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(54) APPARATUS FOR CONTROLLING THE SUPPLY OF ELECTRICITY TO A MOBILE ELECTRICAL POWER UNIT BY A SERVICING STATION

(71) We, GES GESELLSCHAFT FUR ELEKTRISCHEN STRASSENVERKEHR MBH, a Company organised under the laws of the Federal Republic of Germany, of Tersteengenstrasse 77, 4000 Dusseldorf, Germany, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to apparatus for controlling the supply of electricity to a mobile electrical power unit by a servicing station, at which the mobile electrical power unit can be supplied with electricity from the electrical direct, or alternating current network. In the context of the invention, the term "mobile electrical power unit" particularly, but not necessarily exclusively relates to an electric vehicle having an electrochemical energy storage source.

Apparatus of this type is not yet known, because the servicing stations and the mobile electrical power units, more particularly in the form of electric vehicles, are generally owned by the same individuals. However, as more electric vehicles come into use an infra-structure of servicing stations will need to be developed. Known apparatus for recording the services rendered to vehicles with internal combustion engines by conventional servicing (filling) stations is unsuitable for mobile electrical power units, or more particularly electric vehicles, since it cannot cope with the special requirements of electricity distribution.

According to the present invention an apparatus for controlling the supply of electricity to an electrical power unit at a servicing station, at which the electrical power unit can be supplied with electricity from an electrical direct or alternating current network operated by an electricity supply undertaking, comprises a pulse generator to generate a timed sequence of recording pulses of prescribed energy content corresponding to the electricity supplied by the servicing station, and a pulse counter connected to the pulse generator by a transmission line, the pulse generator being constructed to control the timed sequence of recording pulses for the electricity supplied in accordance with a basic tariff and/or a sliding tariff-time scale imposed by the electricity supply undertaking, and there being a pre-set metering unit connected to the pulse counter and coupled with a switching device to limit the supply of electricity to the power unit or interrupt the line taking the electricity to the power unit.

The advantages accruing from the invention are to be seen in that it provides an apparatus for controlling a service rendered to a mobile electrical power unit by a servicing station which is very dependable and requires virtually no maintenance, since it contains few mechanically actuated components and can easily be assembled from proven elements; moreover, it functions as it were autonomously for the servicing station, because the user of the mobile electrical power unit must himself operate the metering unit.

In the simplest case, the pulse generator consists of a switching device in a line supplying the electrical energy to the mobile electrical power unit, which line is also used as a transmission line to transmit the recording pulses from the pulse generator to the pulse counter. In accordance with the invention, the pulse generator is constructed to control the timed sequence of recording pulses for the electricity supplied in accordance with a basic tariff and/or a sliding tariff-time scale imposed by the relevant electricity supply undertaking. By employing a sliding tariff, the output of the servicing station can be controlled so that a high load is maintained at times favourable to

the electricity supply undertaking. During the high-tariff period, the recording pulse frequency is higher than during the low-tariff period. The same applies to the electricity supply undertaking's tariff for static power units, which on the one hand can vary between undertakings and on the other can be set at different levels by day and night within the same electricity supply undertaking. The recording pulses can be introduced either as separate recording pulses or as adjustments to the timed sequence of recording pulses fed to the pulse counter for the electricity supplied. When an appropriate charger is connected between the current network of the electricity supply undertaking and the, for example, electrochemical energy source (lead-acid battery) in the electric vehicle, for recharging purposes, as part of either the electric vehicle or the servicing station equipment, the said charger is generally speaking adjustable in relation to the charging load, the charging voltage and the like. Since chargers in general vary in load rating and efficiency, it is preferred to construct the pulse generator so that it will adjust the timed sequence of recording pulses for electricity supplied, to conform to the charging load and/or the charging voltage at a steady charging current and/or the charging current at a steady charging voltage from the charger. The pulse counter and the metering unit, are preferably associated with the mobile electrical power unit. Moreover, the metering unit can be designed for example to accept payment tokens. By being a pre-set unit, the payment tokens must be fed into the unit before the mobile electrical power unit can start taking electricity from the servicing station. With the cancelling unit coupled with a switching device to limit the load or interrupt the line taking the electricity from the servicing station to the mobile electrical power unit, the limiting or interrupting point in time can be controlled in this case, so that for example the battery can only be charged up to a specified level. This is particularly important when the batteries in the vehicles are themselves the property of the servicing station undertaking. In this case, it is preferable to set the battery hire charge according to the duty conditions, which can be influenced by the user of the electric vehicle, and to take care that prescribed maintenance schedules are observed. It is known that efficiency and life are determined by certain battery parameters such as load, voltage, current, temperature and the like. Moreover, conventional batteries require maintenance servicing at certain time intervals which depend on the amount of energy stored, the number of full discharges, the times spent in the discharged condition and the like. Thus the pulse generator may be associated with a suitable battery testing and data processing instrument to determine one or more of the said battery performance parameters as a function of time, if the pulse generator is associated with the electric vehicle, or can be connected thereto if the pulse generator is associated with the servicing station. In this way, the battery performance parameters can be derived, at least during charging at a servicing station, to generate additional recording pulses and/or to control the timed sequence of recording pulses for electricity supplied by the servicing station. Furthermore, the testing and data processing instrument should be provided with an indicating device for the energy stored in the battery over a maintenance interval and/or an indicating device for the charge in the battery, which is important when costing battery replacements, and/or an indicating device for the servicing requirements of the battery, which can be associated with a switching device to limit the discharge current. The indicating devices are preferably constructed as dial instruments, while the testing and data processing instrument is adapted to generate appropriate electrical counting pulses. Thus, similar proven elements can be used to those for the pulse generator and the pulse counter.

Four embodiments of the invention will now be described in more detail with reference to the accompanying schematic drawings, in which Figures 1 to 4 are circuit diagrams showing each embodiment.

In Figure 1 an electric vehicle 1 has an electrochemical energy source 2 and an electric motor 3, there being a servicing station 4, where the battery 2 is recharged with electricity from the alternating current network of source 6. The current network 5 of the source 6 and the electrochemical energy source 2 in the electric vehicle 1 are connected together in the servicing station 4 by a rectifying charger 7. The apparatus has a pulse generator 8 to generate a timed sequence of electrical recording pulses of prescribed energy content corresponding to the electricity supplied by the servicing station and additional services and goods, a pulse counter 9 connected to the pulse generator 8 through a transmission line 8a and a pre-set metering unit 10 connected to the pulse counter 9. The pulse generator 8 is associated with the servicing station 4, the pulse counter 9 and the metering unit 10 with the electric vehicle 1. The pulse generator 8 is constructed to control the timed sequence of recording pulses for the electricity supplied in accordance on the one hand with a basic tariff and/or a sliding tariff-time scale imposed by the elec-

tricity supply undertaking 6 and on the other hand with the charging load and/or charging voltage and/or charging current of the charger 7, and is accordingly coupled with corresponding measuring elements 11, 12 in the servicing station 4. In the pulse generator 8, the charging load (or charging current) measured by the measuring elements 11, 12 on the charger 7 is converted into a proportional voltage, which is integrated with respect to time and compared against a reference voltage. When the voltages reach equality, a recording pulse is sent down the transmission line 8a to the pulse counter 9. The timed sequence of pulses and the amount of energy represented by each recording pulse are adjusted by varying the reference voltage in conformity with the evaluating parameters, viz., the time of day, the tariff of the electricity supply undertaking, the charging voltage and so on. The metering unit 10 being preset, the electricity supplied by the servicing station must be paid for in advance, for example by inserting tokens in the unit 10. The unit 10 is coupled with a switching device 13 to restrict the load in the line supplying electricity to the battery 2 in the electric vehicle 1. The battery 2 is further associated with a testing and data processing instrument 14, 15 to determine the various battery performance parameters, viz., the current, voltage and temperature of the battery 2 as functions of time. By means of a changeover switch not shown, current and voltage measurements are made on the one hand during the charging of the battery 2 and on the other hand during the discharging of the battery 2 i.e., during normal operations of the electric vehicle 1. The voltage readings during normal operation also indicate the depth of discharge and the time spent in the discharged condition. The testing and data processing instrument 14, 15 is further provided with indicating devices 16, 17 and/or 18 for the energy stored over a maintenance interval, the charge in the battery 2 and the maintenance requirements of the battery 2. These indicating devices 16, 17 and 18 are constructed as dial instruments, and the testing and data processing instrument 14, 15 is correspondingly adapted to generate counting pulses. The energy stored during charging is transmitted in the form of evaluated counting pulses to the dial instrument 16 serving as the indicating device for energy stored over a maintenance interval, and the dial instrument 16 in turn transmits maintenance signals to the dial instrument 18 serving as the indicating device for the maintenance requirements. The pulses sent to the dial instrument 16 are also transmitted to the dial instrument 17. This dial insrument 17 consists of a differential counter. The differential counter 17 receives evaluated counting pulses from the testing and data processing instrument 14, 15 which correspond to the energy balance during normal operation of the electric vehicle 1. In other words, the differential counter 17 indicates the state of charge in the battery 2. When the differential counter 17 stands at zero, the battery 2 is fully discharged. Corresponding maintenance pulses are sent to the dial instrument 18. After a corresponding number of maintenance pulses, the dial instrument 18 signals that maintenance is required. When maintenance is required, the dial instrument 18 can optionally actuate a discharge current limiter.

Figure 2 differs from that in Figure 1 in that the rectifying charger is associated with the electric vehicle 1. The measuring element 12 connected to the charger 7 in Figure 1 is omitted in this case.

The embodiment in Figure 3 schematically shows the apparatus of the invention for the case in which the transmission line for supplying electricity also serves to transmit the counting pulses from the servicing station 4 to the electric vehicle 1. In this case the electrical current to the rectifying charger 7 is periodically switched on and off by a switching device associated with the servicing station, with a corresponding controller (not shown) for the pulse generator 8, so that similarly block-shaped direct current pulses pass from the rectifying charger 7 to the battery 2. The controller, not shown, functions so that every current pulse carries the same quantity of electricity, i.e., as the charging current falls off because of the increasing counter-voltage in the battery 2 the pulse duration increases in proportion. Consequently, the measuring element 12 and the pulse counter 9 need only count the number of direct current pulses delivered. As soon as the amount of charging current prescribed by the cancelling unit 10 has been delivered, the switching device 13 is actuated, so that only a small current can pass through an auxiliary resistor to compensate the self-discharge current from the battery 2. Thus the charging current itself is subdivided into pulse-shaped blocks for determination and recording. Otherwise, the apparatus is designed like the embodiments already described.

In the embodiment shown in Figure 4, a combination of two alternatives is provided which has proved particularly advantageous for supplying electric vehicles with electricity. On the one hand, a high charging current can be delivered as in Figure 1 by a rectifying charger 7 associated with the servicing station 4, while on the other hand the electric vehicle 1 has its own smaller

and lighter rectifying charger 7′, as in Figure 3, adapted for connecting to the servicing station 4 by a switching element 8′ and delivering a lower charging current over the longer time intervals to the battery 2. The construction and functions of the other elements and assemblies shown have already been described in connection with Figures 1 and 3. However, the pulse counter in this case is constructed as a twin-control counter 9, 9′, so that pulses arriving from both the transmission line 8a and the measuring element 12 can be recorded. Also, when charging through the vehicle rectifying charger 7′ it is possible to dispense with the static switching device 8′ and the associated controller to subdivide the charging current into pulses, provided this function is assumed by the switching device 13 supplemented by a suitable controller.

WHAT WE CLAIM IS:—

1. An apparatus for controlling the supply of electricity to an electrical power unit at a servicing station, at which the electrical power unit can be supplied with electricity from an electrical direct or alternating current network operated by an electricity supply undertaking, comprising a pulse generator to generate a timed sequence of recording pulses of prescribed energy content corresponding to the electricity supplied by the servicing station, and a pulse counter connected to the pulse generator by a transmission line, the pulse generator being constructed to control the timed sequence of recording pulses for the electricity supplied in accordance with a basic tariff and/or a sliding tariff-time scale imposed by the electricity supply undertaking, and there being a pre-set metering unit connected to the pulse counter and coupled with a switching device to limit the supply of electricity to the power unit or interrupt the line taking the electricity to the power unit.

2. Apparatus as in Claim 1, wherein the pulse generator consists of a switching device in a line supplying the electrical energy to the electrical power unit, which line is also used as the transmission line.

3. Apparatus as in Claim 1 or Claim 2, in which a charger is connected between the electric current network of the electricity supply undertaking and the power unit for recharging purposes, the pulse generator being constructed to control the timed sequence of recording pulses for electricity supplied in relation to the charging load and/or the charging voltage and/or the charging current in the charger.

4. Apparatus as in any of Claims 1 to 3, wherein the pulse counter and the metering unit are associated with the electrical power unit.

5. Apparatus as in any of Claims 1 to 4, wherein the pulse generator is or can be coupled to a testing and data processing instrument associated with the battery in the electrically powered vehicle to determine one or more of the battery performance parameters, viz., load, current, voltage and temperature, as a function of time.

6. Apparatus as in Claim 5, wherein the testing and data processing instrument is provided with indicating devices for the energy stored over a maintenance interval and/or the charge in the battery and/or the servicing requirements of the battery.

7. Apparatus as in Claim 6, wherein the indicating devices are constructed as dial instruments and the testing and data processing instrument is correspondingly adapted to generate appropriate electrical counting pulses.

8. Apparatus for controlling the supply of electricity at a service station, as in Claim 1 and substantially as hereinbefore described.

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Sheet 1

Fig. 1

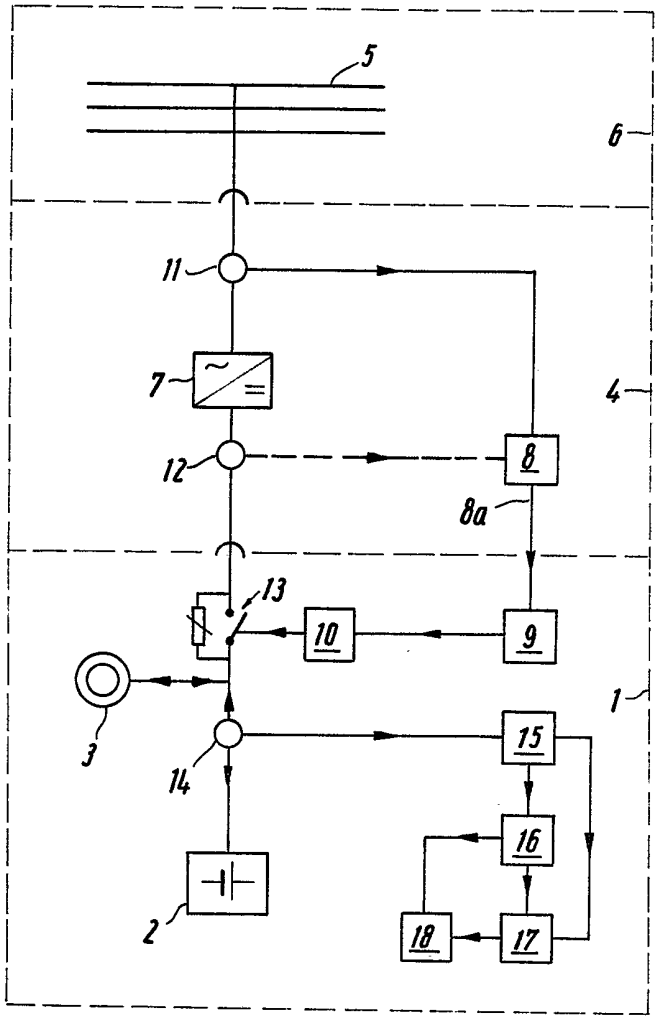

Fig. 2

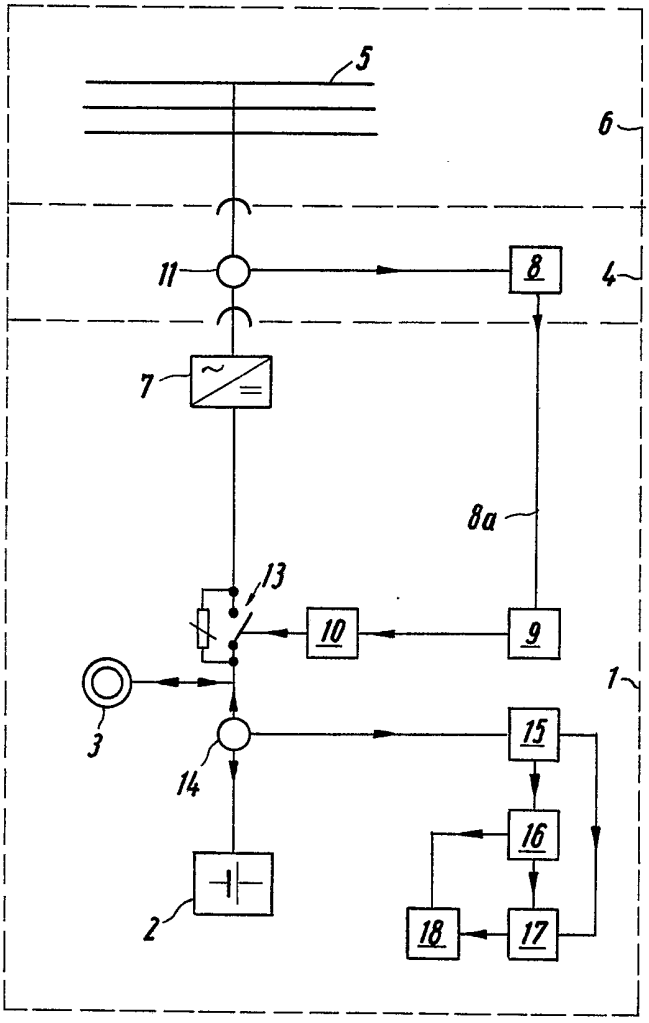

Fig. 3

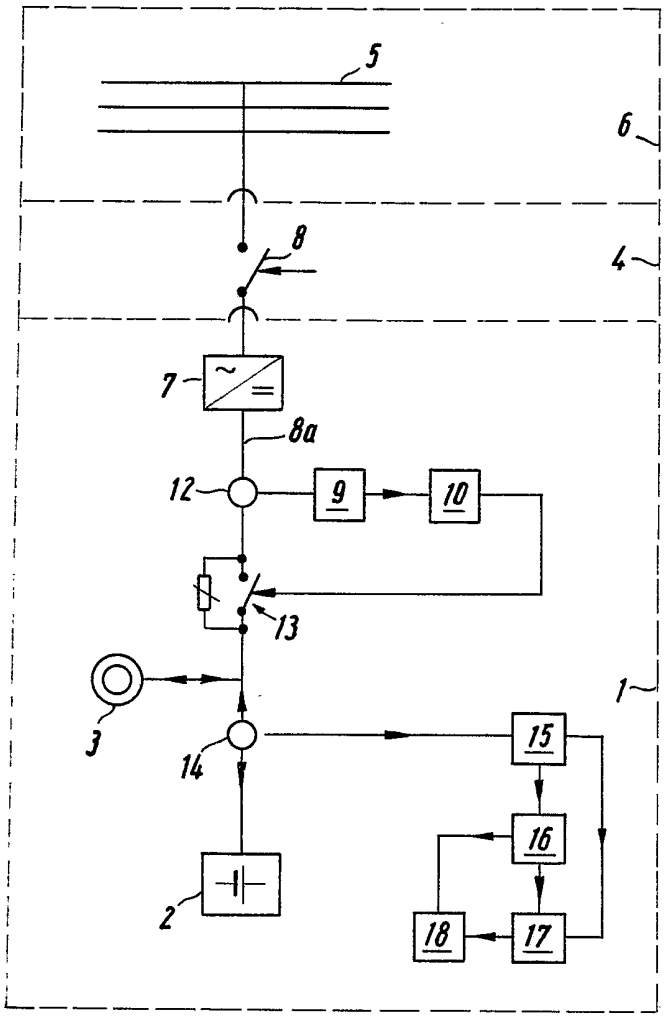

Fig. 4