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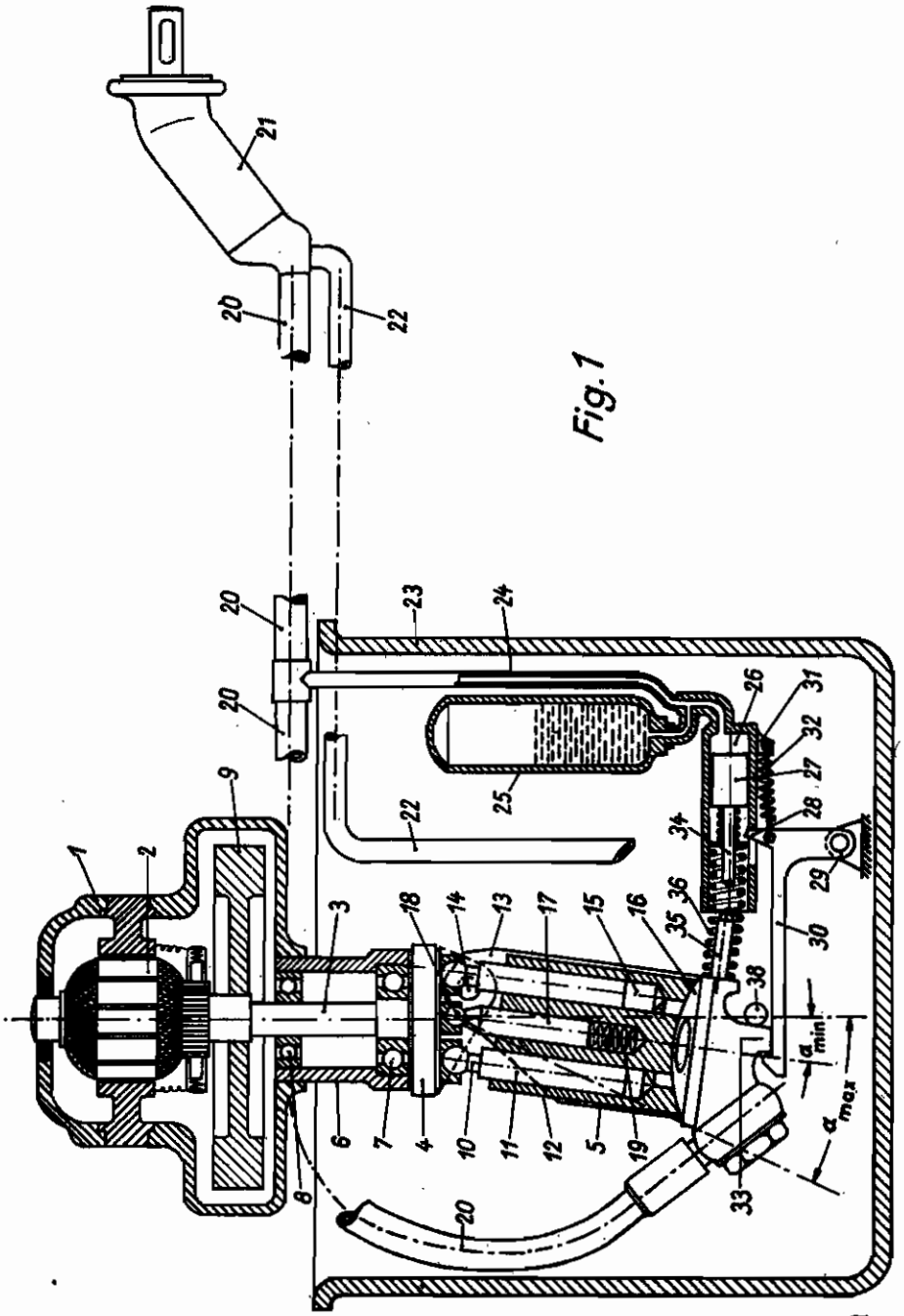

Fig. 1

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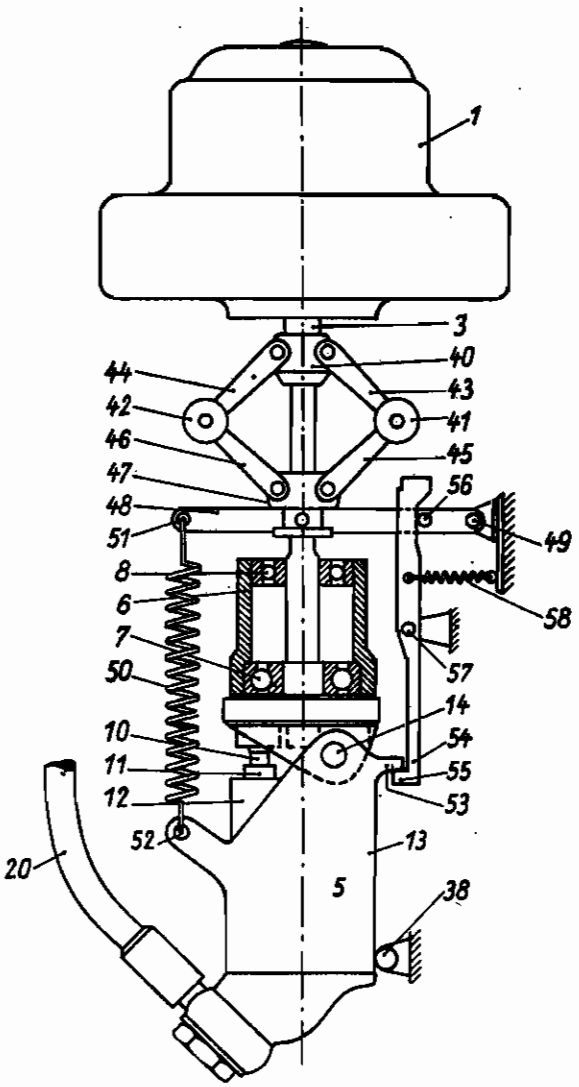

Fig.2

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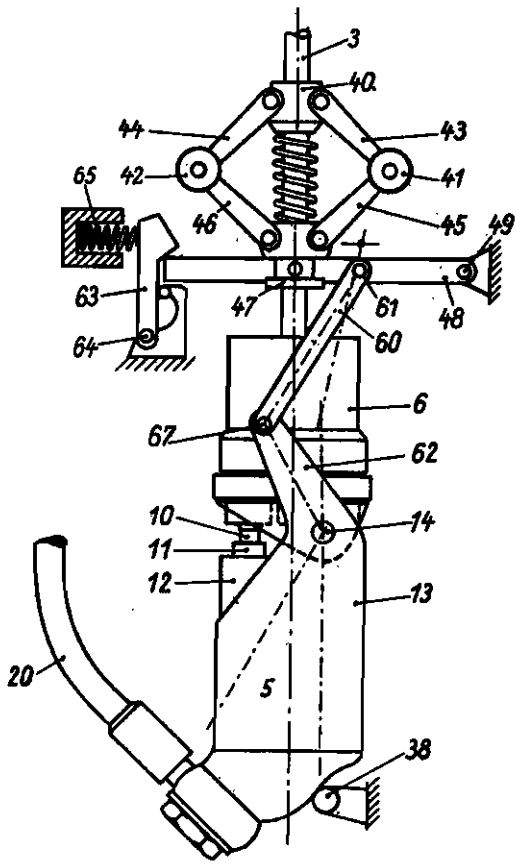

Fig.3

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ALIEN PROPERTY CUSTODIAN

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Application filed August 10, 1940

The present invention relates to a hydraulic device for the starting of engines, more particularly internal combustion engines. It is a well known fact that the torque required to move or force an engine out of its state of inertia must have a value several times greater than that of the torque required to carry on the movement until the picking up of the engine. If the starting is effected by means of a hydraulic device, a high pressure corresponding to a high torque is required in the first instance which may be lessened, as soon as the engine has picked up. According to the invention it is proposed to feed the hydraulic motor serving to drive the starting device from a pump with a stroke volume increasing during the process of starting. Such pumps are known as radial piston pumps and axial piston pumps. It is more advantageous to provide for automatic control of the stroke adjusting member of an axial piston pump in the sense of an increase of stroke.

In this way the high torques requisite for starting the engine may be obtained by means of a very small electric motor serving to drive the pump. By increasing the stroke of the pump in the course of the starting process it becomes possible to distribute the available motor power in such a manner that considerable power is obtained at an inconsiderable displacement or high pressure at a slight delivery, respectively, and a lesser power at a greater displacement or lower power at a greater delivery, respectively, for revolving the engine preparatory to starting it. By providing a hydraulic pump with adjustable stroke it is possible as it were artificially to greatly multiply the torque exerted by the electric motor on the engine to be started. Hence it is not necessary to change the dimensions of the electric motor with a view to its function of starting the engine.

For obtaining automatic control of the stroke adjusting member it is advantageous to have an external force exert a rocking moment, decreasing at increasing rocking angles, on the stroke adjusting member in the sense of a stroke increase, said force being balanced by a counteracting rocking moment produced by the pump pressure. The external force may be supplied by a spring having a variable lever arm or by a spring system with non-linear force-displacement characteristic. The pressure dependent counteracting rocking moment may be produced in a manner already known by having the stroke adjusting member rock about a pivot lying outside the cylinder block axis, so that the pressures produced in the working cylinders must shift the stroke adjusting member into its zero position.

It is essential that the pump produces the full pressure requisite for starting the engine only when the driving motor of the pump has attained to its full number of revolutions and has stored up a certain rocking force to be supplied during the starting process. For this purpose a pressure storing arrangement may be inserted in the pressure conduit of the pump to be charged during the starting period of the pump drive and retarding the attainment of the maximum pump pressure. It is advantageous to increase the retardation and to reduce the pressure from the storing apparatus, respectively, by taking care that the delivery is as small as possible during the starting period of the pump drive. This may be achieved in such a way that the pressure storing apparatus is formed as a cylinder with piston and that a spring is made expansible by means of the piston movement restricted by a stop, said spring exerting the rocking moment on the stroke adjusting member. A further step in this direction might consist in having the stroke adjusting member retained in a slightly deflected position during the piston movement by means of a locking device capable of being released by the piston.

In this arrangement the pump in the first instance at a small stroke delivers relatively small amounts for being stored in the storing arrangement. In this way sufficient time is afforded for the driving motor of the pump to attain its full number of revolutions. Only then the stroke adjusting member of the pump is released and subjected to the spring pressure, so that the pressure now may be increased up to a maximum determined by the spring. This maximum pressure suffices for starting the engine in question. As soon as this is in motion, the pressure is diminished which results in a further deflection of the stroke adjusting member. Further possibilities of retarding the pressure increase during the starting period are afforded, if the external force acting on the adjusting member is released when a certain number of revolutions of the pump driving gear has been reached.

This may be achieved in such a manner that a centrifugal pendulum coupled with the pump driving gear expands a spring exerting the rocking moment on the stroke adjusting member. Here also a locking device capable of being released by the centrifugal pendulum may be provided, said spring in the first instance keeping the stroke adjusting member in the zero position.

It is likewise possible to have the centrifugal

pendulum act directly on the stroke adjusting member, in which case, however, the point of application of the force would have to be chosen in such manner that a rocking moment, decreasing as the rocking angle increases, acts on the stroke adjusting member. In order to obtain the desired retardation during the starting period, the said member may be restrained in its zero position by a tension to be overcome by the centrifugal pendulum at a certain number of revolutions of the driving gear. Instead of a centrifugar pendulum other forces dependent on the number of revolutions may be used in the same sense, as for instance the pressure of a very small gear wheel pump.

The driving motor for the pump may be advantageously coupled with a swinging mass in order to store up energy.

The invention is illustrated in detail by some embodiments shown schematically.

Fig. 1 shows a starting device in which the rocking moment is exerted on the stroke adjusting member by means of a pressure cylinder connected to the consumption conduit, said cylinder having a piston moving therein which contracts a spring.

Figs. 2 and 3 show starting devices in which the rocking moment is produced by means of a centrifugal regulator. In all figures similar characters of reference designate corresponding parts.

In Fig. 1 the reference numeral 1 denotes an electric motor whose rotor 2 is coupled with a driving flange 4 of an axial piston pump 5 by a shaft 3. The shaft 3 of the electric motor 1 is supported in a casing 6 by means of ball bearings 7 and 8. A fly wheel 9 is rigidly connected to the shaft 3, said wheel being likewise enclosed in the motor casing. Piston rods 10 are articulately connected with the driving flange 4 of the axial piston pump 5, said piston rods causing via the pistons 11 a follow-up movement of the cylinders 12. This form of follow-up arrangement may however just as well be replaced by a Cardan joint arrangement. A cylinder block 12 is supported in a swinging frame 13 at the point 14, so that, as already explained elsewhere, the pressure produced in the pump cylinders 15 tends to adjust the swinging frame 13 in the sense of a stroke reduction of the pump 5. The control surface 18 of the cylinder block 12 is spherical and guided by a ball 18 at the driving flange 4 by means of a centering member 17 capable of being longitudinally displaced within the cylinder block 12 whereby overdetermination in the support of the cylinder block 12 between the driving flange 4 and the control surface 16 is avoided and a compensation for the displacements of the cylinder block due to the kinematic conditions is provided. The close contacting of the cylinder block 12 with the control surface 16 is ensured by the action of a spring 19 upon the centering member 17.

If the cylinder block 12 is inclined relative to an axis of the driving flange 4, as shown in Fig. 1, the pistons 11 move to and fro in the cylinders 15 and via the conduit 20 pump a certain amount of fluid into the motor 21 schematically represented as starting motor for instance for a combustion engine. From this the fluid is carried back via a conduit 21 to a container 23, in which the entire pump 5 is likewise arranged. A conduit 24 branches off from the conduit 20, said conduit 24 leading on the one hand to a pressure storing arrangement 25 and on the other to a cylinder 26, in which a piston 27 is movably arranged. When moving in the cylinder 26 the piston 27 strikes against a lug 28 of a lever supported at 29, which is acted upon by the tension of a spring 32 mounted at 31 on the cylinder 26. In consequence of the lug 28 being struck by the piston, the lever 30 is rocked about the point 29 and releases a locking arrangement 33 so that the rocking frame 13 is free to swing the pump 5 by an angle α_{max}. This movement is likewise imparted by means of the piston 27, which contracts a spring 36 articulately connected with the rocking frame 13 and resting against the piston 27, said spring being expanded as a result of the movement of the piston 27 in the cylinder 26. The piston 27 in addition possesses a pin-like lengthening piece 34, the spring 36 being guided on said piece 34 as well as on a pin 35 mounted on the rocking frame 13. A stop 38 is provided to adjust the rocking frame 13 in its initial position, i. e. at a certain angle of α_{min}.

The illustrated starting device operates as follows: When the electric motor 1 is switched on it begins to move slowly and sets the axial piston pump 5 connected with it going so as to deliver pressure fluid to the pressure storing arrangement 25 and the motor 21, respectively, via the conduits 20 and 24. The pressure storing apparatus operates in such manner that the pressure in the conduits 20 and 24 in the first instance does not reach any high values, hence the motor 1 is not forced to exert any great force and is thus capable of reaching the desired number of revolutions within the starting period. When this point has been reached—provided the pressure storing apparatus possesses suitable dimensions—the condition will have been attained at which the pressure in the conduits 20 and 24 will increase considerably. As the pump 5 in the position illustrated operates at the angle α_{min}, said position corresponding likewise to the initial position, a high pressure may be exerted by the pump at a small stroke. The pressure thus reached suffices to start the pressure fluid motor 21 coupled with the motor to be started. Almost simultaneously or even previously the piston 27 will have released the locking arrangement 33 via the lug 28 and the lever 30 so that the rocking frame 13 may be deflected due to the effect of the spring 36 having been expanded by the piston movement. This spring tension is opposed by a force produced by the excentric support of the rocking frame in the sense of a stroke reduction. As the pressure in the conduits 20 and 24 meanwhile has been reduced by the starting of the motor, the stroke reducing force is likewise diminished and the cylinder block carrier 13 is deflected further under the influence of the spring 36 until finally the angle α_{max} has been reached. Thus increasing pressure fluid quantities are being supplied to the motor 21 at decreasing pressure. The force necessary to achieve this is supplied by the motor 1 due to the fact that the swinging mass 9 thereof is only required to bridge over the requisite high initial moment. When the motor has picked up, which should be the case at about the angle of α_{max} of the rocking frame, the pressure in the conduits 20, 24 reaches zero. The spring force, due to the backward stroke of the piston, is likewise reduced to zero and the rocking frame returns to its initial position.

It is of course possible to dispense with the locking at 33. In such case the pump at the

starting of the motor 1 due to the slight counter-pressure in the conduit 20 would assume the angle α_{max}, returning to α_{min} at increasing pressure, whereupon the opposite movement would take place at diminishing conduit pressure.

As shown in Fig. 2, centrifugal weights 41 are articulately connected at 40 to the shaft 3 of the electro-motor 1 via levers 43, 44 and via levers 45, 46 with a sleeve 47 which is shiftable in the direction of the axis of the shaft 3 under the influence of the centrifugal weights 41, 42. The sleeve 47 in turn is connected to a lever 48 swingably supported at 49. A spring 50 is articulately connected to the lever 48 at the point 51, the free end being connected at 52 with the rocking frame 13 of the pump 5. The spring 50 at a displacement of the sleeve 47 tends to shift the rocking frame 13 in the sense of a stroke increase. The articulate connection of the spring has been effected in such manner that the rocking moment produced by it is reduced at an increasing rocking angle.

The pump 5 in its initial position is restrained in the zero position by a lug 53. A rocking moment is not produced until a lever 54 possessing a stop 55 is rocked about the point 57 by a pin 56 secured on the lever 46. A spring 58 forces the lever 54 on to the pin 56. The moment operating in the sense of a stroke decrease in the same way as shown in the embodiment according to Fig. 1 is effected through the excentric support of the rocking frame 13 about the axis 14. The conduit 20 again leads to a pressure fluid motor which is suitably connected with the motor to be started. In all other respects the starting device of the construction shown in Fig. 2 corresponds to that of Fig. 1 with the exception that the pressure storing arrangement and the piston exerting the stroke increasing rocking moment on the rocking frame are missing.

The illustrated starting device operates as follows: In its initial position the pump 5 is at the stroke position of zero. Hence it is possible for the motor 1 on having been switched on to reach its requisite number of revolutions without being submitted to any special load. At the increase in revolutions the centrifugal weights 41, 42 being forced to move outwardly contract the spring 50 and over the lever 54 actuated by the pin 56 release the locking arrangement 53, 55, so that the pump 5 may be angularly deflected. Under the influence of the pressure now produced in the conduit 20, the pump deflects by small angles, at which high pressure suitable for effecting the starting of the respective motor may be exerted at small strokes. This starting moment resulting from the high pressure, as shown above is bridged over by a fly wheel coupled with the motor 1. As soon as the motor to be started has been set in motion, the pressure in the conduit 20 falls off with the result that the moment acting on the rocking frame 13 in the sense of a stroke decrease is likewise reduced. Due to the external force now exerted by the spring 50, the frame 13 swings at greater angles, finally assuming the maximal stroke position when the motor has picked up, in which position large pressure fluid amounts are delivered. When the number of revolutions of the motor 1 declines, the lever 48 again approaches its initial position, which results in a relaxation of the spring 50 so that the pump 5 may also revert to its zero position, in which it may be aided by the force of a spring.

In Fig. 3 the centrifugal pendulum formed by the weights 41, 42 and the levers 43 to 46 directly acts upon the rocking frame 13 at the stroke adjusting member via a lever system 60, 62 secured on the one hand at 61 to the lever 48 connected with the sleeve 47 and on the other hand at the point 67. The points 61, 67 from which the rocking frame 13 is swingable are chosen so as to ensure that a rocking moment declining at increasing rocking angles acts on the stroke adjusting member. Here likewise it is of course necessary to effect a retardation of the pressure increase during the starting period of the electro-motor 1. In this instance this is effected in such a manner that the stroke adjusting member 13 is restrained in its zero position by a tension to be overcome by the centrifugal pendulum, as for instance in such a way that the lever 49 is retained by a catch 63 turnably supported at 64 and acted upon by a spring 65. The operation of the device described should be apparent from the above description.

An mentioned in the beginning, the invention is not limited to the embodiments described. In addition to other obvious advantages, one principal advantage of the starting device consists therein that several motors may be started by means of but one pump, this being provided for several motors connected therewith for instance by a multi-way stop cock.

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