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Schmitz

(54) **RECUPERATIVE HYBRID TRAINS USING BATTERIES IN AN INTERMODAL CONTAINER**

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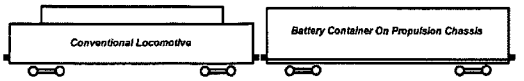
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(57) **ABSTRACT**

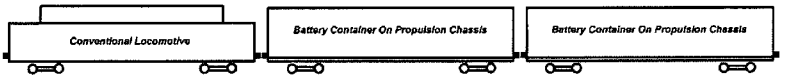
The present invention relates generally to hybrid versions of diesel-electric locomotives and improves the previous art by placing such batteries in standard intermodal containers which can easily be moved by readily available cranes built for the purpose of moving freight containers. The containers housing the batteries are standardized, so that different operators can use them by way of purchase or rental. The invention produces the following advantages. (1) After a descent from high altitudes, a full battery unit can be removed from a train and put in storage to reduce the weight of the train should no extra power be needed for the next leg of the journey. On particular long descents, full battery units can be replaced by empty ones several times to enable further energy recovery as the train continues its way down the mountain. (2) Conversely, a train heading for the mountains can be loaded with one or more full battery containers from storage to reduce the use of fossil fuels during the ascent and, if need be, receive replacement units on the way should the original set not last long enough to reach the high point. (3) Different configurations become possible such as two containers, one on top of the other, to accommodate different requirements. (4) The commercial trade of battery containers, made possible through standardization, will create a market for energy which will result in its most efficient use.



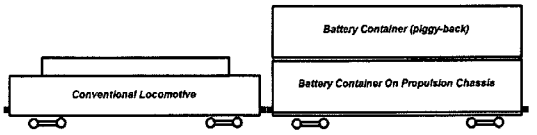
One Locomotive, one Battery Propulsion Unit



Two Locomotives, one Battery Propulsion Unit



One Locomotive, two Battery Propulsion Units



One Locomotive with two Battery Containers

Examples of Configurations

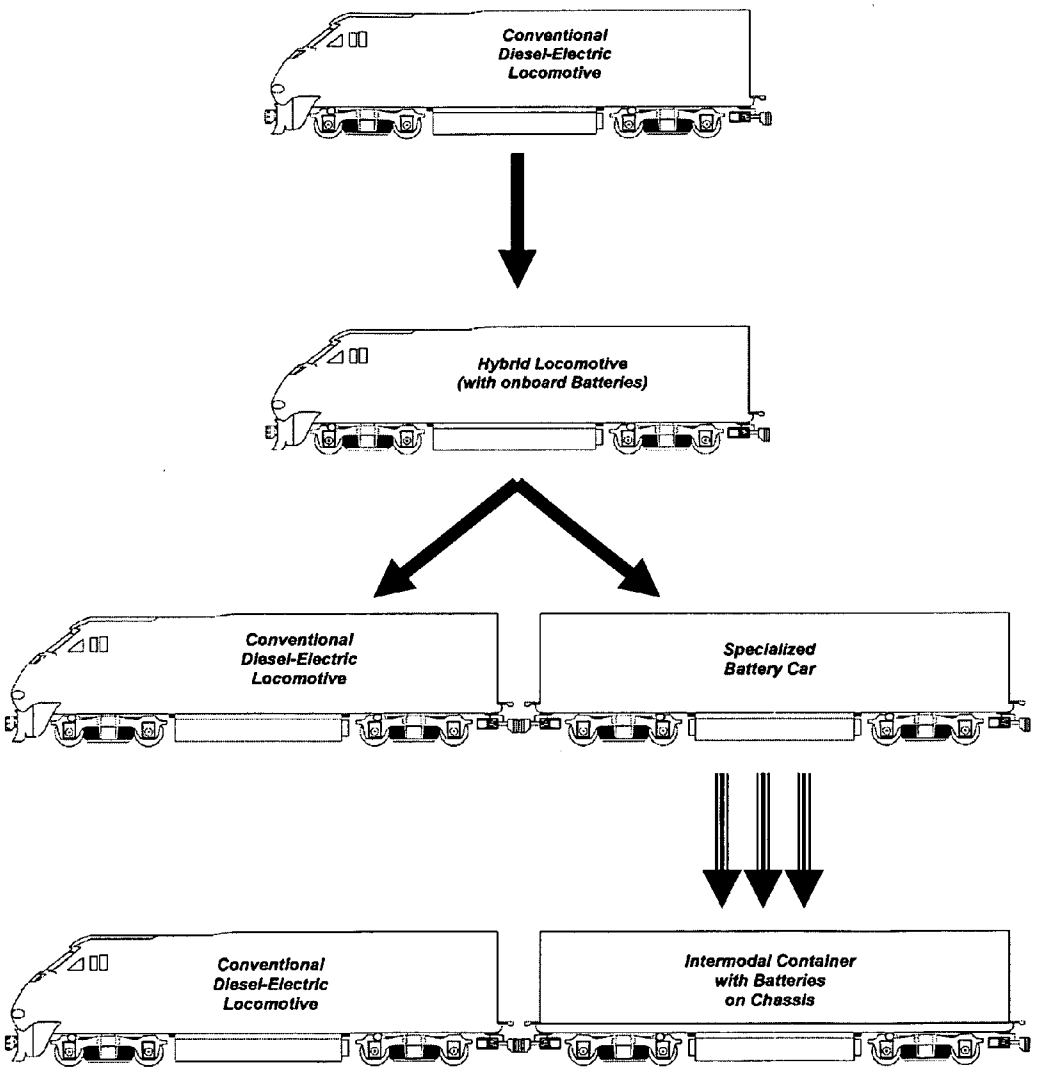
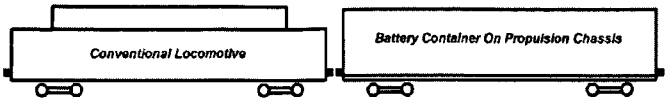
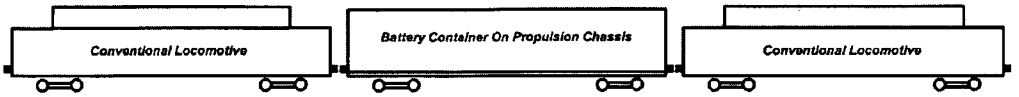


Figure 1

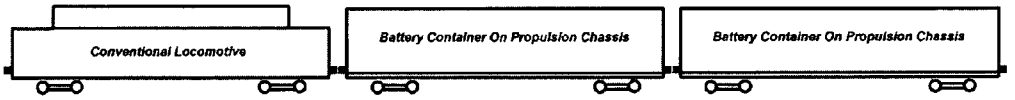
Hybrid Evolution



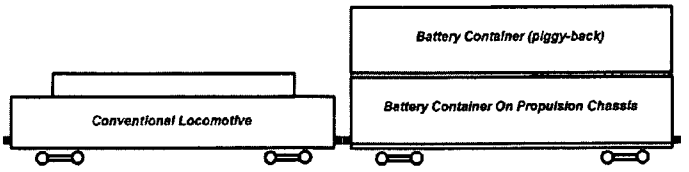
One Locomotive, one Battery Propulsion Unit



Two Locomotives, one Battery Propulsion Unit



One Locomotive, two Battery Propulsion Units



One Locomotive with two Battery Containers

Figure 2

Examples of Configurations

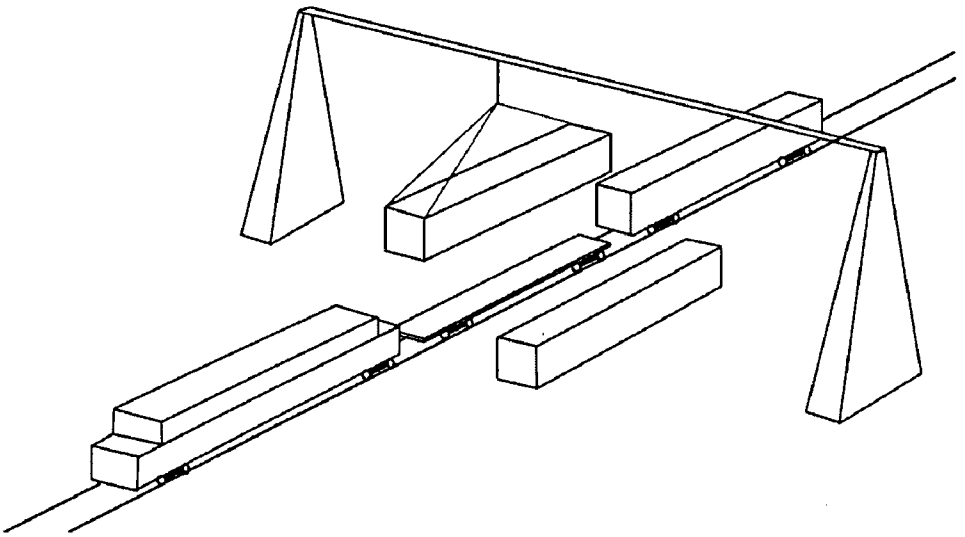


Figure 3

Exchange of Battery Containers by Crane

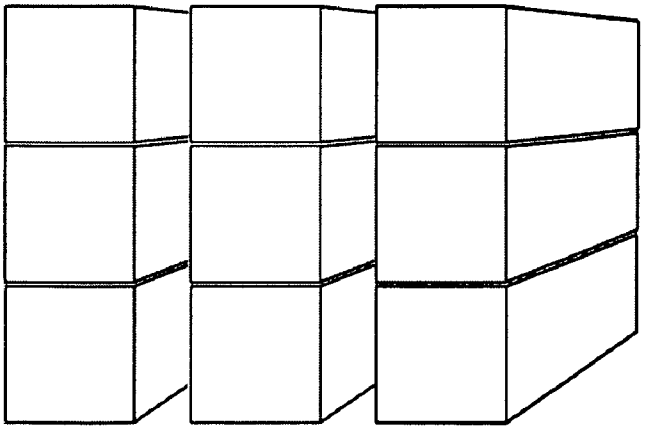


Figure 4

Storage of Battery Containers

RECUPERATIVE HYBRID TRAINS USING BATTERIES IN AN INTERMODAL CONTAINER

CROSS_REFERENCE TO RELATED APPLICATIONS

[0001] Not Applicable

STATEMENT REGARDING FEDERALLY SPONSORED RESEARCH OR DEVELOPMENT

[0002] No federally sponsored research or development was requested or received.

REFERENCE TO SEQUENCE LISTING

[0003] No material is submitted separately on a compact disk.

BACKGROUND OF THE INVENTION

[0004] With the advent of high capacity batteries (30 Watt Hours or more per pound of weight) which are also capable of being rapidly charged and discharged (80% in less than five minutes), the concept of recovering kinetic and potential energy of a moving vehicle for future use (hybrid systems) will increasingly be used in automobiles, trains and other vehicles. Its application for heavy trains such as freight trains poses a particular problem, however, in that the combination of the trains high total weight (in excess of a few thousand tons) and occasional but prolonged descents from mountains (elevation decrease of several thousand feet) requires batteries of tremendous weight while commercial applications require that batteries be highly mobile so that they can be used wherever needed most. The placement of batteries not on the locomotive but on a battery tender has been suggested but results in useful mobility only if a train yard is available.

[0005] Trains, like any other heavy object, require a lot of energy to attain speed (kinetic energy) or higher elevation (potential energy). When a conventional train slows down or descends it loses this energy. If the locomotive uses fossil fuel and if part of such energy is recovered and stored in batteries for later use, the system is called a hybrid and it has been sufficiently described in previous art.

[0006] U.S. Pat. No. 6,591,758 to Ajith Kuttannair Kumar discloses a hybrid energy locomotive system having an energy storage and regeneration system. In one form, the system can be retrofitted into existing locomotives, or installed as original equipment. The energy storage and regeneration system captures dynamic braking energy, excess motor energy, and externally supplied energy and stores the captured energy in one or more energy storage subsystems, including a flywheel, a battery, an ultra-capacitor, or a combination of such subsystems. The energy storage and regeneration system can be located in a separate energy tender vehicle. The separate energy tender vehicle is optionally equipped with traction motors. An energy management system is responsive to power storage and power transfer parameters, including data indicative of present and future track profile information, to determine present and future electrical energy storage and supply requirements. The energy management system controls the storage and regeneration of energy accordingly.

[0007] U.S. application Ser. No. 11/075,550 to Frank Wegner Donnelly is directed to a locomotive that includes: (a) a transmission operable to drive a plurality of axles; (b) an electric motor operatively connected to and driving the transmission; (c) an energy storage unit operable to store electrical energy and supply electrical energy to the electric motor; (d) one or more prime movers operable to supply electrical energy to the energy storage unit and electric motor; and (e) a power distribution bus electrically connecting the energy storage unit, prime mover(s), and electric motor. The energy storage unit and/or generator provide electrical energy to the electric motor via the power distribution bus to cause the electric motor to rotate the axles via the transmission.

[0008] The primary advantage of a hybrid train is that it uses significantly less fossil fuel (practically always Diesel oil) than conventional systems, resulting in lower operating costs as well as the production of less greenhouse gas. In the case of accelerations and decelerations or on routes with frequent but small and alternating inclines and declines, the maximum energy that has to be stored in batteries (before it is being used during a subsequent ascent or acceleration), is small enough for the locomotive to house the necessary batteries as the following example shows.

[0009] A train with four locomotives (120 tons each) and 90 freight cars (85 tons each) is accelerated to 60 miles per hour (mph). Since the kinetic energy equals half the mass times the square of the velocity, it is 14.6 million ton mile^2 per hour^2 or 693 kilowatt hours (kWh). Similarly, since potential energy equals mass times the increase in elevation times the gravitational constant, it takes 691 kWh to move the train up 120 ft. If a conventional battery weighs approx. 65 lbs per kWh of capacity and if only one third of the released energy can be recovered, the total weight of the batteries necessary to accommodate the above scenario is in the order of seven tons or 1.9 ton per locomotive, less than 2% of their respective weight.

[0010] While the increased need for energy storage from higher speeds is relatively small (a factor of four if the train should brake from double the speed or 120 mph in the above example), prolonged declines pose a different scenario. If the above train were to descend, for example, westward from the Cajon Pass towards Los Angeles less than 50 miles away, each locomotive could fill approx. 65 tons of batteries since the elevation of the pass is 4,190 ft. It is not a viable option to permanently increase the weight of a locomotive by over 50% just for the occasional descent from a pass. Therefore, the batteries have to be placed on a separate car or cars. Since removing or exchanging a whole car from a train is time-consuming and requires a train yard, the full potential of hybrid train systems can only be achieved if a more flexible way to remove or adding batteries is found.

BRIEF SUMMARY OF THE INVENTION

[0011] As illustrated in FIG. **1**, this invention improves the previous art for hybrid diesel-electric trains by installing such batteries inside standard intermodal containers which are already used in very large quantities worldwide for the transportation of goods and for which cranes are readily available in many places. The containers housing the batteries are standardized, so that different operators can use them by way of purchase or rental. Such battery containers can be placed on a freight train chassis in different configurations as shown in FIG. **2** to allow a variety of ratios between the number of containers and the number of locomotives to accommodate different requirements. The battery containers itself will be equipped with their own ventilation system to prevent overheating or the accumulation of unwanted fumes as well as

cables with plugs to connect the container's batteries to the power grid and information network of the train and/or chassis if a chassis with motors and recuperative brakes is used. The containers will also house the power conversion and control units necessary to recover or provide electric power. The invention makes it possible to efficiently move the energy recovered from a descending train to another train or trains which are about to ascend to higher elevations, one example being a train going into the opposite direction. This is done by readily available container cranes as shown in FIG. **3**. The present invention makes it also possible to store full or empty batteries in freight storage areas (FIG. **4**) where they can be picked up at a later time by the same or other train, thereby preventing the use of fuel associated with carrying their dead weight during parts of a trip where neither prolonged ascends or descends occur.

BRIEF DESCRIPTION OF DRAWINGS

[0012] FIG. **1**—Hybrid Evolution: shows the invention as a sequel to existing hybrid locomotives with onboard batteries and how a large volume of batteries can be located in a standard intermodal container.

[0013] FIG. **2**—Examples of Configurations: shows the flexibility afforded by this invention as the ratio between number of locomotives and battery/chassis units, and therefore the ratio between locomotive capacity and recuperative capacity, can be easily changed to accommodate different requirements.

[0014] FIG. **3**—Exchange of Battery Containers by Crane: depicts the exchange of containers at one of many freight yards or train stations equipped with suitable cranes.

[0015] FIG. **4**—Storage of Battery Containers: shows how battery containers can be stored just like any other intermodal container when not in use (or when being recharged from a land-based power grid).

DETAILED DESCRIPTION OF THE INVENTION

[0016] The present invention relates generally to hybrid versions of diesel-electric locomotives and improves the previous art (see FIG. **1**) by placing such batteries in standard intermodal containers (referred to in this document as battery containers) which can easily be moved by readily available cranes built for the purpose of moving freight containers (see FIG. **3**). Such battery containers can be placed on a freight train chassis in different configurations (as shown in FIG. **2**) to allow a variety of ratios between the number of containers and the number of locomotives to accommodate different requirements. The battery containers itself will be equipped with their own ventilation system to prevent overheating or the accumulation of unwanted fumes as well as cables with plugs to connect the container's batteries to the power grid and information network of the train and/or chassis if a chassis with motors and recuperative brakes is used. The containers will also house the power conversion and control units necessary to recover or provide electric power. The containers housing the batteries are standardized, so that different operators can use them by way of purchase or rental. The invention produces the following advantages. (1) After a descent from high altitudes, a full battery unit can be removed from a train and put in storage (FIG. **4**) to reduce the weight of the train should no extra power be needed for the next leg of the journey. On particular long descents, full battery units can be replaced by empty ones several times to enable further energy recovery as the train continues its way down the mountain. (2) Conversely, a train heading for the mountains can be loaded with one or more full battery containers from storage to reduce the use of fossil fuels during the ascent and, if need be, receive replacement units on the way should the original set not last long enough to reach the high point. (3) Different configurations become possible such as two containers, one on top of the other, to accommodate different requirements (FIG. **2**). (4) The commercial trade of battery containers, made possible through standardization, will create a market for energy which will result in its most efficient use.

1. The recuperative batteries of a hybrid diesel-electric train are installed not on the locomotive or a battery tender, but in a standard intermodal container in which also are installed a ventilation system to prevent overheating or the accumulation of unwanted fumes as well as cables with plugs to connect the container's batteries to the power grid and information network of the train and/or chassis if a chassis with motors and recuperative brakes is used.

2. The whole container, which houses the batteries, is moved to and from storage areas or other trains through the use of container cranes available at most freight stations. The chassis itself remains part of the train during this process.

3. The battery containers as described above are standardized so that different operators can use them by way of purchase or rental.

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