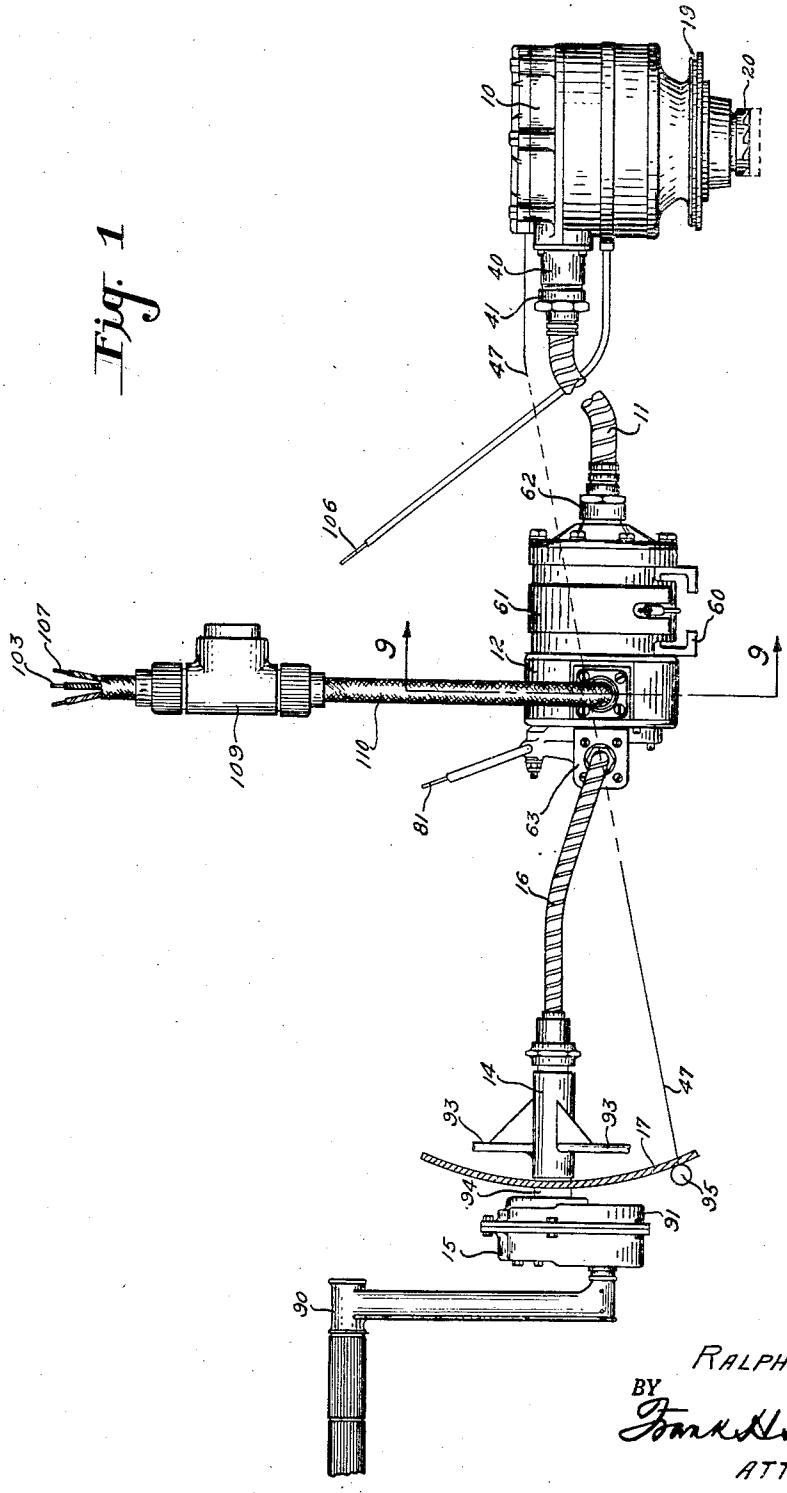
April 11, 1944. R. M. HEINTZ 2,346,303

ENGINE STARTING SYSTEM

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Fig. 1



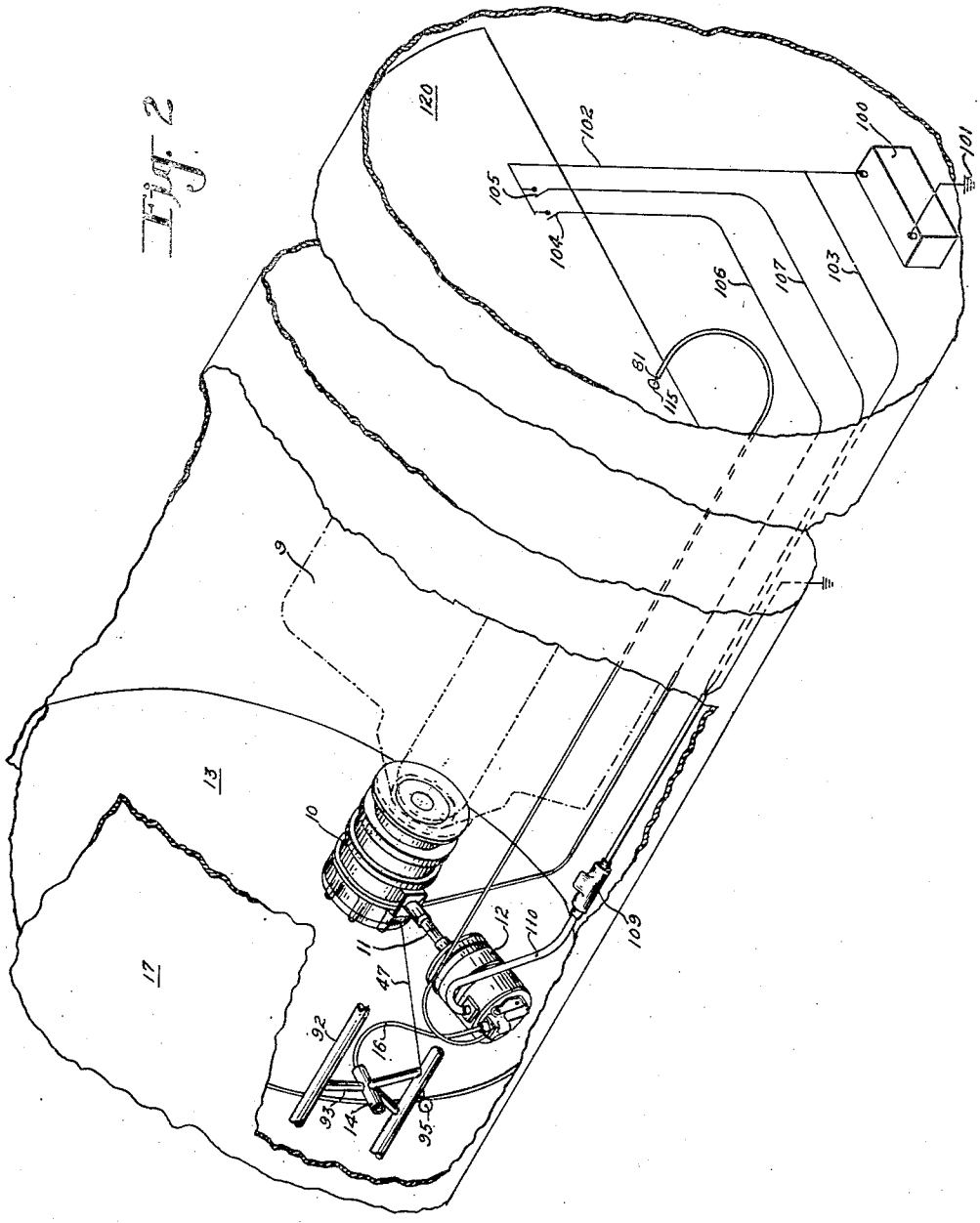
INVENTOR.
RALPH M. HEINTZ
BY
ATTORNEY

April 11, 1944. R. M. HEINTZ 2,346,303

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Fig. 2



INVENTOR.
RALPH M. HEINTZ
BY
Frank A. Harmon
ATTORNEY

April 11, 1944. R. M. HEINTZ 2,346,303

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Fig. 3

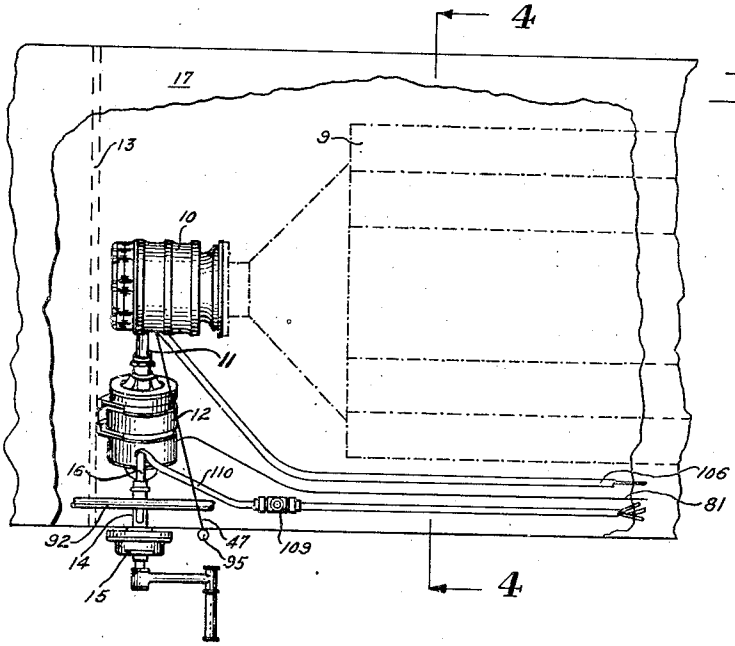


Fig. 4

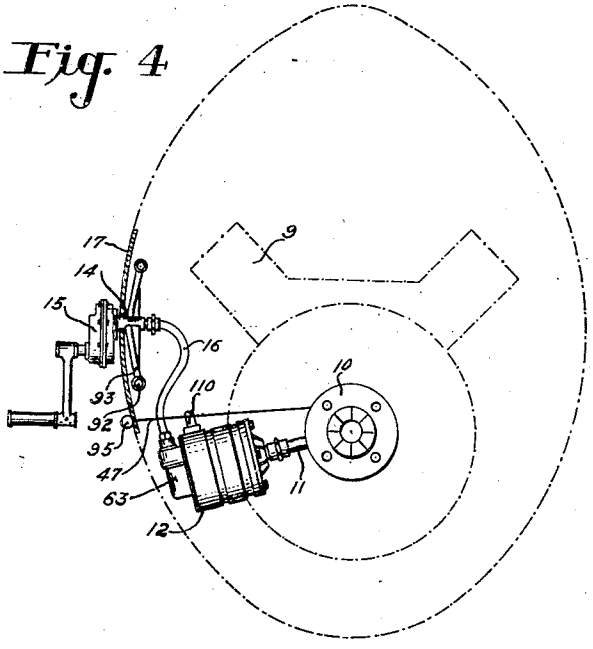
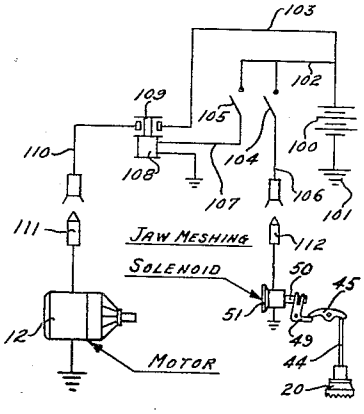


Fig. 5



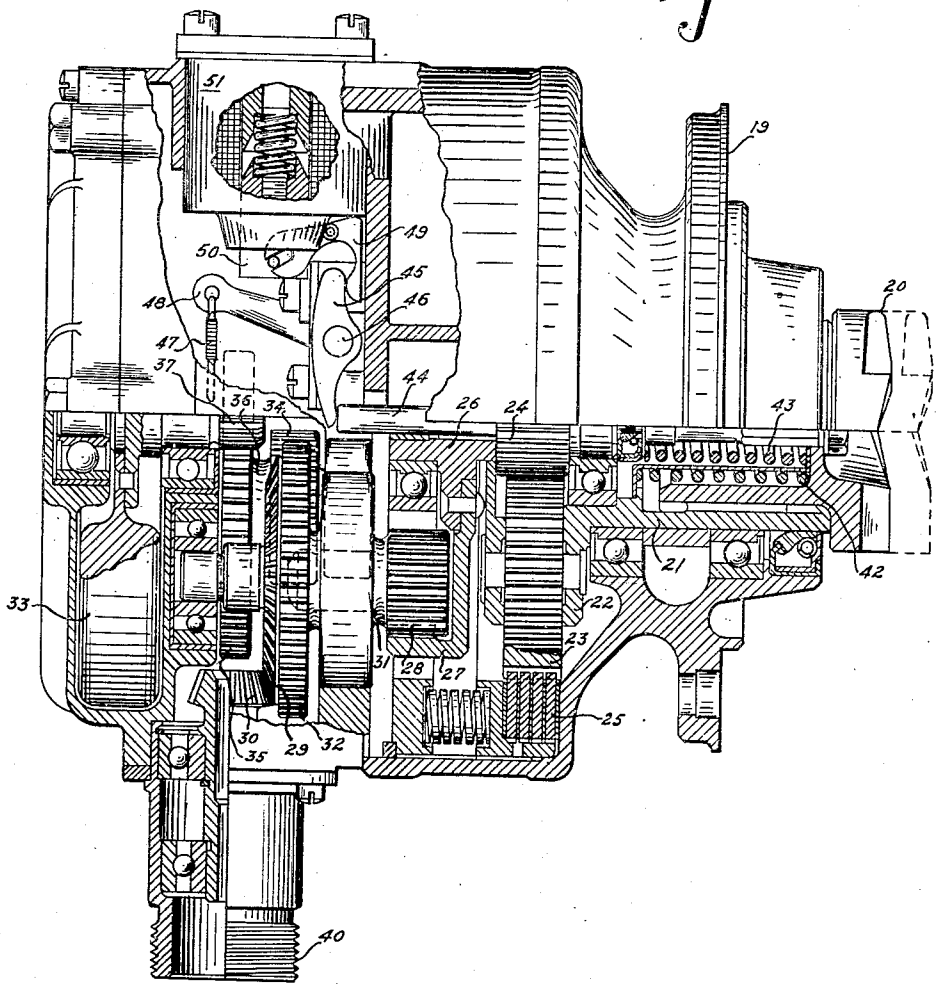
INVENTOR.
RALPH M. HEINTZ
BY
Frank N. Harmon
ATTORNEY

April 11, 1944. R. M. HEINTZ 2,346,303

ENGINE STARTING SYSTEM

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Fig. 6.



INVENTOR.
RALPH M. HEINTZ
BY
Frank H. Harmon
ATTORNEY

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Fig. 7.

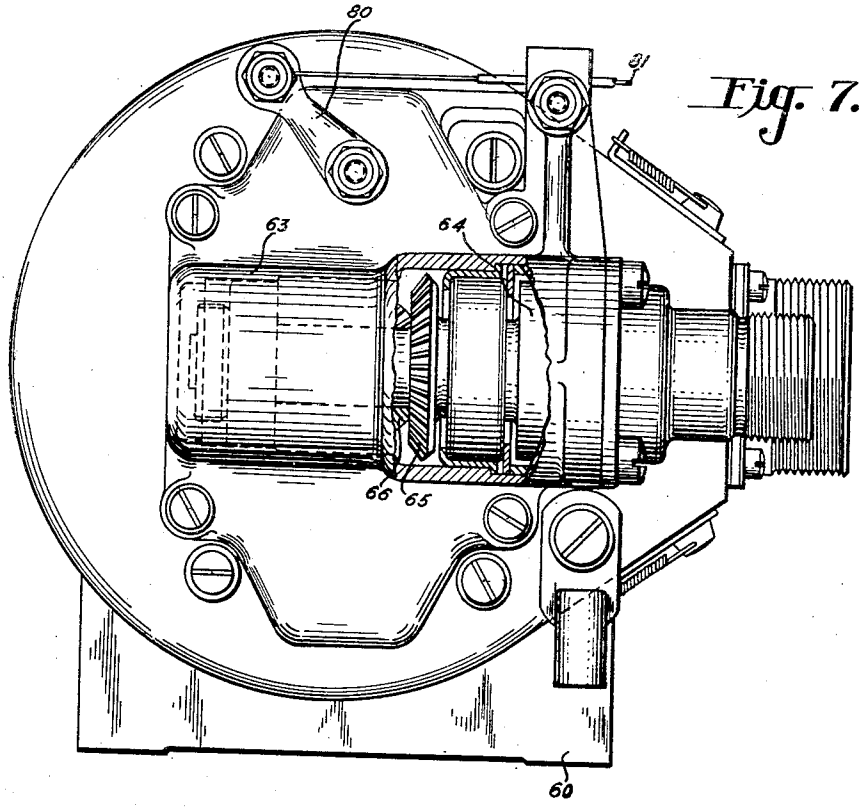
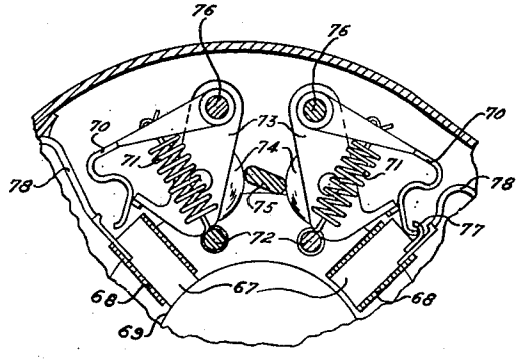


Fig. 10.



INVENTOR.
RALPH M. HEINTZ
BY
ATTORNEY

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Fig. 8.

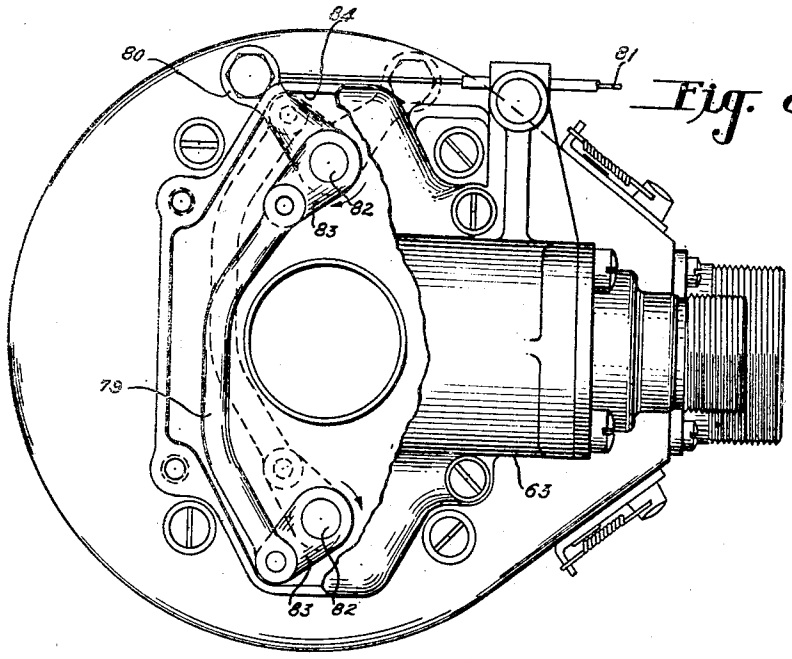
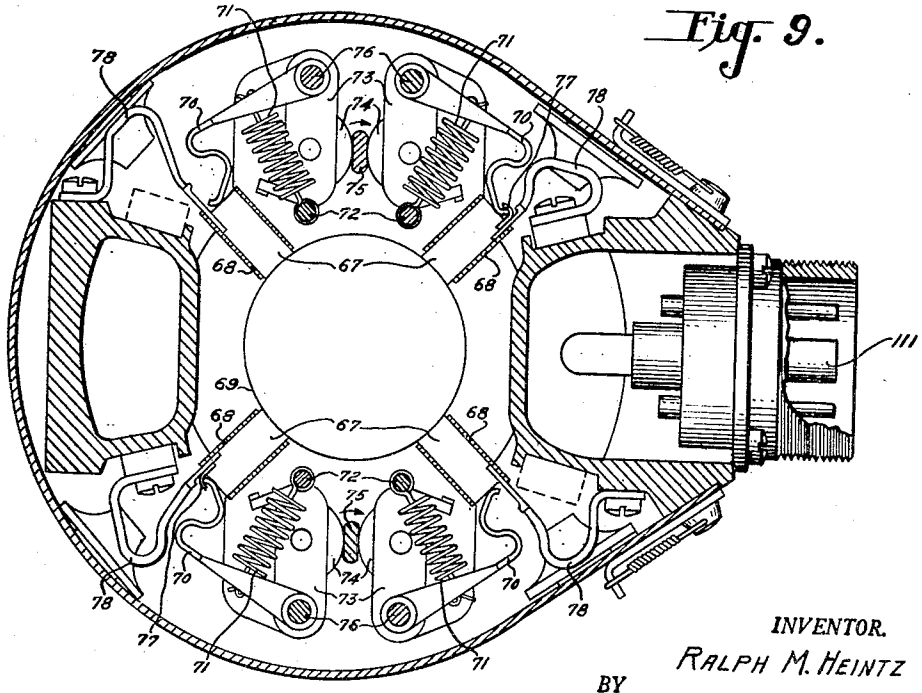


Fig. 9.



INVENTOR.
RALPH M. HEINTZ
BY
Frank A. Harmon
ATTORNEY

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2,346,303

UNITED STATES PATENT OFFICE

2,346,303

ENGINE STARTING SYSTEM

Ralph M. Heintz, Cleveland, Ohio, assignor to Jack & Heintz, Inc., Bedford, Ohio, a corporation of Ohio

Application September 24, 1942, Serial No. 459,566

10 Claims. (Cl. 290—38)

This invention relates to an inertia starting system for internal combustion engines, and particularly the engines of vehicles such as airplanes and the like.

Heretofore it has been the usual practice to include in this type of starter a plurality of components including an electric motor, a flywheel, reduction gearing, extensible jaw clutch member, and a torque limiting clutch all contained in a single housing having a flange attachment with the crank case of the engine. This unitary arrangement has certain obvious advantages, but it also possesses inherent disadvantages rendering it unsuitable for use on some engines. In some installations space limitations prohibit the addition of a large starter unit on the engine, due to proximity of a bulkhead or fire wall, or to the presence of a multiplicity of accessories on the rear of the engine. Further, even though there is sufficient space it is still desirable to avoid subjecting the electric starting motor to the engine vibration, notwithstanding the tendency in the prior art to disregard this consideration.

It is therefore the object of the present invention to separate the components of the starting system so that a relatively smaller unit may be mounted directly on the engine and so that the electric starting motor may be mounted on the airplane or vehicle where the vibration is less severe than on the engine.

A particular object is to provide an improved engine starting system having only those components driven by the inertia flywheel mounted directly on the engine, the flywheel energizing means being separately mounted on the vehicle.

A further object is to provide an engine starting system having an inertia started mounted on the engine, having an electric motor for energizing the inertia member of said starter mounted in the engine compartment and connected with the starter by a flexible shaft, and having a hand crank receiving unit accessible exteriorly of said compartment and connected with said motor by a flexible shaft to drive said inertia member.

A further object is to provide a starting system of the type described having novel and improved brush lifting mechanism for the starting motor to reduce the friction therein when the hand crank mechanism is employed to energize the flywheel for a starting operation.

Additional and more specific objects and advantages will be apparent to those skilled in the art as the description proceeds in connection with the accompanying drawings showing by way of example a preferred embodiment of the invention.

In the drawings:

Figure 1 is a schematic representation of the starting system of the present invention, showing the functional relation of the various units thereof;

Figure 2 is a perspective view of the starting system showing its physical disposition in an application to an airplane or like vehicle;

Figure 3 is a top plan view of a portion of the engine compartment shown in Figure 2;

Figure 4 is a cross sectional view taken on the line 4—4 of Figure 3;

Figure 5 is a wiring diagram showing the energizing circuits for the starting motor and the jaw meshing solenoid;

Figure 6 is a side view of the starter unit with parts broken away and other parts shown in section;

Figure 7 is an end view of the motor with parts broken away to show the drive from the hand crank mechanism;

Figure 8 is an end view of the motor with parts broken away to show the brush lifting mechanism;

Figure 9 is a sectional view through the motor, taken approximately on the line 9—9 of Figure 1; and

Figure 10 is a fragmentary sectional view taken as Figure 9, showing one of the brush lifting cams in over center position.

Referring first to Figures 1 to 4, it will be seen that the present starting system comprises a plurality of separate components connected by flexible shafts. Mounted upon the internal combustion engine 9 to be started is the inertia starting unit 10, the inertia member thereof being energized by means of the flexible shaft 11 from an electric motor 12. The motor 12 is preferably mounted on some part of the airplane adjacent the engine, such as the bulkhead or fire wall 13, for reasons which will later be discussed. A hand crank receiving unit 14 is mounted on the airplane close to the engine compartment in a position for convenient access to the portable hand crank mechanism 15. The hand crank receiving unit is connected with the motor 12 by the flexible shaft 16. The numeral 17 indicates the skin of the fuselage or nacelle of the airplane.

The operating relation of the units forming the component parts of the starting system is illustrated schematically in Figure 1 without reference to a particular kind of craft or vehicle,

while Figures 2 to 4 illustrate a preferred embodiment of the physical disposition of the units and associated control elements in an airplane. The electrical circuits for the starting motor and jaw meshing solenoid are disclosed in the wiring diagram of Figure 5. The individual units will now be described in detail before proceeding with further discussion of the system as a whole.

Inertia starter unit

Referring now to Figure 6, the starter unit 10 is provided with a flange 19 adapted to be bolted to the crankcase of the engine to be started, so as to bring the extensible jaw clutch member 20 closely adjacent a similar jaw member on the engine. The member 20 is splined for rotation with a member 21 constituting an extension on the planetary gear carrier 22 carrying the planetary gears 23. The planetary gears 23 mesh with a sun gear 24 and a ring gear constituted by a plurality of clutch plates in an overload release clutch, or brake, 25. The said ring gear is normally held stationary to cause rotation of the carrier 22 when power is applied to the sun gear 24, but is adapted to slip under excessive loads, as when breaking loose an engine at the start of a cranking operation. Sun gear 24 is mounted on a hollow shaft 26 carrying a ring gear 27 driven by a pinion 28. The pinion 28 is driven by a bevel gear 29 fixed on the shaft 31 therewith, the said bevel gear 29 being in engagement with a bevel gear 30 on the end of the flexible shaft 11. The shaft 31 also carries a gear 32 connected with the flywheel 33 through the gears 34 and 35 fixed on a shaft 36, and the pinion 37 on the flywheel shaft. The flexible shaft 11 is thereby enabled to energize the flywheel 33 by imparting high speed rotation thereto, this energy being delivered to the jaw clutch member 20 through the gear train and planetary transmission just described. A threaded side extension 40 receives the end of the flexible shaft and secures the shaft housing by means of the union member 41.

The jaw clutch member 20 normally resposes in the retracted position shown in full lines in Figures 1 and 6, and to crank the engine this member must be extended to engage the clutch member on the engine. The mechanism for retracting and extending the jaw clutch member 20 includes the springs 42 and 43, and the push rod 44, the spring 43 normally overpowering the spring 42 to hold the push rod and jaw member in retracted position. The push rod is adapted to be extended by the rocker arm 45 on a shaft 46, manual operation being effected by means of the pull cable 47 attached to a lever 48 on the shaft 46, and electrical operation being effected through a bell crank lever 49 actuated by the plunger 50 in a solenoid 51. The solenoid circuit is established through the conductor cable 102 leading to a switch 104 in the pilot's compartment. The disposition of the pull cable 47 will be hereinafter referred to in connection with the hand cranking mechanism and in connection with the operation of the system. The jaw meshing mechanism just described is disclosed and claimed in my copending application Serial No. 439,751, filed April 20, 1942.

Electric motor

The motor unit 12 is provided wtih a base 60 for attachment to any suitable support adjacent the engine and the starter unit 10, such as, for instance, the bulkhead 13. To allow for the most convenient disposition of the motor in any particular installation the base 60 is secured to a band 61 encircling the motor housing or frame and adjustable throughout a range of 360° thereabout. An axial extension 62 on the end of the motor housing secures one end of the housing of the flexible shaft 11, maintaining the flexible shaft in rotative engagement with the end of the motor shaft.

The other end of the motor is adapted to receive another flexible shaft drive for manual operation by means of hand cranking equipment to be presently described. For this purpose a housing extension 63 is adapted to secure the flexible shaft 16 in driving engagement with an overrunning clutch 64 which is preferably of the centrifugal type disclosed and claimed in my copending application Serial No. 434,235, filed March 11, 1942. As shown in Figure 7, bevel gears 65 and 66 complete the power connection with the commutator end of the motor shaft. The clutch member comprises a pair of centrifugal dogs driven by the shaft 16 and adapted to engage internal projections in an encircling member connected with the gear 65 when said shaft is driven in the proper direction. If the rotation of said shaft is reversed the dogs will cam themselves over the internal projections without causing it to rotate, and similarly when the motor is energized to furnish the power source the projections ride over the dogs without turning the hand crank shaft 16. This construction renders it impossible to crank the inertia flywheel in the wrong direction and prevents the driving of the hand crank shaft by the motor.

The motor 12 is equipped with brush lifting mechanism, shown in Figures 8 to 10, to break the circuit and reduce the drag on the commutator during hand cranking operations. Brushes 67 are carried in stationary brush holders 68 and are normally urged against the commutator 69 by fingers 70 actuated by springs 71 anchored on the stationary pins 72. The fingers 70 are adapted to be engaged by arms 73 carrying insulating rollers 74 actuatable by cams 75, the fingers 70 and arms 73 being independently pivotally mounted on fixed posts 76. Hooks 77 on certain of the brushes 67 cause these brushes to be lifted to positively break the circuit when the fingers are raised, but the remaining brushes are not compelled to follow the fingers. Electrical connections are maintained through the flexible pigtail connectors 78. The cams 75 are formed on shafts 82 having arms 83 connected together by the link 79 for movement by the external lever 80. In the position of the cams indicated by the full line position of link 79 in Figure 8 the fingers 70 are lowered against the brushes as shown in Figure 9 to apply the proper pressure for motor operation. In lifting the brushes the cams pass over center to the position shown in Figure 10, the directions of rotation of the cams being indicated by arcuate arrows in Figures 8 and 9. When the cams have just passed over center one of the arms 83 abuts a wall portion 84 of the casting forming the housing extension 63, which wall portion thereby serves as a stop to prevent further movement. Any other form of stop may be utilized which will hold the cams 75 in the position of Figure 10. To return the brushes to lowered positions it is only necessary to impart a slight push to the lever 80 to force the cams out of over center position whereupon the springs 71 will complete the motion returning the parts to the positions shown in Figure 9. The flexible

wire control 81 serves as a convenient push-pull mechanism for operating the lever 80 from the pilot's compartment or other station.

Hand crank mechanism

In lieu of energizing the inertia starting member, or flywheel 33, by the electric motor means 12, hand crank mechanism indicated generally by the numeral 15 may be used. Referring again to Figures 1 to 4, the hand crank mechanism comprises essentially a detachable crank handle 90, a detachable gear box 91, a crank and gear box receiver 14, and the flexible shaft 16. The gear ratio of the gear box 91 is preferably approximately 80:1, causing the shaft 16 to make about eighty revolutions for every revolution of the crank. This turning effort is transmitted through the overrunning clutch 64 to the motor 12 which in turn drives the flywheel 33 through the flexible shaft 11 and the gears 29, 32, 34 and 35. It is intended that the crank 90 and gear box 91 be detachable for stowing in the airplane when not required for use, this equipment being primarily for emergency use only.

The hand crank receiver is preferably welded to a rigid part of the vehicle frame or fuselage 92 by means of struts 93 or the like and is located to present the most convenient access for hand cranking consistent with relatively short flexible shaft connections and the limitations to the curvature thereof. As illustrated in the present embodiment the crank 90 extends on the outside of the fuselage 17 with the shaft 16 on the inside. The crank may obviously be located within the vehicle if the construction and arrangement are suitable. The gear box 91 is supported by an integral tubular shank 94 adapted to fit in a tubular sleeve forming the body of the receiver 14. A squared hole in a stub shaft within the said shank 94 is adapted to receive a squared end on the flexible shaft 16, this association of parts being maintained by cooperating pins and bayonet slots on the shank 94 and receiver 14, respectively.

The hand crank mechanism per se constitutes the subject matter of a separate application, Serial No. 431,850, filed February 21, 1942, and assigned to the assignee of the present invention.

Controls

The controls for the previously described jaw meshing and brush lifting mechanisms are of two types, electrical and mechanical, and are disposed in the pilot's compartment and adjacent the hand crank receiver in the proximity of the engine compartment, but it is to be understood that this arrangement while at present preferred is illustrative only.

The pull cable 47 for effecting manual operation of the jaw meshing mechanism terminates in a loop or handle 95 accessible through the outer wall of the engine compartment adjacent the hand crank receiver 14. When the cable is pulled the rocker arm 45 depresses the push rod 44 to allow the spring 42 to extend the jaw clutch member 20. When the pull cable is released the push rod is returned by spring 43 overpowering spring 42 and carrying the member 20 back to retracted position.

The numeral 100 indicates a battery or other source of electrical supply for the starting system. The representation of the battery in Figure 2 is merely for the purpose of completing certain circuit connections, and is not intended to illustrate a preferred physical disposition of the electrical power source. One side of the battery circuit is grounded at 101 and the other side divides into two conductors 102 and 103. The conductor 102 is connected with switches 104 and 105 in the pilot's compartment, the switch 104 controlling a circuit 106 to the jaw meshing solenoid 51, and the switch 105 controlling a circuit 107 to a relay solenoid 108 in a power relay 109 in the circuit 103, 110 of the starting motor 12. Plug connectors 111 and 112 are built into the motor and inertia starting units, respectively, the return sides of the circuits being completed to ground as shown.

A button 115 in the pilot's compartment operates the flexible wire control 81 for the brush lifting mechanism on the motor, this type of control being capable of applying a push or pull force to the brush operating lever 80 to swing the cams to over center positions and return them to normal positions.

Operation

In the present arrangement it will be seen that only the inertia starter unit 10 is subjected directly to engine vibration, the motor unit 12 being mounted on the bulkhead 13 or other structural part where the vibration is much less severe. Also, by thus separating the motor and starter units the motor may be disposed where it will least interfere with the numerous accessories associated with airplane power plants and the like, and at the same time reduce the clearance which would otherwise be required between the rear end of the engine crankshaft and the bulkhead 13.

Regardless of whether the inertia starter is energized by the hand crank or the electric motor the flexible shaft 11 transmits the necessary torque to the starting unit 10 to accelerate the flywheel therein. The second flexible shaft 16 enables the hand crank receiver 14 to be located in an accessible position without the necessity for a straight line connection with the motor. In Figures 2, 3 and 4 the starting system of the present invention is applied to an airplane of the type having the engine behind the cockpit, or pilot's compartment, but it is to be understood that this arrangement is shown for purposes of illustration only, since the present starting system may also be used on engines forward or laterally of the cockpit. It is also to be understood that the flexible shaft connections with the various units may be varied to best suit the particular installation. For instance, the radial connection of the flexible shaft 16 through the housing extension 63 may be readily changed to an axial connection by merely substituting interchangeable parts. Likewise, the power cable 110 may be end connected instead of side connected. The flexible shaft and electrical connections are thereby adaptable to varied types of installations in addition to the specific embodiment illustrated.

To energize the inertia starter electrically the control button 115 is first pressed in to throw the brush lifting cams over center, causing the motor brushes to be pressed against the commutator under spring action. Then, upon closing the switch 105 the motor 12 will accelerate the inertia flywheel 33 to its proper operating speed. Closing of the switch 104 will energize the jaw meshing solenoid 51 to extend the jaw clutch member 20 to crank the engine. As long as the starter is delivering torque to the engine the friction between the jaw clutch member on the starter and the jaw clutch member on the engine will hold the two members in engagement, but when

the engine fires the member 20 is automatically released for return to its retracted position by the action of the spring 43. If the starter is purely of the inertia type the motor switch 105 is opened when the jaw meshing switch 104 is closed, but if the starter is of the combination type, utilizing both inertia and direct cranking, the motor switch 105 is not opened until it is desired to terminate the cranking operation.

When the engine is to be started by hand cranking the motor brushes are first lifted by pulling out the button 115 to rotate the cams 75 to their over center positions holding the spring fingers 70 retracted. The portable hand crank and gear box are inserted in the receiver 14 and the crank is turned in the proper direction to spin the flywheel 33, it being remembered that the over running clutch 64 prevents cranking the flywheel in the wrong direction. When the desired flywheel speed is attained the engine may be cranked by pulling on the jaw meshing cable 47 to extend the jaw clutch member 20 into engagement with the engine. Once the jaw clutch members are properly engaged the cable 47 may be released and the engagement will be maintained by contact friction between the members until torque is no longer being delivered to the engine. After the starting operation the hand crank and gear box may be removed from the receiver 14 and stowed in the airplane.

While the present starting system has especial utility in aircraft of both the heavier-than-air and lighter-than-air types, it is also applicable to land and marine vehicles and to stationary engines as well. It is obvious that the switches 104, 105, and the control button 115, herein illustrated as being mounted on a control panel 120 in the pilot's compartment, may be located wherever the electrical and mechanical controls may be manipulated and that the hand crank receiver 14 may be located in the same compartment with said controls, or in another compartment, provided the distance from the motor 12 does not exceed the limitations of available flexible shafting.

Various other changes may be made in the arrangement, and certain parts of the system may be used without other parts. All such modifications and sub-combinations are included in the invention, it being understood that the same is to be limited only by the scope of the appended claims and the prior art.

I claim:

1. In a vehicle engine starting system, an inertia starter unit mounted on an engine to be starter, said unit comprising an extensible jaw clutch member for engaging with and turning said engine, jaw extending mechanism, a flywheel, reduction gearing, and overload clutch release means, an electric motor mounted independently of said unit, brush lifting mechanism in said motor, a flexible drive shaft connecting said unit with said motor; a hand crank receiving unit mounted independently of said first named unit and said motor, a flexible drive shaft connecting said motor with said last named unit, said last named flexible drive shaft including an overrunning clutch to prevent driving of said shaft by said motor; manipulable means adjacent said hand crank receiving unit for operating said jaw extending mechanism in said inertia starter unit; and manipulable means in said vehicle for operating said brush lifting mechanism in said motor.

2. In a vehicle engine starting system, a flywheel, hand crank mechanism for energizing said flywheel, an electric starting motor for energizing said flywheel, spring loaded brushes bearing against the commutator of said motor, over center cam means for relieving the brush pressure against said commutator, means for moving said cam means to over center position to facilitate energizing said flywheel by said hand crank mechanism, and means for moving said cam means out of over center position to enable energizing said flywheel by said motor.

3. In a vehicle engine starting system having a flywheel energizable selectively by hand crank mechanism or an electric motor, said motor having cam operated brush lifting mechanism, a pair of cam shafts for operating said mechanism, levers on said shafts, a link connecting said levers to operate same in unison, said brush lifting mechanism having brush tensioning means adapted to urge said cams into a repose position to lower said brushes for operation of said motor, said tensioning means being also adapted to hold said cams in an over center position with said brushes lifted for operation of said hand crank mechanism, and a stop for limiting the cam movement at over center position.

4. In a vehicle engine starting system, a flywheel, hand crank mechanism for energizing said flywheel, an electric motor for energizing said flywheel, a pair of brushes adjacent the commutator of said motor, spring loaded fingers for urging said brushes against said commutator, cam means movable to over center position to lift said fingers and movable out of over center position to lower said fingers, a lever to operate said cam means, and means to move said lever in opposite directions to facilitate selective energization of said flywheel by said hand crank mechanism or said motor.

5. In a vehicle engine starting system having a flywheel energizable selectively by hand crank mechanism or an electric motor, movable brushes in said motor, spring actuated fingers for urging said brushes against the motor commutator for operation of the motor, a pair of opposed rollers for lifting said fingers for operation of the hand crank mechanism, a relatively flat sided cam member between said rollers rotatable to an over center position against a stop for moving the rollers apart to lift said fingers against said spring tension, said spring tension being effective to hold said cam either flatwise between said rollers or in over center position, for selective energization of said flywheel in the manners described.

6. In an engine starting system for a vehicle having an engine compartment and a pilot's compartment, an inertia starter for cranking said engine, extensible jaw clutch means for engaging said starter with said engine, hand crank mechanism operable outside of said engine compartment for energizing said inertia starter, means adjacent said hand crank mechanism for extending said jaw clutch means, an electric motor for energizing said inertia starter, brush lifting means in said motor, and means in said pilot's compartment for operating said brush lifting means, for energizing said motor and for extending said jaw clutch means.

7. In an engine starting system for a vehicle having an engine compartment and a pilot's compartment, an inertia starter for cranking said engine, extensible jaw clutch means for engaging said starter with said engine, hand crank mechanism operable outside of said engine compart-

ment for energizing said inertia starter, a flexible shaft drive between said hand crank mechanism and said starter, a pull cord adjacent said hand crank mechanism for manually extending said jaw clutch means, an electric motor for energizing said inertia starter, over center brush lifting means in said motor, a flexible wire control accessible in said pilot's compartment for operating said brush lifting means into and out of over center position, and switch means in said pilot's compartment for energizing said motor and for electrically extending said jaw clutch means.

8. In an aircraft, an engine compartment, a pilot's compartment, an engine in said first-named compartment, an inertia starter on said engine, extensible jaw clutch means for engaging said starter with said engine, an electric motor mounted in said engine compartment so as to be subject to less vibration than said starter, brush lifting mechanism in said motor, a flexible shaft drive connecting said motor with said inertia starter, a hand crank receiving unit accessible exteriorly of said engine compartment, a flexible shaft drive connecting said unit with said motor, manipulable means adjacent said unit for operating said extensible jaw clutch means, manipulable means in said pilot's compartment for operating said brush lifting mechanism, and manipulable means in said pilot's compartment for energizing said motor and for operating said extensible jaw clutch means.

9. In an aircraft, an engine compartment, a pilot's compartment, an engine in said first-named compartment, an inertia starter on said engine, extensible jaw clutch means for engaging said starter with said engine, an electric motor mounted in said engine compartment so as to be subject to less vibration than said starter, brush lifting mechanism in said motor, a flexible shaft drive connecting said motor with said inertia starter, a hand crank receiving unit accessible exteriorly of said engine compartment, a flexible shaft drive connecting said unit with said motor, a pull cable adjacent said unit for operating said extensible jaw clutch means, a flexible control cable in said pilot's compartment for operating said brush lifting mechanism, and switch means in said pilot's compartment for energizing said motor and for operating said extensible jaw clutch means.

10. A starting system for internal combustion engines comprising an inertia starter unit on said engine, an electric motor mounted adjacent said engine, a flexible shaft drive connecting said motor with said starter unit, a hand crank receiving unit, a flexible shaft drive connecting said last named unit with said motor, an overrunning clutch in said last named drive to prevent driving of said shaft by said motor, and means to lift the brushes in said motor during a hand cranking operation.

RALPH M. HEINTZ.