A BIASED HISTORICAL PERSPECTIVE OF WOMEN IN THE ENGINEERING FIELD AT DRYDEN FROM 1946 TO NOVEMBER 1992

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Summary

Being a woman in engineering, and in particular, being the woman with the dubious distinction of having the most years at Dryden, gives the author a long-term perspective on the women who worked in the engineering field and their working environment. The working environment for the women was influenced by two main factors. One factor was the Dryden's growth of 14 persons (2 of them women) at the end of 1946 to the present size. The other factor was the need for programming knowledge when the digital computers came into use. Women have been involved with flight research at Dryden since the days of the first transonic and supersonic airplanes. This paper uses available records, along with memory, to document the number of women in engineering at Dryden, to comment about observed trends, and to make personal observations.

Establishment of NACA Flight Test Unit

In the early to mid-1940s, the National Advisory Committee for Aeronautics (NACA), Army Air Forces, and Navy decided to build and flight test aircraft that could fly in the transonic Mach number region (Mach 0.7 to 1.3). This decision was made because the wind tunnels at that time could not test at transonic and supersonic speeds. Also, the interim "short-cut" flight programs of that time which included air drops of weighted models, launches of models from rockets, and test models mounted on aircraft wings could not provide all the needed information. Certain requirements for the flight test area had to be met. The area had to be remote for safety reasons and to reduce unwanted observation. Another requirement was that the test area have good flying conditions of few cloudy days and long runways. Previous NACA Langley flight tests had demonstrated the difficulty in tracking aircraft in cloudy skies and the new test aircraft needed long runways for takeoffs and landings.

NACA selected Muroc Army Air Field, which became Muroc Air Force Base in February of 1948 and was renamed Edwards Air Force Base in December of 1949, as the site for the flight tests. Muroc, in the Mojave desert, met the remote location and good flying conditions requirements. Muroc had two other advantages. One was that the Army Air Forces, with whom NACA was working, had established Muroc as a wartime center for advanced aircraft testing. Another was the proximity of Muroc (fig. 1) to the leading aircraft industry in the Los Angeles area. The employees at the Muroc test site were to conduct flight tests and analyze the data for the X-1 (rocket powered) and the D-558 (jet powered and rocket powered) series of aircraft.

In the fall of 1946, NACA Langley began sending people to Muroc. The first contingent (five men) arrived on September 30, 1946. Six more men arrived two days before the first glide flight at Muroc of the XS-1 aircraft on October 11, 1946. The first two women, Roxanah B. Yancey and Isabell K. Martin, arrived in December 1946. The team now consisted primarily of engineers, computers (people who computed), and instrument and telemetry technicians. The computers, following the standard practice of the day, were the two women. In the Federal government's scientific community, almost without exception, the computers were women. In early September of 1947, NACA decided that the unit at Muroc (now 27 persons) would function as a permanent facility (NACA Muroc Flight Test Unit), managed by Langley. On November 25, 1947 the first NACA flight of the D-558-1 aircraft occurred. This meant that the X-1 and the D-558 series aircraft were now being flight tested at the NACA Muroc site.

The history of the establishment of the NACA Muroc site from its beginning to 1981 (then NASA Ames-Dryden Flight Research Facility) is told in reference 1. The purpose of this paper is to discuss the changes in the working environment for the women in the engineering field at Muroc/Dryden. Only the NACA/NASA civil service women are discussed; records were not available for women who worked for contractors.

Women's Involvement from 1946 to the Early 1950s

The women and probably many of the men sent from Langley had volunteered for one-year assignments at the Muroc site. The first two women (the computers) assigned to the Muroc site can be seen in the group photograph taken in late 1946 (fig. 2). The policy at Langley at that time was to hire women with math degrees to be computers. Roxanah Yancey, who had a math degree, retired in 1973 from the Muroc site, then called the NASA Flight Research Center. Isabell Martin, assumed to have had a math degree, left the Muroc site early in 1947.

By October of 1947, 27 persons were working at the Muroc site. The group photograph (fig. 3) shows 22 persons, 4 of them women. The number of people at the Muroc site almost doubled in size each year from 1947 to 1950. There were 40 persons in May of 1948, 60 in January of 1949, and 132 in January of 1950. (In late 1949, the name was changed to NACA High-Speed Flight Research Station.) The group photograph taken in 1950 (fig. 4) shows that the number of women had increased significantly from the four of 1947.

Until 1957, the single women and men could live in dormitories on the base. The women's dormitory at the south base (location shown in fig. 5) was near the base chapel and the base theater. The men's dormitories were on the north base approximately 8 miles away. The dormitories were inexpensive and close to the work site. Figure 6 is an aerial photograph of the Muroc site in the late 1940s. The last two photographs show the desert vegetation and indicates how different the climate was for the people from the east coast. Not everyone wanted to stay. One reason some stayed is related to the noseboom pressure traces, shown in figure 7, from the XS-1 airplane flight on October 14, 1947. These pressure traces are a record of the Mach jump from the first manned airplane to exceed the speed of sound. For some, being able to work on advanced aircraft such as the X-1 and the D-558 was reason enough to stay at the Muroc site.

Translating the traces on the oscillograph film into usable data required considerable effort. Figure 8 shows a roll of oscillograph film and two of the tools used, a film scale and a slide rule. The horizontal traces on the oscillograph film were either reference traces or data traces. The vertical lines were the time scale. A film scale was used to read the difference (delta) between a data trace and its reference trace at the desired time. The engineering value for each delta was then read from the corresponding calibration plot. After the engineering values were obtained, the desired parameters were calculated using the appropriate tools (slide rule, mechanical calculator, standard atmosphere tables, sine and cosine tables, etc.). The engineers did some of this but most of the film reading and calculations were done by the computers. This was tedious and time-consuming work, and required a great deal of patience. Men were not thought to have the patience to do this work. For this reason, almost all computers were women. Figure 9 is a photograph of the computers at work.

The working environment during the early days at the Muroc site was directly influenced by the small number of people working there and by the remote location. The small numbers meant that everyone was known by all in the group. This fostered a strong team spirit that resulted in people helping wherever they were needed. The computers worked closely with the engineers and were often co-authors on technical reports. This small-group working environment existed into the early 1950s.

Working Environment Change in the Early 1950s

The increase in the number of people at the Muroc site and in the number of aircraft being tested (fig. 10) changed the small group working environment. Another change, which was to have a significant effect on the working environment for the women in the engineering field, was that in March 1954, the NACA High-Speed Flight Research Station became the NACA High-Speed Flight Station (HSFS). The HSFS was now autonomous, which meant that Langley was no longer responsible for management or staffing. Also in 1954, the HSFS people (now 250 persons) and airplanes moved into a new, larger building on the main base. This building (4800) has been added to over the years and is still in use. Figure 11 is a group photograph taken in 1954 in front of the new building.

Two name changes were made in the late 1950s. In 1958, NACA became NASA, and in September of 1959, the HSFS became the Flight Research Center (FRC). The number of people at the HSFS continued to increase and by December of 1959 the complement at FRC was 332. One effect of the increase in complement was that people were placed in defined positions. In the early to mid-1950s, the women computers began working in a computer group, which was supervised by one of the senior women computers. Another change was in the technical background of the women in the computer group. Most of the women assigned from Langley had math degrees. The computers hired by the HSFS were usually from the local area and most of them did not have college degrees. This resulted in the working assignments

becoming more routine and meant that there were fewer opportunities for women, even with degrees, to work in the technical engineering areas. The resulting decrease in interaction with the engineers also meant that the women were no longer co-authors on technical reports.

Women Authors from 1949 to 1960

From 1950 to 1960, three women engineers worked at the HSFS. Two of them were authors of NACA reports. The third woman engineer worked only a short time at the HSFS and was not an author on a report. Joan Childs was the first woman to write a technical report at the Muroc site. The year was 1953 and the report was on the Bell X-5 airplane, NACA RM L52K13b (ref. 2). Ms. Childs started as a computer and was reassigned to the engineering group because of her engineering degree. She was at the Muroc site approximately 2 to 3 years. The other woman engineer during that time worked at the Muroc site as a math aide during the summer. After graduation from college, she began working as an engineer and worked in the engineering field until 1983 when she transferred to a congressional staff position.

From 1949 to 1957, 12 computers were co-authors on reports about the X-1, X-3, X-5, D-558, and B-52 airplanes. The number of computers as co-authors was determined by looking through a card file of reports by Muroc/HSFS/FRC authors. The computers were always the last author listed on multiple author reports (usually two or three authors). During that time there were at least 23 computers who worked at Muroc/HSFS.

Later Work Environment Changes

The next change in the hiring and job requirements for women occurred during the early to mid-1960s. This change was caused by the development of digital computers and the need for people with college degrees to program them. One of the new people hired to work with the digital computers (at that time an IBM 3650) was a woman. Her primary duties appear to have been computer programming, which initially required a degree. The digital computers with their capacity for rapid data reduction began to replace the hand calculations. During the early years of the digital computers, most engineers relied on computer programmers to write the data reduction programs required to calculate the desired parameters. Two women programmers were hired during this time.

The oscillograph film recording systems were soon replaced by onboard magnetic tape recording systems. The work done by the women computers was no longer needed and their jobs eventually changed to running the computer programs written by other people. Three of the former women computers moved to engineering positions at this time. One woman had a math degree, one a degree in education, and one did not have a degree. Two of these women had a relatively easy transition to the engineering field; the other did not. Another of the women computers (she had a math degree) became chief of the programming and data processing branch. The remaining women computers eventually quit, retired, or were reassigned to other jobs.

The last change in the hiring and job requirements for women is also related to digital computers. As the digital computers became more powerful, they were used to run the airplane simulators. The early simulators were based on analog systems and the programs used to drive them were maintained and run by men. When digital computers began to replace the analog systems, women were also hired to run and maintain simulation programs. Hybrid analog–digital simulations were used for a few years (for example, X-15-2 simulation). The first all-digital simulation was for the 3/8-scale F-15 Remotely Piloted Research Vehicle (RPRV). Computer simulation programs require much attention to detail and women are well known for their attention to detail.

Number of Women in Technical Areas from 1960s to Present

The women computers of the late 1940s and early 1950s worked closely with the engineers, almost in the capacity of junior engineers. By the early 1960s, this working relationship, with four exceptions, no longer existed. These 4 woman (3 retired in 1973, 1 in 1979) are included in the numbers of women from 1960 to the present, shown in the following table. Also included in the table are the major airplane projects.

Some of the airplanes mentioned in the table are seen in the group airplane photographs of figures 12 to 14. Figure 12 shows the airplanes being worked on in the hangar in late 1966. There are no women working on the planes in this photograph.

In the 1970s, women began working on the flight crews (usually only one or two women) and presently three women (two are mechanics, one works in avionics) work on the flight crews. In general, the women had great difficulty fitting in and until the mid to late 1980s, all changed jobs (one for a better job, one to get a college degree, but most because of a difficult working environment). One obvious difficulty for these women is that of a woman working in a traditional male job. Another is that while most men develop their mechanical skills at an early age, most women do not. This means that using even simple

Number of Women In Technical Fields and Airplane Project from 1960s to the Present Time

Time period	Number	Major airplane projects
Early 1960s	7	X-15
Mid to late 1960s	12	X-15, XB-70, Lifting bodies (M2-F2, HL-10), Lunar Landing Research Vehicle (LLRV)
Early to mid 1970s	13	YF-12, Lifting bodies (M2-F3, HL-10, X-24A, X-24B), F-8 Supercritical wing, F-8 Digital Fly-by-Wire (DFBW), F-111 Transonic AirCraft Technology (TACT), 3/8-scale F-15 Remotely Piloted Research Vehicle (RPRV)
Late 1970s	11	YF-12, F-8 DFBW, KC-135 Winglets, Shuttle Orbiter approach and landing tests, F-111 TACT, Highly Maneuverable Aircraft Technology RPRV (HiMat)
Mid to late 1980s	17	B-720 Controlled Impact Demonstration (CID), X-29, F-111 Mission Adaptive Wing (MAW), F-16 XL Supersonic Laminar Flow Control (SLFC), F-18 High Alpha Research Vehicle (HARV), F-15 Highly Integrated Digital Electronic Controls (HIDEC)
Early 1990s	25	X-29, F-15 HIDEC, F-16 XL SLFC, F-18 HARV
November 1992	23	F-15 HIDEC, F-16 XL SLFC, F-18 HARV, X-31, SR-71

tools, such as pliers or a screwdriver, is not second nature to most women. Many women began working on the flight crews because the upward mobility programs of the late 1970s gave them an opportunity to move from the lower paying clerical jobs to the higher paying flight crew jobs. Those women with limited mechanical skills had an especially difficult time.

Two more name changes occurred from 1960 to the present. In 1976, the Flight Research Center became the Dryden Flight Research Center (DFRC). In 1981, the DFRC was combined with Ames Research Center and DFRC became the Ames-Dryden Flight Research Facility.

The type of work and the number of women who retired, quit, or transferred to another government facility are given in the Appendix for the time periods of the previous table. Of the 23 women presently working in the technical field, 12 are in the engineering disciplines, 3 are in airplane simulation, 4 are in program management (1 is also a flight test engineer on the SR-71 crew), 3 are in nondisciplinary management, and 1 is chief of the branch responsible for computer systems, flight control rooms, and information networks. As a point of interest, 6 of the women presently working at Dryden in the technical field were in its "co-op" program. The co-op program is a cooperative work-study between NASA and different universities. Engineering students alternate between work periods at a NASA site and their course work at the university.

Observations

The initial plan for this paper was to discuss the women with engineering degrees who worked at Dryden throughout its history. Until recently, however, there haven't been many women with engineering degrees who worked at Dryden. In addition, the women (and men) who work in the engineering, or technical, field have degrees in both engineering and the sciences (math, physics, etc.). Another reason the paper topic changed was because during the early years at Dryden, the women with non-engineering degrees (in some cases, no degree) performed the same work as a junior engineer.

The first woman in a technical management position at Dryden supervised the women computers. In the 1960s, this management position included computer programming and data processing. Women are still in management positions in these and related areas. Women began moving into program management in the 1970s and into nondisciplinary management positions in the 1980s. Women have yet to move into engineering discipline management positions.

One difference between the women who worked at Muroc during the early years and those who came later was the attitude toward working after marriage. Unlike now, most of the women who married when they were working appear to have quit their jobs soon after. The women who quit and transferred during the later years did so for a variety of reasons. Two transferred to jobs near where their husbands had moved, one transferred to improve her chances for promotion, one transferred to a nonengineering job (in this case, her husband transferred to be with her), one quit to get a better job, and two quit for other reasons, one being to spend more time with their children.

The number of women in technical fields from the early days to 1963 was based on the women authors and co-authors of technical reports, available organizational

charts, photographs, the information in reference 1, and the memories of people who worked here during that time. The additional information resources from 1963 to the present, included my memories, the memories of those still working at Dryden, and the equal employee opportunity records from 1990 through 1992. I apologize to any of the women I may have missed.

Acknowledgments

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1. Hallion, Richard P.: On the Frontier. Flight Research at Dryden, 1946-1981, NASA SP-4303, 1984.

2. Childs, Joan M.: Flight Measurements of the Stability Characteristics of the Bell X-5 Research Airplane in Sideslips at 59°Sweepback. NACA RM L52K13b, 1953.

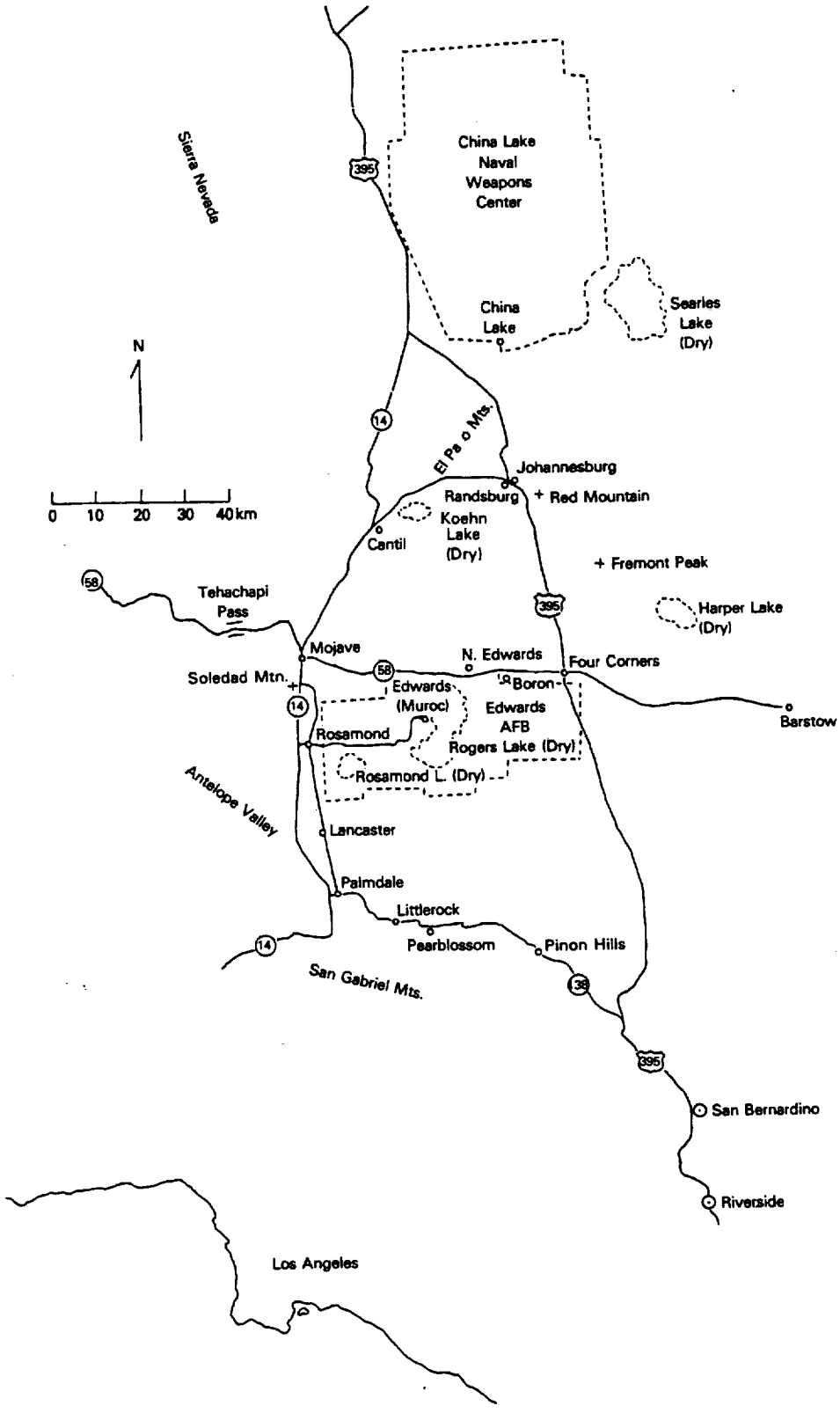
Appendix

Number of Women by Job Category from 1960 to Present

Engineering disciplines	Computer programming	Airplane simulation	Management
Early 1960s			
6 (2 engineers, 4 former woman computers) [1 engineer transferred]*	1		
Mid to late 1960s			
8 [1 transferred, 2 quit]	3		1 Chief of Programming and Data Processing Branch
Early to mid 1970s			
7 [2 former woman computers retired 1973; 1 died in glider accident in 1976]	4 [1 quit]	1	1 Chief of Programming and Data Processing Branch [Retired 1973, former woman computer]
Late 1970s			
6 [1 retired (last of former women computers); 1 quit]	3	1	1 in program management [transferred to congressional staff position]
Mid to late 1980s			
11 (1 an instrumentation engineer responsible for research instrumentation airplane; 1 an operations engineer responsible for flight readiness of airplane) [Medical retirement for instrumentation engineer; 1 quit]		1	2 in program management 1 assistant chief of branch responsible for computer systems, flight control rooms, and information networks, 2 in non-disciplinary management positions
Early 1990s			
13 [1 transferred]		4 [1 quit]	4 in program management 1 branch chief (former assistant branch chief), 3 nondisciplinary management
November 1992			
12		3	4 in program management (1 also serves as a flight test engineer on the SR-71 crew),1 branch chief (former assistant branch chief), 3 nondisciplinary management

*[Change by next time period]

Notes: "Transferred" means the woman went to another government facility. "Engineering discipline" refers to any of the airplane discipline studies, for example, propulsion, aerodynamics, stability and control, structures, etc. and "Program management" refers to general oversight of an airplane program such as coordinating, scheduling, funding, working with any outside partners involvedwith the program, etc.



The western Mojave Desert

Figure 1. Location of Muroc (Edwards Air Force Base since December 1949) with respect to Los Angeles. The names and road numbers are for the present time.

Figure 2. Group photograph taken in late 1946 in front of the XS-1 and the B-29 (carrier airplane for the XS-1). Roxanah Yancey is in the second row, fourth from the right.

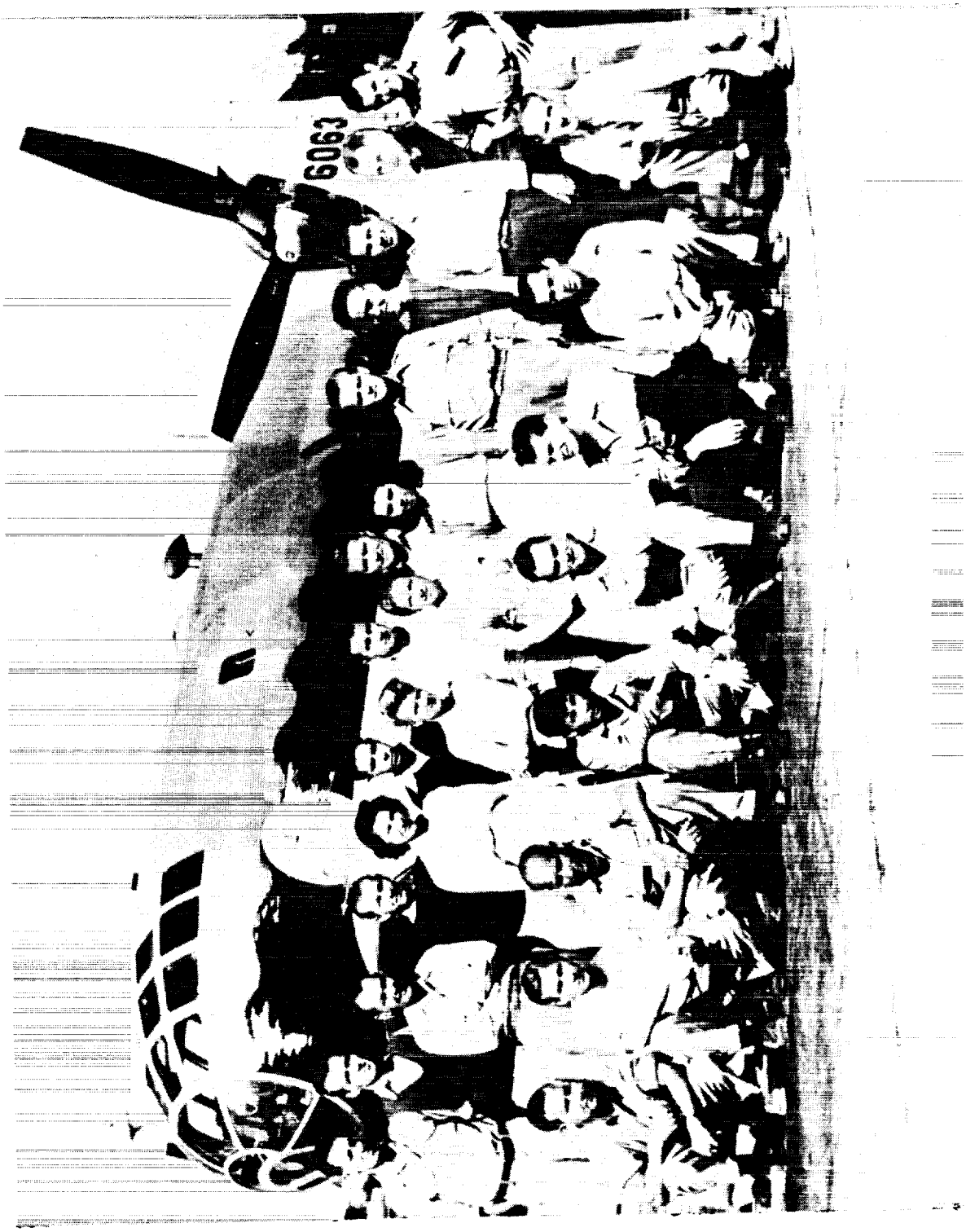


Figure 3. Group photograph taken in October 1947 in front of the B-29. Roxanah Yancey is in the second row, fifth from the left.

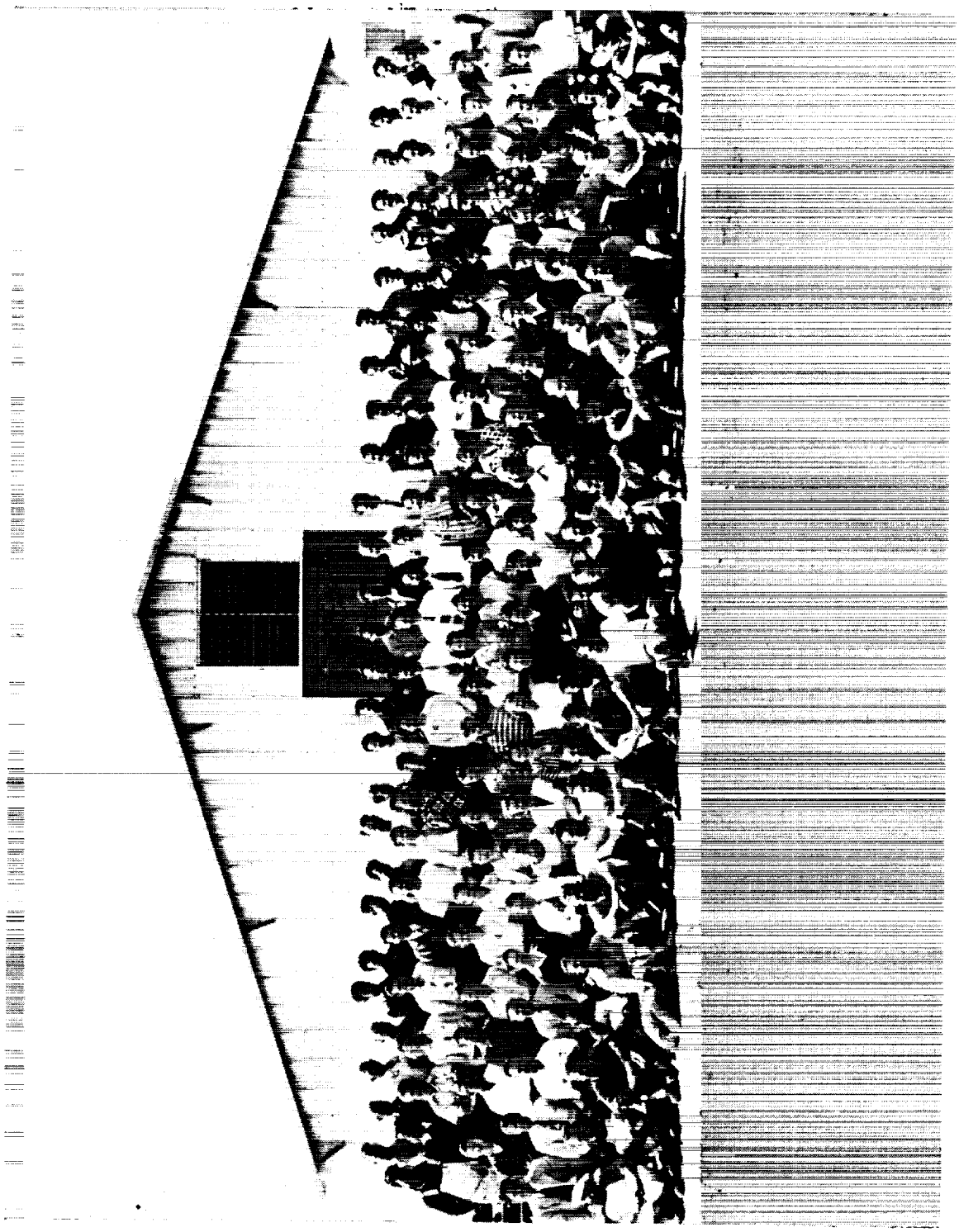


Figure 4. Group photograph taken in 1950 in front of the NACA building. Roxanah Yancey is in the first row of women, third from the right.

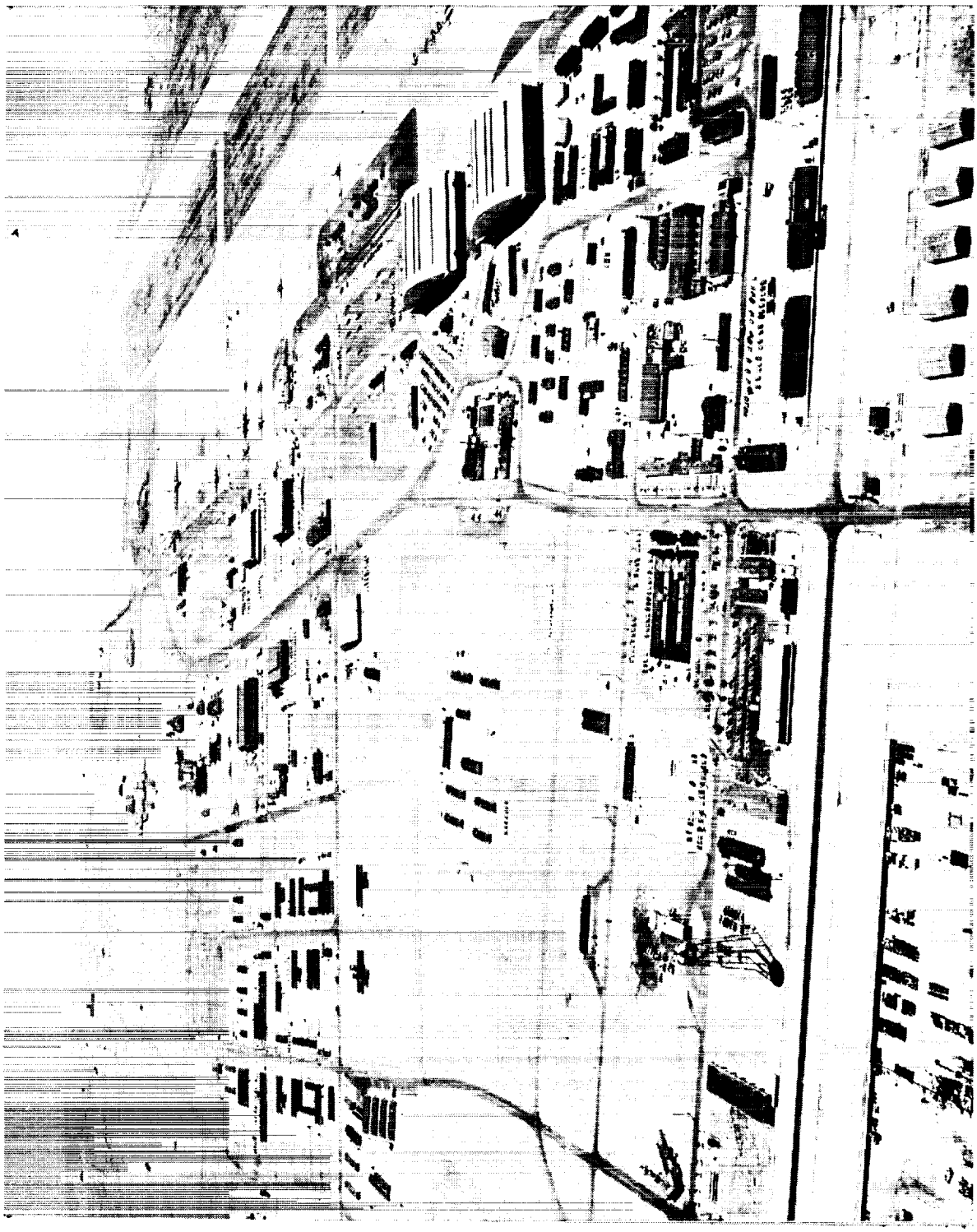


Figure 5. Aerial view of the south base taken July 1951; the women's dormitory, NACA site, and other buildings are indicated.

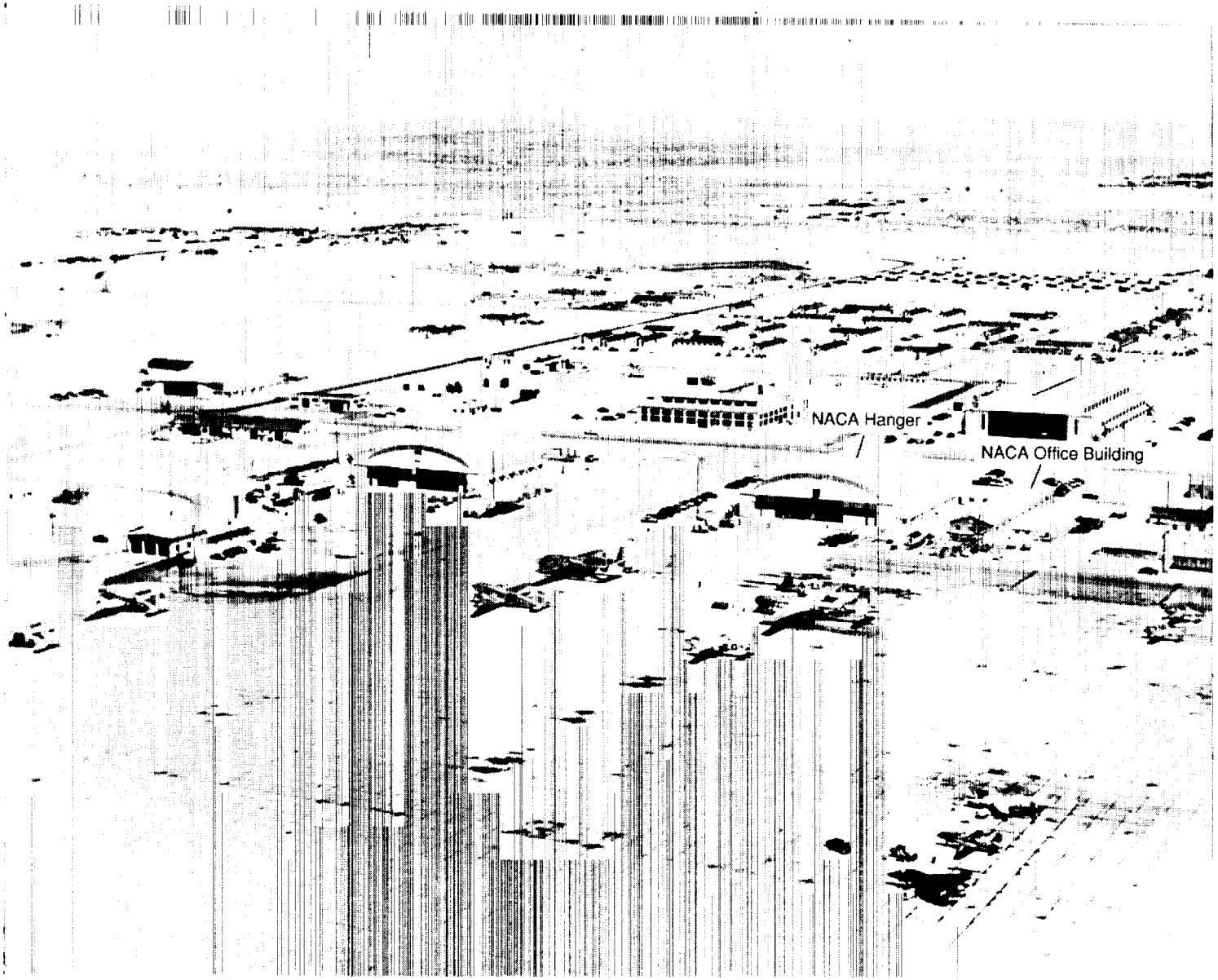


Figure 6. Aerial view of NACA site at the south base late 1940s.

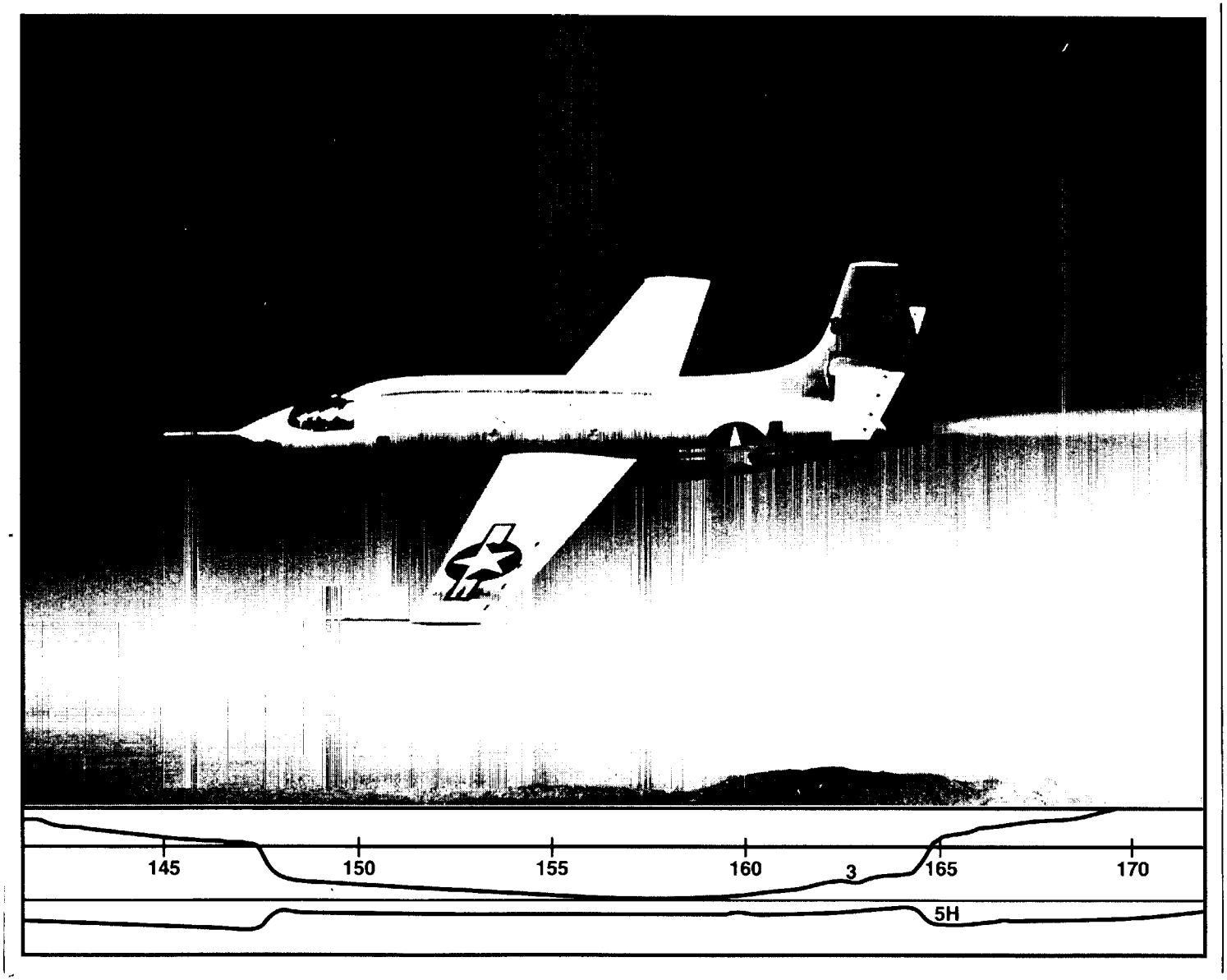


Figure 7. XS-1 and film pressure traces from first airplane flight to exceed the speed of sound. Flown by Charles Yeager on October 14, 1947.

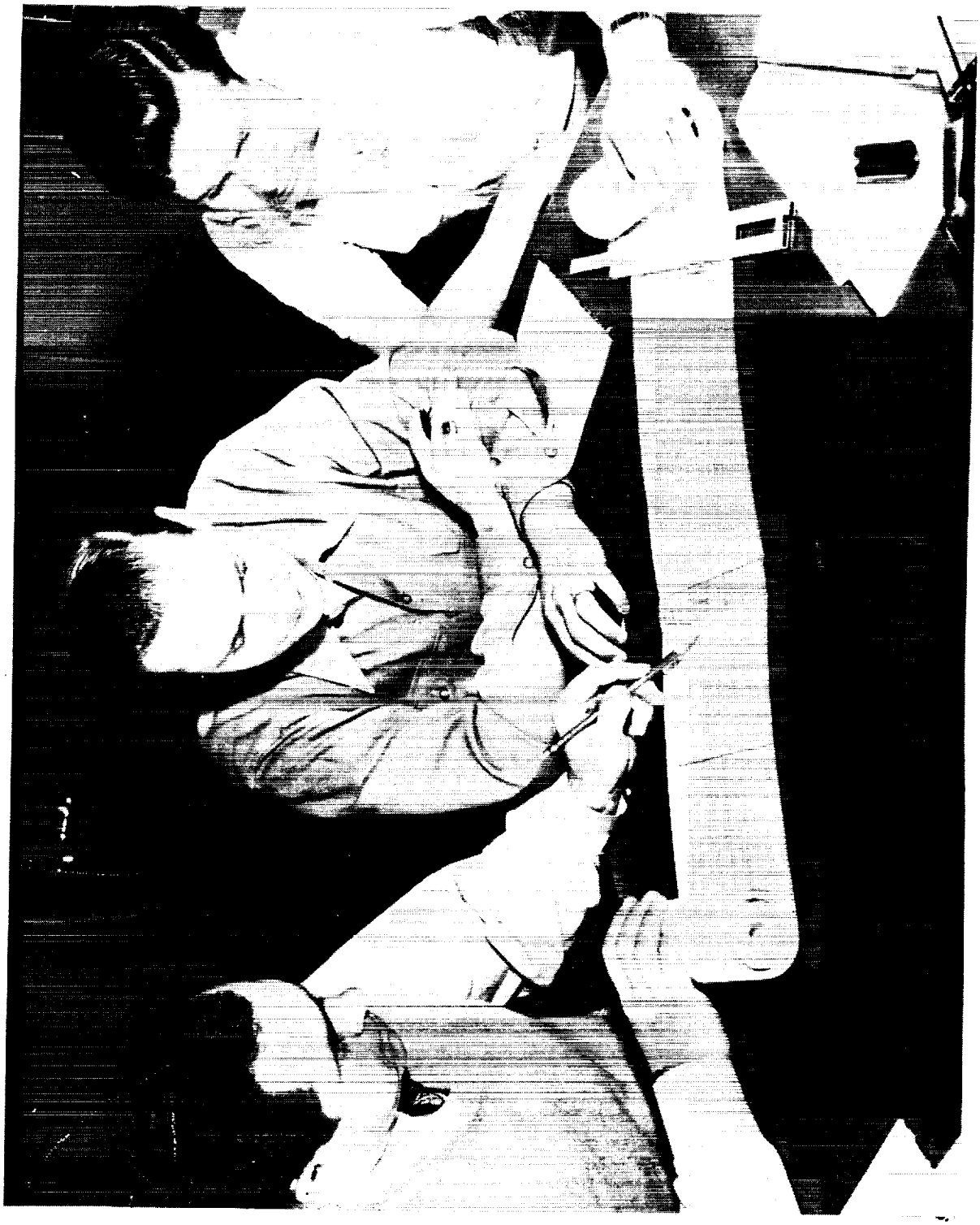


Figure 8. Engineers with oscillograph film, film scale, and slide rule, late 1940s or early 1950s.

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Figure 9. Women computers at work, late summer 1949. Mechanical calculators, Fridens, are seen on desks on the left side. Woman at center desk with lamp is reading film traces.

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Figure 10. NACA's X-series in the early 1950s.

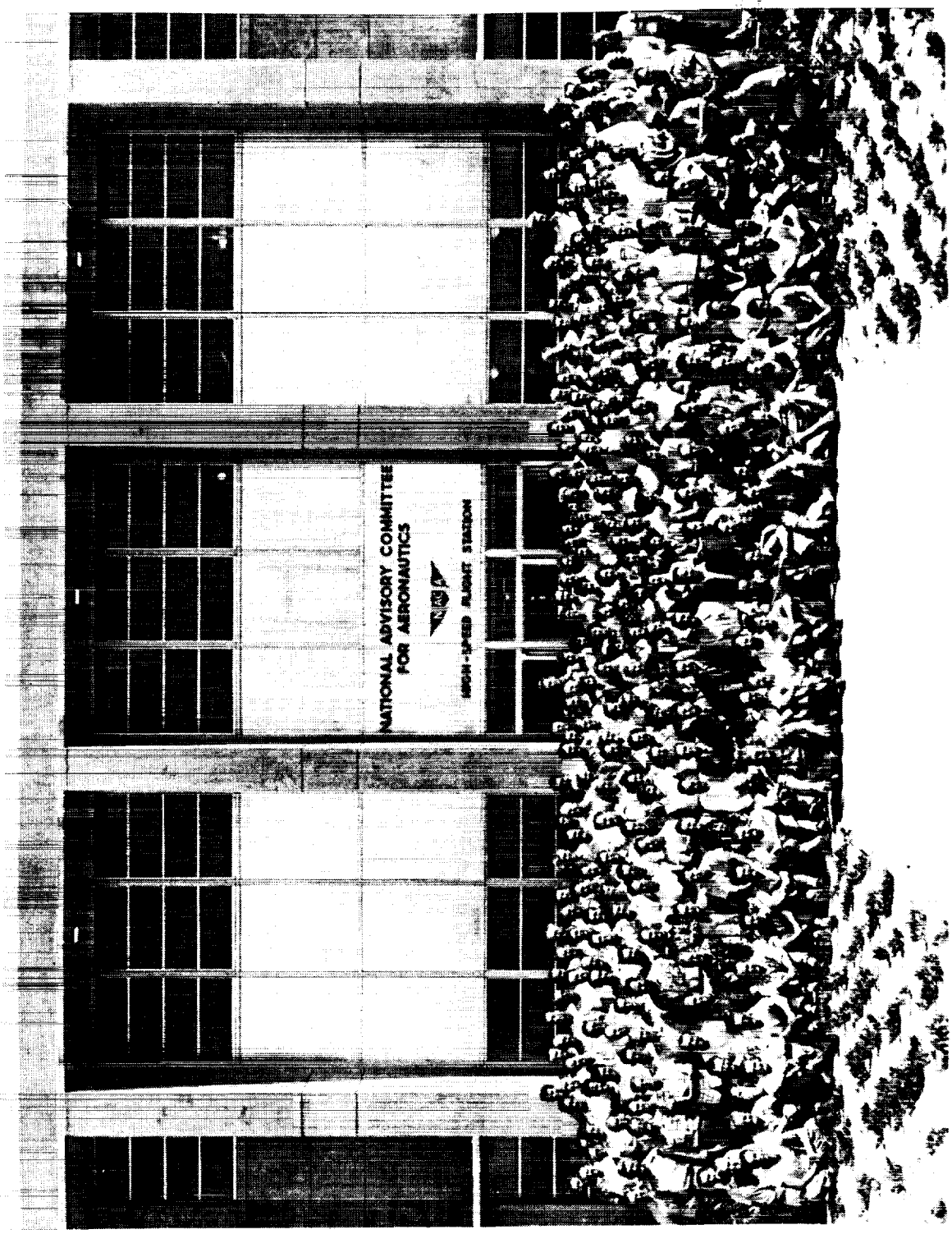

Figure 11. Group photograph taken in 1954 in front of the new building, main base.

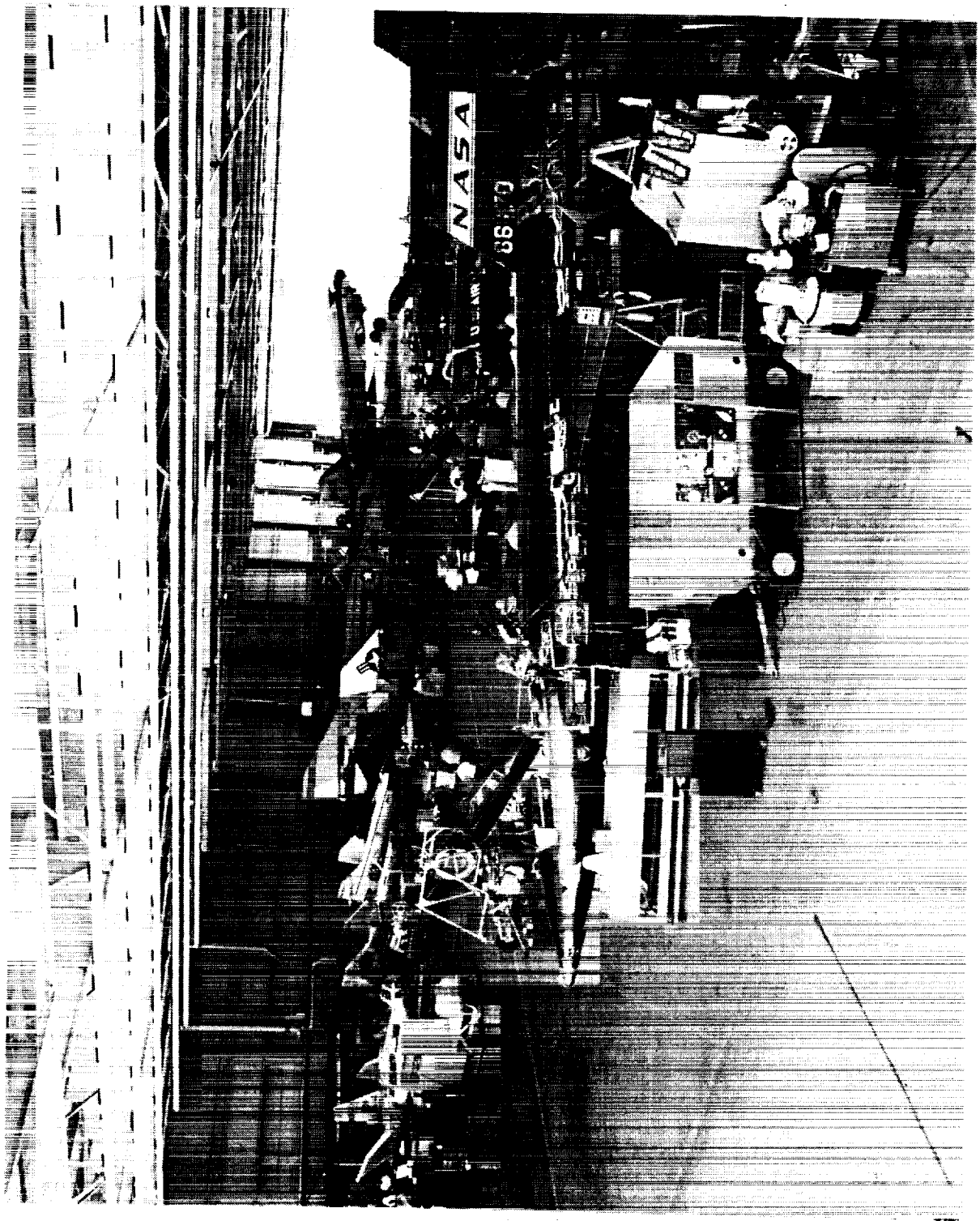

Figure 12. Airplanes in hangar in late 1966. From front to rear: left side, lifting bodies HL-10, M2-F2, M2-F1, F-4, F-5D, F 104, and DC-3; right side, X-15-1, X-15-3, and X-15-2.

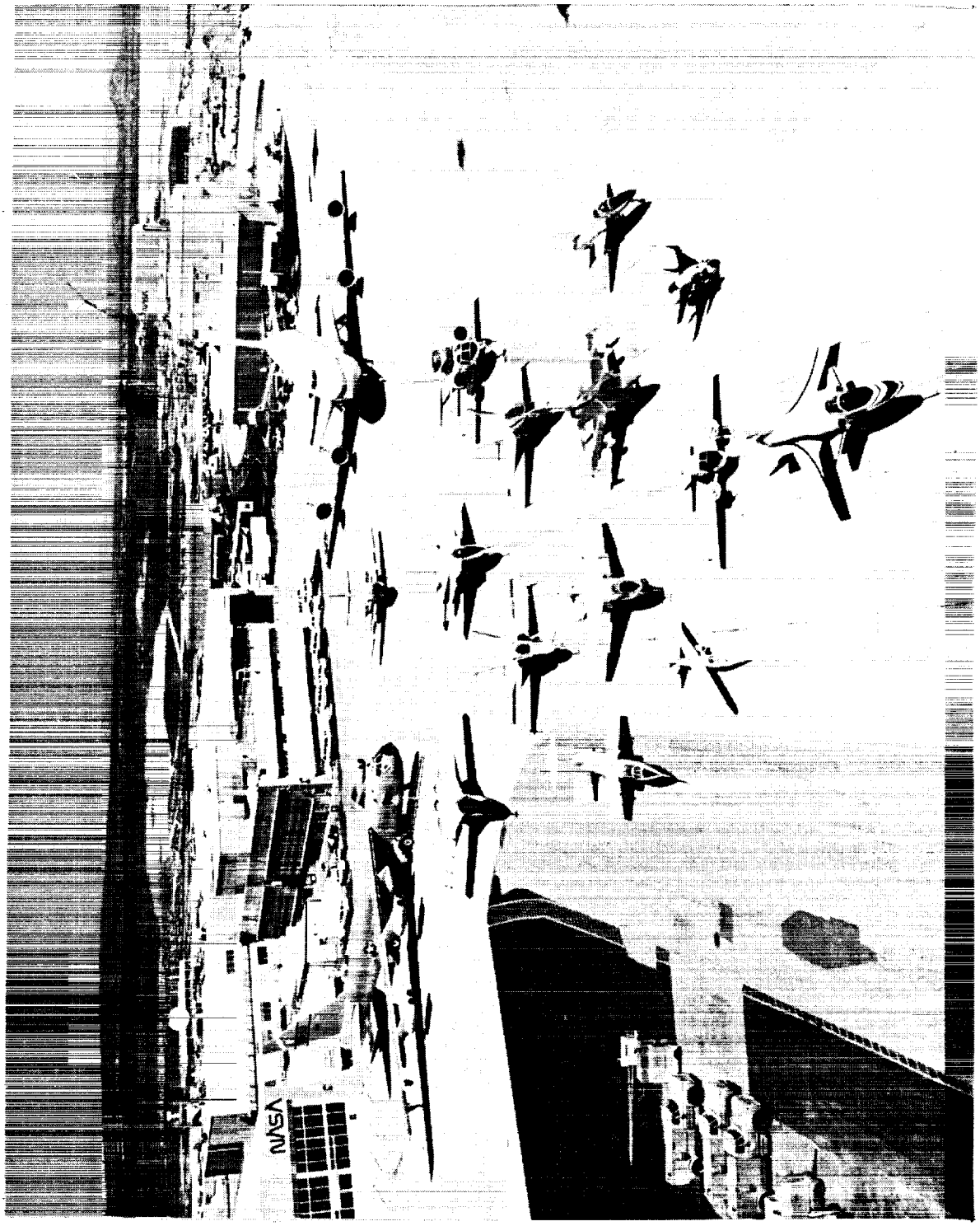

Figure 13. Airplanes on ramp, 1988. From front to back and left to right: X-29, AD-1, PA-30, HiMAT, F-104, F-8 DFBW, F-16 AFTI, T-38, F-18, F-18, F-111 MAW, F-15, RSRA, B-52, Jetstar, and 747 shuttle carrier aircraft.

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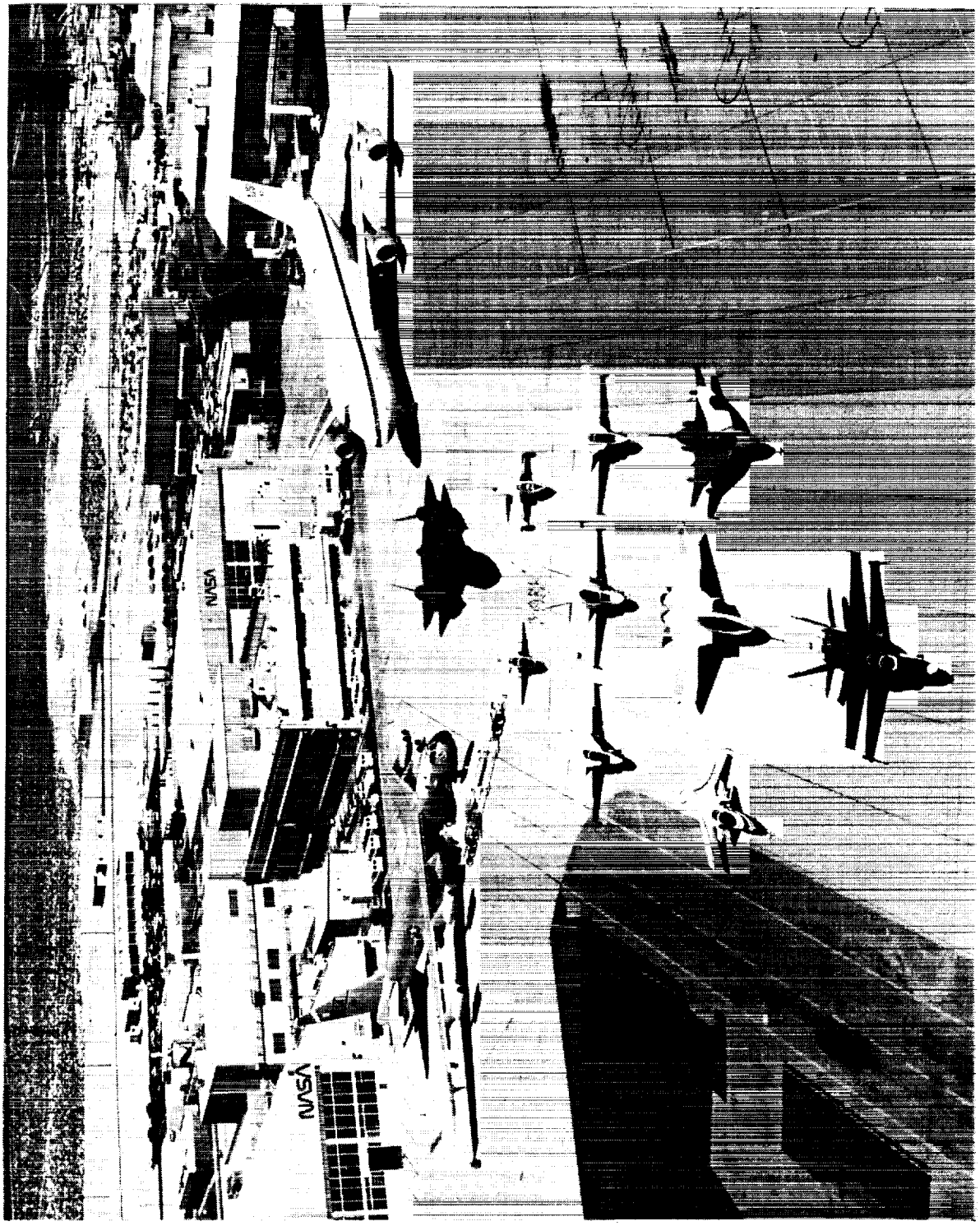

Figure 14. Airplanes on ramp, 1990. From front to back, left to right: F-18 HARV, X-29, F-15, F-16 XL SLFC, 3 F-18 support aircraft, T-38, F-104, B-52, Pegasus, SR-71, and 747 shuttle carrier aircraft.

Biography

Sheryll Goecke Powers first began working for NASA in the cooperative work study plan between Iowa State University and the NASA Flight Research Center (presently the Dryden Flight Research Facility of the NASA Flight Ames Research Center) at Edwards, Calif. She began working full time for NASA at Edwards, Calif. after obtaining her B.S. degree in Aerospace Engineering from Iowa State University. While working, she obtained a M.S. degree and an E.D. degree, both in Aerospace Engineering, from the University of Southern California.

Her first project at NASA concerned the base drag for the sharp leading edge upper ventral fin on the X-15.

Subsequent projects included: determining the base drag for the XB-70; determining the drag caused by surface discontinuities, such included aircraft component base drag reduction and boundary layer measurements, on the F-111 TACT, F-111 MAW and JetStar; lift and drag studies on the space shuttle; lift and drag sensitivity studies on the X-29; and serving as technical director for the F-111 MAW symposium. She presently is a group leader in the Propulsion and Performance Branch.