PUBLISHED
JUNE 1, 1943.
BY A. P. C.

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METHOD FOR THE STARTING OF INTERNAL COMBUSTION ENGINES DRIVING SCREWS, BLOWER BLADES OR OTHER ROTATING MASSES
Filed Oct. 6, 1937

Serial No. 167,568

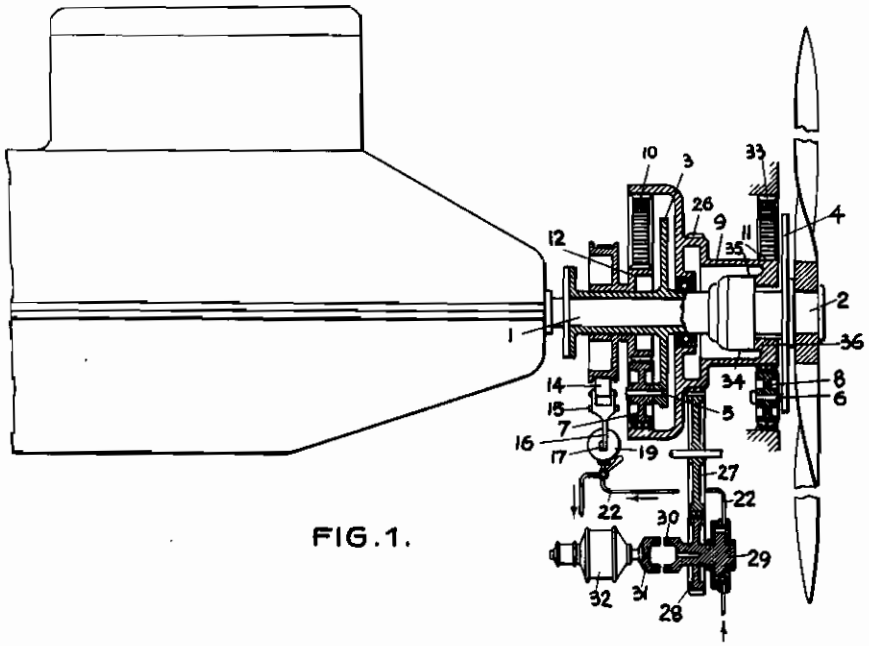

FIG. 1.

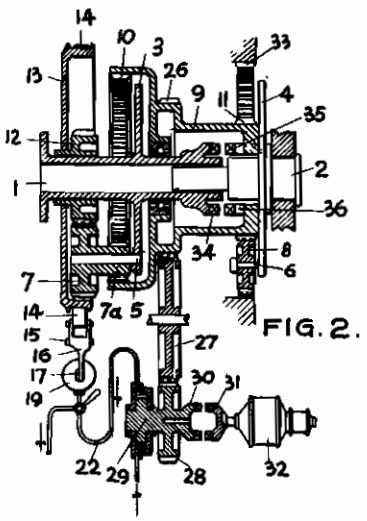

FIG. 2.

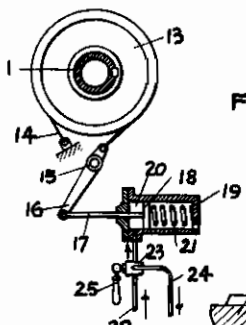

FIG. 3.

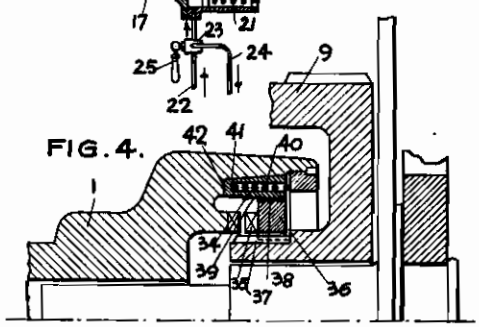

FIG. 4.

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Published June 1, 1943 Serial No. 167,568

ALIEN PROPERTY CUSTODIAN

METHOD FOR THE STARTING OF INTERNAL COMBUSTION ENGINES DRIVING SCREWS, BLOWER BLADES OR OTHER ROTATING MASSES

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Application filed October 6, 1937

In the driving means for screws hitherto known the shaft of the screw is coupled to the engine shaft either directly or by a few gear wheels and at starting the starter is caused to act directly upon the engine shaft.

In contrast thereto the present invention resides in a method for the starting of internal combustion engines driving screws, blower blades or other rotating masses according to which the starter is caused to act upon the uncoupled screw shaft and the screw shaft is coupled to the engine shaft only when so much energy of rotation has been accumulated in the mass formed by the screw shaft and blades that this is capable of turning over the internal combustion engine. This method may also be applied in such fashion that the starter is first caused to act upon the uncoupled screw shaft and somewhat later, immediately before the coupling thereof, also and at the same time upon the engine shaft.

By this new starting method, not only the starter but also the parts to be driven are greatly spared because the transmission of the starting forces and also the initiation of the drive from the engine take place extremely gently. In particular the starter clutch is subjected to no such high wear as hitherto and the starter clutch does not need to be repeatedly renewed. Also it is possible to employ a considerably smaller and simpler starter than hitherto which again represents a saving of weight and starting energy.

An arrangement for carrying out the method in accordance with the invention is illustrated in the drawing in two embodiments by way of example:

Figs. 1 and 2 show two different forms of construction of an airscrew drive in longitudinal section,

Fig. 3 is a detail illustration of a braking device in side elevation and section and

Fig. 4 a self acting dog clutch in longitudinal section and detail illustration.

In Fig. 1 a driving engine-shaft 1 and an airscrew shaft 2 to be driven are located coaxially one behind the other. The two shafts have each a flange-disc 3 or 4 and, near the edge of each flange-disc, Fig. 1 shows a pin 5 or 6 of which there are about six in all. Each of the pins carries a planet wheel 7 or 8. For these planet wheels 7, 8 there is provided a common sun-wheel body 9 which bridges both the axial distance and also the radial distance between the same in such fashion that the planet wheels 7 engage in internal teeth 10 and the planet wheels 8 in external teeth 11. The sun-wheel body 9 has generally the shape of a bell and is mounted in freely rotatable fashion on the shaft 1. The planet wheels 7 also engage with a pinion 12 which is likewise mounted freely on the shaft 1. Also freely mounted on the shaft 1 and rigidly connected to the wheel 12 is a braking drum 13 whose braking band 14 (Fig. 3) can be tightened or loosened by a lever 16 swingable about a pivot 15. Engaged with the lever 16 is the rod 17 of a piston 18 which slides in a cylinder 19 and is influenced on the one hand by oil pressure (20) and on the other hand by a spring 21. The oil flows to the chamber 20 in front of the piston through a passage 22 in which a throttling and closure valve 23 is included. A return passage 24 branches from the valve 23. The valve 23 can be adjusted by a lever 25 in such fashion that the oil flow from the passage 22 to the oil chamber 20 is either cut off completely or is only throttled to such an extent that the oil pressure suffices to overcome the stress in the spring 21 and forcibly to tighten the braking band 14. The excess oil then flows through the passage 24 back to the place from which it was taken. Finally the sun-wheel body has a further ring of external teeth 26 in which a toothed wheel 27 engages. The wheel 27 is in turn in engagement with a toothed wheel 28 which is mounted on the shaft of a liquid pump 29 which supplies pressure oil through the passage 22 to the cylinder space 20 in front of the piston 18. At the end of the pump shaft there is also mounted a clutch-half 30 in the vicinity of a corresponding clutch-half 31 of a starter 32. Finally there is also provided a further stationary toothed ring 33 with internal teeth in which the planet wheels 8 roll. Also a clutch-half 34 (Fig. 4) is provided on the end of the engine shaft 1 towards the airscrew shaft 2. The complementary coacting half 35 is mounted slidably in the sun-wheel body 9 in such fashion that it moves against the clutch-half 34 and engages immediately the sun-wheel body 9 rotates more slowly than the engine shaft. For this purpose the clutch ring 36 carrying the dog teeth 35 is mounted, non-rotatably but guided by grooves 37 parallel to the principal axis, in axially movable fashion on the sun-wheel body 9. On the outside of the clutch ring 36 is a ring of inclined grooves or a kind of flat thread-teeth 38 which engage in corresponding teeth 39. The teeth 39 are cut in a bushing 40 which is pressed with a frictionally tight fit by a spring 41 against a recess 42 in the engine shaft 1.

The manipulation and the manner of opera-

tion of the arrangement in accordance with the invention is as follows:

As starter 32 there is provided a fly wheel starter of such construction that as long as this is actuated or this alone is the driving part its clutch-part 31 is in the engaged position and when it has fulfilled its purpose it springs again into the disengaged position.

Upon actuation of the starter 32, therefore, the clutch parts 30, 31 come into engagement and the wheel 28 together with the pump 29 is set in rotation, for example in the clockwise direction. Consequently the intermediate wheel 27 rotates in the opposite direction and the sun-wheel body 9 in the same direction. Consequently the planet wheels 7 also rotate in the clockwise direction and the toothed wheel 12 mounted freely on the shaft 1 in the opposite direction, provided that the brake is not applied as is initially the case at starting. The wheels 7 and 12 rotate idly and the engine shaft 1 remains initially unaffected. The sun-wheel body 9 also drives the planet wheels 8 which rotate counter-clockwise and roll on the stationary ring of teeth 33. By this means the pivots 6 of the planet wheels 8 are carried along in the clockwise direction and the screw shaft 2 likewise rotates in the clockwise direction and thus, due to the rotary mass constituted by the airscrew blades, the flange-disc 4 and the other rotating gear parts, accumulates a considerable kinetic energy.

The liquid pump 29 also commences to rotate at the same time as the gear wheel 20 and, with the valve 23 open, supplies pressure oil through the passage 22 to the chamber 20 in the cylinder 19 with the result that directly after the airscrew shaft has received a first powerful driving impulse, the piston 18 is displaced to the right against the force of its spring 21 and consequently the braking band is tightened, that is the wheel 12 is braked and brought to rest. As a result the planet wheels 7 driven by the sun-wheel body 8 and rolling on the now stationary wheel 12—acting at their pivots 5—also set the engine shaft 1 in rotation and this likewise in the clockwise direction.

The power transmitted from the starter 32 to the engine shaft 1 then increases in the same measure as the rapidly and steadily increasing braking force on the drum 13. On the other hand the loading on the starter 32 also increases until finally it is no longer capable of driving the gearing and the engine and its rotation commences to become slower. Consequently, working backwardly, the rotating aircrew shaft 2 and the parts rotating with it also commence to give up their stored energy to the engine shaft so that now a driving force both from the starter and also from the airscrew shaft becomes effective upon the engine shaft and this turns over the engine before the action of the starter falls off appreciably. At the instant at which the engine responds, the engine shaft takes over the drive of the gearing and airscrew shaft which, in accordance with the example shown in Fig. 1, may take place through two transmission stages depending upon whether the brake is tightened or released.

With the brake tightened, the sun-wheel body 9 rotates more quickly than the engine shaft 1. The clutch 34, 35 remains in its disengaged position since the frictional force between the shaft 1 and the friction bush 40 (Fig. 4) acts through the teeth 38, 38 upon the clutch ring 36 in such fashion that the latter retains its right hand end position. In this position of the clutch 34, 35 a drive of the screw shaft 2 takes place through the transmission of the planet gearings 7, 10 and 8, 33.

By moving over the valve 23 by the lever 25 (Fig. 3), however, it is also possible to cause the liquid arriving through the passage 22 to flow into the passage 24 and thereby to remove the oil pressure from the piston 18. The spring 21 then expands and displaces the piston 18 into such an end position that the braking band 14 is released and the braking drum 13 can rotate with the wheel 12. From this instant on, the planet wheels 7 and the clutch wheel 12 also rotate idly with the result that the hitherto higher speed of the sun-wheel body 8 as compared with the speed of the engine shaft 1 falls off and the sun-wheel body therefore rotates more slowly than the said shaft. The result of this is that the frictional pressure in the clutch 34, 35 is converted at the inclined teeth 38, 39 into a push which displaces the clutch ring 36 to the left and the clutch 34, 35 then engages. By this means the engine shaft 1 and the sun-wheel body 9 are rigidly connected together. Consequently the two elements rotate at the same speed. The planet wheels 7 and the wheel 12 rotate idly therewith and the engine shaft 1 drives the screw shaft 2 through one transmission only, the teeth 11 and planet wheels 8.

Upon renewed tightening of the brake by a reversal of the valve 23 in such manner that the full oil pressure can again act on the piston 18 the original condition directly after starting is again established in that a negative drive by way of the planet wheel gearing 7, 10 is again established and consequently the sun-wheel body 9 tends again to rotate more quickly than the engine shaft so that the clutch 34, 35 is again disengaged.

Fig. 2 shows how a further transmission can be interposed between the sun-wheel body 9 and braking drum 13. In this example the toothed ring 10 does not engage directly with the wheel 7 but with a smaller wheel 7a arranged in front thereof and rigidly coupled therewith. In order to obviate the greater constructional length necessitated by the inclusion of the wheel 7a the braking ring of the drum 13 is in this example directed towards the bell 9. Otherwise the arrangement in accordance with Fig. 2 operates precisely as does that of Fig. 1. Within the scope of the invention, the brake may be constructed in any desired fashion. In place of the band brake, a liquid brake, a pneumatic brake or an electric brake or any other sutiable clutch device may be provided. The particular construction of the overrunning clutch between the engine and propeller shaft may likewise be as desired. In some cases, the over-running clutch may also directly connect the two shafts. Also, within the scope of the invention, the number of planet wheels and the choice of the transmission between starter and gearing and between sun-wheel body and shafts are left free. The gearing of the arrangement in accordance with the invention need not essentially be constructed as planet gearing. The manipulating members for the starter may be coupled with the manipulating member for the valve 23 in the passage 22 so that both devices can be actuated by a common main manipulating member.

The pump 28 either draws its oil from a separate vessel or it is connected to the lubricating

oil circulation of the engine. Pressure oil may also be replaced by pressure water, for example cooling water. In the case of the adaptation of the brake for another operating medium, the pump **28** is, naturally, replaced by a suitable pressure-or current-producing device. If an electrical arrangement is provided, the braking current may also be taken from the starter circuit. The braking device may also be designed so that the braking band is tightened from two ends.

The provision of the subject of the invention is particularly advantageous for the drive of a variable pitch propeller because with such an arrangement the blades of the airscrew may be set right back at starting and the braking effect of air resistance at starting limited to a minimum value. Consequently the inertia energy of the airscrew set in rotation can be fully utilised at starting.

The invention may also be employed for the driving of rotary masses upon travelling or stationary engines.

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