

# Solar Powered Hydrogen Generating Facility and Hydrogen Powered Vehicle Fleet

Technical Progress Report for the period  
January 1, 1995--March 31, 1995

James J. Provenzano  
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1222 Lincoln Boulevard  
Santa Monica, CA 90401

April, 1995

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PREPARED FOR THE UNITED STATES  
DEPARTMENT OF ENERGY

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## **Technical Progress Report #3**

- 1. INSTRUMENT NO.:** DE-FC36-94GO10039
  
- 2. PROJECT TITLE:** Solar Powered Hydrogen Generating Facility And Hydrogen Powered Vehicle Fleet
  
- 3. REPORTING PERIOD:** January 1, 1995 through March 31, 1995
  
- 4. NAME AND ADDRESS:** Clean Air Now  
Project Office  
1222 Lincoln Boulevard  
Santa Monica, CA 90401  
(310) 394-1214
  
- 5. PROJECT START DATE:** August 11, 1994
  
- 6. COMPLETION DATE:** September 10, 1995

## **DISCLAIMER**

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## **7. APPROACH CHANGES:**

1. (Clarification of item 7.2 of Technical Progress Report #2): By isolating the entire hydrogen generation system from the electrical grid we avoided the need for a rectifier and interface electrical equipment. These savings were applied to the added cost of the addition of the high pressure receiver (5,000 psi.), off-grid batteries, and two inverters to run the AC compressor and to control the current. Isolating the system from the grid has caused The Electrolyser Corporation to incur additional costs that they are willing to absorb.

## **8. PERFORMANCE VARIANCES, ACCOMPLISHMENTS, OR PROBLEMS:**

1. The Project proceeded generally according to schedule, with most of the activity directed at the procurement of materials, initiation of equipment fabrication by the subcontractors, discussion and direction of sub-tasks in partners' scope of work, and the development of educational materials.
2. The first vehicle retrofit was completed in March 1995 on schedule, and prepared for delivery to DOE's/Rocketdyne's Energy Technology Engineering Center (ETEC) for Safety Analysis.
3. An overall systems design and integration review was held on February 15 with all the Project's partners. The Electrolyser Corp. (TEC) gave a presentation on the electrolysis sub-system and received approval to proceed with the final drawings to be submitted to Clean Air Now. The truck's fuel and filling systems were updated with minor changes (See item 11-1). Safety analysis was reviewed. Representatives from Xerox were present to concur with the design and safety activities. Xerox, supporting our earlier decision, presented a strong view that deionized water is appropriate for our electrolysis installation (vs. RO). Before going for permits Xerox will go through its internal plan check procedures in early 2nd quarter. From this meeting work statements were "firmed up".

4. Engineering drawings and specifications (See item 11-2) were received from TEC and a review by the Project Manager and Project Engineer was completed. After changes were made the package was forwarded to the install contractor Matrix Construction and Engineering for use in obtaining Xerox' approval and city permits. The expected completion date of installation still remains August 31, 1995.
5. Discussions continued with the University of California Riverside's College of Engineering - Center for Environmental Research and Technologies (CE-CERT) and ETEC regarding the hydrogen truck's engine performance testing, emissions testing, and safety analysis of all Project systems. Final definition of the Safety Analysis of the truck and systems was reached. ETEC's Test Plan, Safety Analysis Review, and Final Report on the 1st truck will be included in the 2nd quarter progress report(See item 11-3). This work will be performed under a CRADA between ETEC and Clean Air Now, outside TRP funding, and applied towards co-funding. CE-CERT is working on control house design and instrumentation.
6. Managing Director James Provenzano, formerly of Xerox, presented a paper on the Project at the National Hydrogen Association Annual Meeting and Technology Conference, March 7-9, 1995, in Washington, D.C..The corporate perspective was addressed on the impetus to participate in a non-core business project such as this. This is the largest hydrogen demonstration project currently in progress in the country and as such received much interest. The paper will be included with next quarters report.
7. CAN's Executive Director Paul Staples and Project Engineer Dr. Paul Scott of Touchstone Technology visited Solar Engineering Applications Corporation (SEA) in Santa Clara, CA in March to discuss the progress of the photovoltaic array. No delays were determined at that meeting.
8. Clean Air Now showcased its first Xerox Maintenance hydrogen powered truck at the 1995 U.S. DOE Clean Air Road Rally on March 30 and April 1, 1995 at the Los Angeles Zoo. The truck and some of the Project partners were exposed to the press and other interested parties. Due to the lack of safety analysis at that time the truck was a static display. The DOE's Assistant Secretary fro Energy Efficiency and Renewable Energy Christine Ervin viewed the truck and discussed its unique aspects with Clean Air Now personnel (See item 11-8).

## **9. OPEN ITEMS:**

1. Remaining required cofunding documentation is included with this report (See items 11-4-6).

## **10. STATUS ASSESSMENT AND FORECAST:**

1. As stated above, the installation of all the capital equipment is planned to be completed on schedule. Due to the limited time between install completion (Aug. 31, 1995) and Project completion (Sept. 10, 1995) it is anticipated that we will need to ask for an extension of the Final Technical Report filing date, in order to provide time to obtain sufficient project data. Taking ETEC's schedule under consideration, December 1995 is a more realistic target date for Final Technical Report submission. ETEC has agreed to a Nov. 1, 1995 submittal date for their final documents. This will be discussed further in the coming months.
2. It is anticipated that ETEC's scope of work will have to be adjusted in order for Clean Air Now to contract with UCR to perform the vehicles' performance evaluation and emissions testing. This is due to ETEC's contractual procedural constraints and lack of necessary on-site equipment to complete such tasks. This will be discussed more fully in the next report.

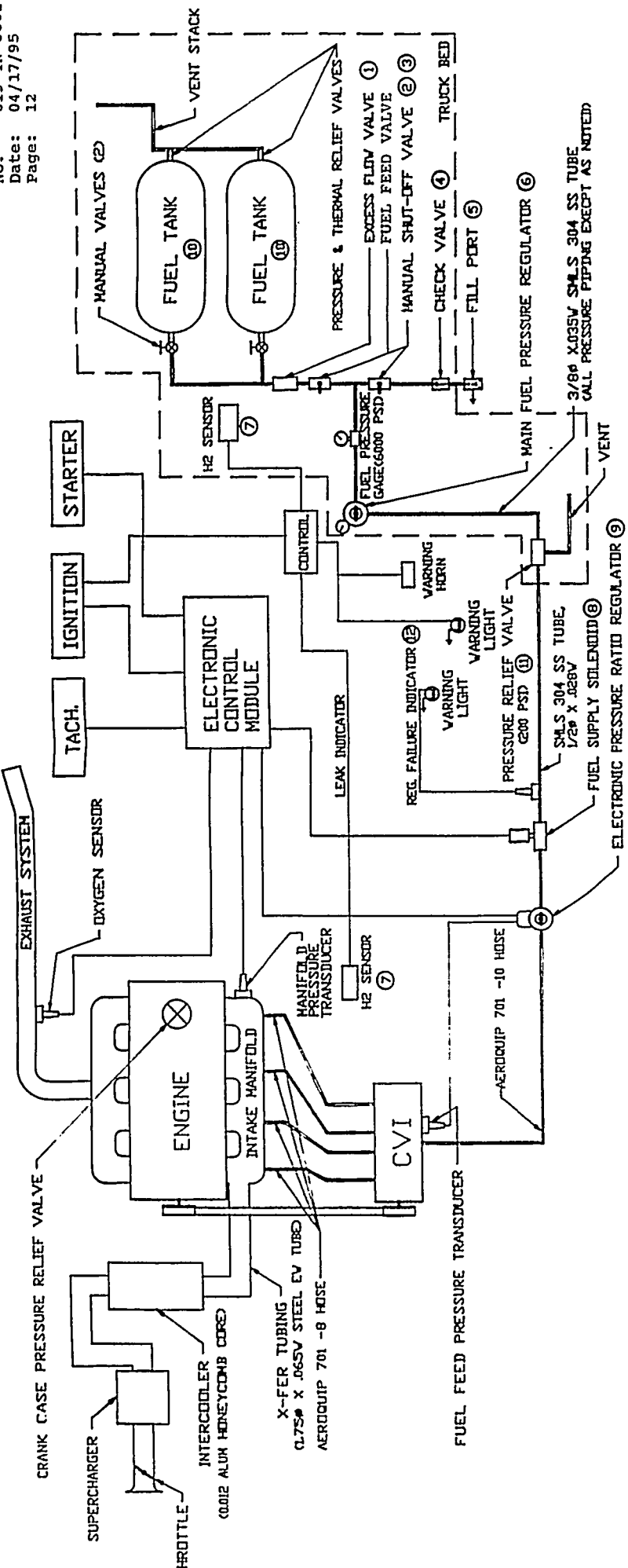
**11. DESCRIPTION OF ATTACHMENTS:**

1. Hydrogen Truck Fuel System Schematic.
2. TEC's and SEA's Draft Specifications for Construction at Site for <Project>.
3. ETEC's schedule for Truck Testing and Safety Analysis.
4. SEA Corporation's co-fund documentation.
5. The Electrolyser Corporation's co-fund documentation.
6. The City of West Hollywood's co-fund documentation.
7. Letter of interest from Cabazon Tribe to further develop the hydrogen infrastructure in California with Clean Air Now.
8. Follow-up letter to DOE Assistant Secretary Christine Ervin post Los Angeles DOE Clean Air Road Rally.
9. March 19, 1995 LA Times article on hydrogen.
10. 1st Quarter '95 Project Financial Report.
11. Project Contact List as of 4/1/95. (This list excludes the US DOE & South Coast Air Quality Management District contacts.)

**12. SIGNATURE OF RECIPIENT AND DATE:**

*James J. Brennan* 5/16/95

**13. SIGNATURE OF DOE REVIEWING REPRESENTATIVE AND DATE:**



**NOTES:**

**E.C.M. SEQUENCING START-UP:**

1. IGN. SV. --- ON
2. ENGINE CRANKING, .5 SEC. approx
3. IGN. SYS. --- ON (CRANKING)
4. FUEL --- ON TILL START

**E.C.M. SEQUENCING SHUT-DOWN**

1. IGN. SV. --- OFF
2. FUEL --- OFF
3. ENGINE SPEED < 100 RPM
4. IGN. SYSTEM --- OFF

**COMPONENT SPEC.**

- 1 CHEM-TECH EFV-250KB494 (ZERO FLOW IN CLOSED POS)
- 2 NUPRO B-4P4T4
- 3 WHITEY SS83K56
- 4 NUPRO SS00CS6-1 DOUBLE CHECK
- 5 STANDARD CGA-350 CONNECTOR
- 6 TESCOH 20-1032-2915 REGULATOR (125PSI MAX. OUT)
- 7 CCI CONTROLS 7707 H2 DETECTOR
- 8 ADVANCED FUEL COMPONENTS MODEL 121 SOLENOID VALVE
- 9 NORGREEN 11-008-130 REGULATOR (400 PSI MAX. IN) BUZMATIC SPCIR-05-0A100-S12 DOME LOADER
- 10 COMDYNE 85710020 AF TANK (3.704 CUFT. VOL) ALUM./FIBERGLAS. 3600 PSI RATED (NGV-2)
- 11 200 PSI RELIEF VALVE (APPROX. 0.25SQ IN FLOW AREA)
- 12 T.I. KLIXON 20PS SERIES SWITCH, 3500PSI BURST U.L. RECOGNISED FILE SA99D CSA CERTIFIED FILE LR2482D

**OPTIONAL SOLENOID OPERATED EMERGENCY FUEL CUT-OFF SYSTEM CONTROL LOGIC**

	IGN. SV	PR. SV.	OPEN	PR. SV.	OPEN	PR. SV.	CLOSED	IGN. SV	PR. SV.	OPEN	PR. SV.	CLOSED
ON	X											
OFF		X										
E.M. VALVE			X								X	

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	IGN. SV	PR. SV.	OPEN	PR. SV.	OPEN	PR. SV.	CLOSED	IGN. SV	PR. SV.	OPEN	PR. SV.	CLOSED
ON	X											
OFF		X										
E.M. VALVE			X								X	

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Figure 1.  
 Fuel System Schematic

ADVANCED MACHINING DYNAMICS	
TOLERANCES: .XX ± .010 .XXX ± .005 FRACT. ± 1/64 ANGLE ± .5 EXCEPT AS NOTED	TITLE FUEL SYSTEM SCHEMATIC
REV.	DATE 2-26-95
FIN.	DATE
HEAT TREAT	MATERIAL SPEC.
DWG. NUMBER	APPLICATION
H28 SYS	XEROX-CANI H2 FUELED FORD RANGER

**Draft Specification for Construction at Site for Xerox/CAN!  
Solar Hydrogen Demonstration in El Segundo CA  
(Date: March 21, 1995)**

This document outlines construction work to be performed at Xerox El Segundo to install a 50 kW **UNICELL-CLUSTER™** Hydrogen gas generator and high pressure storage system for the Xerox/CAN Solar Hydrogen demonstration.

The work description is broken down into tasks. For each task the principle performer(s) of the work and principle material supplier(s) are identified. The following short forms have are used to refer to the different performers: TEC-The Electrolyser Corporation, UCR-University of California Riverside, Xerox/CAN-Xerox Clean Air Now! Project Team, SEA-Solar Engineering Applications Corporation, and Contractor-Matrix Engineering.

Ref. Drawings        EXISTING SITE LAYOUT (TEC DWG: 2076-D-016)  
                         PROPOSED SITE LAYOUT (TEC DWG: 2076-D-017/8)  
                         OUTLINE & MOUNTING LAYOUT, GEN IV (SEA DWG: 10446)  
                         BUS BAR MOUNTING GEN IV (SEA DWG:10450)

are attached.

## **Work Description**

### **Task 1        General Site Construction:**

#### **Sub-Task 1.1:        Removal of Existing Perimeter Fence**

- Work to be performed by Contractor
- Material to be supplied by Contractor

Referring to the Existing Site Layout the fence enclosing the existing fuelling station will be partially removed along the northeast boundary and entirely removed along the south east boundary. Fencing materials will be saved to be used in building the new perimeter fence.

#### **Sub-Task 1.2:        Installation of New Perimeter Fence**

- Work to be performed by Contractor
- Materials to be supplied by Contractor

Referring to the Proposed Site Layout a new fence will be erected of the same type and height as the old fence. The new fence will run along the north boundary , east boundary and along the south boundary to where it joins the existing fence. The fence will be of the same height ( 8') and fabric (chain link) as the existing fence using the same type of line

posts (2 7/8"). The fence will include a 12' sliding gate close to the north-east corner of the site as indicated on the Proposed Site Layout.

**Sub-Task 1.3: Installation of Operator's Cabana**

- Work to be performed by UCR/TEC and portable structure supplier
- Materials to be supplied by UCR/TEC and portable structure supplier

TEC/UCR will arrange the construction and delivery of a portable structure which will be the filling station office and which will house the process monitoring computer. The building, to be supplied locally, will be located as indicated in the Proposed Site Layout, and will be similar to that shown in the attached component data. The building will be of wood frame construction, Pentagon shaped, 8' per side, with overhang (16"), and will have windows on four sides. The structure will be delivered pre-wired with lights, flooring and ready to furnish. No foundation will be required. The need for air conditioning/heating systems in the building will be investigated by UCR.

**Sub-Task 1.4: Electrical Power & Telephone Line to Operator's Cabana**

- Work to be performed by Xerox/CAN
- Materials to be supplied by Xerox/CAN

Power (120V/30 amps) and a telephone line will be supplied to the main junction box at the cabana.

**Sub-Task 1.5: Installation of Feedwater Treatment Station**

- Work to be performed by UCR/TEC and water chemical supply company.
- Materials to be supplied by UCR/TEC

TEC/UCR will arrange the supply and installation of the Feedwater Treatment Station from a local water chemical supplier. The Feedwater Treatment Station will be located directly behind the Operator's Cabana and will consist of a deionizer bed, and electrically driven circulation pump. The water treatment equipment must be accessible to outside personnel who will be contracted to maintain the equipment, regenerate de-ionizer beds etc. An enclosure for the water treatment equipment will be supplied by TEC.

**Sub-Task 1.6: Water Supply to Feedwater Treatment Station**

- Work to be performed by Xerox/CAN
- Materials to be supplied by Xerox/CAN

Xerox/CANI will supply water to the Feedwater Treatment Station (min line flow rate 20 litre/h).

**Sub-Task 1.7: Installation of "New Jersey" Pylons**

- Work to be performed by Contractor
- Materials to be supplied by Contractor

Removable post barricades similar to the type used to protect the storage area will be erected, at positions indicated in the Proposed Site Layout, protecting the high pressure gas line and blocking vehicle access to the Electrolysis Module. The separation distance between pylons will be the same as pylons surrounding the existing gas storage ( approx. 4 1/2').

**Task 2 : Installation of Photovoltaic Power System**

The total number of panels to be supplied by SEA will depend on results of future performance tests. The number of panels may vary between 37 and 40. The position of the three additional panels are identified by dotted outline in the Proposed Site Layout. The panels will be configured in two groups. A group of 6-8 panels will be pre-configured to supply high voltage, 180 V DC, to power the compressor motor and associated controls. A group of Low Voltage, GEN IV, PV panels will supply power to the electrolysis cell bank. The low-voltage panels will occupy the areas east and north of the electrolysis house.

**Sub-Task 2.1: Installation of PV Panel Frames**

- Work to be performed by Contractor
- Materials to be supplied by SEA.

The PV modules sit in PV panel frames. The assembly of the PV panel frame is shown in SEA Drawing: OUTLINE AND BUS BAR MOUNTING GEN IV. The PV panel frames will be positioned as shown in the Proposed Site Layout, in rows, 20 ' apart. The panels will be bolted to 3' screw anchors, detail given in attached component data sheets. The anchors must be installed by the contractor before July 15. After the anchors are installed the PV panel frames can be bolted to the anchors. The contractor will install frames. Information on screw anchors is provided in attached component data. PV panel frames and anchors will be supplied by SEA.

**Sub-Task 2.2: Installation of Low Voltage Bus Bar**

- Work to be performed by Contractor

- Materials to be supplied by TEC.

The low voltage bus bar connects the low voltage PV modules to the electrolysis cell bank bus bar. The main bus bar runs are showed in the Proposed Site Layout. The bus bar will be supported on Unistrut Post Bases (Type P 2073 A) as outlined in Support Detail-1. Further information on Unistrut post bases are given in the attached component data. Main bus bar runs will be coated in "shrink-wrap". The installation of the bus bar to the panel will be as shown in BUS BAR MOUNTING GEN IV. All bus bar runs will be installed by the Contractor before the PV modules are connected to the bus bar.

### **Sub-Task 2.3: Installation of High Voltage Cable**

- Work to be performed by Contractor
- Materials to be supplied by SEA Corp.

The high voltage cable connects the high voltage panels to the electrical control room of the Electrolysis Module. The cable will run inside a conduit supported by Unistrut Post Bases (Type P 2072A) as outlined in Support Detail-3 and to be supplied by TEC. The conduit will run between the two panel rows. The bases will be mounted 5 feet apart. The post bases will be installed by the Contractor. The cable will be grounded to the high pressure gas line which in turn is connected to the common ground (Praxair) at the gas storage site.

### **Sub-Task 2.4: Electrical Connection of Low Voltage Bus Bar to Electrolysis Cell Bank**

- Work to be performed by TEC
- Materials to be supplied by TEC.

The low voltage bus bar will be connected to the electrolysis cell bank by TEC.

### **Sub-Task 2.5: Electrical Connection of High Voltage Cable to Compressor Power System**

- Work to be performed by Contractor
- Materials to be supplied by SEA

The high voltage cable will be connected to the PV modules using the connector supplied by SEA. The cable will run in conduit in between the panels where connections from each panel (#4 wire) will be pulled into the main cable

**Sub-Task 2.5: Installation of PV Modules**

- Work to be performed by Contractor
- Materials to be supplied by SEA

Details of the mounting of bus bar on the PV panel frames is outlined in SEA drawing BUS BAR MOUNTING GEN IV. SEA will install modules and will make electrical connections between modules and bus bars.

**Task 3: Installation of UNICELL-CLUSTER™ Electrolysis Module**

The electrolysis cell bank, compressor, associated power system and controls will be packaged in a single container 40' long by 8' wide by 8' high and will be delivered to the site on a flat bed trailer. The Electrolysis Module will be equipped with lifting lugs. The estimated weight of the unit is 32,000 lb.

**Sub-Task 3.1: Foundation and Erection of Electrolysis Module**

- Work to be performed by Contractor
- Materials to be supplied by SEA

The unit will be installed on a concrete pad 41'x9'x12" and will be anchored at 4 points.

**Sub-Task 3.2: Feedwater Piping from Operator Cabana to Electrolysis Module**

- Work to be performed by Contractor
- Materials to be supplied by SEA

Feedwater will be piped from the feed water treatment station to the Electrolysis Module following the route shown in the Proposed Site Layout. The pipe will be constructed of PVC or equivalent and will travel underground from the Feed Water Treatment Station behind the Operator's Cabana to the edge of the PV field. From the edge of the PV field the water line will be supported by the posts (Support Detail-3) carrying the high voltage line and data link line to the Electrolysis Module.

**Sub-Task 3.3: Data link line between Operator Cabana and Electrolysis Module**

- Work to be performed by Contractor
- RS-485 cable to be supplied by TEC/ Cable supports to be supplied by TEC

The data link line will be strapped to the same support posts that carry the feedwater

pipng. The cable will be supported on post bases (Unistrut P 2072 A) positioned with five foot separation. See Support Detail-3 The bases will be bolted into the pavement according to the pattern shown in the Unistrut product description in the attached component data.

**Sub-Task 3.4: Installation of Piping Run from Electrolysis Module to High Pressure Gas Drier and Storage**

- Work to be performed by Contractor
- Materials to be supplied by Contractor

Piping from the discharge of the compressor will run with the main bus and will be attached to the same supporting posts (Support Detail-1). The piping will run north to the last row of PV panels. From there it will run with the instrumentation cable to the high pressure drier. Pipe connections to the compressor will be threaded stainless steel pipe unions supplied by TEC; socket welded to the pipe. All piping will be welded 1/2 " Schedule 80 stainless steel pipe tested for an operating pressure of 5000 psi.

**Task 4: Installation of High Pressure Gas Drier and Storage System**

The drier unit will be a single tower desiccant bed unit built into a skid along with a junction box for accepting the instrumentation cable and for power distribution to the instrumentation. There will be two pressure transducers on the gas storage and a dew-point meter at the gas drier. The pressure vessel will be 1 ft in diameter and approximately ten feet high. The gas drier will be located in between the existing low pressure storage and the high pressure storage supplied by TEC. The gas drier and storage will have been pressure tested prior to shipment to site. Test documentation will be delivered with equipment.

**Sub-Task 4.1: Installation of the Gas Drier**

- Work to be performed by Contractor
- Materials to be supplied by TEC.

The gas drier skid will be located on a concrete pad on the inlet to the gas storage vessels between the existing low pressure storage and the high pressure storage supplied by TEC. The skid will be mounted on four anchors (1" studs) and will have a footprint approximately 4'x4'.

**Sub-Task 4.2: Piping Connections to Gas Drier**

- Work to be performed by Contractor

- Materials to be supplied by SEA

The inlet to the drier will be connected to the pipe from the Electrolysis Module. The outlet pipe will be connected to the adjacent high pressure gas storage. Both connections will use socket welded stainless steel unions rated for 5000 psi operating pressure.

#### **Sub-Task 4.3: Instrumentation Cable to Gas Drier**

- Work to be performed by Xerox/CAN
- Cable to be supplied by TEC/ All other materials to be supplied by Contractor

Power to instrumentation will come from the electrolysis module through an instrumentation cable to be supplied by TEC. The instrumentation cable will run along the bus bar supports through the middle of the array and then along the piping run behind the last row of PV panels. With the high pressure piping it will travel underground to the high pressure gas drier and storage unit.

#### **Sub-Task 4.4: Installation of High Pressure Gas Storage**

- Work to be performed by Contractor
- Materials to be supplied by TEC

The two high pressure vessels will be packaged as a standard ASME unit (see attached data sheets) measuring approximately 30' long, 4' wide and 2' high. It will be mounted on two concrete pads to be poured by the Contractor. The unit will weigh approximately 13000 lb. The assembly will be bolted to two floating concrete pads by 1" studs/four anchors per I-beam (total of 8 for whole assembly). The exact mounting pattern will be supplied later. The unit will be delivered to site pre-piped with priority fill manifold.

#### **Task 5: Modifications to Dispenser**

The filling station operator will have the option to select between the existing low pressure storage or the high pressure storage by turning two three-way valves at a piping junction to be located at the point which the pipe goes into the ground to travel to the dispensing island.

The high pressure gas storage system will be operated as a cascaded system. When filling a vehicle from the high pressure gas storage the operator will turn a three-way valve at the dispenser to draw from the low pressure receiver first and then from the high pressure receiver.

### **Sub-Task 5.1: Piping Connection to Dispenser**

- Work to be performed by Contractor
- Flow control components to be supplied by TEC. Piping to be supplied by Contractor

The high pressure storage vessels will have separate outlet pipes which will run from the south end of the pressure vessels, above ground, along the base of the existing low pressure storage. The gas lines will be connected to the two existing lines which run from the two banks of low pressure receivers to the dispenser. (photo of location attached) A three way valve on each line will switch between the high pressure vessels and the existing low pressure storage. A non-return valve will be installed on each supply line (four non-return valves in total)

### **Sub-Task 5.2: Modification to Dispenser Controls:**

- Work to be performed by Contractor
- Flow control components to be supplied by TEC/piping to be supplied by Contractor

Modifications to dispenser will include the following:

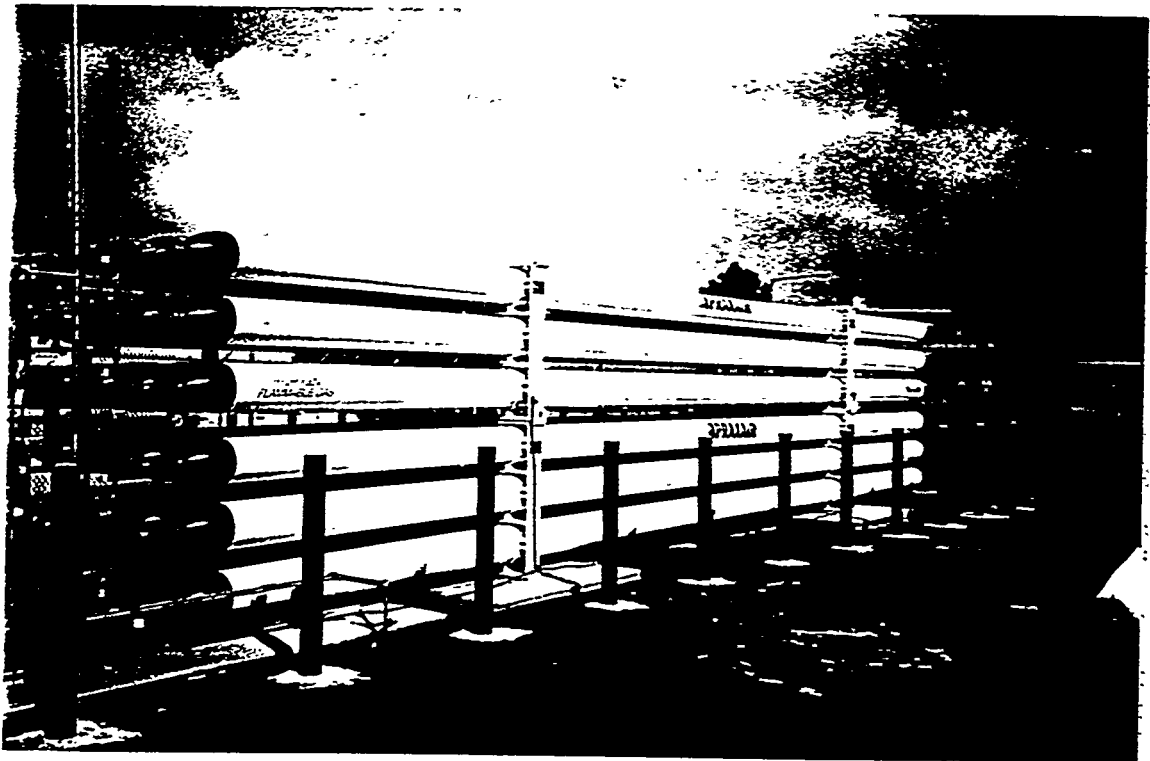
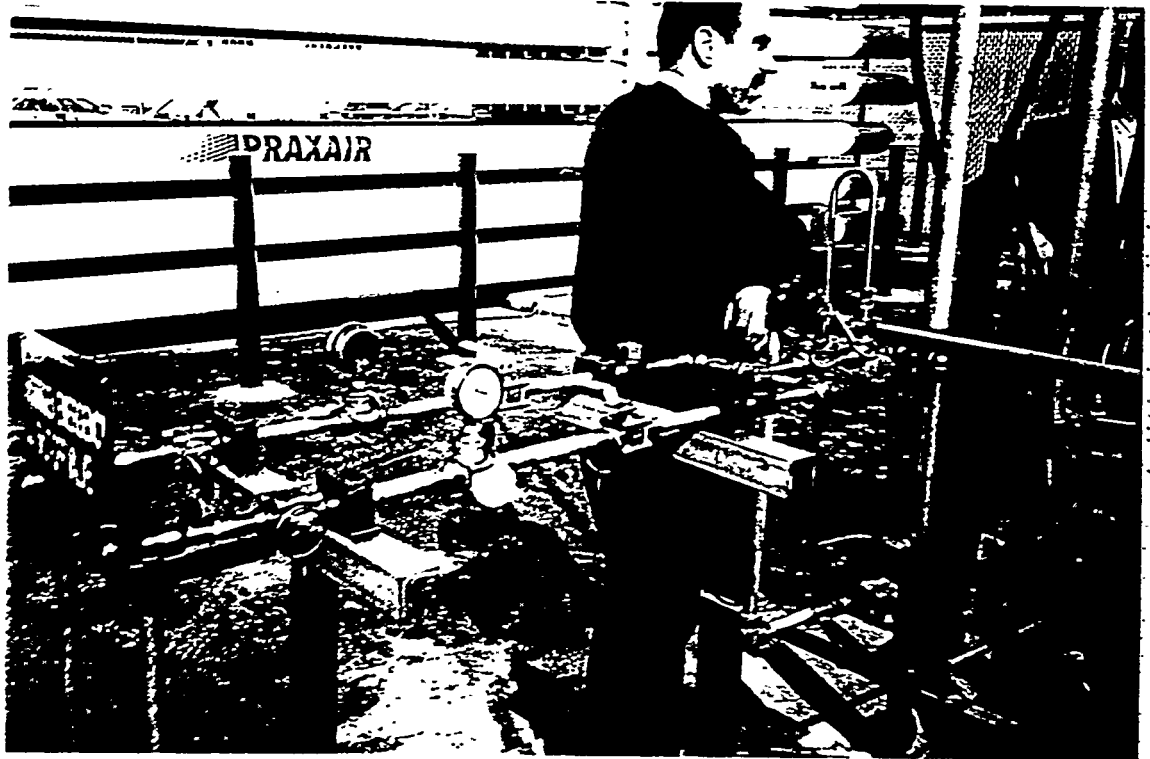
- i) Installation of higher rated (6,000 psi) "fire-valves" at the shut-off as shown in photographs and in the Detail P&I D Modification to Dispenser.
- ii) Installation of three way valve at T junction, where two lines are joined before split to nozzles.
- iii) Installation of regulator on down leg of piping before split to nozzles (photo of location attached).
- iv) Installation of strainer upstream of regulator.

All changes to piping to be welded Schedule 80 stainless steel to socket fittings tested for operating pressure of 5000 psi.

### **Work Schedule:**

A schedule by Tasks is shown in the attached Gant Chart: "Proposed Schedule for Site Construction for Xerox/CAN! Solar Hydrogen Demonstration Project" The firm dates are:

- May 15: Early date for start of construction
- July 15: Complete installation of PV panel screw anchors
- Aug 1: Electrolysis Module Delivery to site  
Gas storage Delivery to site
- Aug 15: Finish site construction
- Aug 31: Complete plant commissioning

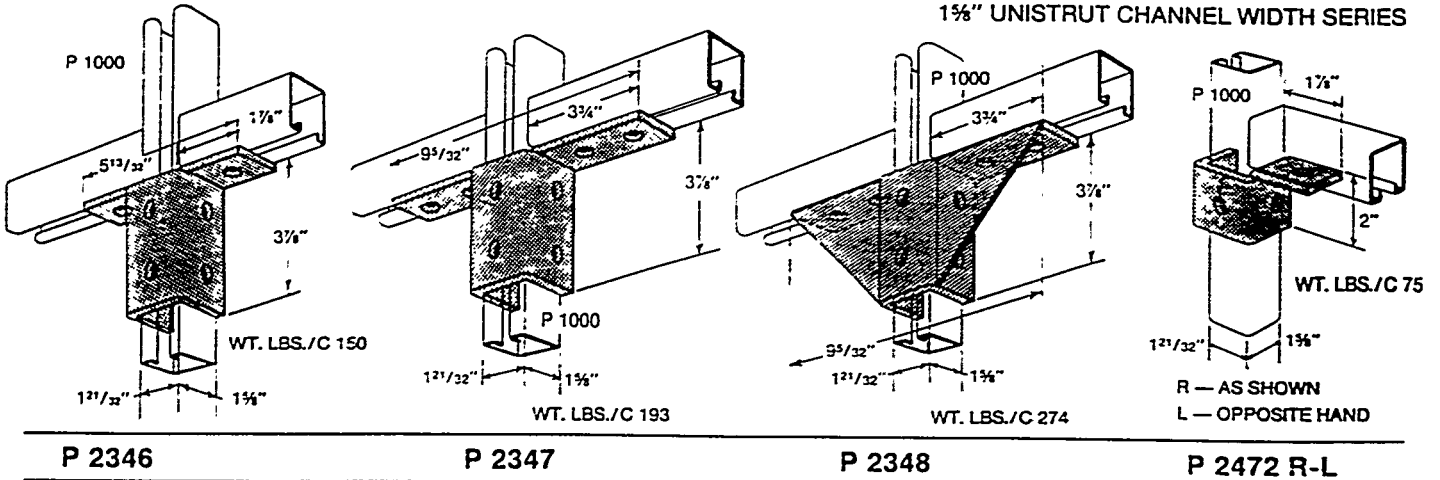


PROPOSED SCHEDULE FOR SITE CONSTRUCTION OF XEROXCANI SOLAR HYDROGEN DEMONSTRATION PROJECT, MARCH 21, 1995

ID	Task Name	May 1995		June 1995		July 1995		August 1995						
		Sun 5/20	Sun 5/21	Sun 6/4	Sun 6/11	Sun 7/2	Sun 7/9	Sun 7/16	Sun 7/23	Sun 7/30	Sun 8/6	Sun 8/13	Sun 8/20	Sun 8/27
1	1.1: Removal of Perimeter Fence													
2	1.2: Installation of New Perimeter Fence													
3	1.3: Installation of Operator's Cabana													
4	1.4: Electrical Power Supply to Operator's Cabana													
5	1.5: Installation of Feedwater Treatment Station													
6	1.6: Water Supply to Feedwater Treatment Station													
7	1.7: Installation of "New Jersey" Pylons													
8	2.1: Installation of PV Panel Frames													
9	2.2: Installation of Low Voltage Bus Bar													
10	2.3: Installation of High Voltage Cable													
11	2.4: Electrical Connection of Bus Bar to Electrolysis Cell Bank													
12	2.5: Electrical Connection of High Voltage Cable Compressor Power System													
13	2.6: Installation of PV Modules													
14	3.1: Foundation and Erection of Electrolysis Module													
15	3.2: Feedwater Piping From Operator Cabana to Electrolysis Module													
16	3.3: Data Link Between Operator Cabana and Electrolysis Module													
17	3.4: Installation of Piping Run From Electrolysis Module to High Pressure Gas Drier and Storage													
18	4.1: Installation of the Gas Drier													
19	4.2: Piping Connections to Gas Drier													
20	4.3: Instrumentation Cable to Gas Drier													
21	4.4: Installation of High Pressure Gas Storage													
22	5.1: Piping Connection to Dispenser													
23	5.2: Modification to Dispenser Controls													
24	Plant Commissioning													
25	Delivery of Electrolysis Module													
26	Delivery of High Pressure Gas Storage													

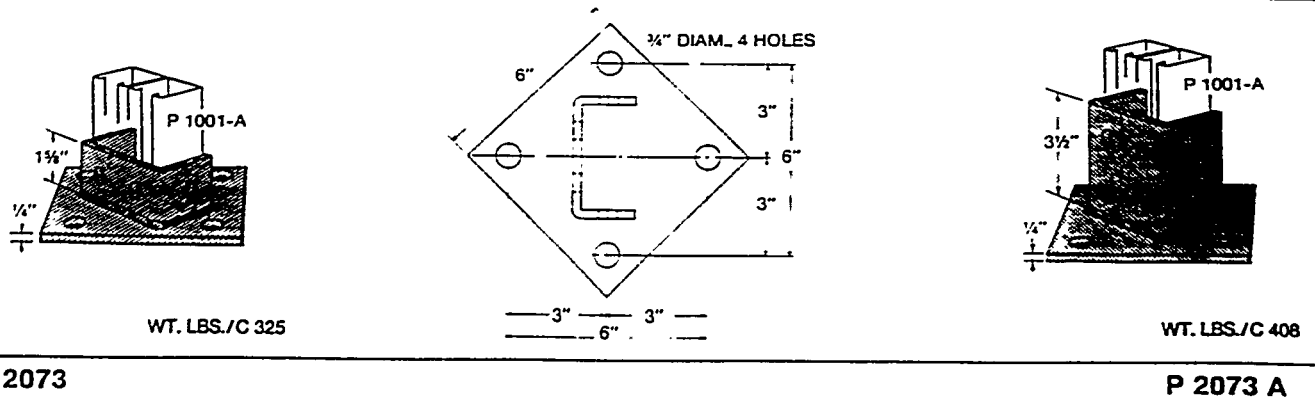
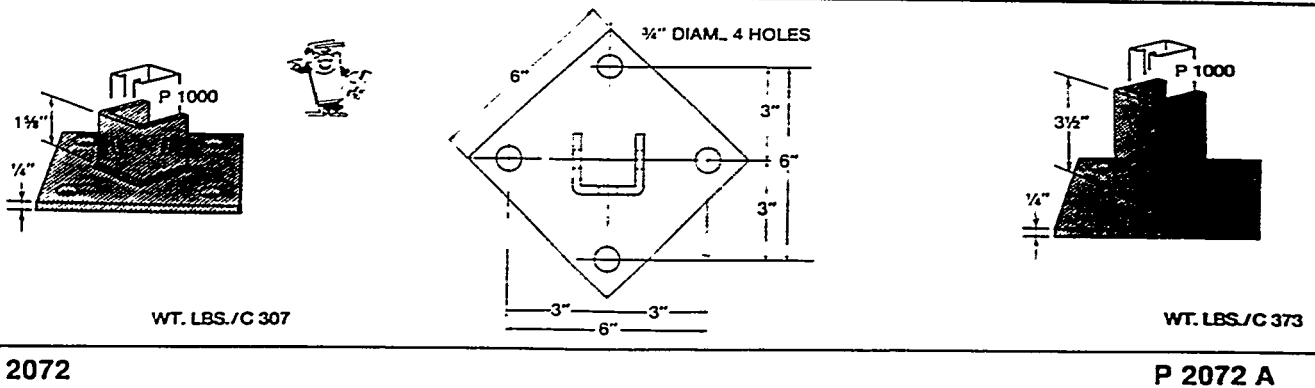
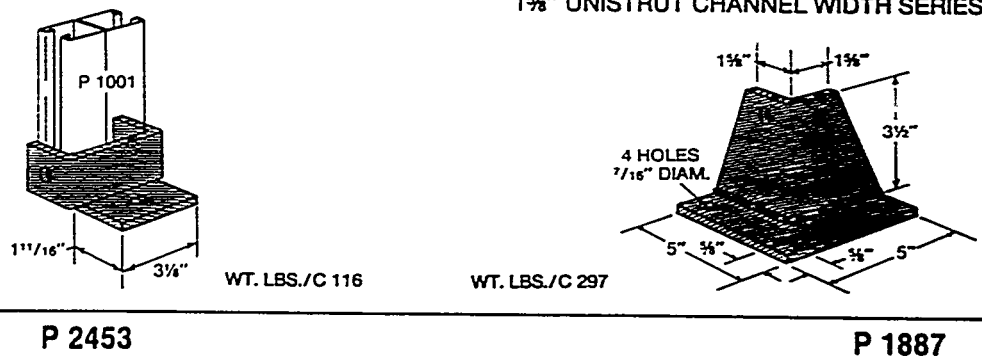
# WING SHAPE FITTINGS

1 1/2" UNISTRUT CHANNEL WIDTH SERIES



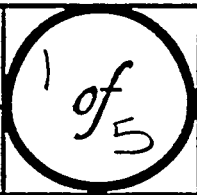
# POST BASES

1 1/2" UNISTRUT CHANNEL WIDTH SERIES



HOLE SIZE 9/16" DIAMETER  
 HOLE SPACING 13/16" FROM END  
 1-7/8" ON CENTER

WIDTH 1-5/8"  
 THICKNESS 1/4"

<b>STEPHEN MACIE</b> <del>XXXXXX</del> Engineer HI Structural #5974-S, CA Civil #28063	SEA Corp. Sunnyvale, Ca.		926'94
1009 MORRO ST., #205 P.O. BOX 13410 SAN LUIS OBISPO, CA 93406 805-541-3837	Powergrid Array Wind Load Analysis		SEA CAN1,1

**PROJECT:** Wind Load Analysis of Solar Array Panel

**CLIENT:** SEA Corp. (408) 986-9231  
 Neil Kaminar FAX 986-9233  
 3500 Thomas Rd. Suite E  
 Santa Clara, CA 95054

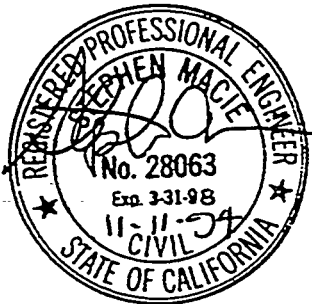
**LOCATION:** CAN-Xerox Corp.  
 El Segundo, CA

**STRUCTURE** Solar Array Panels on Ground Level in Parking Lot  
 Assume Ht= 0 ft Array Ht< 15 ft

**PANEL:** Specification from Manufacturer.  
 -Array module = 20'-0" x 9'0"  
 -Tilt = 35°  
 -Array Weight = 250#  
 -Mounting Grid = 10'0" x 9'0"  
 -Module Width = 10"  
 -Module Spacing = 20"oc (10" opening between modules)  
 -Number of Modules per Array = 12

**FRAME:** -Horizontal Supports = 4" Ht x 3" Wth x 20 ga. Tube Steel  
 -Verical Supports = 4" Ht x 3" Wth x 20 ga. Tube Steel  
 -Diagonal Struts = 1.1/2" Diam. x 20 ga. Tube Steel  
 -The Mounting Foot is 6" long 16 ga. Steel w/ bent flanges  
 to sit on a asphalt surface w/ screw anchors for uplift.

**LAT.LOAD:** As per 1992 UBC, Chapter 23, PART II-WIND DESIGN  
 (Pressure coeff. for minor structures)  
 Exposure = B Coefficient Ce= 0.62  
 Wind Speed = 80 MPH Wind Pressure qs= 12.6 psf  
 UBC Table 23-H(7) Pressure Coefficient Cq= 1.4  
 Importance Factor I=1  
 Design Wind Pressure P=Ce\*Cq\*qs\*I P= 10.94 psf



STEPHEN MACIE XXXXXXXX HI Structural #5974-S, CA Civil #28063	SEA Corp. Sunnyvale, Ca.	2 of 5	926'94
1009 MORRO ST., #205 P.O. BOX 13410 SAN LUIS OBISPO, CA 93406 805-541-3837	Powergrid Array Wind Load Analysis		SEA CAN1,2

Tributary Vertical Surface Area of Modules

Module L=	9 ft	Angle=	35 °	Ht=	6.30 ft
Module W=	10 "	Module Vert. Area=			5.25 ft <sup>2</sup>
		Module No.=	12	Area=	63.02 ft <sup>2</sup>
Rail Ht=	6 "	Rail L=	20'	Area=	10.00 ft <sup>2</sup>
		2-Rails +12 Modules = Total Area=			83.02 ft <sup>2</sup>
				Total Horizontal Fh= P*Area =	908 #/Array
				Uplift Fv = Fh*Tanθ =	636 #/Array

Overturning Moment taken at short strut end of array

Fh=	908	#	@	y=	4.15	ft	M=	3769	ft#
Fv=	636	#	@	y=	4.50	ft	M=	2861	ft#
Array Wt=	-250	#	@	y=	4.50	ft	M=	-1125	ft#
							Total M=	5505	ft#
Struts per Side=	2								
Strut Spacing L=	9	ft	Uplift=ft=	306	#/Mount				
			Strut Horizontal Sliding=Fh/4=fv=	227	#/Mount				

Anchorage of Array Foot to Asphalt Surface

DIXIE Foundation Anchors

4" Helix Diam., Class 7 Soil, Soil Holding Strength= 1500 #  
Cat.#D-6524 (See Pad Mount Stabilizing Anchor, Cat.#D-6234)

AB CHANCE Foundation Anchors (Type GP)

4" Helix Diam. Cat.#C107-0190

Capacity of Foundations with Uplift or Tension Forces

("Foundation Analysis and Design", Bowles, 3rd Ed., 4-11)

Assume Soil wt= 120 pcf c= 300 pcf  
Friction Angle= 39 m= 0.35

B= 4 " D= 36 "  
Limit H/B= 3 Max.H= 12 "  
Tu=pi\*c\*B\*H+sf\*1.57\*wt\*B\*(2D-H)\*H\*Ku\*tan θ +W  
sf=mH/B= 2.05

Ku=Kp=tan<sup>2</sup>(45+20/2)= 2.04

Ku=Kp\*Tan(2θ/3)= 0.995

Ku=sqrt(Kp)= 1.43

Ku=.65+.5θ= 0.99

Ave.Ku= 1.36

W=wt\*B<sup>2</sup>\*pi/4\*D= 31.42 #

Tu= 1056 #

SF= 2 LDF= 1.33

Ta= 702 # > Uplift

Bolting of Array to Foundation Leveling Pad

1/4" MB welded to Leveling Pad (4 each leg)

Weld Check Fy= 36000 psi Fv= 14400 psi  
LDF= 1.33 Fv= 19152 psi

Weld Th= 0.25 " Area= 0.49 in<sup>2</sup>  
w/ 1/2 weld Stress, (Partial insp.) Allow.V= 4701 # \*OK

Bolt Check

A= 0.049 in<sup>2</sup> Allow.V= 470 #

Ft= 28728 psi Allow.T= 1410 #

T/Bolt= 76 # V/Bolt= 57 #

T/All.T+V/All.V= 0.17 \*OK

Weld 4-1/4" Threaded studs to Foundation Leveling Pad

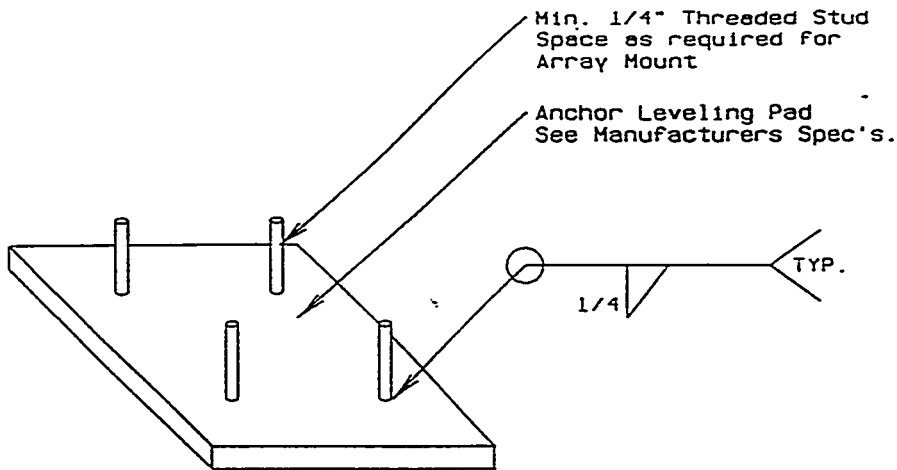
STEPHEN MACIE

HI Structural #5974-S, CA Civil #28063

1009 MORRO ST., #205  
P.O. BOX 13410  
SAN LUIS OBISPO, CA 93406 805-541-3837

3  
of  
5

CANI, 3



Connection for Array Foot to Anchor

3" = 1'-0"

# DIXIE ELECTRICAL

MANUFACTURING COMPANY

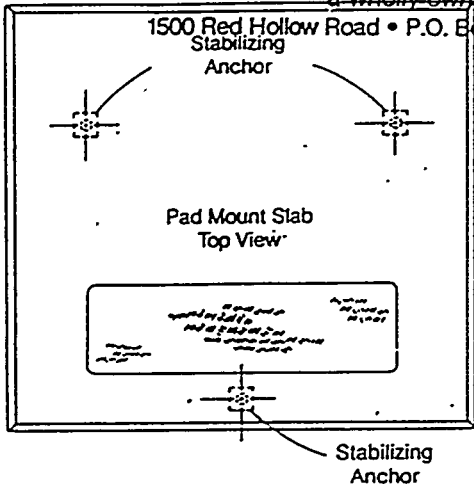
4 of 5

## The Solution

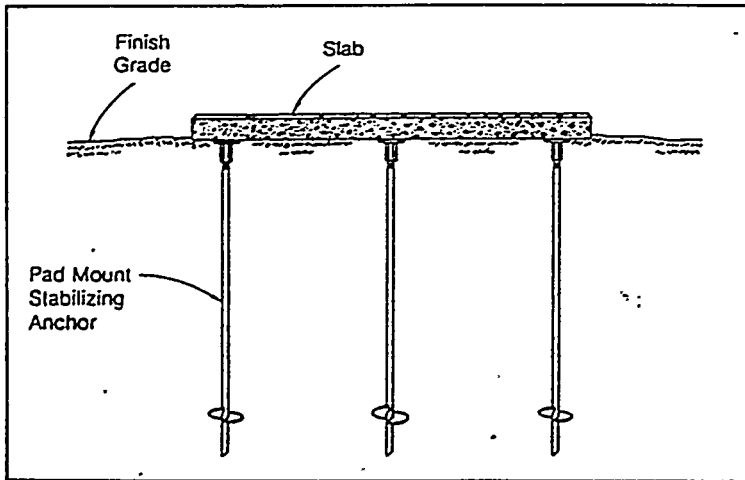
©1984 Dixie Electrical Mfg. Co., Birmingham, AL  
 a wholly owned subsidiary of Alumna-Form, Inc.

1500 Red Hollow Road • P.O. Box 6298 • Birmingham, Alabama 35217 (205) 853-1200

1000-6/87



Typical Triangular Placement of Pad-Mounted Stabilization Anchors



## The Advantages

- This system employs inexpensive "no wrench" anchors - no digger truck required.
- Bearing pads are threaded to easily level the slab.
- Can reduce return service or maintenance stops.
- Simplifies excavation and grading.
- Shares equipment load bearing with the soil, reducing compaction requirements.
- Manual installation tool available, see ordering information.

The Anchor

## No Wrench Type Pad-Mounted Stabilizing Anchor Ordering Information

Catalog Number	Description	Helix Dia.	Approx. Net Unit Weight
D-6234	5/8" Dia. x 36" Long	4"	5 1/2 Lbs.
CF-33056	Manual Installing Tool (not shown)	—	3 Lbs.

4B-6



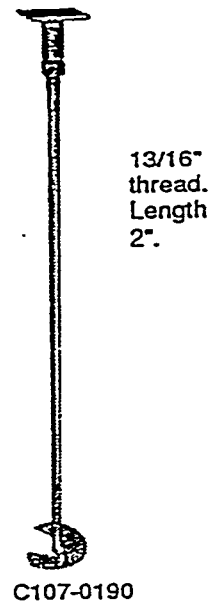
# FOUNDATIONS

5 of 5

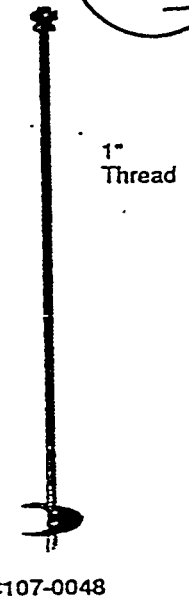
## MANUALLY INSTALLED TYPE GP FOUNDATIONS

These anchors are designed for installation using standard hand tools. (i.e., Ratchet Wrench with deep socket).

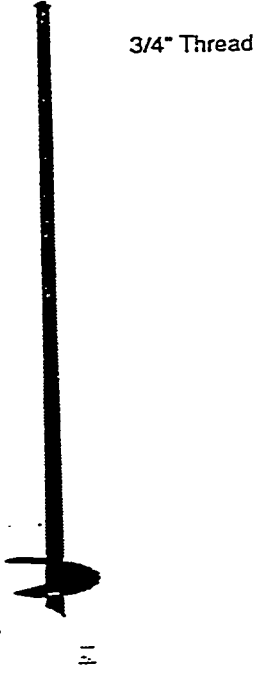
Catalog Number	Description	Suggested Max. Installation Torque	Std. Pkg.
C107-0048	4" Helix, 3/4" x 35" Shaft, includes hex jam nut	350 ft.-lb.	1
C107-0190	4" Helix, 3/4" x 35" Shaft, includes adjustable leveling pad	280 ft.-lb.	1
E107-0188	Leveling Pad Only		



13/16" thread. Length 2".



1" Thread



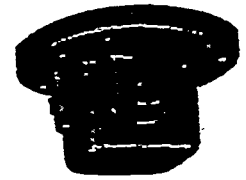
3/4" Thread

## SQUARE DRIVE TYPE LD FOUNDATIONS

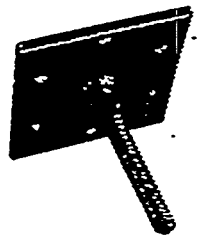
These anchors are designed for installation using power-digging equipment. The 2-inch square head has a tapped 3/4" center hole to permit use of threaded accessories.

Catalog Number	Description	Suggested Max. Installation Torque	Std. Pkg.
C107-0054	6" Helix, 1 1/2" x 69" Shaft	1,800 ft.-lbs.	1
C107-0398	6" Helix, 1 1/2" x 93" Shaft	1,800 ft.-lbs.	1
C107-0049	10" Helix, 1 1/2" x 69" Shaft	1,800 ft.-lbs.	1
C107-0050	10" Helix, 1 1/2" x 93" Shaft	1,800 ft.-lbs.	1
C107-0394	8" Helix, 2" x 69" Shaft	4,000 ft.-lbs.	1
C107-0395	10" Helix, 2" x 69" Shaft	4,000 ft.-lbs.	1

To install square drive foundation anchors use Catalog No. 639000 wrench adapter, combined with the correct size Kelly bar adapter. Complete description of the installation tools can be found in the anchor tools section 4A of the catalog.



639000



LEVEL PAD  
C107-0111  
5" dia. bolt circle  
6-holes equally spaced  
.56" diameter



STRAIGHT STUD  
E211-0037  
3/4" x 6"

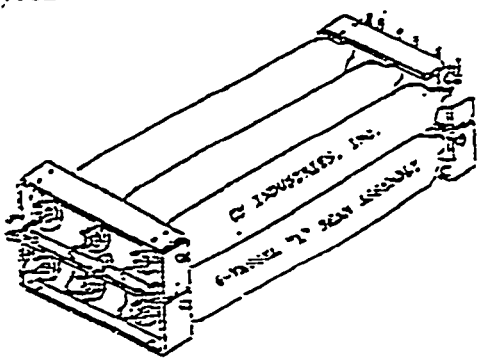
## ACCESSORIES FOR SQUARE DRIVE

Catalog Number	Description	Std. Pkg.
C107-0111	Level Pad	1
E211-0037	Threaded Stud	20

TUE 18:33

CPI SALES DEPT

FAX NO. 412 664 6653



CP INDUSTRIES, Inc.

Christy Park Plant

2214 Walnut Street  
McKeesport, Pennsylvania 15132

FAX

February 28, 1995

Number of pages: 2

TO: Charlie Pappas  
Electrolyser  
416-621-9410  
FAX 416-621-9830

FROM: Mark Semekoski  
CP Industries, Inc.  
412-664-6605  
FAX 412-664-6653

**PLEASE CALL SENDER AT 412-664-6605 IF COPIES ARE NOT LEGIBLE**

REFERENCE: Your RFQ to CPI via Noracor dated 2/27/95.  
CPI Inquiry C-23158.

SUBJECT: Quotation

CPI is pleased to offer the following for your compressed hydrogen needs.

ITEM: One (1) 2-vessel ASME assembly mounted horizontally in I-beams 2 wide X 1 high.

Spec: Seamless pressure vessels to ASME UPV Code Section VIII Division 1 Appendix 22 Safety factor 3 to 1 for dry gas non-corrosive service. Design temperature -20F to +200F.

Size: 16" OD X 1.177" minimum wall X 28'10" long.

Volume: 26.6 cu ft per vessel.  
53.2 cu ft per assembly.

Design pressure: 5471 psi.  
Operating pressure: 4924 psi.

Capacity: 14,700 scf of hydrogen at 4925 psi.

Weight: 13,100 lbs per assembly, estimated.

Other: Each vessel will have 1/2" NPT openings on front and rear plugs. Vessels will be UT inspected and certified for hydrogen service. Assembly will not have shut off valves or safety devices. Entire assembly will be painted with epoxy primer and one coat white high solids urethane enamel.

# ASME Standard Unit

*will adapt this to two vessels*

## Notes

1. Design  
ASME B&PV Code, Section VIII, Div. 1, (SF=3).

2. Design temperature  
Minimum Design Metal Temperature (MDMT) to plus 200°F.

3. Service  
Dry gas, non-corrosive.

4. Vessel material  
ASME SA-372, Type IV.

5. Heat treatment  
Tensile strength—105,000 psi min.  
Yield strength—65,000 psi min.

6. Fabrication  
Vessel shall be seamless type with swaged ends.

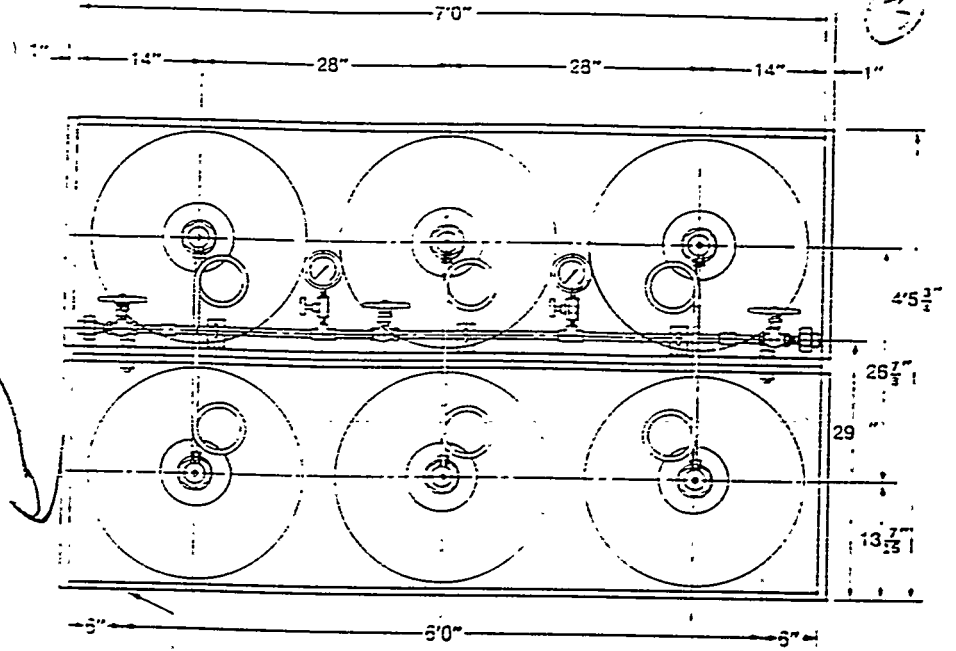
7. Inspection  
ASME-certified and National Board commissioned. Magnetic particle inspect exterior.

8. Stamping  
In accordance with the ASME Code.

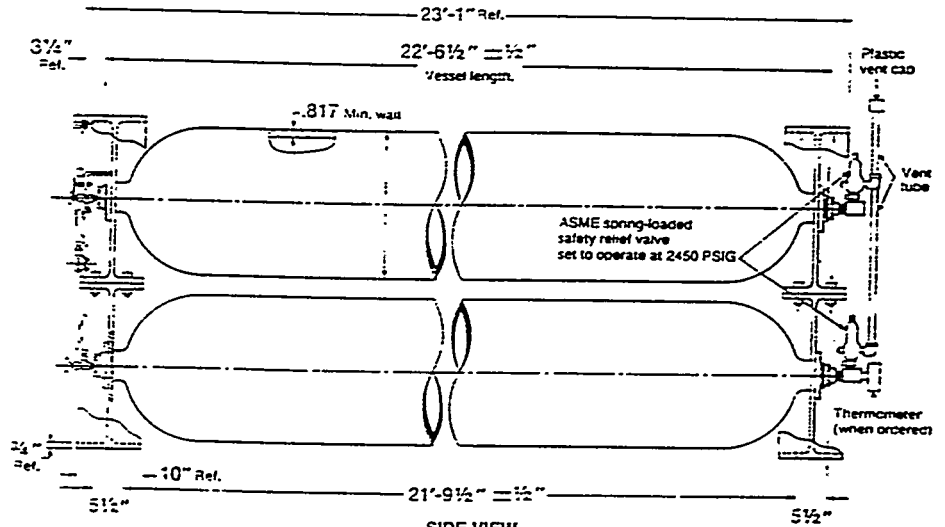
9. Registration  
Register with National Board.

10. Exterior  
Shot-blast and apply one coat zinc chromate primer and one coat enamel.

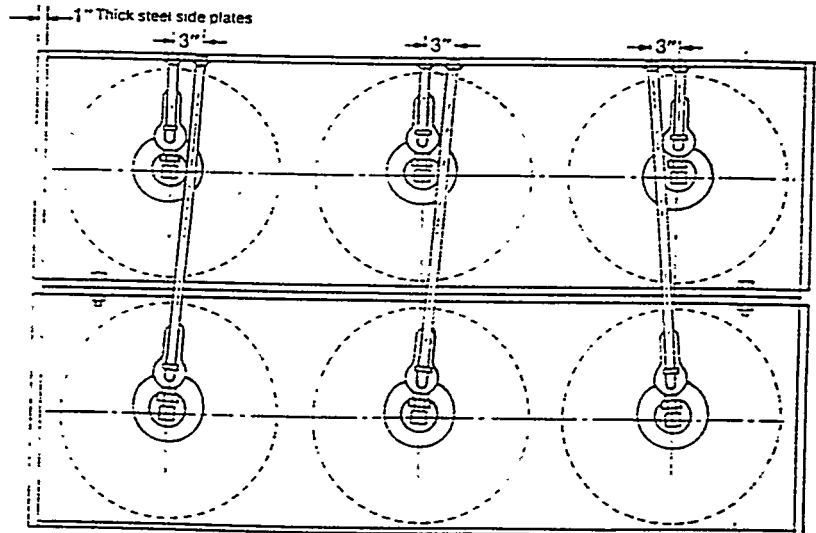
11. Interior  
Shot-blast free of loose scale and evacuate. Inert to a pressure of 7 to 15 PSIG with dry nitrogen and seal for shipment.



FRONT VIEW



SIDE VIEW



Rear safety vent assembly

**Xerox/CAN H2 Truck Testing And Safety Analysis**

ID	Name	Duration	March			April			May			June			July			August												
			19	20	5	12	19	26	2	9	16	23	30	7	14	21	28	4	11	18	25	2	9	16	23	30	6	13	20	27
1	Test Plan	25d	[Gantt bar from March 19 to April 13]																											
2	Prepare Draft Test Plan	3W	[Gantt bar from March 19 to March 26]																											
3	Safety Review Meeting	0d	[Milestone diamond on March 20]																											
4	Final Test Plan	2W	[Gantt bar from March 26 to April 2]																											
5	H2 Fueling Set-up	4W	[Gantt bar from March 26 to April 9]																											
6	Truck Testing	20d	[Gantt bar from April 2 to April 22]																											
7	Truck Delivered	0d	[Milestone diamond on April 9]																											
8	Initial Checkout Tests	1W	[Gantt bar from April 9 to April 16]																											
9	Safety Testing	1W	[Gantt bar from April 16 to April 23]																											
10	Service Testing	2W	[Gantt bar from April 23 to April 30]																											
11	Return Truck	0d	[Milestone diamond on April 30]																											
12	Safety Assessment	70d	[Gantt bar from April 30 to July 10]																											
13	Obtain Requir. Factory Mnt	4W	[Gantt bar from May 7 to May 21]																											
14	Analyze Test Results	2W	[Gantt bar from May 21 to May 28]																											
15	Prepare Final Report	3W	[Gantt bar from May 28 to June 11]																											

**Project:** Critical Progress Summary  
**Date:** 2/22/95 Noncritical Milestone Rolled Up

March 22, 1995

Mr. James J. Provenzano  
Clean Air Now  
660 Venice Boulevard, #112  
Venice, CA 90291

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Re: CAN/DOE Contract DE-FC36-94GO10039

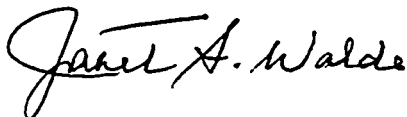
Dear James:

SEA Corporation is pleased to be a participant on the solar hydrogen project. Total cost of the photovoltaic energy system is \$437,271. which as a member of the project team SEA will cost-share. Accordingly, SEA has committed the amount of \$39,633. The resulting cost to Clean Air Now is \$397,638. which will be invoiced monthly.

Each invoice will identify SEA's contribution to assist you in tracking the funding. Please address any technical questions to Neil, any business questions to me.

We look forward to a successful project.

Yours truly,



Janet S. Walde  
Director of Business Operations



# Electrolyser

The Electrolyser Corporation  
1800, One M & T Plaza  
Buffalo, N.Y., 14203

Toronto Office:  
122 The West Mall, Etobicoke  
Toronto, Canada, M9C 1B9  
Tel: (416) 621-9410  
Fax: (416) 621-9461/9830

February 3, 1995

Mr. Paul Staples  
Vice President  
Clean Air Now!  
660 Venice Blvd. #112  
Venice, CA  
90291  
USA

Dear Mr. Staples,

Regarding a breakdown on TEC cost share on services and equipment being supplied to CAN for the Xerox/CAN project in El Segundo (our proposal 1001 : 103-203) , the cost share can be allocated between the **UNICELL-CLUSTER™** PV hydrogen generator and the hydrogen vehicle filling station as follows:

Cost-share on **UNICELL-CLUSTER™** contributed by TEC: \$282,000.00

Cost-share on vehicle filling station consisting of:

IR&D on Hydrogen Vehicle Filling Stations by CECERT/UCR  
(University of California Riverside CA) \$ 45,000.00

Technical assistance in integration of **UNICELL-CLUSTER™**  
with Hydrogen Vehicle Filling Station at Xerox El Segundo \$ 36,000.00

Total Cost-share on Vehicle Filling Station \$ 81,000.00

Total Cost-share on Xerox/CAN Project \$363,000.00

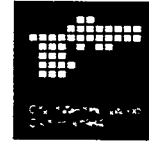
Please don't hesitate to call if further detail is required.

Best regards  
Electrolyser

  
Matthew Fairlie  
Director of Technology, Energy Projects

**City of  
West Hollywood**

David Hare  
Environmental Services and  
Operations Manager  
8611 Santa Monica Blvd.  
West Hollywood, CA 90069



City Hall  
8611 Santa Monica Boulevard  
West Hollywood, CA 90069-4109  
TEL (310) 854-7475  
FAX (310) 854-7391

April 20, 1995

Paul Staples  
Project Manager  
Clean Air Now  
660 Venice Blvd. #112  
Venice, CA 90291

RE: FUNDING SUPPORT

Department of  
Community Development

Dear Mr. Staples:

As per our last meeting, I am forwarding to you a listing of the City's intent to participate in the development of a hydrogen powered vehicle fleet. To date, the City has budgeted almost \$9,000 for the purchase and retrofit of a Ford Ranger Pickup Truck. I have received and reviewed the specifications for the vehicle and the City is currently in the process of purchasing a vehicle which meets the stated specifications.

I will keep you informed of our progress in locating and purchasing a vehicle. I look forward to our next meeting and the further development of this project.

Sincerely,

A handwritten signature in cursive script that reads "Dave Hare".

David Hare

Manager, Environmental Services and Operations



March 7, 1995

*Sent Via FAX (310-917-4426) and U.S. Mail*

Robert M. Zweig, MD  
Chairman, Board of Directors  
Clean Air Now  
1222 Lincoln Blvd.  
Santa Monica, CA 90401

*Re: Development of hydrogen generation and fueling facility*

Dear Dr. Zweig:

In furtherance of our meeting on March 3, 1995, I want to communicate to you that the Cabazon Tribe has a strong interest in further exploring the mutual benefits of co-developing a hydrogen generating and fueling facility in the Coachella Valley with your group.

We view the development of clean renewable energy sources is a paramount issue for southern California. I look forward to touring your facility at UCR in the near future.

Please contact me when you return from Washington.

Sincerely,

Michael Derry  
Planner, Cabazon Band of Mission Indians

MRD/lew



84-245 INDIO SPRINGS DRIVE □ INDIO, CALIFORNIA 92203-3499 □ (619) 342-2593 □ FAX 347-7880



**CLEAN AIR NOW!**



April 11, 1995

*Board of Directors:*

Robert M. Zweig, MD  
*Chair*

Paul Staples  
*Vice Chair*

James J. Provenzano  
*Secretary*

Vernon Hall  
*Treasurer*

Ron Pecoff

Yu-Yue Widrig

*Advisory Board:*

Mark Abramowitz

Charles Bensinger

Don Blöse

Fred Edeskuty

Virginia Field

W. Woodland Hastings

Kevin Hendrick

Tim Little

Kevin McSpadden

Dave Michelfelder

Dr. Joan Ogden

Glenn Rambach

Bryan Tari

William Wybourn

Andrew Zalay

Ms. Christine Ervin  
Assistant Secretary for Energy  
Efficiency and Renewable Energy  
U.S. Department of Energy  
1000 Independence Ave., S.W.  
Room 6C-106  
Washington, D.C. 20585

Dear Ms. Ervin:

In follow-up to your request on March 31 at the road rally in Los Angeles, I'm enclosing a copy of the hydrogen article featured on the March 19 cover of the Los Angeles Times Magazine. I think you will find it very interesting and worthwhile.

Thank you for visiting our hydrogen powered truck and discussing the Clean Air Now/Xerox Solar Hydrogen Vehicle Project. It was a pleasure talking with you once again; it is heartening to listen to someone who cares about the environment and future generations and is in a position to influence people, policy and politicians.

Ms. Ervin, we greatly appreciate you talking with Representative Walker and Senator Harkin regarding hydrogen technology funding. As you know, the United States must increase its commitment to the advancement of the hydrogen economy if we are to maintain our global competitiveness and protect our environment for the long term.

Sincerely,

James J. Provenzano  
Managing Director

ervin.doc

c: Lucito B. Cataquiz - U.S. Department of Energy  
Bill Ives - U.S. Department of Energy



# Los Angeles Times Magazine

MARCH 19, 1995

## The Last

## Best

## Hope of

## Earth?



Trapped in

This Water Is

the Simplest

Element of Them

All—Hydrogen.

Can It Solve All

Our Complex

Problems? Take

a Trip to the

Loneliest Frontier

of Energy Research.

By Alan Weisman

# Alan Weisman

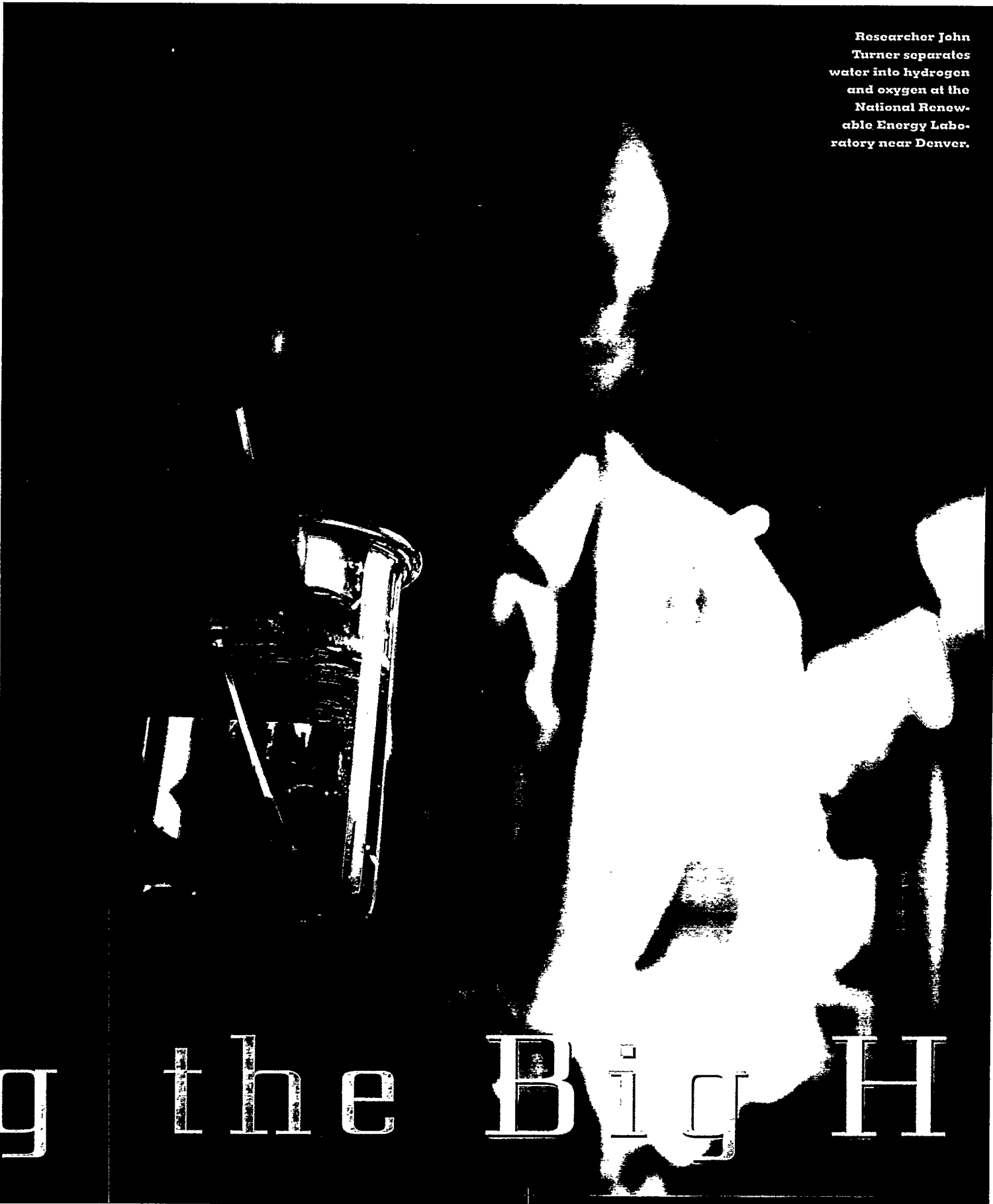
Interstate 70 enters Golden, Colo., and begins to curl through the foothills of the Rockies. There it bisects an unassuming clump of brick buildings—the National Renewable Energy Laboratory. Among the government's national laboratories, NREL is modest, operating on a fraction of the billions commanded by atomic research giants like Sandia, Los Alamos and Lawrence Livermore. Inside, there are no monstrous particle accelerators; experiments here are more likely to proceed in test-tube racks, bell jars and small glass beakers, like the one John Turner is filling with a clear solution of water and household lye.

Turner, a chemist with a graying blond beard and gold-rimmed glasses, sticks a narrow glass slide, coated on one end with a black, mica-like substance, into the lye solution. The humming lab ventilators mask the sound of the vehicles whizzing by on the nearby interstate, but Turner has spent most of his career here, and during those years he's always had those cars in mind. As he aims a pencil-thin beam from a high-intensity lamp at the flask, he puts it this way: "Suppose someone announced he intended to ship millions of gallons of a carcinogenic, explosive fluid that emits toxic fumes through our downtown and then store it underground in our neighborhoods. People would rise up in anger, right?"

Wrong. Just outside on I-70, cars are spraying residues of that very poison all over the mountains. After 11 decades of tinkering, their internal combustion engines are miracles of technology with hundreds of moving parts. Yet various laws of physics still limit their ability to extract energy from petroleum. Nearly three-fourths of its potential simply radiates away or pours, partly combusted, out the tailpipe, rising in geologic layers of brown murk until the Rockies themselves dwindle to ghostly smudges.

John Turner is among a cadre of scientists trying to suppress what he regards as humanity's most pervasive, and self-inflicted, epidemic. In a little more than a

# Harnessin



Researcher John  
Turner separates  
water into hydrogen  
and oxygen at the  
National Renew-  
able Energy Labo-  
ratory near Denver.

g the Big H

century, since Thomas Alva Edison invented the light bulb and Henry Ford began to mass-produce automobiles, man-made energy has become the most addictive drug in history. Everybody today was born into this dependency: No one any longer can imagine life without electricity or motorized vehicles. To slake our craving, we must dose our surroundings daily with filth that would have stupefied our ancestors. This ritual is now doomed to spread, as China, India and other developing nations bestow family cars and refrigerators upon 2 billion new recruits to the industrial age.

Getting an entire world to kick a habit is futile, so Turner is trying to at least find us a clean needle. As the beam strikes the shiny black square centimeter of semiconductor glued to the submerged portion of his slide, the surrounding liquid begins to fizz. Electrons stimulated by light, he explains, are rushing to the semiconductor's surface, hitting water molecules and splitting them into their component parts: oxygen and hydrogen.

He watches the tiny bubbles rise. "For years," he says, "this has been the Holy Grail of photoelectric chemists. We're witnessing the direct conversion of solar energy into hydrogen."

CAPE CANAVERAL, JUNE, 1994: A GROUP OF VISITING SCIENTISTS AND ENGINEERS is touring the John F. Kennedy Space Center in blue-and-white air-conditioned buses. They're here for the World Hydrogen Energy Conference, a biennial event born of the energy crisis 20 years earlier. Although the price of petroleum has since calmed considerably (adjusted for inflation, it's actually cheaper than pre-1973), a groundswell of concern, coupled with numerous breakthroughs, has ballooned this gathering to nearly 600 researchers from 34 countries. They've come to Canaveral this year for inspiration: The huge white spherical tank on the pad, where the shuttle Columbia will presently lift spaceward, is filled with pure hydrogen.

## Hydrogen derived from solar energy emits no noxious fumes

Since even before the moon shots, all U.S. astronauts' heat, electricity and drinking water have been derived from hydrogen. The U.S. space program is the first step toward realizing these scientists' dream: to switch the planet from an economy fueled with dirty coal and petroleum to one run on clean hydrogen.

The idea of something so ubiquitous—hydrogen is the most abundant element, composing three-fourths of the mass of the universe—replacing diminishing fossil fuels seems the stuff of fiction. Once, in fact, it was: In 1870, Jules Verne's "Mysterious Island" described a world that would one day derive "an inexhaustible source of heat and light" from water's component parts.

Back then, Verne didn't realize that this source was also virtually pollution-free. The cycle is so elegant it seems nearly miraculous: Separate water into its two constituent gases, hydrogen and oxygen. Burn the hydrogen for fuel, and it re-couples with oxygen to form water again. No nasty particulates, no insidious carbon monoxide, no eye-stinging ozone or sulfur dioxide (at high temperatures, however, small, controllable amounts of nitrous oxides can form when hydrogen is burned in the presence of air). Mainly, though, hydrogen's exhaust is plain water vapor—which can then be recaptured and neatly converted again to hydrogen.

According to Bill Hoagland, founder of NREL's hydrogen program, it would take less than a gallon of water to get the same range from hydrogen that cars currently get from a gallon of gasoline. Because hydrogen can be made anywhere, I'm told repeatedly, there would be no more dependency on imported oil. No more OPEC. Maybe no more global warming, either, because it emits no greenhouse gases. As for hydrogen's unfortunate association with bombs and blimps, like the ill-fated Hindenburg, Hoagland reminds me that fossil fuels also readily explode, and studies rate hydrogen safer because it's nontoxic and dissipates quickly.

It seems like the perfect fuel. Yet, these scientists insist, it's been under-researched, under-funded and virtually ignored in Detroit, which perseveres in its allegiance to petroleum, and in Washington, which persists in keeping troops ready to defend the Persian Gulf.

So why aren't we leaping at this chance to end pollution, energy wars and economic bondage to a few privileged locations that float atop the earth's ebbing supplies of oil? Much of it comes down to money and the seemingly incontestable reign of the petroleum industry. Unlike natural gas, to which hydrogen is often compared, you can't dig a hole and find it. To tap

hydrogen's energy, you have to expend energy because it's always combined with something else. Having to un-combine it makes it more expensive, at least in the near term, than crude petroleum products, including natural gas. And no alternative-energy constituency has the clout to buck powerful fossil-fuel lobbies and find a way to pay for retrofitting the world for a brand-new technology.

Currently, the U.S. Department of Energy allots hydrogen about one-nineth of what it spends on continuing petroleum research. (And two-thirds of the DOE's budget doesn't go for energy at all, but for nuclear weapons research and cleanup.) Nor has the public thus far demonstrated much interest in trading the ease of dirty energy, available at the turn of an ignition key or click of a light switch, for a major commitment to something cleaner and renewable.

Yet the learned crowd gathered at the World Hydrogen Energy Conference is convinced that hydrogen's time must come. Fossil fuels will become expensive again; even today, their true price isn't revealed at the gas pump, where the numbers don't include the cost of pollution and the expense of protecting our interests in the Middle East.

Other countries are less reluctant about hydrogen than the United States. Two years ago, Japan, an island nation frightened by the prospect of rising seas if the icecaps start to melt, unveiled a multibillion-dollar, 28-year program to form a global hydrogen system. The Japanese are talking power plants, cars, buses, planes, ships and rockets, all over the world, all fueled with renewable hydrogen.

And there's a recent surprise announcement by Daimler-Benz, the parent company of Mercedes-Benz, that has excited many people here: The German auto maker claims it has cleared the major obstacles to producing the first commercially viable hydrogen-powered automobile. Unless Mercedes is just trying to spook the competition, hydrogen's prospects have suddenly improved faster than anyone dared hope. The Mercedes in ques-

tion runs on a fuel cell, a refillable device that, like a battery, chemically converts fuel directly to electricity without having to burn it. Fuel cells can function on methanol or natural gas, but with hydrogen, they're up to three times more efficient than conventional engines.

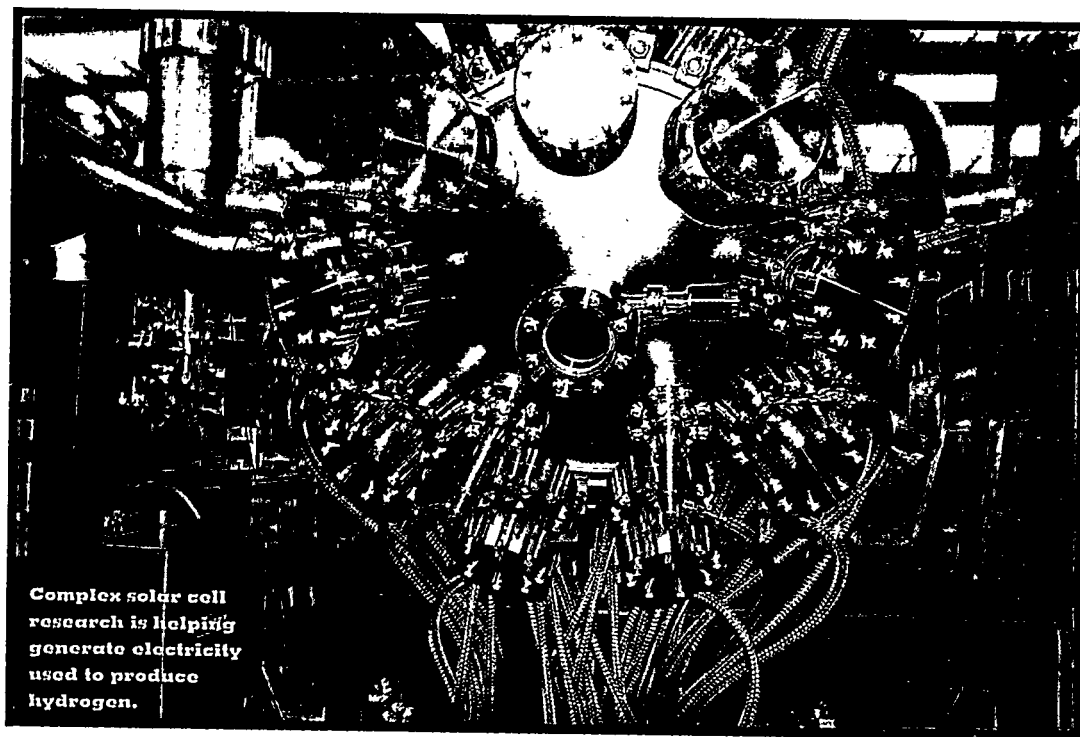
The most advanced models, including the one Daimler-Benz uses, come from the Vancouver-based Ballard Power Systems Inc., which designed fuel cells for the Canadian defense department, using technology NASA developed for the Gemini mission and then shelved. Originally large, boxy affairs of stackable metal plates separated by membranes resembling plastic wrap, Ballard's fuel cells are now small enough to fit inside a minivan chassis. "When we start producing them in volume," says Ballard co-founder Keith Prater, a former University of Texas chemist, "the price will shrink, too."

SURROUNDED BY CONFERENCE BOOTHS PROMOTING THE LATEST IN photovoltaics, fuel cells and electrolyzers—devices that separate water into oxygen and hydrogen—I ask Princeton physicist Joan M. Ogden if the United States is letting the future slip away to foreign competitors. She tells me of a recent, unreleased General Motors study admitting that non-polluting fuel cells could be mass-produced for the same cost as a conventional engine. "Actually, they should cost less, because they have no moving parts," she says. "They'll also last longer and be cheaper to maintain." But while Mercedes, BMW and Mazda race to bring a hydrogen car to market, U.S. auto makers, by comparison, don't seem very interested.

A few years ago, Ogden quit Princeton's glamorous fusion energy program to engage in relatively impoverished research in renewable hydrogen. "Fusion will take decades," she told aghast colleagues. "I want results in my lifetime." Soon after, she co-authored a book that proposed making hydrogen by splitting water with electricity from solar photovoltaic (PV) cells. (In this process, as electricity made from sunlight passes through a pair of electrodes immersed in water, hydrogen bubbles collect around one pole and oxygen around another.) Although PV is still expensive, Ogden argued that mass production and technological improvements would lower costs until they intersect with rising oil prices.

The book has been alternately praised and scorned, the latter because of a map showing how much of the United States would have to be covered by photovoltaic cells to produce sufficient hydrogen to meet the total U.S. annual energy needs. The area is denoted by a circle that reaches from Albuquerque nearly to the Mexican border. Critics who derisively try to guess the value of all that real estate miss the point, she insists. No one ever suggested putting all the PV in the same place.

Contributing editor Alan Weisman lives in Sonoma, Ariz. His last piece for the magazine was about a progressive community in Colombia.



Complex solar cell research is helping generate electricity used to produce hydrogen.

## ozone-depleting gases. Think of it: clean air all over L.A.

"Obviously, deserts are ideal, because they get the most sun, and minimal rainfall is enough to make plenty of hydrogen. But I did a little calculation once. Let's say 2,000 people who work at Princeton drive there every day. If I wanted to run their cars on hydrogen, how much roof space would I need to cover with PV to make enough hydrogen fuel for them? I figured that by putting panels on fewer than half the university rooftops, even with New Jersey's humble sunshine levels, we could convert all those cars to hydrogen. Think if we did that all over the country."

That same afternoon, Peter Lehman, an environmental engineer from Humboldt State University in Northern California, tells me what it would take to do the same for the 9 million cars in the Los Angeles Basin: "An area about 340 square miles. About two-thirds the size, say, of Edwards Air Force Base."

Cover Edwards Air Force Base with shiny photovoltaic panels?

"Sure. It would mean a fairly dramatic reorientation of priorities, and a huge expenditure, probably like building the interstate highway system. That took \$100 billion and 34 years. But we did it because as a society we decided it was important. Wouldn't you think that eliminating all smog might be important?"

All week, people here have been repeating a mantra of massive American investments in the future that paid off, like the Marshall Plan, the interstate highway system and—especially during a pilgrimage to the old Apollo launching pad—President Kennedy's decision to put men on the moon. Although these ventures involved enormous expense, they were embraced by the public because of visionary, daring leadership, but they also coincided, rather than conflicted, with powerful interests. A commitment to transform America's energy infrastructure to accommodate clean hydrogen would, I suspect, evoke awesome resistance from the petroleum and auto industries. And decisions these days seem dictated more by the global marketplace than by the foresight of leaders.

Yet the one vision these scientists from Argentina, Egypt, Russia, Germany and Japan tell me may save civilization from choking on its own exhaust emanates from California. They refer specifically, and reverently, to mandates by the California Air Resources Board and the South Coast Air Quality Management District, which require that zero-emission vehicles (ZEVs) constitute 2% of all cars sold in the state by 1998 and 10% by 2003.

The allure of these requirements is the fact that, with one out of 18 Americans living in the L.A. Basin alone, whoever can first manufacture a viable car that meets this standard will get rich. Everybody assures me that batteries aren't going to do it; the acceleration is rotten, the range is too short, and they must be recharged by plugging into dirty power plants that only

shift the pollution elsewhere. The assumption here is that the only way to build a real ZEV is by using a hydrogen fuel cell, and California's regulations will help force that technology into existence. The air quality district's chief scientist, Alan Lloyd, who's speaking at the conference, agrees.

Lloyd's problem, though, is that he is not exactly considered a prophet in his own land. Rather than instilling native pride, California's world champion air-quality laws, which some believe have wrecked the state's economy, have barely survived legislative plots to scuttle them.

And despite the vaunted environmental pedigree of Vice President Al Gore, the Clinton Administration hasn't been much help either. While a few projects like experimental wind farms have been encouraged, federal efforts have focused more on improving energy efficiency than on developing clean new sources. Most frustrating to Alan Lloyd is a multimillion-dollar Administration program called PNGV: the Partnership for a New Generation of Vehicles, whose goal is to deliver a prototype car that gets triple today's expected gas mileage—about 80 miles per gallon—by the

year 2004. "Which means that after 10 years, they'll develop a vehicle that will be illegal in California because it's too dirty," he says, gazing heavenward. "That's unacceptable. A new-generation vehicle should be fuel-efficient *and* clean. Leadership should come from the White House, but their agenda is being driven more from Detroit."

Other energy advocates claim the technology for an 80-m.p.g. vehicle already exists, but the Administration has simply caved in to the Big Three auto makers and the oil industry. But since I haven't seen filling stations dispensing hydrogen on American street corners, I ask Lloyd if a fuel-cell vehicle designed to run on the stuff is really practical.

In the interim, there are lots of ways to make hydrogen besides solar energy, Lloyd explains. Using steam, it can be derived from natural gas or even mixed with it—known as town gas, that was what America once burned for light and cooking. Hydrogen improves the potency and lowers the emissions of natural gas, and with some modification it might even be shipped through natural gas pipelines. As for a dearth of service stations: a similar alarm was once sounded by buggy-whip manufacturers.

The real obstacle, Lloyd says, is America's current lust to pawn the future for the sake of profits today. "While Detroit hires 100 attorneys to defeat every new emissions standard we establish, Japan assigns 1,000 engineers to meet the challenge."

Maintaining energy's status quo might make some sense, or at least some money, for purveyors of petroleum and internal-combustion engines. But the conference's keynote speaker assures us that the decision won't really be theirs. University of Colorado physicist emeritus Albert A. Bartlett says he knows little about hydrogen but something about basic arithmetic. He's particularly drawn to calculating the time it takes for things to double. This is pertinent, he says, to consumption of fossil fuels, because it allows the petroleum and coal industries to deceive the world about how long those resources will actually last.

To illustrate what he means, he proposes that we imagine a species of bacteria that reproduces by dividing in two. Those two become four, the four become eight, and so forth. "Let's say we place one bacterium in a bottle at 11 a.m., and at noon we observe the bottle to be full. At what point was it half full?" The answer, it turns out, is 11:59 a.m.

"Now, if you were a bacterium in that bottle, at what point would you realize you were running out of space? At 11:55 a.m., when the bottle is only 1/32 full, and 97% is open space, yearning for development?"

Everyone giggles. "Now suppose, with a minute to spare, the bacteria discover three new bottles to inhabit. They sigh with relief: They have three

times more bottles than had ever been known, quadrupling their space resource. Surely this makes them self-sufficient in space. Right?"

Except, of course, it doesn't. Bartlett's point is that in exactly two more minutes, all four bottles will be full. Likewise, when President Jimmy Carter noted that in each of three previous decades the world had burned more fuel than had been consumed previously in all of history, it meant that fuel consumption was doubling every decade. That rate slowed temporarily with the energy crisis, but now, with world population rising and today's breakneck industrialization in the Third World, the exponential gobbling of limited resources is again accelerating.

"It's seriously misleading when we hear, for example, that at current levels of output and

# HI

## hydrogen is already on the road, powering some Vancouver buses

recovery coal reserves can be expected to last 500 years. We get the mistaken impression that there's 500 years' worth of coal left, forgetting that the sentence began with 'at current levels.' That's 500 years, only if there's no growth of production."

And petroleum? "In 1993, they announced the largest discovery of oil in the Gulf of Mexico in the last 20 years: 700 million barrels. It sounds like an enormous number, until you realize that we Americans go through roughly 17.7 million barrels a day. Divide 700 by 17.7. It'll last about 40 days."

The auditorium is now silent. "That indicates," he tells us, "that we've already made the big petroleum discoveries. Now we're picking around the edges, getting the last ones."

IN 1975, DURING THE DEPTHS OF THE ENERGY CRISIS, TOM HARKIN arrived in Washington as an Iowa congressman. In his first year on the House Science and Technology Committee, he decided that the threat to the future of energy was genuine. Then Jimmy Carter was elected and, to Harkin's relief, the Administration began dispensing billions and creating incentives for solar, photovoltaic, wind and ocean thermal energy.

Then the next President, Ronald Reagan, dismantled Carter's solar-heating apparatus on the White House roof and all the tax breaks and funding for alternative-energy research along with it. During those lean years, Harkin, now a senator, joined forces with longtime hydrogen zealot Sen. Spark M. Matsunaga of Hawaii to convince whomever they could that hydrogen wasn't some dumb fantasy. After Matsunaga's death in 1990, Harkin and the only other hydrogen devotees around, Reps. George E. Brown Jr. (D-Colton) and Robert S. Walker (R-Pa.) and Sen. Harry Reid (D-Nev.), pushed through a five-year research bill in his memory.

The appropriation was minimal, but after Clinton and Gore were elected, Harkin was sure that would change. Shortly after their inauguration, he presented the new Administration with a 40-page proposal for a sustainable energy future based on hydrogen. It showed how, by using solar photovoltaic electricity to split water, hydrogen actually becomes a way to store the power of the sun, because it can be burned at night or shipped to cold climates where solar energy is scarce. It explained that the cheapest way to produce hydrogen could be through "electro-farming": using marginal land to grow energy crops like switch grass, which could be reduced to hydrogen in a simple device called a biomass gasifier. The gasifier, in turn, would run on excess heat from a hydrogen fuel cell, providing power for the farm.

Harkin also rebutted the myth that hydrogen is more dangerous than traditional fuels, a belief dating to the 1937 explosion that destroyed the German airship Hindenburg. The 36 who died, he explained, were killed in the fall, not from burning hydrogen, which simply floated away (as it would have had the Exxon Valdez transported hydrogen instead of oil). In fact, the 61 Hindenburg survivors would not have lived had the blimp carried natural gas.

But, Harkin concluded, in order to make fuel cells or hydrogen cars affordable, they have to be mass-produced, and before manufacturers will mass-produce them, delivery systems—hydrogen pumps at the corner gas station—have to be in place. That won't happen until there's mass demand for them, and so on. This classic chicken-and-egg dilemma, he argued, could be resolved by a federal commitment to a comfortable transition from fossil fuels.

He didn't get very far. "I told the President he should grab the public's imagination the way Kennedy did with the moon shot, by announcing in his first State of the Union speech that the U.S. was going all out for hydrogen and fuel cells. He looked at me like I was slightly nuts."

Later Harkin ran into Al Gore. If the government purchased large quantities of photovoltaics, he told the vice president, it would lower the cost immensely. The same for fuel cells. No luck there, either. Instead, the tiny hydrogen coalition in Congress actually has had to fight the Administration's

proposed cuts in funding provided by the Matsunaga Act.

In Washington, Harkin's hydrogen consultant, Sandy Thomas, shows me a chart of the Department of Energy's budget. Out of \$18.6 billion, \$10 billion goes for nuclear-weapons research and cleanup. "That's even though we aren't building nuclear weapons anymore. It's an upper-middle-class welfare program for nuclear scientists. Then there's nearly \$1 billion for fossil fuels, even though they're running out; \$300 million for atomic fusion, though we've stopped building nuclear reactors, and nearly half a billion for fusion, the practical application of which even its most optimistic proponents admit is at least 40 years away."

"And for hydrogen research?" I ask.

"Ten million."

I gape. "I know," he says. "We've argued for shifting even \$100 million out of DOE's nuclear-weapons fund. But those decisions are made at the top. It's hard to get Hazel O'Leary's ear on this one."

At a White House conference on environmental technology in December, chaired by Gore, Energy Secretary O'Leary admits to me that in the wake of a new Republican Congress that threatens to cut not just budgets but the entire DOE, she questions the wisdom of bankrolling fusion. On hydrogen however, she doesn't yield. "I'm not an apologist for traditional energy. But my strong opinion is that hydrogen isn't there yet. We have to deliver more mature technologies to market first. Excepting fusion, I think our investments fairly represent the energy marketplace for the near and midterm."

At the conference, Gore, five Cabinet officers and President Clinton's science adviser meet with 1,400 industrialists, entrepreneurs and environmental representatives to discuss how the U.S. can prosper in the growing international market for clean, green technology. There are seminars on environmental export financing and transitions to industrial ecology—ye barely any mention of energy, except for a small workshop on fuel cells and another on transportation technologies.

In the latter, I join a study group chaired by Ford's representative for the Partnership for a New Generation of Vehicles. Among the points we're asked to consider are the prospects for introducing alternative fuels like hydrogen for motor vehicles in the near future. The first to speak up is General Motors' federal research coordinator. "Very dim. As long as gas and diesel stay around \$1.20, consumers have no incentive to use anything else." Alternative fuels, he says, all lack the energy density of petroleum, so it will always cost more to get the same amount of power.

No one contradicts him, so Ford moves on to the next question. I interrupt. "Wait. Isn't the whole reason for this conference the idea that consumer demand today involves things other than price, such as product that don't pollute us to death?"

"I'll believe that," GM replies, "when Californians start buying the 51 miles-per-gallon vehicles that are already available. The fact is, they don't want cars that are more efficient or cleaner."

"SO HOW WOULD YOU GET PEOPLE TO BUY THIS THING?" I yell to Thomas Klaiber; but he doesn't hear me, because a low-slung, Class C racing series model and a black, V-12 600SL roar past us at that instant, on on either side. We're on the Mercedes-Benz test track in Stuttgart, Germany. Klaiber, a mechanical engineer, is head of the Daimler-Benz hydrogen fuel cell group; the van he's driving is the hydrogen-powered vehicle that prompted Mercedes' grand announcement.

If this is really the future we're driving into, at a top cruising speed of 51 miles per hour, it's a little like riding the tortoise while being passed by a flock of jeering hares. Even Mercedes buses are passing us as we negotiate banked curves and climb steep little hills that suddenly appear in the middle of the straightways. Yet the van itself feels surprisingly normal. Amid the surrounding internal combustion thunder, the most noticeable difference is how quietly it runs. The fuel cell itself makes no sound. There's only the hum of an air compressor.

Some significant technological challenges remain unmet, however. Much c

*Continued on Page 4*



# Hydrogen

Continued from Page 22

the cargo area is filled with fiberglass pressure tanks. Although hydrogen has up to three times the efficiency of gasoline, its lightness gives it such low density that even when compressed, its storage requires at least four times the space of a conventional gas tank. This is fine for the fuel-cell buses that Ballard Power Systems is operating successfully in Vancouver, because there's plenty of room on their roofs to store hydrogen. To partly alleviate this problem for passenger cars, Daimler-Benz plans to shrink the fuel cell to one-fourth its current size, even as it increases horsepower.

"The alternative is we store the hydrogen in metal hydrides," Klaiber says, referring to a process in which certain metals absorb hydrogen like a sponge, then release it when heated. "They're fine for commuter cars; citizens tested a fleet for us in Berlin for four years. But for a range of 250 miles, you'd need a ton of hydride. Too much."

I have just come from Munich, where I rode in a silver 7-Series BMW that uses a third storage option: liquid hydrogen, exactly like the space shuttle. Its ride, acceleration, speed and internal combustion engine made it virtually indistinguishable from a regular car. Underneath the chassis, however, was a double-walled tank to keep the fuel at -423 degrees F. But even with that much insulation, too much hydrogen boils off after three days, making it impractical, say, to leave a liquid hydrogen car in an airport parking lot during summer.

Plus, it takes one-third the energy of hydrogen to cool it to a liquid state. So the simplicity and high efficiency of fuel cells, which run at normal temperatures, seem to be winning the race to the future—whenever that is.

Riding with Klaiber, it doesn't feel distant. His face is glowing, almost cherubic. He confesses that he loves driving this thing just because he knows it's so clean.

We pull over. He doesn't turn off the engine but finds a paper cup and holds it over the exhaust pipe. "Drink?" he offers.

It's pure distilled water.

CONSUMERS, I'M TOLD BY HYDROGEN skeptics, won't buy a vehicle whose power and performance fall short of what we expect from our automobiles. In the Daimler-Benz headquarters, Mercedes' vice president of marketing for passenger cars, Jochen Pläcking, shows me a typical ad they use for the United States: a convertible speeding across a New Mexico desert. "We're selling freedom. The limitless power to go explore."

In the halls here, decades of Mercedes advertising posters show beautiful women in fur coats, leaning against gorgeous roadsters. How can you make an environmentally correct car into a sexy status symbol?

Pläcking strokes his mustache. "We'll have to find a way to make clean cars fascinating," he says. "Like selling people on safe sex."

It's not an altogether encouraging analogy, especially in the context. Germany, world leader in hydrogen research investment—about \$12 million a year since the late 1970s until it was blindsided by the expense of reunification—is hardly the renewable-energy economy I imagined. An official from the state of Bavaria's electric utility, which has the world's biggest hydrogen pilot facility, admits there are no plans to scale up to a full-sized working plant. So what will they do in 30 years, when Bavaria's aging nuclear plants must be phased out and fossil fuels are expected to be scarce?

"I can't answer that question. Nobody can. Nobody gives a damn about the future."

Back in my own country, I share this story with Michael Heben, a lanky young materials scientist at the National Renewable Energy Laboratory. Even at BMW and Daimler-Benz, I tell him, hydrogen only gets a small chunk of the research budget. I suppose it's not in a company's interest to invent something that renders its successful product obsolete.

Heben shrugs. He reminds me we've seen computers grow smaller, faster and cheaper at a breathless pace, all because a couple of kids in a garage dared to try to build something better. When Edison was inventing light bulbs and phonographs, electricity cost 300 times what it does now. As soon as people saw what it could do, they started using it en masse, and the price became practical. Maybe, he suggests, one key discovery will do the same for hydrogen—like the semiconductor work of John Turner, who's splitting water without the intermediate step of making photovoltaic electricity.

Other researchers here are cultivating strains of algae that exhale hydrogen. Heben himself is after a revolutionary way to store it. He's trying to prove that submicroscopic tubes made of activated carbon, developed at IBM, suck up hydrogen atoms via capillary action, like a straw. A fuel tank full of the tough, light tubules, each about a billionth of a meter in diameter, could actually hold far more diffuse hydrogen gas than a tank that was empty.

"Our goal should be a vehicle that performs like today's cars: same size, weight, acceleration, frequency of refueling. With good, compact, energy-efficient storage, there is no reason we can't do that with clean hydrogen."

On NREL's lean hydrogen budget, he's currently able to create enough of a soot-like substance containing carbon nanotubes to coat the inside of a countertop bell jar. To scale up to working size will cost a lot more. At this point, he has no idea where funds will come from, but he believes they will materialize.

"We're so close. So much has been accomplished with

just a little. If we really decided that we wanted a clean hydrogen economy, we could have it by 2010. No more oil spills. Fresh air in Denver and L.A. Think of it."

Maybe he's right. Curiously, amid panic over GOP threats to dismember research budgets, hydrogen may prove to be not just a survivor but also a winner. The new chairman of the House Committee on Science is Bob Walker, longtime science mentor to House Speaker Newt Gingrich and hydrogen ally of Tom Harkin.

In his office, decorated with pictures of the space shuttle, Walker reminds me that one of the most powerful forces in the marketplace is "the love Americans have for roaming the planet freely in their own cars. Hydrogen will make that possible when the present technology gets too dirty to extend into the future." He has introduced legislation calling for a quadrupling of research funds for hydrogen over the next three years. Part of the money will be matched by non-federal sources and part expropriated from technologies Walker believes are either futile or outmoded.

He has little pity for industries that resist change, including auto makers. "If Edison were to invent the light bulb today, the headlines would read, '200,000 candle makers lose their jobs.' We've been through this before, like when cars put blacksmiths out of business. It's wrenching, but overall our national competitiveness gets stronger. The same thing will happen in energy. The people themselves will demand it."

He pauses to gaze at a plaque naming him the latest recipient of the National

Hydrogen Assn.'s Spark M. Matsunaga Award. "Driving on the interstate, I watch them stringing fiber-optic cable up the median strip for the Internet. The government talks about the Internet but can't come up with a structure. Meantime, it's happening because people want it. When they realize they need clean hydrogen, somebody will find a way to supply that, too." ■

# FINANCIAL STATUS REPORT

(Follow instructions on the back)

1. FEDERAL AGENCY AND ORGANIZATIONAL ELEMENT TO WHICH REPORT IS SUBMITTED  
 DEPARTMENT OF ENERGY

2. FEDERAL GRANT OR OTHER IDENTIFYING NUMBER  
 IE-FC36-940010039

3. RECIPIENT ORGANIZATION (Name and complete address, including ZIP code)  
 DEPARTMENT OF ENERGY  
 33-0087555

4. EMPLOYER IDENTIFICATION NUMBER  
 33-0087555

5. RECIPIENT ACCOUNT NUMBER OR IDENTIFYING NUMBER  
 33-0087555

6. FINAL REPORT  
 YES  NO

7. BASIS  
 CASH  ACCRUAL

OMB Approved No. 80-R0180

PAGE OF 1 1

8. PROJECT/GRANT PERIOD (See instructions)  
 FROM (Month, day, year) TO (Month, day, year)  
 JANUARY 1, 1995 MARCH 31, 1995

9. PERIOD COVERED BY THIS REPORT  
 FROM (Month, day, year) TO (Month, day, year)  
 JANUARY 1, 1995 MARCH 31, 1995

PROGRAMS/FUNCTIONS/ACTIVITIES ▶	(a)	(b)	(c)	(d)	(e)	(f)	TOTAL (g)
a. Net outlays previously reported	\$ 594,154.38	\$	\$	\$	\$	\$	\$ 594,154.38
b. Total outlays this report period	620,879.14						620,879.14
c. Less: Program income credits	0						0
d. Net outlays this report period (Line b minus line c)	620,879.14						620,879.14
e. Net outlays to date (Line a plus line d)	1,215,033.52						1,215,033.52
f. Less: Non-Federal share of outlays	607,516.76						607,516.76
g. Total Federal share of outlays (Line e minus line f)	607,516.76						607,516.76
h. Total unliquidated obligations	0						0
i. Less: Non-Federal share of unliquidated obligations shown on line h	0						0
j. Federal share of unliquidated obligations	0						0
k. Total Federal share of outlays and unliquidated obligations	607,516.76						607,516.76
l. Total cumulative amount of Federal funds authorized	607,516.76						607,516.76
m. Unobligated balance of Federal funds	0						0

11. INDIRECT EXPENSE

a. TYPE OF RATE (Place "X" in appropriate box)  
 PROVISIONAL  PREDETERMINED  FINAL  FIXED

b. RATE

c. BASE

d. TOTAL AMOUNT

e. FEDERAL SHARE

12. CERTIFICATION  
 I certify to the best of my knowledge and belief that this report is correct and complete and that all outlays and unliquidated obligations are for the purposes set forth in the award documents.

SIGNATURE OF AUTHORIZED CERTIFYING OFFICIAL  
*James J. Provenzano*

TYPED OR PRINTED NAME AND TITLE  
 JAMES J. PROVENZANO  
 SECRETARY/PROJECT MANAGER

DATE REPORT SUBMITTED  
 5/1/95

TELEPHONE (Area code, number and extension)  
 (310) 391-1214

STANDARD FORM 269 (7-76)  
 Prescribed by Office of Management and Budget  
 Cir. No. A-110

# CLEAN AIR NOW/XEROX SOLAR HYDROGEN PROJECT

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