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HIGH POWER LEAD/ACID BATTERIES

J. HOWLETT

Dunlop Batteries, Sandringham, Victoria 3191 (Australia)

The emergence of a new geometry lead/acid SLI battery (the "Pulsar") from Dunlop in Australia has changed a number of the rules associated with the specification of batteries in certain applications.

The very low impedance of this battery design allows pulses of very high power. As shown in Fig. 1, uniform current distribution is achieved by the copper strip moulded in the ends of the plastic frame which holds the electrode assembly. This, together with the short distance between the centre lines of each strip of electrode paste and the fact that intercell connection is achieved over the full height of the cell, allows maximum use of the specially developed high surface area of the active materials. The novel frame construction enables each strip of active material and the accompanying separator to be held securely in place. This arrangement

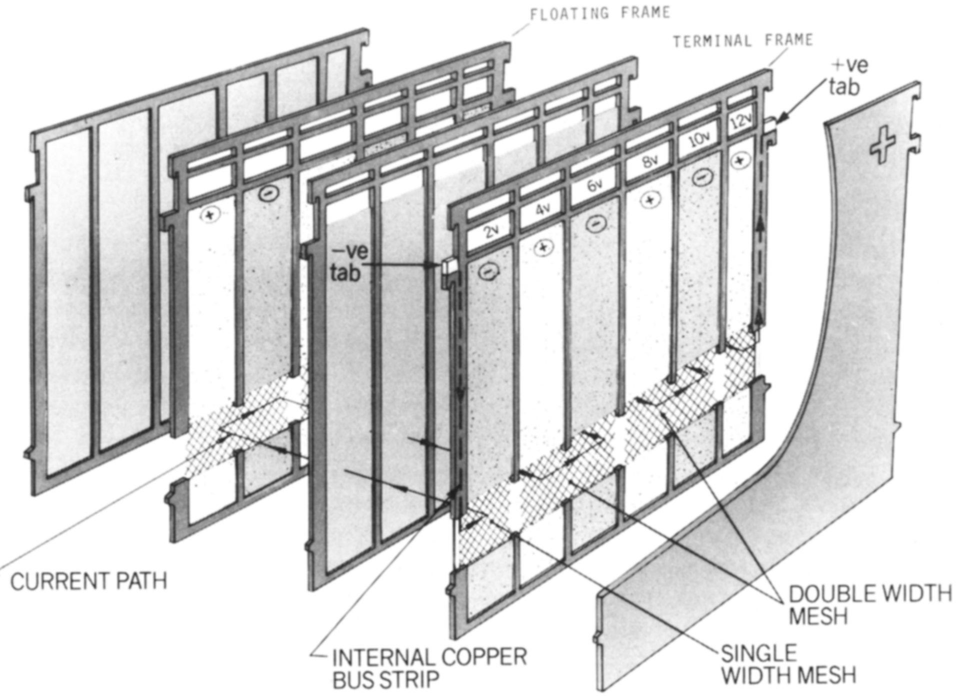

Fig. 1. Schematic view of Dunlop Pulsar lead/acid battery design showing one pair of electrode frames (terminal and floating) with separator between.

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minimizes movement caused by vibration and gives an increase in vibration life of almost two orders of magnitude.

The uniform distribution of current, and the active material coupled with non-antimonial current-collectors, enables the Dunlop Pulsar battery to accept recharge more efficiently and more rapidly than conventional batteries. When charged, these batteries stabilise at a float trickle charge of 500 μA per pair at 13.2 V and 25 °C. (Fig. 1 shows a pair of frames.)

Measurements on batteries under load show that for a unit of 10 pairs of frames, a peak current of 1350 A may be drawn to an end voltage of 10.3 V, *i.e.*, 13.9 kW. This battery weighs 9.6 kg, giving a pulse power density of 1448 W kg^{-1}. Conventional batteries which could give pulses of this order of power are generally around 100 A h at the 20 h rate, whereas the new battery is only 44 A h at this rate. The dilemma in the choice of battery type continues to face the specification engineer. The power demand for applications such as diesel-engine starting or circuit-breaker closing requires high-power initial pulses. For example, in the case of the diesel starter, a high-power demand is required for 300 ms until the first piston passes compression, when the current reduces to about fifty per cent. The new Dunlop battery is particularly suited to such high-power applications.

The new battery mentioned above will yield a cold-cranking performance identical to a conventional lead/acid battery of nine plates per cell, and about 60 A h (C_{20}). However, because of its lower impedance, it will crank six engines of 4-litre capacity simultaneously at 25 °C, whereas the conventional battery of the same cold-cranking rating will crank only three such engines. This increased power density available from the new battery is beneficial in the starting of large diesel trucks where low tare weight means higher pay-load. The weight difference of 55 kg between the conventional and the new design battery becomes a significant factor in the earning capacity of the truck throughout its lifetime.

A better understanding of the battery duty cycle will lead to a revision of battery testing methods and specifications. The principal of matched impedance, applied to the initial few milliseconds of power demand, calls for a knowledge of battery and starter or solenoid initial impedance. The impedance of the new battery is decreased by the addition of active-material pairs to the stack, so it is possible to construct the battery to match the starter motor or other load impedance without the high cost of moulding dies for containers and covers of conventional batteries.

It becomes possible to dedicate the new battery (or portion of this battery) to the starting function only, and by isolating this from the auxiliary services batteries with a power diode, the auxiliary loads may be accommodated without jeopardising the ability to start the engine. This logic may be applied to a number of other scenarios, such as circuit-breaker closing and emergency lighting batteries supplied by a common charging system.

Higher voltages supplied by the new batteries increase starter-motor speed and torque, resulting in a rapid acceleration of the engine's crankshaft to speeds above the minimum required for ignition, while supplying higher potential to the coil for a more energetic spark. The duration of these starting loads is seldom more than 5 s, especially when more rapid acceleration of the crankshaft gives a more certain start in either spark or compression ignition.

Starter motors range in size from 0.85 kW up to about 6 kW, with resistances of 4 - 18 mΩ for 12 V machines. This means that the initial current for the first 100 - 300 ms will be in the 550 - 2400 A range. The current demand is reduced as the motor accelerates, and rapidly reduces to half of the 'breakaway' and still further, when the engine fires and the starter load is removed. Prolonged starter operation at lower voltage, r.p.m., and torque, increases the resistive heating effects, and may damage the starter motor. This reinforces the necessity to review rating and test methods for starter batteries, enabling batteries to be economically matched to the duty for which they are chosen.

The work of Sadedin [1] in the operation of pulsed-current transformers producing MA currents for the operation of the electro-magnetic launcher, and the work of Ogilvie *et al.* [2], have shown some curious phenomena. During the first 2 ms of discharge into matched impedance, a very high current flows, reducing abruptly to a steady rate for the next 500 ms. The interpretation of this phenomenon needs to be studied. The time constant of this initial discharge indicates that for an electrolytic capacitor of about 0.4 F on both the 44 A h new battery and a 100 A h conventional 15-plate battery, these equalities extend to voltage at different lower rates of discharge and, indeed, to the same ability to crank six 4-litre engines. The inference can be made that this electrolytic capacitance reflects the magnitude of the reactive surface area of lead and lead dioxide active materials.

References

1 D. Sadedin, A power source for electro-magnetic launchers — based upon a pulsed transformer and batteries, Materials Research Laboratory, Defence Department, Australia, 1983.

2 G. Ogilvie, A. Schubert and P. Zemancheff, CSIRO Division of Manufacturing Technology, Australia, personal communication.