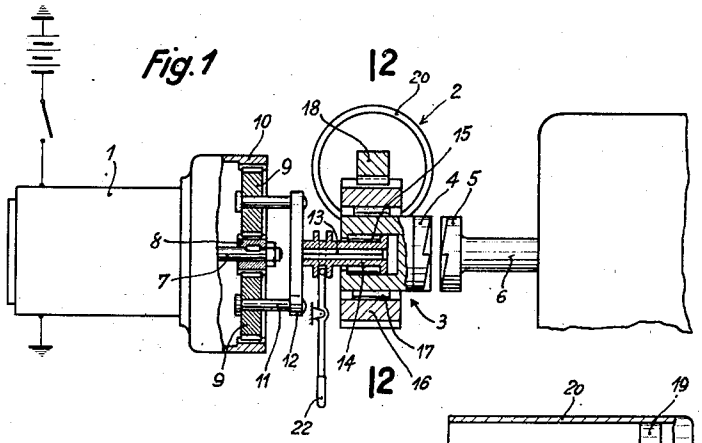
July 12, 1938. A. CALLSEN 2,123,711

METHOD OF STARTING INTERNAL COMBUSTION ENGINES

Filed April 2, 1936

Fig. 1



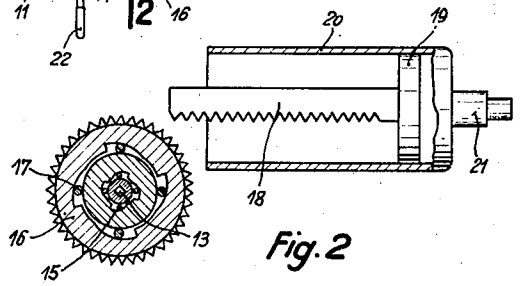
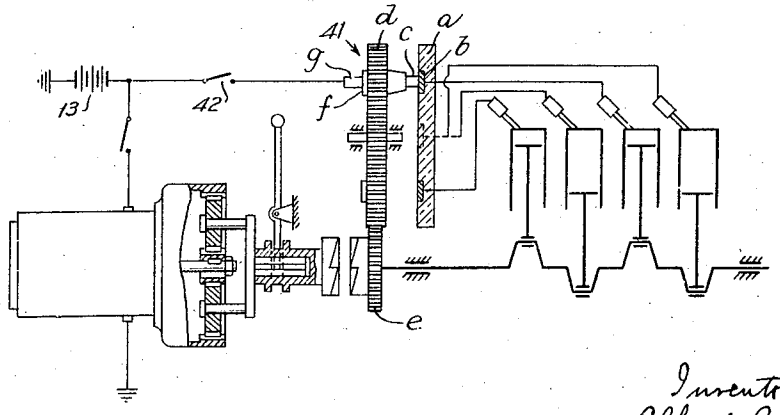


Fig. 2

Fig. 3



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METHOD OF STARTING INTERNAL COMBUSTION ENGINES

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7 Claims. (Cl. 123—179)

The present invention relates to the starting of internal combustion engines.

Large internal combustion engines are started from cold principally in two ways. In one method a starting apparatus is employed in which energy is stored up in some way, for example by means of inertia masses, or in which great pressures are suddenly produced by explosive substances. It is a feature common to these starters that they start the engine with a jerk, and in doing so vaporize a fuel mixture injected into the cylinders to such a degree that it can be ignited. These starting apparatus do their work satisfactorily when the engine is warm, but not when it is very cold and has been stopped for a long time. In this case, the starting apparatus, which functions quite easily in starting a warm engine, is usually unable to cause the engine to make more than about three quarters of a revolution because a large part of the starting energy is consumed by the increased frictional resistance caused by the viscous lubricating oil. The result of this is that not all the cylinder pistons come into the ignition position, and furthermore, the mixture is so badly vaporized that it can only be fired with difficulty. In this case, the starting efficiency of the starter is not assisted or only very slightly assisted by the ignitions in the cylinders. The engine must therefore often be several times started before it begins to run. Under exceptionally cold circumstances starting is often not possible at all.

In the other method, the engine is turned over slowly several times and a mixture injected into the cylinder and ignited by means of an auxiliary starter. The main drawback of this mode of starting consists in that when the engine is cold, the mixture is so little vaporized, and so much heat is withdrawn from it, that it cannot be ignited, or only ignited with difficulty. The engine must therefore be rotated for a long time until such powerful ignitions take place that it continues to run of itself. In this case the danger exists of the plugs becoming sooted up by the injection of too much fuel.

The drawbacks mentioned are avoided according to the invention by the engine being first rotated slowly several times and following this, started with a jerk. This new method of starting engines has the advantage that by the slow starting the starting of the engine with a jerk is prepared for. By the slow starting the friction due to rest is overcome and the frictional resistance reduced, because the viscous lubricating oil is thinned by the injected fuel. Further, the cylinder walls are also preliminarily warmed up by the ignitions which occur, even if they are only weak. The starting shock that now follows can now produce a very rapid piston movement which continues over several revolutions, whereby a sufficient vaporization of the injected fuel is obtained and only little heat is conducted away, so that powerful ignitions at once result which assist the starter and rotate the engine quickly several times so that it starts with certainty.

Three examples of construction of the invention are diagrammatically shown in the accompanying drawing, in which:—

Figure 1 shows a starting apparatus having an electric motor and a powder gas starter.

Figure 2 is a side elevation, partly in section, of the apparatus.

Figure 3 shows a further modified form of construction.

In Figure 1 a starting apparatus is shown, consisting of two main parts, an electric starting motor 1 and a compressed gas starting means 2, which jointly work on a clutch member 3, here formed as a clutch dog 4, which is adapted to engage in a dog 5 on the crank-shaft 6 of an internal combustion engine.

On the armature shaft 7 of the electric motor is mounted a small toothed pinion 8, which is in engagement with the planet-wheels 9 of a planet-gear, which in their turn co-operate with an internally toothed wheel 10 secured on the motor casing. The planet-wheels are mounted on pins 11, fixed in a plate 12. A shaft 13 is firmly connected to this plate, and on this shaft a sleeve 14 is arranged so as to be longitudinally displaceable but prevented from relative rotation. The sleeve is connected to the dog 4 through a free-wheel clutch 15. A lever 22 serves for moving the sleeve.

A toothed wheel 16 is provided externally on the dog 4 and is connected to the dog 4 also by a free-wheel clutch 17. On this toothed wheel a toothed rackbar 18 acts on operating the compressed gas starting means 2, which includes a piston 19 which carries the rackbar 18 and moves in a cylinder 20. On the cylinder a device 21 is provided in which a cartridge can be fired that supplies the necessary gas pressure.

The apparatus works in the following way: To start the internal combustion engine, the driver first switches on the electric motor, and then by the lever 22 brings the dog 4 into engagement with the dog 5 on the crank-shaft. The starting motor and the transmission of the

planet-gear is so proportioned that it rotates the engine slowly several times. During the slow starting an easily ignitable mixture is injected into the cylinders. After a few revolutions of the internal combustion engine, the driver now puts the compressed gas starter into operation. The toothed rackbar 18 engages in the toothed wheel 16 on the dog 4 and sets the crank-shaft with a jerk into a very strong rotation. This sudden and very rapid movement of the crank-shaft causes an energetic eddying and vaporizing of the mixture in the cylinders of the internal combustion engine, and the mixture owing to the sudden compression is greatly heated, and of this heat only little is lost by conduction, because the starting operation is very quickly completed.

When the engine is running under its own power, the dog 4 is pushed back. The two free-wheel devices enable each of the starting apparatus to work independently of the other. The essence of the mode of working described consists in that the internal combustion engine is first slowly revolved several times and then with a jerk rapidly further revolved.

In the second form of construction, the internal combustion engine is also slowly rotated by an electric starting motor, as in the first example. The sudden or jerky rapid further rotation is effected by starting cartridges 40, which are directly built on to the cylinders of the internal combustion engine. The cartridges are fired by a conventional timing device 41, which is so arranged and driven that it causes the firing of the cartridges automatically, each in proper phase relation to the associated cylinder piston. This device comprises a stationary contact disc *a* having a series of contacts *b* each connected with one of the cylinder cartridges. A brush *c* is carried by a gear *d*, the gear *d* being driven at half the speed of the crank shaft by means of a gear *e* fast on the crank shaft. The brush *c* is conductively connected to a contact ring *f* carried by the gear *d*. A stationary brush *g* is in constant engagement with the conductive ring *f*. The firing of the cartridges is controlled by a switch 42 which may be closed by the operator to connect the brush *g* with a source of current. The contacts *b* are so located that after the switch 42 has been closed, each cartridge will be fired at the beginning of the power stroke of the piston cylinder with which the cartridge is associated.

I declare that what I claim is:

1. A method of starting internal combustion engines wherein fuel is delivered to the cylinders of the engine during starting, consisting in first turning over the engine by means of a power motor through at least one cycle at low speed through a reduction gearing, and subsequently suddenly imparting a high kinetic energy impulse from a separate energy source to turn the engine at high speed in order to energetically whirl and vaporize the fuel mixture, the ignition of which subsequently drives the engine.

2. A method of starting internal combustion engines wherein fuel is sprayed into the cylinders of the engine during starting, consisting in electrically turning over the engine through at least one cycle by kinetic energy from an electric motor through a reduction gearing and subsequently imparting a high kinetic energy impulse from a separate energy source to energetically vaporize the fuel mixture, the ignition of which subsequently drives the engine.

3. A method of starting internal combustion engines wherein fuel is sprayed into the cylinders of the engine during starting, consisting in electrically turning over the engine through at least one cycle thereof at a relatively low speed and thence energizing an explosive cartridge, one for each cylinder of the engine to be started, to impart a relatively high kinetic energy impulse directly on the pistons of the engine to be started.

4. Apparatus for starting internal combustion engines comprising a starting motor, a member adapted to be clutched to a moving part of the engine to be started, a transmission gearing between said starting motor and said clutch member for driving the latter at a relatively low speed, a second source of energy, a transmission drive between said second source of energy and said clutch member for driving the latter at a relatively high speed and means to energize said second source of energy after said first transmission drive has turned over said engine through at least one complete cycle.

5. Apparatus for starting internal combustion engines comprising a starting motor, a member adapted to be clutched to a moving part of the engine to be started, a transmission gearing between said starting motor and said clutch member for driving the latter at a relatively low speed, a compressed gas charge operated energy source, a transmission drive between said compressed gas charge operated energy source and said clutch member for driving the latter at a relatively high speed and means to energize said compressed gas charge operated energy source after said first transmission drive has turned over said engine through at least one complete cycle.

6. Apparatus for starting internal combustion engines comprising a starting motor, a member adapted to be clutched to a moving part of the engine to be started, a transmission drive between said starting motor and said member for driving the latter at a relatively low speed, a free-wheel clutch in said transmission drive, a compressed gas charge operated energy source, a transmission drive between said energy source and said clutch member, a free-wheel clutch in said transmission drive and means to energize said compressed gas charge energy source after said engine has been turned over through at least one complete cycle of said starting motor.

7. Apparatus for starting internal combustion engines comprising an electrically operated starting motor, a member adapted to be clutched to a moving part of the engine to be started, a transmission drive between said starting motor on said member for driving the latter at a relatively low speed, a cylinder, a piston displaced within said cylinder by the action of a compressed gas charge, a rack bar carried by said piston, a toothed wheel rotated by said rack bar, a free-wheel clutch between said toothed wheel and said clutch member, means to energize said gas charge for displacing said piston after said motor has rotated said clutch member to turn over said engine through at least one complete cycle, whereby a high kinetic energy is imparted to said clutch member.

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