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A. A. ZUHN
ENGINE BALANCER

2,566,476

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2 Sheets-Sheet 1

FIG. 1.

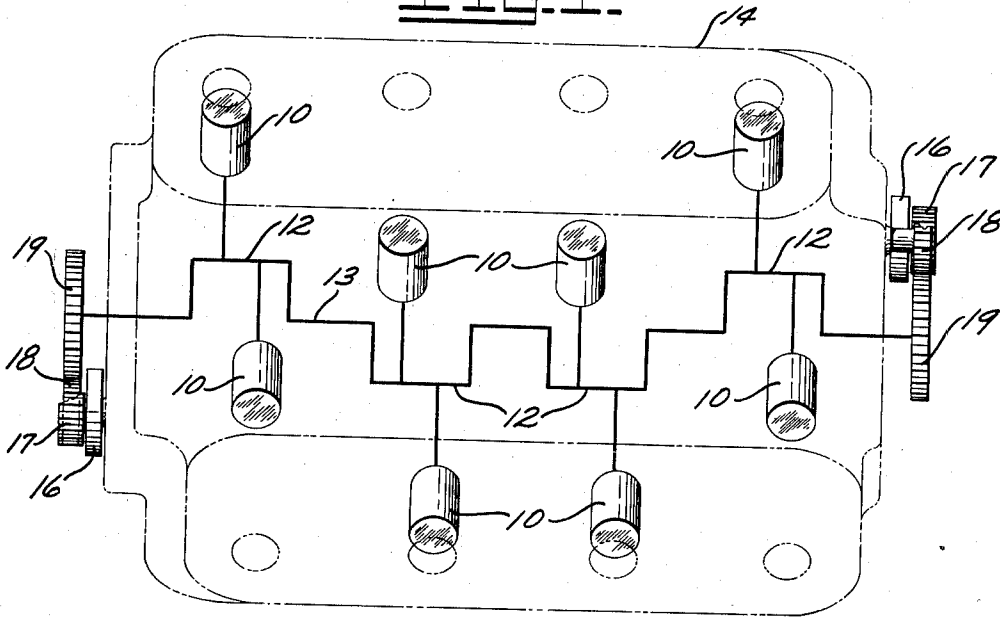
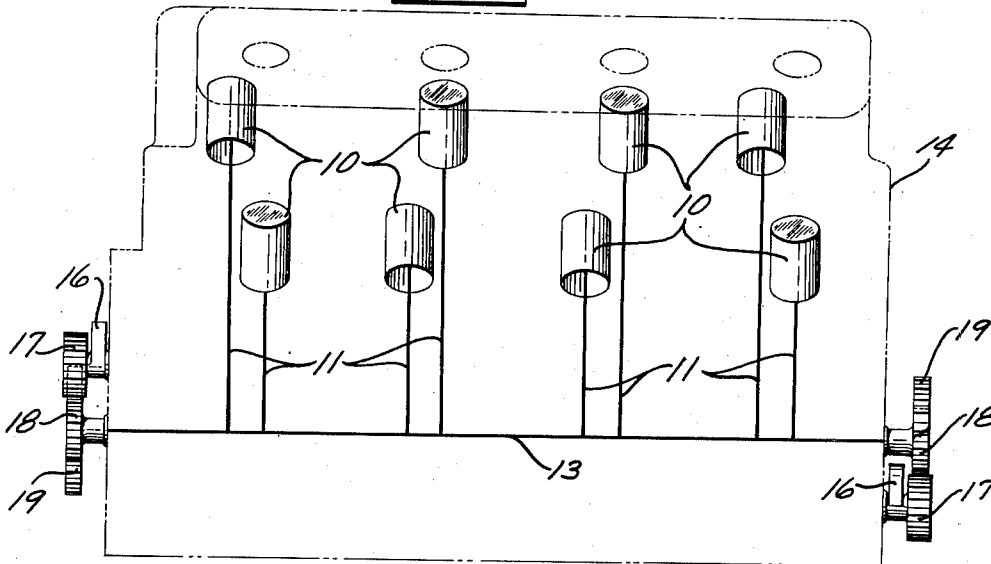


FIG. 2.



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FIG-3-

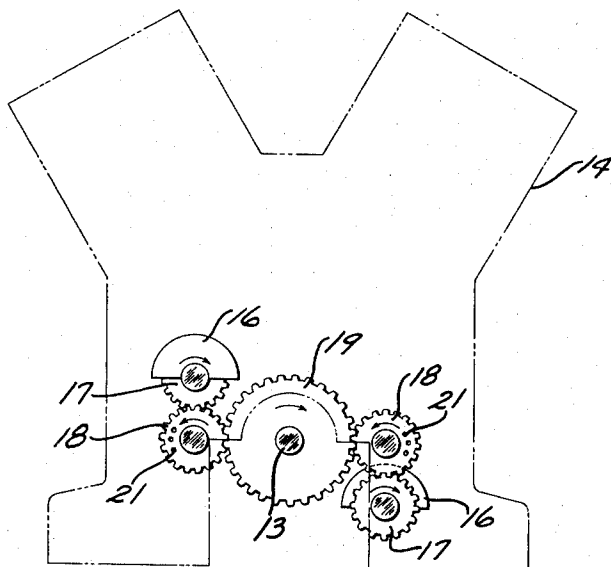
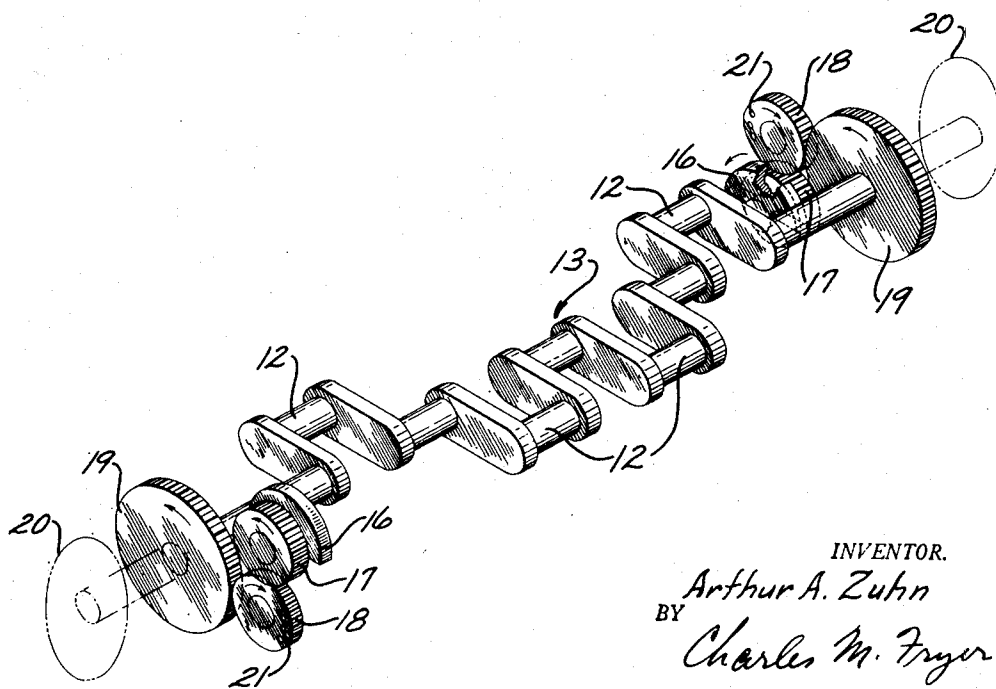


FIG-4-



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ENGINE BALANCER

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3 Claims. (Cl. 74-604)

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This invention relates to reciprocating engine balancers in general and more particularly to an engine balancer for neutralizing simultaneously, force and moment unbalance of the same order.

The present invention is illustrated in its application to a 60° V-8 engine having all of the crankshaft throws disposed in a single plane and in which the cylinders in one bank are offset with relation to the cylinders in the other bank. Such an engine illustrates the conditions of unbalance with which this invention is particularly concerned, however, its application to other types of engines having similar conditions of unbalance will be readily apparent.

For example, in an eight cylinder engine having the cylinders arranged in banks of four inclined at 60° to each other and having a crankshaft in which all the crankpins lay in a single plane, a second order force unbalance rotating in the same direction as the crankshaft is always present. In addition, if in such an engine, the cylinders in one bank are offset with relation to the cylinders in the other bank to permit two connecting rods, one associated with a piston in each bank, to be connected to a single crank throw in side by side relationship, a condition of second order moment unbalance rotating in the opposite direction from that of the crankshaft is produced. The force unbalance may be easily and simply neutralized by the provision of a pair of eccentrically mounted rotating weights, rotated at twice engine speed and in the same direction as the crankshaft. However, in the past, it has not been practical to include means for neutralizing the moment unbalance occurring in such an engine and as a result, it was necessary to rely on engine designs in which moment unbalance was held to a minimum.

It is, therefore, an object of this invention to provide a simple and easily manufactured balancer for neutralizing the moment unbalance occurring in a reciprocating engine. Another object of this invention is to provide a combination moment and force balancer for a reciprocating engine.

Other objects and advantages of this invention, as well as the manner in which the invention is carried into practice, will be made apparent in the following specification wherein reference is made to the accompanying drawings.

In the drawings:

Fig. 1 is a schematic illustration in plan view of a 60° V-8 engine having four crankthrows, all of which lay in a common plane and having the cylinders in one bank offset with relation to the cylinders in the other bank;

Fig. 2 is a similar schematic view in side elevation of the engine illustrated in Fig. 1;

Fig. 3 is a schematic view of the right hand end of the engine illustrated in Fig. 1; and

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Fig. 4 is an isometric view of the crankshaft and balancers for such an engine illustrating a typical force diagram which may exist at each end of the crankshaft due to moment unbalance.

In Figs. 1 and 2, the principal reciprocating masses of an internal combustion engine are illustrated schematically as comprising pistons 10 and connecting rods 11, connecting the pistons to spaced crank throws 12 provided on a crankshaft 13. The crankshaft is supported for rotation in a conventional manner in a cylinder block indicated at 14 in broken lines. The pistons are adapted for reciprocation in conventional cylinders disposed within the cylinder block and are arranged in two banks of four cylinders each bank being inclined at an angle of 60° to the other. Each of the crank throws carries two of the connecting rods in side by side relationship, one of which is associated with a piston in each bank. In an engine of this type, the reciprocating masses inherently produce a second order force unbalance rotating in the same direction and at twice the speed of the crankshaft which is always present in a 60° V-8 engine employing a crankshaft having all of its crank throws in a single plane and a second order moment unbalance rotating at twice crankshaft speed but in the opposite direction which is caused by the offset of the pistons in one bank with respect to the pistons in the opposite bank.

The second order force unbalance may be neutralized in a conventional manner by the provision of a pair of eccentrically disposed balance weights such as those shown at 16, each of which is carried on a gear 17, rotating in the same direction as the crankshaft and at twice its speed. The eccentric balance weights are normally disposed about the longitudinal axis of the crankshaft at its midpoint. However, for purposes of this invention, it is desirable that one of the weights be disposed at each end of the crankshaft as is illustrated in the drawings. Each of the gears 17 is in meshing engagement with and driven by an idler gear 18, which in turn is driven by a gear 19 carried on the crankshaft. The gear 19 on the end of the crankshaft is provided with twice as many teeth as gears 17 and 18, thus the gears 17 and the eccentric weights 16 are driven in the same direction and at twice the speed of the crankshaft. As the weights 16 are disposed at each end of the crankshaft, it is desirable that the axis of rotation of each be displaced an equal amount in both a horizontal and vertical direction from the longitudinal axis of the crankshaft but in opposite directions so that a diagonal drawn from the center of gravity of each weight will pass through the midpoint of the crankshaft. However, if due to mechanical limitations such as interference with other gears or parts of the engine, this is not possible, either

of the weights may be placed in a more convenient location with respect to the longitudinal axis of the crankshaft. If the weights are not equally spaced from each end of the crankshaft, an additional moment unbalance of the same order will be introduced in the system. Thus, in an engine which is not provided with means for neutralizing moment unbalance, the spacing of the force balancing weights must be held to rather close limits.

Moment unbalance occurring due to the offset of the pistons or from other causes such as unequal spacing of the force balance weights may be resolved into a force couple acting on the ends of the crankshaft. The magnitude and direction of the force acting on each end of the crankshaft may be plotted for each position it will assume during rotation, forming a force diagram which is generally elliptical in shape, a typical form of which is illustrated at 20 in Fig. 4 by the phantom lines. The forces acting on either end of the crankshaft can be neutralized by the provision of a pair of eccentrically mounted weights carried adjacent its ends, constituting a set of four weights for the entire engine with the weights in each pair being rotated in opposite directions and angularly phased with respect to each other to produce a force equal in magnitude but opposite in direction, at all positions of the crankshaft, to that of the force acting thereon due to moment unbalance. Thus, by providing such a pair of weights at each end of the crankshaft, the moment unbalance can be simply and effectively neutralized.

As the rotating weights 16 are already present, one at each end of the crankshaft, the addition of an eccentrically mounted weight to each of the idler gears 18, which rotate at the same speed but in the opposite direction to the gears 17, provides all of the elements for a moment balancer comprising a set of four weights. The effect of an eccentric weight on the idler gears is most easily accomplished by drilling holes, indicated at 21, therein. By proper phasing of each of the idler gears with respect to the gears 17, and by controlling the amount of unbalance, the second order moment unbalance may be entirely neutralized.

Other orders of moment unbalance may be neutralized in the manner herein described by the addition of a pair of eccentrically mounted rotating weights, not shown, adjacent each end of the crankshaft, these weights being rotated at a suitable speed to neutralize the particular order of unbalance encountered. In practice, however, other orders of moment unbalance are insignificant within the normal operating range of a reciprocating engine, that is, engines operating at 6000 R. P. M. or less.

I claim:

1. In a V-type reciprocating engine having eight cylinders arranged in two banks of four cylinders with each bank inclined at 60° to the other, a crank shaft having all the throws in a single plane, pistons carried for reciprocation in the cylinders, rods connecting the pistons to the throws of the crankshaft, and the cylinders in one bank offset relative to the cylinders in the other bank to allow the connecting rods in corresponding cylinders in opposite banks to be connected to common crank throws in side by side relationship, said engine having a condition of force unbalance and a condition of moment unbalance of the same order and of generally elliptical diagram, two pairs of eccentrically mounted

weights, means for rotating said weights in timed relation to said crankshaft, one of said pairs serving to correct force unbalance and having phase position arranged to act as a part of a moment unbalance set, and the other pair of weights being balanced and phased to complete the set which corrects the moment unbalance.

2. In a V-type reciprocating engine having eight cylinders arranged in two banks of four cylinders with each bank inclined at 60° to the other, a crank shaft having all the throws in a single plane, pistons carried for reciprocation in the cylinders, rods connecting the pistons to the throws of the crankshaft, and the cylinders in one bank offset relative to the cylinders in the other bank to allow the connecting rods in corresponding cylinders in opposite banks to be connected to common crank throws in side by side relationship, said engine having a condition of force unbalance inherent in a 60° V-8 engine having a crankshaft in which all of the crank throws are in a single plane and a condition of moment unbalance of the same order and of generally elliptical diagram due to the offset relation of the cylinders in each bank, two pairs of eccentrically mounted weights, means for rotating said weights in timed relation to said crankshaft, one of said pairs serving to correct force unbalance and having phase position arranged to act as a part of a moment unbalance set, and the other pair of weights being balanced and phased to complete the set which corrects the moment unbalance.

3. In a V-type reciprocating engine having eight cylinders arranged in two banks of four cylinders with each bank inclined at 60° to the other, a crank shaft having all the throws in a single plane, pistons carried for reciprocation in the cylinders, rods connecting the pistons to the throws of the crankshaft, and the cylinders in one bank offset relative to the cylinders in the other bank to allow the connecting rods in corresponding cylinders in opposite banks to be connected to common crank throws in side by side relationship, said engine having a condition of force unbalance and a condition of moment unbalance of the same order and of generally elliptical diagram, two pairs of eccentrically mounted weights, means for rotating said weights in timed relation to said crankshaft with one pair rotating in the same direction as the crankshaft and the other pair in the opposite direction, said pair of weights rotating in the same direction as the crankshaft having mass and phase position whereby one component of its force during rotation corrects force unbalance and its other component of force during rotation acts as a part of a moment unbalance correcting set, and the other pair of weights rotating in the opposite direction from the crankshaft being balanced and phased to complete the set which corrects moment unbalance.

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