

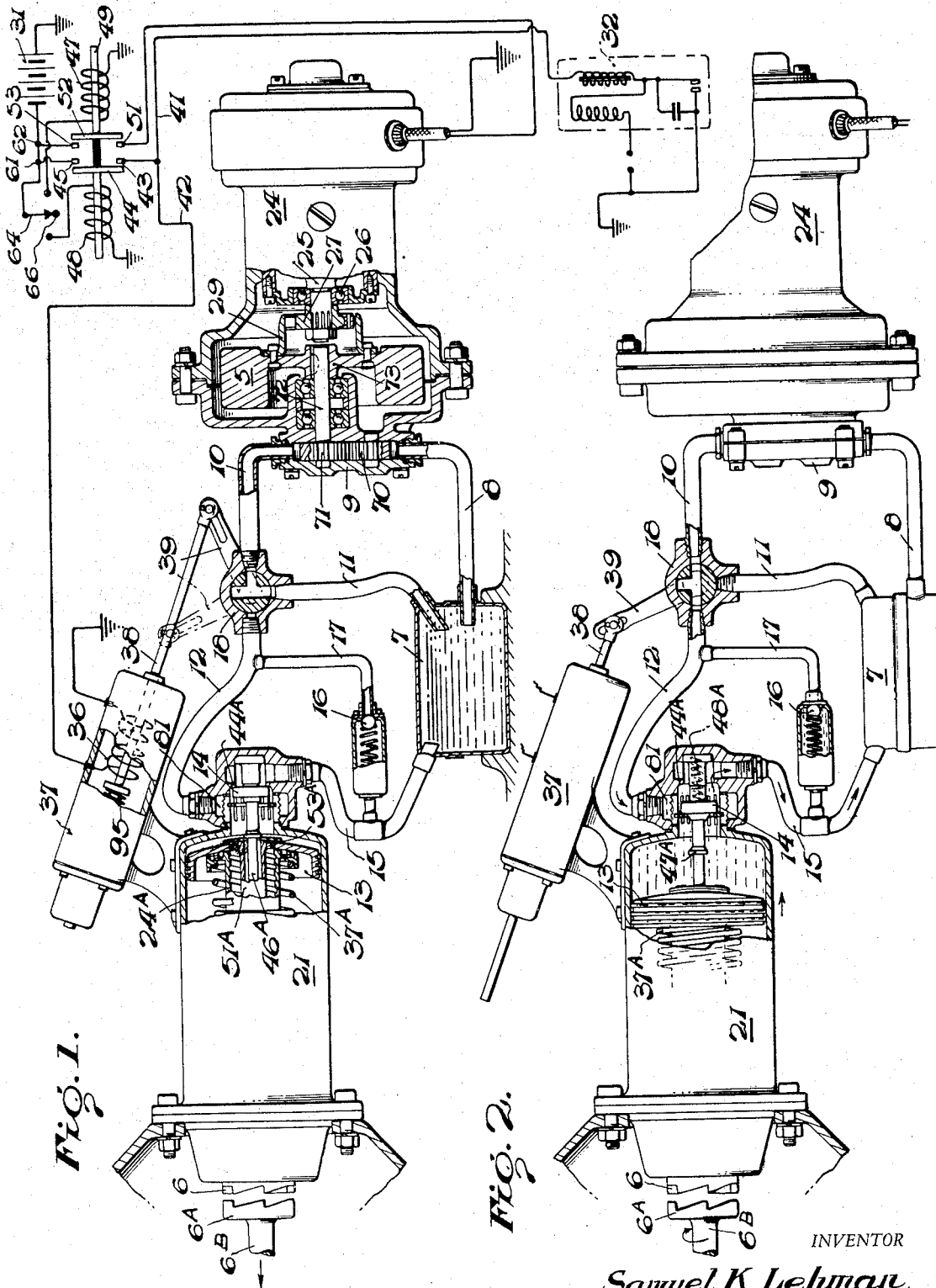
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ENGINE STARTING

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ENGINE STARTING

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This invention relates to engine starting, and particularly to the starting of an internal combustion engine by application of initial turning effort to a rotatable part of such engine.

One commonly used type of starting mechanism employs a flywheel—known in the art as an "inertia" element—in which starting energy is first stored, then transferred to the engine by way of a reduction gear train and a rotatable engine-engaging member; the reduction gearing being employed as a means of converting the exceptionally high speed of the inertia element to the relatively low speed at which the initial turning effort must be applied to the engine crankshaft. The present invention utilizes this inertia principle of starting an engine, but in a manner to render unnecessary the interposition, between inertia element and engine-engaging member, of the usual reduction gear train.

An object of the invention therefore is to provide a novel method of utilizing the inertia principle for starting an internal combustion engine.

A further object is to provide an engine starting mechanism of the inertia type characterized by the absence of the usual reduction gear train between the relatively high speed inertia element and the relatively low speed engine-engaging element.

Another object is to provide an engine starting mechanism characterized by the employment of hydraulic means to drivably connect an inertia element or other driving member to the member which actually engages and imparts rotation to the engine.

These and other objects of the invention will become apparent from inspection of the following specification when read with reference to the accompanying drawing wherein is illustrated the preferred embodiment of the invention. It is to be expressly understood, however, that the drawing is for the purpose of illustration only, and is not designed as a definition of the limits of the invention, reference being had to the appended claims for this purpose.

In the drawing:

Fig. 1 is a diagrammatic representation of a complete system embodying the invention with certain of the component parts in mechanical section; and

Fig. 2 is another diagrammatic view of a portion of the system with certain of the component parts being shown in positions which they occupy at a stage in the operation other than the one illustrated in Fig. 1.

In Fig. 1 the reference numeral 5 designates

the flywheel constituting the inertia element above referred to and numeral 6 designates the engine-engaging element, while the numerals 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17 and 18 designate cooperating parts constituting the hydraulic means which I employ in lieu of the usual gear train for converting the relatively high turning effort of the flywheel 5 to a relatively low speed turning effort to be applied to the engine-engaging member 6. These hydraulic means include a reservoir or storage tank 7 for the motive fluid of the hydraulic system, a conduit 8 leading from the storage tank 7 to a pump 9, a conduit 10 into which the fluid is discharged after passing through the pump, conduits 11 and 12 into which the fluid is delivered from the conduit 10 according to the position of the two-way valve 13, a piston 14 movable in a cylinder 21 by fluid admitted to said cylinder through conduit 12 and subsequently exhausted therefrom (upon opening of the valve 14) to return to the storage tank 7 by way of the return conduit 15; also a high pressure relief valve 16 located in a by-pass conduit 17 to provide a direct return from valve 18 to the storage tank 7 in the event of the development of excessively high pressure in the conduit 12 beyond the safe capacity of the cylinder 21.

The flywheel 5 is adapted to be energized by any suitable means capable of accelerating the said flywheel from zero speed to whatever speed—usually a speed of 15,000 to 25,000 R. P. M.—is required to store in said flywheel 5 sufficient kinetic energy to assure, when transferred to the engine by way of engine-engaging element 6, the effective starting of the engine. As shown, the actuating means is in the form of an electric motor 24 whose armature shaft 25 extends beyond the supporting bearings 26 to drivably receive the inner race 27 of a uni-directional clutch (shown as of the roller type illustrated in Fig. 8 of Patent No. 2,301,071 granted to Romeo M. Nardone on November 3, 1942), the outer race 29 of said clutch being rigidly connected to the flywheel 5 whereby rotation of the armature shaft 25 produces corresponding rotation of the flywheel 5 while permitting overrunning of the flywheel with respect to the electric motor in the event of application by some other means not shown of a turning effort for rotation of the flywheel independently of the motor 24. A storage battery is shown at 31 as a source of energy for the motor 24 and also constitutes a source of energy for a starting ignition mechanism 32 by which ignition current is supplied to the cylinders of the engine to be

started during the cranking period, the unit 32 being of a type well known in the art and illustrated, for example, in Fig. 3 of the Nardone patent above referred to and therefore needing no further description, except to point out that the unit 32 is energized simultaneously with energization of the winding 36 of a solenoid 37 whose movable element operates the valve 18 through the linkage indicated at 38 and 39; the simultaneous energization of the units 32 and 37 being accomplished by providing parallel conductors 41 and 42 leading from one contact 43 of a switch 43-44-45 adapted to be moved to the closed position upon passage of current through the right-hand winding 47 of a double solenoid 47-48 having a single plunger assembly 49 to produce concurrent movement of bridge elements 44 and 52 of the switches 43-44-45 and 51-52-53, respectively; the contacts 45 and 43 of said switches being connected to the positive side of the battery circuit, as indicated at 61 and 62 in Fig. 1, and the selective energization of the windings 47 and 48 being under the control of a manually operable switch 64 movable to the right and the left of a neutral position 66 to produce first an energization of the winding 48 and subsequently an energization of the winding 47. Passage of current through the winding 48 will draw plunger assembly 49 to the left and thereby close a circuit to the motor 24, the circuit being from the battery 31 to the motor by way of switch 53-52-51, and the result being to produce rotation of the armature shaft 25 and the corresponding energization of the flywheel 5. While this action is occurring—the plunger assembly 49 being in its leftward position—the switch contact 44 is in the inoperative position and therefore no current passes to the solenoid 37, hence the valve 18 remains in the position indicated in Fig. 1 in which position no fluid is delivered to the cylinder 21. However, during this period there is an idle circulation of fluid from tank 7 to pump 9 and back to the tank by way of conduits 10 and 11 due to the fact that one of the working elements 71 of the pump (and it may be noted here that while a pump of the spur gear type is illustrated, any other suitable type may be substituted) is directly connected to the flywheel 5 by a shaft 72 which has driving connection with both the element 71 and the hub 73 of the flywheel. This driving connection causes the pump elements 70 and 71 to rotate with the flywheel and thus draw fluid from the tank 7 and cause the return of such fluid to the tank by way of the conduits 10 and 11, but as no actual work is being performed other than to move the fluid against what little friction there may be in the parts over which the fluid passes, this fluid circulating action does not appreciably affect the process of acceleration of the flywheel 5 to the predetermined degree. When this process of acceleration is completed, the operator will throw the switch 64 to the opposite extreme position thereby breaking the circuit to the winding 48 and establishing a new path of flow to the winding 47. The result is to interrupt the flow of current to the motor 25 and to produce a new path of flow, the new path being to the units 32 and 37 by way of the contact 44 which now bridges the contacts 43 and 45 and from which point the current passes in the parallel path 41 and 42 to the units 32 and 37, respectively. Passage of current to the unit 32 initiates the operation of the charge igniting means in the cylinders of the engine and concurrently the passage of current to the winding

36 of the unit 37 operates to shift the linkage 38 and 39 of the solenoid into the position indicated in Fig. 2, in which position the two-way valve 18 cuts off flow into the conduit 11 and establishes a new path of flow directly from conduit 10 to the conduit 12 leading to the cylinder 21 wherein is located the piston 13. While any suitable means may be employed for translating the rectilinear movement of the piston 13 into, first, a forward meshing movement of the engine-engaging element 6 to establish driving connection with the corresponding element 6a attached to the rotatable element 6b of the engine to be started, and, secondly, to produce rotation of the said elements 6 and 6a after they have become inter-engaged, the mechanism indicated for this purpose in the drawing is of the type more fully illustrated and described in Patent No. 2,298,717 granted to Romeo M. Nardone on October 13, 1942. As shown in the Nardone patent just referred to, such motion translating means includes a central tubular member 51a terminating in a solid portion receiving elements corresponding to those shown at 57 and 58 in the Nardone patent which elements are adapted to impart a forward thrust to the engine-engaging element 6 in response to the initial forward motion of the piston 13 upon entry of the fluid to the cylinder by way of the inlet port 81; and the motion translating mechanism further includes an internally threaded driving sleeve 24a adapted to move forward with the piston 13 and thus produce rotation of the engine-engaging member 6 by reason of the inter-engagement of its internal threads with the external threads of a member corresponding to the driven sleeve 22 of the said Nardone patent.

As the rotation ("cranking") proceeds, the engine will "pick up" on its own power, and at the conclusion of the forward movement of the piston 13 the collar 53a on the piston 13 impinges against the head (not shown, but corresponding to the head 52 shown in the said Nardone patent) of the stem 46a of the exhaust valve 14 and moves the said valve 14 away from the circular seat formed in the valve housing 44a, and thereby opens a path by which the fluid which has previously been admitted to the cylinder 21 can flow back to the tank 7 by way of the return conduit 15 which leads from the right-hand portion of the valve chamber 44a back to the tank. As the fluid is thus exhausted from the cylinder 21 the coiled spring 37a, which was compressed during the forward movement of the piston 13, expands and thus drives the piston 13 back to the position indicated in Fig. 1. Upon reaching this "home" position—the member 6 being meanwhile "de-meshed" by the means 57, 58 of the Nardone patent—the collar 53 cooperates with the shoulder 47a on the neck portion of the valve 14 to move the valve back to the seating (flow interrupting) position indicated in Fig. 1, thereby restoring the hydraulic motor to condition for the next starting operation. To insure against a premature reclosing of the valve 14 there is provided a spring 48a yieldably holding the valve 14 in the open position until closed by the positive action of the collar 53a against the shoulder 47a above described.

As the engine becomes self-operative, in response to the cranking action, the operator will of course return the switch 64 to the neutral (mid-way) position, thus deenergizing units 32 and 37, and permitting spring 95, in housing 37, to return valve 18 to the Fig. 1 position; but even if opening of the circuit is delayed (as by inad-

vertence) no harm will result, as the pressure will soon be reduced to zero by reason of exhaustion of the energy stored in the flywheel 5, and transferred from there to the pump 9.

The engine having started, unit 32 (being merely a starting auxiliary) need no longer function, as ignition current is furnished by a conventional magneto (not shown) during the entire operating period of the engine, once the latter has been effectively started.

What is claimed is:

1. The method of starting an internal combustion engine which comprises, first, accelerating an inertia mass to a relatively high speed, secondly, converting the kinetic energy thus stored into hydraulic pressure, and simultaneously applying said hydraulic pressure to a part adapted to drive a relatively low speed engine-engaging member.

2. The method of starting an internal combustion engine which comprises, first, accelerating an inertia mass to a relatively high speed, secondly, converting the kinetic energy thus stored into hydraulic pressure, and simultaneously applying said hydraulic pressure to a part adapted to drive a relatively low speed engine-engaging member and supplying ignition current to the engine during the period of rotation by said engine-engaging member.

3. In an inertia starter for internal combustion engines, an inertia member, means for accelerating said inertia member to relatively high speed, an engine-engaging member and hydraulic means for converting the high speed rotation of the inertia member into low speed rotation of said engine-engaging member.

4. In an inertia starter for internal combustion engines, an inertia member, means for accelerating said inertia member to relatively high speed, an engine-engaging member, hydraulic means for converting the high speed rotation of

the inertia member into low speed rotation of said engine-engaging member, said hydraulic means including a cylinder having a piston therein, a liquid reservoir, means including a pump connecting said reservoir to said cylinder, and means for drivably connecting said inertia member to said pump.

5. In an inertia starter for internal combustion engines, an inertia member, means for accelerating said inertia member to relatively high speed, an engine-engaging member, hydraulic means for converting the high speed rotation of the inertia member into low speed rotation of said engine-engaging member, said hydraulic means including a cylinder having a piston therein, a liquid reservoir, means including a pump connecting said reservoir to said cylinder, means for drivably connecting said inertia member to said pump, and means for causing the liquid to by-pass said cylinder until the inertia member is sufficiently accelerated.

6. In an inertia starter for internal combustion engines, an inertia member, means for accelerating said inertia member to relatively high speed, an engine-engaging member, hydraulic means for converting the high speed rotation of the inertia member into low speed rotation of said engine-engaging member, said hydraulic means including a cylinder having a piston therein, a liquid reservoir, means including a pump connecting said reservoir to said cylinder, means for drivably connecting said inertia member to said pump, means for causing the liquid to by-pass said cylinder until the inertia member is sufficiently accelerated, and additional by-pass means including a conduit having a normally closed valve therein, said valve being yieldable to by-pass liquid directly back to the reservoir in response to exertion of a predetermined pressure upon said valve.

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