Frank O'Shanohun Associates Limited

Public Relations Consultants

47 REEVES MEWS, GROSVENOR SQUARE, LONDON W1

Telephone: Grosvenor 6040

BIOGRAPHICAL DETAILS OF
MR. F.T. BACON

Born 21.12.04

Educated at Eton College 1918-22
Cambridge University 1922-25
B.A. Mechanical Sciences Tripos 1925
M.A. 1946
A.M.I.Mech.E. 1947

1925-28	Served apprenticeship at C.A. Parsons & Co. Ltd., Heaton Works, Newcastle-on-Tyne.
1928-40	Worked in Searchlight Reflector Department and Development Department at Parsons. In charge of production of silvered glass reflectors 1935-39.
1940-41	Started full-time work on Hydrogen-Oxygen Cell at King's College, University of London, for Merz and McLellan.
1941-46	Temporary Experimental Officer at H.M. Anti-Submarine Experimental Establishment, Fairlie, Ayrshire. Work mainly in connection with ASDIC targets.
1946-56	Experimental work on Hydrogen-Oxygen Cell at Cambridge University, first in Department of Colloid Science, then in Department of Metallurgy, and since 1951 in the Department of Chemical Engineering.
1956-present	Consultant for National Research Department Corporation at Marshall of Cambridge; developing and building a unit developing about 5 kW., complete with all automatic controls.

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MAIN DATA

Power per unit volume (considering cell internal volume only)	10.7 KW per cu. ft.	(M)
Power per unit weight (cell pack only) ..	9.2 watts per lb.	(M)
Weight of hydrogen used per KW hour	0.112 lb.	(R)
Weight of oxygen used per KW hour	0.893 lb.	(R)
Volume (at N.T.P.) hydrogen used per KW hour	20 cu. ft.	(R)
Volume (at N.T.P.) oxygen used per KW hour ..	10 cu. ft.	(R)
Rate of condensate per KW hour	0.45 litre	(R)
Operating pressure	300-600 p.s.i.	
Operating temperature	200° C	
Electrolyte concentration, KOH	40% (1.4 specific gravity)	
Free energy efficiency	50% 65%	(M) (R)
Weight of gas storage (cryogenic) per KW hour	4 lb.	(R)
Weight of gas storage (cylinders) per KW hour	17.8 lb.	(R)
Energy per unit volume (traction batteries 5-hour rate) ..	1.5 KW hour per cu. ft	
Energy per unit weight (traction batteries 5-hour rate) ..	11.5 watt hour per lb.	

Rated output assumed at 0.8 v. per cell designated (R)

Maximum output assumed at 0.6 v. per cell designated (M)

NATIONAL RESEARCH DEVELOPMENT CORPORATION

PRESS VISIT TO

MARSHALL OF CAMBRIDGE ELECTRONICS LTD.

August 24th, 1959.

PROGRAMME

Monday, August 24.

9.07 a.m.	Depart King's Cross (Compartments have been reserved for the Party. Buffet car available).
10.41 a.m.	Arrive Cambridge. Met by coaches to convey Party to the Airport.
11 a.m.	Coffee and refreshments.
11.15 a.m.	Explanatory talk by the inventor, Mr. F.T. Bacon.
11.45 a.m.	Demonstration of the Fuel Cell.
12.30 p.m.	Coaches to University Arms Hotel
12.45 p.m.	Reception
13.15 p.m.	Luncheon
14.00 p.m.	Speeches and questions
14.45 p.m.	Coaches leave for Cambridge station.
15.15 p.m.	Depart Cambridge by train.
16.50 p.m.	Arrive King's Cross.

All Press enquiries to:

Frank O'Shanohun Associates Ltd.,
47, Reeves Mews, Grosvenor Square,
London, W.1.

Tele: GROsvenor 6040

THE FUEL CELL

For over a hundred years scientists have been endeavouring to produce a practical fuel cell. First envisaged in 1839 by Sir William Grove, a fuel cell - which converts chemical energy direct into electrical power - did actually work in 1899 but lack of suitable materials and technology prevented its further development. A great deal of work has, however, been done in many countries since the last war.

Now, a team working in Cambridge under the sponsorship of the National Research Development Corporation has produced a cell capable of giving an output of 5 kW. at 24 volts.

Ten years of original research were carried out at Cambridge University under the auspices of the Electrical Research Association and the Ministry of Power, before the National Research Development Corporation placed a development contract with Marshall of Cambridge in 1957. Mr. F.T. Bacon, M.A., A.M.I.Mech.E., who has been intimately associated with the project for 20 years, is head of a team carrying out development work at Marshall's, where the Hydrogen-Oxygen Cell has now become a reality and a practical commercial proposal. The Admiralty has also sponsored some of the work carried out by Bacon.

The fuel cell is an electro-chemical battery which can convert chemical energy direct into electrical energy. Briefly, it consists of a cell containing two electrodes immersed in a solution of caustic soda or potash. Hydrogen and oxygen are introduced into the porous electrodes of the cell as fuel and the reaction of their combining creates heat and electricity which appears as a voltage between the electrodes. From the electrodes the current is conducted away to provide power for whatever task is required to be performed.

Other methods of producing electricity rely on heat engines, such as steam turbines and petrol, or diesel engines - all burning fuel and, in turn, driving generators. These methods involve several steps before electrical power is produced and for this reason have a fairly restricted efficiency.

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The fuel cell, by the direct production of electricity in one stage, can achieve efficiencies of about 80% - several times better than that of conventional methods.

Applications of the fuel cell range literally from submarines to space vehicles. Rail traction is, for instance, an attractive proposal. An electric locomotive equipped with a fuel cell fed from containers of oxygen and hydrogen could operate over long distances. It would not need overhead wires or conductor rails. The fuel cell would produce its own electricity which could be used directly to drive the electric traction motors. Heavy tractors are another possibility, as are public service vehicles - trolley buses without the need of overhead wires and with their own self-contained power stations.

Applications for aircraft are also being considered and there is a promising field for the use of fuel cells as auxiliary power sources for rockets and space vehicles where lightness and endurance are required.

The United States have shown considerable interest in British developments in fuel cells and an American company - The Universal Winding Company - has already become a licensee of the National Research Development Corporation. The Patterson Moos Division of the Universal Winding Company has, using information provided by the N.R.D.C., already manufactured units of the Bacon type and delivered them to the United States Air Force.

Close technical liaison is being maintained between the United States company and the N.R.D.C. and the former is keeping the Corporation informed of the results of its own research and development. This should result in a general speeding up of the tempo of fuel cell development.

TECHNICAL NOTE

THE HYDROGEN-OXYGEN FUEL CELL

A "Fuel Cell" is an electro-chemical cell in which the free energy of combustion of a fuel is converted directly into electrical energy. The Hydrogen-Oxygen cell operates by a simple reversal of the process of electrolysis of water. Such a cell has many advantages over heat engine generators.

The largest battery evolved previously was one of six 5" diameter cells in series. The one now produced consists of 40 cells 10" diameter, giving an output of 2½ kW. at 32 volts (or 5 kW. at 24 volt max. load conditions), providing a power-source of useful application as will be shown at the demonstration. For this, a great many new technical problems have been solved, and automatic controls have been developed.

Each unit cell consists of two electrodes, one for hydrogen and the other for oxygen, separated by electrolyte. The electrodes are made of porous sintered nickel with a thin layer of a smaller pore size on the liquid side. The oxygen electrode is treated with lithium and pre-oxidised to prevent corrosion. The electrolyte is strong caustic potash, and working conditions are around 200^{o}C. and 400 p.s.i. The electrolyte soaks into the sintered metal but, on the application of the gas under pressure from the back of the plate, is expelled from the larger pores; the gas cannot bubble through the smaller-pored surface owing to the surface tension of the liquid. There is thus a very large surface of wetted sintered metal in contact with gas in <u>each</u> electrode - about forty square meters.

Oxygen molecules on the positive electrode combine with water to form negatively charged hydroxyl ions which each remove an electron from the oxygen electrode. The hydroxyl ions migrate through the electrolyte to the negative electrode.where they combine with the hydrogen to form water, depositing an electron in the process. Thus the hydrogen electrode becomes negatively charged with respect to the oxygen electrode and a current flows in the external circuit.

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In order to remove the water formed, the hydrogen is circulated past the back of the hydrogen electrodes and the mixture of hydrogen and steam is cooled externally, so that the condensate can be released as required.

Much work has been done on the control system, since the pressure of the two gases must be very evenly balanced if damage is to be avoided. The system now evolved is to keep the oxygen pressure constant and to control the hydrogen pressure against it by a very accurate differential pressure meter, actuating a power-operated inlet valve controlled by a servo-mechanism. Other problems of initial heating and subsequent cooling have also had to be solved.

As will be seen, the Hydrogen-Oxygen Cell has completed the second stage of development and is now approaching the commercial proposition of a completely automatic and reliable battery, capable of producing power at a moment's notice in a practical installation. In this sense, a Hydrogen-Oxygen Cell is an electrical accumulator - when the National Grid or the Nuclear Power Stations are running at less than optimum load, the surplus can be used for electrolysis to feed a Hydrogen-Oxygen Cell which could then be available as a source of auxiliary power.

It is unlikely, however, that the fuel cell battery could ever be competitive with existing types of accumulators in small sizes owing to the high cost of control gear in comparison with the overall cost of the plant. Power outputs of less than 100 watts are not likely to be economic.

Other advantages of this kind of fuel cell are that it is able to take large overloads at reduced efficiency without damage, it is silent and free from vibration in operation, it has very few moving parts and the "exhaust" is only water; moreover, the "charging" process would merely consist of refilling with the two gases, a very rapid process.

With the advent of new methods of storing hydrogen and oxygen, either in liquid form, or else in the former case as a compressed gas at a very low temperature, it would seem conceivable that vehicles could be propelled over really long distances with fuel cells; and in view of the rapid depletion of the world's oil supplies, the development of a practical fuel cell should be given a high priority.