HYDRAULIC POWER SYSTEM FOR STARTING VEHICLES

A power system for storing, recovering, and/or using energy from a vehicle powered by a prime mover, including a hydraulic pump/motor configured to be driven by the prime mover, a hydraulic accumulator for storing energy, a body hydraulic and/or an auxiliary hydraulic, and a valve manifold selectively fluidly connecting the hydraulic pump/motor to the hydraulic accumulator and the body hydraulic and/or the auxiliary hydraulic. When the prime mover is operating, the hydraulic pump/motor may selectively power the body hydraulic and/or auxiliary hydraulic, or may selectively charge the hydraulic accumulator, or both. When the prime mover is off, the hydraulic accumulator may selectively power the hydraulic pump/motor to start the prime mover. The stored energy in the hydraulic accumulator may be used to power other hydraulic components of the vehicle as well. Such a configuration provides a less complex and more fuel efficient hydraulic power system for starting the prime mover.
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Related Applications
This application claims the benefit of U.S. Provisional Application Nos. 62/017,485 filed June 26, 2014 and 62/018,135 filed June 27, 2014, which are both hereby incorporated herein by reference in their entireties.

Field of Invention
The present invention relates generally to a vehicle having hydraulic energy storage, and more particularly to such a system in which the stored energy can power a hydraulic component to start the prime mover.

Background
Most vehicles, such as commercial on-road vehicles powered by an engine, waste a considerable amount of fuel during periods when the vehicle is stopped and the engine is idling. For vehicles such as refuse trucks, the idling engine is often used to drive hydraulic components, such as the arm used to pick-up trash bins and the compactor that compacts the trash. However, the power required to perform this work may be relatively low compared to the considerable amount of fuel that is consumed while the engine is idling, which results in a relatively low fuel efficiency of the vehicle.

For many years there has been recognition that vehicles could be made more fuel-efficient if the brake energy or surplus energy from the prime mover could somehow be collected, stored, and reused to power the hydraulic components of the vehicle. Although the hydraulic components could be powered independently of the prime mover when the prime mover is turned off, it may not be an acceptable option to restart the engine hundreds or thousands of times per day with a typical electrical ignition system, since such frequent restarting could rapidly drain the electrical battery and cause premature wear of the electric starter.
Summary of Invention

The present invention provides a power system that enables the use of stored hydraulic energy to power one or more hydraulic components of a vehicle to start a prime mover of the vehicle, such as an internal combustion engine. For example, a hydraulic accumulator may be provided that is selectively fluidly connected to a hydraulic pump/motor configured to be driven by the prime mover. When the prime mover is operating, the hydraulic accumulator may be selectively charged by the hydraulic pump/motor; and when the prime mover is off, the hydraulic accumulator may selectively power the hydraulic pump/motor to start the prime mover.

The hydraulic pump/motor may also be selectively connected to a body hydraulic and/or auxiliary hydraulic, which may be used for powering hydraulic components and systems other than those associated with propulsion of the vehicle and typically those that are operated when the vehicle is stationary. Thus, the hydraulic pump/motor may both supply flow for operating the body hydraulic and/or auxiliary hydraulic, and may also receive flow from the hydraulic accumulator to act as a hydraulic starter that starts the prime mover. Such a configuration provides a less complex hydraulic power system for starting the prime mover, as well as leverages the existing body hydraulic and/or auxiliary hydraulic circuit without the need for additional hardware.

According to an aspect of the invention, a power system for storing, recovering, and/or using energy from a vehicle powered by a prime mover includes a hydraulic pump/motor configured to be driven by the prime mover, a body hydraulic and/or an auxiliary hydraulic, a hydraulic accumulator for storing energy, and a valve manifold selectively fluidly connecting the hydraulic pump/motor to at least one of the hydraulic accumulator and the body hydraulic and/or the auxiliary hydraulic.

The power system may be configured such that the hydraulic accumulator is selectively charged by the hydraulic pump/motor when the prime mover is operating, and the hydraulic accumulator selectively powers the hydraulic pump/motor to start the prime mover when the prime mover is off.
Embodiments of the invention may include one or more of the following additional features.

In some embodiments, the power system may be configured such that the hydraulic accumulator does not power the body hydraulic and/or the auxiliary hydraulic. Such a configuration could reduce the size of the hydraulic accumulator, which could reduce the overall costs associated with the power system.

In other embodiments, the hydraulic accumulator may selectively supply or supplement power to the body hydraulic and/or the auxiliary hydraulic.

The hydraulic accumulator may selectively supplement the power supplied by the hydraulic pump/motor to the body hydraulic and/or the auxiliary hydraulic when the prime mover is operating.

The hydraulic accumulator may selectively supply power to the hydraulic pump/motor to supplement power to the prime mover when the prime mover is operating.

The hydraulic accumulator may be selectively fluidly connected to a power steering function and/or a brake function via the valve manifold. The hydraulic accumulator may selectively power the power steering and/or brake function to provide at least a portion of the steering and/or braking of the vehicle.

The auxiliary hydraulic may include the power steering function and/or the braking function.

The hydraulic accumulator may be charged by vehicle brake energy.

The vehicle brake energy may be provided by a resistive torque applied by the hydraulic pump/motor in response to the hydraulic pump/motor supplying pressurized fluid flow to the accumulator.

A second hydraulic pump/motor may be provided that is drivingly coupled to an output shaft of the brake function. The second hydraulic pump/motor may also supply pressurized fluid to the hydraulic accumulator to charge the hydraulic accumulator while applying a resistive brake torque to the vehicle.

The first hydraulic pump/motor and the second hydraulic pump/motor may be provided in parallel to both charge the hydraulic accumulator.
The power system may further include a controller that directs fluid from the hydraulic accumulator through the valve manifold to selectively supply and/or supplement power to one or more of the hydraulic components of the vehicle.

The power system may further include a power take-off configured to be connected to the prime mover to transfer power from the prime mover to the hydraulic pump/motor.

The power system may further include a clutch drivingly interposed between the prime mover and the hydraulic pump/motor, and the clutch may be configured to decouple the hydraulic pump/motor from the prime mover, such as when the hydraulic pump/motor is not demanding flow, for example.

The hydraulic accumulator may supply flow through the valve manifold to the hydraulic pump/motor, whereby the hydraulic pump/motor may act as a motor that runs an alternator or other accessories.

The clutch may be configured to decouple the pump/motor from the prime mover, thereby allowing the energy in the hydraulic accumulator to drive the hydraulic pump/motor as a motor to power an accessory.

According to another aspect of the invention, a power system includes a starter assembly configured to be coupled to the prime mover, the starter assembly including a hydraulic starter and an electric starter; a hydraulic pump/motor; a body/auxiliary hydraulic; and a hydraulic accumulator fluidly connected to the hydraulic pump/motor, the body/auxiliary hydraulic, and the hydraulic starter through a valve manifold.

The hydraulic starter may include a hydraulic motor and the electric starter may include a starter solenoid, gear ratio and electric motor; and the starting torque for starting the prime mover may be supplied by the hydraulic starter that is powered by the hydraulic accumulator.

According to another aspect of the invention, a method of using a hydraulic power system to store and use energy from a vehicle powered by a prime mover includes the steps: (i) selectively charging an accumulator with energy supplied by a hydraulic pump/motor being driven by the prime mover when the prime mover is operating, wherein the hydraulic pump/motor is selectively fluidly connected to the accumulator and a body hydraulic and/or
auxiliary hydraulic via a valve manifold; and (ii) selectively powering the hydraulic pump/motor with energy stored in the accumulator when the prime mover is off, then starting the prime mover with the hydraulic pump/motor powered by energy from the accumulator.

The following description and the annexed drawings set forth certain illustrative embodiments of the invention. These embodiments are indicative, however, of but a few of the various ways in which the principles of the invention may be employed. Other objects, advantages and novel features according to aspects of the invention will become apparent from the following detailed description when considered in conjunction with the drawings.

**Brief Description of the Drawings**

The annexed drawings, which are not necessarily to scale, show various aspects of the invention.

Fig. 1 is a schematic illustration of an exemplary hydraulic power system according to the invention.

Fig. 2 is a schematic illustration of another exemplary hydraulic power system according to the invention.

Fig. 3 is a schematic illustration of another exemplary hydraulic power system according to the invention.

Fig. 4 is a diagrammatic side view of an exemplary hydraulic/electric starter motor assembly.

Fig. 5 is a schematic illustration of the layout for a power take-off device and a hydraulic/electric starter assembly in relation to a prime mover and a transmission.

Fig. 6 is a schematic illustration of another exemplary hydraulic power system according to the invention.

Fig. 7 is a schematic illustration of a portion of the power system circuit showing a power take-off integrated with an electric motor and a hydraulic pump/motor.

Fig. 8 is a schematic illustration of a portion of the power system having only one clutch.
Fig. 9 is a schematic illustration of a portion of the power system having multiple clutches.

**Detailed Description**

The principles of the present invention have particular application to hydraulic systems for vehicles, particularly for on-road vehicles, such as vocational vehicles (refuse, dump, concrete trucks, etc.), medical vehicles (ambulance, fire and rescue, etc.), transit vehicles (bus, shuttle, etc.), or similar other vehicles, and will be described below chiefly in this context. It is also understood that principles of this invention may be applicable to other vehicles, such as off-road vehicles, where it would be beneficial to store hydraulic energy that can power one or more hydraulic components of the system to start the prime mover of the vehicle after the prime mover has been turned off.

Referring now to the drawings, and initially to Fig. 1, an exemplary hydraulic power system 10 for a vehicle is shown. The power system 10 includes a prime mover 12, a hydraulic pump/motor 14 drivingly coupled to the prime mover 12, one or more body hydraulics and/or auxiliary hydraulics 16, a hydraulic accumulator 18, and a valve manifold 20 that fluidly connects the hydraulic pump/motor 14 to the hydraulic accumulator 18 and the one or more body hydraulics and/or auxiliary hydraulics 16.

The prime mover 12 preferably is an internal combustion engine powered by diesel or gasoline fuel, but other prime movers could also be used, such as electric motors, gas turbines, fuel cells, or other fuel powered motors. The prime mover 12 is drivingly coupled to a transmission 22 that transfers power from the prime mover 12 to one or more wheels (not shown) that propel the vehicle. The transmission 22 may be an automatic or manual transmission, or a continuously variable or infinitely variable transmission, that is drivingly coupled to the prime mover 12 by any suitable means, such as via mechanical gears, a clutch, a torque converter, a hydraulic hybrid, an electric hybrid, or the like. The transmission 22 is also drivingly coupled to an output shaft (not shown) that drives the one or more wheels by any suitable means, such as by a drive shaft and transaxle.
The hydraulic pump/motor 14 is configured to be driven by the prime mover 12 by any suitable means, such as via a shaft 24 directly connected to the hydraulic pump/motor 14. In other embodiments, one or more shafts may drivingly couple the prime mover 12 and the pump/motor 14 together, and respective clutches may be interposed between the one or more shafts (as shown in Fig. 3, for example).

The hydraulic pump/motor 14 may be any suitable type of pump/motor that can be reversibly driven to function as a motor or pump, such as fixed displacement or variable displacement hydraulic pump/motor, i.e. an over-center pump/motor. In some embodiments, the pump/motor 14 may be an axial piston pump/motor, where displacement of the pump/motor is varied by changing the tilt angle of a tiltable swash plate in a well-known manner. In the illustrated embodiment, the hydraulic pump/motor 14 is a single hydraulic pump/motor interposed between the hydraulic accumulator 18 and the prime mover 12, which may enable a reduction in the complexity and/or cost of the hydraulic power system 10. In other embodiments, more than one pump/motor 14 may be employed.

The body hydraulic and/or auxiliary hydraulic 16 is selectively fluidly connected to the hydraulic pump/motor 14 through a valve manifold 20 and fluid circuitry 26, including fluid conduits, for example. The body hydraulic and/or auxiliary hydraulic 16 may be powered by the hydraulic pump/motor 14 to operate hydraulic components and systems other than those associated with propulsion of the vehicle, such as those that are operated when the vehicle is stationary. For example, the body hydraulic may be used to operate a compactor of a refuse vehicle, an arm of an off-road vehicle, a blade, a packer, a lift, a bin handler, a suspension lift, a claw, an arm, a door actuator, and/or similar body components. The auxiliary hydraulic may be used to operate a sweeper, auger, compressor, a boom, a bucket, power brakes, power steering, and/or similar auxiliary component of the vehicle. The body hydraulic and/or the auxiliary hydraulic 16 may be part of a hydraulic circuit that includes an optional body and/or auxiliary hydraulic pump (not shown). The body hydraulic and/or auxiliary hydraulic 16 may also be selectively fluidly coupled to the hydraulic
accumulator 18 via the manifold 20 and fluid circuitry 26. The body and/or auxiliary hydraulic (including optional body/auxiliary pump) may be powered by hydraulic fluid from the accumulator 18 when the prime mover 12 is not operating, as will be discussed below. Optionally or additionally, the body hydraulic and/or auxiliary hydraulic 16 may be powered by the prime mover 12 via a power take-off device (shown in Fig. 3) when the engine is operating, also as described below.

The hydraulic accumulator 18 is configured as an energy storage device for storing pressurized hydraulic fluid, such as a hydropneumatic accumulator, for example. Other energy storage devices may also be used, such as a mechanical fly wheel or batteries. In the illustrated embodiment, the accumulator 18 is supplied with pressurized hydraulic fluid from the hydraulic pump/motor 14 by means of the valve manifold 20 and fluid circuitry 26. The valve manifold 20 selectively supplies and demands fluid flow to and from the accumulator 18, the hydraulic pump/motor 14, the body hydraulic and/or auxiliary hydraulic 16, and/or other hydraulic components, the function of which is discussed below.

To facilitate the selective supply of flow to and from the various hydraulic components, the valve manifold 20 and/or fluid circuitry 26 may be commanded by a system controller 28. The controller 28 may direct fluid through the valve manifold 20, the fluid circuitry 26, and/or the various hydraulic components (e.g., accumulator 18, pump/motor 14, etc.) by controlling one or more valves (not shown) that are located in the valve manifold 20 or at suitable locations fluidly coupled to the fluid circuitry 26. The system controller 28 may be an electronic system controller including one or more microprocessors and associated components programmed with logic to carry out the herein described operations. The controller 28 may have various inputs for receiving data from various sensors that monitor various operational parameters of the vehicle and various outputs by which the controller commands various operations. The controller 28 may include, or may be in communication with, a storage device, such as a non-volatile memory or similar component, for storing the data received from the various sensors and/or other components.
Still referring to Fig. 1, the operation of the power system 10 will be described in further detail. In a first mode of operation, when the prime mover 12 is turned on and is still operating, the hydraulic pump/motor 14 may be driven by the prime mover 12 to operate as a pump that supplies pressurized fluid through the valve manifold 20 to the hydraulic accumulator 18, the body hydraulic and/or auxiliary hydraulic 16, and/or other hydraulic components. In this manner, the hydraulic accumulator 18 may be selectively charged by the pump/motor 14 when the prime mover 12 is operating, so as to store hydraulic energy for later use. The system controller 28 may modulate the quantity of energy that is stored or directed to the accumulator based on the energy level in the accumulator 18, which may be determined by one or more sensors provided at suitable locations. For example, if the energy level in the accumulator 18 is low, then the controller 28 may direct pressurized fluid from the pump/motor 14 to charge the accumulator 18. On the other hand, if the energy level in the accumulator 18 is near maximum, then the controller 28 may instead direct the pressurized fluid from the pump/motor 14 to power the body hydraulic and/or auxiliary hydraulic 16, without depleting the energy stored in the accumulator 18.

In another mode of operation, when the prime mover 12 is turned off and is not operating, the hydraulic accumulator 18 may selectively supply stored energy (as pressurized hydraulic fluid) through the valve manifold 20 to the pump/motor 14, the body hydraulic and/or auxiliary hydraulic 16, and/or other hydraulic components. In this manner, the power system 10 enables energy to be stored to operate various hydraulic components fluidly connected together, without requiring the use of the prime mover 12, which enables a reduction in the fuel consumption of the vehicle.

The exemplary configuration of the power system 10 also enables the hydraulic accumulator 18 to selectively power the hydraulic pump/motor 14 to start (or restart) the prime mover 12 when the prime mover has been turned off. For example, the controller 28 may command the valve manifold 20 and/or fluid circuitry 26 to supply high pressure fluid from the accumulator 18 to the pump/motor 14 (if then not operating as a pump) to drive the pump/motor 14 with sufficient torque, which can be applied through the shaft 24 or other driving
means, to start the prime mover 12. The prime mover 12 may be considered started (or restarted) when it has reached its idling speed. In this manner, the hydraulic accumulator 18 may be sized to store sufficient energy to satisfy at least the power requirement for driving the pump/motor 14 to start the prime mover 12. Sensors may also be provided in the valve manifold 20, the fluid circuitry 26, the hydraulic accumulator 18, and/or at other suitable locations to determine whether the level of energy stored in the accumulator 18 is sufficient to start the prime mover 12, and then communicate this information to the controller 28. If it is determined that the energy level in the accumulator 18 is not sufficient to start the prime mover 12, then the prime mover 12 may be started (or restarted) via another starter, such as a standard electrical ignition switch provided on the vehicle.

Providing the same hydraulic pump/motor 14 both as the source of flow to operate the body hydraulic and/or auxiliary hydraulic 16 and as the means for starting the prime mover 12 by receiving power from the hydraulic accumulator 18 enables a less complex and more easily adaptable hydraulic power system 10. For example, the system 10 may leverage the hydraulic circuitry and components on existing vehicle platforms to include the associated circuitry and hydraulic components of the system 10 so as to achieve the desired functions described herein.

In certain preferred but non-limiting embodiments, the power system 10 is configured such that the hydraulic accumulator 18 does not power the body hydraulic and/or auxiliary hydraulic 16 and only powers the hydraulic pump/motor 14. The hydraulic accumulator 18 may therefore be sized to store sufficient energy to satisfy only the power requirement for driving the pump/motor 14 to start the prime mover 12. Since such a configuration may reduce the required size of the accumulator 18, the overall cost associated with the power system 10 may be reduced.

Other modes of operation for the power system 10 are also possible. For example, the power system 10 may be configured such that the hydraulic accumulator 18 selectively supplies power to drive the hydraulic pump/motor 14 (when not operating as a pump) for supplementing drive power to the prime
mover 12 when the prime mover is operating. The system 10 may also be configured such that the hydraulic accumulator 18 is selectively charged by the hydraulic pump/motor 14 when the prime mover 12 is operating at a low power demand, such as idle; and that the accumulator 18 selectively powers the hydraulic pump/motor 14 to supplement power to the prime mover 12 when the prime mover is operating at a high power demand, such as during driving or acceleration.

Sensors may be provided with the accelerator pedal, hydraulic circuitry, or other suitable locations to communicate with the controller 28 for determining whether the prime mover 12 is idling or accelerating, and whether sufficient energy is stored in the accumulator 18 to supplement power to the prime mover 12. For example, the pump/motor 14 may supplement drive power to the prime mover 12 by applying torque to increase the speed of the prime mover 12 to a predetermined speed that is greater than the minimum fueling speed, such that the time it takes for the prime mover 12 to produce output power during restart is reduced. In addition, the displacement of the pump/motor 14 (when acting as a motor) may be actively varied by the controller 28 to control the rate of power supplied to the prime mover 12 for accommodating increases or decreases in vehicle speed and/or the amount of charge in the accumulator 18.

The hydraulic accumulator 18 may also selectively supply power to the one or more body hydraulics and/or auxiliary hydraulics 16, or other hydraulic components, when the prime mover 12 and the pump/motor 14 are not operating. For example, during the stop of a refuse vehicle, when the prime mover 12 is off, the accumulator 18 could power the arm and compactor of the refuse vehicle to compress the trash. In yet other modes of operation, when the prime mover is operating 12, for example, the hydraulic accumulator 18 may selectively supplement at least a portion of the required power to the body hydraulic and/or auxiliary hydraulic 16, with the remaining portion of power being supplied by the hydraulic pump/motor 14. In still other modes of operation, the hydraulic accumulator 18 may be charged with surplus flow from the hydraulic pump/motor 14, such as when the body hydraulic and/or the auxiliary hydraulic 16 are demanding low power from the hydraulic pump/motor 14, for example.
Storing and using the energy in the hydraulic accumulator in this manner may require less power from the prime mover, thereby improving fuel efficiency of the vehicle.

Turning to Fig. 2, another exemplary power system 30 is shown. The power system 30 is substantially the same as or similar to the above-referenced power system 10, and consequently the same reference numerals are used to denote structures corresponding to the same or similar structures. In addition, the foregoing description of the power system 10 is equally applicable to the power system 30, except as noted below. Moreover, it will be appreciated that aspects of the power systems 10 and 30 may be substituted for one another or used in conjunction with one another where applicable.

In the illustrated embodiment, the power system 30 includes a brake function 32 and a power steering function 34 that are each selectively fluidly connected to the valve manifold 20, which also selectively fluidly connects the other hydraulic components in the system 30, such as the hydraulic accumulator 18, the hydraulic pump/motor 14, the one or more body hydraulics and/or auxiliary hydraulics 16, etc. In this manner, the controller 28 may direct fluid flow via the valve manifold 20 between the respective hydraulic components in the system 30 to achieve certain desired modes of operation. For example, when the prime mover 12 is off, the hydraulic accumulator 18 may be used to power the power steering function 34 and/or the brake function 32. On the other hand, when the prime mover 12 is operating, the power required by the power steering function 34 and/or the brake function 32 may be supplied by the pump/motor 14, the accumulator 18, or some other power source. In some embodiments, including the exemplary power systems 10 and 30, the one or more auxiliary hydraulics may include the power steering function and/or the braking function such that the hydraulic pump/motor 14 may supply flow to the steering and/or brake functions.

In another mode of operation, if the vehicle is already moving and a desired action is to decelerate or brake the vehicle, the controller 28 may direct the valve manifold 20 and/or fluid circuitry 26 to receive pressurized fluid from the hydraulic pump/motor 14, which will then be reversibly driven to act as a
pump to supply pressurized fluid to the accumulator 18. The hydraulic
pump/motor 14 acting as a pump will generate resistance in the drive train, via
shaft 24 for example, to slow the vehicle down. This action may also recover
most of the kinetic energy from the vehicle and stores it in the accumulator 18 for
later use by the drive system or for performing other hydraulically powered work
on the vehicle, such as restarting the prime mover 12. This method also reduces
wear on friction brakes of the vehicle, since the kinetic energy is stored in the
accumulator 18, rather than dissipated as heat through the friction brakes. The
larger the flow rate of hydraulic fluid pumped by the pump/motor 14, the larger
the assistance to braking of the vehicle. In some embodiments, it may be
beneficial to set the displacement of the hydraulic pump/motor 14 at a relatively
low value that is sufficient to charge the accumulator 18, but which minimizes the
additional braking feel imposed on the vehicle during accumulator charging.

The exemplary power system 30 may optionally or additionally include a
second hydraulic pump/motor 36, as illustrated in Fig. 2. In the illustrated
embodiment, the second hydraulic pump/motor 36 is drivingly coupled to an
output shaft 38 of the brake function 32 (such as the rear driveshaft), and is
fluidly coupled to the valve manifold 20. In this manner, the controller 28 may
direct fluid to and from the second hydraulic pump/motor 36 in the same or
similar ways that fluid is directed to and from the first hydraulic pump/motor 14.
For example, the second hydraulic pump/motor 36 may be used to capture and
store vehicle brake energy in the accumulator 18, similar to the method
described above for the first hydraulic pump/motor 14. Furthermore, by
providing the second hydraulic pump/motor 36 to the output shaft 38 of the brake
function 32, which is in parallel with an output shaft 39 of the transmission 22, a
dual hybrid function may be achieved for capturing and storing the brake energy,
which can later be used to power the body hydraulic and/or auxiliary hydraulic
16, or other hydraulically actuated function of the vehicle.

As shown in the illustrated embodiment, the second hydraulic pump/motor
36 may be directly coupled to the output shaft 38, or the pump/motor 36 may be
drivingly coupled through suitable gears or similar driving means such as belts,
chains, or the like. A clutch mechanism 33 may optionally be provided to
selectively engage or disengage the second pump/motor 36 from the output shaft 38. In the illustrated embodiment, the brake function 32 includes the clutch mechanism 33 which is drivingly coupled to the output shaft 38, and which is also drivingly coupled to the output shaft 39 of the transmission 22 via gears 35 within a gear box 37, or via other suitable driving means. The clutch mechanism 33 may include a wet clutch, a dry clutch, a dog clutch, a split shaft, or other suitable mechanism for selectively engaging or disengaging the pump/motor 36 from the shaft 38.

Turning to Fig. 3, another exemplary power system 40 is shown that is substantially the same as or similar to the power systems 10 and 30. Consequently, the same reference numerals are used to denote structures corresponding to the same or similar structures, and the foregoing description of the power systems 10 and 30 are equally applicable to the power system 40. It will also be appreciated that aspects of the respective power systems 10, 30 and 40 may be substituted for one another or used in conjunction with one another where applicable.

In the illustrated embodiment, the power system 40 includes a power take-off 42 drivingly connected to the prime mover 12 via a clutch 44. The power take-off 42 is configured to transfer power from the prime mover 12 to power other parts of the vehicle, such as the one or more hydraulic pump/motors 14, which may charge the accumulator 18 and/or power the body hydraulic/auxiliary hydraulic 16, as discussed above. Alternatively, the power take-off 42 may be connected to the transmission 12 that transfers power from the prime mover 12, which is shown at alternative power take-off position 46. The clutch 44 is drivingly interposed between the prime mover 12 and the hydraulic pump/motor 14, which allows decoupling the pump/motor 14 when the prime mover 12 is running but no flow is required from the pump 14, such as during transit between stops for most refuse vehicles, which avoids parasitic losses and improves the fuel economy.

The system 40 may further include an alternator or other accessories 48 (e.g., air-conditioning compressor) that are drivingly coupled to the pump/motor 14 via a belt, shaft, or other driving means. So as to power such accessories 48
when the prime mover 12 is off, the clutch 44 may decouple the pump/motor 14 from the prime mover 12, and the hydraulic accumulator 18 may supply flow through the valve manifold 20 to power the pump/motor 14 as a motor that runs the alternator or other accessories 48.

The system 40 may further include a starter assembly 50 (shown in Fig. 4) including a hydraulic starter 51 and an electric starter 52 for starting (or restarting) the prime mover 12. The hydraulic starter 51 includes a hydraulic motor 54, and the electric starter 52 includes a starter solenoid 56, a starter gear 58 (having a gear ratio) that engages the flywheel, and an electric motor 60. To restart the prime mover 12, the controller 28 may command the hydraulic accumulator 18 to provide hydraulic fluid to the hydraulic starter 51. The system utilizes the starter solenoid 56 and the gear ratio of the starter gear 58 of the electric starter 52 to crank the flywheel, but receives the starting torque from the hydraulic motor 51. This improves the life of the electric starter 52 and allows for frequent start/stops of the prime mover 12 without increasing the duty cycle of the electric starter 52. An electrically driven (e.g., battery powered) charge pump may also be added to the circuit to maintain accumulator 18 pressure at all times, which may allow the electric starter 52 to be removed altogether. Such a charge pump may be provided in any of the embodiments described herein.

Various configurations for locating and/or integrating the power take-off 42, the starter assembly 50, and/or the alternator or other accessories 48 are possible.

For example, referring to Fig. 5, the configuration of the power take-off (PTO) and the starter assembly 50 in relation to the prime mover 12 and transmission 22 is shown. In the illustrated embodiment, the power take-off may be a front engine mounted PTO 42a, or a rear engine mounted PTO 42b, and the starter assembly 50 is mounted to the prime mover 12 or to the transmission 22 to engage the flywheel 62.

Referring to Fig. 6, another exemplary power system 70 is shown. The power system 70 is substantially the same as or similar to the power systems 10, 30, and 40. Consequently, the same reference numerals are used to denote structures corresponding to the same or similar structures, and the foregoing
description of the power systems 10, 30, and 40 are equally applicable to the power system 70. In the illustrated embodiment, the starter assembly 50 is integrated into the hydraulic circuit at a different location, and in which the power take-off 42 is integrated into the hydraulic pump/motor 14. The power take-off 42 may be a front-mounted PTO as shown, or may be a rear-mounted PTO provided at the alternate location 46, for example.

Referring to Fig. 7, a portion of a circuit for a power system (e.g., 10, 30, 40, and 70) is shown in which the power take-off 42 is integrated with both the electric motor/starter 52 and the hydraulic pump/motor 14. As shown in the illustrated embodiment, a function 72 (e.g., accessories 48 or other components) is driven by the power take-off 42, which is drivingly coupled to the prime mover 12 via a shaft 74. The shaft 74 is drivingly coupled to a separate shaft 76 via gears 78, or other similar driving means. The shaft 76 is drivingly coupled to the electric starter 52 and the hydraulic pump motor 14. In such an exemplary configuration, the hydraulic pump/motor 14 and/or the electric starter 52 may be used to start the prime mover 12, or provide power to other system components, as described above, but are integrated into the power take-off 42 to provide a more compact power system design. As with the foregoing power systems, the hydraulic pump/motor 14 may be a bidirectional fixed displacement pump, or other suitable pump/motor as described above. The power take-off 42 may be a rear-mounted of front-mounted PTO, and may be a conventional or continuously variable PTO which operates in the same manner as described above for power system 40.

Turning to Fig. 8, the hydraulic pump/motor 14 is shown attached to or integrated both with the alternator, A/C compressor, or other accessories 48 and with the power take-off 42. In the illustrated embodiment, a single clutch 44 is used to drivingly decouple the hydraulic pump/motor 14 from the prime mover 12, at which point the accumulator 18 may be used to power the pump/motor 14 as a motor to power the alternator or other accessories 48, as described above with reference to Fig. 3.

Fig. 9 illustrates a series of clutches 44a, 44b, 44c interposed between the prime mover 12 and the power take-off 42, between the pump/motor 14 and
the alternator or accessories 48, and between the alternator/accessories 48 and a belt that may be driven by the prime mover 12. Such a configuration allows the alternator 48 to be driven either by the prime mover 12 (through the belt) or the pump/motor 14, yet still allows the pump/motor 14 to be decoupled when the prime mover 12 is not in use. The clutches 44a, 44b, 44c could be any suitable type, including a one way clutch, specifically for clutches 44a and 44b. By using one way clutches, no control would be required because the higher of the two speeds (belt or pump) would automatically drive the alternator 48, in which case the other associated one-way clutch would free-wheel.

Although methods for controlling or operating the power system (e.g., 10, 30, 40, and 70) have been described above, various other methods for controlling the power system are also possible. For example, the power system may be controlled based on the state of charge of the accumulator 18 (e.g., fully charged, partially charged, or no charge), such that if the accumulator 18 is charged below a predetermined minimum value, then a prime mover 12 shutdown command may be prevented while the prime mover 12 is operating. If the state of charge of the accumulator 18 falls below a predetermined minimum value when the prime mover 12 is off, then a prime mover 12 start command may be initiated. The controller 28 may be programmed with logic that is used to determine whether the hydraulic pump/motor 14 or the electric starter 52 should be used to start the prime mover 12 based on the state of charge in the accumulator 18. In addition, the speed of the prime mover 12 and/or the state of charge of the accumulator 18 may be used to actively modify the displacement of the hydraulic pump/motor 14 to prevent stalling or overspeed of the prime mover 12.

The controller 28 may control the rate at which the accumulator 18 is charged for enhancing the energy storage in the accumulator 18. For example, the accumulator 18 may be charged slowly in a near isothermal method to maximize the stored energy.

In some embodiments, historic data of the vehicle and/or body hydraulics/auxiliary hydraulics operations may be stored in a storage device in communication with the controller 28, such that the data of the previous
operations may be used to control the power system when deciding whether or not to command shut-down or start-up of the prime mover 12.

The control of the power system may also be based on signals provided by one or more sensors located on the vehicle and/or throughout the system. For example, the controller 28 may determine whether to start the prime mover 12 based on external command signals other than the prime mover ignition. Such signals may include a command to turn on the power take-off and/or a command requesting the body hydraulic/auxiliary hydraulic functions. Alternatively or additionally, the prime mover restart may be commanded based on a steering command. The command to start or stop the prime mover 12 may be based on the state or values of one or more signals, including but not limited to: the vehicle speed, prime mover diagnostics, prime mover temperature, fueling rate, prime mover speed, transmission gear, transmission operating mode, brake pedal position, parking brake status, accelerator position, or the like.

A power system that enables the use of stored hydraulic energy to power one or more hydraulic components of a vehicle to start a prime mover of a vehicle has been described in various exemplary embodiments above.

According to an aspect of the invention, a power system for storing, recovering, and/or using energy from a vehicle powered by a prime mover includes a hydraulic pump/motor configured to be driven by the prime mover, a body hydraulic and/or an auxiliary hydraulic, a hydraulic accumulator for storing energy, and a valve manifold selectively fluidly connecting the hydraulic pump/motor to at least one of the hydraulic accumulator and the body hydraulic and/or the auxiliary hydraulic.

The power system may be configured such that the hydraulic accumulator is selectively charged by the hydraulic pump/motor when the prime mover is operating, and the hydraulic accumulator selectively powers the hydraulic pump/motor to start the prime mover when the prime mover is off.

Embodiments of the invention may include one or more of the following additional features.
In some embodiments, the power system may be configured such that the hydraulic accumulator does not power the body hydraulic and/or the auxiliary hydraulic.

In other embodiments, the hydraulic accumulator may selectively supply or supplement power to the body hydraulic and/or the auxiliary hydraulic.

The hydraulic accumulator may be sized to store sufficient energy to satisfy only the power requirement for driving the hydraulic pump/motor to start the prime mover.

In some embodiments, only a single hydraulic pump/motor is interposed between the hydraulic accumulator and the prime mover for both charging the hydraulic accumulator when the prime mover is operating, and for being powered by the hydraulic accumulator to start the prime mover when the prime mover is off.

The hydraulic accumulator may selectively supply power to the hydraulic pump/motor to supplement power to the prime mover when the prime mover is operating.

The hydraulic pump/motor may apply torque to increase the speed of the prime mover to a predetermined speed that is greater than the minimum fueling speed of the prime mover to reduce the time required for the prime mover to produce vehicle drive power after the prime mover has been started.

The hydraulic accumulator may be selectively charged by the hydraulic pump/motor when the prime mover is operating at a low power demand, and the hydraulic accumulator may selectively power the hydraulic pump/motor to supplement power to the prime mover when the prime mover is operating at a high power demand.

The hydraulic accumulator may selectively supply power to the body hydraulic and/or the auxiliary hydraulic when the prime mover is off.

The hydraulic accumulator may selectively supplement the power supplied by the hydraulic pump/motor to the body hydraulic and/or the auxiliary hydraulic when the prime mover is operating.
The hydraulic accumulator may be charged with surplus flow from the hydraulic pump/motor when the hydraulic pump/motor is supplying power to the body hydraulic and/or the auxiliary hydraulic.

The auxiliary hydraulic may include at least one of a power steering function and a braking function.

The hydraulic accumulator may be selectively fluidly connected to a power steering function and/or a brake function via the valve manifold.

The hydraulic accumulator may power the power steering function and/or the brake function to provide at least a portion of the steering and/or braking of the vehicle, respectively.

The hydraulic accumulator may be charged by vehicle brake energy, which may be provided by a resistive torque applied by the hydraulic pump/motor in response to the hydraulic pump/motor supplying pressurized fluid to the hydraulic accumulator.

The displacement of the hydraulic pump/motor may be set at a low value to minimize additional braking feel imposed on the vehicle during charging of the accumulator.

The hydraulic accumulator may supply stored vehicle brake energy to selectively power the hydraulic pump/motor to start the prime mover when the prime mover is off.

The power system may further include a second hydraulic pump/motor drivingly coupled to an output shaft of the brake function, and the hydraulic accumulator may be selectively charged by the second hydraulic pump/motor.

The hydraulic accumulator may be selectively charged by at least one of the hydraulic pump/motor, the brake function, and the second hydraulic pump/motor.

The hydraulic accumulator may selectively supply stored energy to power at least one of the hydraulic pump/motor, the second hydraulic pump/motor, the body hydraulic and/or the auxiliary hydraulic, the brake function, and the power steering function.

The power system may further include a controller, and the controller may direct fluid from the hydraulic accumulator through the valve manifold to
selectively supply and/or supplement power to at least one of the hydraulic pump/motor, the second hydraulic pump/motor, the body hydraulic and/or the auxiliary hydraulic, the brake function, and the power steering function.

The controller may direct fluid to the hydraulic accumulator through the valve manifold to selectively charge the hydraulic accumulator from at least one of the hydraulic pump/motor, the second hydraulic pump/motor, the body hydraulic and/or the auxiliary hydraulic, the brake function, and the power steering function.

The power system may further include a clutch configured to be drivingly interposed between the prime mover and the hydraulic pump/motor, and the clutch may be configured to drivingly decouple the hydraulic pump/motor from the prime mover.

The power system may further include a power take-off configured to be connected to the prime mover to transfer power from the prime mover to the hydraulic pump/motor.

The power system may further include a starter assembly coupled to the prime mover, the starter assembly including a hydraulic starter and an electric starter.

The hydraulic starter may include a hydraulic motor and the electric starter may include a starter solenoid, starter gear, and electric motor.

The hydraulic accumulator may be fluidly connected to the hydraulic starter via the valve manifold to supply power to the hydraulic starter, and the starting torque for the prime mover may be supplied by the hydraulic starter that is powered by the hydraulic accumulator.

The hydraulic accumulator may supply flow through the valve manifold to the hydraulic pump/motor, and the hydraulic pump/motor may act as a motor that runs an alternator or other accessories.

The clutch may be configured to decouple the pump/motor from the prime mover, thereby allowing the energy in the hydraulic accumulator to drive the hydraulic pump/motor as a motor to power an accessory.
The power system may be controlled such that a prime mover shutdown command is prevented if the state of charge of the accumulator is below a predetermined minimum value.

The power system may be controlled such that a prime mover start command is initiated if the state of charge of the accumulator falls below a predetermined minimum value.

The controller may provide a prime mover start command based on external command signals other than the prime mover ignition command.

For example, the external command signals may include one or more of a command to turn on the power take-off, a command requesting body hydraulic and/or auxiliary hydraulic functions, and a steering command.

The controller may use logic to determine whether the hydraulic pump/motor or the electric starter provides power to start the prime mover based on the state of charge of the accumulator.

The power system may be controlled such that a command to start or stop the prime mover is based on one or more signals including vehicle speed, prime mover diagnostics, prime mover temperature, fueling rate, prime mover speed, transmission gear, transmission operating mode, brake pedal position, parking brake status, and accelerator position.

The speed of the prime mover and/or the state of charge of the accumulator may be used to actively modify the hydraulic pump/motor displacement to prevent stall or overspeed of the prime mover.

The power system may be controlled such that a command to start or stop the prime mover is based on data of previous operations including one or more of the vehicle operations and the body hydraulics and/or auxiliary hydraulics operations.

The accumulator may be charged slowly in a near isothermal method to maximize the energy stored in the accumulator.

The power system may include the prime mover.

The power system may be considered a power source for storing, recovering, and/or using energy from a vehicle.
According to another aspect of the invention, a vehicle may include a prime mover and the power system according to any of the embodiments discussed herein.

According to yet another aspect of the invention, a power system includes a starter assembly configured to be coupled to the prime mover, the starter assembly including a hydraulic starter and an electric starter; a hydraulic pump/motor; a body/auxiliary hydraulic; and a hydraulic accumulator fluidly connected to the hydraulic pump/motor, the body/auxiliary hydraulic, and the hydraulic starter through a valve manifold.

According to another aspect of the invention, a method of using a hydraulic power system to store and use energy from a vehicle powered by a prime mover includes the steps: (i) selectively charging an accumulator with energy supplied by a hydraulic pump/motor being driven by the prime mover when the prime mover is operating, wherein the hydraulic pump/motor is selectively fluidly connected to the accumulator and a body hydraulic and/or auxiliary hydraulic via a valve manifold; and (ii) selectively powering the hydraulic pump/motor with energy stored in the accumulator when the prime mover is off, then starting the prime mover with the hydraulic pump/motor powered by energy from the accumulator.

The method of using the hydraulic power system may include one or more of the following steps.

- Selectively supplying power to the body hydraulic and/or auxiliary hydraulic from the hydraulic pump/motor when the prime mover is operating.
- Selectively supplying power to the body hydraulic and/or auxiliary hydraulic from the accumulator when the prime mover is off.
- Supplementing power to the prime mover by selectively powering the hydraulic pump/motor with energy from the accumulator when the prime mover is operating.
- Selectively charging the accumulator with energy supplied by the hydraulic pump/motor during braking of the vehicle.
- Commanding the prime mover to start or stop based on one or more signals indicating vehicle speed, prime mover diagnostics, prime mover
temperature, fueling rate, prime mover speed, transmission gear, transmission operating mode, brake pedal position, parking brake status, accelerator position, amount of charge in the accumulator, body hydraulic and/or auxiliary hydraulic function, power take-off function, and steering function.

According to still another aspect of the invention, a power source includes a prime mover, a hydraulic pump/motor, a power take-off connected to the prime mover to transfer power from the prime mover to the hydraulic pump/motor, a body/auxiliary hydraulic, and a hydraulic accumulator connected to the hydraulic pump/motor and the body hydraulics through a valve manifold, and the hydraulic accumulator is configured to be charged by the hydraulic pump/motor to operate the body hydraulics when the prime mover is off.

Embodiments of the power source may include one or more of the following additional features.

The power source may further include a clutch between the prime mover and the power take-off.

The clutch may be configured to allow declutching of the pump when the prime mover is running and the pump is not demanding flow.

The hydraulic accumulator may be configured to restart the prime mover and/or supplement the prime mover during driving/acceleration.

The power source may further include a starter assembly coupled to the prime mover, and the starter assembly may include a hydraulic starter and an electric starter.

The hydraulic starter may include a hydraulic motor and the electric starter may include a starter solenoid, gear ratio and electric motor.

The starting torque may be supplied by the hydraulic motor.

The hydraulic accumulator may be connected to a power steering function and/or a brake function through the valve manifold.

The hydraulic accumulator may be configured to supply fluid to the power steering and/or brake functions when the prime mover is off.

The power source may further comprise a controller that causes the hydraulic accumulator to direct fluid through the valve manifold to the power steering and/or brake functions when the prime mover is off.
According to another aspect of the invention, a power source includes a prime mover, a starter assembly coupled to the prime mover, the starter assembly including a hydraulic starter and an electric starter, a hydraulic pump/motor, a power take-off connected to the prime mover to transfer power from the prime mover to the hydraulic pump/motor, a body/auxiliary hydraulic, and a hydraulic accumulator connected to the hydraulic pump/motor, the body hydraulics, and the hydraulic starter through a valve manifold.

The hydraulic accumulator may provide hydraulic fluid to the hydraulic motor of the hydraulic starter.

The power source may further include a clutch between the prime mover and the power take-off. The clutch may be configured to allow declutching of the pump when the prime mover is running and the pump is not demanding flow. The hydraulic accumulator may be configured to restart the prime mover through the hydraulic starter and/or supplement the prime mover during driving/acceleration.

When the hydraulic accumulator supplies flow through the manifold to the pump/motor, the hydraulic pump/motor may act as a motor and may run an alternator or other accessories.

The hydraulic accumulator may be connected to a power steering function and/or a brake function through the valve manifold. The hydraulic accumulator may be configured to supply fluid to the power steering and/or brake functions when the prime mover is off. The power source may further comprise a controller that causes the hydraulic accumulator to direct fluid through the valve manifold to the power steering and/or brake functions when the prime mover is off.

The clutch may be configured to decouple the pump/motor from the prime mover, thereby allowing the energy in the accumulator to drive the pump/motor as a motor and power an accessory.

The power source may further include a series of clutches.

Although the invention has been shown and described with respect to a certain embodiment or embodiments, it is obvious that equivalent alterations and
modifications will occur to others skilled in the art upon the reading and understanding of this specification and the annexed drawings. In particular regard to the various functions performed by the above described elements (components, assemblies, devices, compositions, etc.), the terms (including a reference to a "means") used to describe such elements are intended to correspond, unless otherwise indicated, to any element which performs the specified function of the described element (i.e., that is functionally equivalent), even though not structurally equivalent to the disclosed structure which performs the function in the herein illustrated exemplary embodiment or embodiments of the invention. In addition, while a particular feature of the invention may have been described above with respect to only one or more of several illustrated embodiments, such feature may be combined with one or more other features of the other embodiments, as may be desired and advantageous for any given or particular application.
Claims

What is claimed is:

1. A power system for storing, recovering, and/or using energy from a vehicle powered by a prime mover, the power system comprising:
   a hydraulic pump/motor configured to be driven by the prime mover;
   a body hydraulic and/or an auxiliary hydraulic;
   a hydraulic accumulator for storing energy; and
   a valve manifold selectively fluidly connecting the hydraulic pump/motor to at least one of the hydraulic accumulator and the body hydraulic and/or the auxiliary hydraulic;
   wherein the hydraulic accumulator is selectively charged by the hydraulic pump/motor when the prime mover is operating; and
   wherein the hydraulic accumulator selectively powers the hydraulic pump/motor to start the prime mover when the prime mover is off.

2. The power system according to claim 1, or any claim that depends from claim 1, wherein the hydraulic accumulator does not power the body hydraulic and/or the auxiliary hydraulic.

3. The power system according to claim 2, or any claim that depends from claim 2, wherein the hydraulic accumulator is sized to store sufficient energy to satisfy only the power requirement for driving the hydraulic pump/motor to start the prime mover.

4. The power system according to claim 2, or any claim that depends from claim 2, wherein only a single hydraulic pump/motor interposed between the hydraulic accumulator and the prime mover for both charging the hydraulic accumulator when the prime mover is operating, and for being powered by the hydraulic accumulator to start the prime mover when the prime mover is off.
5. The power system according to claim 1, or any claim that depends from claim 1, wherein the hydraulic accumulator selectively supplies power to the hydraulic pump/motor to supplement power to the prime mover when the prime mover is operating.

6. The power system according to claim 5, or any claim that depends from claim 5, wherein the hydraulic pump/motor applies torque to increase the speed of the prime mover to a predetermined speed that is greater than the minimum fueling speed of the prime mover to reduce the time required for the prime mover to produce vehicle drive power after the prime mover has been started.

7. The power system according to claim 5, or any claim that depends from claim 5, wherein the hydraulic accumulator is selectively charged by the hydraulic pump/motor when the prime mover is operating at a low power demand, and wherein the hydraulic accumulator selectively powers the hydraulic pump/motor to supplement power to the prime mover when the prime mover is operating at a high power demand.

8. The power system according to claim 1, or any claim that depends from claim 1, wherein the hydraulic accumulator selectively supplies power to the body hydraulic and/or the auxiliary hydraulic when the prime mover is off.

9. The power system according to claim 1, or any claim that depends from claim 1, wherein the hydraulic accumulator selectively supplements the power supplied by the hydraulic pump/motor to the body hydraulic and/or the auxiliary hydraulic when the prime mover is operating.

10. The power system according to claim 1, or any claim that depends from claim 1, wherein the hydraulic accumulator is charged with surplus flow from the hydraulic pump/motor when the hydraulic pump/motor is supplying power to the body hydraulic and/or the auxiliary hydraulic.
11. The power system according to claim 1, or any claim that depends from claim 1, wherein the auxiliary hydraulic includes a power steering function and/or a braking function.

12. The power system according to any preceding claim, wherein the hydraulic accumulator is selectively fluidly connected to a power steering function and/or a brake function via the valve manifold.

13. The power system according to claim 12, or any claim that depends from claim 12, wherein the hydraulic accumulator powers the power steering function and/or the brake function to provide at least a portion of the steering and/or braking of the vehicle, respectively.

14. The power system according to claim 12, or any claim that depends from claim 12, wherein the hydraulic accumulator is charged by vehicle brake energy, which is provided by a resistive torque applied by the hydraulic pump/motor in response to the hydraulic pump/motor supplying pressurized fluid to the hydraulic accumulator.

15. The power system according to claim 14, or any claim that depends from claim 14, wherein displacement of the hydraulic pump/motor is set at a low value to minimize additional braking feel imposed on the vehicle during charging of the accumulator.

16. The power system according to claim 14, or any claim that depends from claim 14, wherein the hydraulic accumulator supplies stored vehicle brake energy to selectively power the hydraulic pump/motor to start the prime mover when the prime mover is off.
17. The power system according to claim 12, or any claim that depends from claim 12, further including a second hydraulic pump/motor drivingly coupled to an output shaft of the brake function,

wherein the hydraulic accumulator is selectively charged by the second hydraulic pump/motor.

18. The power system according to claim 17, or any claim that depends from claim 17, wherein the hydraulic accumulator is selectively charged by at least one of the hydraulic pump/motor, the brake function, and the second hydraulic pump/motor; and

wherein the hydraulic accumulator selectively supplies stored energy to power at least one of the hydraulic pump/motor, the second hydraulic pump/motor, the body hydraulic and/or the auxiliary hydraulic, the brake function, and the power steering function.

19. The power system according to any preceding claim, further including a controller, wherein the controller directs fluid from the hydraulic accumulator through the valve manifold to selectively supply and/or supplement power to at least one of the hydraulic pump/motor, the second hydraulic pump/motor, the body hydraulic and/or the auxiliary hydraulic, the brake function, and the power steering function; and

wherein the controller directs fluid to the hydraulic accumulator through the valve manifold to selectively charge the hydraulic accumulator from at least one of the hydraulic pump/motor, the second hydraulic pump/motor, the body hydraulic and/or the auxiliary hydraulic, the brake function, and the power steering function.

20. The power system according to any preceding claim, further including a clutch configured to be drivingly interposed between the prime mover and the hydraulic pump/motor, the clutch being configured to drivingly decouple the hydraulic pump/motor from the prime mover.
21. The power system according to any preceding claim, further including a power take-off configured to be connected to the prime mover to transfer power from the prime mover to the hydraulic pump/motor.

22. The power system according to any preceding claim, further including a starter assembly coupled to the prime mover, the starter assembly including a hydraulic starter and an electric starter; wherein the hydraulic starter includes a hydraulic motor and the electric starter includes a starter solenoid, starter gear, and electric motor; wherein the hydraulic accumulator is fluidly connected to the hydraulic starter via the valve manifold to supply power to the hydraulic starter; and wherein the starting torque for the prime mover is supplied by the hydraulic starter that is powered by the hydraulic accumulator.

23. The power system according to any preceding claim, wherein, when the hydraulic accumulator supplies flow through the valve manifold to the hydraulic pump/motor, the hydraulic pump/motor acts as a motor that runs an alternator or other accessories.

24. The power system according to any preceding claim, wherein the clutch is configured to decouple the pump/motor from the prime mover, thereby allowing the energy in the hydraulic accumulator to drive the hydraulic pump/motor as a motor to power an accessory.

25. The power system according to claim 1, or any claim that depends from claim 1, wherein a prime mover shutdown command is prevented if the state of charge of the accumulator is below a predetermined minimum value.

26. The power system according to claim 1, or any claim that depends from claim 1, wherein a prime mover start command is initiated if the state of charge of the accumulator falls below a predetermined minimum value.
27. The power system according to claim 1, or any claim that depends from claim 1, wherein a controller provides a prime mover start command based on external command signals other than the prime mover ignition command.

28. The power system according to claim 27, or any claim that depends from claim 27, wherein the external command signals include one or more of a command to turn on the power take-off, a command requesting body hydraulic and/or auxiliary hydraulic functions, and a steering command.

29. The power system according to claim 1, or any claim that depends from claim 1, wherein a controller uses logic to determine whether the hydraulic pump/motor or an electric starter provides power to start the prime mover based on the state of charge of the accumulator.

30. The power system according to claim 1, or any claim that depends from claim 1, in which a command to start or stop the prime mover is based on one or more signals including vehicle speed, prime mover diagnostics, prime mover temperature, fueling rate, prime mover speed, transmission gear, transmission operating mode, brake pedal position, parking brake status, and accelerator position.

31. The power system according to claim 1, or any claim that depends from claim 1, wherein the speed of the prime mover and/or the state of charge of the accumulator are used to actively modify the hydraulic pump/motor displacement to prevent stall or overspeed of the prime mover.

32. The power system according to claim 1, or any claim that depends from claim 1, in which a command to start or stop the prime mover is based on data of previous operations including one or more of the vehicle operations and the body hydraulics and/or auxiliary hydraulics operations.
33. The power system according to any preceding claim, wherein the accumulator is charged slowly in a near isothermal method to maximize the energy stored in the accumulator.

34. The power system according to any preceding claim, wherein the power system includes the prime mover.

35. A vehicle including a prime mover and the power system according to any of claims 1 to 34.

36. A power system for storing, recovering, and/or using energy from a vehicle powered by a prime mover, the power system comprising:
   a starter assembly configured to be coupled to the prime mover, the starter assembly including a hydraulic starter and an electric starter;
   a hydraulic pump/motor;
   a body/auxiliary hydraulic; and
   a hydraulic accumulator fluidly connected to the hydraulic pump/motor, the body/auxiliary hydraulic, and the hydraulic starter through a valve manifold.

37. The power system according to claim 36, or any claim that depends from claim 36, wherein the hydraulic starter includes a hydraulic motor and the electric starter includes a starter solenoid, gear ratio and electric motor; and
   wherein the starting torque for starting the prime mover is supplied by the hydraulic starter that is powered by the hydraulic accumulator.

38. A method of using a hydraulic power system to store and use energy from a vehicle powered by a prime mover, comprising the steps:
   selectively charging an accumulator with energy supplied by a hydraulic pump/motor being driven by the prime mover when the prime mover is operating, wherein the hydraulic pump/motor is selectively fluidly connected to the
accumulator and a body hydraulic and/or auxiliary hydraulic via a valve manifold;
and
selectively powering the hydraulic pump/motor with energy stored in the accumulator when the prime mover is off, then starting the prime mover with the hydraulic pump/motor powered by energy from the accumulator.

39. The method according to claim 38, or any claim that depends from claim 38, further comprising one or more of the steps of:
    selectively supplying power to the body hydraulic and/or auxiliary hydraulic from the hydraulic pump/motor when the prime mover is operating; and
    selectively supplying power to the body hydraulic and/or auxiliary hydraulic from the accumulator when the prime mover is off.

40. The method according to claim 38, or any claim that depends from claim 38, further comprising the step of supplementing power to the prime mover by selectively powering the hydraulic pump/motor with energy from the accumulator when the prime mover is operating.

41. The method according to claim 38, or any claim that depends from claim 38, further comprising the step of selectively charging the accumulator with energy supplied by the hydraulic pump/motor during braking of the vehicle.

42. The method according to claim 38, or any claim that depends from claim 38, further comprising the step of commanding the prime mover to start or stop based on one or more signals indicating vehicle speed, prime mover diagnostics, prime mover temperature, fueling rate, prime mover speed, transmission gear, transmission operating mode, brake pedal position, parking brake status, accelerator position, amount of charge in the accumulator, body hydraulic and/or auxiliary hydraulic function, power take-off function, and steering function.