May 16, 1944. O. CELIO 2,348,958

VARIABLE STROKE PUMP

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Fig.1.

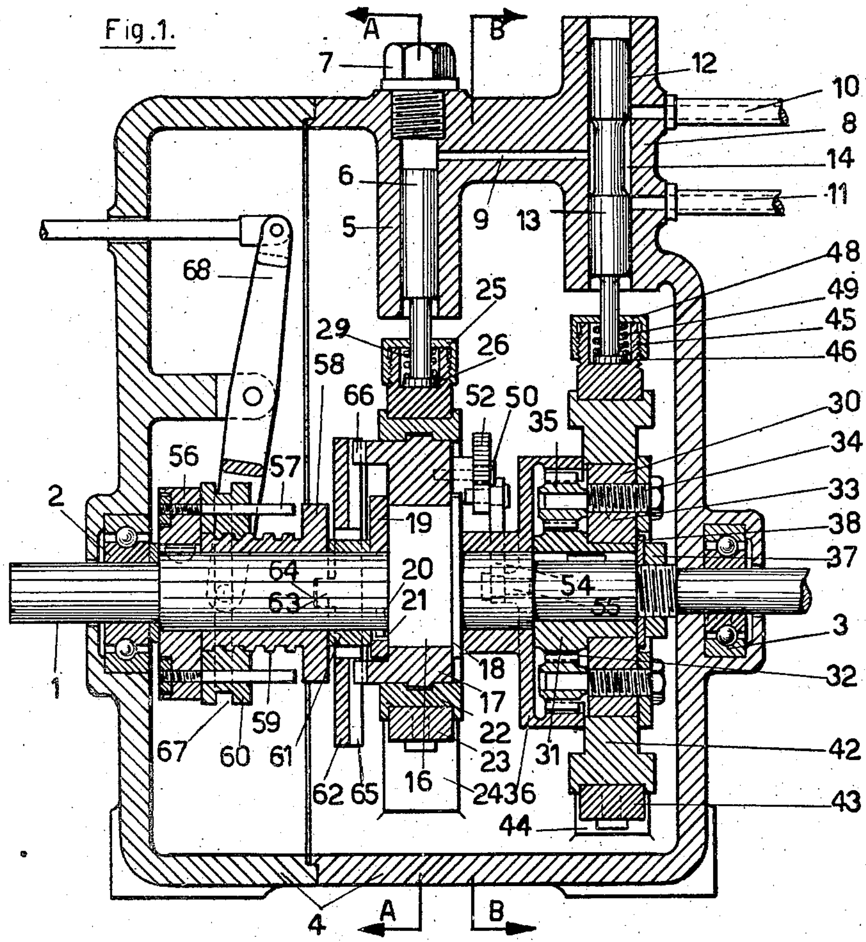

Fig.4.

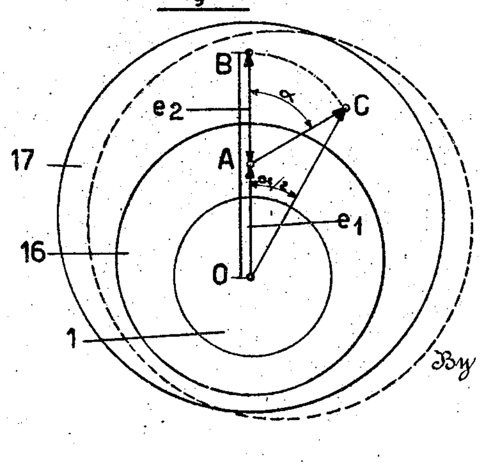

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Fig. 2.

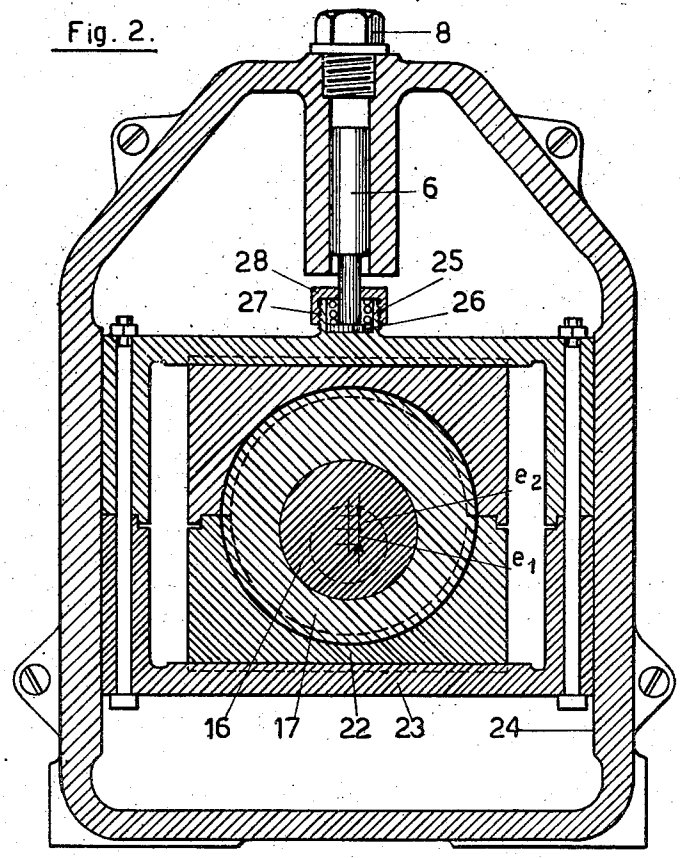
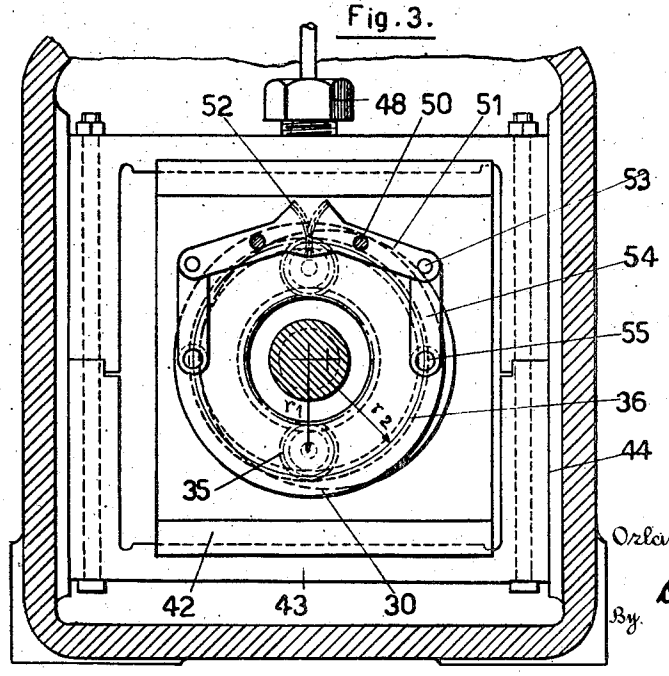


Fig. 3.



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UNITED STATES PATENT OFFICE

2,348,958

VARIABLE STROKE PUMP

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4 Claims. (Cl. 103—38)

The present invention relates to a slide valve controlled piston engine of the free stroke type, carrying on its shaft mutually displaced eccentrics for communicating reciprocating rectilinear motion to the working piston and slide valve, respectively, the object of the invention being to provide an improved construction as hereinafter indicated.

According to the invention, a slide valve controlled piston engine of variable piston stroke is characterized in that the eccentric device communicating reciprocating rectilinear motion to both the working piston and slide valve, respectively, includes an inner eccentric fast on the shaft of the engine, an adjustable outer eccentric carried by said inner eccentric and having an operative connection with the working piston of the engine, said outer eccentric being combined with an operating mechanism therefor, and a revoluble control eccentric on said shaft, said control eccentric being operatively connected with the operating organ of the slide valve and coupled for adjustment with the outer eccentric of the working piston for adapting the moments of operating of the slide valve to the varying times of the beginning and end of the piston stroke.

Preferably, adjustment of the outer eccentric of the working piston is transmitted to the revoluble control eccentric of the slide valve through the agency of a movement transmitting device, said device including means operative to turn the control eccentric of the slide valve in the same direction through half the angle which the adjustable outer eccentric of the piston is turned over on the inner eccentric.

Further according to the invention, a preferred arrangement is one in which said means comprise one or more pinions revolving on axles attached to the revoluble control eccentric of the slide valve, said pinions being in gear with a fixed external toothing carried by the shaft of the engine and also with an internally toothed concentric spur wheel which is freely revoluble forward and backward on said shaft and coupled for rotation with the adjustable outer eccentric of the working piston, whereby rotation of said spur wheel causes said pinions to turn on their axles and also to rotate about the relatively stationary toothing on the shaft, thereby entraining the revoluble control eccentric with half the angular speed imparted by the adjustable outer eccentric to said spur wheel. The revoluble control eccentric of the slide valve is preferably seated on a bush keyed to the shaft and carrying adjacent said eccentric the external toothing meshing with said pinions.

As will be appreciated, this improved construction is marked by a high measure of simplicity and it is found in actual use to be exceedingly effective. It is also relatively inexpensive to produce and it lends itself to neat and attractive design.

The invention is also concerned with a simplified operative connection between the adjustable outer eccentric and the working piston, said connection comprising a collar embracing said eccentric and mounted for lateral reciprocating movement in a frame which is vertically displaceable in the machine casing and provided with a central boss at the top wherein is rigidly fitted the outer end of the piston rod.

The invention will now be further described with reference to the accompanying drawings which illustrate a preferred embodiment of the invention by way of example.

In these drawings:

Fig. 1 is a longitudinal axial section through a slide valve controlled piston engine and the eccentric mechanism according to the invention.

Fig. 2 is a section along the line A—A of Fig. 1, showing a part of said eccentric mechanism.

Fig. 3 is a section along the line B—B of Fig. 1 showing another part of said eccentric mechanism.

Fig. 4 illustrates by means of a vector diagram drawn on a larger scale the operation of the mechanism shown in Fig. 2.

In the Figures 1 to 3, the numeral 1 designates the shaft of a piston engine, which may be rotated by any suitable prime mover, not represented, and turn in ball bearings 2 and 3 mounted in a two-part casing 4. 5 designates the working cylinder of the piston engine which cylinder is shown formed integral with the casing 4 and wherein reciprocates with a tight fit the working piston 6 of the engine. The upper end of the cylinder 5 is closed by a removable screw plug 7. Parallel to the working cylinder 5 is disposed a valve cylinder 8 formed in the casing 4 and communicating, on the one side, by a passage 9 with the working cylinder 5 of the engine and, on the other side, by two pipings 10 and 11, intended respectively for admission and exhaust of pressure fluid, with a supply chamber and a pressure chamber not represented in the drawings. The valve cylinder 8 contains a reciprocable control valve which is in the form of a slide valve or piston valve cast with two operating pistons 12 and 13. The tail rod intermediate said pistons is shown forming

an annular groove 14 which upon reciprocating of the slide valve establishes alternatively communication between the working cylinder 5 of the engine and the two pipings 10 and 11 respectively.

The operation of the working piston 6 of the engine is effected by eccentrics including an inner eccentric 16 fast on the shaft 1 and having an eccentricity e_1, and an adjustable outer eccentric 17 which is angularly displaceable on said inner eccentric and has an eccentricity e_2. The eccentricities e_1 and e_2 are preferably of equal length so as to allow of varying the total eccentricity of said eccentric device between the limits O and e_1+e_2 according to the relative angular position of the adjustable outer eccentric on the inner eccentric. The outer eccentric 17 is held against axial displacement, on the one side, by a flange 18 fast on the inner eccentric 16 and, on the other side, by a distance ring 19. Rotation of the ring 19 on the shaft 1 is prevented by a pin 20 seated in the shaft and engaging an internal slot 21 of the said ring.

The above eccentric device is assembled with the working piston 6 of the engine by means of a two-part collar 22 embracing the outer eccentric 17 and mounted for lateral reciprocating movement in a two-part frame 23 (see Fig. 2). The frame is itself vertically reciprocable in guides 24 forming a part of the casing 4, and it presents on its top a centrally disposed boss 25 for reception of the lower disc shaped end 26 of the piston rod. The boss 25 is shown having an outer thread 27 engaging a screw cap 28 which forms a passage for the said piston rod. The latter is surrounded by a rigid spring 29 bearing, on the one side, against the disc shaped end 26 of said piston rod and, on the other side, against the screw cap 28. In this way, a rigid axial connection is obtained between the working piston 6 and the eccentric device associated therewith, with the advantage, however, of permitting a slight lateral play of the lower end of the piston rod within the boss 25.

For operating the pistons 12 and 13 of the slide valve, there is provided a control eccentric 30 which is revoluble on the shaft 1. In the present instance, said control eccentric is rotatably seated on a bush 31 keyed to the shaft and carrying adjacent said eccentric an external toothing 32. The eccentric 30 is shown having two threaded holes 33 symmetrically disposed as to the shaft 1 and accommodating each a screw bolt 34. The free end of each of said bolts projects beyond the eccentric 30, and it is formed to act as axle for a pinion 35 meshing, on the one side, with the external toothing 32 on the bush 31 and, on the other side, with an internally toothed spur wheel 36 concentric with and freely revoluble on the shaft 1. The pinions 35 are mounted with a slight axial play between opposite plane faces of the eccentric 30 and the concentric spur wheel 36, respectively, and are freely revoluble on their axles so as to turn thereabout upon a relative angular displacement of the internal and external toothings meshing therewith. The control eccentric 30 is held against axial displacement by a washer 38 and nut 37 screwed on the shaft 1.

The operative connection between the control eccentric 30 and the piston rod of the slide valve 12, 13 is the same as has been described relative to the eccentrics 16, 17 of the working piston 6 of the engine. 42 designates the collar bearing the eccentric 30 which is freely rotatable therein; 43 is the frame accommodating said collar for lateral reciprocating movement and being itself vertically reciprocable in guides 44 forming a part of the casing of the engine; 45 is the central boss formed on top of said frame for reception of the lower disc-shaped end 46 of the piston rod; 48 designates the screw cap on said boss, and 49 the rigid spring interposed between said cap and the disc-shaped end of the piston rod.

The concentric spur wheel 36 is coupled for rotation with the adjustable outer eccentric 17. The latter carries, for this purpose, on the side facing the wheel 36 two pivot pins 50 which are parallel to the shaft and spaced at equal distance from the axis of symmetry of the eccentric 17 on either side thereof. Upon each of said pins is rockingly mounted a lever 51 provided at one end with a toothing 52, which toothings are shown meshing with each other along pitch circle arcs of equal radius having their centers in the pivots 50 of the levers (see Fig. 3). The other ends of the levers 51 carry pins 53 upon which are applied links 54 of equal length, said links being pivoted to diametrically opposite pins 55 on the concentric spur wheel 36. Upon turning the outer eccentric 17 on the inner eccentric 16, the levers 51 are caused to rock about the pivot pins 50 in opposite directions with respect to the outer eccentric, whereby the plane intersecting the axes of said pins is displaced within certain limits in a parallel movement perpendicularly to the axis of the shaft 1. The distance between the pins 53 which are then slightly displaced along arcs determined by the links 54 remains practically unaltered. Consequently, the concentric spur wheel 36 is caused to always follow the rotatory motion of the adjustable outer eccentric 17 and, in other words, to partake of its exact angular displacement.

The adjustable outer eccentric 17 is also coupled with an operating mechanism for varying its angular position on the inner eccentric 16. Said mechanism comprises a disc 56 keyed to the shaft 1 and carrying two parallel guide bars 57 disposed diametrically opposite each other, a sleeve 58 freely rotatable on said shaft, the outer periphery of said sleeve carrying a quick pitch thread 59 which always cooperates with a corresponding complementary thread in a ring 60. Ring 60 is adapted to slide longitudinally on said guide bars. Between the sleeve 58 and the distance ring 19 is interposed on the shaft 1 a distance sleeve 61.

The sleeve 58 is connected with the outer eccentric 17 by means of a coupling disc 62 which is shown surrounding the distance sleeve 61 with a certain radial play. The said disc has on its side facing the threaded sleeve 58 two square projections 63 disposed diametrically opposite each other and engaging with corresponding slots 64 in the sleeve 58; the disc 62 is thus displaceable in said slots relative to the sleeve 58, perpendicularly to the axis of the shaft 1 and, at the same time, partakes of the rotation of said sleeve. On the other side of the disc 62, looking towards the eccentric 17, there is provided a groove or guide 65 extending along a diameter which is perpendicular to the diameter connecting the projections 63; said guide engages two projections 66 fast on the outer eccentric 17 and lying in the axis of symmetry thereof. The adjustable outer eccentric 17 is thus displaceable in the guide of the disc 62 perpendicularly to the axis of the shaft and, simultaneously, rotates in unison with said disc; consequently, it is also coupled for rotation with the threaded sleeve 58, while being freely movable relative thereto in a plane perpendicular to the axis of the shaft, this movement

being possible in either direction as far as required to allow for rotation of the outer eccentric 17 on the inner eccentric 16.

The slide ring 60 which has a steep pitch threaded engagement with the sleeve 58 presents a circumferential groove 57 concentric with the shaft 1 and adapted to engage the fork shaped end of a lever 68 which is pivoted to the casing 4 and connected in any known manner to an operating device not shown in the drawings.

The above described piston engine may be employed either as pump or hydraulic motor; the operation of this engine is as follows:

The shaft 1 when rotating entrains simultaneously the inner eccentric 16 together with the adjustable outer eccentric 17, the whole operating mechanism 56—60 associated with said outer eccentric, and the bush 31 carrying the external toothing 32. Rotation of the outer eccentric 17 is transmitted through the lever and link mechanism 50—55 to the concentric spur wheel 36 so that the internal toothing on the latter revolves synchronously with the external toothing 32. Consequently, also the pinions 35 which are constantly in gear with either one of said toothings partake of this rotation round the axis of the shaft 1 without turning about their own axles or bolts 34 and thereby entrain, by means of said bolts, the control eccentric 30 of the slide valve. The eccentrics of both the working piston and slide valve are thus rotated in unison with the shaft 1 and the operating mechanism 56—60 carried by said shaft.

As clearly shown in Figs. 1 to 3, the control eccentric 30 of the slide valve is set 90° with the resultant eccentricity of the eccentrics 16, 17 of the engine. Supposing, for instance, the line of resultant eccentricity of the two eccentrics 16 and 17 be lying in the plane of the drawings, as is the case in Fig. 1; the line of eccentricity of the eccentric 30 then extends in a direction perpendicular to the said plane. This mutual angular displacement of the said eccentrics results in the slide valve 12, 13 being alternately removed from its mid or starting position when the working piston 6 of the engine reverses its stroke. In this way, during downward stroke of the working piston 6, the slide valve 12, 13 may be caused to move upwards for establishing communication between the cylinder 5 and the piping 10. In the lower end position of the piston 6 the slide valve 12, 13 will retake its mid position shown in Fig. 1 in which pipings 10 and 11 are out of communication with the cylinder 5. During upward stroke of the working piston 6 the slide valve will be displaced downwards to establish communication between the cylinder 5 and piping 11, while in the upper end position of the piston 6 the slide valve will have returned again to its mid position.

Assume that it is desired to vary at a given speed of the shaft 1 the quantity of fluid delivered per stroke of the working piston 6. For this purpose the outer eccentric 17 has to be displaced on the inner eccentric 16 so as to alter the effective stroke of the working piston 6, and such displacement is operated by the lever 68. By turning said lever while the engine is in action, or at rest, the ring 60 having a steep pitch screw thread is displaced on the guide bars 57 so that the sleeve 58 with the complementary thread 59 is rotated on the shaft and the rotation transmitted by the coupling disc 62 to the outer eccentric 17 which may be adjusted circumferentially into any desired position according to the piston throw that is required.

The relative angular displacement of the adjustable outer eccentric 17 on the inner eccentric 16 is apparent from the vector diagram in Fig. 4. In this figure, $OA \equiv e_1$ designates the eccentricity of the inner eccentric 16 and $AB = e_2$ the eccentricity of the outer eccentric 17 according to the position of the eccentrics shown in full lines. The resultant eccentricity of both eccentrics is then represented by the vector OB. When displacing the outer eccentric 17 over an angle α in clockwise direction into the position shown in dotted lines, the resultant eccentricity in the new position will be represented by the vector OC. Since the eccentricities e_1 and e_2 are supposed to be of equal length, the resultant vector OC leads the original resultant vector OB by the angle

$$\frac{\alpha}{2}$$

Thus, when adjusting the angular position of the adjustable outer eccentric 17 on the inner eccentric 16 by means of the lever 68, the resultant eccentricity OB of the whole eccentric device is always turned through half the angle which the outer eccentric 17 is turned over. This reduced angular displacement of the effective eccentricity of the eccentrics 16, 17 must be transmitted to the same degree upon the control eccentric 30 of the slide valve in order to maintain the mutual angular displacement of

$$\frac{\pi}{2}$$

of said eccentric devices unaltered.

The transmission of half the angle of rotation of the outer eccentric 17 upon the control eccentric 30 of the slide valve is effected through the agency of the internally toothed concentric spur wheel 36 and the pinions 35. The latter are in gear with the external toothing 32 fast on the shaft 1 and also with the internal toothing carried by the concentric spur wheel 36 which is free to turn forward and backward on the said shaft. Upon operation of the outer eccentric 17 by means of the lever 68, the lever and link mechanism 50—55 communicates to the spur wheel 36 the full angular displacement or angular velocity of said outer eccentric on the inner eccentric 16; the internal toothing on the spur wheel is then brought into rotation relative to the external toothing 32, and since the latter is stationary on the shaft 1, the pinions commence to turn about the bolts 34 while simultaneously rolling on said external toothing, thus making the bolts 34 and also the control eccentric 30 travel round the shaft 1 with half the circumferential velocity imparted to the spur wheel 36 by the outer eccentric 17.

When employing pinions of relative small diameter so as to reduce to a minimum the difference of length between the radius r_1 and r_2 (see Fig. 3), the angular velocity may be substituted for the circumferential velocity in the end points of these radii, causing but a little error in the transmission ratio of the angular displacements transmitted from the spur wheel 36 upon the control eccentric 30. It will be appreciated, therefore, that the control eccentric 30 of the slide valve is always displaced on the shaft 1 through half the angle which the adjustable outer eccentric 17 has been turned over on the inner eccentric 16. The error in the pre-

cise division of the angular displacement of said outer eccentric is of minor importance and can be compensated by appropriate constructional features, i. e., by providing a certain tooth play between the pinions 35 and the external and internal toothings meshing therewith.

It is to be understood that the invention is not limited to what is illustrated in the drawings. In particular, the coupling employed between the adjustable outer eccentric 17 and the eccentric spur wheel 36 as well as the operating means provided for adjusting said outer eccentric on the inner eccentric 16 may be varied without departing from the spirit of the invention.

I claim:

1. A slide valve controlled reciprocating piston engine of variable piston stroke comprising in combination a cylinder; a piston reciprocable therein; a reciprocable slide valve serving to control admission and exhaust of fluid to and from said cylinder; a driving shaft; an inner eccentric fast on said shaft; an outer eccentric angularly adjustable relatively to said shaft by rotation on said inner eccentric; adjustable means connecting said outer eccentric in driving relation with the shaft in its various angular relations; a driving connection between said outer eccentric and said piston serving to reciprocate the piston upon rotation of the shaft; a valve-actuating eccentric angularly adjustable on said shaft; a driving connection between the valve actuating eccentric and the valve, for reciprocating the valve upon rotation of the shaft; and connecting means for coordinating the angular adjustments of said outer eccentric and of said valve-actuating eccentric comprising a planetary gear train interposed between the shaft, the outer eccentric and the valve actuating eccentric, and so arranged that the angular displacement of the outer eccentric relatively to the shaft will be twice the angular displacement of the valve actuating eccentric relatively to the shaft.

2. A slide valve controlled reciprocating piston engine of variable piston stroke comprising in combination a cylinder; a piston reciprocable therein; a reciprocable slide valve serving to control admission and exhaust of fluid to and from said cylinders; a driving shaft; an inner eccentric fast on said shaft; an outer eccentric angularly adjustable relatively to said shaft by rotation on said inner eccentric; adjustable means connecting said outer eccentric in driving relation with the shaft in its various angular relations; a driving connection between said outer eccentric and said piston serving to reciprocate the piston upon rotation of the shaft; a valve-actuating eccentric angularly adjustable on said shaft; a driving connection between the valve actuating eccentric and the valve, for reciprocating the valve upon rotation of the shaft; a spur gear fast on the driving shaft; an internally toothed gear concentric with and encircling said spur gear, said internally toothed gear being swiveled on the shaft and coupled with the outer eccentric to rotate on the shaft in consonance with the angular adjustment of the outer eccentric; and pinions meshing with said gears and journaled on axes moving with the valve-actuating eccentric.

3. A slide valve controlled reciprocating piston engine of variable piston stroke comprising in combination a cylinder; a piston reciprocable therein; a reciprocable slide valve serving to control admission and exhaust of fluid to and from said cylinder; a driving shaft; an inner eccentric fast on said shaft; an outer eccentric angularly adjustable relatively to said shaft by rotation on said inner eccentric; adjustable means connecting said outer eccentric in driving relation with the shaft in its various angular relations; a driving connection between said outer eccentric and said piston serving to reciprocate the piston upon rotation of the shaft; a valve-actuating eccentric angularly adjustable on said shaft; a driving connection between the valve actuating eccentric and the valve, for reciprocating the valve upon rotation of the shaft; and connecting means for coordinating the angular adjustments of said outer eccentric and of said valve actuating eccentric comprising a gear fixed to the driving shaft, a gear swiveled on the driving shaft, a connection between the outer eccentric and the second named gear constraining the gear to assume the angular adjustments of the outer eccentric relatively to the shaft, and at least one planet pinion interposed between said gears and meshing with both, said pinion being journaled on an axis carried by said valve actuating eccentric.

4. A slide valve controlled reciprocating piston engine of variable piston stroke comprising in combination a cylinder; a piston reciprocable therein; a reciprocable slide valve serving to control admission and exhaust of fluid to and from said cylinder; a driving shaft; an inner eccentric fast on said shaft; an outer eccentric angularly adjustable relatively to said shaft by rotation on said inner eccentric; adjustable means connecting said outer eccentric in driving relation with the shaft in its various angular relations; a driving connection between said outer eccentric and said piston serving to reciprocate the piston upon rotation of the shaft; a valve-actuating eccentric angularly adjustable on said shaft; a driving connection between the valve actuating eccentric and the valve, for reciprocating the valve upon rotation of the shaft; and connecting means for coordinating the angular adjustments of said outer eccentric and said valve actuating eccentric comprising a gear swiveled on the drive shaft, a pair of levers journaled on the outer eccentric and geared together to move in reverse senses at the same rate, a pair of links connecting said levers with said swiveled gear; a second gear fixed on said driving shaft; and at least one planet pinion meshing with both said gears and journaled on an axis carried by said valve actuating eccentric.

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