March 23, 1937. P. F. KIPFER 2,074,588

DRIVING MECHANISM FOR CONTROL VALVES OF INTERNAL COMBUSTION ENGINES

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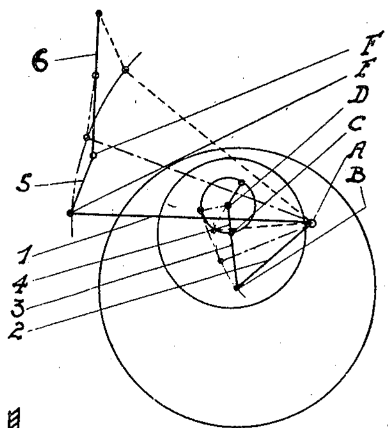


FIG. 1.

FIG. 2.

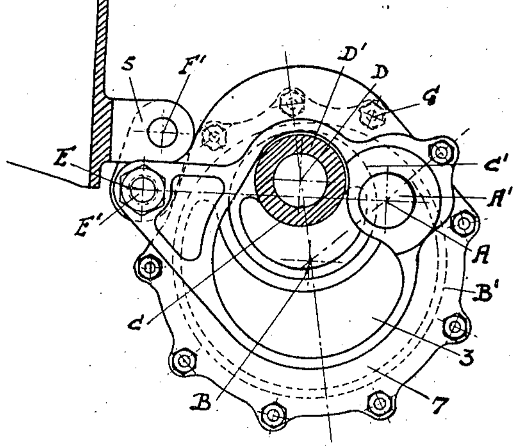
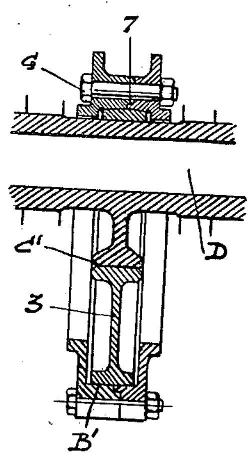


FIG. 4.



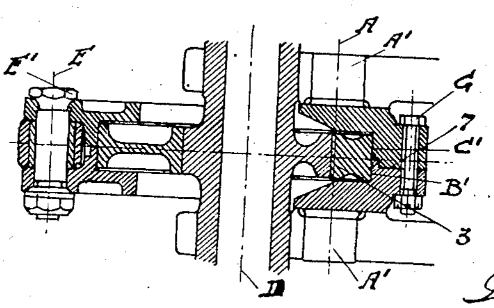


FIG. 3.

Inventor
Paul Fritz Kipfer
By Victor D. Borst
Attorney

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FIG. 5.

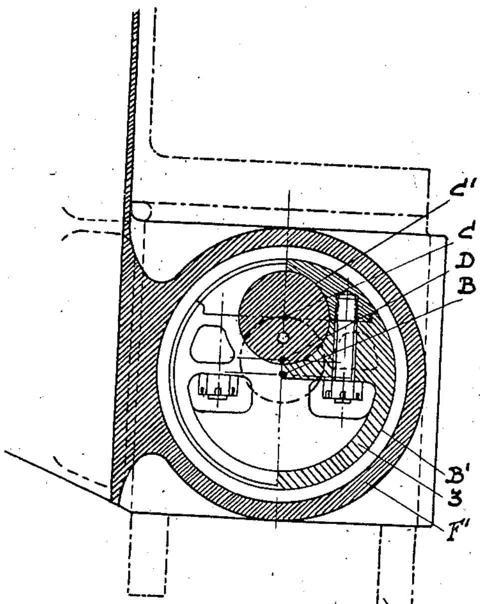
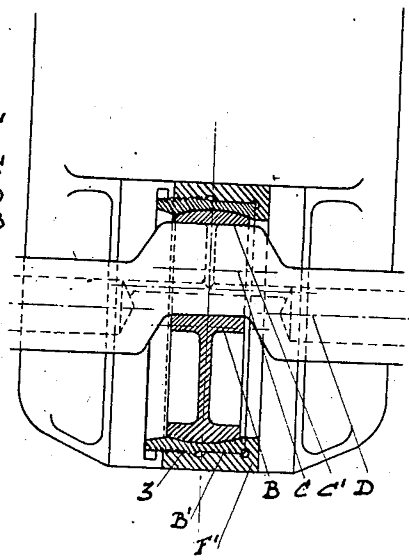


FIG. 7.



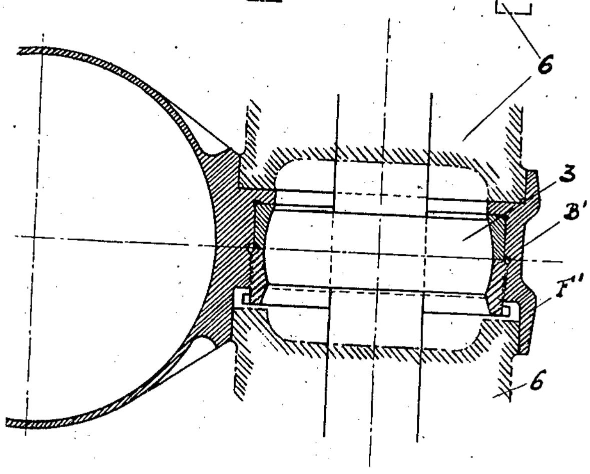


FIG. 6.

Inventor
Paul Fritz Kipfer
By Victor D. Borst
Attorney

March 23, 1937. P. F. KIPFER 2,074,588

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FIG. 9.

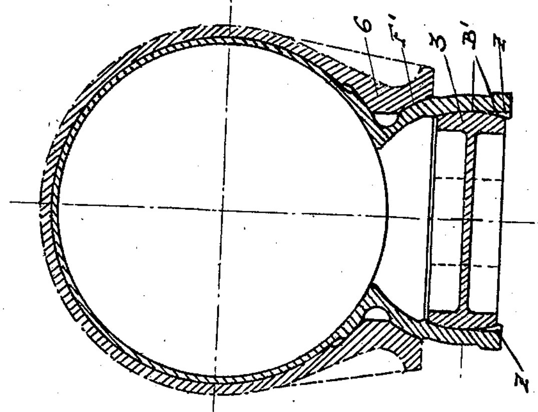


FIG. 10.

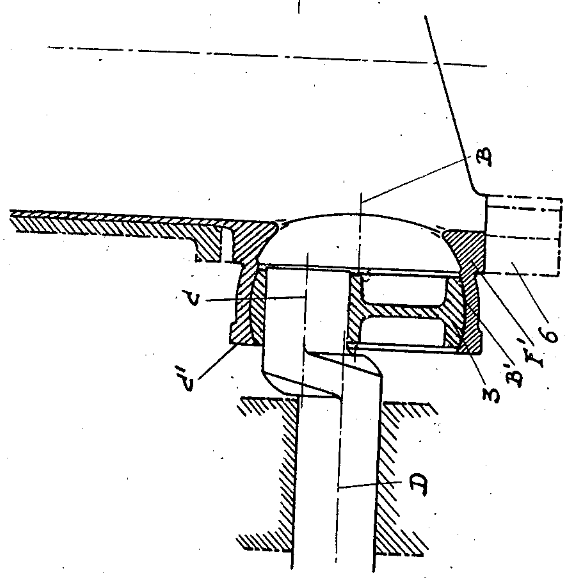
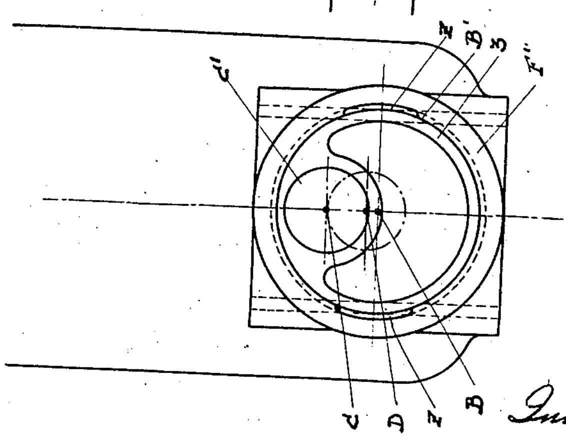


FIG. 8.



Inventor
Paul Fritz Kipfer
By Victor D. Borst
Attorney

March 23, 1937. P. F. KIPFER 2,074,588

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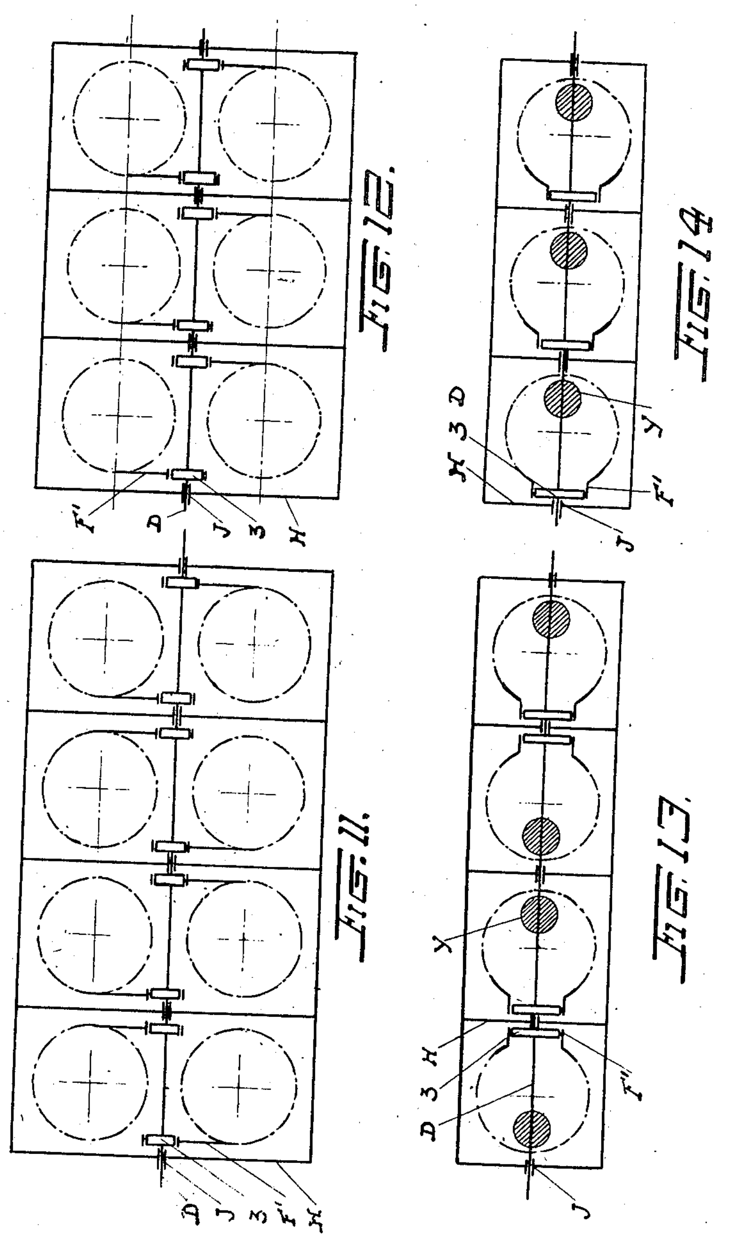

Inventor:
Paul Fritz Kipfer
By Victor D. Borst
Attorney

Patented Mar. 23, 1937 **2,074,588**

UNITED STATES PATENT OFFICE

2,074,588

DRIVING MECHANISM FOR CONTROL VALVES OF INTERNAL COMBUSTION ENGINES

Paul Fritz Kipfer, Boitsfort, Brussels, Belgium

Application May 23, 1935, Serial No. 23,044
In Germany May 24, 1934

5 Claims. (Cl. 74—45)

My invention relates to a driving mechanism for reciprocating or oscillating control valves of internal combustion engines in which the rotary motion of a crank shaft or eccentric shaft is converted into a reciprocating or oscillating motion. Devices of this sort in which a connecting rod at one end engages with a rotating eccentric pin or crank pin of a control valve and at the other end transforms the rotary motion into a reciprocating or oscillating motion by means of a pin connection or ball-and-socket coupling, are known and are referred to as crank gear.

In the driving mechanism for reciprocating or oscillating control valves of internal combustion engines according to the invention the reciprocating or oscillating motion is produced by a crank gear and the crank pin or the bearing surface of the eccentric is enveloped by the cylindrical surface which is described when a straight line parallel to the axis of the eccentric or crank pin is displaced parallel to itself in a path equatorial to the right cylindrical or spherical bearing surface of the reciprocating or oscillating pivot.

In the first case the reciprocating or oscillating motion will be assumed to be that of the control slide member which reciprocates within a fixed slide frame and in which the reciprocating pivot is embedded by means of its cylindrical or spherical bearing surface. In the second case the reciprocating or oscillating motion will be assumed to be that of one arm of a bell-crank lever oscillating about a fixed centre, the oscillating driving pivot being cylindrically or spherically mounted on the other arm. The invention fulfills the following purpose.

(1) With a given speed of rotation of the crank shaft or eccentric shaft and a given stroke of the oscillatory or reciprocating motion the acceleration may be varied in accordance with the ratio of the distance between the rotating member and the oscillating or reciprocating pivot to the radius of the crank. By this means the maximum acceleration may be varied as desired within very wide limits provided that constructional considerations do not prevent this. This is of extreme importance for the control drive of very light high speed two stroke internal combustion engines with valve control, i. e. this type of machine is made possible for the first time, since with a normal crank drive it is impossible to ensure sufficiently accurate division of time.

(2) Absolute dependability of working coupled with absence of noise are ensured even at the highest velocity and with considerable pressure on the bearings by simple parts which are subjected to the smallest possible number of operations and can be produced to fine limits by mass production methods.

Figures 1 to 10 illustrate three different embodiments of the invention having given on the one hand the maximum acceleration and stroke of the reciprocating motion and on the other hand the speed of rotation of the control shaft the member producing the required motion completely fulfilling the above constructional and technical conditions.

Fig. 1 represents the mechanical principle of a specific embodiment. A bell-crank lever with its two arms **1** and **2** oscillates about a fixed centre A. The bell crank lever **1**—**2** has an oscillatory motion imparted to it at the point B by the connecting rod **3** of the crank pin C which rotates on the crank arm **4** about the centre D of the crank shaft or eccentric shaft. This oscillatory motion of arm **1** of the bell-crank lever is taken up by the pin E of rod **5** and is converted into a simple reciprocating movement in the fixed guide frame **6** at the pin F of rod **5**. The ratio of the lengths of the arms **1** and **2** and also the angle enclosed by these can be selected in accordance with the space available and other conditions imposed by the construction. Moreover the centre D of the control shaft D′ may be moved closer to the arm **1** and the pin B, and also the whole system may be brought closer to the fixed guide frame **6** in accordance with mechanical and constructional requirements.

Figs. 2, 3 and 4 represent a constructional embodiment of the arrangement in side view, horizontal section and vertical section.

The complete drive consists of four closely cooperating parts, namely the eccentric shaft D′ with its centre at D and the eccentric disc C—C′ with its centre at C and bearing surface C′, the disc **3**, the housing **7**, and the rod **5**. Corresponding to the connecting rod **3** with its end B oscillating about the centre A, and its end C rotating about the centre D, in Fig. 1 is the disc **3** shown in Figs. 2, 3 and 4 with a centre B oscillating about the centre A and its bearing surface B′ and the centre C rotating about centre D with its bearing surface C′. The eccentric or crank shaft together with the centre of the shaft D′ and the eccentric or crank centre C which are represented diagrammatically in Fig. 1 are represented in Figs. 2, 3 and 4 by the shaft D′ with its centre D and the eccentric disc C—C′ with its centre C and bearing surface C′. By means of the rod **5** shown in Figs. 2, 3 and 4 the oscillatory motion of the pin E′ in the housing **7** is converted into the reciprocating motion of the pin F'. The eccentric C—C' of the mechanism possesses the peculiarity that its bearing surface C' lies within the bearing surface D' of the oscillating pivot B of the disc 3. On account of this distinctive feature it is possible, with the smallest distance between the centre B and C and with given forces, to make the bearing surfaces B' and C' of as large a diameter as desired without causing them to overlap i. e. without the construction becoming impracticable. The housing 7 in Figs. 2, 3 and 4 is preferably made of two saucer-shaped members fixed together along their peripheries by the bolts G and the pin E' shown having its centre at E. These saucer-shaped members are formed of high grade steel, well-tempered, and having the bearing surfaces case-hardened or nitrated, and ground.

The bearing surface B' which represents the bearing surface of the member B can be made cylindrical or preferably spherical. According as to whether the control shaft is constructed as a crank shaft or an eccentric shaft with floating crank pins or a crank mounted on both sides or separable the disc 3 can be made in parts or in one piece.

If an eccentric control shaft is employed with discs in one piece which can be mounted by fitting on to the shaft the individual units produced are somewhat larger in diameter than those produced by using a crank shaft and connecting discs formed in parts. The first embodiment however with relatively little trouble on account of the simplicity of the individual parts and their small number per drive permits of the highest precision and workmanship in their mechanical construction and heat treatment and accordingly gives the highest efficiency in operation coupled with silent running and low losses. The bearing surfaces B' and C' can with advantage consist of point bearings, cylindrical bearings, or spherical bearings of the same or different radius. When constructed as frictional bearings the disc 3 is preferably constructed of high grade forged bronze or wrought light metal alloys. In addition to the advantage of exceptional sliding capacity and rapid dissipation of heat this latter proposal has the further advantage of lightness, Another very satisfactory solution of the problem resides in forming the disc 3 of forged steel, the bearing surfaces B' and C' being coated with a thin layer of white metal.

Figs. 5 to 10 represent two embodiments of the invention partly in section and partly in elevation. In these embodiments the reciprocating motion is produced quite simply without the intervention of a bell-crank lever or connecting rods in that the disc 3 with its bearing surface B' is mounted directly in a reciprocating slide F'. This slide F' is either directly connected to the disc to be controlled or by means of corresponding movable members. The slide itself is guided in a corresponding slide frame which takes up the lateral pressure. In the embodiments shown in Figs. 2 to 10 the central plane through the eccentric disc or the crank pin coincides with the central plane through the control disc. This condition need not be fulfilled, however, the leading principle of the invention being that the crank pin or bearing surface of the eccentric is enveloped by that cylindrical surface which is described when a straight line parallel to the axis of the eccentric or crank pin moves parallel to itself along a path equatorial to the right-cylindrical or spherical bearing surface of the reciprocating or oscillating centre.

In all the three embodiments of the drive represented by Figures 1 to 10 the bearing surface B' is made spherical and this fact has three important advantages.

(1) The control disc itself is secured against axial displacement.

(2) Angular displacement from the true setting or mounting between the bearing axis D, the control shaft and the bearing axis of the pin A' relative to the plane of motion of the reciprocating slide F' is ineffective since on account of the automatic adjustment of the control disc no jamming can occur. The surface pressure on the spherical bearing surface B' is always equally divided.

(3) The bearing surface B' of the bell-crank lever 1—2 or the slide F' need not necessarily be divided for the purpose of mounting the control disc 3, as is shown in Figs. 2 to 7. In many cases the bearing surface B' can with advantage be cut out directly from the undivided bell-crank lever 1—2 or slide F' or from a corresponding pressed in or screwed in bearing bush. For the insertion of the disc 3 the bearing surface B' of the bell-crank lever 1—2 or slide F' or of the corresponding bearing bush must be provided with slots Z (Figs. 8 to 10) lying diametrically opposite to one another which must be at least as wide as the connecting disc. Figs. 8 to 10 represent an elevation, horizontal section and vertical section of an embodiment of the sort just described. It is most suitable for high quality, air-cooled, two-stroke aeroplane engines having radially arranged cylinders. The control valve and control slide comprise a single forging. The cylinders and slide frames also are made from forgings. Each cylinder has its own control shaft parallel to the crank shaft. The individual control shafts may with advantage be made to operate as driving shafts for the fuel injection pumps. This whole system may be driven by a set of spur wheels or a parallel crank drive from the crank shaft. The latter method when carefully carried out is particularly cheap, simple and noiseless, and yet is absolutely certain in operation. Since in radial motors the connecting rods are coupled eccentrically to a main crank pin the distance-time diagrams of the individual pistons vary considerably. It is thus of considerable advantage in radial motors that by using a control shaft for each cylinder the control of the admission, exhaust and scavenging mechanisms and also of the fuel injection pumps for each cylinder may be made individual.

The embodiment of Figs. 5 to 7 is specially suitable for multicylinder engines with one or more rows of cylinders. If a plurality of rows are provided a control valve for each two rows can be driven by a shaft parallel to the crank shaft. Preferably a drive for each cylinder is displaced from the middle plane of the cylinder and that for each of each pair of cylinders of a row is arranged on opposite sides of a control shaft bearing I (Fig. 11). In the direction of the control shaft, therefore, the drive for two cylinders of one row follows alternately with that for two cylinders of the other row (Fig. 11). The order of the drive can also be so chosen that a cylinder of the one row follows a cylinder of the other row and in this case the drive is again displaced from the midplane of the cylinder and arranged on both sides of a control shaft bearing (Fig. 12) or alternatively a drive for each valve takes place directly from above by arranging a control shaft above each row of cylinders in the midplane or displaced sideways (Figs. 13–14). This shaft can at the same time, be used to operate the individual fuel injection pumps Y arranged above the cylinder head, or on both sides of a control shaft bearing, in the direction of the control shaft, there can be arranged alternately the control valve drives for two working cylinders and then the drives for two fuel injection pumps Y (Fig. 13), or a control valve drive and a fuel injection pump Y of a working cylinder can be arranged on opposite sides of a control shaft bearing (Fig. 14). In all these arrangements it is advantageous for the control shaft bearing I (Figs. 11–14) to be built in to the transverse walls H which carry the crank shaft bearings.

The drive arrangement shown in Figs. 1–4 which is somewhat more expensive and complicated is particularly suitable for very high speed two stroke Diesel aeroplane engines either water cooled or air cooled and of the in-line radial type of at least 1000 H. P. per unit in which a still more rapid opening and closing of the exhaust and scavenging ports is desirable than can be attained with the relatively simple embodiments of Figs. 5–10. As regards the general arrangement of succession and position relative to the crank shaft the control shafts and drives for radial and in-line engines are generally the same for the embodiments of Figs. 1–6 as for the embodiments in Figs. 5–10 with the exception that for engines with a plurality of rows of cylinders each row must have its own control shaft. The driving of a plurality of control shafts parallel to the crank shaft can be effected from the crank shaft by a spur wheel drive or by a parallel crank drive. If in the case of engines of either the in-line or radial type with a control shaft supported on both sides of the drive, a control crank shaft is employed which as regards the crank operation is divided in such manner that the undivided eccentric disc together with an undivided housing 7 or control slide F′ can be moved on the crank pin, a particularly simple and compact variation of the drive is produced.

In the case of in-line engines with one or two rows of cylinders with only a single crank shaft it is even possible on the basis of the invention to construct these engines without a control shaft since the control drive, for instance in Figs. 1–4 or 5–10 can be mounted directly on the crank shaft for each two working cylinders on both sides of the crank shaft bearing. In these circumstances in the various embodiments the control shaft with the axis D must be considered to be directly replaced by the driving crank shaft. This latter solution, however, is only technically possible by the employment of the arrangement according to the invention since an ordinary eccentric drive with a long eccentric rod as determined by the comparatively thick main crank shaft would not give sufficient acceleration and speed to the control devices. The property of the arrangement according to the invention favours the combination of the control and main crank shafts only to the extent that the large diameter of the eccentric and control discs enables the drive to be made exceedingly small so that the distance between the cylinders of such an engine need only be slightly increased while on the other hand the general appearance for instance of a two stroke double block engine with a crank shaft is very pleasing.

What I claim is:

1. In a driving mechanism for the control valves of an internal combustion engine, the combination comprising a rotatably mounted eccentric section, an annular eccentric surrounding said rotatably mounted eccentric section and means for transmitting the reciprocating movement of the annular eccentric to the control valves of an internal combustion engine.

2. In a driving mechanism for the control valves of an internal combustion engine, a shaft, an eccentric on the shaft, an annular eccentric disc surrounding the eccentric on the shaft, the center of said annular disc receiving a reciprocating movement upon rotation of the eccentric, and means for transmitting the reciprocating movement of the annular disc.

3. In a driving mechanism for the control valves of an internal combustion engine, a shaft, an eccentric on the shaft, an annular eccentric disc surrounding the eccentric on the shaft, the center of said annular disc receiving a reciprocating movement upon rotation of the eccentric, and means for transmitting the reciprocating movement of the annular disc including a pivotally mounted strap surrounding the annular disc and a link.

4. In a driving mechanism for the control valves of an internal combustion engine, a crank shaft, an annular eccentric surrounding the crank shaft, the center of said annular eccentric receiving a reciprocating motion upon rotation of the crank shaft and means for transmitting the reciprocating motion of the annular eccentric including an eccentric strap surrounding the annular eccentric.

5. In a driving mechanism for the control valves of an internal combustion engine, a crank pin, an annular eccentric surrounding the crank pin, the center of said annular eccentric receiving a reciprocating motion upon rotation of the crank pin, and an eccentric strap surrounding said annular eccentric.

PAUL FRITZ KIPFER.