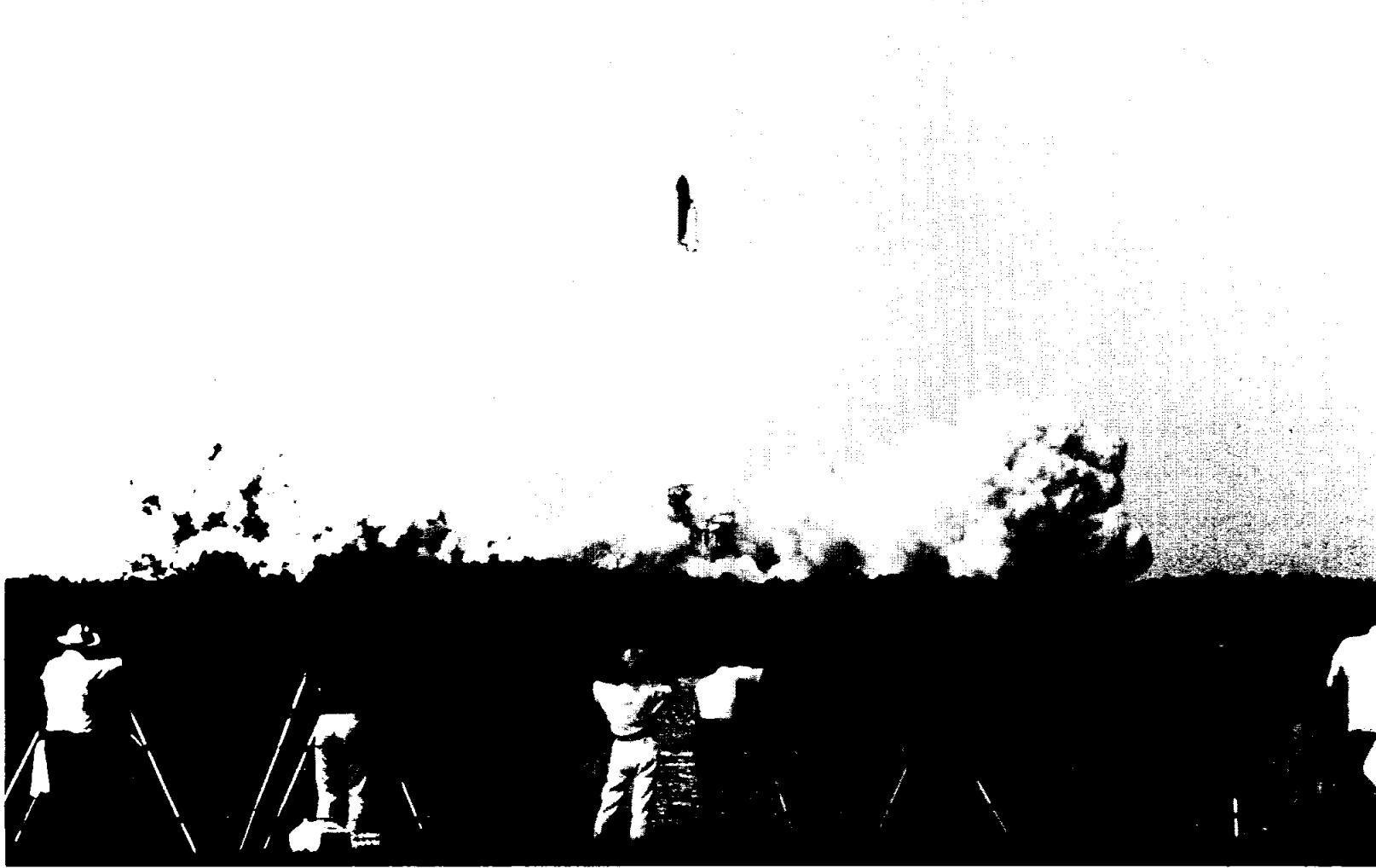


Space News Roundup

“Limits to inhibit”

Sensors cited as cause of center engine shutdown on 51-F



Challenger roars toward space July 29, minutes before an engine shutdown. (Photo by Otis Imboden)

A review of engine data following last week's 51-F launch has led engineers to the conclusion that failed sensors—not an engine failure—were the probable cause of the No. 1 Space Shuttle Main Engine being commanded to shut down before the Shuttle *Challenger* reached orbit.

That engine shutdown, and the subsequent failure of another sensor on the No. 3 Main Engine, put JSC's Mission Operations team to the test in some of the most demanding moments yet in the Shuttle program.

The shutdown caused Mission Control to instruct the flight crew of *Challenger* to select an "Abort to Orbit" case (ATO), the most desirable of the Shuttle abort modes, but one which might not have been possible had the engine gone down even a few seconds earlier. Had the *Challenger* not gained sufficient velocity to reach a high enough apogee (about 100 nautical miles) to go into orbit, a high speed trans-Atlantic landing at Zaragosa, Spain might have been necessary.

After the dust settled, flight controllers and mission officials remarked how closely the situation resembled the simulations which are regularly held to train the flight operations teams. In the final abort sim prior to the 51-F launch, in fact, Cleon Lacefield's

(Continued on page 3)

Aldrich named NSTS Program Manager

Arnold D. Aldrich has been appointed Manager of the National Space Transportation System. Aldrich, a 26-year NASA veteran and head of the Space Shuttle Projects Office at the Johnson Space Center, fills the vacancy left when Glynn S. Lunney retired in April.

The Level II NSTS organization at JSC will assimilate the Projects Office to consolidate all program elements under Aldrich's direction. Richard H. Kohrs, who has been acting program manager, and Lt.

Col. Thomas W. Redmond, USAF, have been named Deputy Managers.

In a related move, Thomas E. Utsman, head of Shuttle Management and Operations at the Kennedy Space Center, will become Deputy Director of KSC. Shuttle Management and Operations will be divided into two primary organizations: Shuttle Engineering and Shuttle Operations.

The functions of the Engineering Directorate at KSC headed by

Horace L. Lamberth, will be expanded to include skills necessary for sustaining engineering of the Orbiter.

The KSC Operations Directorate, headed by Robert B. Sieck, will retain all functions necessary to manage the day-to-day Shuttle processing and its logistical support.

All of the appointments are effective August 12.

Launch Support Services and Orbiter Thermal Protection System manufacturing contracts, functions

closely associated with KSC responsibilities for Shuttle maintenance and launch preparation, will be transferred from JSC to KSC later this year. At the beginning of 1986, KSC will also take over logistics responsibility for spare parts refurbishment and procurement and will begin assuming sustaining engineering responsibility for Orbiter subsystems.

The moves are an administrative realignment reflecting the maturation of the Shuttle program. Staffing levels at the two Centers

will not be affected by the new organizational structure.

With the combined responsibility, Aldrich takes charge of integration of all Space Shuttle Program elements including flight software, Orbiter, external tank, solid rocket boosters, main engines, payloads, payload carriers and Space Shuttle facilities. Responsibilities also include directing the planning for NSTS operations and for management of Orbiter and Government Fur-

(Continued on page 2)

Space Ops to get new office complex

To address critical space limitations within the Mission Operations Directorate, work began recently on the first dedicated office complex to be built on site since original construction of JSC in the early 1960s.

The 19,600-square-foot modular building, to be known as Bldg. T-585 or, the Space Operations Modular Complex, is going up between Bldgs. 5 and 29.

The structure will consist of 24 prefabricated modules and is scheduled to be completed by the end of the year. The modules will be constructed in a factory, transported to JSC, and set in place on a foundation prepared by the Facilities Design Division, according to Project Engineer Ed Hubenak. Each module is 60 feet long, and all are either 12 or 14 feet wide.

The building will house approximately 140 people — about the size of a division — according to Center Operations Director Kenneth Gilbreath.

The last two buildings constructed at JSC, Bldgs. 17 and 31A, are laboratories and contain no appreciable office space. The Lunar Curatorial Facility, Bldg. 31A, was the last new structure built on site. It was completed in 1979. Bldg. 17 was completed in 1971.

The building will be given a "T" designation (for temporary) because it is considered to be relocatable. "In general, the building is temporary in nature relative to our other buildings," Gilbreath said. "It is good for several years, but does not have the same specifications as the permanent structures at JSC. It is relatively inexpensive compared to our other office structures, and the need for it was considered to be an emergency.

"The congestion in Bldgs. 4, 29 and 30A is critical. This gives us additional office space of about 14,500 square feet," Gilbreath said. "The major objective is to offload Bldg. 4."

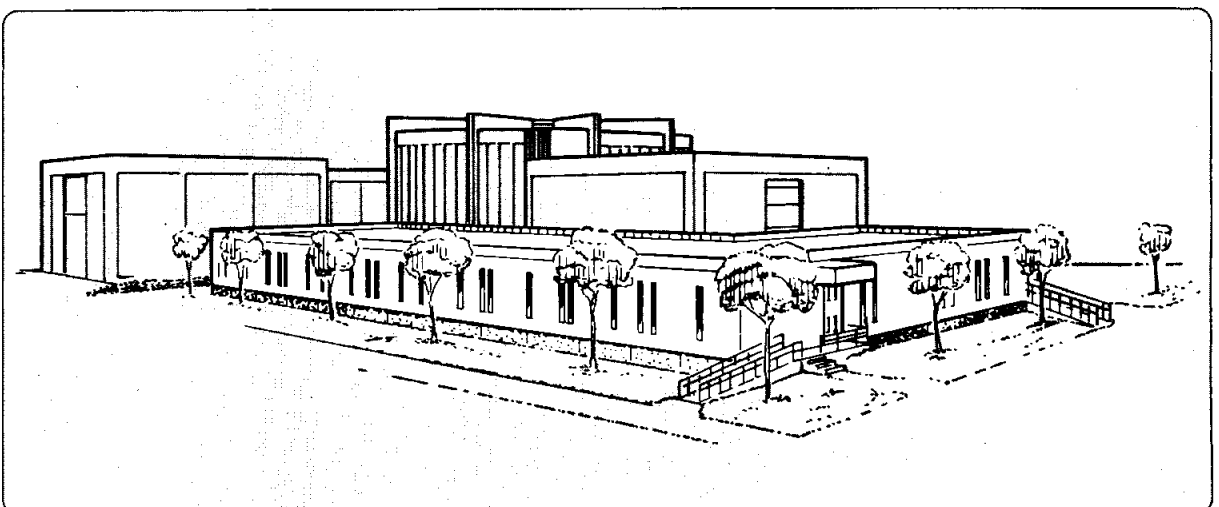
In addition to 14,500 square feet of offices, the new building will also include a conference room, rest rooms and a room for reproduction equipment, Hubenak said.

Mission Operations Director

Eugene Kranz said it has not yet been decided which elements of his directorate will occupy the new building, but it became clear months ago that something had to be done. "We have saturated our facilities," he said. "I think it

is fair to say that MOD has the highest density of people per building on-site."

The \$1,392,000 contract for construction of the building was awarded to C.L. Vick Construction Co., Inc. of Houston on July 5.



Artist's concept of new building to go up next to Bldg. 29.

Space News Briefs

Board to study Galileo II crash

NASA has convened an investigation board to study the July 17 accident in which 19 people escaped injury when fire destroyed the Galileo II aircraft. During a takeoff roll at March Air Force Base, Calif., a tire on the specially modified jet aircraft blew just prior to rotation. A fuel tank fire began in connection with the blowout. Pilot Casey Call was able to bring the Convair 990 to a full stop and the 15 passengers and 4 crew members evacuated the aircraft in about 30 seconds using two inflatable slides. The heavily instrumented research plane, attached to the NASA Ames Research Center fleet, was on a mission to view and record the making of an artificial comet over the Pacific Ocean as part of the multi-nation Active Magnetospheric Particle Tracer Experiment (AMPTE). Ames official Robert Cameron said Pilot Call did a remarkable job of maintaining control of the jet. "If anyone deserves a medal, he does."

Martin Marietta delivers 30th ET

The 30th Space Shuttle external tank has been delivered to NASA by Martin Marietta. The tank is scheduled to fly in March 1986 on STS 61-E, which will carry the ASTRO-1 ultraviolet astronomy package and the WESTAR-7 communications satellite. The 154-foot-long fuel tanks are built at NASA's Michoud Assembly Facility near New Orleans. So far in the program, productivity has increased due to new tools and assembly line techniques, and a 10,000 pound weight reduction has been incorporated into the design of the tanks. Contracts to date provide for delivery of 59 external tanks, the company said.

2d Space Wing activated

The 2d Space Wing, under the command of Col. Richard L. "Larry" Griffin, was activated July 8 in ceremonies at Falcon Air Force Station near Colorado Springs, Colo. The new wing, a major component of the U.S. Air Force Space Command, will manage and control operational military satellites and Department of Defense Space Shuttle missions. Gen. Robert T. Herres, commander of the Air Force Space Command, passed the new 2d Space Wing flag to Col. Griffin during the activation ceremony. On hand for the occasion were JSC Director Gerald D. Griffin and STS Operation Integration Manager Jay Honeycutt, as well as astronauts Karol Bobko, John Casper, Lloyd Hammond, Brewster Shaw and Loren Shriver, all U.S. Air Force officers. By October, the wing will have approximately 275 active duty military and Air Force civilians assigned at Falcon AFS. When fully operational in the early 1990s, the wing will have grown to around 2,600 active duty military and Air Force civilians and about 1,500 contractors worldwide.

INMARSAT to fly Shuttle

The Space Shuttle has been selected to provide launch services for two International Maritime Satellite Organization (INMARSAT) satellites in 1988 and 1989. The two communications satellites are part of INMARSAT's second generation series, and will enhance the existing satellite network that serves 43 nations, including the United States. The satellites will be built by British Aerospace with Hughes Aircraft supplying the spacecraft communications payload. A McDonnell Douglas Payload Assist Module (PAM-D) will be used to boost each satellite to geosynchronous Earth orbit. The launches are scheduled for July 1988 and mid-1989.

Bulletin Board

BAPCO to meet Aug. 20

The Bay Area PC Organization (BAPCO), the local IBM-PC users' group, will hold its next monthly meeting at 7 p.m. Tuesday, Aug. 20 at the Sheraton King's Inn on NASA Road 1. BAPCO meets regularly on the third Tuesday of each month. For more information, call Earl Rubenstein at x3501 or Hattie Thurlow at x2213.

Alley Theatre passes available

Alley Theatre preferred passes are again being offered to JSC employees and contractors this year for the 1985-86 season. Ten plays are on schedule for the Alley this year. Brochure order forms, which also explain the preferred pass program, are available at the Bldg. 11 Cafeteria or from your EAA representative. To subscribe, fill out the form, enclose a check or indicate a charge plan, and mail to Doris Wood at Mail Code FD4 (x5263). Orders may be placed until Oct. 4. Those who order before Aug. 19 will receive a free pass to the summer play, "Kind Lady," which runs through Sept. 1.

Intersections to get traffic lights

The two busiest intersections at JSC will soon get smart traffic lights capable of sensing traffic flow and reacting accordingly.

The lights will be installed at the intersection of Second Street and Avenue E and at the intersection of Second Street and Avenue B.

The basic principle behind the lights involves a magnetic loop system. To a magnet, a car is a large ferrous object, and when large ferrous objects pass over magnetic loop sensors buried in the roadway, they will be sensed and responded to. The traffic light is thus able to sense which lanes of traffic have the most cars awaiting passage.

MOD Olympics event set

The Mission Operations Directorate will hold the first annual MOD Olympics from 9 a.m. to 3 p.m. Sept. 7. The friendly competition between MOD's six divisions will be a family event with participation from both spouses and children. There will be three age groups: 10 years and below, 11-16 years and 17 and over. More detailed information on the events will be circulated within MOD.

Pricing policy set

President Reagan last week directed a new pricing policy for the Shuttle in accordance with the National Space Strategy.

Beginning in FY 1989, Shuttle flight capacity will be sold at auction to foreign and commercial users. The NASA Administrator will establish auction procedures to ensure maximum return to the government and equitable treatment for all potential launch customers.

The National Space Strategy directs the development of a plan for implementing full cost recovery of foreign and commercial Shuttle flights occurring after October 1, 1988.

The minimum acceptable bid

will be \$74 million (in 1982 dollars) per Shuttle equivalent. Three Shuttle equivalents per year will be available to the foreign and commercial market until 2 years before the launch year, at which time NASA may offer any remaining unused capacity. NASA may accept bids for multiple payloads at the auction price, subject to the above quotas. The above quotas will not apply to flights for new and innovative uses of space.

NASA will review annually Shuttle cost experience and the anticipated future effectiveness of this pricing policy in implementing National Space Policy goals under changing market conditions. NASA will submit its annual report,

together with any recommendations for changes in the auction floor price or other aspects of this pricing policy, to the Assistant to the President for National Security Affairs and the Director of the Office of Management and Budget. Any policy issues resulting from this annual report may be referred to the Senior Interagency Group for Space.

The price charged to the Department of Defense for Shuttle flights will be negotiated separately from this foreign and commercial pricing policy and will be based on the National Security Launch Strategy and appropriate compensation for DOD services rendered in connection with Shuttle flights.

Bush announces teacher in space

Vice President Bush announced July 19 that Sharon Christa McAuliffe will be the teacher to go into space aboard the Space Shuttle next January.

McAuliffe, who prefers to be called Chris, is a social studies teacher at Concord High School, Concord, N.H. She is the finalist in the NASA Teacher in Space Project, which was announced by President Reagan in August 1984. Her back-up will be Barbara R. Morgan of McCall-Donnelly Elementary School, McCall, Idaho.

The eight other teachers who reached final competition for the flight opportunity accompanied McAuliffe and Morgan to the White House.

The 10 project finalists, selected from 114 elementary and secondary school teachers, were announced on July 1 and reported to JSC on July 7 for thorough medical examinations and space flight suitability testing. Beginning July 15, the teachers were interviewed by the NASA Space Flight Participant Committee in Washington, D.C.

McAuliffe has proposed that while in space, she would gather information for a personal journal. "My journal would be a trilogy. I would like to begin it at the point of selection through the training for the program. The second part would cover the actual flight. Part three would cover my thoughts and reactions after my return," McAuliffe said.

After the flight, McAuliffe has expressed her desire to share her

experiences with educators. She said, "As an educational conference speaker, I would share my space flight experiences through a slide or video tape presentation and lecture. As a presenter in the

workshop format, I would have the opportunity to meet with small groups of educators from different disciplines and give them suggestions for class projects and activities."

Cookin' in the Cafeteria

Week of August 12 — 16, 1985

Monday — Cream of Potato Soup; Franks & Sauerkraut, Stuffed Pork Chop, Potato Baked Chicken, Meat Sauce & Spaghetti (Special); French Beans, Buttered Squash, Buttered Beans. Standard Daily Items: Roast Beef, Baked Ham, Fried Chicken, Fried Fish, Chopped Sirloin. Selection of Salads, Sandwiches and Pies.

Tuesday — Navy Bean Soup; Beef Stew, Liver & Onions, Shrimp Creole, Smothered Steak w/Dressing (Special); Corn, Rice, Cabbage, Peas.

Wednesday — Seafood Gumbo; Roast Beef, Baked Perch, Chicken Pan Pie, Salmon Croquette (Special); Mustard Greens, Italian Green Beans, Sliced Beets.

Thursday — Beef & Barley Soup; Beef Tacos, Diced Ham w/Lima Beans, Stuffed Cabbage (Special); Ranch Style Beans, Brussels Sprouts, Cream Style Corn.

Friday — Seafood Gumbo; Fried Shrimp, Deviled Crabs, Ham Steak, Salisbury Steak (Special); Buttered Carrots, Green Beans, June Peas.

Week of August 19 — 23, 1985

Monday — Cream of Chicken Soup; Beef Burgundy over Noodles, Fried Chicken, BBQ Sausage Link, Hamburger Steak (Special); Buttered Corn, Carrots, Green Beans. Standard Daily Items: Roast Beef, Baked Ham, Fried Chicken, Fried Fish, Chopped Sirloin. Selection of Salads, Sandwiches and Pies.

Tuesday — Beef Noodle Soup; Baked Meatloaf, Liver & Onions, BBQ Spare Ribs, Turkey & Dressing (Special); Spanish Rice, Broccoli, Buttered Squash.

Wednesday — Seafood Gumbo; Broiled Fish, Tamales w/Chili, Spanish Macaroni (Special); Ranch Beans, Beets, Parsley Potatoes.

Thursday — Navy Bean Soup; Beef Pot Roast, Shrimp Chop Suey, Pork Chops, Chicken Fried Steak (Special); Carrots, Cabbage, Green Beans.

Friday — Seafood Gumbo; Broiled Halibut, Fried Shrimp, Baked Ham, Tuna & Noodle Casserole (Special); Corn, Turnip Greens, Stewed Tomatoes.

Sensor upgrade set for 51-I

Engineers are examining the role sensors played in the 51-F main engine shutdown and looking ahead for transducer upgrades slated for 51-I.

All data indications suggest the high pressure fuel turbopump on that engine performed normally, and specific indications that would have been expected if the pump were running hot were absent. Until such time as this is confirmed by an examination of the engine and its various systems and the cause of the shutdown is fully understood, NASA will not launch another mission. NASA does not anticipate at this time, however, that there will be any resultant delay in the next mission.

If the pump had actually been running hot, flight engineers at JSC, who monitor engine performance during ascent, would have expected to see changes in the position of an oxidizer valve indicating an increased flow to supply the pump with more power. Data showed the valve position did not change.

A second data indication of normal pump performance was present in the engine discharge pressures, which also are monitored by ground controllers as well as by the main engine controller and were found to be nominal.

Based on the data indications showing pump performance to have been nominal, space agency engineers reviewing the cause of the engine shutdown have tentatively concluded that the main engine controller was receiving faulty data from failed sensors.

The sensors are very thin wires. Resistance measurements taken by the engine controller provide an indicator of pump temperatures because the resistance increases as the temperature increases. The controller logic is able to distinguish, within certain limits, a valid reading from one which indicates the sensor wire is broken or has otherwise failed.

The controller itself recognized the bad reading from the Channel B sensor. The reading from Channel A, however, drifted, indicating a temperature rise above the redline limit.

Because of the failure mode in the second sensor, which gave readings above the redline limit, but below those which would cause the controller to disregard them as "unreasonable" and indicative of a sensor failure, the engine controller believed there was a possible pump problem and shut the engine down.

A temperature sensor on Engine 3 also failed. There is a history of these temperature transducers

(sensors) failing on previous Shuttle flights. This has led to a space agency decision to develop a new sensor for use on future Shuttle flights, beginning with the Aug. 24 STS 51-I mission.

Aldrich

(Continued from page 1)

nished Equipment (GFE) projects.

Aldrich's NASA career began with preparations for Project Mercury flight operations. Later he served as a remote site capsule communicator and as spacecraft systems engineer in the Mercury Control Center at Cape Canaveral. Subsequently, he was responsible for operations at key spacecraft systems console positions in the Mission Control Center during the Gemini and Apollo Programs.

Aldrich was chief of the Apollo Systems Branch, Flight Control Division, from 1966 to 1972 when he became deputy manager of the Skylab Program. A year later he was named manager.

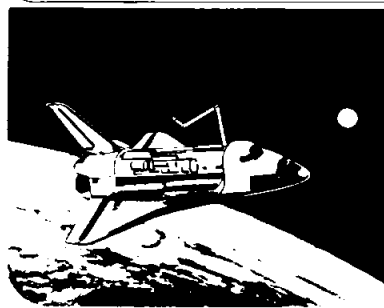
He also has served as deputy manager of the Apollo Spacecraft Program Office, manager of the Space Shuttle Program Assessment Office, manager of the Orbiter Avionics Systems Office and deputy manager of the Space Shuttle Program.

NASA
Lyndon B. Johnson Space Center

Space News Roundup

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Editor Brian Welch
Editorial Assistant Tina Griego



ATO puts flight team to the test

(Continued from page 1)

Ascent/Entry team practiced a center engine down ATO very similar to that which happened three days later.

"It all seemed real familiar," said Brian Perry, the Flight Dynamics Officer whose job was to determine which abort mode to go for when the engine went down.

In the aftermath of the ATO, attention focused on Booster Systems Officer Jenny M. Howard, who made the call to inhibit a sensor on the No. 3 engine before the potential of a second engine shutdown could come to pass. "I was a little overwhelmed by all of the attention from the news media," she said. "I just didn't want another engine to go down, and the call to inhibit the limits was made to protect against that. That's our job."

"I think the action she took relative to that last sensor was important, but it might not be correct to say 'she saved the Shuttle,' since it is very difficult to know if that sensor really would have shut No. 3 down," said Tom Holloway, Chief of the Flight Director Office. "But it certainly is correct to say that the call potentially could have saved the Shuttle. If we were passing out medals for that day, I think both Howard and Perry would have gotten them. They both did just the right thing, and quickly."

"Center engine down."

The *Challenger* launched at 4 p.m. CDT on July 29 after having been delayed more than one hour so that a software patch to one of the ship's solid rocket booster gyro assemblies could be properly executed.

Weather was good at the launch site, and onlookers later said the hot Florida summer afternoon seemed particularly conducive to relaying the sound and vibration of a Shuttle liftoff.

At the Flight Dynamics console in the Mission Control Center, Perry and Bruce Hilty were among the busiest people in the room. Hilty, monitoring the output of the Abort Region Determinator, the ARD, was seeing displayed before him continuous updates on the various abort options available during any launch. The ARD cranks out guidance solutions for each of the four abort cases, updating those solutions every second.

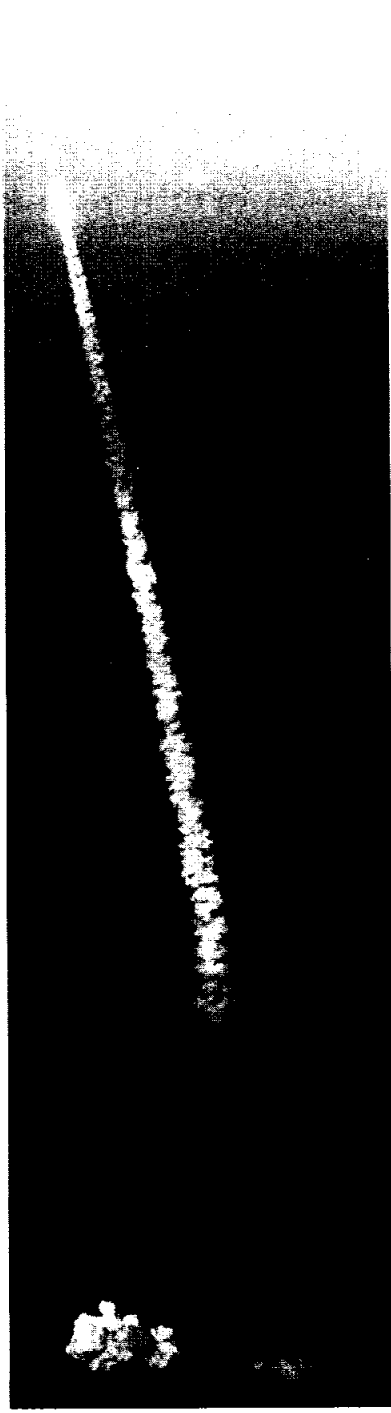
Perry meanwhile was monitoring *Challenger's* trajectory, watching for lofting or depression as she made her way to space. As he watched the total vehicle velocity change, he also was watching the ground guidance model. "We model the guidance solution on the ground completely independent of the vehicle," he explained. "We watch the relative compare between the ground and the Shuttle, and depending on what situation you are in, you then choose which solution to take."

Three tiers up at the Booster console, Howard was watching the parameters of the main engines as they were sent down via telemetry from onboard sensors to the ground. The sensors, two on each engine, are actually very thin platinum wires. Resistance measurements are made which provide an indicator of pump temperatures for each engine. As the temperature increases, so does the resistance. The controller logic aboard Orbiters is able to tell, within certain limits, a valid reading from one which indicates the sensor wire is broken or has otherwise failed.

The rationale behind the engine sensors is to protect against worst case shutdowns — to react with the speed of a computer to prevent an engine from going beyond redline temperatures and exploding. The problem, however, is that sensors are metal, and have to



Jenny Howard at the Booster console (top). Members of the Ascent/Entry Team confer after *Challenger* was safely on orbit (bottom). *Challenger's* launch as seen from the air (right).



withstand very high temperatures but still allow an electronic system to sense thermal changes. In some cases, temperatures can surpass the melting point of these metals. The technology of the transducers has to be pushed to the limit in order to provide sensory data to the main engine controller and to the ground.

At 3 minutes, 31 seconds, the high pressure fuel turbopump turbine discharge temperature B transducer failed. This put the center engine on a single string for redline shutdown redundancy. Two minutes, 12 seconds later, the other sensor failed, taking the center engine down with it. Automatically, sensors on the two remaining engines were inhibited by the system, to guard against the possibility of other sensor failures and the loss of the other engines.

"Center engine down," Howard called on the Flight Director loop.

"Houston, we show the center engine thermal," Commander Gordon Fullerton radioed to the ground almost at the same moment.

"We copy, stand by," said Capcom Dick Richards.

"Abort ATO. Abort ATO."

At this point, Perry, Hilty and their back room support were well into the drill. *Challenger* was at about 58 nautical miles in altitude, about 275 nautical miles down range of KSC. The ship had already passed a point in the launch phase that allowed safe return to KSC and was within a 45 second window where it would be necessary to dump orbital maneuvering system fuel if one engine went down. At that point, *Challenger* was capable of making orbit on two engines. One critical calculation which had to be made, however, was to figure the under-

stand and determine the ever changing impact point of the external tank.

It took only a matter of seconds for Perry and his flight dynamics team to analyze all of this data and assess all of the ramifications. "Flight, were ATO," Perry said.

There followed a very quick succession of events, only seconds after the center engine had gone to zero thrust. Lacefield told Capcom to abort ATO.

"Abort ATO. Abort ATO," Richards radioed *Challenger*.

Fullerton responded by turning a rotary dial to a setting marked "ATO" and then punched a button to execute the command. *Challenger* responded by immediately dumping 4,400 pounds of Orbital Maneuvering System (OMS) fuel through the OMS engines, igniting the fuel as it went. This had the effect of providing some additional thrust, but that effect was small compared to the loss of the weight. The setup was now complete for the proper disposal of the tank. The total time from shutdown of the center engine to analysis and decisions by two flight controllers to instructions from Richards to Fullerton for selection of the ATO mode and finally, to dumping the fuel: 25 seconds.

"It doesn't take long to make the call," Perry later said. "It depends on where we are in the launch phase. In this case, we were fairly close to the boundary where we wouldn't have to dump fuel. It took a few seconds to confirm that and then decide to go ATO with a fuel dump on the fly."

At 7 minutes into the flight, *Challenger* reached the single engine trans-Atlantic landing (TAL) capability, meaning she could make a landing in Europe even if another engine were to go down. "After that point, we could

absolutely avoid the water, even if a second engine failed," Perry said. "There was never a time when we didn't have an acceptable place to land. The problem was where the tank would go."

"*Challenger*, Houston," Richards broadcast. "Single engine TAL capability."

"Roger, single engine TAL," Fullerton said.

"Roger that, and main engine limits to enable, Gordo," Richards replied.

That last call to the crew was based on Booster's desire to again engage the sensors on the two remaining engines. "When we got to single engine TAL," Howard said, "we then reenabled the sensors because we could make TAL on only one engine. We don't want to inhibit (the sensors) unless we really have to. One of our most important jobs is to figure out where that switch should be."

Howard's hardest job was still ahead of her. Between 8 minutes and 8 minutes, 10 seconds into the flight, *Challenger* flew beyond the point where she could absorb another engine loss and still dump the tank safely. "She had flown out of single engine TAL capability with ET protection," Lacefield said. There was now no choice but to keep climbing uphill, to make for space.

Five seconds after that, a transducer failed on engine No. 3. "At that point, the parameters from the engines looked good, but I now had lost 3 out of 6 sensors," Howard said.

The remaining sensor on No. 3 engine then recorded a temperature excursion near the engine redline. Like all such sensors, it was taking a sample at the rate of once each second. In order to shut the engine down, the sensor has to record temperature violations on three successive samples, and then pass a logic test from

the onboard controller. If the controller makes an electronic decision that the sensor is telling it the truth, it will shut the engine down to prevent an explosion.

Jenny Howard, within that scope of a few seconds, was seeing exactly the same data as the engine controller. She had 3 sensors down out of 6. She had one main engine down and another that seemed to be wavering. Her one remaining sensor on that engine seemed to be behaving like the ones on the center engine had. *Challenger* was, in those seconds, not capable of a TAL with safe ET disposal. They had to go to orbit, and they had to have two engines. It was time for a decision.

"Flight, limits to inhibit," she called.

There is an economy of language on the loops in the flight control world that approaches a practiced art. To the layperson, a terse phrase such as "limits to inhibit" would not mean much. To the flight controllers, the call for inhibiting the sensors was an immediately recognizable signal carrying with it many ramifications. It was a call for quick action. Flight Director Cleon Lacefield, now standing at his console, turned to Richards and repeated the instruction for the crew. "Capcom, limits to inhibit."

"*Challenger*, Houston," Richards radioed immediately. "Main engine limits to inhibit."

In those few moments, a gamble was underway. The team was gambling — perhaps not against great odds, but who could say at the time — that a human being could monitor the engine parameters, armed with an additional data point that *Challenger's* onboard controller could not possess — the knowledge that there was only one acceptable way to go, and that was up. They were banking on the faith that a highly trained human being could monitor the data and make a decision as fast as a computer could if the engine really did go past the redline.

At 9 minutes, 42 seconds, *Challenger* reached main engine cutoff. Her inertial velocity was 25,760 feet per second, 110 feet per second short of her target, but that could be made up with an OMS burn. After MECO, she came off the external tank at 4 feet per second, then translated away at another 5 to 10 feet per second. Tumble valves opened on the external tank, giving it a tumble of 2 revolutions per minute. The tumble helps controllers model its entry characteristics. The tank then traveled halfway around the Earth and landed in the Indian Ocean south of Australia.

Richards radioed *Challenger*. "No OMS-1 required. APUs off on time," he said. There was no immediate response.

Richards called back with a radio check.

"Okay, you're loud and clear," Fullerton responded cheerfully. "No OMS-1 and APUs off on time. Sorry, we were busy with the tank DTO."

Only a few seconds after experiencing the first in-flight abort case in the Shuttle program, Fullerton and Pilot Roy Bridges were coolly fulfilling a minor test objective, to photograph the tank as it separated, in order to help engineers get an idea how tank insulation weathers the launch phase.

Looking back on it, Holloway gave what is perhaps the highest praise in the flight control world: "It sounded just like a simulation."

Gene Kranz, the Director of Mission Operations, said of those 10 minutes, "Everybody did what they were supposed to do, correctly, quickly and crisply."

And then he added "I love to hear it crackle like that."

—Brian Welch

Roundup Swap Shop

All Swap Shop ads must be submitted on a JSC Form 1452. The forms may be obtained from the Forms Office. Deadline for submitting ads is 5 p.m. the first Wednesday after the date of publication. Send ads to Roundup, AP3, or deliver them to the Newsroom, Bldg 2 Annex, Room 147. No phone in ads will be taken.

Property & Rentals

For sale: Galveston county off Highway 6, 3-2, brick, water well and septic systems, paved drive, one acre, fenced and cross fenced, \$80,000. Call 432-4746 days, (409)925-7495 weekends.

For sale: Lakefront investment property in Brazoria county, low 30's, 12% assum. Call Don. 280-6307 or 554-6205.

For lease: University Green townhouse, 3-2.5-2, FPL, ceiling fans, patio, fenced yard, swimming pool privileges, \$650/mo. Call 554-2065.

For sale: League City, Pecan Forest, 3-2-2, landscaped, immaculate, energy efficient, must sell, make offer, see at 212 Pecan Drive. Call 554-6200.

For sale or lease: Baywind II townhome, 3-2.3-2, quiet end unit, FPL, W/D, refrigerator, large closets, pools, clubhouse, owner finance equity, assume 11.5% loan, \$600/mo. Call Fred Toole, x2731.

For sale or lease: League City, 2 or 3 BR custom townhouse, 2.5 baths, garage, jacuzzi, refrigerator, W/D, pool, tennis, paid lawn care, FPL. Call Mike, 554-6378 or 280-4313.

For sale: Sterling Knoll, 4-2-2, deck with heated spa, professional landscaping, ceiling fans, indoor utility room, \$82,000, assumable 10.5 FHA, owner financed. Call 280-0549.

For sale: Baywind II cond, 2-2.5-2, large two story unit, FPL, W/D, ceiling

fans, pool, tennis, \$480/mo. Call Jeff, x5595 or 280-8608.

For lease: Heritage Park, 3-2-2 split floor plan on cul-de-sac, near elementary, pool, tennis, fans, microwave, refrigerator, wood fenced yard, pets O.K., \$575/mo. Call Mark, 333-0667 or 482-4400 evenings.

For rent: Galveston/Tiki Island, new 3 BR home on canal, furnished, dock your boat, fish, swim, TV, master bath spa, weekend, weekly and monthly rates. Call 486-9335.

For rent: Galveston Gulf Front condo, full accommodations for a two day to one month vacation or business retreat, low rates. Call Nussman, 488-7762.

For lease: Heritage Park, 3-2-2, new paint in and out, six month lease, \$550/mo. firm. Call Tom, x4501 or 482-7967.

For lease: CLC, 3-2, white brick, split BR plan, FPL, double garage, first, last, deposit. Call Lyn Amann, x4415 or 333-2359.

For lease: Forest Bend townhouse, 2-1.5 ceiling fans, two story patio, \$395/mo. Call Betty Craig, x4031 or 1-420-2936.

For lease: League City/Bayridge, 3-2-2a, FP, fenced, deposit, references, no pets. Call 488-1301.

Cars & Trucks

1966 Mustang convertible, str. 6 automatic, runs, excellent, body in

good condition, \$4,000 OBO. Call Tami, 333-4980 or 532-2642 after 6 p.m.

1977 VW Scirocco, AC, manged transmission, black, recent valve job, new battery and starter, runs well, \$2,100. Call 471-3498.

1979 Ford van, six cylinder, two-toned blue, PS, PB, AC, AM/FM radio w/speakers, dual fuel tanks, carpeting, paneling, recently tuned, good condition, \$3,300. Call Valerie, x6125 or (409)935-1149 after 5 p.m.

1965 Thunderbird, fully loaded, excellent engine, needs starter, take "as is", no reasonable offer refused, \$750 OBO. Call 554-2908 after 6:30 p.m.

1978 Silver Anniversary edition Corvette, good condition, low mileage, \$8,500 OBO. Call 280-0133.

1982 Mustang GL, six cyl., air, auto, WW, AM/FM stereo, beige, \$4,300. Call Barr, 485-6074.

1985 Honda Prelude, grey, ultra-seal, AC, five year unlimited mile warranty. Call Jon, 280-1500 x3191.

1975 Datsun 710, auto, AM/FM stereo, no rust, good work or school car, \$1,000. Call 474-5601 after 5:30 p.m.

1984 Ford F-150 model XL pickup, V8, AT with O/D, AC, PB, PS, tilt wheel, two-tone paint only 10K miles, \$8,000. Call Dick Bishop, 280-6890 or 326-1666.

1978 Ford van, eight passenger, cruise, AT, PS, PB, air, good condition, \$2,700. Call 280-6727.

1980 Cadillac Sedan de Ville diesel, 57K miles, leather, fully equipped, runs perfect, showroom condition, \$5,200. Call 326-3370.

1980 Ford Fairmont SW, no air, 79K miles, loan value \$1,900 asking \$1,895. Call Thomas, x3655.

1972 Super Beetle VW, has only forward gears, good workhorse, asking \$325. Call Thomas, x2936.

1981 Mazda RX7, five speed, silver/black, looks and runs great, excellent condition, \$6,450. Call Jim, x3241 or (409)925-3036.

1985 Honda Prelude, auto with cruise control, \$12,000. Call Tom, x4501 or 482-7967.

1984 Chevy Silverado P.U., shortbed, V8, auto trans w/overdrive, all power, AM/FM/cassette, 2,900 miles, immaculate, \$9,000. Call Carol, 486-1652 or 482-1859.

1977 Ford F-150 pickup, supercab, 351 V8, auto, power, dual tanks. Clean, good condition, \$1,750. Call Dave, x2301 or 474-2981.

1981 Ford F150 pickup, 5 ton, one owner, long bed, cold air, automatic, V8, dual tanks, clean, book value, \$6,200, sell \$3,395 or trade. Call 280-0454.

1979 Toyota Corolla, four speed, AC, AM/FM, runs well, looks good, 25-30 m.p.g., \$2,700. Call 538-4206.

1979 Cadillac Fleetwood Brougham, low mileage, new tires, blue book, \$6,000, sell for \$5,000. Call Ben, x3731 or 488-3683.

1983 Honda A.C., five speed standard, four door civic, silver/grey. Call Phyllis, 486-1635 after 7 p.m.

1977 Ford L.T.D., four door, low mileage, excellent body, needs minor repairs, \$950 OBO. Call Kari, x5111 or 488-8919 after 6 p.m.

1983 Chevy Camaro, excellent condition, AC, AM/FM cassette, low mileage, five year 50,000 mile option, \$8K OBO. Call Marco, x3601 or 480-0703.

1979 Chevy Monza, AM/FM stereo cassette, 75K miles, good condition, \$1,200. Call Jim, x4794 or 488-7055 after 5 p.m.

1965 Cadillac convertible, black & white interior and top, new top, good condition, runs like new, \$2,600. Call Bass, 480-3812.

1971 sand rail buggy, good condition, runs like new, \$1,500. Call Bass, 480-3812.

1980 Ford Fairmont, 4 cyl., AT, AC, PB, PS, AM/FM cassette, no rust, dents, excellent condition, \$3,200. Call Mike, 532-1793.

1976 Toyota Corona sedan, good engine, no rust, new tires, four speaker Jensen stereo/cassette player, four speed manual, \$1,500 firm. Call Mitch, 280-7183.

1981 Grand Prix "LJ", beautiful original owner car, economical V-6, reduced to \$5,700 for quick sale. Call Nussman, 488-7762.

1977 Chevy Vega hatchback, not running, for body or parts, make offer. Call Max Kijbourn, x3278 or 482-7879 evenings.

Boats & Planes

1974 Columbia 34' sailboat, Wester-beke 4/107, diesel, wheel, bimini, roller furling, autopilot, H/C pressure water, shower, K/M, D/S, VHF, documented, \$34,500. Call 486-9140.

Jon-boat, 12 ft., 8 h.p. Mariner outboard, good condition, \$550. Call 474-2906 after 6 p.m.

1981 Tidecraft bass boat, 80 h.p. Mercury, power tilt and trim, aerated live wells, depth finders, trolling motor, etc., \$4,850. Call Don, 280-6307 or 554-6205.

Sailboat, Gulfcoast 20, trailer, outboard, excellent rigging and sails, \$3,400 OBO. Call Dick Bishop, 280-6890 or 326-1666.

Bikes

1979 Kawasaki KZ 650 4 cylinder, windshield, new battery, very recent tune-up, excellent shape, 14K miles, \$950. Call Randy, 482-4083.

Raleigh boy's bike, 20" wheels, good condition, \$25. Call 333-3382.

Honda 350, 1970 license, sticker, great shape, \$300. Call 488-3288.

1981 Honda XL80S, street legal, less than 1,000 miles, excellent condition, \$450 firm. Call Cheryl, x4521 or 538-3043.

1973 AMC Hornet, 82kmi, very reliable, good student/work car. Call 485-5106 after 5 p.m.

20" girl's bicycle, Huffy "Pink-thunder", excellent condition, \$25. Call 485-5106 after 5 p.m. weekdays.

1971 Honda CB450, 2,400 actual miles, wixom fairing, crash bars, carrier, mint condition, \$1,100. Call 486-9335.

1980 Suzuki 450L, black on black, excellent condition, \$700. Call Jim, x3241 or (409)925-3036.

Audiovisual & Computers

Commodore 64, 1541 disk drive, 1702 color monitor, letter quality printer, software including word processing, Visicalc and more. Call Gail, 486-5454 after 5 p.m.

64K Coco system, includes disk, printer, modem, cassette, joysticks, OS-9, basic-09, hardware/software accessories. Call Steve, x7254.

Victor 9000, complete w/monitor, kybd, disk drives, MS-DOS, CP/M-86, Supercals, programmers toolkit, Adventure & basic, \$1,500 firm. Call Mitch, 280-7183.

Mitsubishi 19" color TV and service manual, needs color adjustment, \$50. Call 944-6457 after 6 p.m.

Kodak Super 8 millimeter zoom camera, projector, screen, \$100. Call 487-3799.

Beseler 23CII enlarger with Dichro 23 dga colorhead, stab. power supply, PM2 analyzer, El Nikkor 50mm 2.8 and 80 mm 5.6 lenses, motor base, neg. holders, timer and more, \$900. Call 532-4621 from 5 to 9 p.m.

Two black and white portable T.V.'s, 10", \$15 OBO. Call Ed, x5489 or 480-0273.

Household

Full size bed with Sears-O-Pedic mattress, box spring, headboard, frame, \$50 OBO. Call Ed, x5489 or 480-0273.

15.1 cubic ft. Sears freezer, two years old, excellent condition, \$300 OBO. Call Barbara, x6251 or Mike, x2383.

Montgomery Ward large capacity dryer, excellent condition, like new. Call Carla Brown, x5911 or 338-2008.

Solid wood birch chairs, new, still in carton, \$35 each; maple butcher block table tops to match. Call Beth, x2076 or 554-2908 after 6:30 p.m.

Couch and chair, solid wood construction, reversible vinyl/cloth cushions, brown and gold, perfect for college, \$100. Call Beth, x4451 or 996-9247 after 5 p.m.

Matching yellow double dresser w/mirror, desk, chair, and night stand, nice for young girl, \$100 set. Call 488-0035.

King size waterbed w/oak headboard, etched mirror, many extras, very good condition, paid \$525, sell \$280. Call 482-4666.

Dining table with six chairs, \$130; six ft. long couch, \$60; TV-stereo stand, \$15; 12" oscillating fan, \$10; Kingsize bed w/frame, box spring and mattress, \$100. Call 996-9628.

Sewing machine and cabinet, good condition, \$100. Call 280-0549.

Musical Instruments

Ludwig drums, five piece, plus hi-hat, two cymbals, seat, \$500. Call 481-1172 after 5 p.m.

Buffett clarinet, master model, \$200. Call Don Amann, x2449 or 333-2359.

Hammond rhythm II deluxe organ with two keyboards and many extras, full size electric with footpedal base, instrument selection, background rhythm, vibrato and reverberation, \$700 OBO. Call 337-5018.

New Kimbell artist console piano, walnut with leather bench, paid \$2,700, sell for \$2,300 OBO. Call Marcia, x4119 or 326-4320.

Alvarez 12 string guitar w/case, \$250. Old Sonor four piece drum set w/some H/W, no cymbals, \$100; men's size 10 (fits 11-11.5 reg. shoe size) ccm hockey skates, \$35. Call Chuck Borne, x6226 or 332-0326 evenings.

Fender acoustic steel string guitar, new still in box, first \$100 takes it. Call Patrick, 484-3020 after 5 p.m.

Miscellaneous

1983 lawn mower, 22 in., Briggs & Stratton, 3.5 h.p., side discharge w/bag, excellent condition. Call 482-9189 after 7 p.m.

Free kittens, litter trained, cute. Call Joan, x3057 or 486-1058 after 5 p.m.

Antique wooden trunk, \$100 OBO. Call 944-7457 after 6 p.m.

Join our van pool from the West Loop Park and Ride lot to NASA and relax, save dollars on gas and wear and tear on your car. Call Richard Heetderks, x4651 for information.

Childcraft - The How and Why library by Worldbook Encyclopedia, complete set, never opened, \$145. Call Max Kilbourn, x3278 or 482-7879 evenings.

California Friendship motorcycle sidcar, perfect condition, six mos. old, \$900. Call 487-3799.

Pool table and accessories, regulation size, solid mahogany, excellent condition, you move, \$700 OBO. Call 554-4315.

Yamaha generator 2600, \$600. Call 554-4315.

Wilson staff Pro Woods (1, 3, 4); U.S. divers scuba tank/bc/backpack, AKA1 reel-to-reel tape deck (auto rev/six heads), 10 tapes (Maxell VD-XL) Bell "Star" motorcycle helmet and two lenses; ATARI video game and tapes. Call Blaine, x3856 or 488-4890.

Top-of-the-line Venture tent trailer by Starcraft, loaded, awning, AC, dual bottles, gas/elec. refrigerator, plenty of storage, must see to appreciate. Call Carol, x5514 or Ken, x5169.

Six foot slate pool table, seven cue sticks, rack, balls, etc., \$150. Call 481-1172 after 5 p.m.

Rent my motor home by day or week, self-contained with onboard generator, roof air, the comforts of home on wheels. Call Dave, x5111 or 480-0202 after 6 p.m.

Cocker spaniel, AKC, three mos., platinum blonde, male, papers, \$95. Call 488-5889 after 5 p.m.

Golf clubs, Wilson 1200, 2-PW irons only, \$135 OBO. Call Patrick, 484-3020 after 5 p.m.

Rear bumper for Ford van, fits 75 through 85, like new; Boy's clothes, jeans, shirts, jackets, excellent condition. Call 488-2822.

Lathe, 14" metal, needs some repair, \$200. Call 944-3105.

5 x 7 ft. utility trailer, fair condition, \$225 OBO. Call Wayne Chapman, 488-9005.

Desk with glass top, \$75; dark brown canvas and chrome chair with foot stool, \$15; 6' x 9' rust rug, \$65. Call 487-1883 after 5 p.m.

Daiwa left-handed golf clubs, two all-graphite wood and two-through-PW irons, purchased 1984, list \$780, asking \$400 OBO. Call Ken, 280-2442.

9' longboard, good starter surfboard, must sell, \$20; 5' castnet, \$10 OBO; RCA 19" black and white T.V. w/stand, needs work, \$20. Call Wade, 333-3183.

Electronic flash for Cannon AE1 or similar camera, \$12. Call 996-9628 or 333-6449.

1890's steamer trunk by Lord & Taylor, worth \$500 if restored, sell \$100 or trade. Call 280-0454.

Two-wheel covered utility trailer, 6' x 4' x 4' high, rear swinging doors, easily adapted for camping or hunting, \$300. Call 554-2908 after 6:30 p.m.

Wanted

Roommate for large 2-2.5 Baywind II townhouse, next to NASA, cable T.V., W/D, private bath, \$240 plus 1/2 utilities. Call Kari, x5111 or 488-8919 after 6 p.m.

Roommate to share 3 BR lakehouse in League City between South Shore and Watergate. Call Mark, x3417 or 334-4373.

Sturdy bed frame for queen size bed in good condition. Call Jeff, x4237 or 482-5393.

Gilruth Center News

Call x3594 for more information

Auto repair - Learn to diagnose minor problems with your car before they become major expenses, as well as how to perform preventive maintenance and normal upkeep, including a tune-up. Topics covered are: engine theory, operation of ignition and carburetor systems, air conditioning and brakes. Class begins Aug. 7 for 8 weeks and runs from 7:30 to 9:30 p.m. The cost is \$25 per person.

Pest control - This class will help you learn how to spray your home, what chemicals to buy and how to safely and effectively apply pesticides. Class runs from 7 to 10 p.m. Aug. 8. The cost is \$7.50 per person.

Tennis lessons - Beginning tennis is designed to teach the basic fundamentals, including forehand, backhand service, footwork, body movement and conditioning. Class begins Monday, Aug. 5. Intermediates will help you develop and improve strokes such as spins and spin service, and improve your net. Class begins Wednesday, Aug. 7. Cost for these classes is \$28 per person.

Ballroom dance - This class will teach you the basics of such steps as the rhumba, foxtrot, the cha cha and the waltz. Beginners will dance from 7 to 8:45 p.m. beginning on Aug. 1 for 8 weeks. Intermediates and advanced will dance from 8:15 to 9:30 p.m. Cost is \$60 per couple. No individual registration.

Singles table tennis tourney - Come and test your skill at our annual table tennis tourney. This event will take place Aug. 24 from 11 a.m. to completion. Entry fee will be \$2 per person. Trophies will be awarded to the top three finishers. Deadline to register is Aug. 21 on a first come, first served basis. For more information, call Helen x3594.

Ladies weight training - This popular course begins Aug. 5 and runs for 4 weeks. The class meets on Mondays and Wednesdays from 7 to 8 p.m. The cost is \$20 per person. Limited enrollment exists.

Home maintenance and repair - Learn residential carpentry, drywall and plaster patch, tilework, cabinet installation and all the odds and ends. Models and diagrams, notes and handouts will provide general knowledge with opportunities to air individuals' specific housemending needs. The class begins Sept. 4 from 7 to 9 p.m. and runs for 6 weeks. The cost is \$40 per person.

Country western dance - This course begins Sept. 9 and two beginners' classes will be offered. The first session runs from 7 to 8:45 p.m. while the second session dances from 8:45 to 10:15 p.m. This 6-week course costs \$20 per couple.

Photography - Basic camera technique and artistic creativity are taught. Learn about lenses, filters, depth of field, exposure, camera angle, lighting, color and composition. Topics to be covered include photographing people, animals, nature, action, still life and architecture. This Tuesday night class meets for 6 weeks from 6:30 to 8:30 p.m. Class begins Aug. 6 and the cost is \$30 per person.

Plumbing repairs - If you're tired of high plumbing bills for minor problems then this course is for you. The class meets on Aug. 20 from 7:15 to 10:15 p.m. The cost is \$20 per person.

Electrical repairs - Learn how to fix and trouble-shoot electrical systems around the home. This class is designed for your individual questions and the emphasis is on simple repairs and safety precautions you need to take while working on electrical equipment. This 1 day class meets from 7:15 to 10:15 p.m. and costs \$20 per person. Call x3594 for more details.

Speedreading - This course covers the techniques needed to gain greater reading speed and comprehension. The class meets for 7 weeks beginning Aug. 5 from 6:30 to 8:30 p.m. This Monday night class costs \$70 per person.

Lawn and garden - Learn how to control insects, how to select plants, and how to drain your lawn and maintain landscaping. This class meets Wednesday and Thursday, Aug. 14 and 15, and Aug. 21 and 22 from 7 to 8 p.m. Cost is \$10 per person.

Ceramics - Learn how to make pots from a wheel and work with clay by using just your hands. The majority of this class will focus on pouring clay and working with ceramic glazes. This 6 week class meets on Aug. 6 from 7:30 to 8:30 p.m. The cost is \$30 per person.

Volleyball clinic - Come learn how to set, bump, and spike. The cost for this three day session will be \$10 per person. Dates and times are as follows: Friday, Sept. 6, from 6 to 9 p.m. Saturday, Sept. 7, from 9 a.m. to 6 p.m., and Sunday, Sept. 8, from 1 to 4 p.m. Deadline for registration is Aug. 30. For more information, call Helen Munk x3594.