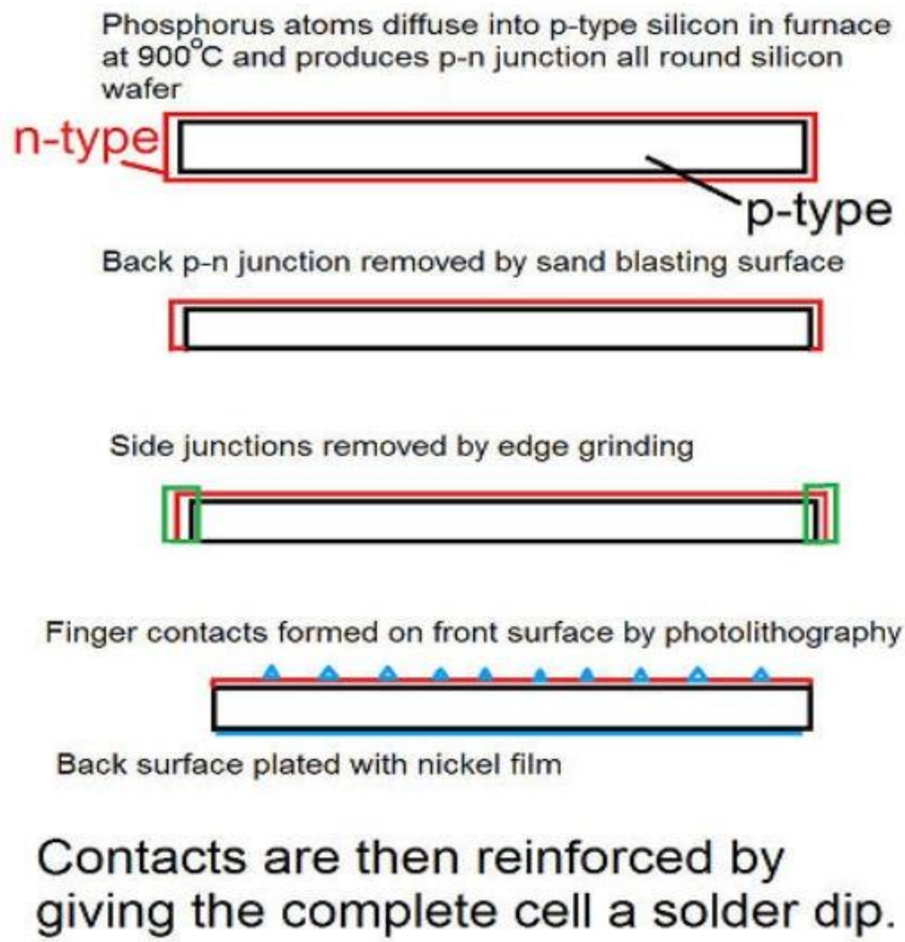
Photovoltaic cells – the Ferranti adventure

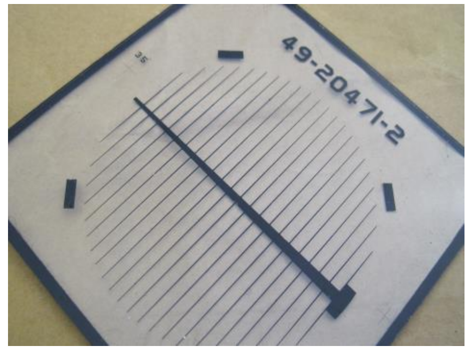
Generating electricity by sunlight conversion is one of several ways of producing "Green Energy" and the Photovoltaic (solar) cell, made typically from silicon, is central to the process. Crystalline silicon is a poor conductor of electricity and therefore is termed a "semi"-conductor. However, phosphorus impurity atoms make it a better conductor as this atom has FIVE outer electrons and only FOUR of these are needed for bonding. The "spare" electron is the current carrier. We call this material n-type silicon. In a similar way we can have impurity Boron atoms in the silicon which makes it a better conductor and this material is called p-type silicon. A p-n junction (i.e. a sandwich of the two materials) makes a solar cell.

Construction of an actual cell has two basic processes - produce a p-n junction and then make metallic contacts to the two areas. The Ferranti process followed a series of steps as follow:



The photolithographic process only involved one mask to define the finger contacts, (please see illustration below). This process starts with the cell being held firmly on a vacuum plate and then spun at about 1000 rpm. Two drops of photo-resist, placed at the centre, spreads out to give a uniform layer over the whole silicon wafer.

The cell, covered by the mask, is then exposed to Ultra Violet light.



After washing, a scrubbing brush removes the unexposed photo-resist material and then the whole cell is placed in a nickel solution so that electrode-less plating gives a metallic nickel film on the front "finger" formation and the back silicon surface. A dip in a large heated solder bath completes the final stage of fabrication with the solder adhering only to the nickel plated areas.

(It should be noted that in step ONE of the Ferranti process, a copious supply of Phosphorus atoms is present in the heated chamber. This comes from a phosphine/ hydrogen gas mixture and these atoms diffused into the silicon. The boron atoms, already in the p-type material, are outnumbered by Phosphorus atoms and therefore this diffusion changes an outer thin layer from p-type to n-type.)

In the late 1960's Ferranti commenced the production of cells for space craft. The voltage of a single cell is only about ½ volt so it is necessary to connect several cells in series to produce, say, a battery charger. The collection of cells is called a MODULE and therefore a solar electricity unit becomes an expensive item partly because of the cell cost but also the costs involved in making the interconnections and a framework necessary to support the cells. Clearly, space projects always have generous funding as the finished module has to be reliable and capable of withstanding the rigours of space. To replicate such power sources for "earth-use" is an uneconomic task and only a few stand alone generation units were produced for terrestrial applications in very isolated locations. An example of the unit used in the Everest expedition is given below:

286 ELECTRONICS & POWER MAY 1976

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ERA IMPROVES EFFICIENCY

Good results backed by improved operating efficiency are reported by ERA Ltd. in its annual report for 1975. Income totalled £1 717 469, an increase of £423 015 or 33% over the previous year, and an operating surplus of £72 384 was achieved compared with £27 102 for 1974, a rise from 2 to 4% of total income. These results were achieved without any significant increase in the number of ERA staff and represent an improvement in operating efficiency, even absorbing the 27% rise in employees' remuneration. Investment in new equipment was doubled, although the company did not require to increase its bank loan or to draw on other liquid resources.

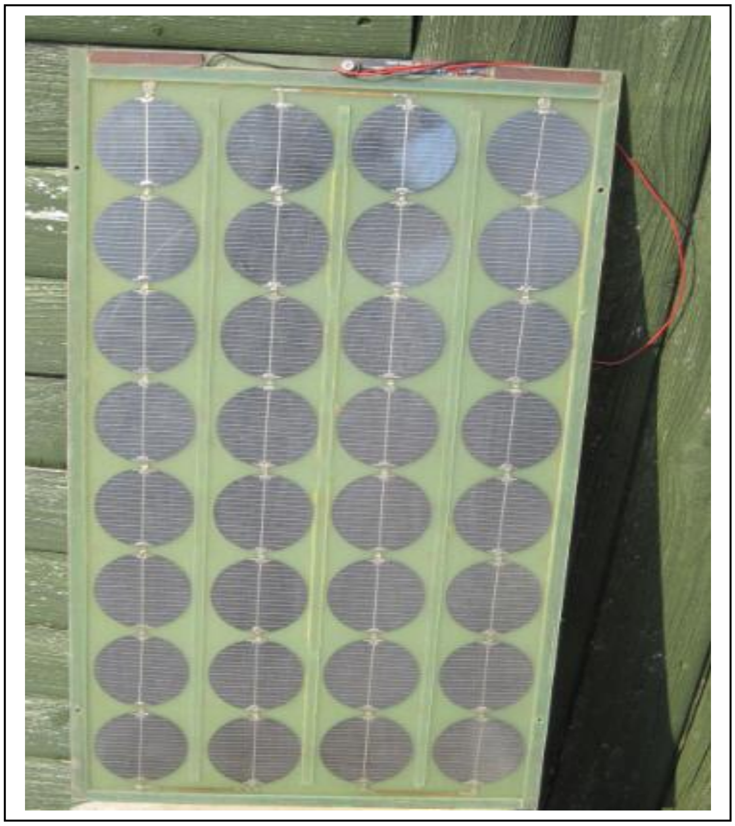
Overseas business continued to expand (from 13·5% of income in 1974 to 17·5% in 1975) and almost a third of members recruited in 1975 were based outside the UK. Joint activities were initiated with overseas organisations, notably the Illinois Institute of Technology Research Institute, Chicago; Laboratoire Centrale des Industries Electriques, Paris; and the Ontario Research Foundation,

Two Ferranti MST1000 solar-cell arrays charging the camera batteries of the BBC team that accompanied the successful 1975 British Everest expedition

More money for solar research?

In the late 1970's Ferranti felt that terrestrial solar energy may be a growth area and embarked on making modules which would be cost competitive for home use.
The basic cell production could not be changed greatly but the module costs needed to be reduced drastically for a solar unit to be reasonably priced. It was decided to use a fibre glass sheet to support the cells and a silica gel to hold each cell in position.

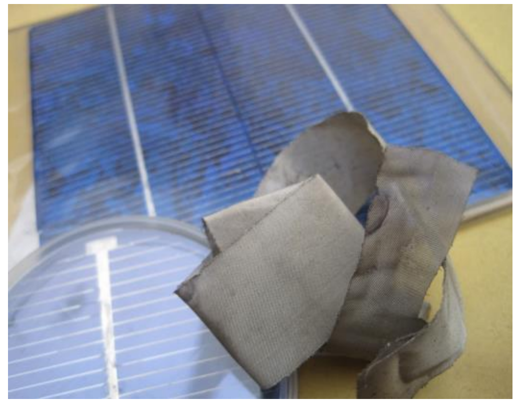
An example of one of the early modules is given:



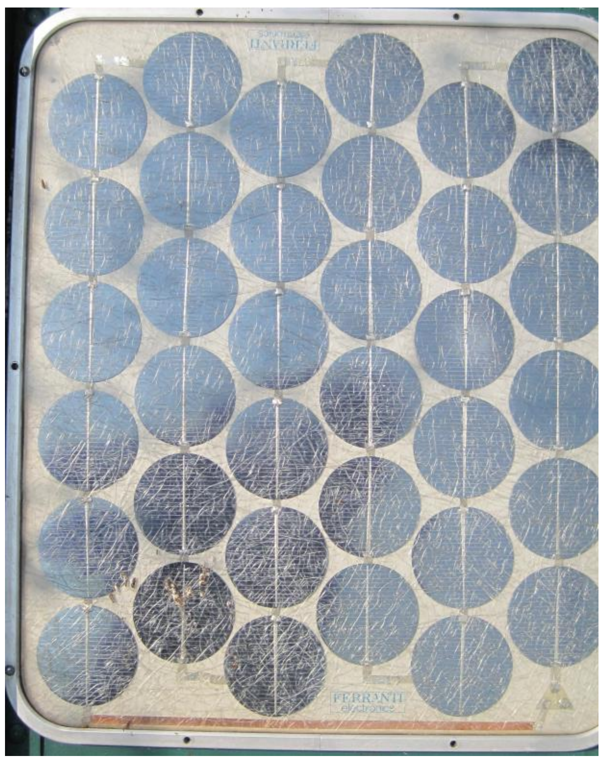
The colour of the base is immaterial but it was felt that GREEN was a most acceptable colour in rural locations. The silicon wafer diameter was 2 inch and the cells were 0.5 mm thick.
The interconnections were tinned metal tabs which were soldered from the reverse side of one cell to the front side of the next cell.
32 cells were used so that the module voltage was close to 16 volts
With the cells laid in position, the heated gel was poured onto the tray and solidified on cooling. The cells were totally immersed in the gel so giving them modest protection from the weather.
Trials of the module showed that the fibre glass base deformed too much in windy conditions and quite a number of interconnection links fractured. In tropical countries an unexpected problem arose; various species in the bird population took a liking to the gel and continuous pecking gave irreparable damage to the modules.

Although nothing changed with the cell manufacture other than and increase in wafer diameter to three inch, the module construction was significantly changed. An anodised aluminium base was employed to support the connected cells and a protective transparent screen was place in front of the cells. A silicone gel was injected into the cavity where the cells were positioned so maintaining their fixed positions. The structure was considerably more costly then the fibre glass model but it was felt to be environmentally very much more secure.

Another change involved the interconnection tabs. These were made from a nickel plated gauze as shown so that ANY flexing would not cause them to break. (A polycrystalline cell is included in the illustration to show that square cells are preferable to the round Ferranti cells for module fabrication in that the whole area can be covered with cells. Thus, all of the sunlight falling onto the module can be intercepted by cells.)

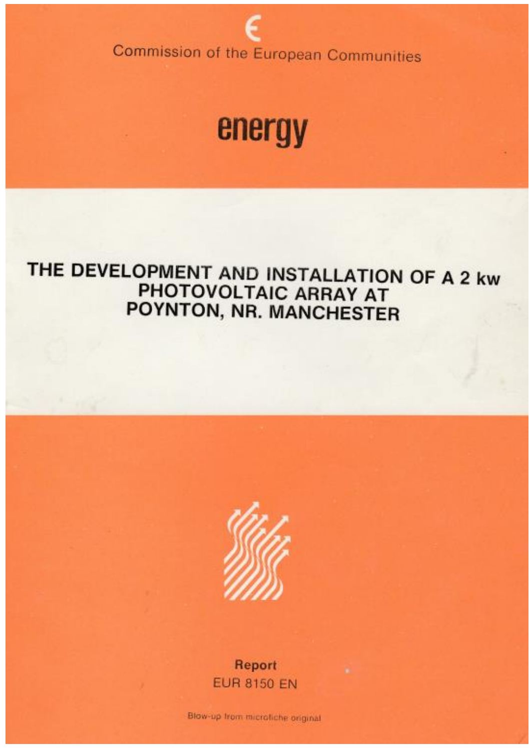


A finished Ferranti module is illustrated below and was designated as MST 300 .



This much improved module found a ready market for battery charging for (a) water pumps and electrical fencing on farms and (b) for those seeking leisure pursuits --- caravans, boats, etc. It was modest in output (about 10 W, though the specification gave 15 W) and relatively expensive to buy.. £250 per module. Production was labour intensive with cells being handled by operatives at each stage. A three inch diameter cell could be held relatively easily but it was anticipated that breakages would be common if a FOUR INCH DIAM. cell were to be introduced.

Acceptable sales and further successful trials with this module gave the Company confidence to apply for funding from the European Community in 1982.


Commission of the European Communities

energy

THE DEVELOPMENT AND INSTALLATION OF A 2 kw PHOTOVOLTAIC ARRAY AT POYNTON, NR. MANCHESTER

Report
EUR 8150 EN

Blow-up from microfiche original

The attractive feature with this project was that the Ferranti Poynton site was concerned with radar and microwave engineering. It was envisaged that the 2 kW array would power a radar system for remote sensing of missiles. Though the experimental work would be carried out at Poynton, the whole system could be transferred to remote sites in any part of the world and it would be completely mobile. Such missile detection systems were a very saleable item for defence departments all over the world.

In an array, the modules are connected in series chains which are then connected in parallel to give a desired output voltage. In the Poynton experiment this voltage was 108 V and the total array comprised of 114 modules.
Very early in the trials faults began to appear. The nickel plated gauze interconnection tabs had been cut with tin shears without due regard to the manner in which they were to be used. In some cases small wire fibres were observed to be pressing onto the anodised aluminium base and causing a short to earth. In single module trials (where typically 15 V potentials were present on the cells) the anodisation did provide sufficient insulation for electrical isolation but, with 120 V in the module array, breakdown occurred.

It is sad to report that the 2 kW power source did not ever function in a satisfactory manner and the European Commission were generous in that they never demanded repayment for this failed project.

Shortly after the event the Ferranti Company discontinued the manufacture of all of their discrete devices (including PV cells) in order to concentrate on their production of integrated circuit devices.

Any success in this area was short lived and Ferranti ceased to be a viable company in the early 1990's

Acquisition of International Signal & Control

In 1987 Ferranti purchased International Signal and Control (ISC), a US defence contractor based in Pennsylvania. The company subsequently changed its name to **Ferranti International plc.** and restructured the combined business into the following divisions: Ferranti Computer Systems, Ferranti Defence Systems, Ferranti Dynamics, Ferranti Satcomms, Ferranti Telecoms, Ferranti Technologies and International Signal & Control.

Unknown to Ferranti, ISC's business primarily consisted of illegal arms sales started at the behest of various US clandestine organizations. On paper the company looked to be extremely profitable on sales of high-priced "above board" items, but in fact these profits were essentially non-existent. With the sale to Ferranti all illegal sales ended immediately, leaving the company with no obvious cash flow.

In 1989 the UK's Serious Fraud Office started criminal investigation regarding alleged massive fraud at ISC. In December 1991 James Guerin, founder of ISC and co-Chairman of the merged company, pleaded guilty before the federal court in Philadelphia to fraud committed both in the USA and UK. All offences which would have formed part of any UK prosecution were encompassed by the US trial and as such no UK trial proceeded.

Collapse

The financial and legal difficulties that resulted forced Ferranti into bankruptcy in December 1993.

Postscript
A helpful video is available from the University of Delaware