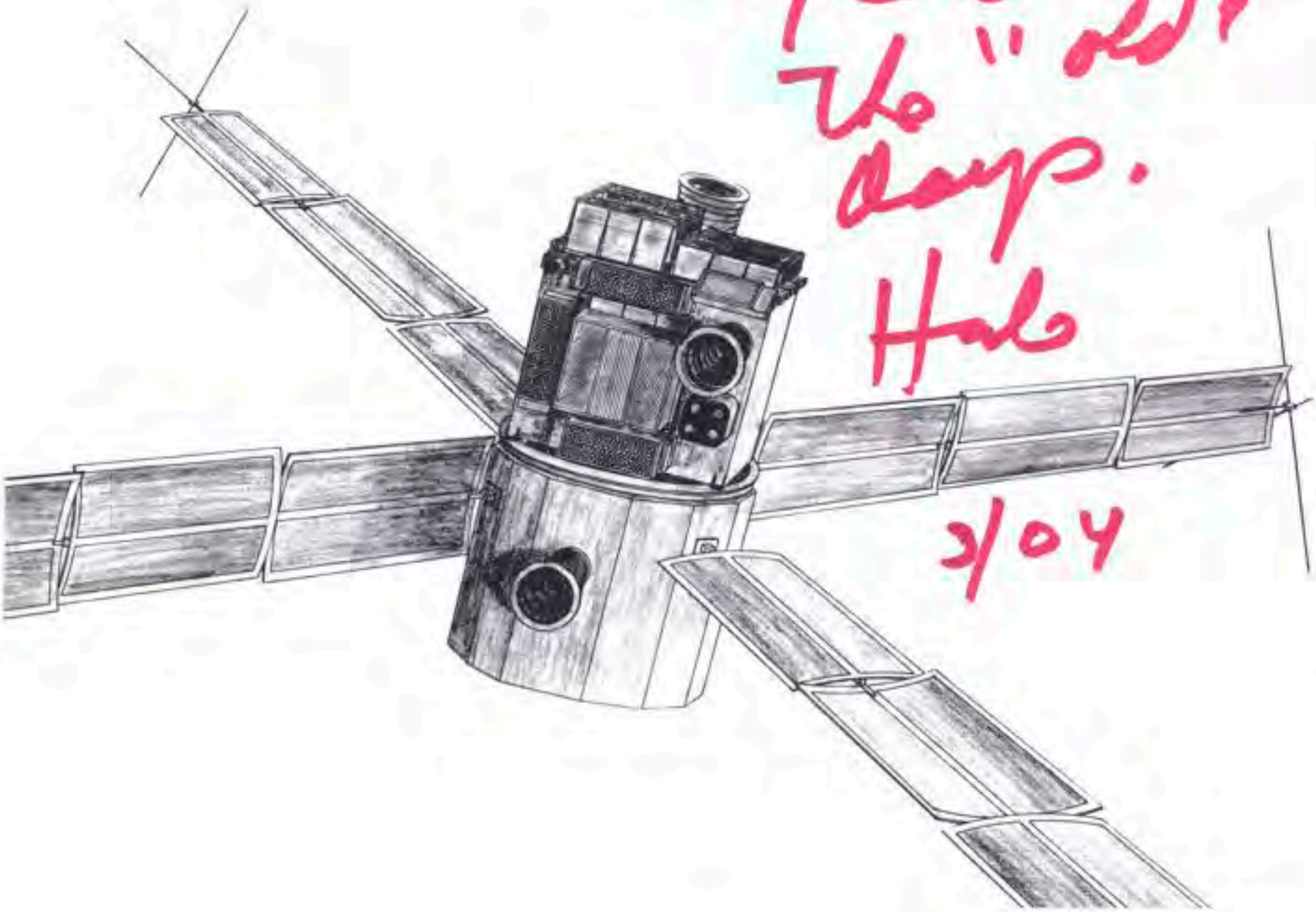
SAS-3
May 8, 1975 to April 9, 1979
An informal history



To Dave the "old" days. Hale 3/04

Consisting of available photographs and monographs by the SAS-3 crew on the occasion of the Last SAS Bash, May 18,1979
Edited and Collected by Thomas J Spisak

Preface (April 2009)
Background on SAS-3
(in orbit 1975-79)

The Small Astronomy Satellite #3 (SAS-3) – we never gave it a jazzy name – was a NASA/MIT satellite that carried out observations of celestial x-ray sources in the second decade of celestial x-ray astronomy. X-ray astronomy began with the discovery of the first celestial x-ray source with a sounding rocket flight in 1962 (Giacconi, R., Gursky, H., Paolini, F., Rossi, B. 1962, Phys. Rev. Lett. 9, 439 (1962)). (X-rays do not transit the atmosphere so one's instruments must be carried above most of the atmosphere.) Rockets provided only five minutes of observation time, but satellites could provide nearly continuous observations for several years. We now know that the brighter celestial x-ray sources are primarily neutron-star or black-hole binary stellar systems, supernova remnants, the active nuclei of galaxies, and the gases in clusters of galaxies. X-ray astronomy is now a full-fledged branch of astronomy.

This booklet was put together in May 1979. It describes experiences from the very early days of satellite astronomy. It consists of photos of the scientific and engineering participants in the SAS-3 project at MIT and the reminiscences of many of them just after the completion of the mission. I believe it was my idea to spice up our post re-entry party ("Last SAS Bash") with such a booklet, which we could and did present to the Principal Investigator, Prof. George W. Clark, with copies to all. I asked our data aide Tom Spisak to pull it together and to be the one to pester people to write up their contributions. Tom also took most of the pictures. More typical of those days, some were not comfortable telling their personal stories for public consumption but many overcame this and did contribute. I believe we are richer for it.

The scientific payload of SAS-3 was entirely conceived and constructed by our group at MIT (The Rossi group). George's "co-investigators" were physics faculty members Herbert Schnopper, Walter Lewin, and myself. We each had our "own" instrument on board, but all instruments were available to whomever was the active observer. Each of us had our own science programs and operated relatively independently. Other faculty, staff members and students became deeply involved. Other major players in the science included (Drs and Profs) Claude Canizares, John Delvaille, Rodger Doxsey, David Hearn, Jeffrey Hoffman, Garrett Jernigan, Paul Joss, Fred Marshall, Terry Matilsky, Jeff McClintock, Larry Petro, Saul Rappaport, and George Ricker. During fabrication of the payload, Project Scientist Bill Mayer was our principal liaison with the engineers, thus ensuring that the four principals were pulling in the same direction, while Bob Rasche and later Dick Taylor supervised the engineering as Project Engineer. Our technical crew included Ed Boughan, Mike Doucette, and many others (see photos in the booklet). After launch, Bill remained the keystone of spacecraft operations and safety at MIT. Marjorie Townsend of GSFC/NASA was our Project Manager. (See the photos for more participants.)

SAS-3 was launched successfully into an equatorial orbit at about 500 km altitude on May 8, 1975 from the Italian San Marco launch platform just off the coast of Kenya, Africa; it reentered the atmosphere on April 9, 1979. It followed the pioneering SAS-1 (Uhuru), which was in orbit from 1970 to 1973. Uhuru established the binary nature of one class of x-ray sources and the diffuse emission from clusters of galaxies among other significant discoveries. The British Ariel-5 was launched some months prior to SAS-3 with similar and also complementary capabilities. It too was a highly productive mission. Uhuru was a high bar to reach and competition from Ariel-5 encouraged greatly our science efforts, and vice versa from what they tell me.

While on orbit, commands to SAS-3 were sent directly from the Goddard Space Flight Center (GSFC) control center, but we used a primitive facsimile machine (fax) to send commands, orbit by orbit, from MIT to GSFC, for forwarding on to the satellite. SAS-3 could point to a celestial position but would drift a few tenths of a degree per orbit, so constant tweaking of the magnetic torquing-coil currents was required to keep our ~1 deg collimators pointed toward an x-ray source. For this, and to respond to other eventualities, we continuously (24-7) manned the MIT control center with a single duty scientist or technician. I believe I was the first to introduce the term “duty scientist” into the x-ray astronomy lexicon. (The genesis of this term was “duty officer” from my two-year duty on a Navy cargo ship, though I did not advertise this because military references were not generally viewed favorably in those days.)

The science was initially in the hands of our group alone. George Clark would decide on priorities, based on brief proposals. Nevertheless each subgroup could be assured of significant observing time each week or month and anybody's bright idea was likely to lead to an observation the following week or month – or even that very day!. The science and the objectives moved fast. Scientists from other institutions did visit and participate. (I remember Laura Maraschi from Italy for example), and later in the mission, guest observers were accepted by NASA. All in all, those four years were one wild ride for the participants, and I am pleased that this little booklet is still around to remind us of those days.

The science results from SAS-3 were indeed impressive, even from the perspective of 2009. The instruments and science results are briefly summarized in the following published selection from the Annual Reviews of Astronomy and Astrophysics; the journal references are easily located with the Astrophysics Data System (ADS): http://adsabs.harvard.edu/abstract_service.html.

“3.4.2 The SAS-3 mission was designed as a spinning satellite, but its spin rate was controlled by a gyroscope that could be commanded to stop the spin. Thus all its instruments could be pointed to a position on the sky, albeit with a modest drift. This provided ~30-min. continuous trains of data from pulsars, bursters and transient sources, a novel capability for X-ray astronomy. SAS-3 carried a proportional counter array with slat and tubular collimators (~0.03 m^2) (Buff et al 1977, Lewin et al 1976a), a small collector system with thin window proportional counters for the study of ~0.2 keV emission (Hearn et al 1976a), and a modulation collimator system of substantial area (0.03 m^2) to measure source positions to ~1' (Schnopper et al 1976, Doxsey et al 1976).

The scientific yield included (i) the discovery of a dozen X-ray burst sources (Lewin & Joss 1981) including the dramatic and unique 'rapid burster' (Lewin et al 1976b) which probably gains its energy from accretion instabilities rather than nuclear flashes, (ii) the discovery of the first highly magnetic white-dwarf binary system (AM Her) through its X-ray emission (Hearn et al 1976b), and the discovery of X-ray emission from HZ 43 (Hearn et al 1976a; see also Rockets above), (iii) an all-sky survey of the soft X-ray flux (Marshall & Clark 1984), and (iv) the precise celestial locations of ~60 X-ray sources which identified Algol as an X-ray emitter (Schnopper et al 1976), established Be-star binaries as a class of X-ray emitters (Bradt et al 1977), brought about the first identifications of bursting X-ray sources with visible stellar systems (McClintock et al 1977), identified the first quasar located through its X-ray emission (Ricker et al 1978), and demonstrated the central location of X-ray sources in globular clusters (Jernigan & Clark 1979)." [From H. Bradt, T. Ohashi & K Pounds, , Ann. Rev. Astron. Astrophys. 30, 402–3 (1992)]

My thanks to Dave Pooley for the good sense to put this on the internet for all to see.

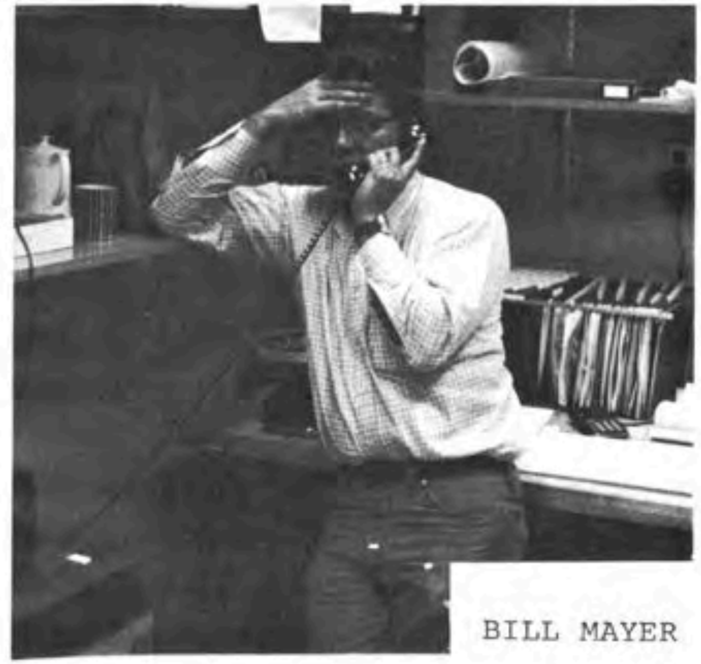
Hale Bradt
(April 2009)


GEORGE CLARK


HALE BRADT


HERB SCHNOPPER


WALTER LEWIN

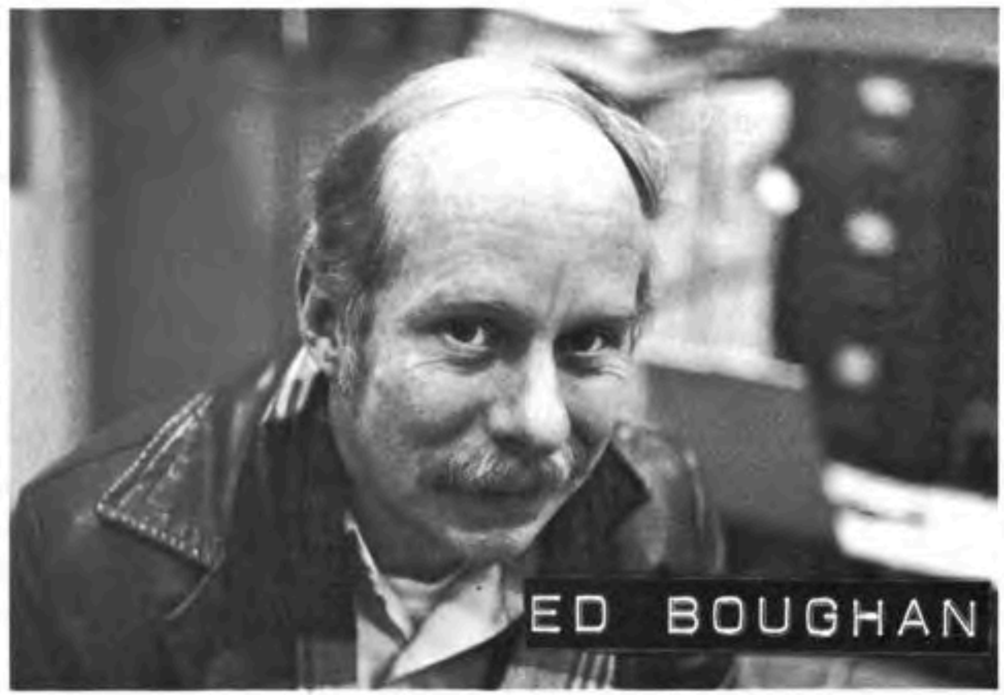


BILL MAYER


EVERETT JOHNSTON


WILL SHAW


WIL YELLE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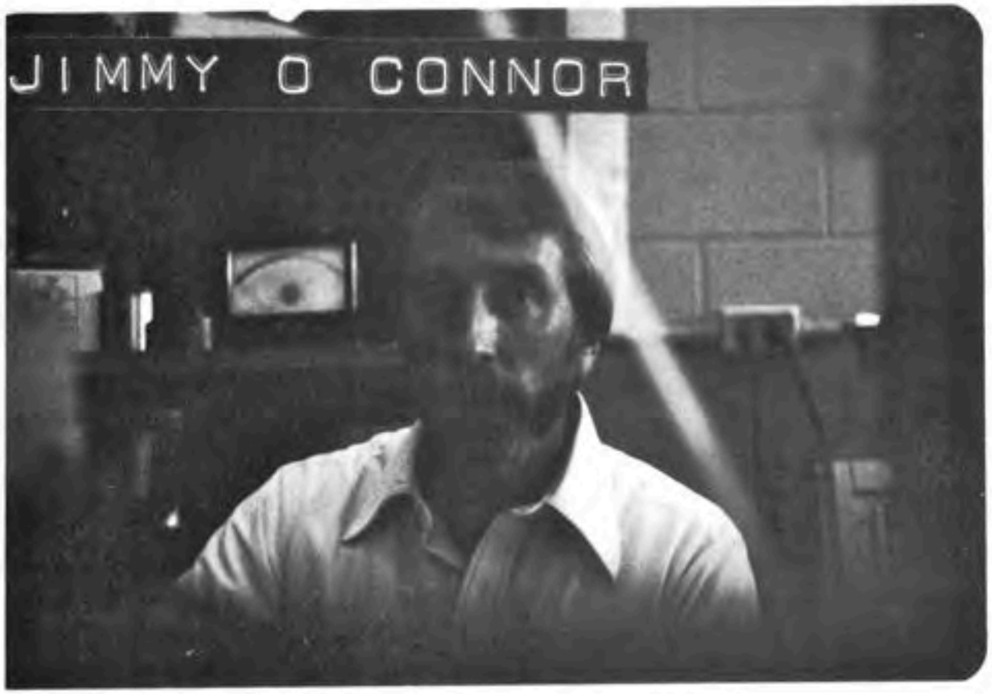
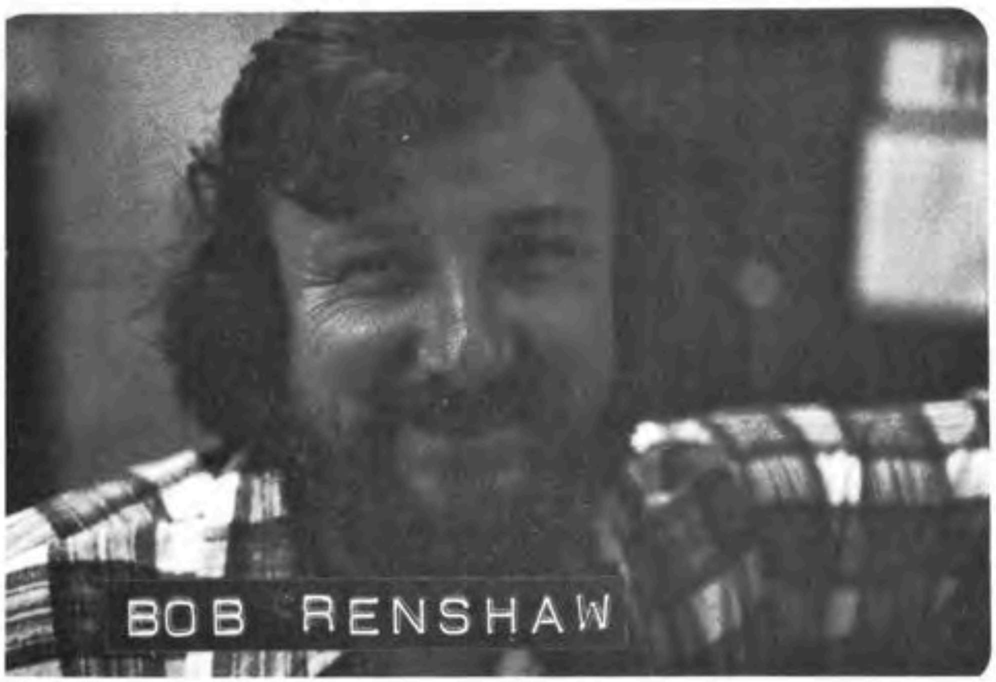
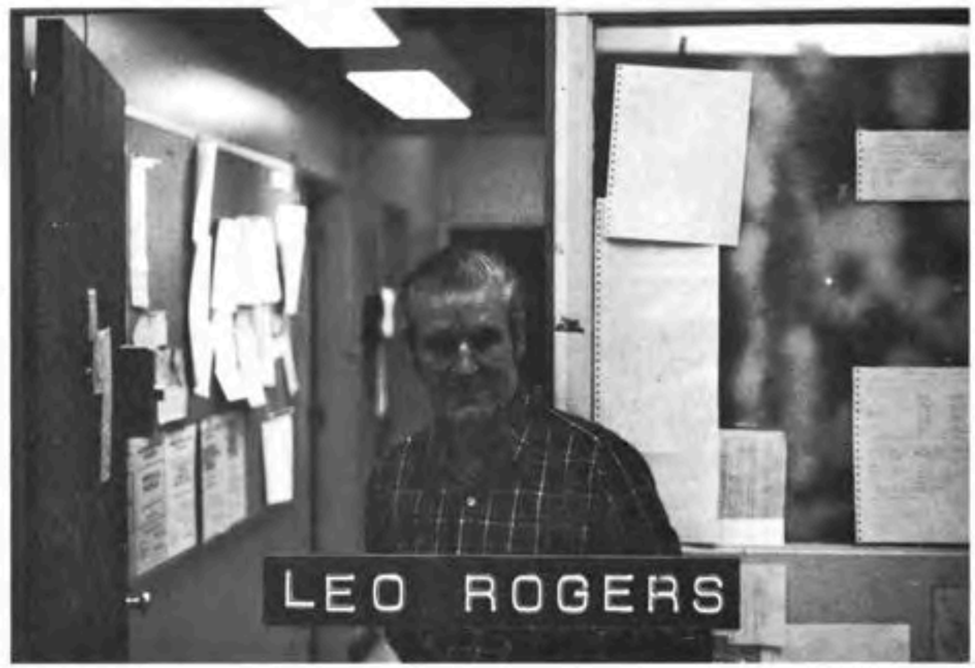


JIMMY O CONNOR

PAUL JOSS

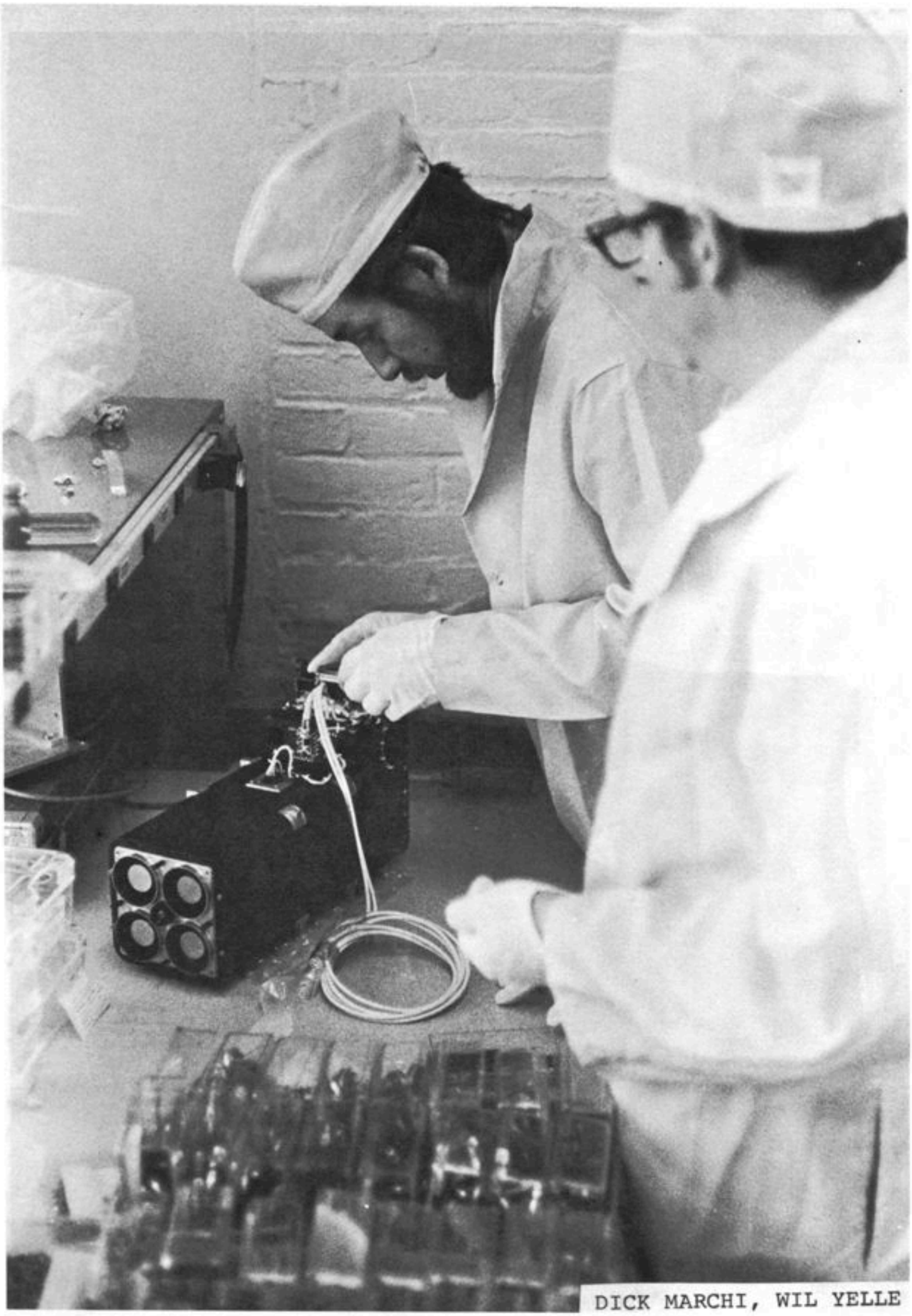


BOB RENSHAW

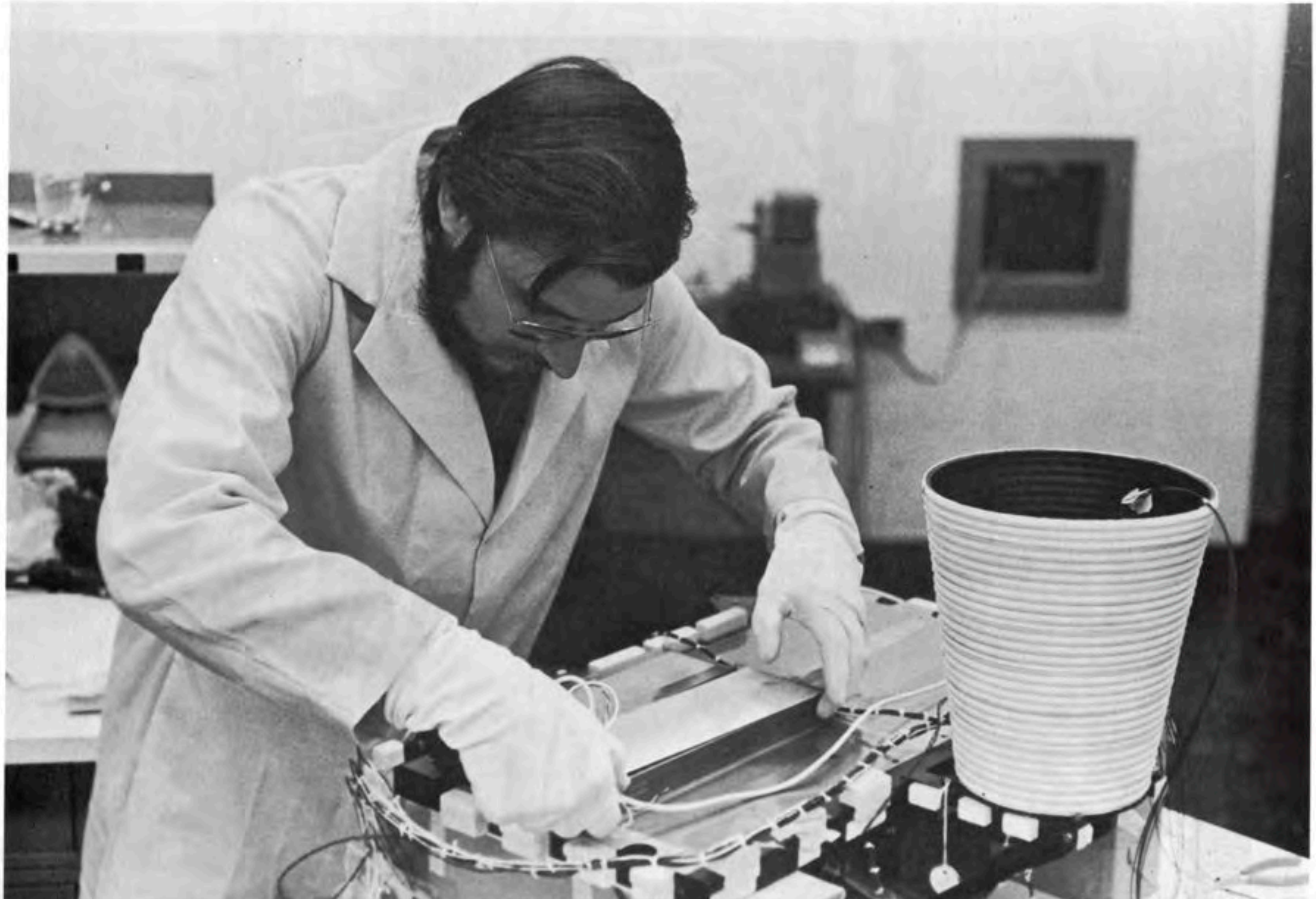


LEO ROGERS

JACK GOMES, TOM DAWSON



DICK MARCHI, WIL YELLE



BILL FREY

BOB RENSHAW, TOM DAWSON, BILL MAYER, PETE TAPPEN, DICK MARCHI

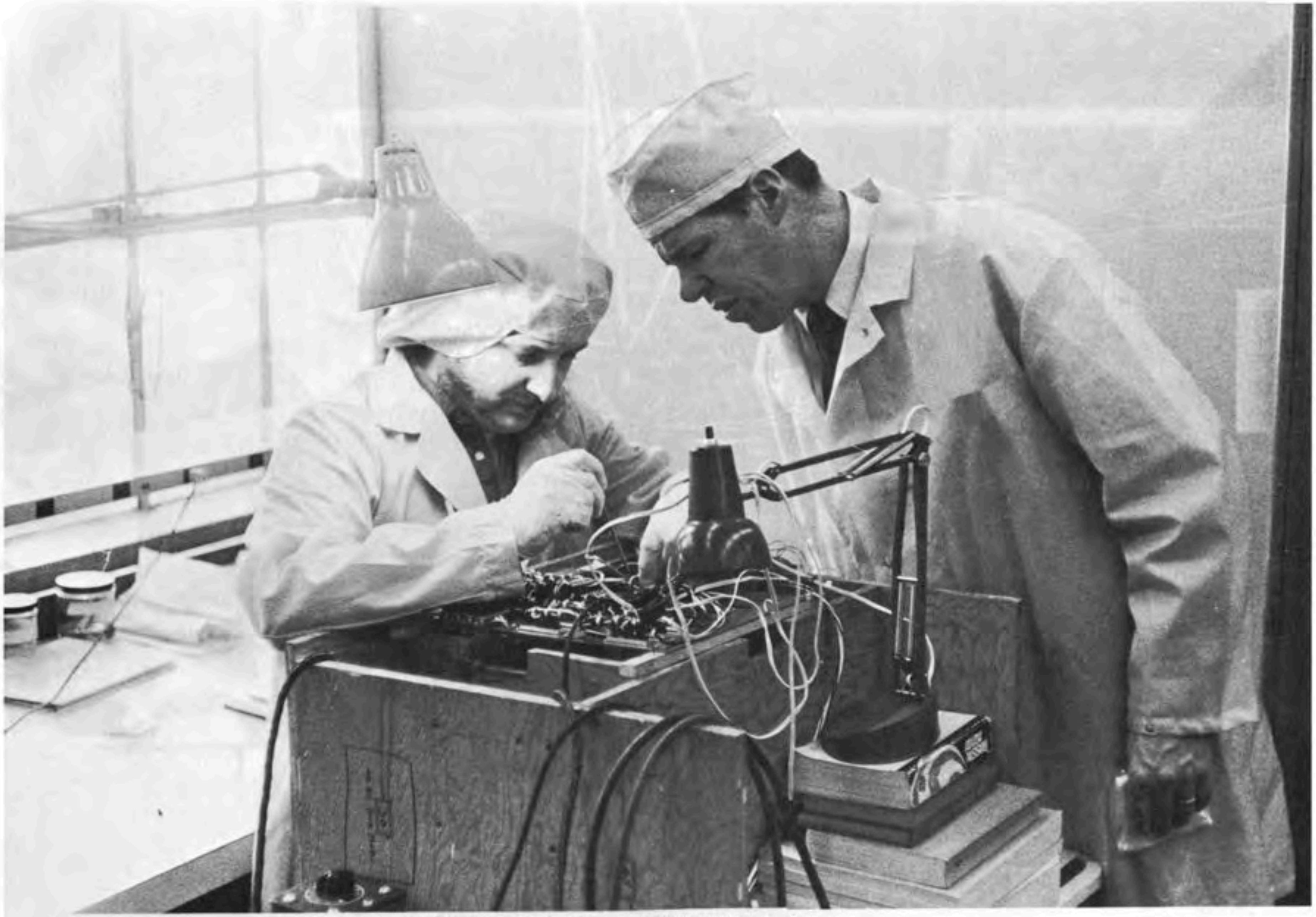
WANDA QUEEN

BETTY RYAN

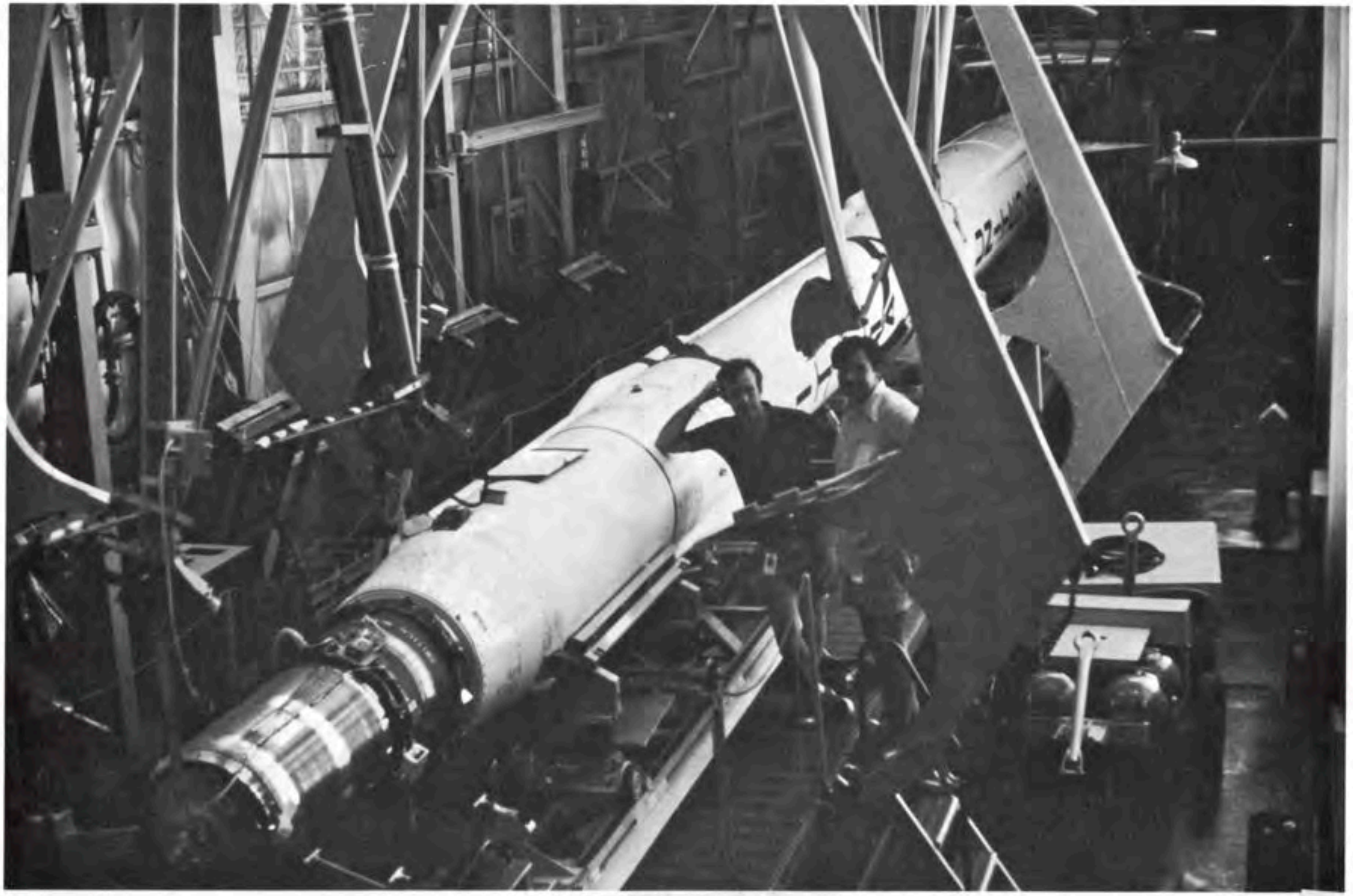
DICK JENKINS

JIM O'CONNOR

BOB PAQUET



BOB RENSHAW, ED MANGAN

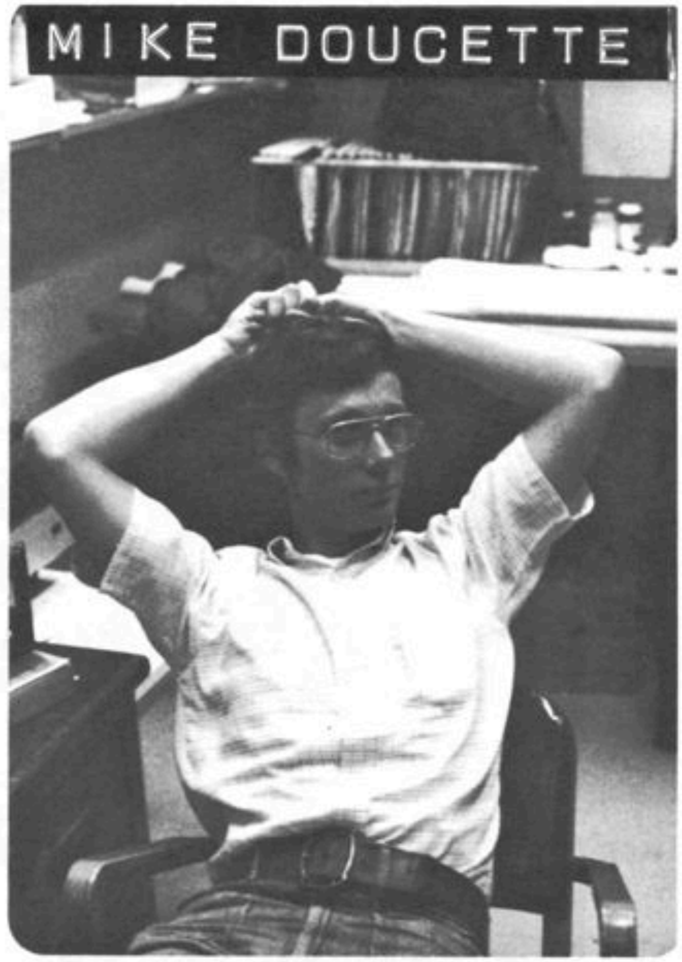


GEORGE CLARK, DICK TAYLOR

THE AFRICA CREW

JIM BUFF, BEN LAUFER, CLAUDE CANIZARES, TONY CAPORAL, EV. JOHNSTON, MARJORIE TOWNSEND, JOHN SACHS, AND RODGER DOXSEY


GARRETT JERNIGAN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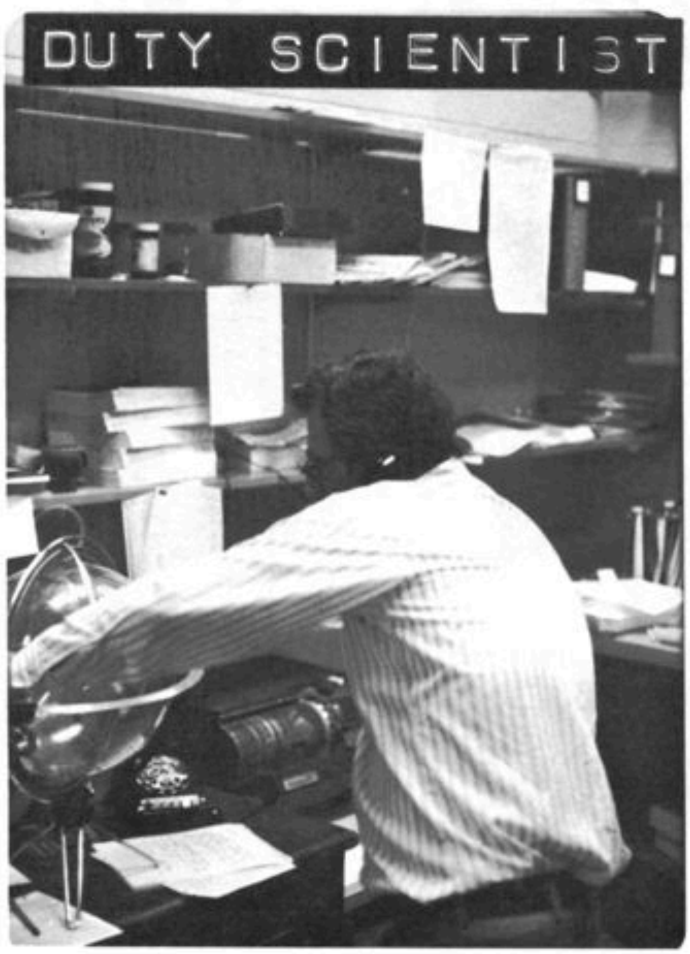
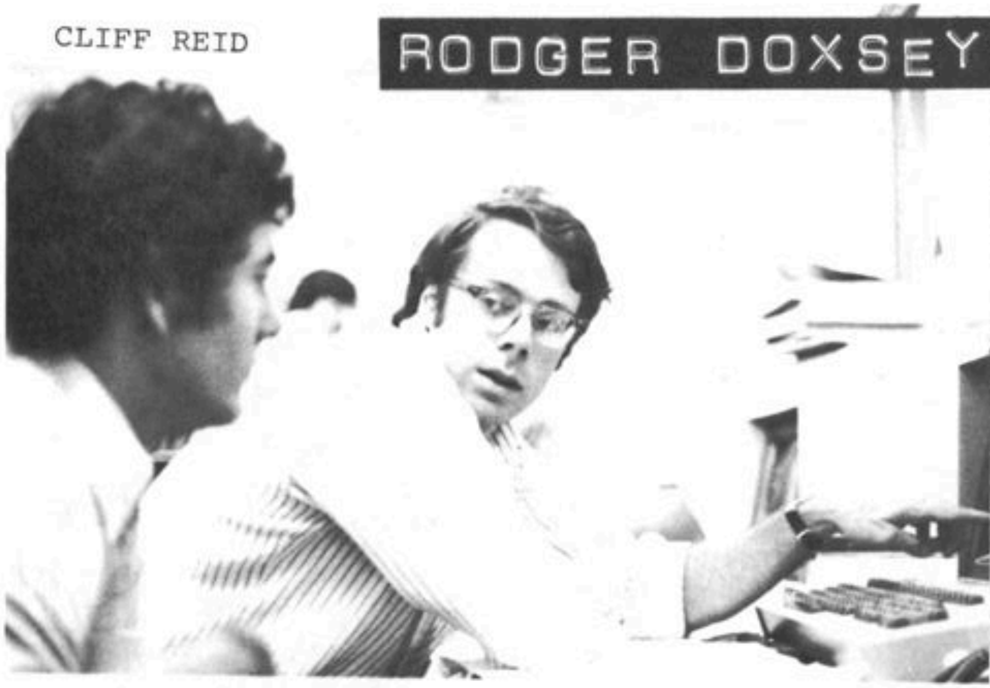

DUTY SCIENTIST


GLENN WARGO

CLIFF REID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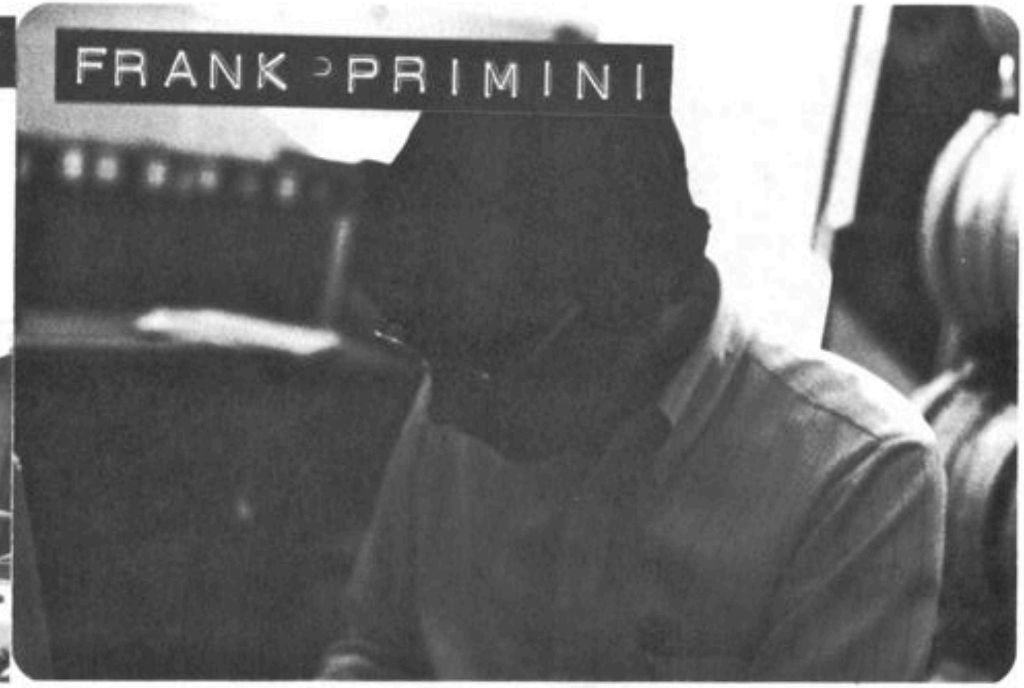
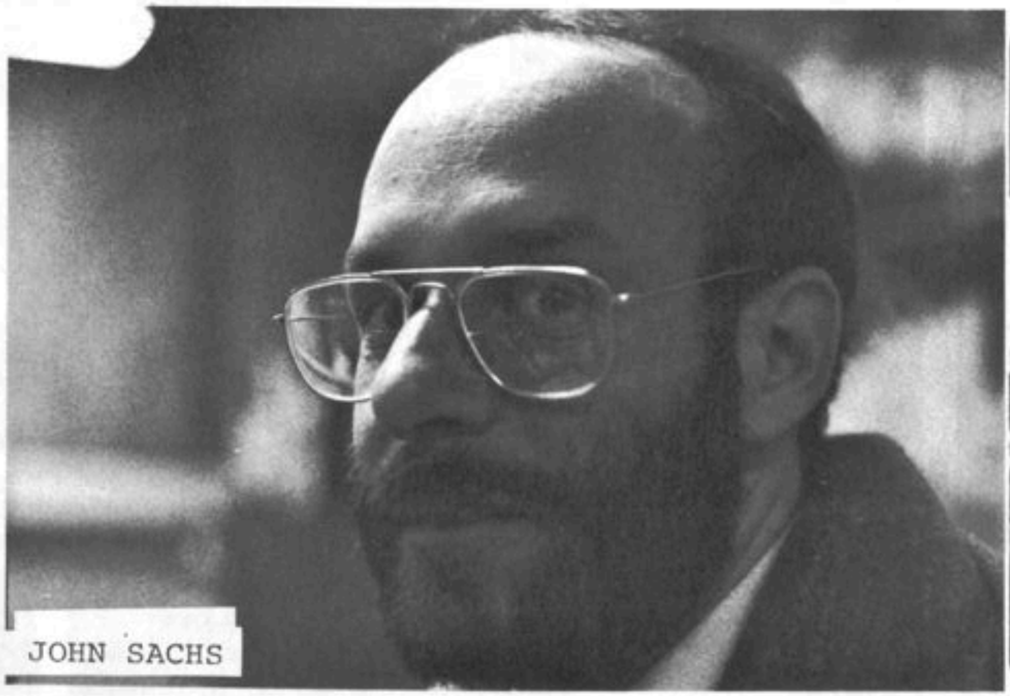

FRANK PRIMINI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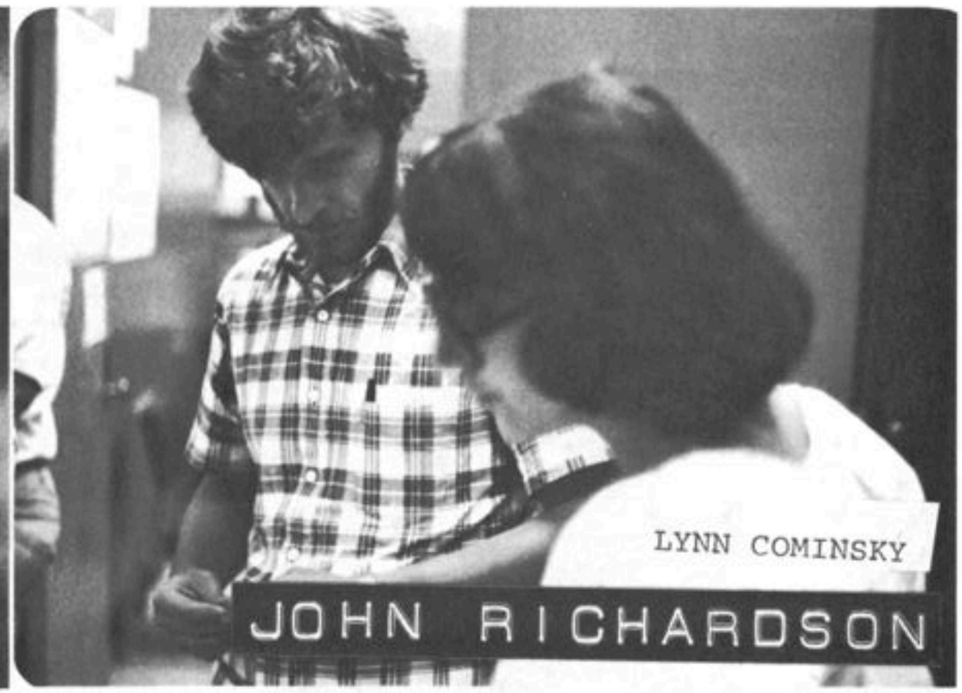
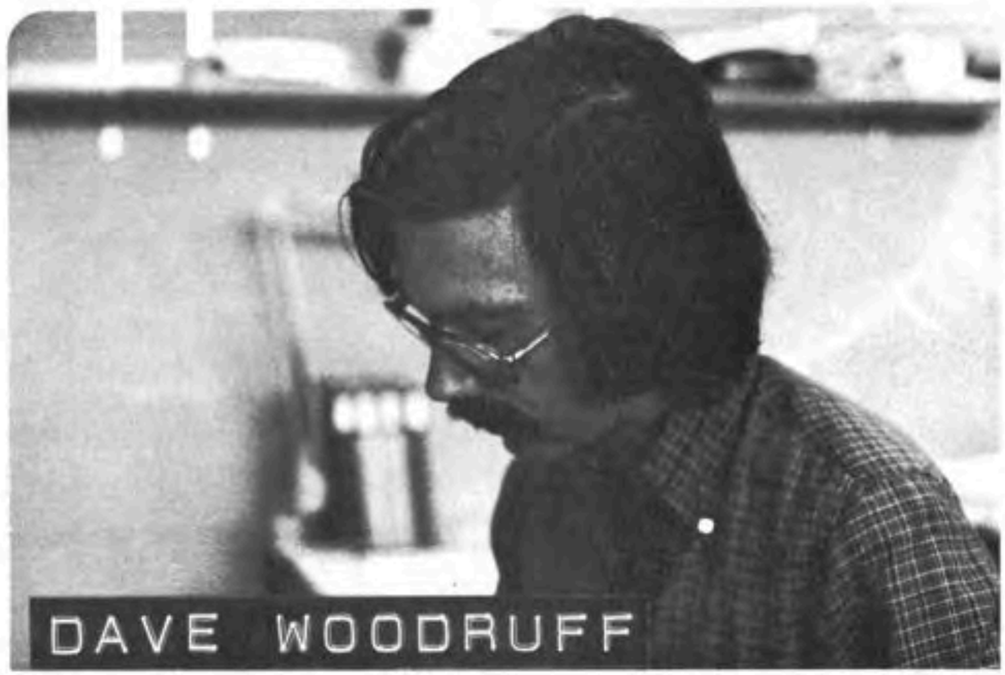

LYNN COMINSKY
JOHN RICHARDSON


J SPANGLER


MARGARET CHARTRES

STEVE LARSEN


DAVE WOODRUFF


ROBERTA CARUSO

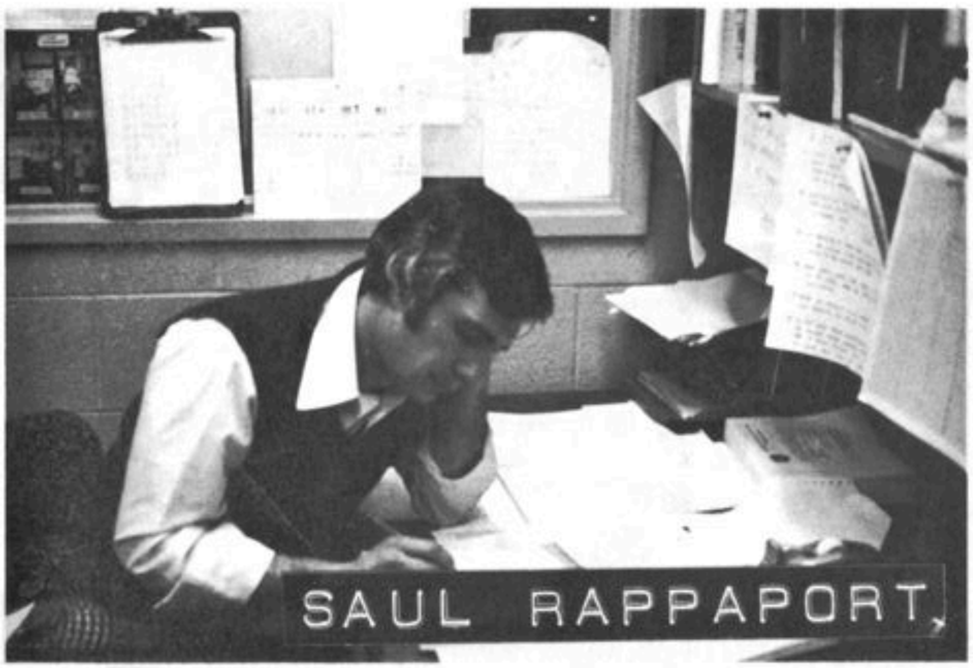

SUSAN BLACK


MARY DICACCIO


MARGARET LANIA


CLAUDE CANIZARES


BRUNO ROSSI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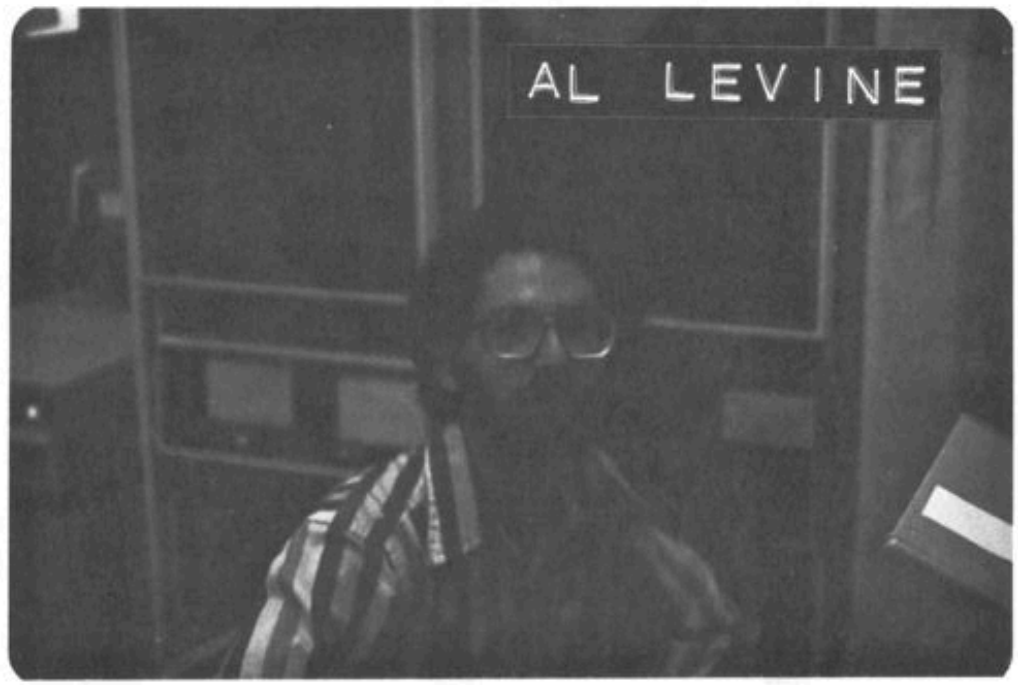
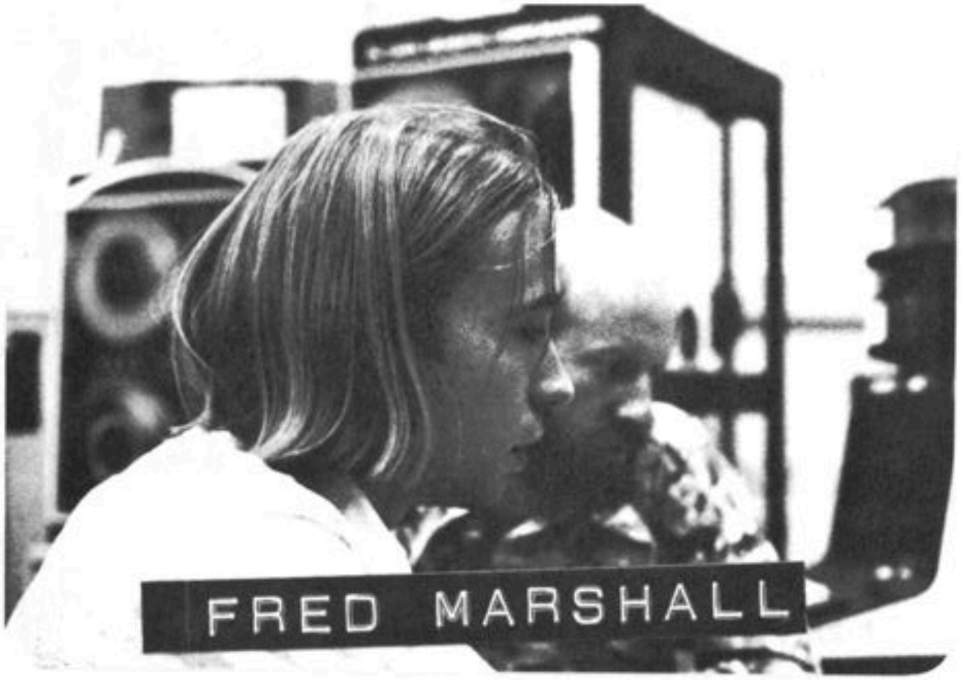

AL LEVINE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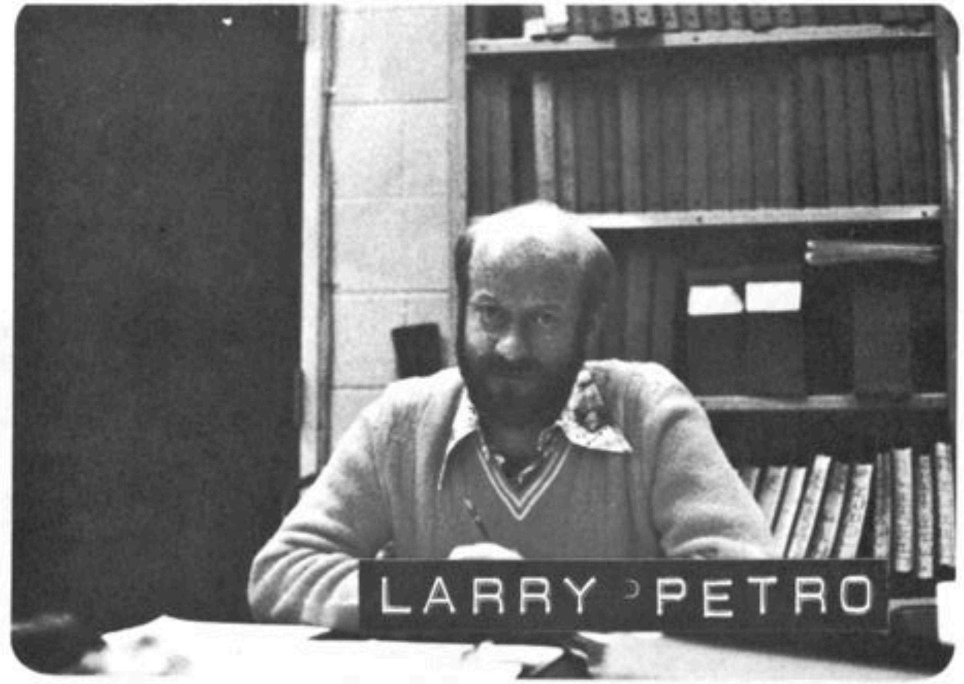
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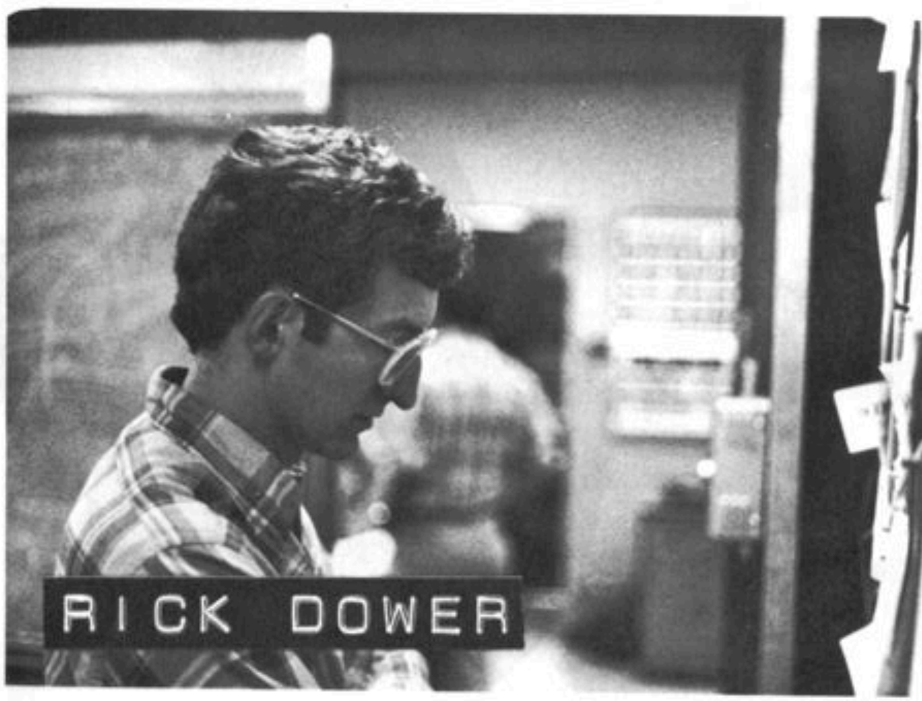
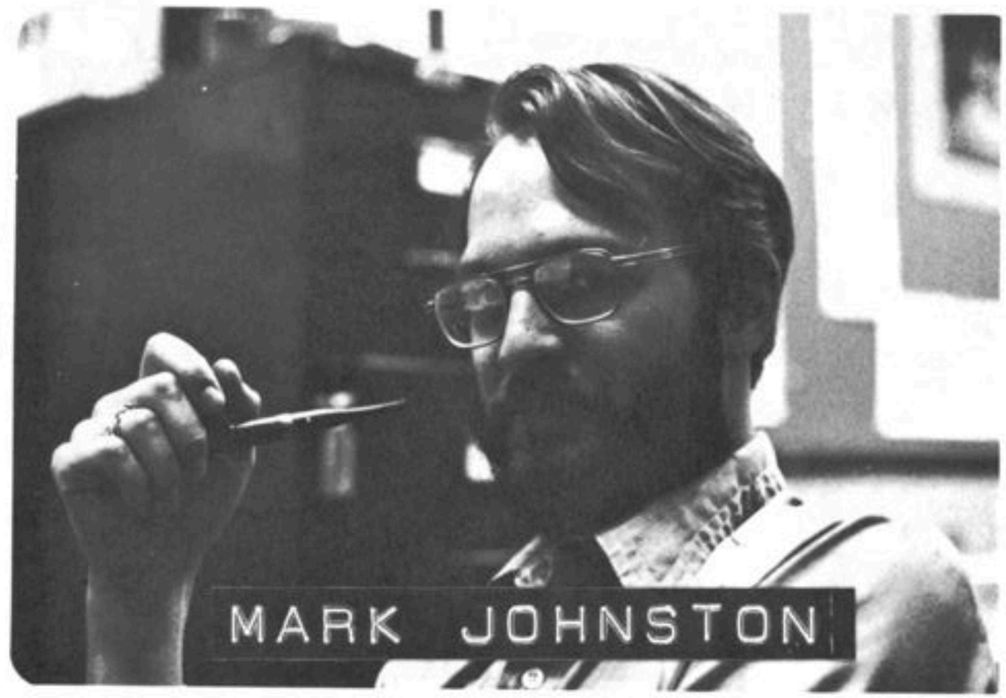

RICK DOWER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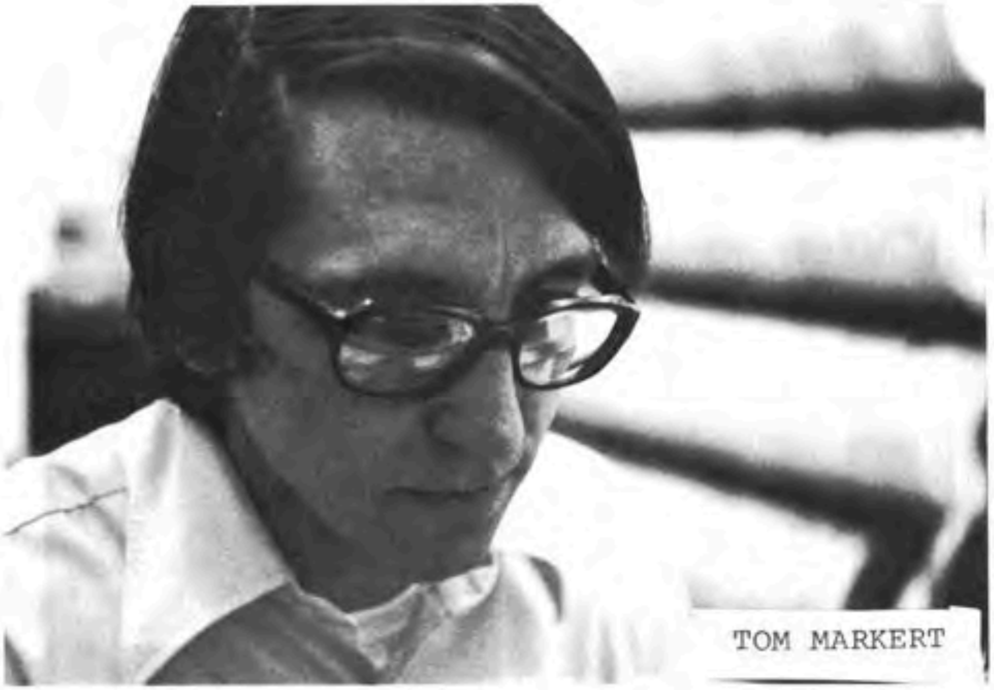
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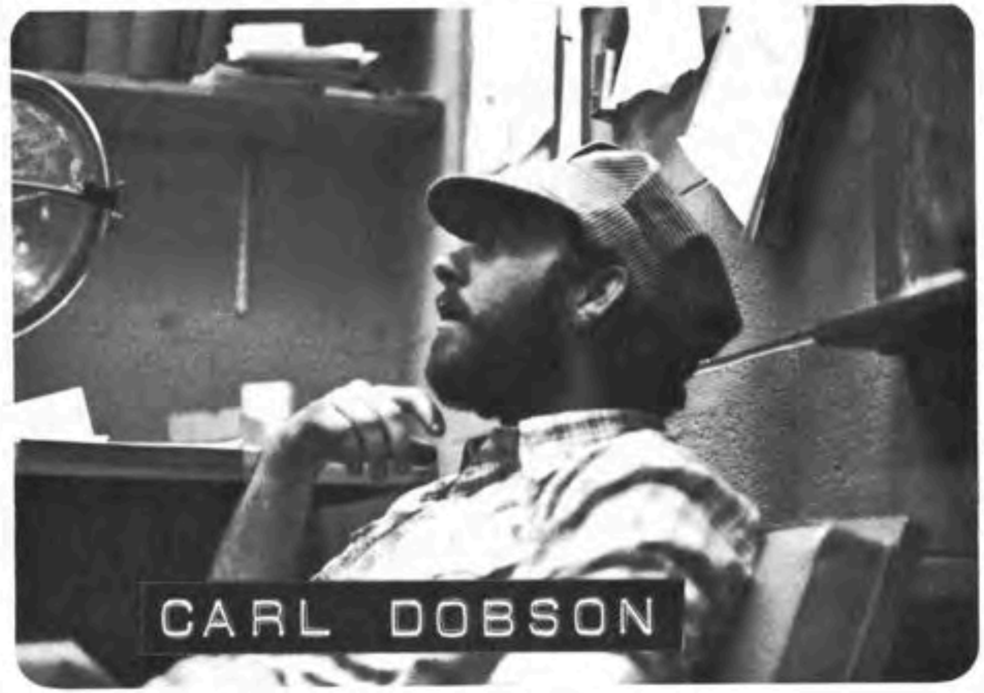
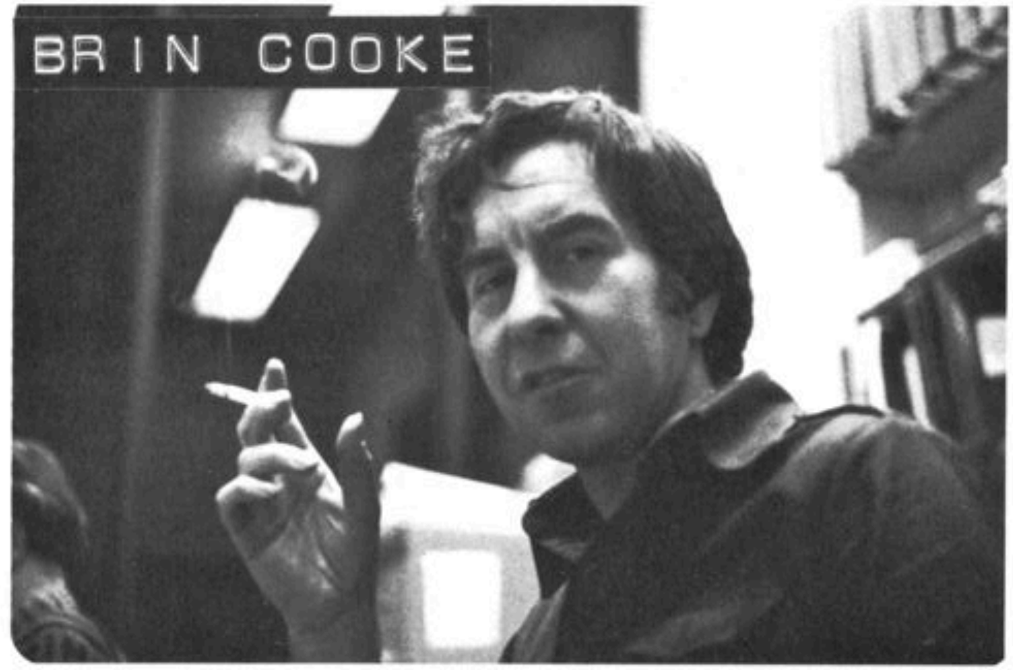
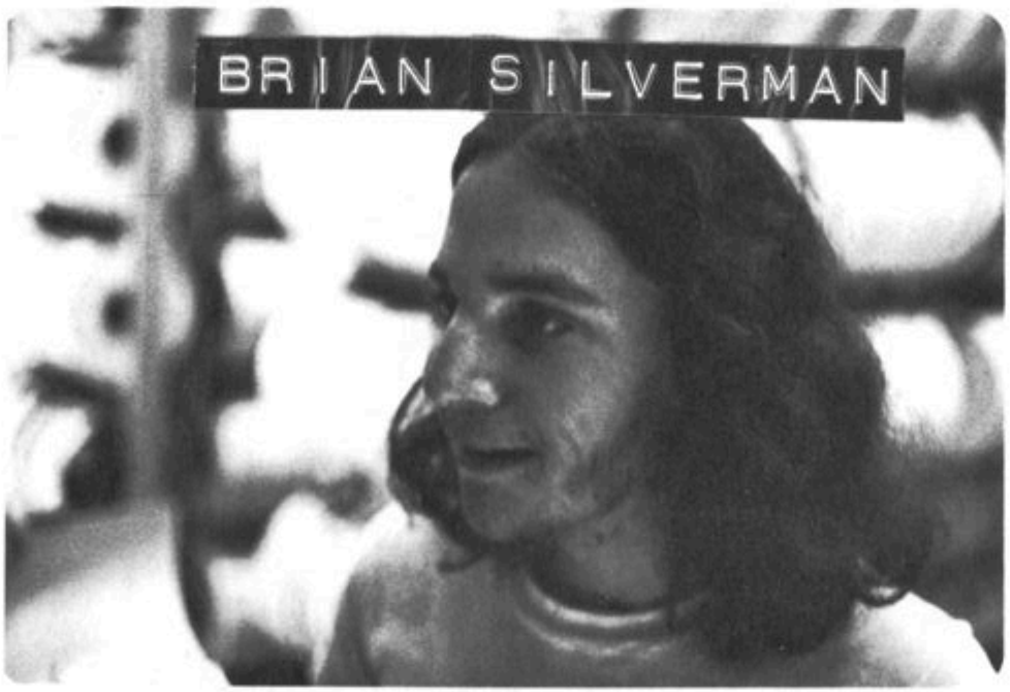

CARL DOBSON


JOHN P DOTY

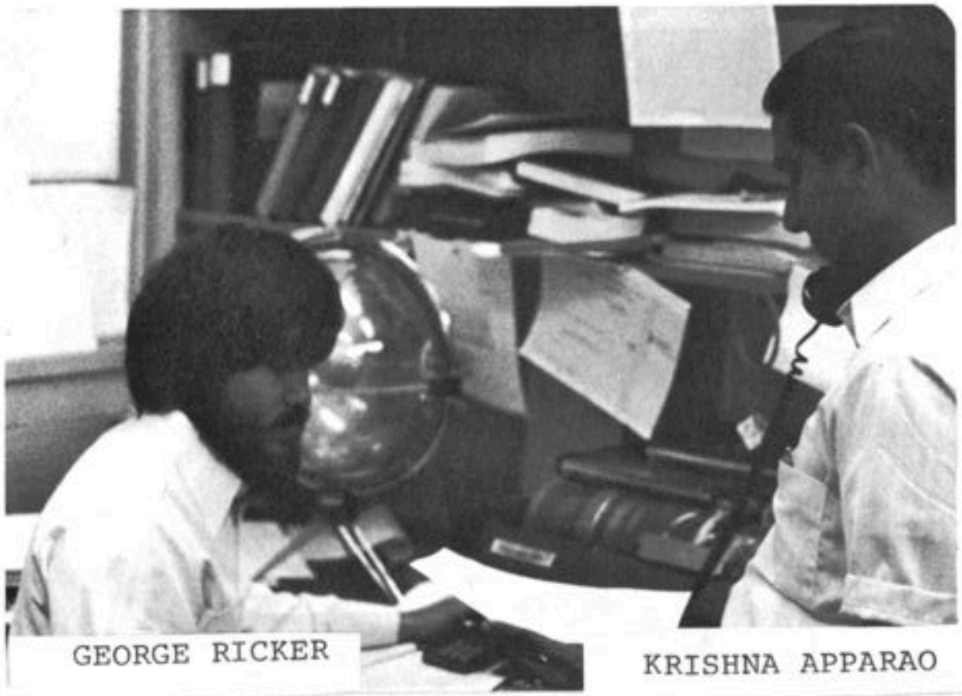

WILL COERTNIK

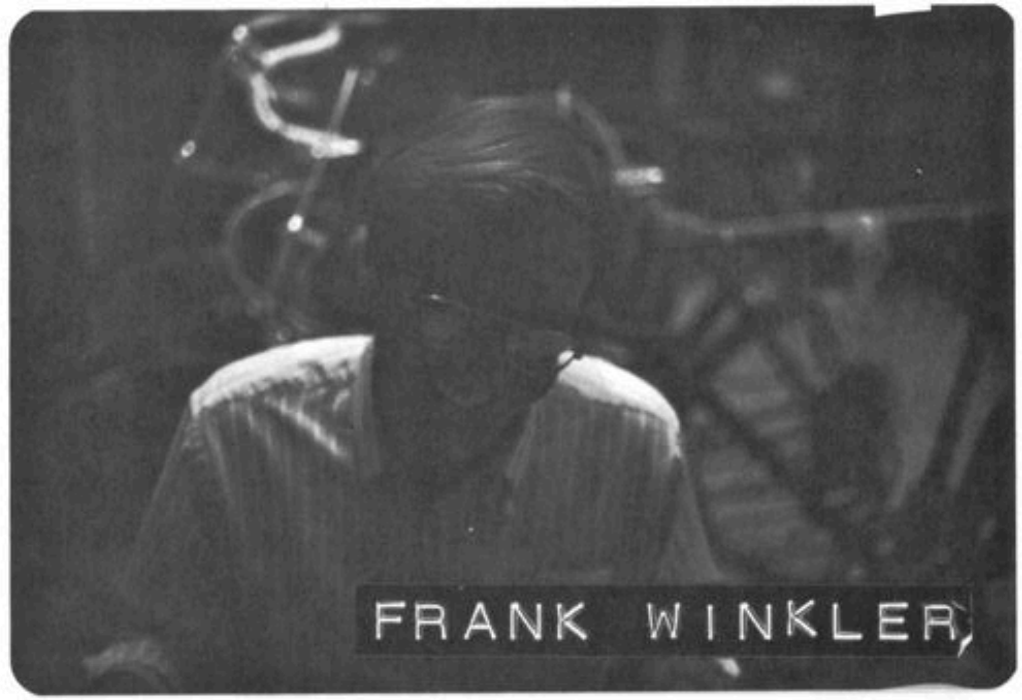

BILL WHEATON

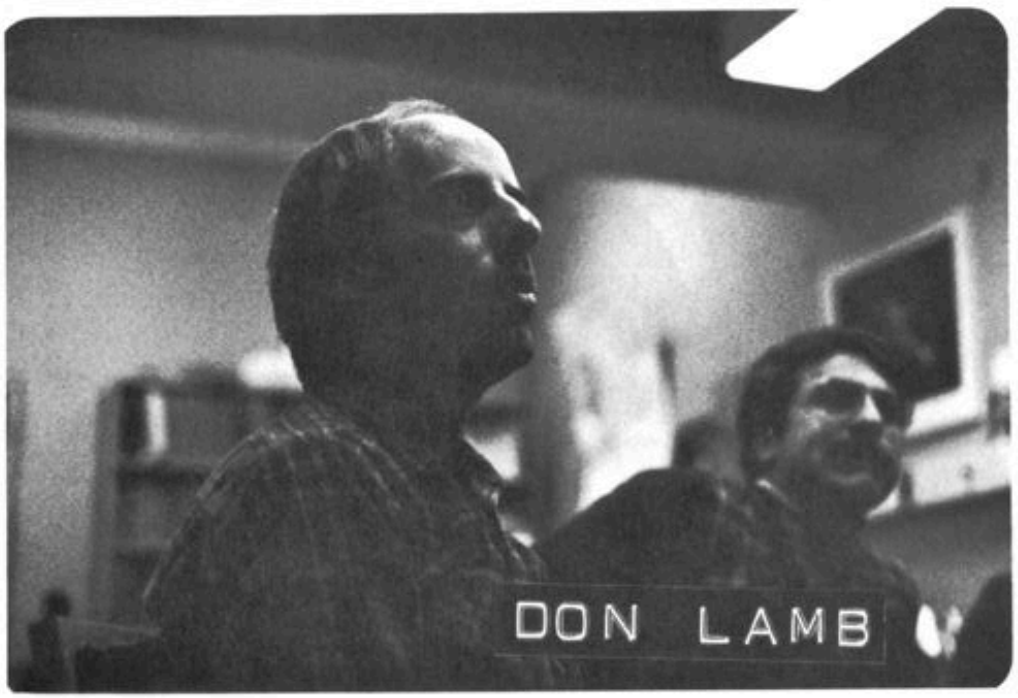

BRIN COOKE

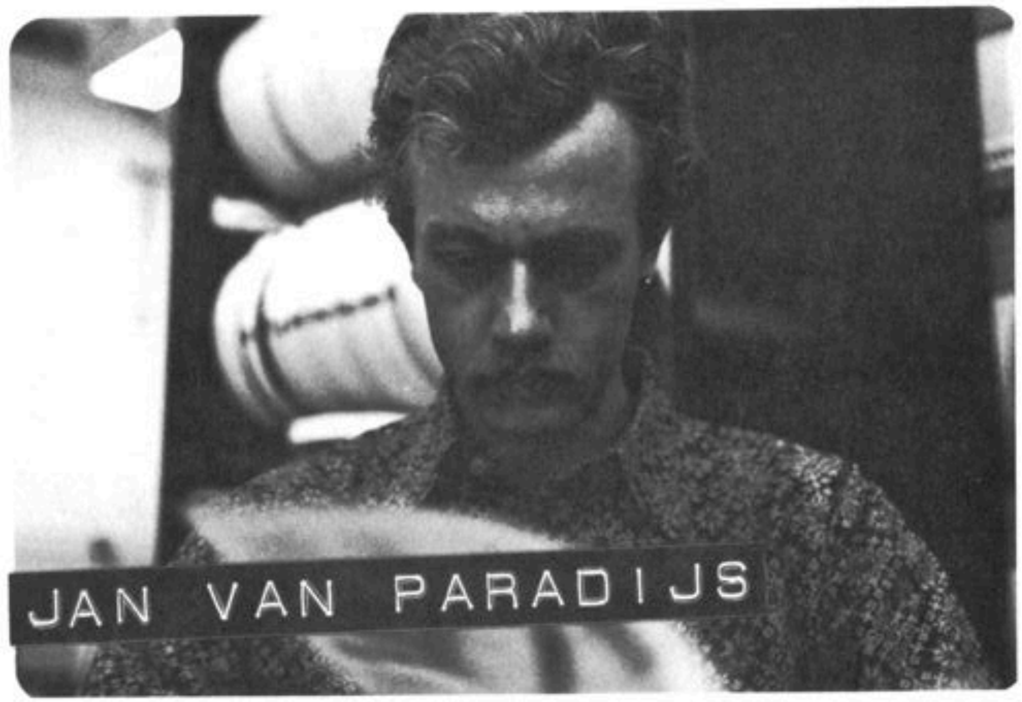

BRIAN SILVERMAN


GENE TSIANG

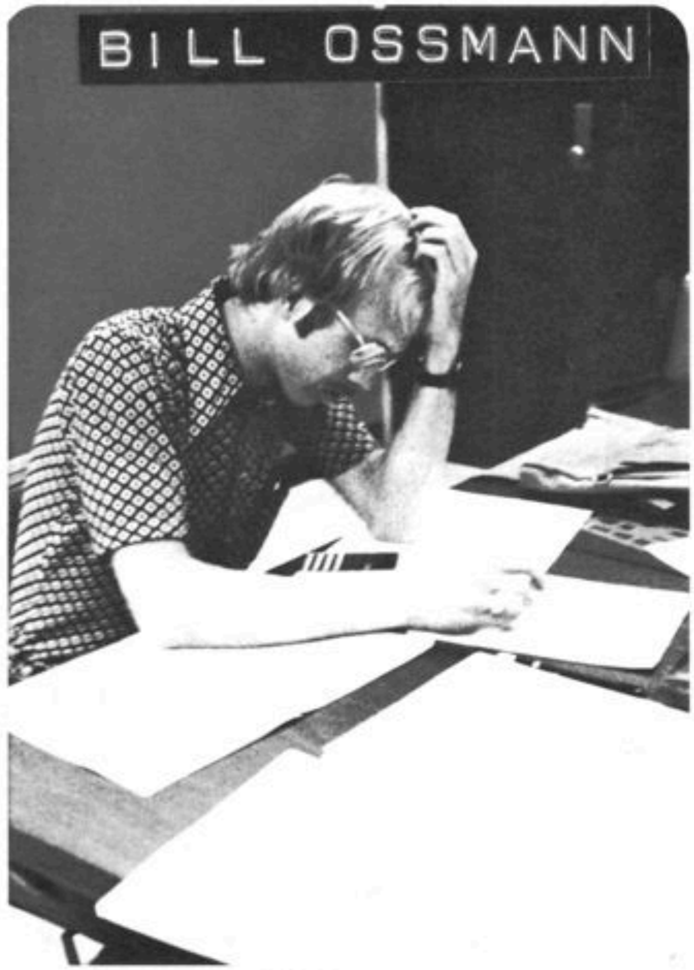

GEORGE RICKER
KRISHNA APPARAO








DANA BACHMAN


BILL OSSMANN


FUK LI

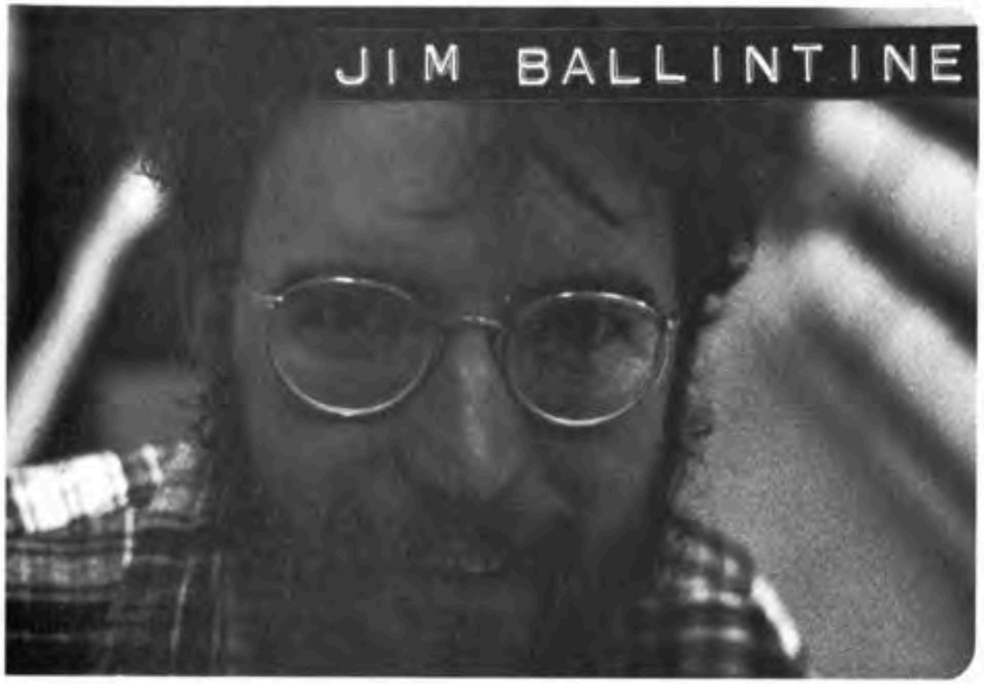

RON REMILLARD

LYNN COMINSKY

RICH KELLEY

DAVE JOHNSTON

FERNANDO PINEDA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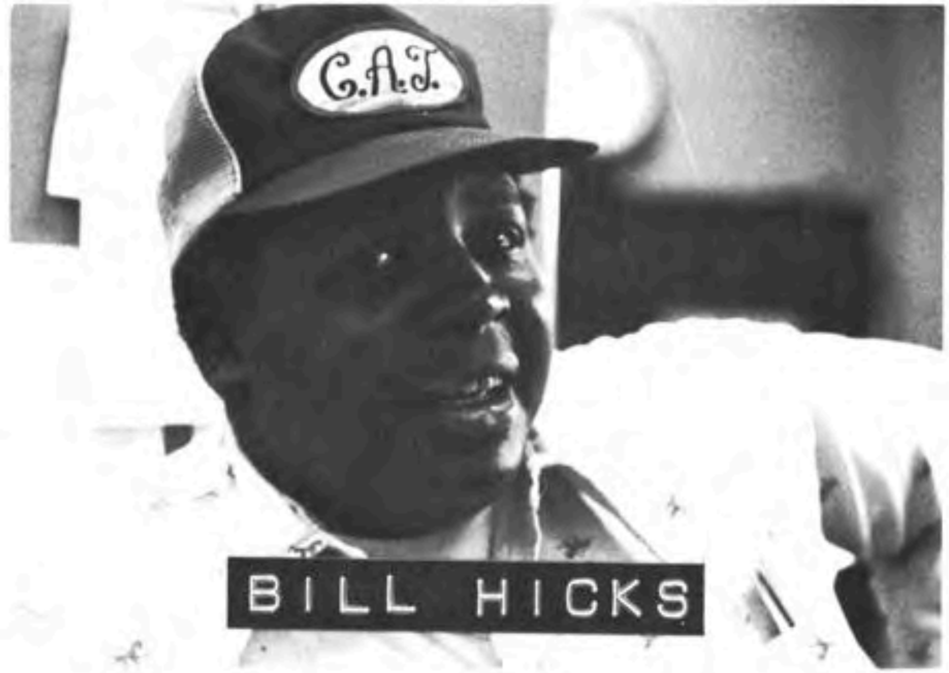
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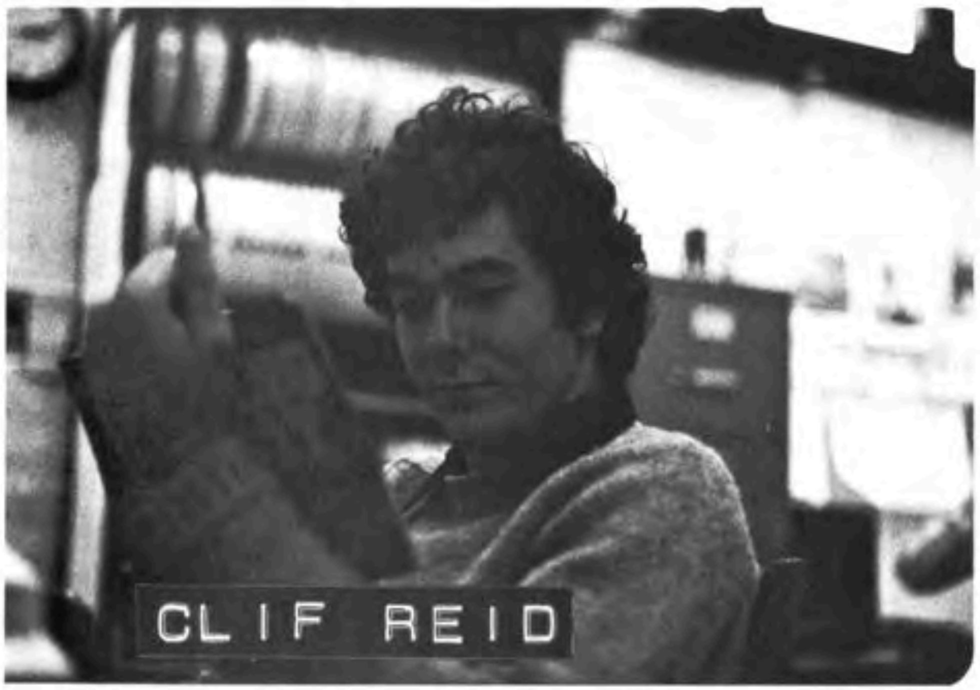
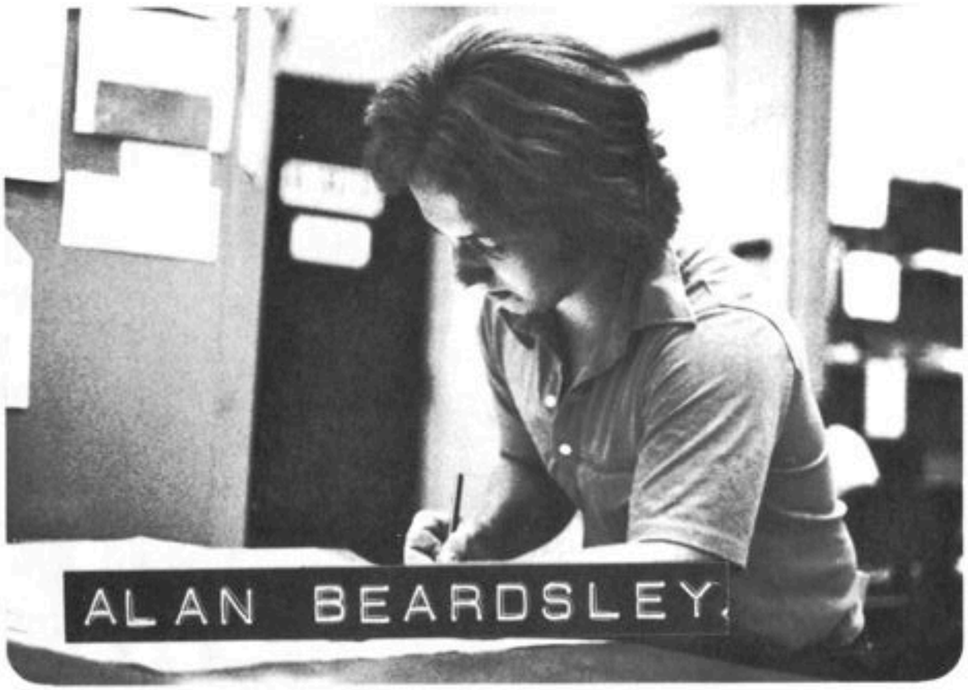

CLIF REID


ROB PETRE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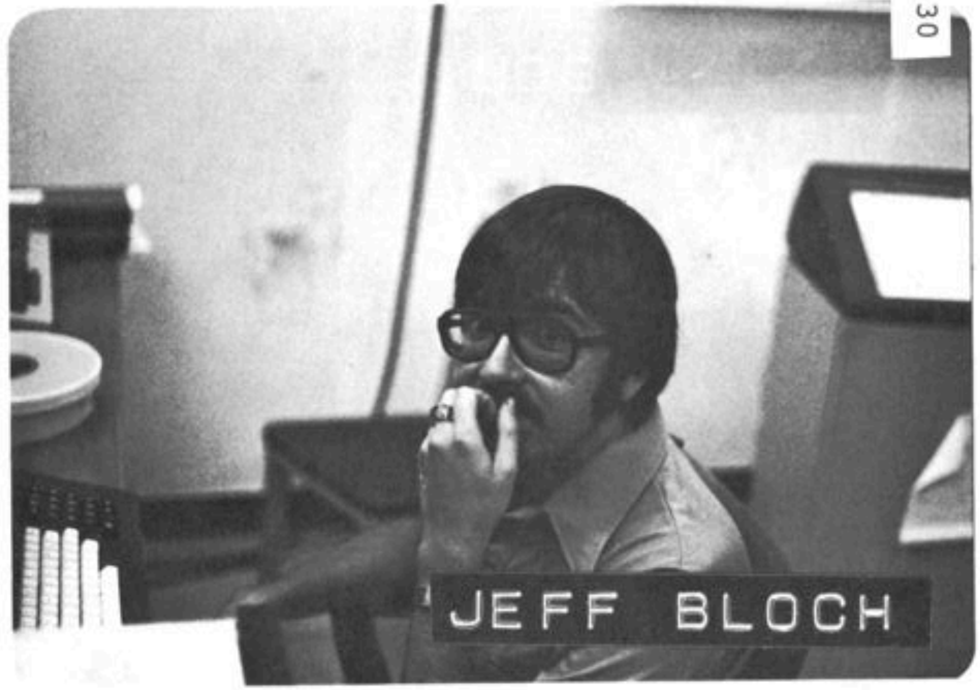
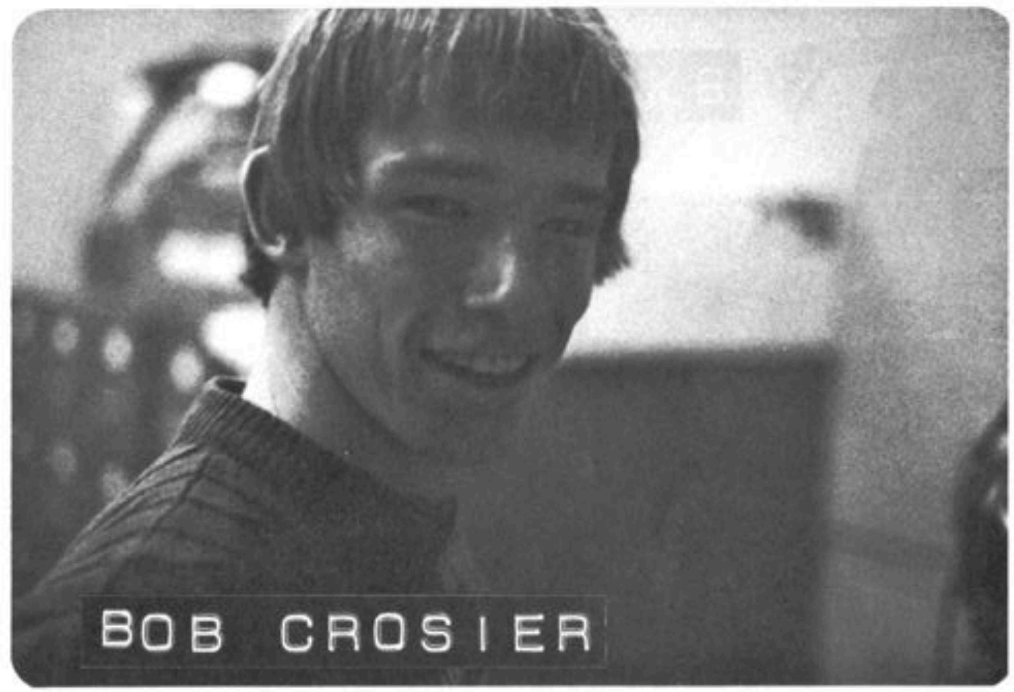
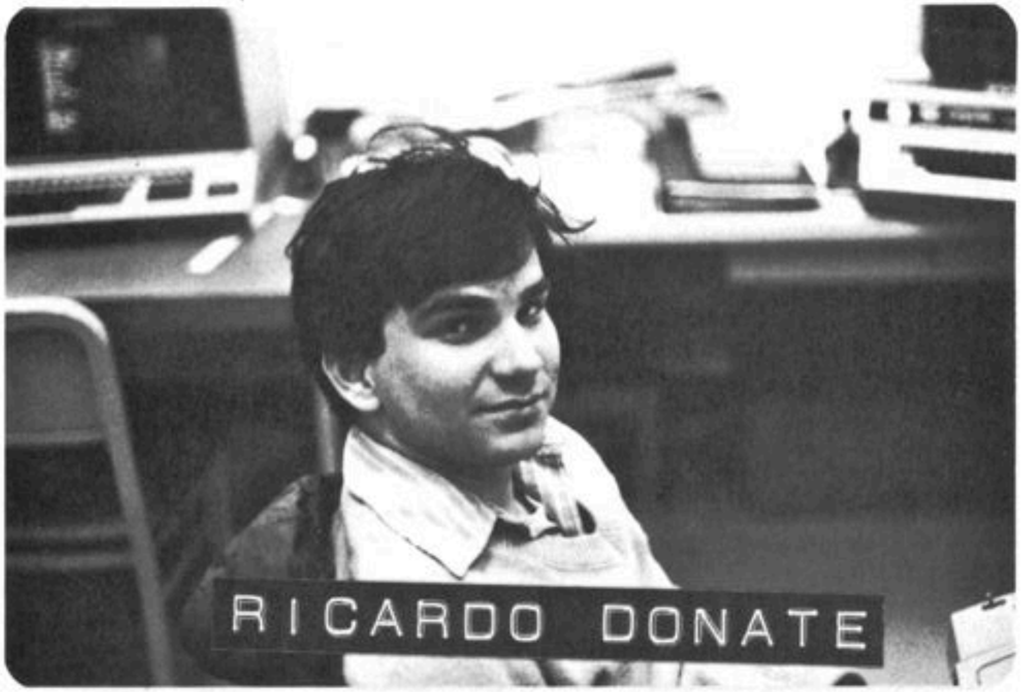

JEFF BLOCH


JIM COOGAN


BOB CROSIER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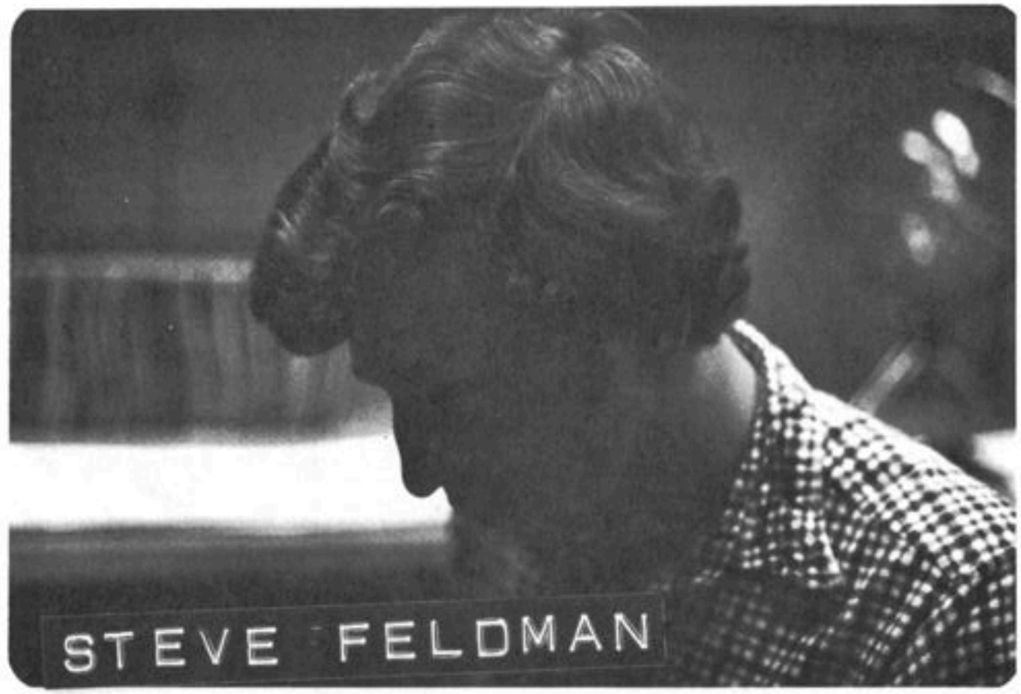
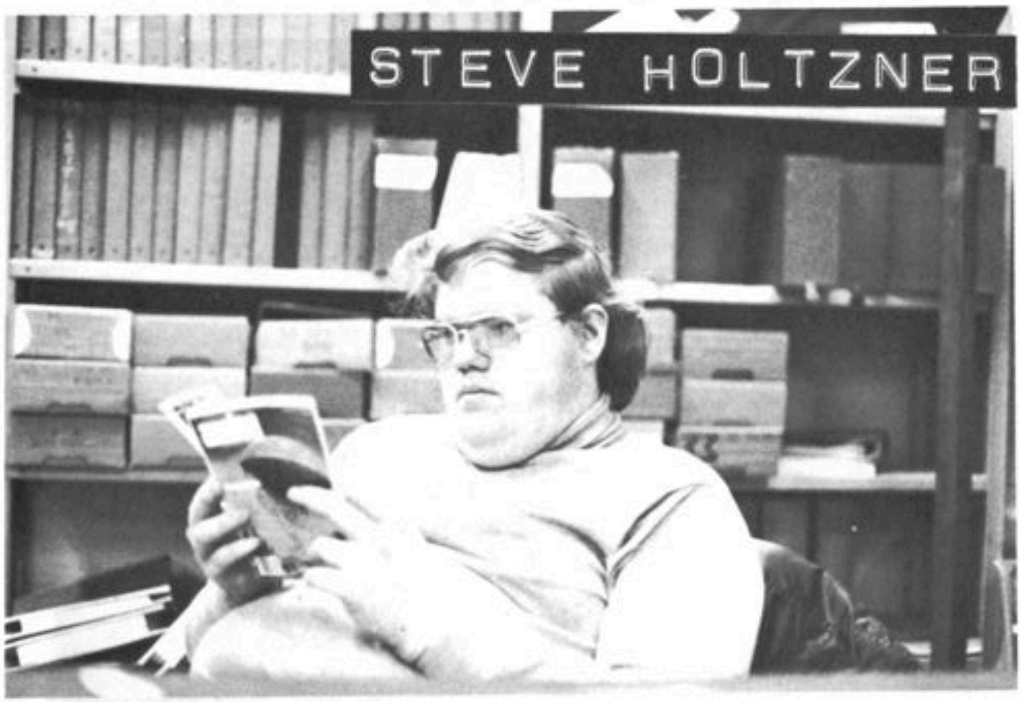

STEVE FELDMAN


STEVE HOLTZNER

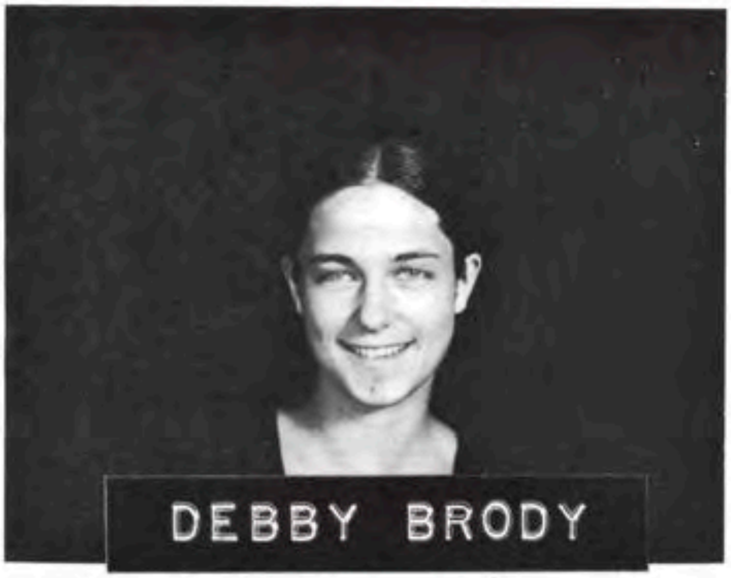

HARSHA


JOE KULIK


KATHERINE RALSTON


STACEY TABOR


RICHARD TUCKER



DEBBY BRODY

JEFF HOFFMAN

BOB DOBBIN

YOSHIKO ITO

MIKE HANEY

ANNE JOHNSON

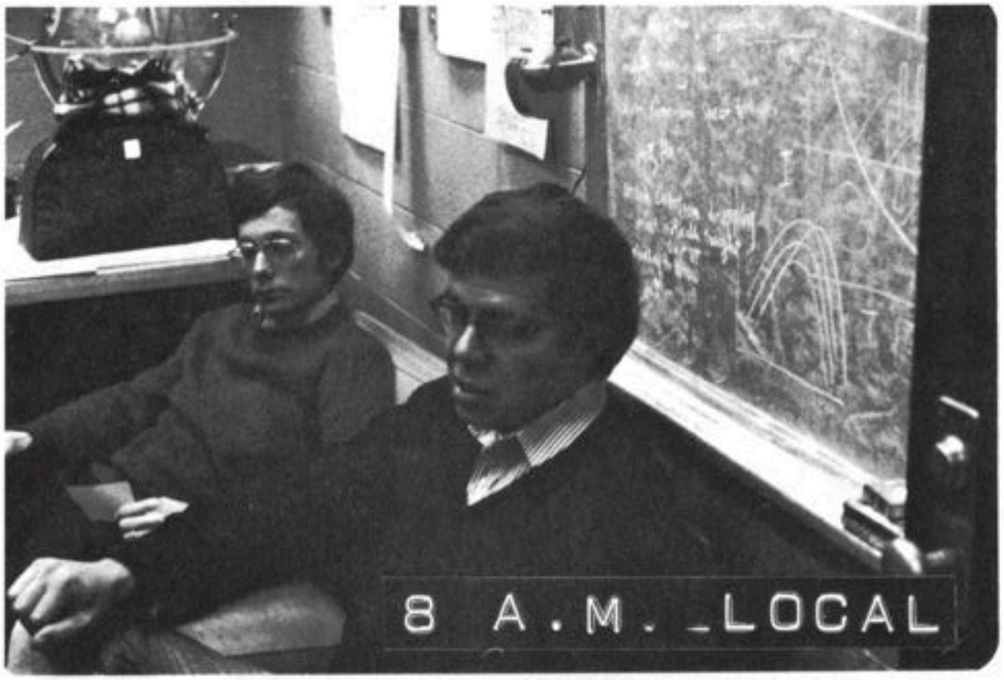

STEVE JOYCE


PHIL KESTEN

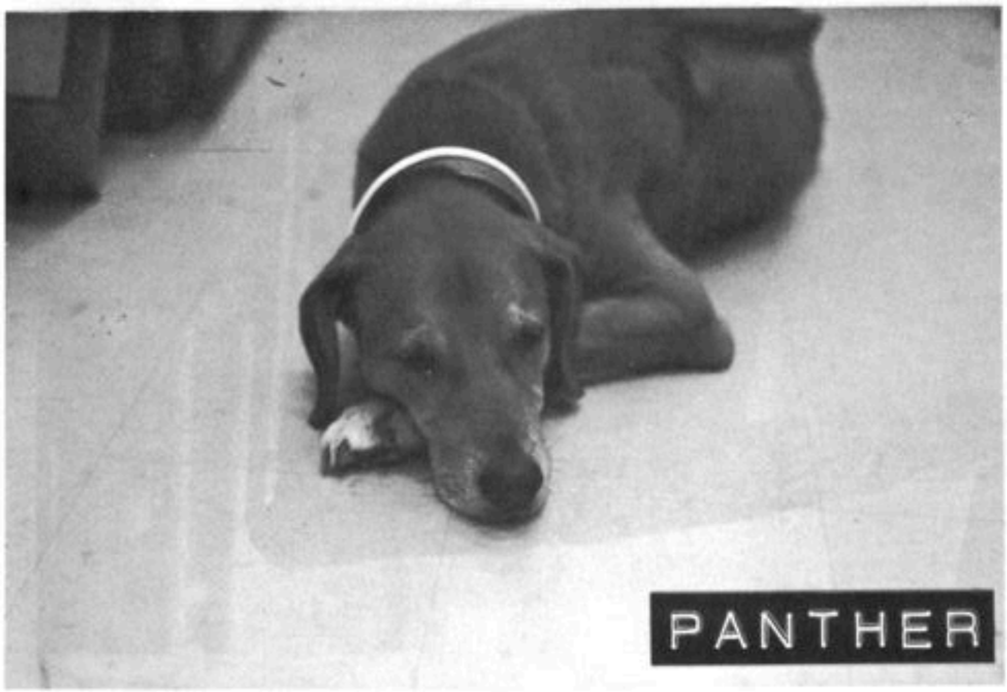

HERMAN MARSHALL


CATHERINE THOMAS

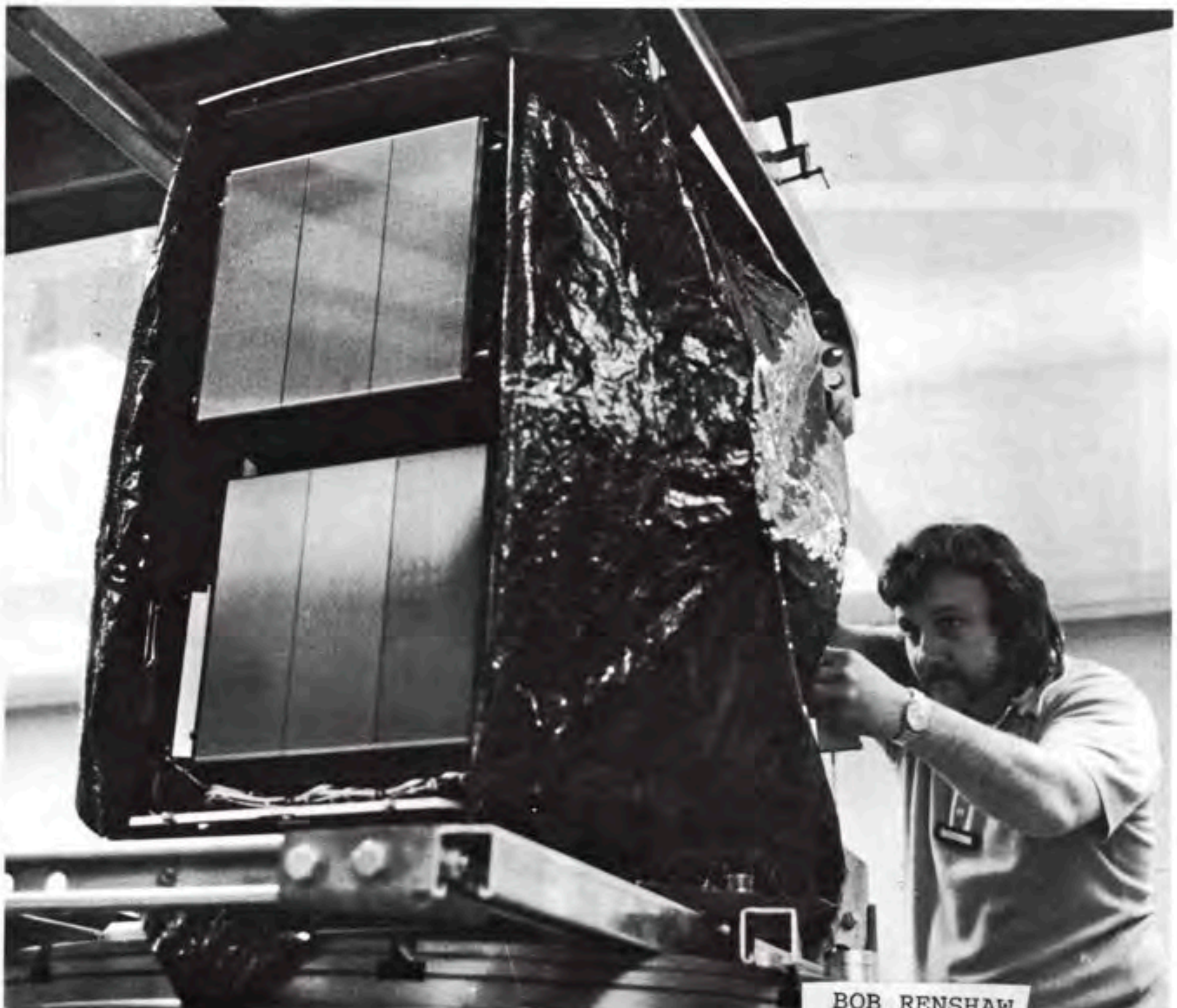

MEL ULMER



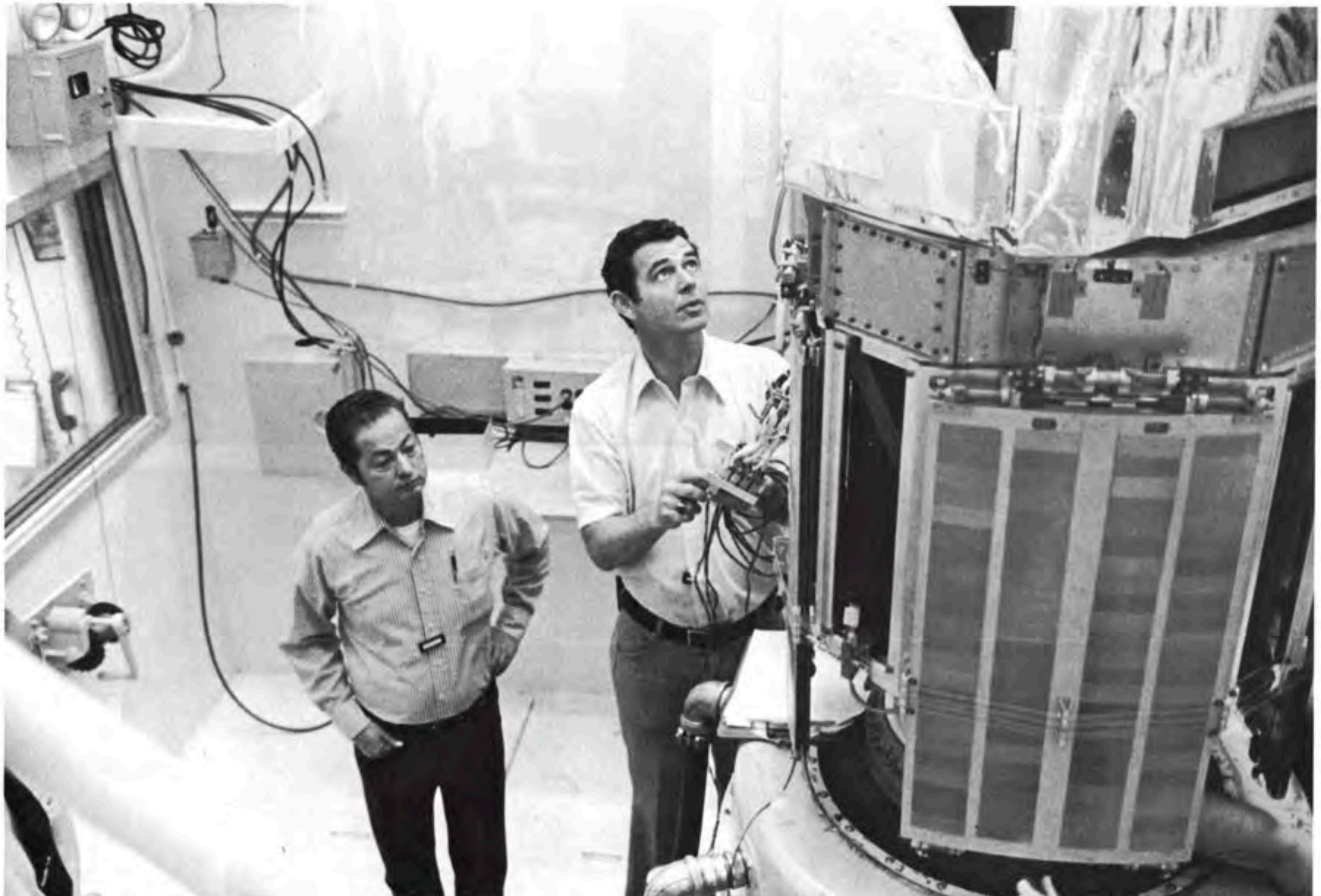
FELICIA



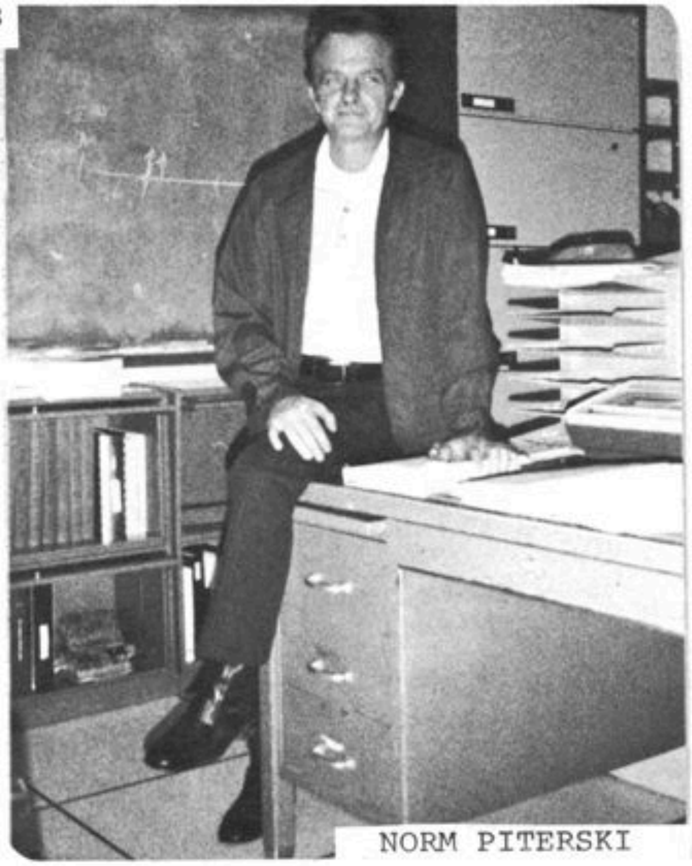
WILL YELLE, BILL MAYER, DICK MARCHI, WHITNEY HAMMET, ED BOUGHAN
(no wonder the z camera failed)



BOB RENSHAW

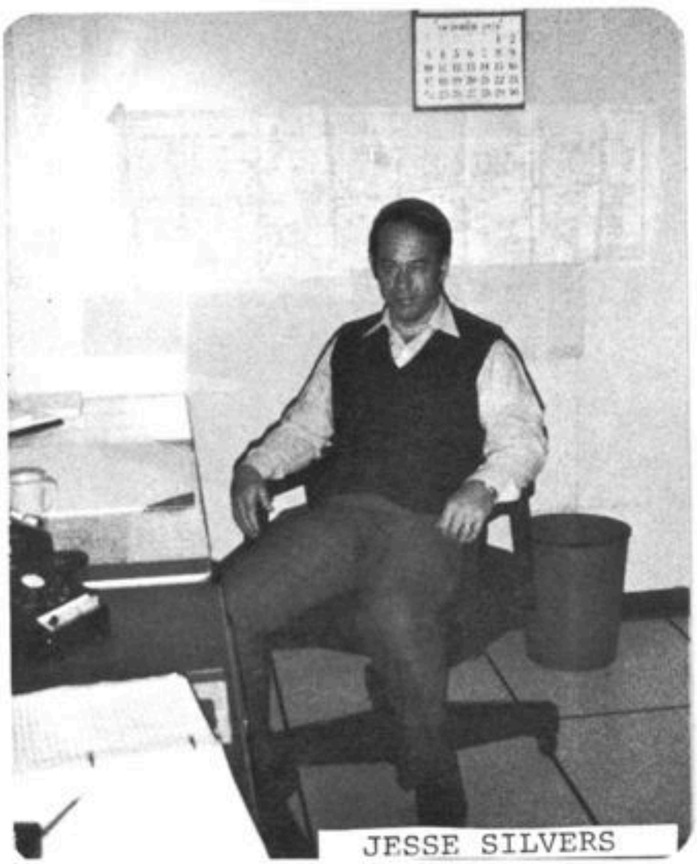


TOM DAWSON, EV. JOHNSTON



NORM PITERSKI

FRANK COLESANTI

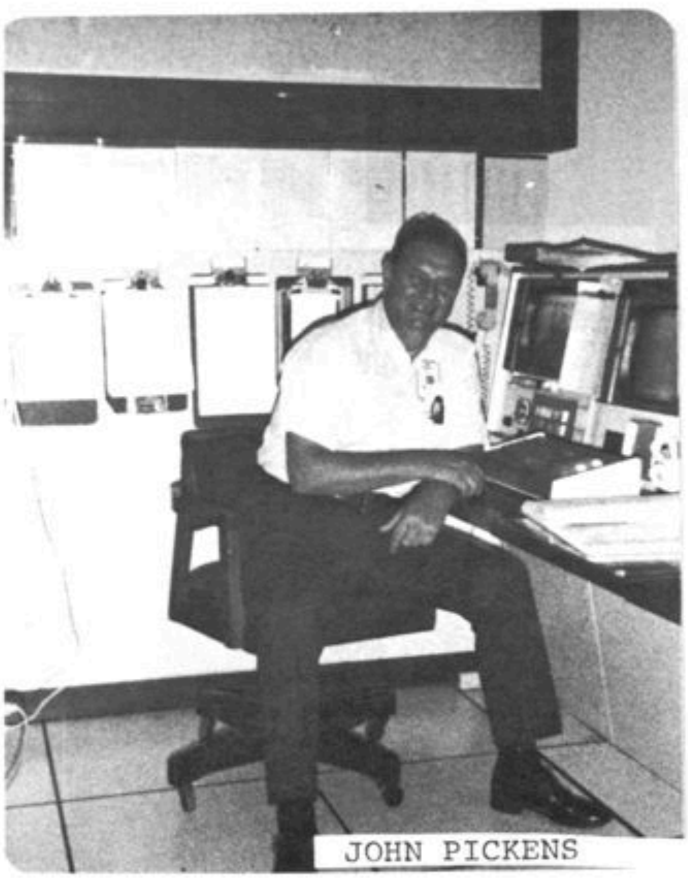


JESSE SILVERS

JANE SCHAUB

MILBURN WALTERS

LAURA HUDDLE



JOHN PICKENS

STEVE MILES

THE EDITOR

My first task for SAS was to modify a program which made tangent plane maps of the sky so that it could read a more complete version of the SAO star catalog obtained on tape from Kitt Peak.

Once the catalog was transferrred to a disk file, I wrote a set of subroutines that could acccess any part of the file in less than one second. This was achieved through the use of a look up table and a binary search algorlthm. This greatly reduced the time required to produce a map since the older method read through the entire catalog to find the stars needed. I have since involved in an entire revamp of the program which will allow it to do a variety of sky projections, the first added being the Aitof case.

My experience as an undergraduate working for SAS has been a very positive one which built a lot of needed self confidence. Not only have the people of SAS been friendly but they have always lent their expertise when asked. It was very gratifying when after I spent a few months of getting to know how things worked, I could reciprocate in kind. For instance, the struggle involving several weeks of attempting to load the Kitt Peak SAO star catlog enabled me later to help Larry Petro load some tapes of programs generated at another computer facility.

All in all my work with SAS has been an important part of my education.

--Jeff Bloch

I REMEMBER:

PRE-LAUNCH

1: The natural way that George Clark melded together his interests and ideas with those of Walter, Herb and myself to put together an impressive proposal (G.W.C.: low energy x-rays, absorption of x-rays in the galaxy; Walter: flares in Sco X-1; Herb: faint extragalactic sources; H.B.: variability in galactic sources).

2: The complete reconfiguration of SAS-3 to solve a severe weight crisis - in a cocktail lounge in Logan Airport - in about 2 hours (by Bill Mayer, Bob Rasche, George Clark, myself, others?) Several instruments were coalesced and everybody's objectives were better fulfilled!

3: The incredible knack that Bill Mayer had for resolving design issues without ruffling feathers. How he represented fairly all the experiments and the engineers with no favoritism for his (proud) ex-thesis supervisor (me).

4: How David Hearn joined MIT, immediately evaluated the low energy experiment and sold everybody (including NASA) on a much more powerful (and yet low-cost!?!) concentrator system. How some of us wondered how that complex system would ever survive the launch and space enviroment - completely underestimating Dave's and our engineers' artistry and ingenuity.

5: How Garrett (Jernigan) almost went to grad school at Berkeley. We needed some RA's to assist with the data system. From a phone call I learned he knew what a black hole was and that he liked computers. I then sent him a big line drawing of SAS-3, the SAS-3 computer analysis plan, and many beautiful pictures of MIT (sailboats, etc.) - gave him everything but a football scholarship. Thank goodness he came and joined John Sachs, Frank Primini, Terry Matilsky, Jim Buff, et al. on the data system preparations.

6: My last-minute instruction re the SAS-3 operating systems before launch, mostly at APL, under Bill's patient tutelage.

7: How much the staff at the Laurel Howard Johnson's (near APL) Motel loved the SAS-3 engineers and technicians group, and especially Bob Farnsworth. (What a welcome they gave me when I said I was from MIT!) How their highway sign said "Go MIT SAS-C" or something like that - just before launch.

8: The professional appearance (to my novice's eyes) of the GSFC control center at the first launch rehearsal. (Actually, it was in a relatively poor state of preparedness.) Someone apologized to me for their software situation; otherwise I wouldn't have known the difference. At the next rehearsal things went much better. John Donaghy and I learned how to read displays; made charts of bit arrays so we could read the status even if all the decoding failed or the bits were inverted.

9: How patient Jesse Silvers the chief controller was with me when I interrogated him at length tring to understand just how NASA was sure, sure, sure that "Mark 207" keyed in at GSFC would really put the correct 64 bits into the spacecraft. (I'm still amazed that it does.)

10: How everybody who played a major part in the hardware development went to Africa for the real show. Figured the only place I might do some good was at GSFC. Plan was for the critical Africa personnel (Mayer, Taylor, et al.) to return to GSFC immediately after launch, thus leaving open only a short period wherein I might do serious damage. It didn't work out that way , and did I ever have a time! They stayed in Africa to help solve problems, then returned to MIT (pooped). For about two weeks, most of the control was from GSFC while MIT control capability was being brought up to speed.

IMMEDIATE POST-LAUNCH

11: The successful launch - quite a thrill to hear the acquisition after the first full orbit. Ann Scales helped prepare a world map and a little cutout of SAS-3 showing the progress around the 1st orbit for the group at MIT. John Donaghy and I kept them informed by phone.

12. How the APL group, on the night of the launch, let me go to bed without mentioning the jammed nutation damper - hoping it was only a readout error. The next day, the groups in Africa and GSFC tried to jar it loose with spin rate changes. How APL finally took out the nutation manually - Wow, what a smooth operation. At AOS they put the camera on star-lock, loaded the DCS with two high dipole commands (+ and - each 1/2 nutation period), read the phase of the nutation from the camera readout (real-time from strip chart) and the direction of the earth's magnetic field (real time from the print-out) and then epoch set the DCS loads at the appropriate nutation phase. After several cycles, the nutation was almost completely removed. Then (naturally!) the nutation damper came loose that night. Terry Matilsky called me up screaming "it's free, it's free!!" Quite a relief - our RMC observations would have been impossible or difficult at best.

13. How we left the heater on continously for 12 (?) orbits and how I casually requested (about 5 minutes before an AOS) it be turned off ("if convenient on this pass"). I was completely unaware that the voltage had gotten so low that SAS-3 would certainly have gone off the air during that orbit and during the second night in orbit!! (Fact is, I'd never heard of the circuit breaker or 13.2 volts.)

14. How, after about 1 day the satellite came around to Quito with the experiment turned on thanks to the Africa team, to the complete surprise of the GSFC team, and the great consternation of the GSFC operations management. This concern was considerably increased as both groups proceeded to send commands to SAS-3 to fill and make operational the low energy system. However, all went well and our general competence was appreciated. (but see item 13 above!)

15. The miles and miles of real-time strip charts I looked at over the next two weeks and the facetious award I was given by the GSFC personnel: "To Hale V. D. Bradt, PhD:

> Presented on the occasion of the 25,000th nutation of the Small Astronomy Satellite (Also known as OTIS). Citation: for diligence, excellence, and indefatigability in the observation and analysis of strip charts. Dr. Bradt demonstrated a tirelessness that was above and beyond the call of duty and raised the art of strip chart watching to a new level."

(Otis was John Sachs' dog - a regular and much loved member of the group. There was considerable sentiment for naming SAS-3, "Orbiting Telescope In Space", but we never could sell the PI on it.)

16. The fire in Norm Pitersky's console in the control center just when he was being called by Marjorie from Africa and Mobley's cool "Majorie, we have a small problem here."

17. The one small computer and one phone in the MIT SAS computer room which were supposed to do it all.

18. The many discussions in the SAS-3 room about which observation(s) to do next (i.e., starting on the next pass) and how often we were able to meld the operations/engineering requirements and diverse scientific objectives to accomplish nearly everything everyone wanted; did we ever get science out of that bird!

19. How we did our first "point." [Because of the specs on the unpredicitable gyro drift ($\sim 1^\circ$/hour), the plans were to do no more than to slowly raster over a source]. I was at GSFC using the GSFC strip charts to center up the transient 0535+26 in the middle of the raster and making the raster quite slow when George Clark dropped by. He assessed the situation and simply said "Why don't we just stop on it?" [So obvious - just like Einstein and special relativity]. With that inspiration and having seen the APL jocks do real-time nutation damping, I knew just how to do it. On the next pass, we rastered over the source real time (watching the charts) to see where 0535 was (with the center slat), reversed direction and gave a real-time "stop". The MIT crew were keeping the z axis on the dwell circle. SAS-3 went over the horizon with 0535 shining right down its throat. That orbit of beautiful data was sent up to MIT and yielded the 104 sec period within a few hours.

20. The first quasar (MR2251-178) found through x-rays, by George Ricker with SAS-3. How George would optimize his RMC observations with every possible trick and always find something.

21. How a Cos-B gamma ray source led to another x-ray quasar (0241+622) and how excited Bruce Margon was when he called and told me he'd found a red-shifted object right smack in the galactic plane.

22. How the RMC galactic scan was slow to produce final results but was eventually very fruitful thanks to the herioc persistence of Rodger Doxsey and Garrett Jernigan on the aspect and RMC mapping programs, Krishna Apparao and Joe Kulick with the production processing and RMC analysis system and Rick Dower's observational prowess.

23. How George Clark let everyone do his thing - within reason - so an incredible diversity of science was forthcoming from SAS-3.

24. How I paid no attention to Garrett's Bursts in the RMC. I actually saw (or "didn't see") x-ray burst before their discovery.

25. How I was almost trampled to death in the duty scientist room then the "Rapidly Repetitive Burster" was discovered.

26. How the sky gave us (and Ariel-5) an x-ray nova (0620-00) a mere 3 weeks before the brightest optical nova (Nova Cygni 1975) since 1942 which did not emit x-rays (as Lewin and Hoffman were quick to find out). Both occurred within 4 months of the SAS-3 launch.

27. How Nova 0620-00 showed in our data (after a maneuver) confused by the sun during the Friday afternoon SAS-3 1000 orbit party (August 1975) and how, even if we (especially me) had not been slow to recognise its existence, Ariel-5 would have scooped us anyway, as their IAU Circular the following Monday made clear. How Ken Pound's heart sank (he later told me) when Dave Hearn showed up at Leicester (not having seen the telegram) and was asked by Ken "Anything hot from SAS-3?" and Dave replied, "Not much, -- oh yes, there was the earth's horizon which we thought was a nova for awhile." How proud I was of the crew at MIT (Rappaport, Matilsky, Doxsey, et al.) when I called from Leicester and Terry (Matilsky) told me that SAS-3 had stopped on the source and that a million photons were being Fourier analyzed. How Rodger dragged (with much effort and no sleep) a position out of the sun-lit RMC data and gave McGraw Hill observatory its first discovery (the star was identified).

28. How Saul thought 0535+36 had brightened again, stopped SAS-3 on it and found pulsing in 0900-40! (We could have used a good slat chart identification program in those days.)

29. How it felt like the Navy again with all those duty scientist watches, and how a 24 hour watch seemed like nothing when things were really hot. I take complete credit for the invention of such a wonderful concept as a 24 hour watch. However, it was a great relief to go to 8 hour shifts and to have professional help from Everett, Mike and Will.

30. How we gave up (or got discouraged) by the Z camera failure and the worsening battery condition, serenely believing we had a 10 year (i.e. infinite) orbital lifetime.

31. How I personally succeeded in forcing SAS-3 off the air more than anyone else. Thank goodness the for the Circuit Breaker (Now, at least I knew about the CB).

32. How George Clark and I (unknowingly) tried to outdo each other with abrupt spin rate changes which led to big swings in the nutation damper and calls the following mornings from Frank Colisante: "What were you guys up to last night?"

33. How nobody, but nobody, would, or could, drive SAS-3 like Walter Lewin: never lost a photon - and never a relaxed GSFC operator.

34. How, in one observation of the Orion Nebula (our 2nd try), Rich Kelley and I found the Trapezium source, a burst-like flare from GX301-2 and NGC2110 - all in one week - a triple winner!!

35. How I took the trouble (I didn't always) to untangle a group of confusing blips in the slat data during one midnight watch and deduced that Cir X-1 was finally on again. This led to the successful series of observations by Rick Dower.

36. How I was supposed to have the duty at 8 AM on the morning of the Blizzard of '78; how Dana Backman called the previous evening (it was snowing like hell) and said he could stay late, e.g. till 10 AM if I had trouble getting in (!!) Fred Marshall then walked in to the SAS room and volunteered to take my shift (Thank Goodness). Fred, Dana and Fuk ran the satellite for the whole week of Governor Dukakis' automobile ban.

37. Being told at midnight that: "everything is under control, it should be a quiet watch; oh yes, I made a minor change in the solar panels a couple of orbits ago - you should keep an eye on the power." And then: big problems, a frantic and sleepless night.

38. Bill Mayer's patient voice over the phone at any time of the day or night coaching me through a crisis.

39. How we put off doing a Sco X-1 observation until the very last month and wow - were those hard flares that Larry Petro found beautiful! How a preprint with similar (2 years old) SAS-3 data (a guest observation) landed on our desks a week later. As Larry said, "It's one thing to be scooped, but by our own instrument???!"

40. How, in the last few months, Bill Mayer, Fred Marshall, and Garrett Jernigan flew SAS-3 by the seat of their (its) pants - using new tricks and incredible ingenuity and how useful data (bursts) were obtained right up to the very last orbit.

41. How many times the GSFC controllers and their supervisors went out of their way to help us do the unusual to (hopefully) increase the data yield; and how many times they saved me by catching an erroneous or overlooked command. We'll never forget Jesse, Norm, Frank, Steve, Perry, John, Milburn, and especially Laura.

42. Mark 451, Mark 139, P1 ON, "Do NOT Epoch set", "It's time to despin" (in the middle of a critical observation), "You're too late - but I'll try to get it in", Extension 6656, the maneuvering globe, Dower's HP programs, Clark's and Hearn's multex programs, Mike and Ev when the operations were too complex for my reflexes, John Richardson's total dedication (he was not alone), Jeff McClintock's never-fail (almost) proportional counters.

43. The way I felt when I called from Florida at 7 AM on Monday April 9, 1979 and was told by Bill Hicks that SAS-3 had reentered on hour previously.

--Hale Bradt

Buff

The 24 hour duty scientist shifts, one computer, launch duty, a beer-party/A0620, panic during prelaunch calibration, bursters.

--Jim Buff

When I arrived, SAS had been in orbit for about a year. The SAS Processing System was being created and maintained by scientists John Richardson and Garrett Jernigan and by systems programmer Glenn Wargo.

By then John Sachs, Wizard-Programmer, had already left MIT. But his programs remained, all of which were well written, easy to follow and were even likely to be documented somewhere.

John Sachs wrote all the programs for recieving SAS quick look data, time ordering and splitting it into enginneering, aspect, and x-ray data files. He also wrote or rewrote such every day utilities as the CLI (Command Line Interpreter), the text editor, and all the printing, plotting and tapehandling programs for our Data General NOVA minicomputers.

John Sachs essentially made it possible to routinely process SAS data in "quicklook" real-time and to generate commands to be sent to the satellite on the next pass.

This had not been done before on a minicomputer.

John Richardson wrote many of the engineering programs which compute parameters such as voltages, temperatures, spin rates and magnetometer aspect solutions.

John Richardson, Frank Primini, and Rodger Doxsey were the programmers primarily responsible for the 1-arc second aspect system.

While these people and many others were writing all these individual programs, Glenn Wargo was busily writing a production system to to run them.

Rather than typing in each program's name each time it was to be run on each orbit of data, one would rather say, "I want these operations (specified in my control file) to be run on this sequence of orbits (specified in my sequence number parameter file)," and have all these programs automatically run and the output routinely produced and collected. This completely restartable GO.GO processing system was written in John Sachs' CLI. Glenn Wargo also did much of the work on the IBM 360 which went on in the early days of SAS.

I arrived, along with the disk drives, spare memory, CRT terminals, etc., when John Richardson's plan for converting each minicomputer from single user to a dual user system was adopted. All of the SAS software had to be made to run in the new dual-user environment. Each program had to be re-compiled; libraries and utilities had to be modified. All rather routine perhaps, but not too terribly discouraging. Except for finding all the definitive source code for the hundreds of programs, subroutines, parameter files and CLI indirects which were scattered over one hundred source tapes and personal work tapes.

Glenn and I employed the traditional MIT solution of hiring a couple of undergraduates who resolved about 80% of the problems. Glenn and I handled the remaining set of software problems which we knew to be finite but suspected might be unbounded.

Coertnik cont.

At last, sucess followed persistence and, almost six months later, all the numbers in the SAS aspect system agreed out to the fifth decimal place and we had a system. Suddenly bugs were becoming the exception rather than the rule.

The dual user Purple System was released to replace the single-user Green System. Purple was chosen because all other colors had previously been used for one system or another.

The Green System ensured the integrity of all machine-executable object programs in the SAS production system, but the task of preserving the source code for the programs in the SAS system was left to the individual scientistsor their students who wrote them. Inevitably source code was sometimes lost.

Often two scientists, Mutt and Jeff, would work on a program; each would work on his own worktape. Thus, the programming improvements would have to choose between the tall, skinny version and the short, round version of the program rather having all the new features available at once.

The Mailbox System was developed as an attempt to prevent this confusion by allowing each scientist to add his contributions to the common Purple Source Tapes, with identification and comments.

Previously the only backup and record of a SAS system modification had been a one generation buffer provided by the OLD/CURRENT Tape Clasp System whereby the update was to the OLD tape which got the CURRENT clasp while the former CURRENT tape got the OLD clasp. Valuable person-hours often were wasted in lost and duplicated programming effort.

By routinely archiving all additions to the Purple System are preserved and our tape librarian Margaret Chartres assures that all changes to the Purple System are preserved and that the integrity at the source code and environment levels is always maintained.

David Woodruff has written a cross reference program which inspects all source and environment tape directories and spots missing or duplicated programs immediately.

The contents of eachpurple tape live in a corresponding Purple Notebook. All NOVA-readable SAS documents are collected on the WU Purple Tape (WU stands for Write Up) for handy reference.

Many of the more general programs that make up the SAS production are also being used by the HEAO groups, since the data files for SAS and HEAO are similarly structured.

Working with the people and programs of SAS has been an unforgettable experience...

--Will Coertnik

Cominsky

In the fall of 1976, I was applying to graduate schools after working in x-ray astronomy for 3 years.

Since I did not want to leave the East Coast I really only had three choices and so I sent of my applications to Harvard, MIT and the University of Maryland. I decided to come speak to George Clark about working on SAS-3 and I talked to my colleagues at SAO about working on HEAO-B. A funny thing happpened, however, on the way out of George's office: I was called in to see Walter Lewin. Since I had heard him speak about bursts and he seemed like a wild and crazy guy, I seriously considered attending MIT for the first time as I had always been steered towards Harvard by my advisors at SAO.

By the spring of 1977, my perspectives changed as MIT immmediately acccepted me and Harvard stalled. Then I was invited to a women's open house at the President's House where I met some interesting women and my mind was made up. As long as SAS lived for one year after I got here, it would be worth it to miss HEAO-B to fly a satellite.

My first semester at MIT was horrible. I was totally buried under the course work and too busy to do my research. Learning physics in one year was not as easy as I had hoped it would be but it was not as hard as I had feared.

By IAP in January 1978 I had finally convinced someone to let me be a duty scientist. (There were really no complaints as everyone was in Hawaii at an AAS meeting and nobody around to work over Christmas holidays). I sat and stared at the plots every day for two weeks, it seemed, until one day George Clark walked in and well, the rest is history. We had discovered a pulsar in in 4U0115+63 which later became the first transient x-ray source to be proven to be a member of a binary system.

This exciting event changed my image of MIT and helped me feel more acccepted into the group, which had previously seen me as a defector from SAO and a spy from the enemy camp, or so I thought.

Being duty scientist, however, is the one thing SAS-3 allowed me to do that no other woman had ever done, and I always found it exciting and challenging, even up to the last minute as we were forced to fly SAS by the seat of our pants, thus recreating its beginnings.

Attempting to arrange simultaneous coverage of x-ray and optical bursts occupied most of the summer of 1978 and when we finally got one (with Josh Grindlay at CTIO) we were ecstatic. Although I was not here when the burst watches began, I knew it had taken a tremendous amount of dilegence and effort to finally capture the elusive phenomenom,

So working for SAS has been every bit as exciting as I had hoped when I took the big plunge into Physics at MIT. Two discoveries in one year is more than enough for any graduate student and flying the satellite was an unrepeatable experience and one well worth the time (even midnight to 8) and energy. I wouldn't have done it any other way.

--Lynn Cominsky

Delvaille

Long after the phrases, "Mark Number," "ATT Command," "Epoch Set" have been forgotten, I will remember all the neat SAS people who worked, laughed, and occasionally panicked with me while running the satellite. I'll miss you all.

I am sorry that Tom Egan who helped design and build the rotating modulation collimaotrs wasn't here to see their successes. His careful work, and patient skill will be missed by all.

--John Delvaille

The thing that has set SAS-3 apart from all other instruments of X-ray astronomy is its flexibility. The people who designed and built SAS-3 certainly deserve a lot of credit for this flexibility, but it took a lot of work to gain the fluency with the satellite's facilities that we took for granted during most of the mission.

It may seem hard to believe now, but pointed Y-axis observations were considered very difficult in the early days and only a few of them were performed during the first nine months of the mission.

Several very early pointed observations were performed with sun dithers, a technique which worked fairly well once you got it going , but which was rather inflexible and very difficult to plan (if you want to know how this technique worked, there was an early SAS memo by George Clark on the subject).

In an attempt to overcome the problems with sun dithers, we decided to try measuring and adjusting the aspect in real time. Behind these schemes was the belief that the gyro couldn't hold you on source for more than a couple of orbits; the gyro specification was a stability of 1 degree over a period of three hours.

Real time steering worked as follows: at the end of a Quito pass, start up a DCS load containing a dither program. The dither was designed to bring the slats across a bright source (the source you were observing or something nearby) during the early portion of the next Quito pass. SAS Control was instructed to wait until this operation was completed before starting the tape dump. We would take the real time data, and as soon as the tape dump started, plot it with FPLT. The duty scientist would stand impatiently over the Infomax plotter, waiting to snatch the plot and rush to his room with it. There he would compare the slat crossing times with a time mark and compute an azimuth correction to be performed at the end of the current pass. The dither load would be restarted (no cycling DCS loads in those days), and the whole process would be repeated on the next pass.

It was the most exciting method we ever devised for controlling aspect.

It even worked fairly often.

Walter Lewin loved it, and demanded its use for all his observations.

SAS Control hated it, and used two controllers whenever we were trying it: one to control SAS and one to try to deal with the phone calls by the frantic duty scientist.

The trouble with this scheme was that its sucess depended on doing a lot of things correctly in a short period of time. A single mistake could send you way off target where your next dither would see nothing but empty sky. The tight schedule during the pass left no margin for error. Propagation problems were quite common during the fall of 1975, the heyday of this techique, and they caused lots of trouble with lost data and lost commands. When we started doing this, we were using spin rates that were much too high for proper azimuth corrections (+1 r.p.o.), and the controllers had a lot of trouble doing the corrections with adequate accuracy.

Doty cont.

Futhermore this technique could only be used for about half the day; the rest of the time part or all of the pass occurred during earth blockage.

The necessity to do something else led us to the later pointing techiques. With no way to determine aspect in real time, we had to get star or X-ray aspect from the playback data and extrapolate.

In the beginning, we felt that we would be lucky to get any data during these times. After a few observations, however, it became apparent that we were doing better when we couldn't get real time aspect.

I began to use the extrapolation technique all of the time, using the real time aspect only as a check. By this time we had learned to use slow spin rates for azimuth corrections; this, along with the smaller number of corrections necessary with the extrapolation technique, greatly reduced the size of the errors incurred in the correction process itself.

It became apparent that the gyro was much better than we had been told.

The final blow to real time steering came when we started to cycle DCS loads; with cycling loads it was inconvenient to have things happen at the synodic rate.

We still used dithers (the camera aspect system was not adequately reliable for these observations until mid-1976), but we did them at the rsidereal period, analyzed them from the playback data, and extrapolated.

--John P Doty

Who would be calling at 7 a.m. Sunday?

As I staggered to the phone, I remembered that I was Hale Bradt's graduate student, and the answer was clear. "Good morning, Hale."

That's how my thesis work started.

During a routine RMC observation of the galactic plane, Hale had spotted activity from Circinus X-1, stayed through the next duty scientist shift and maneuvered SAS-3 to point the Y-axis detectors at Cir X-1. He was calling to tell me that the maneuver would be finished in an hour but he had to go to church.

Krishna Apparao and I spent the day in the duty scientist's room performing real-time dithers across the source to get our pointing position correct since we had very little aspect information. We luckily got the pointing position right for a full orbit while we watched the source intensity fluctuate wildly then disappear (right on schedule with its 16.6 day period we later learned.).

That first pointed observation of Cir X-1 led to several others during the next two years, to two AAS talks, to a thesis, and (soon) to an Ap. J. paper, all in an effort to understand this peculiar x-ray source that may be a black hole--all because of a sharp eyed enthusiastic professor and a phone call at 7 a.m. Sunday.

--Rick Dower

TRAVELS WITH THE SHOEBOX
David Hearn

As the SAS-3 launch approached, John Richardson and I were spending our days and nights calibrating the protoflight (prototype/flight) unit of the Low Energy System in the vacuum x-ray beam in building 37. It had to be done just in case the flight unit, already on its way to the launch, had to be replaced at the last minute. Meanwhile, I was planning spend a week or so in England on my way to the launch, taking in London shows and touring the country pubs. My plans were rather deflated when I learned that the protoflight unit would have to go to Kenya with me, which meant that I would not have much time for sightseeing. The real blow fell when I talked to Marjory Townsend about it:

MT: "Since the hardware is irreplaceable, you will have to accompany it all the way."

DH: "That should be no problem, since it's only the size and heft of a shoebox filled with bricks. The carrying case isn't very big, either."

MT: "You will not let it out of your sight, of course."

DH: "...uh, I was planning to do some sightseeing. I should be able to check it in a hotel safe, so..."

MT: "Absolutely not! It must not leave your sight."

DH: "You mean literally...?"

MT: "I'm afraid so."

Although it was a real drag to have to lug the case with its shoebox around the streets of London, I was relieved to note that the populace tolerated this minor eccentricity perfectly, and did not even seem to suspect that I could be from the Provo wing of the IRA. As I toured Oxford, a friend even volunteered to carry the case part of the time. Of course, seeing shows was definitely out. It was bad enough to plop the case on the chair next to me when I went to a restaurant. Imagine buying a ticket for the LES!

With some trepidation, I approached the Customs officer in Nairobi, having been filled with stories of these fellows insisting that exhorbitant duties be paid, or the materials be impounded. Just in case, I had a very official-looking letter from Herb Bridge, addressed to all of the relevant officials of the US, UK, and Kenya. It declared that the device I had was space hardware, and definitely not for import, and anyone who interfered would be halting the march of science, or something like that. After double-checking that I had the letter with my passport, I summoned my most man-of-affairs air, plopped the case in front of the inspector, and flourished the letter for his inspection. He seemed not at all interested in the fascinating and powerful-looking stuff in the case, and seemed to regard the letter as if it were written in Sanskrit. When it dawned on me that he didn't care about the shoebox in the case, I wrapped it all up and suantered casually away, before he thought to call over his superior. I just settled down to wait for the flight to Malindi that never came, along with the gin-soaked woman who tried to get me to hijack the next plane. But that is another story.

--Dave Hearn

I remember:

--Tony Caporal picking up candy wrappers in the spin test room at Goddard.

--turning off the experiment in the middle of a computer test and telling Henry Riblett I would not turn it on again until Harold Goodnight had that <deleted> Sigma 5 run properly

--the Sigma 5 crashing just as Dick Marchi completed the final fill of the low energy system

--how Bill Mayer and I **very** carefully opened then closed the exhaust valves on the low energy system prior to backfilling the vacuum chamber at APL

--lots of people pouring down the ladder into the test chamber after the Z-axis shock test (to catch the pieces?)

--Bob Renshaw making two tours of the "area" in Amsterdam

--Ed Boughan writing parking tickets in Rome

--Dick Taylor's expression upon dicovering the supply of Scotch in the equipment boxes shipped to San Marco.

--introducing Marjorie Townsend to the pool at Lawford's Hotel...twice.

--the 10:30 p.m. tour of the Coliseum and the Roman police outside.

--Whitney Hammmet's performance as the rejected suitor in a Roman ginmill

--losing Bob Renshaw in Rome

--Ed Boughan and his "porter"

--George Clark and Carl Fictel throwing an unidentified German tourist in the pool.

--Renshaw trading a set of Swiss files with the Italians for a case of Tuska.

--the daily car ralley to and from the Base Camp

--Boughan's first right turn in Kenya

--the night we convinced Fran McClintock that Jeff was stuck on the tower for the night

--chasing the manager of Lawford's Hotel through his kitchen

--throwing an unwilling Dick Taylor into the hotel pool

--throwing John Bosworth into the pool, chair and all

Johnston cont.

--the half gallon of Chianti Ruffino that cost $10 a bottle with every evening meal

--the security guard at Alllegheny Airlines who did not want Dick Marchi to bring his briefcase fulll of sharp pointy objects onto the plane

--Renshaw's medicine. Wil, Bob and I were in HoJo's after a long, hard day at APL. We decided to unwind a little with some cards and bottles. About 3 a.m., we figured it would be a good idea to go to sleep since we had to do it all again at 7. I called the desk and asked for wakeup calls to Wil and I at about 7. I also told them that Renshaw was sick and needed to take his medicine every hour on the hour while Wil and Bob fought across the room as Bob tried to rip the phone from my hands.

--Renshaw's portrait.

--Ev Johnston

The thing I hated the most were those <deleted> 24 hour duty scientist shifts.

The most exciting time was the all-night 0620 chase.

The most rewarding times were those beautiful pulsar Doppler curves.

--Paul Joss.

REAL TIME ANALYSIS
Kelley

One of the most memorable occasions I have had during my short 2 years working on SAS-3 was during the one month observation of GX301-2, in which the term "real time analysis" was borne out.

There we would recieve a QL orbit, fold and crosscorrelate it 30 minutes later, run over to LNS and keypunch a card, add it to the deck and submit the program which would run in about 30 minutes.

From the time the satellite took the data until the time the answers came out was just 3 hours!

Of course, with each orbit of good data the answers changed, so the excitement lasted the entire 30 days.

--Richard Kelley

Kulik

SAS was ephemeral. I only hope that my memories have more permanence.

--Joe Kulik

Laufer

For two and a half years, SAS-3 was a significant part of my life.

--Ben Laufer

The SAS-3 group will long be remembered for its work on Bursters. It all began in January 1976 and it reached a climax on March 2 when we discovered the Rapid Burster. It was the fifth burst source that we found in less than one month. I remember the glowing feeling of the burst fever. It was very contageous; almost everyone caught it: graduates and undergraduates, operators and post-docs, controllers and faculty. There was an all-out effort to reach for more. Luck was holding surprisingly and by the end of 1976 we had discovered an additional 5 burst sources and studied their behavior. We uncovered their idiosyncracies; each source was different and unique in its own rights. They were like friends, we lived with them and slept with them. A wealth of richness of information was obtained and the ground work was laid that gradually dissolved the mysteries around the bursts.

In the years that followed the puzzle was put together piece by piece. To date (May 1979), the picture is pretty clear, though not yet complete.

Our success on the bursters stimulated some to do very different things with comparable enthusiasm. Several groups evolved which worked more or less independently. This was an important turning point in our way of operating. It generated competitive feelings in our own group. Some regret this, but others (I am one of them) believe that it stimulated our scientific output substantially.

My SAS-3 years oscillated between extremes. They were dynamic, happy, sometimes explosively exciting but at times very tense and even sad. I made many friends but also enemies; success makes people jealous.

SAS-3 has both enriched and damaged my life. I left my family for which the uncontrolled obsession caused by SAS is partially responsible. Perhaps too high a price to pay. It's too early to call, too early to make up a balance, it's all so fresh. But no doubt, the impact on my life is enormous and far reaching. If I had the choice, I would probably do it again.

-- Walter Lewin

One could always depend on the solid engineering which went into the design of SAS. This pulled us through on many separate emergency situations.

--Frederic Marshall

During the first few years, bimonthly interface meetings were held with APL and GSFC in Maryland. We would leave Boston on a 7 a.m. Allegheny flight to Baltimore. George Clark, not wishing to waste time waiting for the plane to leave, would always cut it pretty close.

Finally, he overdid it and they closed the door and rolled away the ramp without George. As the rest of us started to consider various ways of stalling the meeting, the ramp was rolled back to the plane, the door opened and in walks George, smiling from ear to ear.

The on board timing on SAS is determined by the high resolution minor frame counter (0-255 minor frames and the coarse Time Code Generator (TCG). Since both are driven from the same 5 MHz oscillator, the TCG enables you to sort out the sets of 256 minor frames. However all all of GSFC's experience and software is related to spacecraft with a minor frame counter and a major frame counter, which are the least significant bits and most significant bits of the same scaler.

Therefore, GSFC assigned a new, young staff member in the production data group to work on the problem of using the TCG. After he had worked on the problem for a few months, GSFC called a meeting which John Sachs and I attended. The staff member rambled on for about half an hour on how with 100 second resolution of the TCG, it would take about a year's data to fit the TCG vs UT to produce timing information for the production data which had 100 msec accuracy.

At this point, we broke into his dissertation and explained in three sentances how to use the TCG to identify the minor frame and thereby obtain 5 millisecond accuracy.

All of a sudden, the GSFC person, who was standing at the blackboard, realized the simplicity of what we said passed out and fell over backwards on the floor. They called an ambulance and doctor and took him away to a hospital. The GSFC manager adjourned the meeeting for lunch to enable everyone to recover.

When the meeting reconvened after lunch, the GSFC manager insisted that from now on everyone be seated before MIT says anything.

SAS was controlled by the exact timing of specfic commands, e.g.the duty scientist would determine where the Y-axis was at a given time and then, taking into account the spin rate of the satellite, figure out exactly when in the future to stop the spin to point at the target source.

Well, for the first few months we couldn't come close to stopping on a source. Even after we corrected for the digitization of our time request by GSFC and the reconversion on the satellite of the digital number into a time delay, commands were not being executed at the correct time.

We finally had GSFC send us the actual 900 bit command which comprised a specific DCS load of commands and deleys. When we decoded this DCS load, we found that the GSFC was not quantizing our time request in any standard fashion. Unbeknownst to them, their software was rounding up for even mark numbercommands and truncating for odd mark number commands. MIT then compensated in our DCS software for the GSFC software error. Finally the DCS commands executed at the time predicated and we could reliably point the Y-axis.

--Bill Mayer

MALINDI
McClintock

My wife Fran and I arrived in Malindi in the evening and joined the APL crew and our MIT friends for a drink by the hotel pool. A native was probing the nearby bushes with a stick. We were told that he was a "bush beater" acting as a snake guard. Quite unconvinced, we laughed and talked over other things. A drink later the man had killed a deadly green mamba only a dozen feet from where we sat.

From our hotel, the Sinbad, to the rocket base was a dozen or so miles of dirt road which at one point passed a remarkable village waterhole located in a field of dirt. It was not unusual to see 10 or 20 villagers filling clay pots, drinking, wasking themselves and their clothes and permitting their livestock to drink and root about in this small tropical pool which many of us were certain contained the most biologically toxic soup imaginable.

A few miles further on at the bizarre Italian rocket base were the APLs, the NASAs, the LTVs, the Italians and the MITs. We got things ready bit by bit and at one point the concern arose that the spacecraft pointing system, which had never been made to point at anything whatsoever, might fail. The feeling of those back at MIT was hang SAS up by a piece of piano wire and watch it point. Those of us in Africa, Dick Taylor, Bill [Mayer], the APL crew felt that it was just too risky an undertaking in that environment, and we became convinced in dicussions with designers and builders that it was OK.

It was, of course, OK.

I was amazed to learn how chockfull a rocket is of gyros, yo-yos and stuff. A critical switch that caught my fancy consists of two spring-loaded contacts seperated by naphthalene--a mothball--which sublimates closing the contacts at a precise altitude.

Shortly after the flash and thunder of the launch, Marjorie Townsend produced a box with many switches which allowed her to make SAS roll over or to turn a PSD off. This caused George, Bill, and others of us some concern. But all went well.

When Fran and I arrived in Africa we toured the game parks and Olduvai Gorge where from a fragment of a child's fingerbone the Leakey's took us back a million years. In several ways, I feel their work parallels the work we have done with SAS.

--Jeff McClintock

I was very happy to work on a "seat-of-the-pants" satellite. I don't think I'll ever have that kind of opportunity again. I feel that I have been greatly enlightened and have matured scientifically thanks to Arnie (Epstein), Herb (Schnopper), and John (Delvaille). Because of the small size of our (SAO) group and its informality, I was able to exercise my creative potential. I enjoyed the thrill of participating in the discovery of four new x-ray galaxies (3C120, IIIZw2, MCG-5-23-16, and MCG-6-30-15).

--Fernando Pineda

SAS ROOM
Petro

To me, SAS was the SAS room (37-422) and the people who inhabited it. Some of them inhabited the room more than others.

Take the team photographer, Tom Spisak, for instance. He fills the room with his hulking, glowering presence when he senses another emergency has arisen in the jerky flow of data from the Goddard Space Flight Center.

Bill Mayer carries a different presence. Imagine that you're a new duty scientist and that you're behind. It's 20 minutes until the pass, the power is low, aspect won't solve, and we're spinning. Bill will walk in and during the next five minutes determine the proper solar panel rotation, deliver a talk on x-ray navigation, determine the Z-axis position and calculate a Z-bias change. Then as he writes these changes up, he calls Goddard to read them to Marlon. Real cool all the time.

Then there is the hyperkinetic kid, Fred Marshall. During the last months he seemed to live in the SAS rooms as he wrote programs that would allow us to squeeze data out of SAS during its protracted re-entry.

These three aren't the only inhabitants. There is the constantly moving tapestry of student operators which wandered through their shifts.

The rooms have been shared with the HEAO investigators, who, like the SAS computer pundits, could be found hard at work preferentially in the middle of the night. Some of the HEAO people cut their teeth on SAS. Garrett Jernigan was one of these people and he continued to live in both the SAS and the HEAO worlds. Garrett's stature was an important factor in providing a sense of purpose among the foot soldiers of the SAS group during the last months of the satellite's life.

The group has left me with a memory of hardworking, concerned people such as distinguishes MIT.

--Larry Petro

It began over breakfast.

The day promised to be cool for mid-August as I set my tray down across the Lobdell table from Jay Spangler, an old friend from my days of tending counter and hustling backgammon at the Student Center Coffeehouse.

We hadn't seen each other in more than a year. I had spent the six months since finishing my National Guard active duty training fruitlessly looking for gainful employ--not even the security guard agencies were hiring.

I mentioned to Jay, who had spent some time in the Army, that I was fed up enough with the bleakness of the Boston economic picture to consider seriously returning to active duty. "At least it's three squares and a bed."

Jay too was having employment problems. The NASA project on which he worked had just fired the night computer operator and Jay was filling in until another was found.

That a common solution to our mutual difficulties existed became glaringly obvious. "But don't I need to know some computer language for the job?"

"No," he replied. "If you can stay awake all night we can teach you everything you need to know."

After a strange interview with Bill Mayer in which I remember trying fairly hard to convince him that I was grossly underqualified for the job and he was trying equally hard to convince me that I was not, and a short wait while the Personnel Office posted the job listing, I joined the SAS-3 program.

At risk of sounding trite or maudlin, that mid-August breakfast was probably the best I ever ate.

--Tom Spisak

Taylor

In thinking back over SAS, I find that I remember a few specifics which set the tone of the program for me. I remember:

--the flight low energy "shoebox" collapsing during the final subsystem test

--all the star tracker hassles. There seemed to be a thousand ways to get image drift in that system and Ball had the "final solution" each time it happened. When we finally got a stable tracker, Archie Fitzgee took one look in its eyes and pronounced the thremal coating on its (inaccessible) shutter blades unfit. Then some of the shutter mechanisms jammed during shake tests, the IDTs found new ways to during potting and during the first look at real stars, the prototype tracker wouldn't track anything.

--two and a half years of overnight trips to Boulder.

--blowing out ICs on the welding machine at Draper.

--Joe Morris cooling Christmas party beer in the large test chamber.

--the Hotel Sinbad with its snake beater, land crabs on the dining room floor, lizards on the dining room ceiling and the 10,000 bugs in my room the day I left the ventilator open. Also shaking my shoes in the morning to get the lizards out.

--being chased by rhinos in Tsavo National Park. Ask Pete Tappen or Bob Renshaw what happens when one catches you.

--the pleasure Ev Johnston got in driving our push start Mercedes on safari.

--sipping Jack Daniels on the veranda of Ngulia Lodge.

--walking to breakfast at Keekorock Lodge across fresh animal tracks with giraffe and water buffalo at a water hole just a few hundred feet away.

--the APL pro who underexposed most of his film.

--Marjorie Townsend's knitting.

--Tom Dawson's "four hats."

--those sledge hammer kicks during shock testing at Goddard.

--making Goddard and APL work to the same cleanliness specs they imposed upon us.

--Moe Kazimi ruining the Malindi souvenier business by finding the real bottom price for hand carved elephants (about a factor of five below what we had been paying).

--going to work in a Billy Pugh net.

--Tuska beer and the local pineapple and fish.

--the good Italian food at the Base Camp and on the towers, although I never did get used to tuna fish and tomatoes for breakfast.

--the joke one of the Italians told me: if the "islands" offshore are Santa Rita and San Marco then the Base Camp must be ...Venice.

--the excitement when SAS came over the hill right on schedule and George Clark kissing Marjorie the moment we heard it.

Mostly I remember the pride of the men and women who built the SAS-3 experiment and how much everyone cared and worried about building the payload right. The level of craftsmanship in it was top rank. I remember a comment from a friend at NASA: that we were the only university group in country that could have pulled it off.

Managing SAS was an exciting and challenging experience for me. It is a genuine pleasure to have worked with a group of such highly skilled and talented people.

I only wish we could have carried on.

--Dick Taylor

The SAS-3 satellite was constantly crusing around the earth at 18,000 miles per hour or so, but for me the motion around the SAS room was more interesting and much less predictable. It seems I always hit a duty scientist shift at times of disruption. I remember trying to plan a crucial maneuver while carpenters were banging away to enlarge the SAS area. And after a couple of enlargements, I was duty scientist on the great day when the computers were moved from the original SAS room (where the HEAO successors now reside) to their new quarters to the East. Ever try to get an aspect plot from a moving computer?

In the summer of '76 I again found myself in the D.S. chair on the day that the chair (along with the rest of the paraphenalia (beloved Magnafax, cracked celestial globe,...)) was also moved Eastward.

The first year was one of such perpetual panic - transient sources, new pulsars, the discovery of bursters...SAS was always chasing after another "biggie." Did the X-ray sky quite down after 1976, perhaps self-conscious at being under such careful scrutiny?

But there was always something to provide amusement - like the time when it was 0° outside, and 90° in the computer room, presenting a crisis that was "solved" by running the giant-plastic-bag air hose from the one openable window to the computer room.

Where did the old Magnafax machine go, anyhow? And how did the horizon ring on the celestial globe get cracked?

--Frank Winkler

Photography by Dick Taylor, Will Shaw, Hale Bradt, and Spisak.

Thanks to everyone who contributed, especially Hale Bradt who pushed me into doing this booklet, and apologies to anyone I missed--I did not mean to diminish anyone's contribution to creating the greatest adventure in my life.

Special thanks to Trish Welch without whom this booklet would not have been possible.

--The Editor