

## Spotlight on NSLS Research



Doug Humphrey

Jerry Silverman (center) talks to visitors from the IBM Research Group based in Yorktown Heights, New York.

### X-Ray Lithography

An integrated circuit is several square millimeters in area, and scientists are attempting to make it even smaller by reducing the sizes of its components: capacitors, resistors, diodes, and transistors.

Jerry Silverman, Rolf Haelbich and Dino Costas of IBM's Research Group from Yorktown Heights, New York are doing research at the National Synchrotron Light Source (NSLS) to determine the capabilities of x-ray lithography for the replication of circuit patterns, a necessary step in the production of integrated circuits.

To achieve the high resolution needed to make the components of an integrated circuit smaller, the patterns must be copied with short wavelength radiation, such as x-rays. And the synchrotron radiation at the NSLS provides both the best available resolution, as well as extremely high intensity.

There are two reasons to make smaller components. First, it would be more economical. But, more important, what slows down a computer is the interconnections between the integrated circuits. If integrated circuits were smaller and denser, electrons

would flow along a shorter path and the computer would operate more efficiently.

The components of an integrated circuit are similar in structure and material — that is, similar techniques are used to make both a transistor and a capacitor. A transistor consists primarily of a silicon substrate to which dopant atoms (boron, phosphorus, or arsenic) have been added to alter the silicon's conductivity. Then, by applying appropriate voltages in different areas, the flow of electrons can be controlled, resulting in the desired currents. The doped areas, called the source and the drain, as well as metal interconnections, must be precisely patterned. That's where x-ray lithography comes in.

The silicon substrate is cleaned and heated, forming a silicon dioxide layer which acts as both a diffusion barrier against dopants and as an electrical insulator. The wafer is then coated with radiation-sensitive material, usually an organic compound, called a resist. Positioned between the radiation source and the resist is a mask which acts as a stencil.

The vacuum ultraviolet ring (750

MeV) of the NSLS provides the x-ray source needed by the IBM group. The wavelengths of light emitted from the NSLS's other ring, the x-ray ring (2 GeV), are too short. Instead, the softer x-rays from the VUV ring are used.

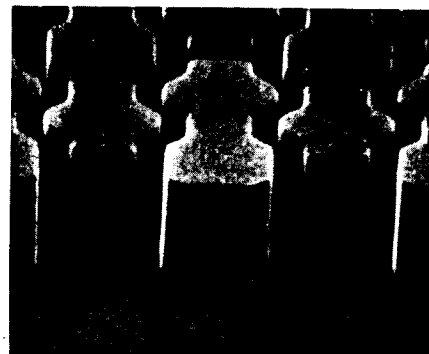
At the U-6 beam port, the beam emanates tangentially from the ring and deflects off an oscillating cylindrical mirror, which scans the beam over the wafer. It next passes through a beryllium window which filters out the less desirable longer wavelengths. The window also acts as a vacuum barrier between the storage ring and the exposure chamber, which is 10 meters from the source.

Inside the chamber is the wafer and the mask. The mask consists of a thin silicon membrane, covered with a gold pattern that absorbs the x-rays and allows a pattern to be formed on the resist. Gold is preferred because it is easy to electroplate, and because of its high density, it has a high absorptivity.

Once the resist is exposed, it's developed and the exposed areas are dissolved, revealing the silicon dioxide layer. An etching step, involving hydrofluoric acid, is then used to remove the oxide in the exposed areas. The regions of the silicon exposed by the silicon dioxide etch process are then treated with silicon dopants to form the source and drain regions, in the same pattern as on the mask.

Next, a gate oxide between the two regions must be formed. The remaining resist and the silicon dioxide from the previous step are removed, and the silicon surface is reoxidized and is recoated with resist. Another exposure step, using a mask with a different pattern, allows an opening to be etched in the new silicon dioxide layer. A thin layer of oxide is then allowed to form in this region. Still another exposure step creates patterns for a metal layer, such as aluminum, which acts as a wire connecting the wafer's regions. The transistor can now become part of an integrated circuit. Size and levels and types of impurities, such as dopants, determine the difference between the transistors.

"A lot of people think we do the actual etching of the wafer here,"



A PMMA resist, 3.4 microns thick, exposed using the IBM x-ray lithography beam line.

says Silverman. "But that's all done at Yorktown. The only thing we do here is the exposure step."

Two types of research can be done at the NSLS: basic and proprietary. Most scientists at BNL are involved in basic research — that is, the results are not directly applicable. The IBM group at beam port U-6 is doing basic research; papers describing their work have been published. "We're happy to let the world know a lot about what we're doing," says Silverman. "Of course, IBM does have an interest in making money, and if we work on something that we may wish to keep as a trade secret, that work would be proprietary."

When, and if, IBM decides to do proprietary research they will have to pay for operating costs and for a percentage of the construction costs. There is no fee for basic research.

What they do varies from day to day. Some days they do exposures. Other days they try to get the beam line to work better. They also make plans and designs for future work. And sometimes they go to Yorktown to collaborate with scientists handling other phases of the research.

Eventually, more people will be arriving from Yorktown Heights to work with new equipment and perhaps to man the beam line around the clock if the method proves to be effective.

—Steve Eisenberg

Next week the Bulletin will explore the research on x-ray microscopy being done by a university team.

### BNL Participates in US/Canada Acid Rain Study

A six-week scientific experiment jointly conducted by the United States and Canada will begin in September. Brookhaven scientists, along with those from DOE's Environmental Measurements Laboratory and Pacific Northwest Laboratory, will be working with a team of Canadian scientists to study how pollution is carried over long distances by wind currents in the atmosphere.

This joint study, which has been planned for several years, has been officially recognized as part of an agreement signed this week by the United States and Canada to cooperate in research on the movement of pollutants that cause acid rain. The study is known as Captex, an acronym for cross-Appalachian tracer experiment.

Russell Dietz, in the Environmental Chemistry Division, DAS, originally developed a technique using perfluorocarbon compounds to trace air masses over long distances, in an

economically viable way. The method uses portable sampling units called BATS, for Brookhaven Atmospheric Tracer Samplers, which were developed at BNL and are now commercially available.

For the U.S./Canada experiment, the BNL tracer technique will be used with perfluoro-monomethyl-cyclohexane (PMCH). Inert, colorless and non-toxic, PMCH will be released from two industrialized areas regarded as major sources of air pollution — the region around Dayton, Ohio, and Sudbury, Ontario. Using airplanes and a network of ground-sampling stations, both equipped with BATS, the scientists will trace the movement of PMCH east across the continent.

Funding for the project comes from the National Oceanic and Atmospheric Administration, the U.S. Department of Energy, the Environmental Protection Agency, the Electric Power Research Institute, and Canadian Government agencies.



Doug Humphrey

Rolf Haelbich (left) and Dino Costas at beam port U-6 used by IBM.

# A Night at the Main Gate

"How much do I owe you, honey?" "Excuse me." "Isn't this a toll booth?" "No. It's the entrance to Brookhaven National Laboratory." "Well, could I come in?" "Who are you visiting?" "You." "Sir, I'll have to ask you to leave." "I don't have to. I pay my taxes."

Patrol Officer Cathy Vanderoef steps into the booth at the main gate, picks up a walkie talkie and speaks with Captain Baulch, her shift supervisor, who arrives in a few minutes to escort the man off-site.

It's twilight and Vanderoef has just started a two hour shift. Deer, some coughing softly, begin to walk around the booth. And a nine point buck gets hit by a speeding car near the blinking light farther down the road as a limousine drops off a visitor near the main gate.

Two dogs, a German Shepherd and a Labrador Retriever, both with leashes, come out of the woods, lope over to the booth, and rub their paws against the bricks. They begin to pout, then whimper, but don't bark. Vanderoef lets them into the booth where she pets them.

The traffic light on the William Floyd turns green and a set of high beams comes toward the main gate. They pass the sign, "Headlights Off," and pull up to the booth.

"Could you shut your lights please?" "I'm looking for two dogs." "What kind of dogs?" "A mutt and a Dalmation." "When did you last see them?" "A few hours ago." "And you think they're here?" "Don't you take dogs off the street and use them for experiments?" "No." "Then why are those dogs inside with you?" "They're leaving as soon as the captain escorts them off-site." "Can you arrange it so he also talks with me?" "Yes. Just pull up alongside the information booth." "Thank you."

Patrol Officer Jeff Taylor and Captain Baulch, in a green pick-up, stop at the main gate. Taylor relieves Vanderoef, who goes back with Baulch after he talks with the owner of the lost dogs.

Taylor listens to the radio and watches as a Cadillac stops at the gate.

"Excuse me, officer, is this the turn-off for Brooklyn?" "No." "Is this the

entrance to the LIE?" "No. Can I help you?" "I'm looking for Brooklyn." "What you have to do is turn around, make a left at the traffic light and take the second right, which will take you to the expressway." "Thank you."

The Cadillac turns around but into the oncoming lanes of traffic. Taylor picks up the walkie talkie and talks with Baulch who speeds down the road. Patrol Officer Roger Kiely in a green pick-up is two car lengths behind. They turn left at the light and coming toward them is the Cadillac. So they stop him and show him where the LIE really is.

It's midnight, and Kiely is now on duty. He looks up and sees Igor the Bat flying near the lights which shine upon a stopped car whose driver is screaming that he's having a heart attack. An ambulance arrives and takes him to Brookhaven Hospital.

Kiely steps out of the booth and walks around it a few times. He sees a car stop thirty feet from where he's wiping sweat from his forehead. The car makes a U-turn and leaves the Lab.

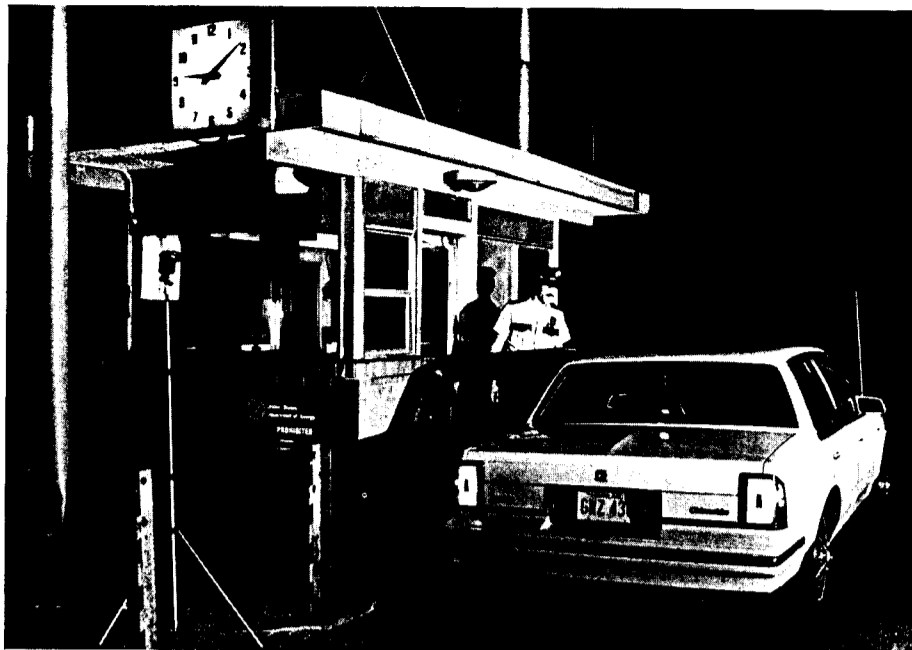
The booth phone rings. It's Baulch, who tells Kiely that Patrol Officer Harvey Richardson is on the Lab's outer perimeter and will be a few minutes late.

Seven minutes, to be precise. He turns on his scanner, sits down and looks at a moth sliding down the tinted glass of the booth. Lightning begins to strike. The moth flies off into the lights to which several types of insects are attracted.

Richardson packs tobacco into his pipe and strikes a match. He strikes two more matches, and smoke fills the booth. He slides the door open after the lightning stops and begins to imitate a cat meowing below the insect zapper attached to the information booth.

An orange Vega stops at the gate. "I know you're in there, Harvey." "How are you, buddy?" "I'm fine. Have a good night." "You too, buddy."

A station wagon with a flat tire follows the Vega past the booth, turns around at the traffic light, and returns in the same lane. Richardson chases the car with a flashlight and waves it over to the other side of the



Tom DeSimone greets a nighttime visitor.

Peter Horton

road. The driver's window rolls down.

"Could you check to see if I have a flat tire?"

"You sure do."

"Thank you."

It's 4:25 and a Suffolk County police officer pulls up to the booth and chats with Patrol Officer Frank Crifasi. They talk about the humidity and the fallen tree near the cafeteria. He stays for five minutes and leaves.

Crifasi sits down and calls headquarters. He talks about a mouse crawling underneath the pipes in the back of the booth. It's not a very big mouse; it's a little over two inches long. And it's dirty white.

The deliveries are next. Milk. Newspapers. Bread. The drivers are always the same.

Two minutes after the bread truck leaves, a pick-up with two people on the back passes Crifasi who watches a car follow the pick-up. The driver of the second car yells, "I'm a Suffolk County cop." Crifasi picks up the

walkie talkie and notifies Baulch who, with another patrol officer, chases the pick-up to one of the firebreaks, where it can't drive any further, turns around and is about to ram into the captain's pick-up when he pulls out his pistol and shoots the left front tire. By this time the two on the back are running into the woods, and the driver is being handcuffed.

The three had robbed a gas station. The sun is rising.

*Not a typical night at the main gate. The names, of course, are true. The stories are true. But the events occurred over a long period of time with the stories not necessarily matching the names.*

*A typical night usually entails recording license plate numbers or entering cars from 8:30 p.m. to 6:30 a.m. and of exiting cars from 10:30 p.m. to 6:30 a.m.*

*...and sometimes something interesting happens.*

— Steve Eisenberg

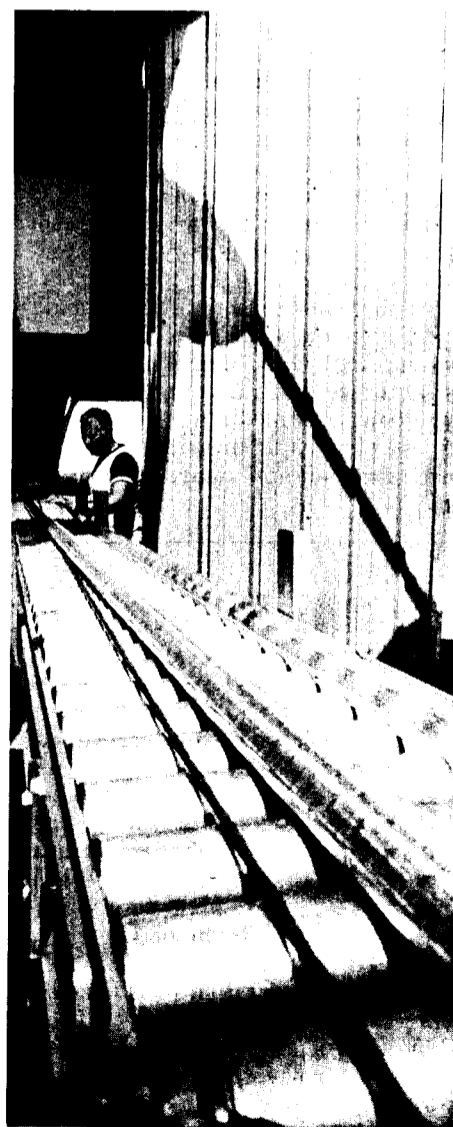


Alex Reben

The technology for creating high temperature, solid oxide electrolyte fuel cells was the subject of a three-day conference which concluded last week in Berkner Hall. The workshop was a follow-up to a 1977 meeting on the same topic, also held at BNL. Over 70 of the world's leading experts in this field, from both research and industry, participated in this year's program, including representatives of DOE's Office of Fossil Energy, which sponsored the conference, and members of the Organizing Committee (OC): (from left) Frank Salzano, OC, BNL; Frank Gmeindl, DOE; Mo Zahid, DOE; Hugh Isaacs, OC, BNL; Darrell Fee, OC, Argonne National Laboratory; Ann Schuler, OC, BNL; Clovis Linkous, OC, BNL; John Fillo, OC, BNL; and Richard Gariboldi, DOE. (Not shown: Gerald Wirz, OC, University of Illinois.) In the opening address, Gariboldi said, "The solid oxide fuel cell, with its potential for high system efficiency and high quality waste heat, has great promise as a system for distributed power generation... Clean, quiet, highly efficient electricity from a variety of fuels at a lower cost continues to be the major reason for pursuing more advanced fuel cells." At BNL, research into fundamental fuel cell phenomena is conducted by the Materials Chemistry & Energy Conversion Division of DAS, headed by Salzano, as well as the Materials Technology and Reactor Systems Divisions of DNE.



On August 10, Eric Forsyth (above, left), head of the Power Transmission Project, gave a tour of the superconducting power transmission facility to Volker Soergel, director of DESY, the accelerator laboratory in West Germany. Dr. Soergel was at BNL for a general visit. He also toured the CBA tunnel and magnet facilities, the National Synchrotron Light Source and PETT VI, the positron emission transaxial tomography brain scanner which is jointly operated by the Chemistry and Medical Departments. A week later, the Power Transmission Project was busy with a very different activity. On August 16, W.A. Chester, Inc., high voltage installation specialists who install cable for commercial utility companies all over the country, came to BNL. Their purpose was to install a room temperature cable that has been developed by the BNL group and built on the same winding machine that manufactured the superconducting cable. This innovative room temperature cable carries considerably more current at higher voltage than the same size conventional cable. Also, it can be retrofitted (pulled into an existing pipe) and impregnated in the field with oil in a very small fraction of the time it takes with ordinary cables, which must be impregnated under special conditions at the factory. On August 17, W.A. Chester began to install high voltage stress cones and termination bushings. When that was finished at the end of the week, the BNL team began preparations to connect power to the newly installed terminations. Next the pipe will be evacuated and filled with special cable oils. Pictured at right is Bill Kristiansen, who was guiding the room temperature cable during installation.



Doug Humphreys

# BROOKHAVEN BULLETIN

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## Train Taxi

Every weekday, a Laboratory driver meets the 8:40 a.m. train from Penn Station on its arrival at 10:16 a.m. in Patchogue. BNL-bound travelers are then brought to their individual destinations on site.

At 4:25 p.m. every weekday, New York-bound visitors may take a Laboratory car to Shirley to meet the 4:55 p.m. train which gets in to Penn Station at 6:32 p.m. The car leaves from Bldg. 134 (Public Relations) and passengers should be on hand by 4:20 p.m. Reservations must be made by calling Ext. 2345.



John Lee Hooker



Doug "Harmonica" McLean

John Lee Hooker will sing the blues at Berkner Hall on Saturday, September 3, at 8 p.m. One of the all-time greats, Hooker said in a California Today interview that there are five or six bluesmen still performing, and that "When we're gone, they'll still be people playin' the blues, but not the way we play it." And he's probably right. There won't be many opportunities left to hear a singer who really knows how to sing the blues. Hooker will be accompanied by his Coast to Coast Blues Band. On the same bill is Doug "Harmonica" McLean's Blues Band. McLean has worked with Hooker and other blues greats, B.B. King and Muddy Waters. Now, with his own band, he is delighting audiences with his innovative, electrified harmonica. Tickets are \$10, if purchased in advance from the BERA Sales Office, or from ticket reps. The night of the concert, tickets will be \$12 at the door. Ticket reps are: Mary Durham, Ext. 7982; April Donegain, Ext. 2903; Mac Thomas, Ext. 2959; Kay Hunt, Ext. 2882; Deidre Seymour, Ext. 5037; and Sandra Green, Ext. 4933.

## Ph.D.'s on the Rise

A nine-year decline in the number of science and engineering doctoral graduates ended in 1981 when the number of degrees granted increased to 17,600, up 400 from the previous year, according to a report by the National Science Foundation. Preliminary data for 1982 show the number of science/engineering degrees virtually unchanged from 1981.

The report also found that the number of science/engineering doctorates granted to women has increased yearly, from 400 in 1960 to 4,000 in 1981. Still, women doctorates were concentrated in the life and social sciences.

Since the 1960's the fields in which doctorate degrees are concentrated have been shifting. The proportion of doctorates in the life and social sciences and psychology rose from slightly more than one-half in 1960 to three-fifths in 1981, while the share for the physical sciences declined from 25 percent to 15 percent.

The report provides such information as sex, race and citizenship of new doctorates, as well as their post-graduate plans. Also included are rank-ordered lists of the 100 institutions that awarded the most science/engineering doctorates during the 1960-81 period and the 300 baccalaureate institutions with the largest number of alumni holding science/engineering doctorates.

Copies of the report, NSF 83-309, are available from the Division of Science Resources Studies, National Science Foundation, Washington, DC 20550. Telephone (202)634-4622.

## Cafeteria Menu

Week Ending September 2

<b>Monday, August 29</b>	
Cream of celery soup	(cup) .65 (bowl) .75
Cheese omelet & 1 veg.	1.80
Beef chow mein on rice	1.85
Hot Deli: Corned beef	(bread) 1.85 (roll) 2.00
<b>Tuesday, August 30</b>	
Turkey okra Creole	(cup) .65 (bowl) .75
London broil w/1 veg. & mushroom gravy	2.10
Baked lasagna & 1 veg.	1.95
Hot Deli: French toasted ham & cheese	1.80
<b>Wednesday, August 31</b>	
Old fashioned bean soup	(cup) .65 (bowl) .75
Beef Stroganoff on egg noodles	1.95
Ham & broccoli crepes & 1 veg.	1.85
Hot Deli: Knockwurst & sauerkraut	(bread) 1.85 (roll) 2.00
<b>Thursday, September 1</b>	
Split pea soup	(cup) .65 (bowl) .75
Stuffed pepper & 1 veg. w/spaghetti	1.85 2.05
Tuna noodle casserole & 1 veg.	1.85
Hot Deli: Barbeque boneless pork rib	2.00
<b>Friday, September 2</b>	
Fish chowder	(cup) .65 (bowl) .75
Fish & chips	1.85
Beef hash & 1 veg.	1.85
Hot Deli: Baked ham	(bread) 1.85 (roll) 2.00

## Arrivals & Departures

### Arrivals

Robert D. Baldwin, Jr. .... Reactor

### Departures

This list includes all employees who have terminated from the Laboratory, including retirees:

Aryeh A. Frimer ..... Medical  
Masanori Okawa ..... Physics

## Service Awards

The following employees received service awards during the month of August:

- Thirty-Five Years**  
Murray J. Klein ..... Reactor  
Smith G. Pearsall ..... S&EP
- Twenty-Five Years**  
Benon H.J. Bielski ..... Chemistry  
Leon Green ..... Nuclear Energy  
Blanche R. Laskee ..... Personnel  
Dorothy C. Luther ..... Plant Eng  
Benjamin Magurno ..... Nuclear Energy  
Paul A. Michael ..... App. Science  
Edward A. Pluta ..... Central Shops
- Twenty Years**  
Nicholas Alonzo ..... Biology  
Daniel L. Gilliam ..... S&EP  
Richard Lehmann ..... Accelerator  
Erno A. Ostheimer ..... Accelerator  
Joseph T. Russo ..... Physics  
Roy Skarka ..... P&GA  
Robert J. Warkentien ..... Accelerator  
George C. Warner ..... Accelerator
- Ten Years**  
Peter M. Heotis ..... Medical  
Fletcher E. Johnson ..... S&M  
Renee M. Tonini ..... MIS

## Diners Note

The Cafeteria will be closed on Saturday, August 27. On that day, snack bar service will be available from 9 a.m. to 2 p.m. at the Brookhaven Center.

## Swimming Pool

Summer season tickets are valid through Sunday, September 4. During the week of August 29 through September 4, the pool will be open as follows:

**Monday through Friday**  
(Employees only)

11 a.m. to 1:30 p.m.  
(Employees/Families/Guests)

1:30 p.m. to 9:30 p.m.

**Saturday and Sunday**  
(Employees/Families/Guests)

1 p.m. to 6 p.m.

The pool will be closed on Monday, September 5 (Lab holiday).

### New Season

Tickets for a new four-month pool season will be sold at the pool starting Tuesday, September 6.

### Fees:

Season Tickets (fees not prorated)	
Individual Membership	\$23.00
Family Membership	33.00
Daily Admissions	
Employee/Family Member	1.25
Guest	1.75

### Schedule:

**Monday through Friday**  
(Employees only)

11 a.m. to 1:30 p.m.

(Employees/Families/Guests)  
5 p.m. to 9:30 p.m.

**Saturday and Sunday**  
Employees/Families/Guests

1 p.m. to 6 p.m.

**Guest Ruling** (Applies to all recreation facilities)

**One Guest** - An employee is allowed to bring one guest per visit without special permission or prior arrangement. The guest must be accompanied by the employee.

**Two to Five Guests** - Advance arrangements for two to five guests may be made at the Recreation Office. (No more than five guests per employee is ever permitted.) When such an arrangement is made, the Recreation Office issues an admission card stating the sponsor's name and life number, the number of guests permitted, the date of visit, and the facility to be visited. Guests must be accompanied by the employee, who will be requested to show the admission card at the main gate and at the swimming pool ticket desk.

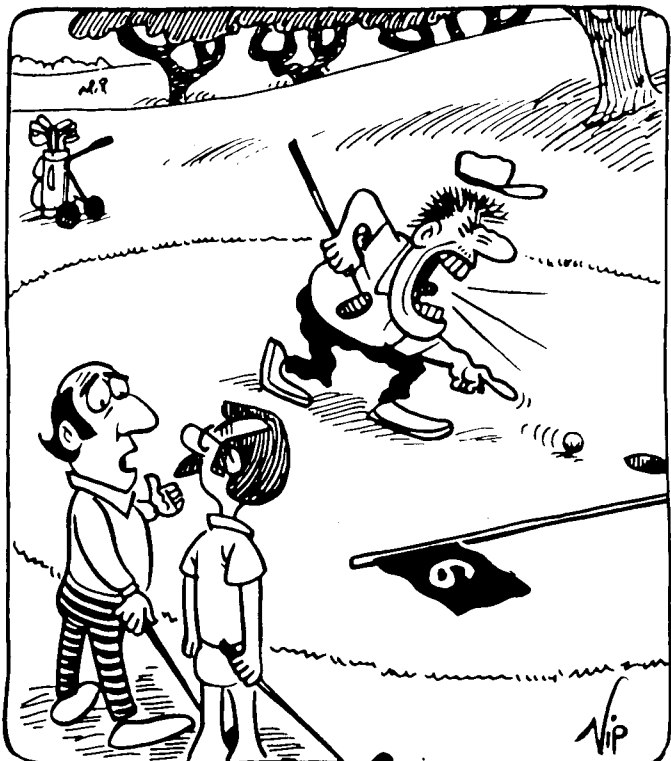
Sponsoring employees are responsible for their guests during the entire time they are on site.

## Special Event

Reserve the date of October 14 or 15 for Dinner Theatre at BNL sponsored by the Special Events Committee of BNL. Watch for additional details in future Bulletins.

## Att: Commodore Users

All those interested in joining the Commodore Users Club may contact Ken Orsini at Ext. 5042, Bldg. 901A.



"Isn't there anything in the rules about browbeating a ball into the hole?"

## NYC Train Trip

The Hospitality Committee is planning a group railroad trip to New York City on Wednesday, September 7. Departure will be at 7:55 a.m. from the Patchogue LIRR station. Round-trip fare for adults is \$3.50; children under five years ride free.

Reserve a ticket by sending your fare through the U.S. mail to BNL, P.O. Box 322, Upton, New York 11973. Please do not send cash. Checks or money orders, payable to BNL, must be received by Thursday, September 1. Put the date of the trip, your BNL life number and your phone number on the back of your check or money order. Your tickets will be given to you at the railroad station on the day of the trip. Refunds will be made only if cancellations are received by the Monday morning preceding the trip.

## Sugar Facts

If you're an average American, the Cooperative Extension Association of Suffolk County says you probably consumed about 125 pounds of sugar last year. About two-thirds of the sugar eaten in the U.S. is in the form of refined sugar, while the rest comes from dairy products, fruits and other foods. As far as your body is concerned, sugar is sugar. But eating foods that contain natural sugar gives you an added bonus — important nutrients, rather than just energy and calories.

