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REVERSING GEAR

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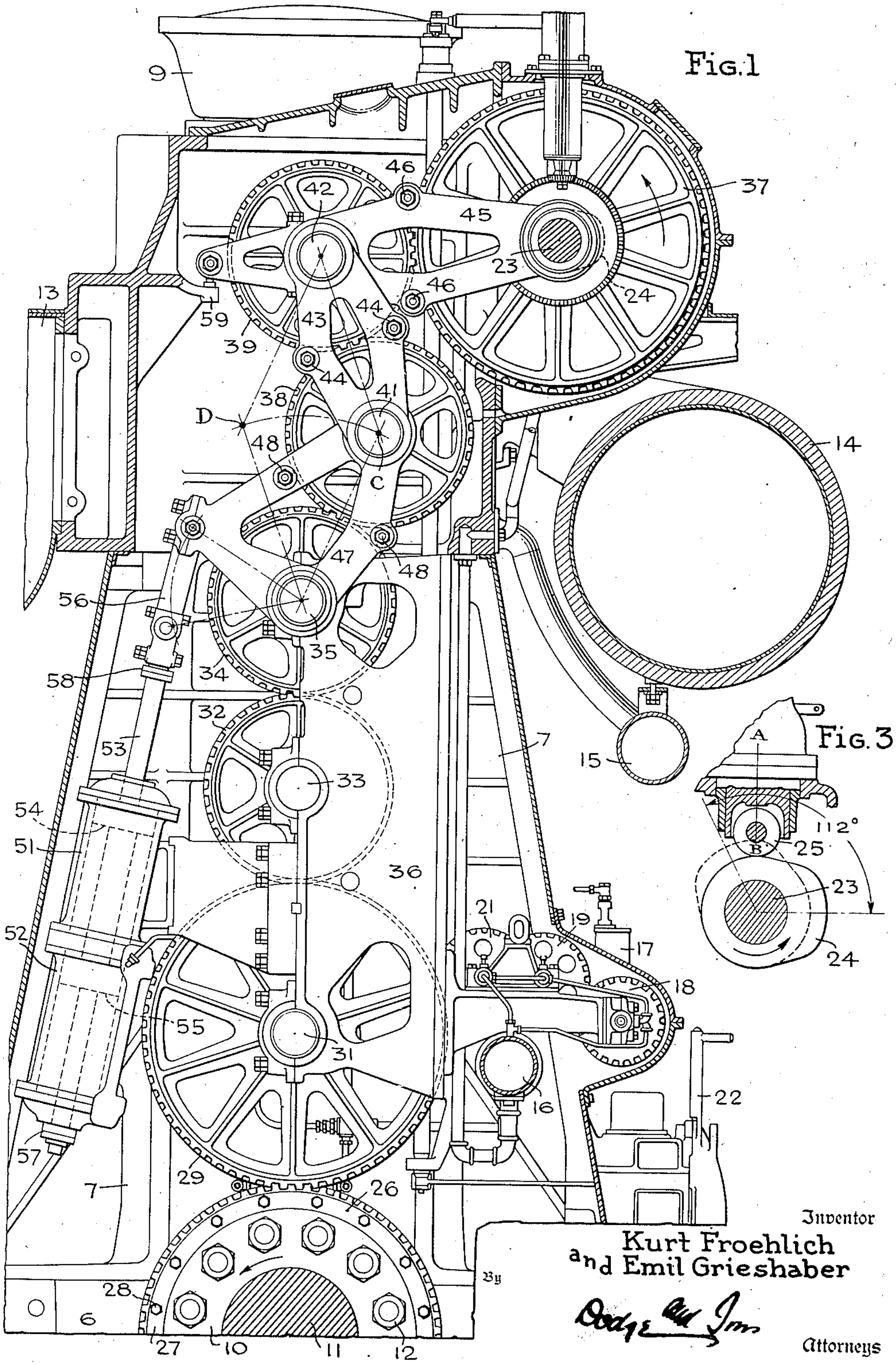

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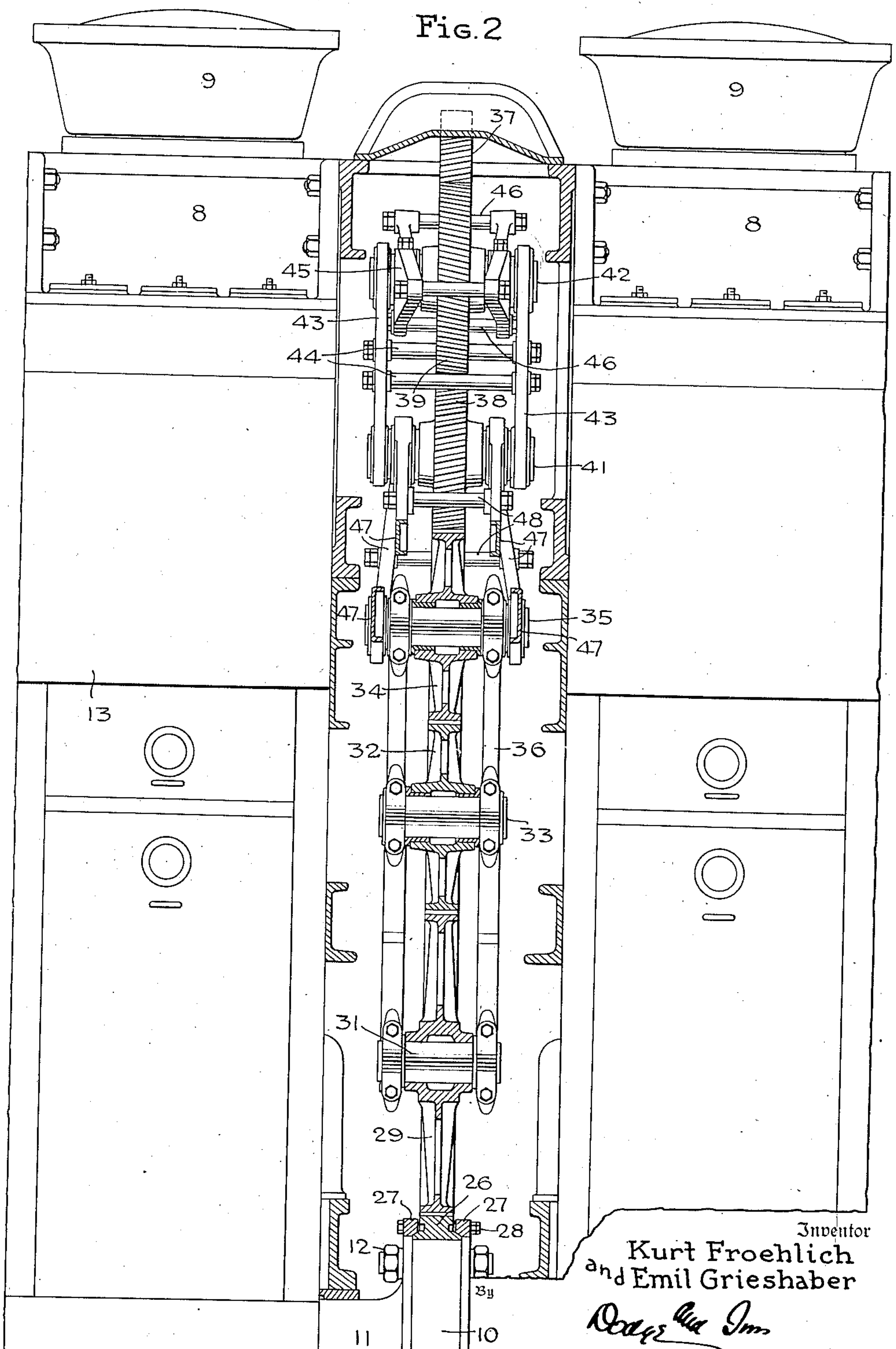
Fig. 2



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REVERSING GEAR

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6 Claims. (Cl. 121—122)

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This invention relates to reversing gears for engines having a crank shaft which is the main driving shaft of the engine and a secondary shaft commonly called a cam shaft which times events in the engine cycle.

To adopt a very simple engine as a basis of discussion a two cycle Diesel engine of the single acting terminal exhaust type has been selected, although the principles underlying the invention can be used to time events in steam engines and in Diesel engines of other types than the one specifically mentioned.

In a two cycle Diesel engine such as specified the event to be timed is the start of fuel injection. When fuel injection is caused by a cam on the cam shaft reacting upon the moving element of the fuel injection pump (and this is the usual arrangement) the cam shaft must be turned to present one or the other side of the cam nose to the cam follower at or near the head-end dead-point.

As a practical matter, if we assume that the crank shaft is at rest and that the reversing gear is shifted between the forward and reverse positions, the desired effect is rotation of the cam shaft through an appropriate angle. This angle for the particular engine hereinafter discussed is 112°. This is illustrative, it being understood that the precise angle depends on the design of the cam and on other characteristics of the engine which will readily suggest themselves.

Such angular displacement has been produced in a number of ways, one of which involves the use of a sort of planetary train interposed between a driving gear turning with the crank shaft and a driven gear turning with the cam shaft. Two planet idlers mesh with each other, and one meshes with the driving gear while the other meshes with the driven gear. The first is guided in an orbit about the axis of the driving gear and the second is guided in the orbit about the axis of the driven gear. Means are provided to limit the range of motion.

The present invention contemplates the incorporation of a drive of this type with a guiding mechanism for the planet gears so contrived as to produce a sort of toggle which may be loaded by the weight of the parts or otherwise to afford a reversible bias, i. e., a bias toward whichever setting may exist.

There are additional possibilities. In the first place the gears may be arranged to span a substantial portion of the interval between the cam shaft and the crank shaft, and if this interval is too great to be spanned by the reversing train proper, the remainder of the interval may be spanned quite simply by idler gears.

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In the preferred construction illustrated in the accompanying drawings the reversible bias is produced by the weight of the idler gears and to some extent also by the weight of the guiding mechanism associated therewith.

An even more important feature is that the design of the drive is such that the torque developed upon the idler gears by the driving gear further biases the idlers toward whichever operating position is appropriate for the direction of rotation of the engine. Consequently, the train is stable because it tends to remain in the appropriate operating position. This tendency is important even in a stationary engine.

A marine engine is subject to more severe requirements, because of the rolling of a ship. This may tend to neutralize the bias of the reversing gear and even create forces (as the result of gravity or inertia) which urge the reversing gear away from its appropriate position. The gear herein described has desirable characteristics in this regard, because the normal bias is not neutralized until the ship has rolled through a large angle from its upright position. In case of the particular engine illustrated the angle is of the order of 55°, and this angle could be increased by loading the toggle formed by the gear sustaining linkage.

Stability of the type indicated is important because the reversing gear must be motor actuated, and the incorporation of positive locks in a motor actuated gear involves considerable complication with increased first cost and maintenance expense. A number of gears which have otherwise proved highly satisfactory, have been commercially objectionable because they required secondary locking mechanism whose performance was not satisfactory.

In order to disclose a rather extreme case the engine chosen for illustration is of the type in which the cam shaft is adjacent the cylinder head and there is therefore an extreme distance to be spanned from the crank shaft to the cam shaft. In the example illustrated three idler gears are used to reduce the distance spanned by the reversing train proper. It will readily be understood that where the cam shaft is relatively close to the crank shaft, the idler gear train becomes unnecessary. The principles of the invention can readily be adapted to such an engine.

In very large engines it is necessary to construct the crank shaft in sections which are connected by couplings. The reversing drive forming the subject matter of the present application is particularly well adapted to engines of this type because the primary driving gear can be mounted on one of the shaft couplings, and the entire gear train from the crank shaft to the cam shaft can be housed in the space above the coupling between two adjacent engine cylinders. Thus in a nine cylinder engine in which the cam shaft and the crank shaft are both of considerable length, it is possible to locate the drive between the fourth and fifth cylinders and thus drive the cam shaft from a point near its mid length. The same advantage is possible, but not so important, with engines having smaller numbers of cylinders.

The construction just mentioned makes it possible to support major components of the gear train on the engine frame. The arrangement is such that the shifting gears may be of moderate size and weight.

The above considerations will be better understood after a detailed description of the preferred embodiment which is illustrated in the accompanying drawings.

In these drawings

Figure 1 is a vertical section transverse to the crank shaft of a multi-cylinder vertical engine. The plane of section is adjacent the reversing gear train which is shown in detail.

Figure 2 is a fragmentary side elevation of the engine with portions of the housing broken away to show the reversing gear train. This train is shown partly in elevation and partly in section.

Figure 3 is a transverse section through the cam shaft showing in full lines the forward position of one of the fuel cams and in dotted lines the reverse position thereof. These two positions of the cam correspond to the same position of the crank shaft and indicate the angular shift of the cam shaft necessary to effect reversal of the engine.

The main components of the engine will first be identified. A portion of the bed plate appears at 6 and one of the A frames is indicated at 7. As is well understood in the engine art there are a plurality of A frames carried by the bed plate, and these sustain the various cylinders and related parts. In Figure 2 portions of two cylinders are visible at 8 and the corresponding cylinder heads appear at 9.

The engine crank shaft 11 is made in sections connected by couplings 10, the halves of the coupling being connected by bolts 12. The scavenging air manifold is shown at 13, the exhaust manifold at 14, the cooling water manifold at 15, and the lubricating oil manifold at 16. The lubricating pump 17 is driven by a train of gears 18, 19, 21. The control lever for the engine is indicated at 22. No novelty is claimed for any of the parts above enumerated.

The engine cam shaft appears at 23 and is near to and to one side of the upper ends of the cylinders 8. As is usual in engines of this type the cam shaft is provided with a plurality of suitably spaced cams, one for each cylinder, each cam operating a corresponding fuel injecting pump for that cylinder. The cams are appropriately positioned on the cam shaft and operate their respective pumps in proper timed relation.

One such cam is indicated at 24 in Figure 3. As is well known in this art, reversal of the engine entails angular displacement of the cam shaft 23 through a definite angle with reference to the engine crank shaft 11. In Figure 3 the cam 24 is shown in full lines in its forward running

position. To reverse the engine the cam shaft 23 must be shifted relatively to the crank shaft 11 to a position in which the cam 24 assumes the dotted line position of Figure 3. In this case the angular displacement is 112°. The roller 25 is the cam follower and is reciprocated in the path A—B indicated on Figure 3.

Since the same shaft 23 is located near the top of the engine and the crank shaft 11 is at the base plate, it is necessary to use a number of idler gears to transmit motion between the two.

A divided ring gear 26 is mounted in a groove surrounding the coupling 10, and is clamped therein by the wedging rings 27. These rings are drawn together by the bolts 28 so that the ring gear is tightly clamped in the groove on the coupling. This provides a simple and convenient method of mounting this ring gear.

Extending vertically above the ring gear 26 is a train of three idler gears. The lowermost of these is a gear 29 which is of the same diameter as the ring gear 26 and which is mounted on a journal 31. The second is a smaller gear 32 mounted on a journal 33 and the third is gear 34 which is equal in size to the gear 32 and is mounted on the journal 35. Journals 31, 33 and 35 are supported on frame members 36, which in turn are carried by the A-frames.

The supporting structure is not elaborated in the drawings for it is not a feature of the invention. The essential thing is that the journals 31, 33 and 35 are fixedly supported. The crank shaft 11 is indicated by the arrow as rotating in a counterclockwise direction in Figure 1. This is the forward direction of rotation of this engine. The gear 34 necessarily rotates in an opposite direction. In Fig. 1 the reversing gear is shown in forward position. The direction of rotation of the gear 34 is important because it determines the bias developed upon the reverse gear by the driving reactions.

The gear 34 is the driving gear of the reversing train and the gears 32 and 29 are idlers. The cam shaft 23 carries fixed to it a gear 37. This gear is of the same pitch diameter as the gear 26, and since the gear train interposed between the two is composed of an odd number of idlers, the shafts 11 and 23 turn in the same direction and at equal angular velocities.

Interposed between the driving gear 34 and the gear 37, which is the driven gear of the reversing train, are two shiftable idler gears 38 and 39.

The gear 38 turns on a journal formed on pin 41 and the gear 39 turns on a journal formed on pin 42. These two pins 41 and 42 serve as hinge pins at the opposite ends of a diamond shaped spacing frame 43 made up of two similar side plates connected by bolts and spacers indicated generally at 44 (see Fig. 2). The construction of this spacing frame is conventional and is sufficiently illustrated in the drawings. It is simply a yoke which maintains the spacing of the journals for the idler gears 38 and 39 so that these gears are always in mesh. The idler 39 meshes with the driven gear 37. Its journal 42 is approximately at the same height as cam shaft 37 and nearly vertically above the axis of driving gear 34.

The idler 39 is guided in an arcuate orbit about the axis of the cam shaft 23 by a diamond shaped frame 45 formed of two bowed plates which are connected by bolts and spacers generally indicated at 46. The frame 45 is swiveled at one end on cam shaft 37 and is hinged to the upper end of yoke 43 by pin 42.

A sustaining frame made up of two triangular yokes 47 tied together by bolts and spacers 48, swings about journal pin 35 and is hinged to the lower end of the frame 43.

Thus the idler 39 is guided in a nearly vertical arcuate path, and the idler 38 is guided in a nearly horizontal arcuate path. In the forward setting, the axis of the journal 41 is located at C and in the reverse setting it is located at the point D. Thus as the idler gear 38 is swung to the left from the position shown in the drawing, the gear 39 and the supporting yoke 45 move upward through the first half of the motion and then down again through the last half.

In short the frame 43 and the frame 47 form a toggle mechanism between the journal pin 35 and the journal pin 42, the pin 35 being fixed relatively to the engine frame and the pin 42 being guided by the frame 45. As the toggle breaks beyond its aligned or mid position it is reversely biased toward its two opposite limiting positions by the weight of the yoke structures 43, 45 and 47 and the weight of parts carried thereby, notably the two idler gears 38 and 39. The reversible bias so produced can be increased by increasing the weight of any of these components.

Obviously the reversible bias could be created by any loading means which urges the journal pin 42 toward the journal pin 35. It is preferred and is normally sufficient to rely upon the weight of the parts, but any means which would bias the fulcrum pin 42 downward or which would urge the frame 45 in a counter-clockwise direction will suffice. For this purpose a spring is considered the approximate equivalent of a weight.

Since the driving gear 34 turns clockwise in the forward setting illustrated in Figure 1, the torque reaction urges the movable parts of the reversing gear to the position shown in that figure. Similarly, the gear 34 would turn in the opposite direction in a reverse setting and consequently would develop an appropriately opposite bias.

To shift the reversing gear a servo-motor is connected to the yoke 47. The servo-motor comprises two aligned cylinders 51 and 52. A piston rod 53 extends through and beyond both cylinders, and carries a piston 54 in cylinder 51 and a piston 55 in cylinder 52. The cylinder 51 is simply a double acting motor cylinder whose action is controlled by the control handle 22. The control connections are conventional and are not illustrated. The two end working spaces of cylinder 52 are connected together by a restricted flow passage. The cylinder 52 is oil filled so that it operates as a cataract or retarding device, to control the rate of shift of the piston rod 53.

The piston rod 53 is connected at its upper end by a pitman 56 with the yoke 47. Consequently as the rod 53 is forced upward, the reversing gear is shifted to the forward position shown in Figure 1. The downward motion of the rod 53 shifts the gear to reverse position. In order to define these positions positively an adjustable stop collar 57 is threaded on the lower end of the rod 53 and defines the forward setting by collision with the lower head of cylinder 52. The "reverse" position is defined by a similar adjustable stop collar 58 threaded on the upper end of the rod 53 and coacting with the upper head of cylinder 51.

Adjustment of the stop collars 57 and 58 would obviously modify the timing of the event affected by reversal. In the case of the engine illustrated this event is the start of fuel injection. Consequently the adjustable collars 57 and 58 are means for varying the lead of fuel injection.

There is shown also a stop 59, which engages the outer end of the yoke 45. This stop is adjustable and is set to an inactive position under normal conditions. Its purpose is to position the yoke 45 during assembly and during timing operations on the engine, after which it is lowered.

From a consideration of Figure 2 it will be apparent that the reversing mechanism is of limited width measured in the direction of the axis of the crank shaft. By mounting the ring gear 26 around the crank shaft coupling it is possible to locate the entire reversing gear between two adjacent cylinders at a point in the engine structure where the cylinders are moderately spaced.

The arrangement of the gears 34, 38 and 39 in a nearly vertical line causes the shifting components of the reversing mechanism to span part of the considerable space between the crank shaft 11 and the cam shaft 23. It also makes it possible to use the weight of the shifting components to afford a reversible bias, which when assisted by the driving torque developed by the driving gear 34, makes the reversing gear stable. This is particularly important in ships. The gear illustrated has no locking mechanism and nevertheless would be stable on a ship up to a 55° angle of heel.

From the above discussion it will be apparent that there are several significant characteristics of the arrangement illustrated. In the first place the guide structure produces a toggle mechanism which with proper loading gives a reversible bias which tends toward stability in either setting. In the second place with the vertical arrangement shown this bias can be produced by the weight of the reversing mechanism itself, thus doing away with the necessity of any independent loading means. Third, the train is so arranged that the torque exerted upon the drive has a stabilizing effect because the torque itself biases the gear to whichever position it may assume.

These features are important and are important in combination. The particular engine chosen for illustration shows an extreme case where the distance from the axis of the crank shaft to the axis of the cam shaft is large and where the movable components of the reversing gear are near the top of the engine and consequently peculiarly susceptible to the disturbing effects created by the rolling of a ship. This type of installation is selected to emphasize the great advantage which the invention has in an installation of this type, but the invention is not limited in its utility to such an installation.

The toggle mechanism with a proper loading mechanism can be made to give the desired primary bias, and the weight of the parts can be used for loading purposes in arrangements other than the one specifically described above. For instance in cases where the cam shaft 23 is close to the crank shaft 11, the idler train 29, 32, 34 can be reduced in its span or even eliminated altogether, care being exercised, however, to make certain that the thrust of the gear 34 on the movable components of the reversing train is such as to give the necessary secondary bias, i. e. the bias created by the torque exerted upon the drive. If these features are properly coordinated, the advantages of the improved reversing gear may be had with engines of various designs.

Thus while the embodiment in a vertical engine of the marine type has been described in great detail this is intended to be illustrative and implies no necessary limitation to the particular details which are illustrated.

The scope of the invention is defined solely by the claims.

What is claimed is:

1. The combination of a vertical reciprocating engine having a crank shaft near its base and a secondary shaft at a higher elevation, said secondary shaft serving to control events in the engine cycle and requiring to be shifted between two distinct angular positions relatively to a given position of the engine crank shaft to time the events for forward and for reverse rotation of the engine drive shaft; a driving gear driven by the engine drive shaft; a driven gear turning with said secondary shaft; a first idler gear meshing with said driving gear and located above the same; a second idler meshing with said driven gear and with the first idler, said second idler being located at one side of said driven gear and substantially vertically above the driving gear; guiding means constraining the first idler gear to move in a generally horizontal direction in an arcuate path about the axis of the driving gear; guiding means constraining the second idler to move in a substantially vertically direction in an arcuate path about the axis of the driven gear; means connecting the axes of said idlers to maintain them in mesh with one another; stop means to limit the shifting motion of said guiding means in each direction; and means for shifting the axis of the first idler gear between limits so defined.

2. The combination of a vertical reciprocating engine having a crank shaft near its base and a secondary shaft at a higher elevation, said secondary shaft serving to control events in the engine cycle and requiring to be shifted between two distinct angular positions relatively to a given position of the engine crank shaft to time the events for forward and for reverse rotation of the engine drive shaft; a driving gear driven by the engine drive shaft; a driven gear turning with said secondary shaft; a first idler gear meshing with said driving gear and located above the same; a second idler meshing with said driven gear and with the first idler, said second idler being located at one side of said driven gear and substantially vertically above the driving gear; guiding means constraining the first idler gear to move in a generally horizontal direction in an arcuate path about the axis of the driving gear; guiding means constraining the second idler to move in a substantially vertical direction in an arcuate path about the axis of the driven gear; means connecting the axes of said idlers to maintain them in mesh with one another; a reversible motor for shifting the guiding means of the first idler gear in opposite directions; means for limiting the rate of such shifting motion; and stop means associated with said motor for defining the range of shifting motion in both directions.

3. The combination of a vertical reciprocating engine having a crank shaft near its base and a secondary shaft at a higher elevation, said secondary shaft serving to control events in the engine cycle and requiring to be shifted between two distinct angular positions relatively to a given position of the engine crank shaft to time the events for forward and for reverse rotation of the engine drive shaft; a driving gear driven by the engine drive shaft; a driven gear turning with said secondary shaft; a first idler gear meshing with said driving gear and located above the same; a second idler meshing with said driven gear and with the first idler, said second idler being located at one side of said driven gear and substantially vertically above the driving gear; guiding means constraining the first idler gear to move in a generally horizontal direction in an arcuate path about the axis of the driving gear; guiding means constraining the second idler to move in a substantially vertical direction in an arcuate path about the axis of the driven gear; means connecting the axes of said idlers to maintain them in mesh with one another; stop means to limit the shifting motion of said guiding means in each direction; and means for shifting the axis of the first idler gear between limits so defined, the direction of rotation of the driving gear being such that the force reaction developed by it through the first idler gear urges said idler gear selectively toward that position which is appropriate to the direction of rotation of the crank shaft.

4. The combination defined in claim 1, in which the engine is constructed as at least two units having cylinders of the two units aligned, and the idler gears are housed between proximate cylinders of the two units.

5. The combination of a reciprocating engine, having a crank shaft and a secondary shaft serving to control at least one event in the engine cycle, and requiring to be shifted between two distinct angular positions relatively to a given position of the engine crank shaft, to time said event for forward and for reverse rotation of the engine drive shaft; a driving gear driven by the engine crank shaft; a driven gear turning said secondary shaft; a first idler gear meshing with said driving gear; a second idler gear meshing with said driven gear and with the first idler; guiding means constraining the axis of the second idler to move in an arcuate path about the axis of the driven gear, and in a direction generally toward and from the axis of the driving gear; guiding means constraining the axis of the first idler gear to move in an arcuate path about the axis of the driving gear, between two limiting positions respectively on opposite sides of the imaginary line connecting the axes of the driving gear and the second idler; loading means urging the second idler gear toward the driving gear; stop means serving to limit the shifting motion of said guiding means in each direction of motion; and means for shifting the first idler gear between limits defined by said stop means.

6. The combination of a vertical reciprocating engine having a crank shaft near its base and a secondary shaft at a higher elevation, said secondary shaft serving to control events in the engine cycle and requiring to be shifted between two distinct angular positions relatively to a given position of the engine crank shaft to time the events for forward and for reverse rotation of the engine drive shaft; a driving gear driven by the engine drive shaft; a driven gear turning with said secondary shaft; a first idler gear meshing with said driving gear and located above the same; a second idler meshing with said driven gear and with the first idler, said second idler being located at one side of said driven gear and substantially vertically above the driving gear; guiding means constraining the first idler gear to move in a generally horizontal direction in an arcuate path about the axis of the driving gear; guiding means constraining the second idler to move in a substantially vertical direction in an arcuate path about the axis of the driven gear; means connecting the axes of said idlers to maintain them in mesh with one another; stop means to limit the shifting motion of said guiding means

in each direction; and a double-acting piston motor operable to shift the axis of the first idler gear between limits so defined, the direction of rotation of the driving gear being such that the force reaction developed by it through the first idler gear urges said idler gear selectively toward that position which is appropriate to the direction of rotation of the crank shaft.

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