

Feb. 9, 1926.

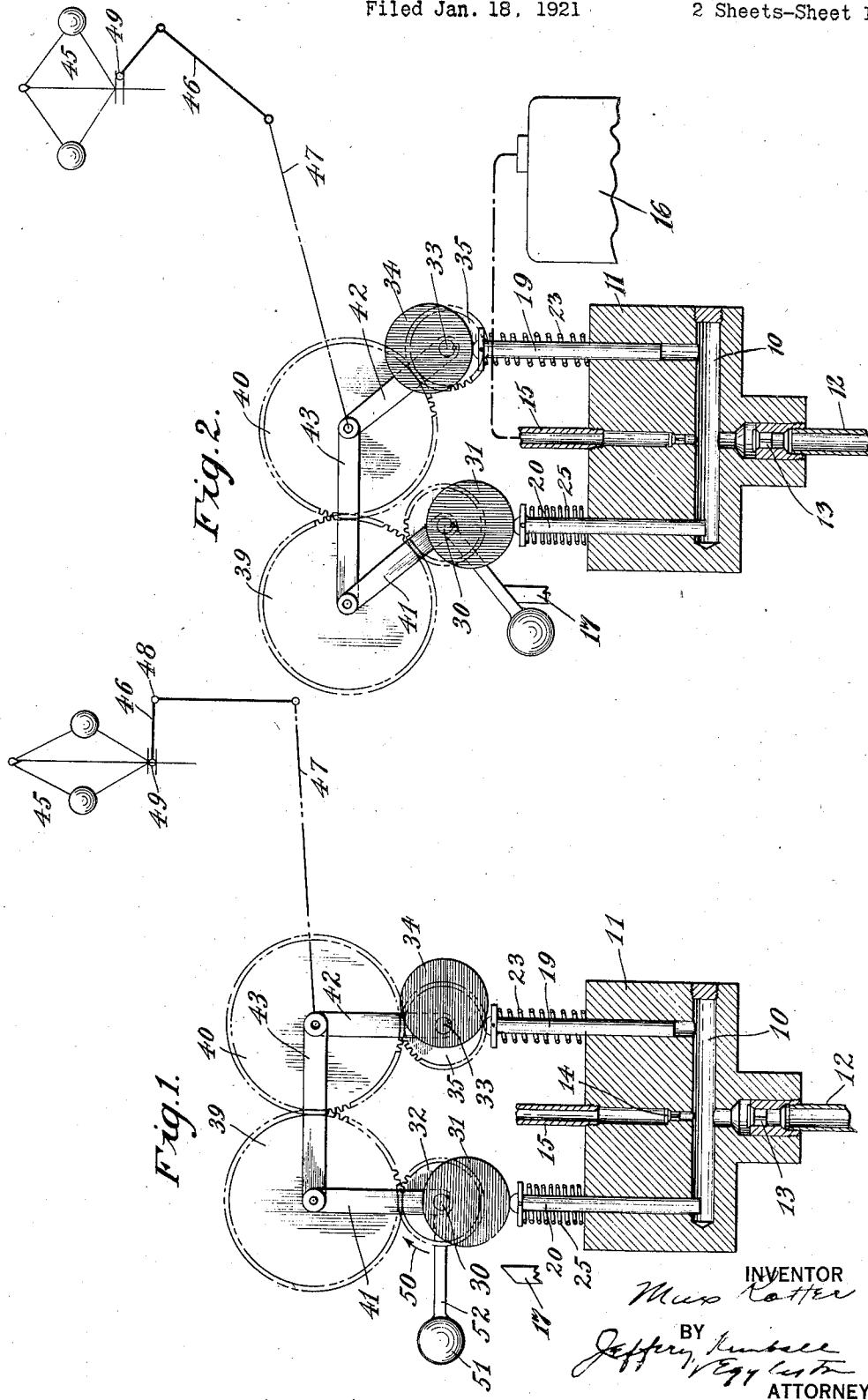
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INTERNAL COMBUSTION ENGINE

Filed Jan. 18, 1921

2 Sheets-Sheet 1



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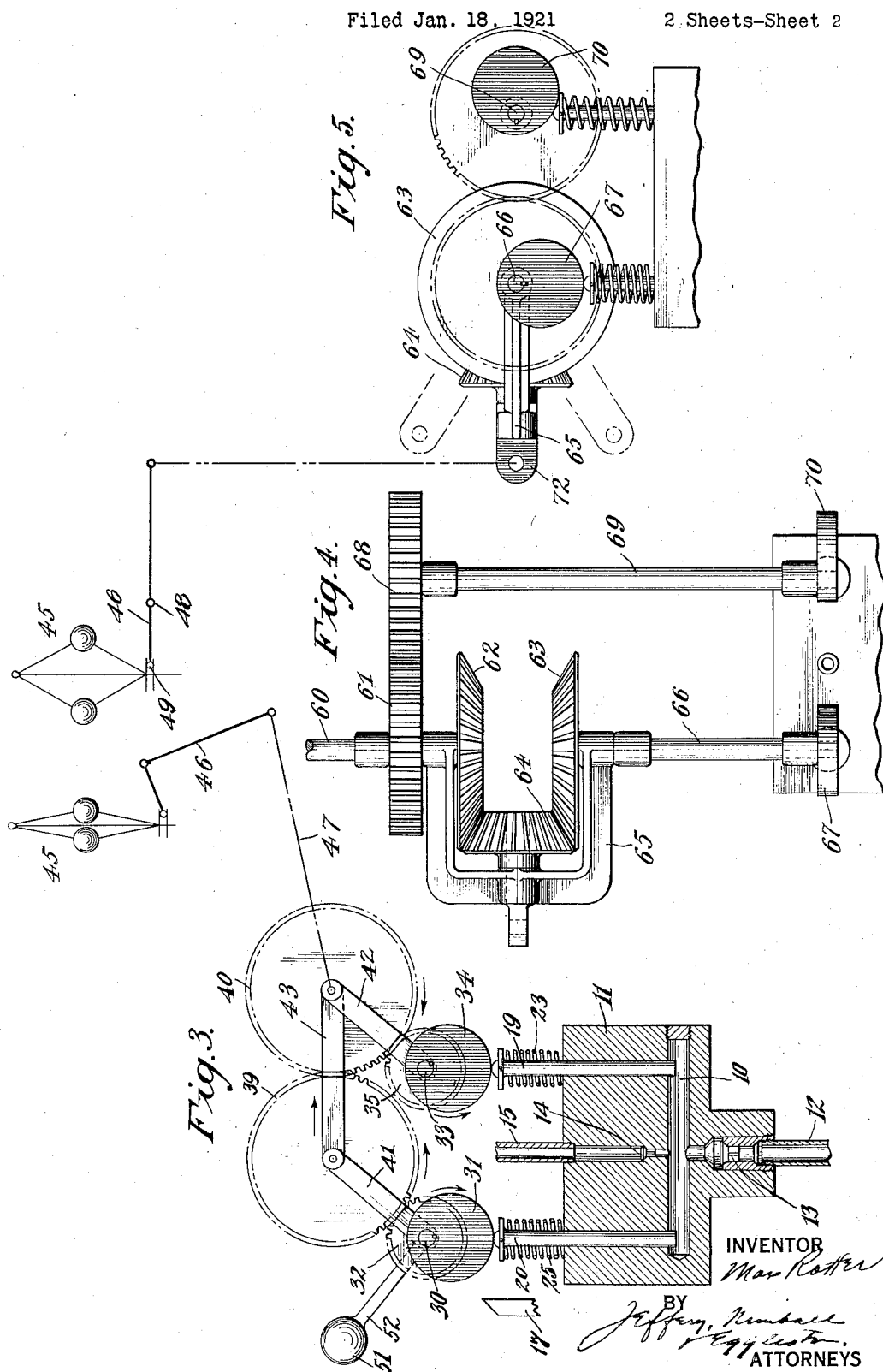
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2 Sheets-Sheet 2



UNITED STATES PATENT OFFICE.

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DIESEL ENGINE COMPANY, OF ST. LOUIS, MISSOURI, A CORPORATION OF MISSOURI.

INTERNAL-COMBUSTION ENGINE.

Application filed January 18, 1921. Serial No. 438,116.

To all whom it may concern:

Be it known that I, MAX ROTTER, a citizen of the United States, residing in Milwaukee, Wisconsin, have invented the following new and useful Improvements in Internal-Combustion Engines.

My invention relates to fuel pumps for internal combustion engines of the fuel injection type and contemplates a pump having multiple plungers interconnected by epicyclic gearing. The amount of fuel delivered is changed by changing the relations of the gears of the epicyclic train, thus altering the phase relations of the pump plungers and their resulting joint displacements. The gear relations may be changed by hand or by the engine governor as preferred, and preferably the operating mechanism is so arranged that on an accidental rupture of the connections through which the gear relations are altered, the phase relation of the plungers is automatically changed to complete opposition so that no fuel is delivered to the engine.

In the accompanying two sheets of drawings—

Figures 1, 2 and 3 are diagrammatic representations of a governor controlled two-phase pump involving my invention: In Figure 1 the pistons are about 90° out of phase and the pump capable of delivering only a part of its full capacity; in Figure 2 they are in complete opposition and the pump is incapable of delivering any fuel while in Figure 3 they are in phase or complete synchronism and the pump is adapted to deliver its full capacity;

Figures 4 and 5 are respectively a plan and elevation of a modification embodying another form of epicyclic gearing.

In Figures 1, 2 and 3 a space or chamber 10 connects the two cylinders which accommodate the pistons or plungers 19 and 20 in the pump body 11. Under the suction strokes of the plungers liquid fuel is drawn into space 10 from a fuel tank (not shown) through the inlet pipe 12 and a suction check valve 13, and on the compression strokes is delivered from the same space through an outlet check valve 14 and pipe 15 leading to or toward the engine cylinder or cylinders 16. The check valves 13 and 14 represent any suitable pump valve construction and the plungers 19 and 20 any suitable form of

plunger construction. Springs 23 and 25 actuate the plungers 19 and 20 respectively on their suction strokes.

The pump is driven by a shaft 30, on which is keyed a cam 31 for depressing the plunger 20 and also a gear 32. An adjacent parallel shaft 33 carries a cam 34 for operating the other plunger 19, and likewise a gear 35. Circular cams set eccentric to the shafts are shown in these diagrammatic drawings but will be understood to represent any appropriate plunger-operative elements. The two gears 32 and 35 are connected in an epicyclic train so that the former drives the latter, and the phase relations between the two shafts can be changed, as mentioned above, by means of the intermediate or planetary gears 39 and 40 which mesh respectively with the gears 32 and 35, which are sun gears, and with each other. The planetary gears are carried by links 41 and 42 respectively mounted to swing concentrically to the cam shafts 30 and 33 and are connected by a link 43. The position or adjustment of the linkage and gears 39 and 40 with reference to the shafts 30 and 33 is illustrated here as controlled by the governor 45; for example, 47 represents a connection between the link 42 and the governor bell crank so arranged that increasing the governor speed which turns the bell crank about its pivot 48 as the collars 49 on the governor rise, will swing the linkage to the left. This movement, it will be apparent, will alter the angular relation of the shafts 30 and 33, for if the shaft 30, which is the driving shaft, be conceived to be stationary, this movement of the linkage will turn gear 39 counter-clockwise on its axis, and this in succession will turn gear 40 clockwise and gear 35 (on shaft 33) counter-clockwise, and thereby turn shaft 33 and its cam 34 through an angular displacement corresponding to the angular movement of the linkage and according to the well understood principles of epicyclic gearing. Obviously the same change of angular relation will be accomplished if the driving shaft is in motion.

The pump operating cams are so set on their respective shafts 30 and 33 that when the linkage is in the extreme lefthand position shown in Figure 2 the cams are in complete opposition or 180° apart and accordingly the plungers are driven in opposition

and each makes a suction stroke as the other makes a delivery stroke. If the capacities of the two plungers are equal, the suction stroke is equalized by the delivery stroke and the liquid fuel merely travels from one cylinder to the other through space 10 and back again, none being taken in through check valve 13 and none passing out through the outlet. As the linkage is moved from this position toward the right, however, the change in the angular relation of the cams causes the plungers to approach synchronism, the degree of approach depending on the change and Figure 1 shows the situation when the linkage is midway between the two extremes of complete opposition in Fig. 2 and complete synchronism in Figure 3. As may be seen from Figure 1, in each of the intermediate positions the cams cause the plungers to perform a part of their suction strokes together and a part of their delivery strokes together, and at other times cause one plunger to move faster in one direction than the other moves in the opposite direction; the net result of this partial in-phase or partial synchronous movement is that during each cycle some fuel is drawn into the space 10 from the inlet 12 and an equivalent amount delivered through the outlet pipe 15, the total delivery depending on the degree to which the plungers operate in synchronism and hence on the position of the linkage. In Figure 3, where the plungers work in complete synchronism, that is, make the whole of their suction strokes together and the whole of their delivery strokes together, the pump delivers its full capacity or the sum of the stroke volumes of the two pistons.

The operation of the device illustrated will be apparent from the above description. As the shaft 30 is driven the cams 31 and 34 depress their plungers 20 and 19 successively or together as before pointed out; as the cams pass their lowermost positions the springs 23 and 25 move the plungers upward but always in contact with and controlled by the cams. When the engine is lightly loaded the tendency for its speed to increase results in the governor moving the pump linkage towards the phase opposition position of Fig. 2, thereby reducing the amount of fuel supplied to the engine to the necessary extent. When the load comes on again and the engine tends to slow down, the consequent change in governor position moves the linkage toward (or even to) the complete in phase position of Figure 3 so far as necessary to increase the fuel to an amount sufficient to keep the speed at the desired value. Moving the linkage by the governor or otherwise to the position of Figure 2 stops the engine.

The regulating action is brought about, it will be observed, by the interconnection of

the plungers by a differential or epicyclic train, two of the gear elements being connected respectively to the plungers so that altering the position of the third alters their phase relation; I prefer to actuate the plungers from the sun gears and exert the control through the planetary element as shown, but my invention contemplates all other connections as well as all forms of such gearing however connected to the plungers, for once the principle is disclosed it will be apparent to those skilled in the art that the result may be accomplished by all the other possible schemes of connection and all other forms of differential gearing. Figures 4 and 5, for example, illustrate the obvious use of bevelled epicyclic gearing. The drive shaft 60 carries a spur gear 61 as well as a bevelled sun gear 62 that faces another bevelled sun gear 63 on a shaft 66 carrying the plunger cam 67. The planet gear 64 is carried by a yoke 65 hung on the two shafts. The spur gear 61 meshes with another spur gear 68 on a parallel shaft 69 carrying the second plunger cam 70. Obviously turning the yoke (as indicated in Figure 5) by a suitable connection with its eye 72 changes the phase relation of the plungers as before.

To stop the engine automatically on an accidental rupture of the controlling connections, it is only necessary to provide for the movement of the linkage to or near the position of phase opposition. Thus in Figs. 1, 2 and 3 on a rupture of connector 47, the weight 51 on the arm 52 extended from the link 41 pulls the linkage to the extreme left-hand position against a stop 17,—Figure 2. A further purpose of this weight is to minimize the power the governor need exert on the linkage and hence enable it to respond more sensitively to changes in speed. As will be understood rotation of the drive shaft 30 in the direction of the arrow in Fig. 1 tends to move the linkage as a whole to the right; without the weight 51 the governor would be required to support the linkage against the whole of this force, but by the use of the weight to more or less counterbalance the inherent tendency of the linkage to move as a whole, the governor is required to support only the difference between the two forces, though obviously the control of the linkage by the governor can be effected by any suitable means which will not tend to react against it to such an extent as to affect its sensitiveness and various means having this effect will be apparent to the designer. If the direction of rotation of shaft 30 were opposite to that of the arrow the linkage would of course tend to move to the phase opposition position of Fig. 2 and stop the engine on rupture of the connector 47 although weight 51 were omitted, and in this case to counterbalance the pull

of the gearing on the governor the weight should act in the opposite direction from that shown.

Claims:

5 1. The combination with a combustion engine, of a fuel pump mechanism comprising a plurality of plungers, an epicyclic gearing interconnecting the plungers and having an
10 element tending to move toward a position in which the plungers work in opposition, and means to normally hold said element in a position in which the plungers work other than in opposition, whereby the pump delivery is reduced upon the occurrence of an
15 accident releasing said element from the effect of said means.

2. The combination in a combustion engine, of a fuel pump comprising a plurality of plungers and epicyclic gearing interconnecting the plungers, and having an element
20 tending to move toward a position in which the plungers work in opposition, and a governor for the engine controlling the position of said element to control the phase relation of the pistons, whereby on a rupture of the
25 governor connection the fuel delivery of the pump is reduced.

3. The combination with a combustion engine, of a fuel pump comprising a plurality
30 of plungers, an epicyclic gearing intercon-

necting the plungers, a connection to one of the elements of the gearing for adjusting the same to vary the phase relation of the plungers, and means substantially counterbalancing the inherent tendency of the gear- 35 ing to change the position of said element.

4. A combustion engine having a fuel pump comprising a plurality of plungers and epicyclic gearing interconnecting said plungers, an engine governor connected to an element of the gearing to change the
40 phase relation of the plungers, and means to counteract the inherent tendency of the gearing to change the position of said element, said means and said tendency being
45 so related that their difference is capable of moving said element toward position in which the plungers work in phase opposition.

5. The combination with a combustion engine, of a fuel pump comprising two
50 plungers, an operating cam for each plunger, a driving shaft, and an epicyclic gearing having a sun gear driven by said shaft and arranged to rotate with one cam, another sun gear arranged to rotate the other cam, and
55 a planetary gearing between the sun gears.

In testimony whereof, I have signed this specification.

MAX ROTTER.