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GEARING FOR AIRCRAFTS
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3 Sheets-Sheet 1

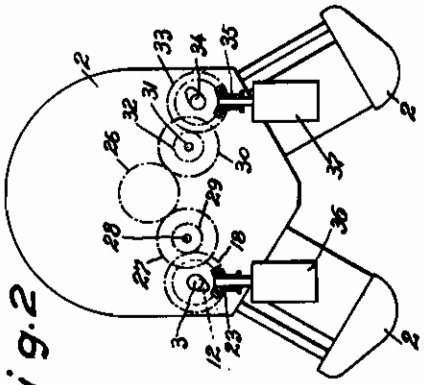

Fig. 2

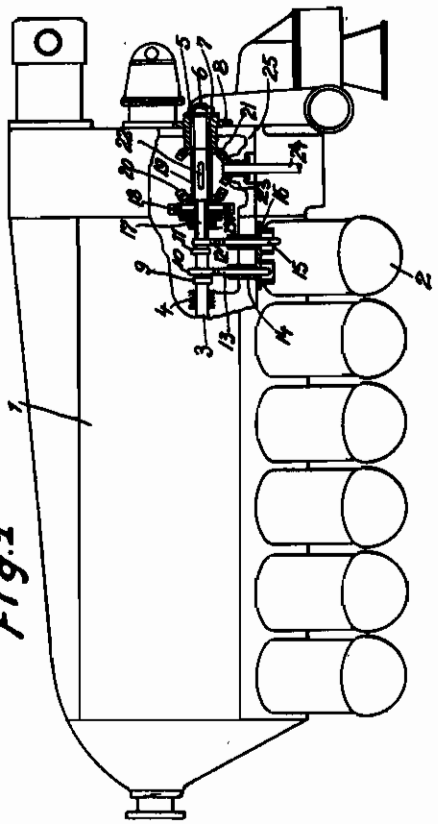

Fig. 1

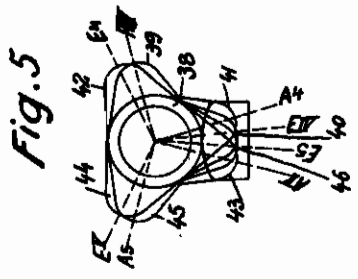

Fig. 5

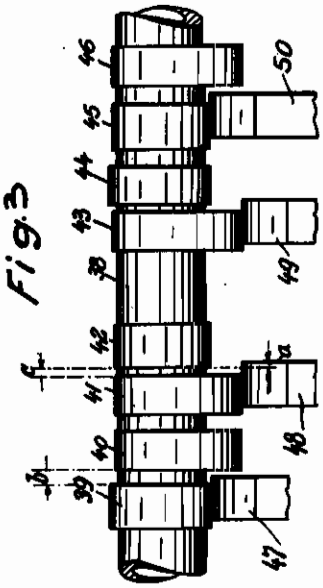

Fig. 3

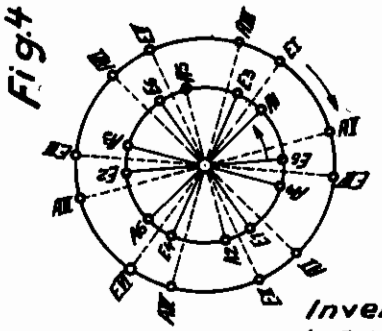

Fig. 4

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Fig. 7

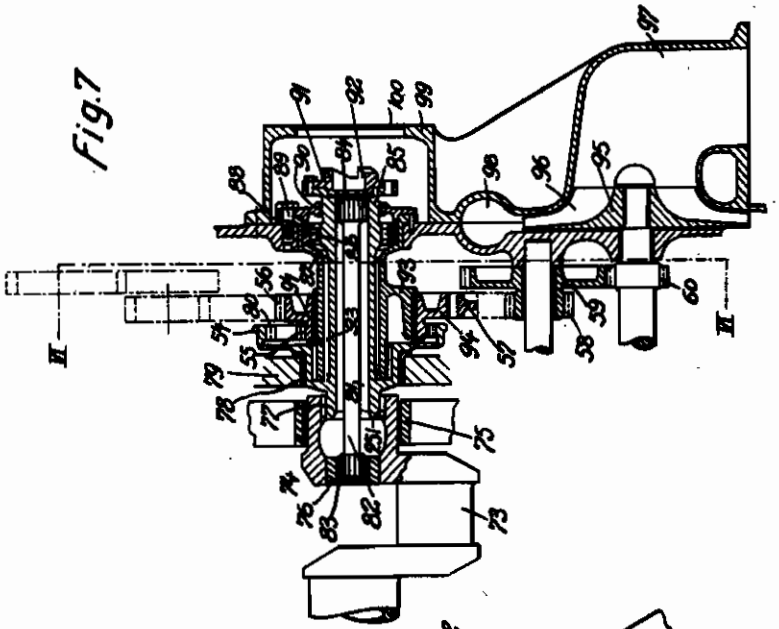

Fig. 6

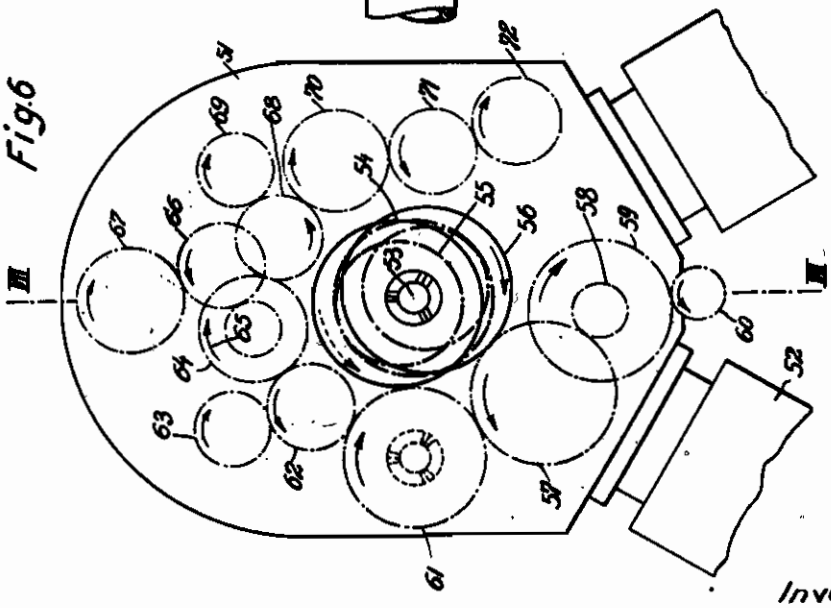

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Fig.10

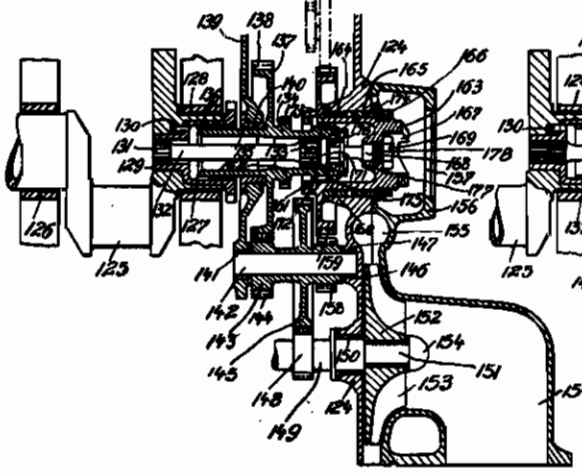


Fig.11

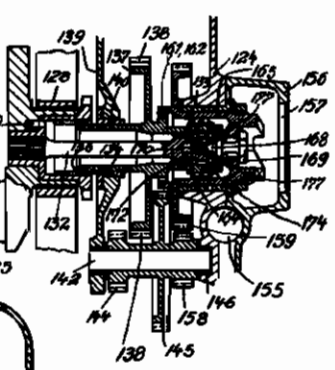


Fig.12

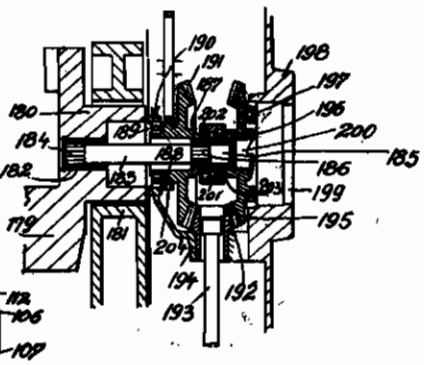


Fig.8

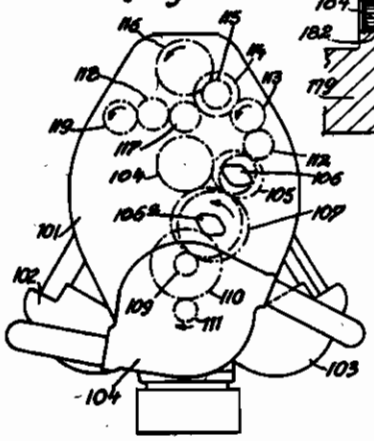
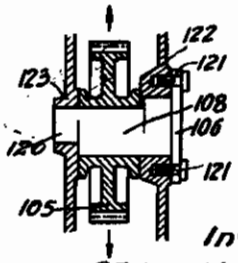


Fig.9



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GEARING FOR AIRCRAFTS

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Application filed October 16, 1939

The present invention relates to a gearing which particularly is designed and adapted for aircrafts and is provided with means for changing the sense of rotation of the driving member, for instance the air propeller, and also with means for maintaining the sense of rotation of the auxiliary apparatus, as for instance the ignition device, the charger, the dynamo, the air compressor and so on. Preferably, an ordinary combustion engine is used as prime mover.

The present invention is not concerned with a so-called reversible internal combustion engine of usual construction, i. e. with an engine which during operation may be adjusted to a reversed direction of rotation by a simple manipulation by means of a lever system and so on. In contradistinction thereto, the invention is concerned with a gearing which without necessitating many additional parts and particular space- and weight-expenditure allows, preferably during stoppage of the motor, adjustment to the reversed direction of rotation in a simple manner, for instance in the workshop. As all means are provided on the motor itself, difficulties never may arise due to accessories not being at hand.

The gearing according to the invention is to serve various purposes. One of the purposes for instance is to provide particular favorable service conditions of motor for aircrafts having a plurality of motors.

In connection with aircrafts having a plurality of motors it is advantageous to build in motors having air propellers rotating clockwise and anti-clockwise. For this purpose it has been proposed to provide clockwise and anti-clockwise rotating gears for the air propellers and to build in these gears according to demand.

This proposal, however, did not lead to useful results, as for obtaining the two different directions of rotation two reducing gears are required for a motor rotating in a constant sense. If now reducing gears of different reducing ratios are used, the number of the individual parts of the gearings which already must be provided in duplicate and kept in stock for the flying service must be multiplied in accordance with the reducings required.

Moreover, in gearings in which the air propeller shaft rotates in a direction opposite to that of the crankshaft the drawback exists that the counter-moment acting upon the crank case is equal to the sum of the torsional moments or torques produced by the propeller on the one hand and by the crankshaft on the other hand. Due to this relatively large torsional moment or torque the crank case is extremely heavy stressed. Particularly expensive and complicated arrangements are required to obviate these stresses.

If, however, the reducing gear rotates in the same direction as the crankshaft and the air propeller shaft, then the difference of the torques produced by the air propeller shaft on the one hand and the crankshaft on the other hand only acts upon the crank case.

Now, it has been found that the gearing may in a particular simple manner be so constructed that for both directions of rotation of the air propellers such gearings only need be used in which the air propeller shaft and the crankshaft have the same direction of rotation and in which the auxiliary apparatus of the motor aggregate may maintain the same sense of rotation so that on reversal of the machine an exchange of these apparatus is not necessary.

All these requirements are fulfilled according to the invention by the fact that the members controlling the change of gas are, by very simple auxiliary means, reversed in accordance with the altered direction of rotation of the crankshaft at the stoppage of the motor, the driving means for the auxiliary apparatus being provided with reversible driving members which allow a constant sense of rotation of the drive of the apparatus.

Preferably, the cams exchanged against each other during the reversing operation are so arranged that during reversal the control rods of the cylinder valves of the engine associated to the cams are prevented from further cooperation with the one cam and caused to directly cooperate with the other cam.

For this purpose some of the cams provided for the opposite control operations are arranged on their shaft in axially staggered relation with regard to each other in such a manner that on changing the basic control position the shaft may first of all axially be displaced for the amount of the staggering and the distance of the cams from each other (smallest distance for reasons of manufacture), whereupon the shaft may be rotated about 180° and finally be shifted axially for the rest amount still possible.

The above described construction of the cams and the arrangement of the latter upon the control shaft for instance have the substantial advantage that special change-over surfaces between the individual cams are not required. Moreover, the very troublesome lifting of the valve tappets also is not required with the construction and arrangement of the cams according to the invention.

With regard to known devices for effecting reversal during operation, the actuation by means of levers, forks, sleeves, and associated lever systems is dispensed with according to the present invention and replaced by a simple guide bearing having a connecting flange arranged out of the middle. For the purpose of adjustment this element is removed and inserted again after having been turned about 180°.

In carrying out the invention into effect a twelve cylinder motor for instance is provided with two cam shafts journalled in the crank case. Each cam shaft carries a set of twelve cams for an anti-clockwise rotation and a set of twelve cams for a clockwise rotation six cams of each set of twelve cams serve for controlling the admission and the other six cams of each set of twelve cams are used for controlling the exhaust. The cam shafts for instance are guided in side bracket bearings. The flange of the bearing is arranged upon its hub outside the middle so that if the hub is reversely mounted, the cam shaft is guided in the correct longitudinal position for the other direction of rotation. An alteration of the basic control position, i. e. a reversal of the gearing is effected for instance by bringing the crankshaft of the cylinder I into the position at the upper dead centre. The cam shaft then occupies the position diagrammatically indicated in the well-known control diagram shown in Fig. 4.

Preferably, the cams mounted upon the upper half of the shaft are staggered with regard to the cams on the lower half of the shaft in the longitudinal axis for two millimeters multiplied by the distance the valve spindles are separated from each other in the longitudinal direction.

Therefore, the cam shaft may first of all be displaced towards the left for two millimeters multiplied by the smallest distance *c* of the cams from each other until some of the cams abut against the adjacent guides of the control rods of the valve. Another portion of the cams thereby is shifted for a certain amount, for instance for the distance *a*, over the coordinated control rods of the valve.

On rotation of the cam shaft for 180° those cams which are situated for the measure *a* above the coordinated control rods will lift the corresponding control rods. Then, the cam shaft may be shifted for instance towards the left for the amount of the rest of the path of displacement possible (see Fig. 3). The constructional details and the particular arrangements will be described later on.

Now, eventually the guide bearing of the cam shaft brought into the new basic control position is fixed. Furthermore, for instance the corresponding ignition cables of the magnet ignition device are exchanged. Then the reversible gearings for the means driving the auxiliary apparatus and connected to the cam shaft, for instance, by way of the crankshaft, are operated and reversed respectively. This change-over has the effect that for the new basic control position of the cam shaft also the sense of rotation of the driving means for the auxiliary apparatus remains unchanged and constant. The auxiliary apparatus, as for instance the charging device, the magneto ignition device, the dynamo or lighting machine, the air compressor, the lubricating pump, the fuel pump, the revolution indicator, eventually are screwed to a special casing and elastically driven by the crankshaft by means of a common driving wheel. Particularly, all auxiliary apparatus are, according to the present invention, brought into engagement with the main driving wheel by way of two intermediate wheels, the change of the sense of rotation of the main driving member, supplying the power in such a manner that the auxiliary apparatus always are driven in the same sense of rotation, being effected for instance by the fact that by oscillation the main driving wheel selectively is brought into engagement always with one of the intermediate driving wheels. Another possibility consists in this that the intermediate wheels are eccentrically journalled and are selectively swung towards the fixed main driving wheel. Preferably, the eccentric bolts of the intermediate wheels are so arranged that they may be turned from the outside. This has the substantial advantage and is a great advantage of the present invention that the motor during adjustment of the cams need not be dismantled.

A further possibility consists in fixing upon the cam shaft two bevel gear wheels the points of the cones of which are staggered about the way of displacement of the cam shaft in the longitudinal axis, another bevel gear wheel being provided which on displacement of the cam shaft selectively engages the one or the other bevel gear wheel. The third bevel gear wheel not mounted upon the cam shaft is used for driving an auxiliary apparatus.

A particular simple arrangement for obtaining the constant sense of rotation of the auxiliary apparatus consists, according to the present invention, in providing a screw or the like of definite length which may be exchanged against a screw of other length and whereby the exchange alters the position of the main driving gear and thereby effects a reversal of the sense of rotation of the auxiliary apparatus.

Preferably, an elastically acting member is inserted, according to the present invention, in the system of power transmission from a main driving wheel or the like to the driving members of the auxiliary apparatus. Preferably, a torsion rod, a rod-like torsional spring or the like is used for this purpose one end of which is inserted in a bore of the crankshaft and the other end in a bore of a pinion.

The gearing according to the present invention has various advantages. The individual auxiliary apparatus need not as hitherto be combined to a block to allow reversal whereby the block as a whole had to be exchanged against another block.

The gearing according to the invention, moreover, has the advantage of being provided with all parts required for the various basic control positions (clockwise- and anti-clockwise rotation). The reversal itself, i. e. the change of the basic control position for instance from clockwise rotation to anti-clockwise rotation may be effected in the shortest time and eventually also at any desired place. The basic control position may be made discernible by providing signs on the outside of the reversing members in consideration, for instance, by applying a dye of a special color for each direction of rotation in such a manner that persons not familiar with the arrangement may be able to at once ascertain the direction of rotation adjusted.

Other features of the invention will be explained in the following description of the various constructions.

In the accompanying drawings some embodi-

ments of the invention are shown by way of example.

In these drawings:

Fig. 1 is a side elevation of a twelve cylinder motor, for instance of an aero-motor, partially in section,

Fig. 2 is a rear view of the construction illustrated in Fig. 1 diagrammatically showing some particular important members,

Fig. 3 is an elevation on enlarged scale of a portion of a cam shaft having four control cams for each of the two control rods or tappets of the valve of a cylinder,

Fig. 4 shows a well-known control diagram representing diagrammatically the various admission and exhaust positions of the different cams,

Fig. 5 is an end view of the construction illustrated in Fig. 3 showing the positions of the various cams,

Fig. 6 illustrates another modification substantially in section on line VI—VI of Fig. 7 in which an oscillatable stepped gear wheel is provided allowing to always drive the auxiliary apparatus of the gearing in the same sense,

Fig. 7 is a section on line VII—VII of Fig. 6 the section being taken through the main parts only,

Fig. 8 shows another modification of the construction illustrated in Figs. 1, 2 and 6, 7; according to this modification a fixed main driving wheel and two selectively swingable intermediate drive wheels are provided which by their oscillation allow the auxiliary apparatus of the gearing to effect driving in the same sense of rotation,

Fig. 9 is a section of a detail of the construction illustrated in Fig. 8,

Figs. 10 and 11 show another modification, Fig. 10 representing the reversible gearing in the one position and Fig. 11 shows the same gearing in the other position, the reversal in this construction being possible due to the fact that a pinion may axially be displaced and alternately be brought into engagement with further different driving wheels, and

Fig. 12 shows a section through a still other construction of the reversible gear for the auxiliary apparatus.

The construction shown in Figs. 1 and 2 is particularly adapted for the drive of some individual auxiliary apparatus, i. e. particularly of the lubricating pump and the fuel pump the driving power for these apparatus being derived from the cam shaft.

The crankshaft case is designated with *1*. *2* are the motor cylinders set at an angle to the crankshaft in V-fashion. *3* is one of the shafts provided with cams. The shaft *3* is journalled at *4* in a journal bearing. Another journal bearing arranged at the end face of the crank case is provided with a bushing *5*. The end of the cam shaft extending outwardly at this point is designated *6* and provided with a thread upon which a nut *7*, for instance a hexagon nut, is screwed. The bushing *5* is arranged in the interior of the bearing body *8* which is reversibly arranged in the crank case in such a manner that the bearing body together with the bushing may be brought axially into another position and be fixed in this position in the longitudinal direction. One of the axial positions is shown in Fig. 1. In this position one of the bevel wheels described in detail later on engages into the bevel wheel *23* driving the associated auxiliary apparatus. In the other axial position of the bearing *8* the other of the two bevel wheels engages the just mentioned driving bevel wheel *23*.

Four cams of the shaft *3* are designated *9*, *10*, *11* and *12*. The two cams *9* and *10* form a group and alternately cooperate with the control rod or tappet *13*, for instance of an admission valve of the cylinder *2*. The control rod *13* is in its axial direction displaceably mounted in a guide *14*.

The two cams *11* and *12* also form a group. Each of these cams alternately cooperates with the control rod or tappet *15* which, for instance controls the exhaust valve of the cylinder *2* of the internal combustion engine. The control rod *15* is mounted in an axial guide *16*.

In the direction looking from the cams towards the bearing *5*, *8* the cam shaft *3* has a part *17* provided with wedge grooves or the like into which engage wedges by means of which driving wheels rotate the cam shaft, the wheels *18* being journalled in the crank case by means of a side bracket bearing *250*. In all positions of the crankshaft *3* the spur gear wheel *10* mounted in this manner maintains its position with regard to the crank case *1*. The wheel *18* serves as driving wheel for the cam shaft and always engages a corresponding gear wheel mounted upon the crankshaft of the internal combustion engine. Consequently, during rotation of the crankshaft the cam shaft also is rotated. Hereby the power is transmitted to the cam shaft by way of the driving wheel *18* and the wedge.

Adjacent the driving wheel *10* and in the direction towards the bearing *5* a sleeve-like body *19* is so connected to the cam shaft *3* as to be capable of axial displacement. The ends of the sleeve-like body *19* carry bevel wheels *20* and *21* respectively the teeth of which face each other.

The two bevel wheels *20* and *21* may alternately be brought into engagement with another bevel wheel *23* fixed upon a shaft *24*. In a manner not shown in the drawings the shaft *24* is connected to the driving mechanism of the auxiliary apparatus, particularly the lubricating pump and the fuel pump. The bevel wheel *23* as well as the shaft *24* are journalled in the casing portion *25* of the internal combustion engine.

26 in Fig. 2 designates a driving wheel fixed upon the crank-shaft of the internal combustion engine and engaging another driving wheel *27* rotatably mounted upon the shaft *28*. Rotatably mounted upon the latter is another driving wheel *29* rigidly connected to the driving wheel *27*. The driving wheel *28* engages with the already mentioned driving wheel *18* which is connected to the part *17* of the cam shaft *3* by means of keys.

The driving wheel *26* mounted upon the crankshaft also engages a driving wheel *30* rotatably mounted upon an axis *31*. Also rotatably mounted upon the latter is a driving wheel *32* rigidly connected to the driving wheel *30* and engaging another driving wheel *33* which corresponds to the already mentioned driving wheel *10* and is arranged upon a cam shaft *34* which as cam shaft belongs to the other group of cylinder rows arranged in V-fashion. *35* designates the driving shaft for an auxiliary apparatus corresponding to the driving shaft *24*. One of these auxiliary apparatus, for instance the oil pump, is designated *36* and another auxiliary apparatus, for instance the fuel pump, is designated *37*. The driving wheel *23* drives the pump *36* and the driving member *35* drives the pump *38*.

In Fig. 3 the cam shaft is designated 38, the illustrated broken away portion of which carries eight cams 39, 40, 41, 42, 43, 44, 45 and 46. Any two of these cams form a group for alternately actuating a coordinated valve tappet for a cylinder of the internal combustion engine. So, for instance, a group is formed by the cams 39, 40, another group by the cams 41, 42, another group by the cams 43, 44 and still another group by the cams 45, 46. The cams 39 and 40 cooperate with the tappet 47, the cams 41, 42 with the tappet 48, the cams 43, 44 with the tappet 49 and the cams 45, 46 with the tappet 50.

The cams 39 and 40 are arranged in an axially spaced relation from each other for the distance *b*. The cams 41 and 42 are spaced from each other for the axial distance *c*. The vertical projection of the cam 42 overlaps the tappet 46 about the distance *a*.

The control surfaces projecting furthest outwardly of the cams 39, 42, 44 and 45 are directed upwardly, whereas the control surfaces projecting furthest outwardly of the other cams 40, 41, 43 and 46 are directed downwardly. In the left hand group of cams 39, 40, 41 and 42 controlling the valve tappets of the cylinder 4 of the internal combustion engine the two outer cams 39 and 42 are directed upwardly, whereas the two inner cams 40 and 41 are directed downwardly.

In the group of cams 43, 44, 45, 46 serving to actuate the valve tappets, for instance of the cylinder 5 of the internal combustion engine, the two outer cams 43 and 46 are directed downwardly, whereas the two inner cams 44 and 45 are directed upwardly.

Whereas with the tappets of the cylinder 4 the tappet 47 arranged at the left hand side occupies the upper position, the corresponding tappet 49 of the cylinder 5 occupies its lower position. The tappet 48 of the cylinder 4 arranged at the right hand side, however, occupies its lower position, whereas the corresponding tappet 50 of the cylinder 5 occupies its upper position.

The various tappets and their positions partly may be seen from the end view shown in Fig. 5 and particularly from the control diagram shown in Fig. 4. Here also the following designations have been used. The capital letters E and A designate the admission and exhaust respectively. The Roman figures designate for instance a basic control position, the Arabic figures then designate the other basic control position. Furthermore, the Figures 1–6 and I–VI respectively designate the various cylinders of the internal combustion engine. The ignition is for instance effected in the succession 1, 5, 3, 6, 2, 4 for the rotation in the clockwise direction and 1, 4, 2, 6, 3, 5 for the rotation in the anti-clockwise direction.

Reversal of the internal combustion engine 1, 2 may for instance be effected as follows: The engine is stopped, whereupon the cam shaft is shifted towards the left about 2 mm and the measure *c* until some of the cams abut against adjacent tappets. Another portion of the cams thereby is moved about the distance *a* over the coordinated valve tappets. Thereupon, the cam shaft is rotated about 180°, whereby such cams overlapping the coordinated valve tappets for the distance *a* are caused to lift these tappets. After rotation round 180° has been effected, the cam shaft may be shifted further towards the left for the rest amount of the still possible way of displacement.

Before carrying out these operations the bevel gear 20 had been in engagement with the bevel gear 23. After carrying out these operations and after the shifting of the cam shaft towards the left has been effected, the bevel gear 20 no longer engages the bevel wheel 23, but now the bevel wheel 21 is in engagement with the bevel wheel 23.

After the displacement of the control shaft towards the left has been terminated, the reversible bearing 5, 6 is fixed and thereby the new operative position of the cam shaft is warranted. Two other cams now cooperate with the tappets of the admission and the exhaust respectively. Consequently, the internal combustion engine is, according to the arrangement and construction of the cams shown in Figs. 3, 4, and 5, reversed in such a manner that the crankshaft now rotates in opposite direction to that in which it was rotated before the reversal of the cam shaft was effected. The direction of rotation for the auxiliary apparatus, however, is the same as before, because the change gearing 20, 21, 23 has also been reversed during displacement of the cam shaft.

In the modification shown in Figs. 6 and 7 the crank case of the internal combustion engine is designated 51. The cylinders shown partially in front elevation only are designated 52 and the geometrical axis of the crankshaft is designated 53. Round the axis 53 a main driving gear 54 is rotatably arranged which, however, is neither displaceable nor swingable with the wheel 54 provided with an internal toothed rim 60 the wheel 55 cooperates in various positions. The wheel 55 is swingably journalled in such a manner that in any position of oscillation it always is brought into engagement with the surrounding wheel 54. The wheel 55 is formed as a spur gear wheel and fixed upon a sleeve or the like upon which also is fixed another spur gear wheel 56 provided with an external toothed rim. This other gear wheel 56 therefore may be swung in the same manner as the gear wheel 55 the swinging being positively effected together with the swinging of the wheel 55. According to the position into which it has been swung, the gear wheel 56 either engages a spur gear wheel 57 or another spur gear wheel 61. The two gear wheels 57 and 61 are in engagement with each other.

If the gear wheel 56 engages the gear wheel 57, the latter receives a definite rotation. This rotation is transmitted in the same or opposite sense but in a quite definite manner to all the spur gear wheels 61–72 connected to the wheel 57.

Reversed direction of rotation of each individual spur gear wheel connected results if the swingable gear wheel 56 engages the gear wheel 61 as this latter engages the gear wheel 57 and any two gear wheels engaging each other rotate, as is well-known, in opposite directions. The gear wheel 61 is connected by way of the pinion 62 with the driving wheel 63 for the dynamo or lighting machine. Moreover, the pinion 62 engages the gear wheel 64 upon the shaft of which another gear wheel 65 is fixed which engages a gear wheel 66. The latter drives a spur gear wheel 67 serving to drive the magneto ignition device. The already mentioned spur gear wheel 64 also drives a spur gear wheel 69 for the air compressor by way of the spur gear wheel 69. From the latter the driving power for a gear wheel 70 is derived which directly engages the wheel 60. The wheel 70 is in engagement with another spur gear wheel 71 which drives a gear wheel 72 for actuating the lubricant pump.

By way of the spur gear wheels 58 and the gear wheel 59 mounted on the shaft carrying the gear

wheels 58 the gear wheel 57 drives another spur gear wheel 60 by means of which the charger of the internal combustion engine is actuated.

In the construction shown in Fig. 7 the crank pin of the crankshaft of the internal combustion engine is designated 73. Connected to the one cheek or side wall of this crank pin 73 is a hollow pin 74 journalled in a slide bearing 75. Inserted into the recess of the pin 74 is a sleeve 76 which may for instance be fixed by friction, and at the inner surface of which are provided teeth, serrations or the like 83 into which engage corresponding teeth, ribs or the like of a torsional spring 82. The ribs of the torsional spring 92 engaging the grooves of the sleeve 76 warrant the elastic transmission of the torque from the crankshaft 73 to the connected gearing elements. A large portion of the length of the torsional spring 82 is surrounded by a sleeve 77 carrying various gearing elements and which may be rotated in a definite manner about the longitudinal axis. The sleeve 77 is provided with a projection which is journalled in the bearing 79. The latter may for instance be carried by the crankshaft case 79. The portion of the sleeve 77 supported by the bearing 78 is continued as a bushing 54 surrounding the sleeve 77. This bushing 54 is provided with the already mentioned internal toothed rim 80. Between the outer wall of the sleeve 77 and the inner wall of the crankshaft rib-like supporting members 251 for the sleeve 77 may be arranged with sufficient play so that stops of the rib-like supporting members 251 prevent overloading of the torsional spring, for instance during starting. The end of the rod 82 not cooperating with the crankshaft 73 is provided with a piston-like enlargement having externally axially arranged ribs, teeth or the like 84. The latter engage corresponding grooves or teeth of the portion 85 of the sleeve 77 protruding from the crankshaft casing. The portion 85 bears by way of a ball bearing 86 against a sleeve 87 which is journalled in the wall of the crank-shaft casing, a flange 88 of the sleeve 87 bearing against the outer wall of the crankshaft casing and being held by means of a cap screw 89. This screw simultaneously also holds a disc 90 or the like provided with a centre bore.

The outwardly directed end face of the portion 85 of the sleeve 77 is provided with a flange to which a flange disc 91 is fixed for instance by means of screw bolts. The disc 91 has a recess 92 in its middle portion into which a pin (not shown in the drawing) of a starting crank or handle for the crankshaft of the internal combustion engine may engage. The walls of this recess 92 are in a manner known per se provided with further inclined recesses or notches which allow that during rotation in one direction the starting crank or handle is coupled to the part to be actuated, but is disengaged as soon as rotation in opposite direction is effected. This has the advantage that on starting of the machine return shocks of the crankshaft are not transferred upon the starting crank or handle.

The above mentioned sleeve 87 is made integral with the eccentric sleeve 93 and is connected to the crankshaft casing by means of a flange. The sleeve 93 freely surrounds the sleeve 77 in a spaced relation. Rotatably and swingably mounted upon the eccenter 93 is a body 94 carrying two spur gear wheels which are axially arranged side by side but have different diameters so that the two gear wheels form a step. The one of these gear wheels is designated 55 and has already been described in connection with the modification shown in Fig. 6. The other gear wheel designated 56 also has already been described in connection with the modification illustrated in Fig. 6.

According to the position into which the carrier body 94 has been swung the gear wheel 55 comes at different places into engagement with the toothed rim 80 driven by the crankshaft 73 by means of the spring rod 82. This toothed rim 80, therefore, rotates the toothed rim 55, whereby the body 94 of this portion and thereby also the toothed rim 56 is rotated. By rotating the sleeve 93, 87 about its longitudinal axis the carrier body 94 is lifted or lowered. Simultaneously the eccentrically arranged toothed rim 56 also is lifted or lowered and selectively brought into engagement either with the gear wheel 61 (see Fig. 6) or with the gear wheel 57 (see Figs. 6 and 7).

In the service position shown in Fig. 7 the toothed rim 56 engages the toothed rim 57 which in turn engages the toothed rim 58 the hub of which is rigidly connected to the hub of a further toothed rim 59. The latter engages a toothed rim 60 upon the shaft of which the body 95 carrying the vanes 96 of a charger is arranged in suspension. If the vanes 96 are rotated, air is drawn in by way of the socket 97 and is forced into the channel 98 annularly surrounding the vanes 96. The channel 98 is formed on the one hand by the crankshaft case of the internal combustion engine and on the other hand by a joined special casing 98 having a recess 100 by which access may be had to the clutch members 91, 92 of the starting crank or handle.

If due to a reversal of the cam shaft the direction of rotation of the crankshaft of the combustion engine is changed, then rotation of the sleeve 93 causes swinging of the eccenter provided at said sleeve so that the gear wheel 56 is brought into engagement with another spur gear wheel for instance from 57 to 61 disengaged from the wheel 57 and engaged with the wheel 61 or vice versa disengaged from the wheel 61 and engaged with the wheel 57. By this change of engagement the altered direction of rotation of the crankshaft is so changed for the auxiliary apparatus that these continue to rotate in the same sense of rotation.

If the motor is started with a centrifugal starter having a large starting torque it is preferable to cause the starter to directly act upon the crankshaft, i. e. by cutting out the torsional rod by way of the stops 251 after overcoming the play prevailing in the state of rest. In the modification shown in Figs. 6, 7, 8 and 9 it is preferable to exchange the starter and the starter jaws 91 when altering the direction of rotation of the crankshaft, whereas this is not required with the constructions shown in Figs. 10, 11 and 12.

In the construction shown in Fig. 8 the crank case of the internal combustion engine is designated 101. The two cylinder rows are designated 102 and 103 respectively and the casing of the charger is designated 104. The charger is provided with two spirally arranged channels which are connected to the casing proper of the rotating vanes.

Of the various spur gear wheels diagrammatically shown in Fig. 8 two pinions the axes of rotation of which are swingable are designated 105 and 107 respectively. The pinion 105 is mounted for instance upon an eccentrically arranged carrier 108 as shown in Fig. 9. The latter is by means of a cylindrical pin 120 rotatably supported in the casing portion 123 of the crank-

shaft case 101. On the other side the eccentric bolt 108 carries a disc 106 about in the shape of a parallelogram provided with two diametrically arranged bores through which extend screw bolts 121. The thread of the bolts 121 is screwed into the female thread of the wall 122 of the crankshaft case 101. The axes of the screw bolts 121 are both arranged in the same distance from the center axis of the pivoted pin 120 of the carrier body 108. The pinion 105 may for instance be swung by loosening the two screws 121, gripping the disc 106 of the carrier body 108 and turning same round 180°, whereby the eccentric portion of the carrier bolt 108 for instance is swung upwardly (see Fig. 9). Then the screw bolts are again inserted into the holes of the disc 106 and screwed into the female thread of the bearing portion 122.

The pinion 107 is correspondingly journalled. The swingable disc of the eccentric bearing pin for this pinion 107 is designated 108*a*.

Depending on the position into which the pinion 105 has been swung, the latter engages the main pinion 104, the pinion 107, engaging the pinion 105, thereby maintains its position and is prevented from engaging the pinion 104.

If now the main pinion 104 which for instance is mounted upon the crankshaft and rotates with the latter in the same sense is rotated in another direction, then reversal must be effected in such a manner that the drives of the auxiliary apparatus continue to rotate in the same direction of rotation in spite of the other direction of rotation of the crankshaft. For this purpose during reversal the pinion 108 is brought out of engagement with the pinion 104. The pinion 107, however, is so swung that it engages the pinion 104 and simultaneously remains in engagement with the pinion 105. Consequently, the opposite sense of rotation of the crankshaft is so changed that all driving wheels connected thereto continue to rotate in their previous sense of rotation.

The pinion 107 engages a pinion 109 upon the axis of which another pinion 110 is fixed engaging a pinion 111 fixed upon the axis of the charger 104*a* which latter is driven thereby.

The pinion 105 engages a pinion 112 in turn engaging another pinion 113. The latter engages a pinion 114 upon the shaft of which a pinion 115 is fixed. The pinion 114 rotates a pinion 116. The pinion 115 drives a pinion 117 engaging another pinion 118 which finally engages a pinion 119.

Some of the pinions mentioned serve for instance for operating the lighting machine or dynamo, the air compressor, the magneto ignition device, the pumps and so on.

Eventually, the eccentric pin of the swingable pinions may be rotated by means of a worm actuated from the exterior.

In the construction shown in Figs. 10 and 11 a portion of the wall of the crankshaft case is designated 124. The crankshaft 125 is journalled in the slide bearing 126 and is provided with a sleeve 127 connected to one of the cheeks of the crank and facing towards the gearing driven by the crankshaft. This sleeve 127 is journalled in a slide bearing 128. In the sleeve-like portion of the shaft another sleeve 129 is provided which by means of a fitting pin 130 or the like is connected to the crankshaft in a manner to be rotated with the latter. The interior of the sleeve 129 is provided with axially extending ribs, teeth or the like into which engage correspondingly shaped teeth or grooves 131 of a rod 132 acting as torsional spring. The other end of the rod 132 also is provided with axially extending grooves, teeth or the like engaging in corresponding grooves or teeth of the sleeve 134. This sleeve partially surrounds the rod 132 in spaced relation. The side of the sleeve 134 facing the crankshaft is provided with a sleeve-like projection 135 having at 136 teeth projecting to the exterior which engage axial grooves or the like of the sleeve 129 and serve the purpose of transmitting the power from the crankshaft upon the sleeve 135. Projecting from the sleeve 134, 135 is a carrier body 137 of a spur gear rim 138. The carrier body 137 and the sleeve 134, 135 are made integral. Adjacent the carrier body 137 a wall 139 is provided which serves as a bearing. In this wall 138 the sleeve 135 is rotatably and shiftably arranged by means of a slide bearing bushing 140.

The wall 139 carries another bearing bushing 141 in which a bolt 142 is rotatably journalled carying a hub 143 forming one piece with two gear wheels 144 and 145. The gear wheel 144 is smaller than the gear wheel 145 and in the position of the gearing shown in Fig. 10 engages with the toothed rim 138 of the carrier body 137.

The bolt 142, moreover, is journalled in a bearing bushing 146 resting in a recess 147 of the wall 124 of the crankshaft case.

The spur gear wheel 145 engages with a further spur gear wheel 148 fixed upon the shaft 149 which is rotatably journalled in a slide bearing 150.

The bolt 149 is provided with a projection 151 upon which a carrier body 152 for vanes 153 is mounted in suspension. The carrier body 152 together with the vanes 153 is prevented from performing undesired axial displacements by means of a shoulder 154 of the bolt 149. By way of a socket 154*a* air, for instance, may be sucked in by means of the charger 151—154 which air then is pressed into a channel 155. The latter on the one hand is formed by a recess of the casing wall 124 and on the other hand by a casing 156. The latter has an opening 157 through which a handle or starting crank for starting the crankshaft may be inserted.

Upon the above mentioned bolt 142 a further gear wheel 150 is fixed the hub of which preferably is made integral with the hubs of the gear wheels 143 and 145. Another gear wheel 159 is fixed upon a sleeve-like hub 160. The latter surrounds the sleeve 134 mentioned above and is provided with jaws or claws 161 or the like directed inwardly which may be coupled with correspondingly shaped claws 162. These claws are arranged upon the sleeve 134 and project outwardly. By axially shifting the sleeve 134 the claws 162 and 161 may be engaged and disengaged respectively. Moreover, the gear wheel 137, 138 may be disengaged from the gear wheel 144, 143 by an axial displacement of the sleeve 134.

In the construction shown in Fig. 10 the gear wheel 138 engages the gear wheel 144, whereas the claws 162, 161 are out of engagement. In the construction shown in Fig. 11 the gear wheel 138 is out of engagement with the gear wheel 144, whereas the claws 162 and 161 are coupled together.

Into the casing 158 another sleeve body 163 projects forming a continuation of the sleeve 160. The sleeve body 160, 163 is journalled in the wall 124 of the crankshaft case. To this purpose bearing bushings 164 and 165 are provided be-

tween the sleeve body 160, 163 and the wall 124. The bearing bushing 164 is directed towards the inner walls of the casing 124, whereas the bearing bushing 165 is directed towards the outer wall of the casing 124 facing the space surrounded by the casing 156. The end of the portion 163 of the sleeve 160 projecting outwardly carries an outer thread upon which is screwed a nut 169 by means of which the sleeve 160, 163 may axially be fixed in position.

The front end of the portion 163 of the sleeve 160 is provided with a recess 167 into which the handle or starting crank may engage. The recess 187 is provided with other recesses not shown in the drawings which serve the same purpose as the corresponding recesses in the modification shown in Fig. 7, i. e. the purpose of allowing coupling of the handle or starting crank with the sleeve 163 during rotation in one direction only, whereas on rotation in the opposite direction the crank or handle is disengaged or released.

In the recess 167 a screw bolt 168 is arranged having a hexagon head 169 or the like. The end of the bolt 168 carrying the thread 170 is screwed into the above mentioned head 133 of the spring rod 132 less deep in the position shown in Fig. 10 and deeper in the position shown in Fig. 11. By means of this screw connection the rod 132 and the sleeve 135 coupled thereto together with the gear wheel 137, 138 and the coupling claw 162 may axially be shifted on rotation of the bolt 168, 169, 170.

For instance, after rotation of the bolt 168, 169, 170 the rod 132 together with the sleeve 135 is shifted so far towards the right until a limitation of the movement is effected by striking against a fixed portion, whereupon the position shown in Fig. 11 is obtained.

The outer periphery of the head 133 of the spring rod 132 is provided with grooves or ribs 171 which engage in corresponding ribs or grooves of the portion 172 of the sleeve 134 and thereby form a coupling for transmitting the torque. The power, therefore, is transmitted from the crankshaft 125 by way of the grooves and ribs of the portion 131 of the rod 132 upon the other head 133 of this rod. The grooves and ribs provided here transmit the power upon the portion 172 of the sleeve 134. From the latter the power is transmitted to the gear wheel 137, 138 and the coupling claw 162 respectively. Moreover, as soon as the resilient rod 132 is twisted to a definite degree, the sleeve 135 is coupled to the sleeve 129 by means of its outer projections 136. This coupling of the projections 136 has the advantage that on starting the twistable rod 132 is not damaged or destroyed by the return shock. The stops 136 have so much tangential play that the crankshaft during normal operation may freely swing, i. e. may transmit its power by way of the resilient rod.

The portion 172 of the sleeve 134 bears against the sleeve 160 by way of a roller bearing 173. Moreover, the front end of the portion 172 is provided with a shoulder 175 against which bears a ball bearing 174 held against axial displacement by means of an expanding ring 176 or the like. A projection of the sleeve 160 directed towards the interior is designated 177. Axial displacement towards the right of the screw bolt 168, 169, 170 is prevented by the safety member 178 if by rotating of the screw bolt 168, 159, 170 the head 133 of the spring rod 132 is removed towards the left away from the stop 177.

In Fig. 10 the individual elements or members occupy the position adapted for an anti-clockwise rotation, whereas Fig. 11 shows the position of the individual elements adapted for a clockwise rotation. In the first case (Fig. 10) the main driving wheel 137, 138 is coupled by way of the gear wheel 144 to the gear wheel 159, the power from the wheel 144 then being transmitted to the gear wheel 159 by way of a wheel 158 and another gear wheel not shown in the drawings. The coupling claws 162 and 161 are out of engagement in this position. All other driving wheels for the various auxiliary apparatus, as ignition device, charger, pumps and so on, are connected to the driving wheel 159.

For rotation in an anti-clockwise direction (Fig. 11) the gear wheel 137, 138 is out of engagement with the gear wheel 144. The gear wheel 137, 138 is coupled in this case to the gear wheel 159 directly by way of the claws 162, 161. In this case the gear wheels 137, 138 and 159 have the same direction of rotation, whereas in the position shown in Fig. 10 the two gear wheels rotate in opposite directions. The wheel not shown in the drawings and arranged between the gear wheel 158 and the gear wheel 159 effects a reversal of the direction of rotation in the position of the individual elements shown in Fig. 10. In this position according to Fig. 10 the ball bearing 174 acts as thrust bearing as the gear wheels 137, 138 on the one hand and 159 on the other hand rotate in opposite directions.

The not particularly designated starting claws at the front ends of the sleeve 168 and the crankshaft rotate in the same direction.

In the modification shown in Fig. 12 the crankshaft 179 provided at its end facing the gearing with a sleeve 180 is journalled in a slide bearing 181. Into the sleeve 180 of the crankshaft 179 extends the rod 183 which in this case is not formed as a torsional spring but as a coupling member and is provided at one end with a head 184. The latter has axially extending grooves, teeth or the like which engage in corresponding teeth or grooves 182 of the bore surrounding the bolt and thereby warrant a transmission of the torque from the crankshaft upon the bolt. With the rigid construction of the coupling rod 183 the stops 251 shown in Fig. 7 may be dispensed with. The shaft 193 in this case is used as an elastic member for driving the charger.

The other end 185 of the bolt 183 has a shoulder 186 which is formed in a distance from the end of the bolt corresponding about to the axial length of the head 184 provided at the other end of the bolt. The outer surface of the shoulder 186 is provided with axially extending grooves, ribs or the like which cooperate with corresponding ribs, grooves or the like 187 of bevel wheels. The grooves, ribs or the like are provided in the interior of a hub 188 which by means of a ball bearing 189 is rotatably journalled in the wall 190 of the crankshaft case. The hub 188 carries a disc with a cone-shaped toothed rim 191 engaging a toothed rim 192 the axis of rotation of which is arranged about vertically to the axis of rotation of the crankshaft 179 and the coupling rod 183. The bevel wheel 192 is fixed upon a shaft 193. The bevel wheel and the shaft are arranged in a neck-journal 194.

Another hub 196 surrounds the portion 185 of the bolt 183 and the inner wall of same facing the bolt is provided with grooves, ribs or the like by means of which a coupling to corresponding grooves or ribs of the bolt could be effected if the corresponding grooves, ribs and so on engage each

other. As the end portion 185 of the bolt is not provided with grooves, ribs or the like, the hub 188 is not coupled to the bolt 183 but loosely rotates round this bolt, the rotation being transmitted by means of the bevel wheel 195. The hub 196 bears against the wall 198 of the crankshaft case by way of a ball bearing 197. This portion of the case has a perforation 199 by means of which access may be had to the gearing. Through this perforation 199, for instance, a handle or starting crank may be inserted and applied to the head portion 200. The two ends of the hubs 188 and 196 facing each other are surrounded by a ring 201 which bears against the hubs by way of two further rings 202 and 203.

If the direction of rotation of the crankshaft 179 is changed, the direction of rotation of the shaft 193 which serves for driving the charger also would be changed. To warrant, however, that the direction of rotation of the shaft 193 remains the same as previously, the bolt 183 after loosening the members fixing same in its position is axially withdrawn, swung about 180° and inserted again. Hereby the axial ribs or the like of the head 184 of the rod 183 engage corresponding ribs, grooves or the like of the hub 188 so that now this hub is positively coupled to the rod and thereby also to the crankshaft, whereas the hub 188 loosely, i. e. without coupling, surrounds the portion of the rod 183 provided behind the head 184.

Due to this reversal the change of the direction of rotation of the crankshaft has no effect on the shaft 193.

A gear wheel 204 fixed upon the hub 188 serves for driving all other auxiliary apparatus including the cam shaft. The gear wheel 204, for instance a spur gear wheel, is for a clockwise and anti-clockwise rotation always rotated in the same direction.

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