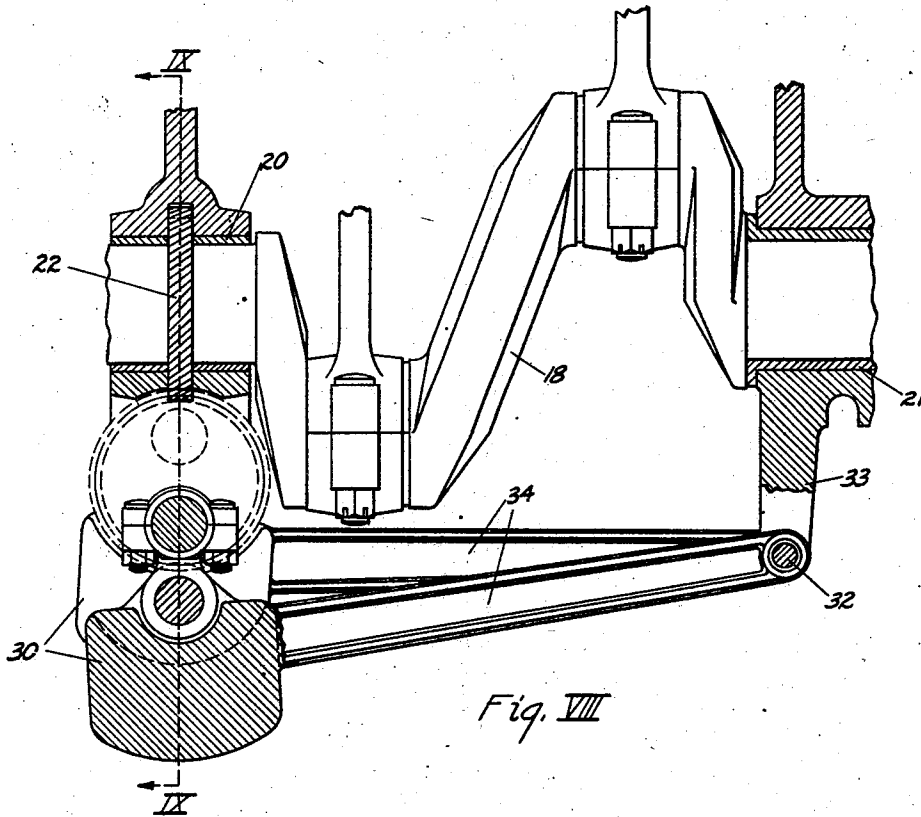


Fig. VIII

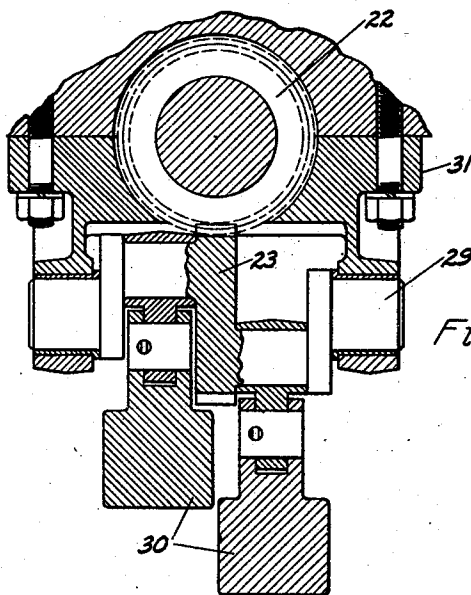


Fig. IX

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UNITED STATES PATENT OFFICE

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BALANCER FOR RECIPROCATING ENGINES

Application filed April 12, 1924. Serial No. 706,099.

This invention relates to improvements in means for counterbalancing secondary inertia forces in reciprocating engines.

One object of the invention is the production of relatively simple, inexpensive and reliable mechanism for accomplishing this purpose.

Another object is to eliminate the necessity for moving parts at relatively high speeds, as for instance, at double crankshaft speed.

Other objects, and objects relating to details of construction and economies of manufacture, will appear as I proceed with the description of that embodiment of the invention, which, for the purposes of the present application, I have illustrated in the accompanying drawings, in which:

Figure I is a vertical longitudinal section through an internal combustion engine, embodying my invention.

Fig. II is a transverse vertical section through a portion of the engine, the section being taken substantially on the line II—II, Fig. I.

Fig. III is a diagrammatic view showing the relative proportions and positions of the parts in one form of the invention.

Fig. IV is a diagram of inertia forces in a two, four or eight-cylinder motor, where the cylinders are all in line and the crank throws all in the same plane.

Fig. V is a diagram of inertia forces of my counterbalancing mechanism.

Fig. VI is a diagram in which the secondary inertia force curves of Figs. IV and V are superposed.

Fig. VII is a vertical longitudinal sectional view of an internal combustion engine, showing a modified form of the invention.

Fig. VIII is a vertical longitudinal sectional view of a portion of an engine showing another modification, and

Fig. IX is a transverse sectional view taken substantially on the line IX—IX, Fig. VIII.

Similar reference characters refer to like parts throughout the views.

Referring to Fig. IV, the curve A may be considered as the total inertia force curve of one of the pistons with its associated moving

parts, in a two-cylinder engine, where the cylinders are parallel and side by side, while B is a similar curve for the other piston and associated parts, it being understood that in plotting the curves, the ordinates represent the inertia forces, while the abscissas represent the corresponding crankshaft angles. The curves A and B are identical and spaced 180° apart, but owing to the angularity of the piston connecting rods, the portion of each curve above the base line $o-o$ is different from that below the base line, and the two curves do not balance. The line $o-o$ represents the abscissa at which the forces are numerically zero. When superposed, they combine to form the curve C representing what is known in the art as the secondary inertia force. Fig. IV would be the same for a four-cylinder in line engine, or an eight-cylinder in line engine, with the crank throws all in the same plane, each curve A and B then representing the total inertia force of a set of pistons moving together, instead of one piston.

It is a principle of the present invention to counterbalance the secondary inertia force represented by the curve C with another secondary force whose curve has the same amplitude and period as the curve C, but which is in phase directly opposed to that of the curve C. It will be noted that in Fig. IV, the curve C has two complete periods for every one of the curves A and B. It has been proposed to balance such secondary force by means of a weight of proper size rotated at twice crankshaft speed, the total inertia force of the weight which induces no secondary force being utilized to balance the secondary force of the engine. In order to cancel out horizontal inertia forces, the weight is generally divided into two parts which are rotated in opposite directions. In my invention, however, instead of making use of the simple inertia forces of weights, rotating at twice engine speed, I move the weights at engine speed in a manner to produce secondary inertia forces, and I employ only such secondary forces for engine balancing purposes, the primary forces being balanced against each other in the same man-

ner as in the engine itself. The secondary force thus obtained from the motion of the weights is represented in Fig. V of the drawing, by the curve C'. This curve is the resultant of the curves A' and B', which represent the total inertia forces of two weights presently to be described. The resultant of the two curves C and C' is a straight line coinciding with the base line, as illustrated in Fig. VI.

My invention in its broader aspect, comprehends the use of various means for moving weights in paths parallel or substantially parallel to the paths of movement of the engine pistons, giving them the same number of reciprocations as the engine pistons have, and producing secondary forces in the weights by causing them to move faster between the middle point and one extreme of their motion, than between the middle point and the other extreme of their motion. A convenient way to produce this result, is by the use of connecting rods for the weights, and this is the means which I have illustrated in the drawings.

In Fig. III, which is more or less diagrammatic, an engine piston is illustrated at 10. A connecting rod 11 joins the latter with the corresponding crank of a crankshaft 12. The circle of motion of the crankshaft crank is indicated by the line 13. The circle of motion of the crankshaft 14 of the counterbalancing device, is indicated by the line 15, one of the connecting rods being shown at 16, and the corresponding weight driven thereby, at 17. The weight might be of the same mass as the piston 10, the connecting rods 11 and 16 of the same length, and the circles of motion 13 and 15 of the same radius. For practical reasons, however, it is desirable to use relatively short connecting rods 16 and to make the ratio between crank throw or radius and connecting rod length, as large as practicable. The weights 17 may be mounted to slide between guiding walls, or the direction of their motion otherwise controlled.

Referring now particularly to Figs. I and II, the engine crankshaft is represented at 18 and the crankshaft bearings at 19, 20 and 21 respectively. The central bearing 20 is split in order to accommodate a spiral gear 22 fixed upon the crankshaft. The latter gear meshes with a second spiral gear 23, which is preferably integral with a small transverse crankshaft 24 mounted in bearings in the ends of a box-like frame 25, which may be secured to the central bearing bracket by means of bolts 26 or the like. The crankshaft 24 is formed with four cranks upon which are journaled four short connecting rods 27 pivoted at their outer ends to four weights 28. The weights, as shown, are relatively long and narrow, their end surfaces being guided between the side

walls of the frame 25. With the exception of the gear 22 upon the engine crankshaft, all parts of the counterbalancing mechanism of Figs. I and II may be assembled as a unit and may be readily applied to or removed from an engine, it being noted that the upper portions of the side walls of the frame 25 are cut away, thus giving access to the bolts 26, as well as clearing the adjacent cheeks of the engine crankshaft.

The modification illustrated in Figs. VIII and IX is similar to that just described. In this form, however, the small crankshaft 29 has two throws instead of four, and each weight 30 is equivalent in mass to two weights 28, it being assumed that the ratio between the crank rods and connecting rod lengths remains the same. In theory, the weights 30 are out of balance in a transverse direction, but they are so close together that the couple set up would probably not be objectionable. In this form of the invention, the frame 31 extends downwardly only far enough to provide bearings for the crankshaft 29, the weights 30 oscillating in an arc of long radius whose center is at the pivot bearing 32. The pivot 32 is supported upon a bracket 33 which may be an integral part of the support for the main bearing at one end of the engine. The rods 34 integral with or fixed to the weights 30, are loosely mounted upon the pivot 32.

In Fig. VII, I have illustrated my balancing device as applied directly to the engine crankshaft, all gears being eliminated. The balancer may be located upon the crankshaft at whatever point of the latter may be convenient. If it is to be mounted at the front end of the engine, I prefer to use a small separately constructed two-throw crankshaft 35, which is mounted at its forward end in a bearing 36 supported in an extension 37 of the crank-case. The rear end of the shaft 35 is in the form of a cup adapted to fit snugly upon the constricted forwardly projecting end of the engine crankshaft 18, being keyed thereto to turn therewith. If desired, the rear end of the shaft 35 may have a timing gear 38 cut therein. The two weights 39 are driven by means of short connecting rods 40 journaled upon the two throws of the shaft 35, the weights being guided in any suitable manner, preferably between the walls 41 integral with the housing extension 37.

In the forms of the invention shown in Figs. VII, VIII and IX, the two weights moving oppositely to each other are balanced so far as primary inertia forces are concerned. In the four-cylinder engine illustrated, two of the pistons with their associated moving parts are balanced against the other two, insofar as primary inertia forces are concerned. These two sets of pistons in the engine, however, produce a

secondary inertia force represented by the curve C in Figs. IV and VI. The balancers illustrated in Figs. VIII and IX and in Fig. VII, also have secondary inertia forces, and the proportions of the parts are so selected that this secondary force shall be equal to that set up in the engine, as represented by the curve C' in Figs. V and VI. The two secondary forces being in opposite phase, cancel out, and such engine vibrations as are due to this cause are eliminated.

The apparatus shown in Figs. I and II is the same in principle, but the two weights are split up into four, in order to permit a construction for the small crankshaft, which will eliminate the couple heretofore mentioned in connection with Figs. VIII and IX.

As a usual thing, it will be found desirable to select weights and design the proportions of the moving parts of the mechanism, such that the balancer will compensate for all of the secondary inertia force in the engine. It may be, however, that under some circumstances, as for instance where the balancer is applied to one end of the engine as in Fig. VII, it will be desirable to compensate for a portion only of the engine secondary force.

While I have illustrated and described somewhat in detail, certain modifications of my invention, it is to be understood that this showing and description are illustrative only, and that I do not regard the invention as limited to the details of construction illustrated and described, except insofar as I have included such limitations within the terms of the following claims, in which it is my intention to claim all novelty inherent in the invention broadly, as well as specifically.

I claim as my invention:

1. In combination, a multi-cylinder engine, a crankshaft having cranks with relatively long throws spaced 180° apart, pistons, relatively long connecting rods between said cranks and pistons, a pair of reciprocating weights, a pair of relatively short cranks spaced 180° apart, connected to be driven at the same speed as said long throw cranks, and relatively short connecting rods between said short cranks and said weights, the ratio of the length of each short crank to the length of each short connecting rod being greater than the ratio of the length of each long crank to the length of each long connecting rod.

2. In a multi-cylinder engine, an even number of pistons, a connecting rod for each piston, a crankshaft having a crank for each piston and two additional cranks, connecting rods for said additional cranks and weights connected to said connecting rods, said additional cranks being arranged to drive said weights in opposite phase and

to produce secondary inertia forces in the weights directly opposite to the secondary inertia forces of the pistons, the ratio of the length of each additional crank to the length of its respective connecting rod being greater than the ratio of the length of each main crank to the length of each piston connecting rod.

3. In a multi-cylinder engine, an even number of pistons, a connecting rod for each piston, a crank shaft upon which said connecting rods have bearing, two additional connecting rods having bearing upon two opposed cranks of said crank shaft the ratio of the length of each additional connecting rod to the length of its respective crank being greater than the ratio of the length of the opposed crank to the length of the piston connecting rod, and guided weights connected to said additional connecting rods whereby said weights are driven in opposite phase and together produce secondary inertia forces directly opposite and substantially equal to the secondary inertia forces of the pistons.

4. In combination, a multi-cylinder engine including a crankshaft and reciprocating parts having secondary inertia forces, said reciprocating parts being operated by connecting rods connected to cranks forming a part of said crankshaft, auxiliary connecting rods and crank shaft having counterbalancing weights joined thereto and driven at crankshaft speed, the ratio of the length of the counterbalancing weight crank throw to the corresponding connecting rod length being greater than the ratio of the said reciprocating parts crankthrow to the corresponding connecting rod, whereby the reciprocating parts may have their secondary inertia forces balanced by weights of less mass than the mass of the said reciprocating parts.

5. A multi-cylinder engine including a main crankshaft having pistons connected thereto by connecting rods inherently balanced as to primary forces, an auxiliary crankshaft having weights of predetermined mass connected to the individual cranks by connecting rods rotated in synchronized relation with respect to the main crankshaft and likewise inherently balanced as to primary forces the ratio of the length of the main crank to the length of the main connecting rod being less than that of the auxiliary crank to its connecting rod.

In testimony whereof, I affix my signature.

ALVA B. GILBERT.