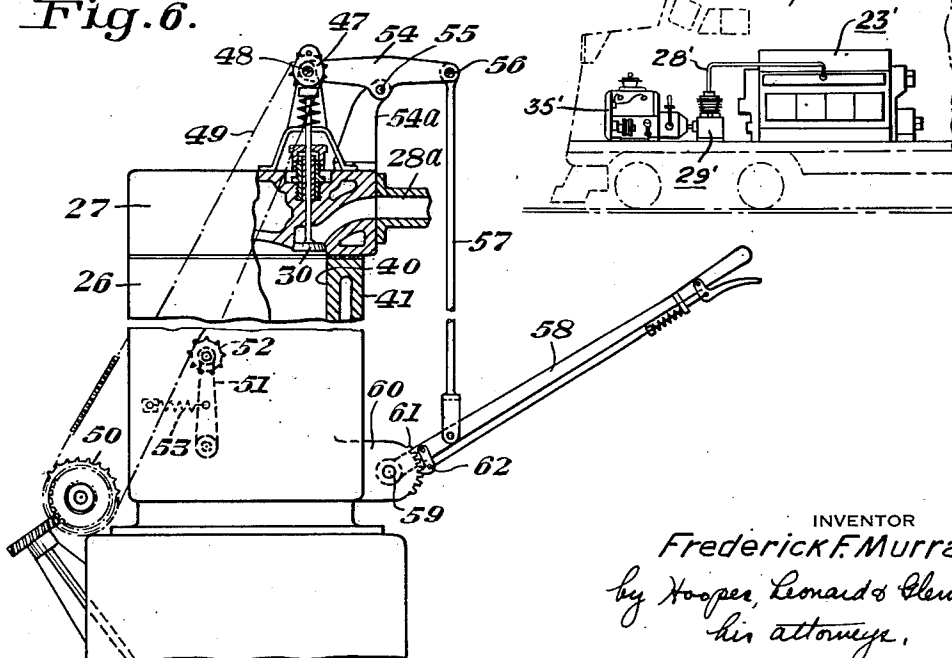


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2 Sheets-Sheet 1.

Fig. 6.



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STARTING SYSTEM FOR LOAD CONNECTED
INTERNAL-COMBUSTION ENGINES

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Fig. 2.

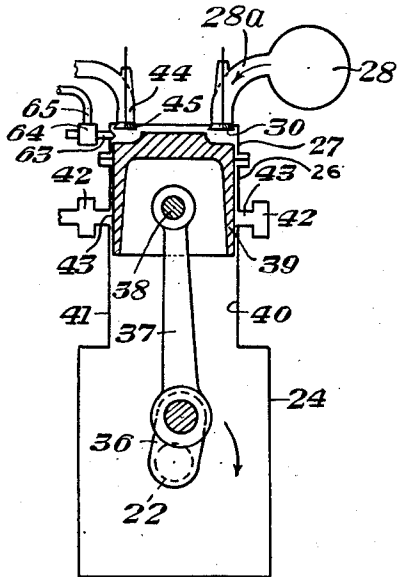


Fig. 3.

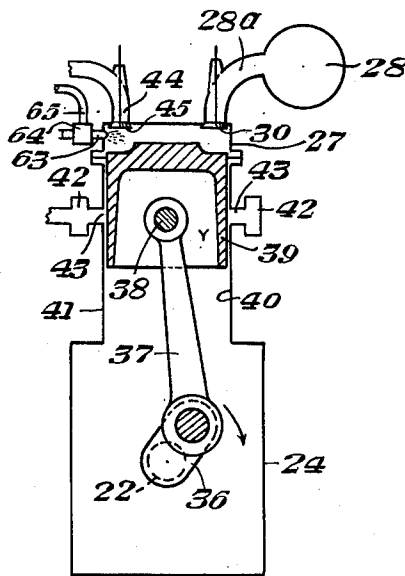


Fig. 4.

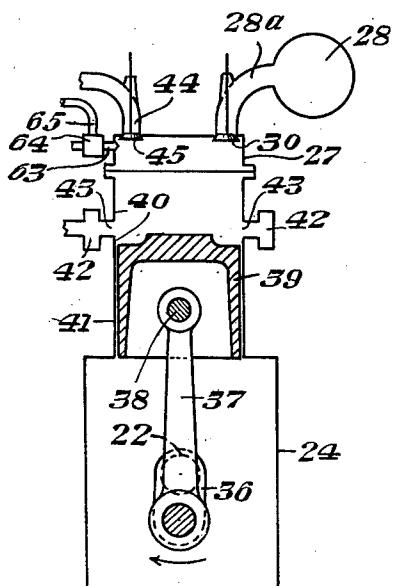
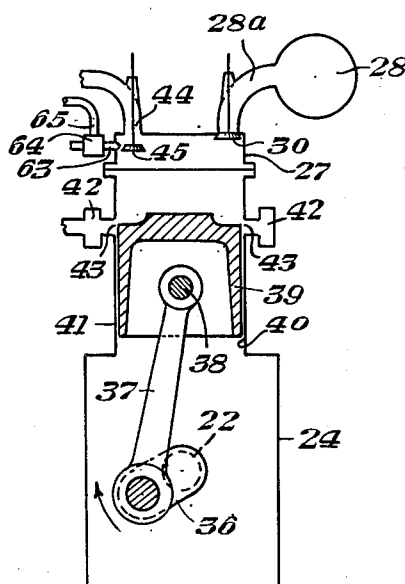


Fig. 5.



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STARTING SYSTEM FOR LOAD-CONNECTED INTERNAL-COMBUSTION ENGINES

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5 Claims. (Cl. 123—182)

This invention relates to a starting system for load-connected internal combustion engine. More particularly, it relates to a system wherein an internal combustion engine assembly can be started while connected to or under a large load without requiring the usual interposition of mechanical or electrical clutch devices.

At the present time there is no practical system in use whereby internal combustion engines, such as Diesel engines, can be permanently connected to their respective loads because of the problem presented in starting such engines. As a consequence, such internal combustion engines are presently provided with means for disconnecting the engines from their respective loads during the time that the engines in question are being started. As they become power producers the loads are usually gradually connected until full driving connection is established between the engines and the loads.

A common means for connecting and disconnecting an internal combustion engine and its load may take one of the innumerable forms of friction clutch devices. Normally, such clutches are used where the load is relatively light. Where, however, the load to be carried or moved is relatively large or heavy, resort may be had to an electrical clutch device such as those used in some diesel locomotives. This electrical clutch device may comprise an electric generator and electric motors so that when the diesel engines of the locomotives are started, they turn the generator under substantially no load until operating speed of the generator is attained. At that point the load is applied gradually through the electric circuits connecting the generator and motors. The electric motors in turn are mechanically and permanently connected to the driving wheels of the locomotive. Not only is such an electric clutch device extremely expensive in that the internal combustion engines must be supplemented by the electric generators and electric motors of correlated capacity but in addition the added control circuits and mechanisms increase the expense and complexity of the operation.

In the case of hoisting machinery, the problem of internal combustion power application and transmission during a starting phase follows the same general pattern. That is to say that where the loads are relatively light, mechanical means such as friction clutches are used with resort to the above described electrical clutch means when the loads to be started are relatively great.

In the present invention the foregoing difficulties are overcome and internal combustion engines can be effectively and efficiently used while substantially constantly under or subject to load, even though that load be relatively heavy or requires a high torque to move it. Further, by means of the system of this invention, such internal combustion engines can be started without the interposition of any clutch device, whether mechanical, electrical, or of other nature. In brief, in the provided system of this invention a compressor for the starting and combustion air is in a new cooperative relation to operate the internal combustion engine in question. This compressor is driven wholly independently of the engine and hence is capable of making such air available at a pressure and at a temperature called for in the design of the engine for the efficient operation thereof. It is part of my system to use this air under pressure to start the engine and to ignite fuel introduced directly into the engine whereby combustion is provided within the engine cylinders to operate them and move the load firmly connected thereto either directly or

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through positively connected power transmission devices such as gears. Thus, by the system of this invention conventional items of equipment are used and interconnected to produce an internal combustion engine assembly which can remain in relatively permanent connection to its load and, at the same time, be stopped and restarted without requiring any complete or partial disconnection between that engine and that load.

Other objects and advantages will be apparent from the following description and from the drawings, which are schematic only, in which,

Figure 1 is a diagrammatic view of a hoisting machinery assembly employing the system of this invention with a two-cylinder, two-cycle diesel engine;

Figure 2 is a view in schematic cross section taken through the axis of one of the cylinders of the diesel engine shown in Figure 1 and normal to the crankshaft thereof, with air admission to said cylinder beginning to start the engine;

Figure 3 is a view similar to the view shown in Figure 2 with fuel injection and combustion taking place;

Figure 4 is a view similar to the view shown in Figure 2 with the piston substantially at the end of its outward or power stroke with exhaust taking place;

Figure 5 is a view similar to the view shown in Figure 2 with the piston on its inward or extended stroke with auxiliary exhaust taking place;

Figure 6 is an enlarged end view in partial section of the engine shown in Figure 1 illustrating a means for advancing and retarding the opening of the air admission valve;

Figure 7 is a view corresponding to the view shown in Figure 2 showing advance air admission after the engine is running, having been started as shown by the sequence in Figures 2 to 5 inclusive; and

Figure 7A is a schematic view of a diesel locomotive employing the system of this invention.

In the assembly shown in Figure 1, a derrick-type structural hoisting rig 10 is provided with a crown pulley 11 and a cable drum 12 pivotally mounted thereon. A flexible cable 13 is engaged by the drum at one end and anchored at its other end 14 after passing around pulley 11 and a block sheave 15. A hook 16 is connected to block 15 and supports a load 17 to be raised or lowered by the counterclockwise or clockwise movement respectively of drum 12. When drum 12 is at rest a brake drum 18 fixed to the shaft of drum 12 may be engaged by a suitable brake block (not shown) to insure the holding of sheave 15 in whatever rest position is desired whether load 17 is suspended or otherwise.

A sprocket wheel 19 is also fastened to the shaft of drum 12 and is engaged by a sprocket chain 20. Sprocket chain 20 also engages a drive sprocket 21 keyed to the end of a crankshaft 22. Crankshaft 22 is a part of a two-cylinder, two-cycle diesel engine 23 and is suitably mounted on bearings within a crankcase 24. A flywheel 25 is provided at the other end of shaft 22. It will thus be seen that engine 23 is permanently connected to load 17 without any interposition of a friction clutch or any other form of mechanical, electrical or other clutching device intended to disconnect the engine and the load before starting the engine. Engine 23 is wholly conventional except that no provision is made in connection therewith for taking air into the cylinders thereof in the course of any of the return or inward strokes in order to have the engine compress that air for use as combustion air.

Engine 23 includes a cylinder block 26 bolted to crankcase 24 and a cylinder head 27 in turn bolted to block 26. A high pressure air manifold 28 which is preferably suitably lagged is connected to engine head 27 and communicates with the interior of each cylinder of engine 23 through suitable air admission valve means. The other end of duct 28 is connected to the delivery end of an air compressor 29 which, as shown, is a reciprocating compressor although a centrifugal compressor may also be used. A relatively small receiver insulated to maintain temperature may be interposed between reciprocating compressor 29 and manifold 28. In general, such

a receiver is not necessary particularly if a centrifugal compressor is used.

An air admission valve 30 is positioned in each duct 28a connecting a cylinder with manifold 28. A valve 29a may be used to shut compressor 29 off from engine 23 when engine 23 is to be brought to a stop. A combination pulley flywheel 31 is keyed to a crankshaft 32 of compressor 29 and is driven by V-belts 33 engaging the grooves in wheel 31 and corresponding grooves in a driving pulley 34 directly connected to the armature shaft of an electric motor 35. Instead of electric motor 35, a gasoline motor or other prime mover wholly independent of engine 23 may be used.

Crankshaft 22 is provided with two throws 36 angularly separated by 180° inasmuch as engine 23 is illustratively described as a two-cylinder engine. Similarly, each cylinder operates through the identical cycle as the companion cylinder by 180 angular degrees removed. In the cylinder shown in Figures 2, 5 and 7, a connecting rod 37 connects crankshaft 22 with a wrist pin 38 which in turn is connected to a piston 39 provided with the usual rings (not shown) for sliding engagement with the walls 40 of each cylinder 41. Each cylinder is connected to an annular exhaust manifold 42 communicating with the interior of the cylinder through ports 43 located adjacent that portion of walls 40 uncovered as piston 39 approached the end of its working or outward stroke as shown in Figure 4. Inasmuch as engine 23 is a two-cycle engine, it is apparent that exhaust begins during the latter part of the outward or working strokes when the pistons 39 uncover the respective ports 43. Such exhaust continues after the piston reaches retracted dead center as shown in Figure 4 and commences its return or inward stroke. After the ports 43 of the respective cylinder are closed off by the piston 39, exhaust still continues through an auxiliary exhaust valve 45 in the form of a poppet valve in cylinder head 27. The valves 45 control the openings in the respective cylinders into the auxiliary exhaust ports 44. Normally, such ports 44 will be closed prior to the admission of air from the respective ports 28a although high pressure air may be admitted through the ports 28a into the respective cylinders to scavenge those cylinders prior to the final closing of the valves 45. Such final closing normally will be caused to occur by conventional controls before the pistons 39 begin their respective outward strokes and will occur before completion of the introduction of air through the respective valves 30. In some cases such an auxiliary exhausting of the gaseous products of combustion through port 44 may be eliminated provided if, for example, ports 43 are moved nearer to cylinder head 27 and valved to avoid premature exhaust on the outward stroke.

As shown in Figures 2 to 7, air inlet valve 30 in the form of a poppet valve or other suitable form is provided in cylinder head 27. Each poppet valve 30 is conventionally actuated by a cam 47 on a camshaft 48 shown in Figure 6. Camshaft 48 is turned by a sprocket chain 49 which also engages a driving sprocket wheel 50 connected in a conventional way to crankshaft 22 in synchronism therewith. A tensioning arm 51 having an idler sprocket wheel 52 rotatably fastened thereto is held in tensioning position by a spring 53. The other end of arm 51 is pivotally connected to cylinder block 26 of engine 23.

A pair of rocking brackets 54 rotatably support the ends of camshaft 48 for movement through an arc about the rocking centers 55 of the brackets 54, said brackets being pivotally mounted on fixed lugs 54a on cylinder head 27. A connecting bar 56 joins the other ends of the bracket 54 and is pivotally fastened to a link 57. Link 57 in turn is pivoted at its lower end to a movable lever 58 rotatably mounted about its axis 59 to a lug 60 extending outwardly from cylinder block 26. A fixed quadrant 61 has its arcuate surface indented for engagement by a movable dog 62 on lever 58 to hold camshaft 48 at any desired preset height above the upper end of the stems of the valves 30. It is evident that as lever 58 is swung downwardly, camshaft 48 will be raised, delaying the time when cam 47 starts to open the respective valves 30, thereby retarding the admission of starting and combustion air through air admission valves 30.

At the starting of engine 23, air from compressor 29 can only be admitted to whichever cylinder has its piston 39 just past its extended dead-center position, as shown in Figure 2, in order to insure adequately high start-

ing torque for such starting in the desired direction of rotation which it is to have when it itself begins to run as a power producer. When engine 23 itself is running as a power producer, lever 58 may be raised the desired amount to lower camshaft 48 and provide thereby for initiating air admission to the cylinders 41 respectively somewhat in advance of extended or top dead-center. Further, the cams 47 may each be made of angularly rotatable portions which can be bolted together or otherwise adjusted to change the length of the peripheral cam face and thereby change the duration of the air admission period to the respective cylinders 41.

Fuel is injected into each cylinder 41 through a conventional fuel injection nozzle 63 extending through wall 40 as shown within the clearance space in cylinder 41 substantially at the beginning of the outward stroke. A conventional nozzle regulating valve 64 is connected to nozzle 63 between it and a duct 65 through which fuel, usually in the form of a liquid, is fed. This fuel, which may also be in the form of a pulverized solid, or in some cases of a very high pressure gaseous fluid under a pressure higher than the pressure which it will encounter within cylinder 41 during the period of its introduction thereto. Such injection of the fuel is preferably caused to occur by standard timing devices (not shown) so as to follow air admission initiation and overlap at least the end of the air admission period. So introduced, the fuel and air commingle, burn and force piston 39 into a power or working stroke, as shown in Figure 3, with valves 30 and 45 closed.

The burning of the air-fuel mixture so introduced into each cylinder 41 is brought about in the embodiment shown by having compressor 29 deliver its starting and combustion air through valve 30 at such pressure that its corresponding temperature is sufficient to ignite the fuel independently injected through the respective nozzle 63. On the other hand, standard ignition devices, such as spark plugs, may be provided in the cylinder head or wall adjacent the head and timed to spark by well-known means to ignite the combustible mixture of air and fuel introduced into the cylinders 41 substantially upon completion of the inward stroke of the pistons 39 therein. At first upon admission of air from compressor 29 and immediately thereafter during the burning of the air and fuel mixture causing the gaseous expansion to move each piston 39 as shown in Figure 3, crankshaft 22 is turned in the desired direction and moves the load to which it is connected, slowly at first and with increasing rapidity until the frequency of the working or power strokes of the cylinders 41 based upon the design factors of the engine 23 are such as to change engine 23 over from its starting phase as itself a load into its engine phase as a running power producer. When running, engine 23 continues to receive its combustion air under sufficient pressure and temperature from compressor 29, the admission thereof being suitably regulated as to initiation and duration by the respective valves 30. Under such circumstances, the return or inward stroke of the cylinder pistons in engine 23 is not a "compression" stroke in any sense of that term in the internal combustion engine art.

Instead, by the system of this invention, when each piston 39 reaches its top or extended dead-center substantially as shown in Figure 2 it there defines the minimum cylinder clearance space under the relatively low pressure of the exhaust step. Into that space starting and combustion air under high pressure is admitted through valve 30. Hence, engine 23 itself has no compression of air to perform on its inward strokes allowing the full power application of its power strokes to be converted into useful work on its load. Such increases the efficiency of the system of this invention and partly at least offsets the expense of providing the air compressor means 29. In selecting compressor 29 it will be preferable not only to correlate it with the internal combustion engine with which it is to be used but also to provide a type of air compressor which will have sufficient flexibility to afford desired changes in air pressure, volume and/or temperature. In this way, the equipment under this system can be used to provide a greater range of performance for varying conditions than would otherwise be the case if the performance were solely limited by the rating of the internal combustion engine used. It is evident that the system of this invention is wholly different in concept and operation from any conventional supercharging that is sometimes used with internal combustion engines.

As described above, the appropriate selection of one

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of the many forms of conventional air compressors will provide starting and combustion air for use in the system of this invention at the predetermined volume, pressure and/or temperature desired. Usually, these factors will correspond to the pressure and temperature of air which would be provided if engine 23 in each were wholly conventional and were operated in a conventional manner with air admitted thereto for compression on the inward strokes.

The system of this invention is also fully applicable to the art of machines such as Diesel locomotives. In such a case, a combustion engine turbine or turbo-jet might be provided as the prime mover for a single or two-stage centrifugal compressor. This compressor in turn would supply starting air at starting or higher pressure and ignition temperature respectively to the Diesel engine cylinders on the locomotive substantially at the time of "minimum clearance" dead-center whether the pistons in such cylinders are single or double-acting. In this way, the high pressure air would start to move the locomotive drivers. Then, as each piston in the engine moves or starts to move along its working or power stroke under the pressure of the air from the independent centrifugal compressor, fuel would be injected into the cylinder and ignite because of the temperature of that independently supplied air to expand and increase the force on the respective piston or respective side of a double-acting piston. Such fuel combustion substantially relieves, during the remainder of the power or working stroke, the amount of output demanded of the compressor so that the compressor need only have enough capacity to initiate starting movement of the pistons in the Diesel engine provided. This means, of course, that the injection of the fuel begins to occur before the capacity of the compressor is exceeded at the time of starting. For example, a Diesel locomotive 66, partly shown in dot and dash outline in Figure 7A, may be provided with a conventional Diesel engine 23' directly coupled by suitable gearing to the locomotive wheels. Starting and combustion air may be supplied to the manifold of the engine 23' through a high pressure pipe 28' the other end of which is connected to the outlet of a suitable conventional air compressor 29'. Compressor 29' may be directly driven by a prime mover 35' which is shown may be an independent internal combustion engine.

Thus, in the system of this invention starting and combustion air at a pressure at least equal to the pressure which would be produced by the normal compression ratio pressure of the engine used were that engine to operate in a fully conventional manner with a "conventional compression stroke" is supplied beginning substantially in the minimum clearance space in the cylinders and preferably at least at fuel ignition temperature by wholly outside and independent means. The engines constructed for operation under the system of this invention therefore have no need of any air "intake" or "compression" strokes but simply engage in "expansion" and "exhaust" strokes with the starting and other advantages heretofore in-achievable in any conventional engine assembly.

The selection of the relative weights, pressures and temperatures of air and fuel to be used in the system of this invention may be made by those skilled in the internal combustion engine art in accordance with existing known relationships. Still further, in the system of this invention the initiation of the respective air and fuel introduction periods and the respective durations thereof may be preset each independently of the other by the use of means currently available to those same people who are skilled in this art. For example, the timing and quantity of fuel injection may be independently selected to continue for a predetermined angular travel of the piston after it has reached top or extended dead-center dependent upon the torque or load-carrying requirements of the particular assembly under construction. The valve timing for the fuel injection nozzles as well as that for the air admission valves can be accomplished by any of a number of valve-gear mechanisms which are well established in the art of machine design.

Although the embodiment shown in the drawings is described in terms of a two-cylinder, two-cycle Diesel engine, it will be evident that the system of this invention may be equally well applied to double-acting single-cylinder internal combustion engines and to internal combustion engines having more than two cylinders. Moreover, in using either a single cylinder or two-cylinder engine a standard mechanical jack to move the engine

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off dead-center may be provided for use in the unlikely event that such engines should stop or be allowed to stop precisely on such dead-center. It can also be applied to engines operating on a four-cycle basis nor is this invention to be limited to particular nozzle, valving or porting details. For each range of desired output all of the engine factors and air compressor factors will be correlated prior to the assembly in accordance with the knowledge of those skilled in the art in the light of the teaching of this invention. Thus, various modifications may be made which are within the spirit of this invention and the scope of the appended claims.

I claim:

1. In a system for starting an internal combustion engine under load, steps comprising, in combination, compressing a combustion supporting fluid by means of a prime mover driving a compressor independent of said engine to a pressure at least as high as that required to turn said engine over, admitting said fluid under such pressure into the combustion space of said engine when the position of extended dead center has been substantially attained, introducing fuel into said fluid and igniting the mixture of the same beginning at least by the time the maximum output capacity of said compressor is reached, and porting said engine in the course of the return of the piston to said extended dead center to prevent material back pressure at least until said engine becomes a power producer.

2. In a system for starting and operating an internal combustion engine under load, steps comprising, in combination, compressing air by means of a prime mover driving a compressor independent of said engine to a pressure at least as high as that required to turn said engine over, admitting said air under such pressure into the combustion space of said engine when the position of extended dead center has been substantially attained to turn said engine over, continuing said admission while said engine is being accelerated sufficiently to become a power producer, porting said engine in the course of the return of the piston to such extended dead center position to provide a relatively low pressure in said combustion space during said return, introducing fuel into said air beginning at least by the time the maximum output capacity of said compressor is reached, igniting said air and fuel, and continuing the admission of compressed air and fuel into said engine after said engine has become such a power producer.

3. In combination, in a system for starting an internal combustion engine under load, apparatus comprising, a cylinder, a piston reciprocable therein, a load-connected crank shaft turned by said piston, an air compressor for compressing air to a pressure at least as high as that required to move said piston, means independent of said engine for driving said compressor, means for introducing compressed air from said compressor into said cylinder at about the time said piston has substantially attained its extended dead center position, means for exhausting said cylinder in the course of return of said piston substantially until said means for introducing compressed air again introduce said compressed air to maintain a relatively low pressure in said cylinder substantially throughout said inward stroke, means for introducing fuel into said cylinder for admixture with said compressed air beginning at least by the time the maximum output capacity of said compressor is reached, and means for igniting said mixture of compressed air and fuel.

4. In combination, in a system for starting an internal combustion engine under load, apparatus comprising, a cylinder, a piston reciprocable therein, a load-connected crank shaft turned by said piston, an air compressor for compressing air to a pressure at least as high as that required to move said piston, means independent of said engine for driving said compressor, means for introducing compressed air from said compressor into said cylinder when said piston has substantially attained is extended dead center position, means for exhausting said cylinder in the course of the return of said piston substantially until said means for introducing compressed air again introduce said compressed air to maintain a relatively low pressure in said cylinder substantially throughout said inward stroke, means for introducing fuel into said cylinder for admixture with said compressed air beginning at least by the time the maximum output capacity of said compressor is reached, and means for continuing to

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supply such compressed air to said cylinder after said engine becomes a power producer.

5. In combination, in a system for starting and operating a self-propelled land or marine vehicle, apparatus comprising, a power producing internal combustion engine to normally drive said vehicle, an independent prime mover mounted in said vehicle, an air compressor connected to said prime mover to compress air at least to a pressure high enough to turn said engine over to start said vehicle, means for continuing the admission of such compressed air to said engine at least until the time the maximum output capacity of said compressor is reached, injecting fuel into said engine in timed relation to such admission of compressed air to form a combustible mixture, means for igniting said mixture of fuel and air, means for exhausting the products of combustion from said engine, means for valving said engine to prevent normal compression stroke back pressure therein during non-working strokes thereof at least until said engine becomes

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a power producer, and means for continuing to supply said compressed air to said engine after it becomes such a power producer to supply at least a major portion of the combustion air required by said engine.

References Cited in the file of this patent

UNITED STATES PATENTS

859,746	Crowe	July 9, 1907
1,063,386	Reuter	June 3, 1913
1,106,180	Bachelder	Aug. 4, 1914
1,113,852	Winton	Oct. 13, 1914
1,122,007	Kramer	Dec. 22, 1914
1,305,580	Wolfard	June 3, 1919
1,381,294	French	June 14, 1921
1,537,128	Mayer	May 12, 1925
1,568,431	Weger	Jan. 5, 1926
2,033,155	Scott	Mar. 10, 1936