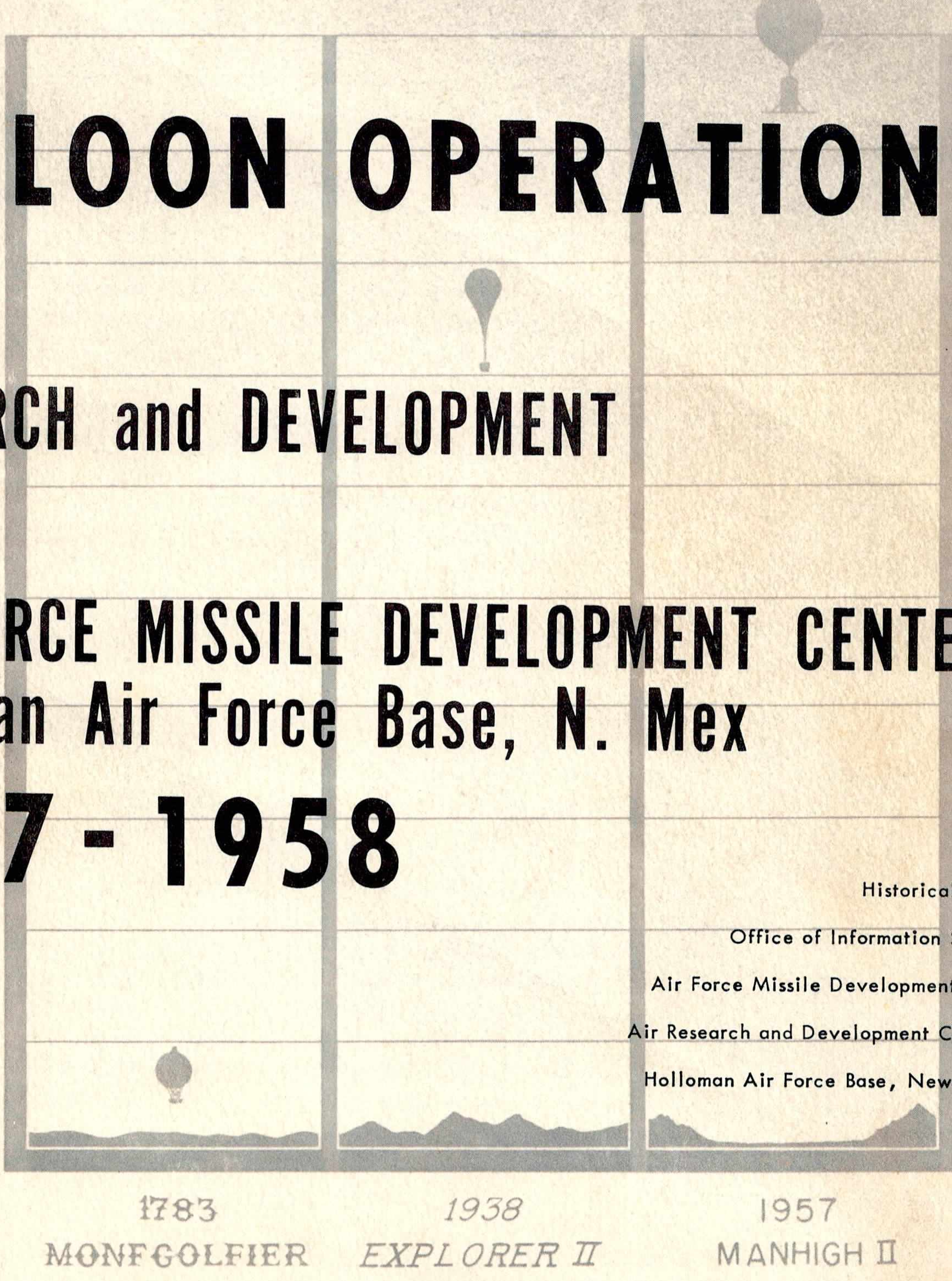
DUKE GILDENBERG

Contributions of BALLOON OPERATIONS to RESEARCH and DEVELOPMENT at the AIR FORCE MISSILE DEVELOPMENT CENTER Holloman Air Force Base, N. Mex 1947 - 1958



Historical Branch
Office of Information Services
Air Force Missile Development Center
Air Research and Development Command
Holloman Air Force Base, New Mexico

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AIR RESEARCH AND DEVELOPMENT COMMAND
UNITED STATES AIR FORCE

FOREWORD

Among the many activities at the Air Force Missile Development Center contributing to the expanding fields of guided missiles and space technology, that of the Balloon Branch is among the more important. Upon first consideration, the contributions of ballooning may seem detached from the development of missile weapon systems or the conquest of space. Actually, the connection is direct and of greatest importance.

Over the past twelve years the accomplishments of Holloman's Balloon Branch have contributed significantly to the work of many other units--various missile projects, research in space biology and biodynamics, the exploration of the upper atmosphere, and the development of artificial cabin environments which will be required for manned space flight. In addition, they have materially furthered the entire state of the art of ballooning, itself. In the historical monograph here presented, Dr. David Bushnell, of the Air Force Missile Development Center's historical office, with the assistance of key persons of the Balloon Branch, has carefully documented the contributions of twelve years of balloon operations at this major test, research and development center.

Bringing the history of these activities to the close of 1958, Dr. Bushnell has expressly excluded all classified information. Fortunately, the vast majority of balloon work accomplished from Holloman Air Force Base either has been entirely unclassified or can be described in unclassified terms without sacrificing essential detail. For the record---and for the convenience of posterity---it may be noted that classified aspects of Holloman balloon operations are covered in volumes of the semiannual histories of the Air Force Missile Development Center and other Centers of the Air Research and Development Command involved in various balloon-supported projects.

This volume, one of the series of special monographs prepared by the Center's Historical Branch, was made possible in considerable part by the cooperation of the Balloon Branch and of its next higher echelon, the Technical Services Division of the Directorate of Advanced Technology. The study draws heavily upon records and reports in the files of both Branch and Division, and upon extensive interviewing of the members of their staffs. Because it is difficult to acknowledge separately the assistance of each individual, the Historical Branch expresses its appreciation in general terms to all concerned through Major Lawrence M. Bogard, Chief of the Balloon Branch, and Major John R. Patterson, Chief of the Technical Services Division.

Most of this volume has been inspected in draft form by

different members of the Balloon Branch and the Technical Services Division. Those who have checked advance portions for technical accuracy include Mr. Bernard D. Gildenberg, Chief of the Balloon Control Section; Mr. Ernest F. Sorgnit, Research Administrator in the Technical Services Division; Mr. David S. Willard, Chief of the Communications and Electronics Section; as well as Major Bogard and Major Patterson. The Historical Branch, of course, assumes final responsibility for the text and recognizes that the technical reliability of the finished product has been increased by this preliminary review.

Mr. Gildenberg, moreover, is actually co-author of the chapter dealing with advances in balloon technology. In that chapter the general description of plastic balloons has been largely compiled from articles he has written, while the section on launch techniques was prepared by Mr. Gildenberg expressly for this volume. A few editorial changes have been made in his original wording, in hope of simplifying certain matters for those uninitiated in plastic balloon lore, but his distinctive style is still easily recognizable.

Thanks are due also to individuals from other Center units for information they supplied related directly or indirectly to balloon operations. They include Doctor (Lieutenant Colonel) David G. Simons, who recently transferred from the Aeromedical Field Laboratory, and Captain Druey P. Parks, who at present is head of the Laboratory's Administrative Services Branch. Also helpful have been Mr. James O. Rogers, Assistant Chief of the Manpower and Organization Division; Senior Master Sergeant Albert D. Vizcarra, Sergeant Major of the Military Personnel Division; Captain Thomas U. McElmurray, Chief, and Captain Carl R. Wheaton, Assistant Chief, of the Sidewinder Branch; Captain Stephen E. Moore and Master Sergeant Elmer B. Tixier of the Fighter Missile Test Branch; Lieutenant Gerald E. Weinstein, until recently assigned to the Evaluation Division; and Captain Michael L. Hoptay, Chief of the Falcon Branch. Mr. Bernard E. Oldfield, manager of the local Field Operations Department for the Hughes Aircraft Company also supplied information.

Finally, assistance has been received from persons not directly related to the Air Force Missile Development Center. Professor Edward P. Ney, of the University of Minnesota; Mr. Joseph C. Groth, formerly of Winzen Research, Incorporated; and Captain Richard Armstrong, Assistant Administrative Officer at Headquarters, 1110th Balloon Activities Group, Lowry Air Force Base, Colorado, have supplied specific information. Mr. Charles Tilton and Mr. Thomas W. Kelly of the Atmospheric Devices (now Balloon Development) Laboratory at the Air Force Cambridge Research Center provided considerable assistance during a visit of Dr. Bushnell at that establishment, as did Dr. Julius King, Center Historian at Cambridge, who kindly made available relevant records in his own office, including the semiannual histories of the Cambridge Center which are cited repeatedly in the footnotes of this volume. More recently, Major Richard H. Braun, Chief of the Balloon Development Laboratory, has supplied additional information. Dr. Herman Yagoda, of the same Center, was interviewed while at Holloman as a member of the scientific panel of experts monitoring the Man-High III balloon flight. To all these persons, the Historical Branch would like to express its appreciation.

James Stephen Hanrahan
Center Historian
February 1959

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CHRONOLOGY

5	June	1947	First research balloon launch at Holloman, by New York University team under contract with Air Materiel Command. This was a cluster of rubber balloons.
3	July	1947	Start of polyethylene balloon operations at Holloman. A ten-balloon cluster launched by the New York University team; payload less than fifty pounds, peak altitude 18,500 feet.
		1948	Beginning of research balloon flights launched at Holloman by Air Force personnel.
		1949	The present Balloon Branch organized as a subdivision within the Electronic and Atmospheric Projects Section.
21	July	1950	First polyethylene balloon launched at Holloman, by the Balloon Branch, with Air Force personnel. The series of Holloman numbered flights begins with this flight, which was launched for atmospheric sampling.
28	September	1950	First successful animal balloon flight in aeromedical cosmic radiation series takes eight white mice to 97,000 feet from Holloman Air Force Base.
	September	1951	Beginning of the Holloman phase of Project Moby Dick.
1	May	1953	Start of Holloman flight operations by the manned-balloon program of Wright Air Development Center's Aero Medical Laboratory ("High-Dive").
	November	1953	Holloman Balloon Branch conducts static tests of balloon performance at a Navy blimp hangar in California.

26 August	1955	First use of a balloon target in missile testing.
25 February	1957	Balrok design contract signed with Aerophysics Development Corporation.
19-20 August	1957	Man-High (II) flight by Lt. Col. David G. Simons, attaining record altitude of 102,000 feet. Flight was launched in Minnesota, by crew of Winzen Research, but supported by the Holloman Balloon Branch.
19 February	1958	First attempted air launch (unsuccessful), from a balloon platform, of Hi-Fly target rocket.
27 February	1958	First Balrok test mission, dropping a dummy HTV from a balloon positioned at 93,000 feet. The vehicle attained mach 1.51 with zero thrust.
8 August	1958	Attempted "hot" firing with Balrok system. Balloon performance was satisfactory but the rocket failed to release.
8 October	1958	Man-High (III) flight by Lt. Clifton M. McClure III launched at Holloman, reaching altitude of 99,900 feet.
14 November	1958	First military launch anywhere of a 3,750,000-cubic-foot plastic balloon. Launch was off-range; payload was the special parachute test vehicle used by Cook Research Laboratories and Wright Air Development Center for development of high-mach parachute systems.
18 December	1958	Plastic balloon flight number 1000 launched by the Balloon Branch.

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CHAPTER I

ORIGIN AND EXPANSION OF HOLLOMAN BALLOON OPERATIONS

Since the close of World War II, aircraft have repeatedly established new records in speed and altitude, research satellites have begun to crowd the skies, and the day of manned space vehicles already seems close at hand. Yet one of the most interesting of all recent developments in the field of manned and unmanned flight has been a spectacular revival of free ballooning. The balloon, which was man's first aerial vehicle, has found many new applications as a result of post-war improvements in manufacturing and flight techniques. These new applications have been particularly evident at the military test, research, and development complex that is located at Holloman Air Force Base, New Mexico, and now bears the name of Air Force Missile Development Center.

As a matter of fact, the first research balloon flight at Holloman Air Force Base was launched over a month before the first missile: on 5 June 1947, as compared with the first Holloman missile firing on 23 July of the same year. This was not actually a single but rather a multiple launching, using a cluster of rubber-type weather balloons. The flight lasted not quite six hours, rose to a maximum altitude of 58,000 feet, and ended with successful recovery of the balloon equipment at a point east of Roswell, New Mexico. The first polyethylene plastic balloons, of the type generally used today, were launched on 3 July 1947, still before the first missile. This, too, was a cluster flight, using ten seven-foot-diameter plastic balloons. Payload was well under fifty pounds, duration 195 minutes, and maximum altitude 18,500 feet; recovery, however, was unsuccessful.[1]

Both of these balloon "firsts" were conducted by the Research Division of New York University's College of Engineering, under a contract that it held with Watson Laboratories, Air Materiel Command, "to design, develop, and fly constant-level balloons to carry instruments to altitudes from 10 to 20 km...."[2] Headquarters of the university's "Balloon Group" remained in New York City, but a great number of actual test flights were launched at Holloman by specialists sent out to New Mexico on temporary duty. New York University crews continued to visit the air base intermittently to launch balloons from 1947 to 1950. However, not all the flights were concerned exclusively with development of balloon techniques. Certain flights were made, using plastic vehicles, to measure cosmic ray intensities with special scientific equipment and to study atmospheric wind conditions by means of extended constant-level balloon trajectories.[3]

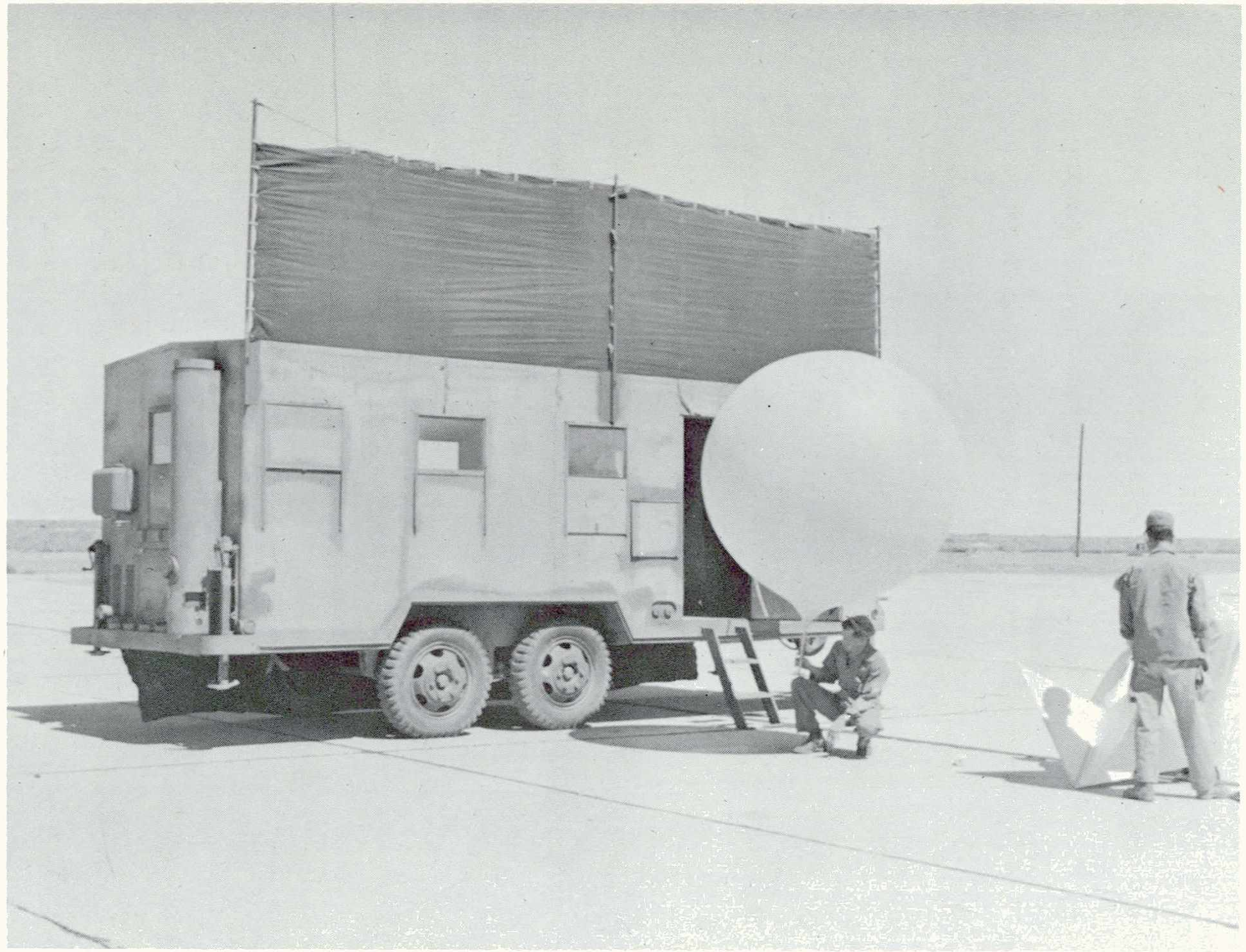
Although New York University sent its own people to Holloman to conduct balloon flights, they naturally obtained various forms of support from the base organization. This could mean either standard services such as weather information and meals in the base cafeteria, or more specialized assistance such as the use of range instrumentation and Holloman-assigned aircraft for balloon tracking purposes. Moreover, Holloman's own Electronic and Atmospheric Projects Section also conducted balloon flights, with Air Force personnel, starting apparently some time in 1948. The first flights were launched in connection with radar research and development, using different types of balloon vehicles (with or without attached reflectors) to test the tracking capability of radar equipment.[4] Not later than September 1948 the Section began conducting balloon flights for upper-air research projects, which came to absorb an ever greater share of its total effort. In this phase of its balloon operations, the Holloman unit at first worked solely with rubber-type balloons, either singly or in clusters--unlike the New York University crews, which experimented with both plastic and rubber balloons but especially with the former.

Of the various upper-air projects for which balloons were launched by the Holloman unit, the first and probably most persistent was known as the Atmospheric Sampling Project (short for "Physical and Chemical Atmospheric Constituents"). This was a project directed by Watson Laboratories (and later the Air

Force Cambridge Research Center), and involved catching air samples at various altitudes in balloon-borne sampling bottles. At first it was concerned with the development of sampling and recovery techniques rather than sampling as such; but it progressed beyond this stage, and under different project names it has continued ever since.[5]

One rather unusual activity of the Electronic and Atmospheric Projects Section was the High Altitude Dust Diffusion Project. In this Air Force basic research effort, talcum powder was sometimes placed inside a balloon, which burst on reaching desired altitude and released an artificial cloud; in other cases an actual smoke charge was sent up attached to the balloon. Either way, the diffusion rate was then measured by a system of ground cameras.[6] The Electronic and Atmospheric Projects Section assisted in development of an instrument recovery program for Air Materiel Command V-2 research flights by dropping an experimental transmitter from a balloon cluster; later, captive balloons were used to hold such transmitters in place for calibration tests.[7] Naturally, the Section also helped provide the base support required by visiting New York University teams.

New York University was not the only outside organization to receive support from Holloman for balloon operations. The United States Navy conducted a number of balloon flights during



Rubber-type Balloon Operations at Holloman Air Force Base: June 1949 these same years, for which the primary supporting agency was the Navy's missile test facility at White Sands Proving Ground, located across the Tularosa Basin from Holloman. Additional support was obtained, for certain flights, from balloon technicians of General Mills, Incorporated, the country's largest manufacturer of polyethylene balloons, who journeyed from Minneapolis to New Mexico for the occasion. However, assistance was rendered from time to time by the New York University balloon people at Holloman and by the Electronic and Atmospheric Projects Section, which would lend balloons or other equipment and provided auxiliary theodolite and radar tracking units. In one spectacular test of April 1949, sponsored by the Navy but supported in some small measure by the Air Force, three seventy-foot-diameter plastic balloons carried a free-fall test vehicle to roughly 100,000 feet, where it was cut loose to gather flight environmental data on its way back to earth. It is interesting to note that much of this Navy balloon activity in southern New Mexico was directly related to the Navy's development of "Rockoon" or balloon-launched rocket systems.[8]

With the growing scale of Holloman balloon operations, the present Balloon Branch emerged as a recognized subdivision of the Electronic and Atmospheric Projects Section. It appears that its creation can best be dated from the year 1949, although it is also true that the beginnings of the Balloon Branch were somewhat informal.[9] It was usually known at first simply as the

Balloon Unit, or Balloon Sonde [Sub-] Unit, and it assumed immediate responsibility for all balloon services provided by the Section--that is, miscellaneous support to New York University crews and other outsiders, plus launch, tracking, and recovery of balloons for various Air Force research projects.

The Balloon Branch truly came of age only on 21 July 1950, when it launched its first polyethylene plastic vehicle for high-altitude research. This was an atmospheric sampling flight to be exact.[10] As the work of New York University, General Mills, Incorporated and other organizations had by now clearly demonstrated, polyethylene plastic was far superior to either natural or synthetic rubber for research ballooning. Above all, polyethylene balloons had much greater stability and payload capacity. During fiscal year 1951, twenty flights were conducted by the Holloman Balloon Branch using these plastic vehicles. Over the following years the number of such flights mounted steadily, until on 18 December 1958 the Balloon Branch launched its 1000th plastic vehicle.[11]

Total payloads flown by the Balloon Branch have also increased sharply, during the years to and including 1958, as indicated in the following table:[12]

Fiscal Year	Number of Flights	Total Pounds Payload Flown	Total Hours Airborne	Total Miles Traversed
1951	20	1344	92	4470
1952	43	9326	694	16123
1953	85	23827	1470	20162
1954	91	26302	732	15177
1955	70	24822	317	6574
1956	132	34993	488	13603
1957	243	57607	583	10408
1958	215	70996	557	12894
1959 (to 18 Dec)	101	40957	288	4236
	1000	290174	5221	103647

The table refers to plastic balloons launched for all types of projects, including the target balloons that have been used, starting in 1955, for missile test operations. On the other hand, some rubber-type balloons were still being launched and are not considered in these figures. Their number fell off steadily, just as the number of polyethylene balloon flights rose.

Members of the Balloon Branch have graphically summarized the progress made since 1950 by pointing out that the first 1000 plastic balloon flights, if all rolled into one, would have carried 145 tons of payload, remained aloft some 217 days, and traversed a total distance forty-three percent of the way to the moon. The longest single flight was over eight days, the highest altitude 123,000 feet, and the heaviest single payload 3,000 pounds. This last figure was more than the total flown on the first thirty-three plastic flights.[13]

N O T E S

1. Research Division, College of Engineering, New York University, Technical Report No. 1 (New York, 1 April 1948), Table VII.

2. Ibid., p. 1.

3. New York University's balloon operations are described in the report cited above; in Research Division, College of Engineering, New York University, Technical Report No. 93.03, Constant Level Balloons Final Report (New York, 1 March 1951); and also, passim, in Progress Summary Report on U.S.A.F. Guided Missile Test Activities (HAFB, published monthly 1 November 1947-1 June 1950).

4. Cf. "Visit of General Joseph T. McNarney Commanding General, Air Materiel Command to Holloman Air Force Base 9 April 1948;" Progress Summary Report, 1 August 1948, p. 26.

5. Progress Summary Report, 1 October 1948, pp. 16, 22; later issues, passim.

6. Progress Summary Report, 1 May 1949, pp. 31-33.

7. Progress Summary Report, 1 March 1949, p. 38, and 1 February 1950, p. 60.

8. Progress Summary Report, 1 May 1949, pp. 31, 32 and 1 May 1950, p. 65; interview, Mr. Bernard D. Gildenberg, Chief, Balloon Control Section, Balloon Branch, AFMDC, by Dr. David Bushnell, AFMDC Historian, 9 September 1958; ltr., Maj. Richard H. Braun, Chief, Balloon Development Laboratory, AFCRC, to Cmdr., AFMDC (attention: Dr. Bushnell), subj.: "Air Force Missile Development Center Balloon Launching History," 15 January 1959.

9. Interview, Mr. Gildenberg by Dr. Bushnell, 9 September 1958.

10. 6580th Test Squadron (Special), Flight Summary, Non-Extensible Balloon Operations ... June 1950 to October 1954.

11. Interview, Mr. Gildenberg by Dr. Bushnell, 18 December 1958.

12. Balloon Branch, "Statistical Summary of First 1000 AFMDC Flights," 12 January 1959.

13. Ibid.

CHAPTER II

OPERATIONAL RESEARCH AND DEVELOPMENT MISSIONS

The Balloon Branch at the present Air Force Missile Development Center has served an almost bewildering variety of research and development activities. Its "customers" have ranged from the private individuals who have "hitchhiked" small items of scientific equipment on Holloman balloon flights to such key military organizations as the Air Force Ballistic Missile Division of Air Research and Development Command. The payloads transported have ranged all the way from small animals for research in space biology to huge dummy loads used in testing new launch and flight techniques. The special requirements of different projects have often taxed the resources and ingenuity of the Balloon Branch, but by and large it has met those requirements successfully, and in the process it has made important contributions both to the national defense effort and to the increase of basic scientific knowledge.

Some of the best known of all the flights launched by the Holloman Balloon Branch were those conducted for research in space biology. Flights in this series were also among the first to be launched after the Balloon Branch converted largely to polyethylene balloon vehicles. Beginning in late summer of 1950, Holloman balloons carried mice, dogs, hamsters, seeds, and other specimens (even including excised segments of human skin) to high altitude, for exposure to cosmic rays. These flights were originally conducted for the Aero Medical Laboratory of Wright Air Development Center, but direction of the research program was later transferred to the Aeromedical Field Laboratory established at Holloman Air Force Base.[1]

The first really successful animal flight took place on 28 September 1950, when eight mice journeyed by balloon to 97,000 feet, remained aloft for three hours and forty minutes, and were recovered alive at the end of the flight. On later experiments the flight duration increased substantially. Even so, it was found that flights at the latitude of Holloman Air Force Base did not provide a sufficient exposure to primary cosmic ray particles at balloon altitudes for the study of possible biological hazards. Accordingly, in the spring and summer of 1953 personnel of both the Balloon Branch and the Aeromedical Field Laboratory--naturally including Major (Doctor and later Lieutenant Colonel) David G. Simons, who served as space biology project officer--moved off from Holloman to Oregon and Montana, to launch biological flights in northern latitudes where cosmic rays suffer less deflection by the earth's magnetic field. From that point on, space biology balloon flights were made from Holloman principally to test equipment and techniques and to expose "control" specimens to the relatively weaker radiation obtainable over southern New Mexico and adjacent regions.

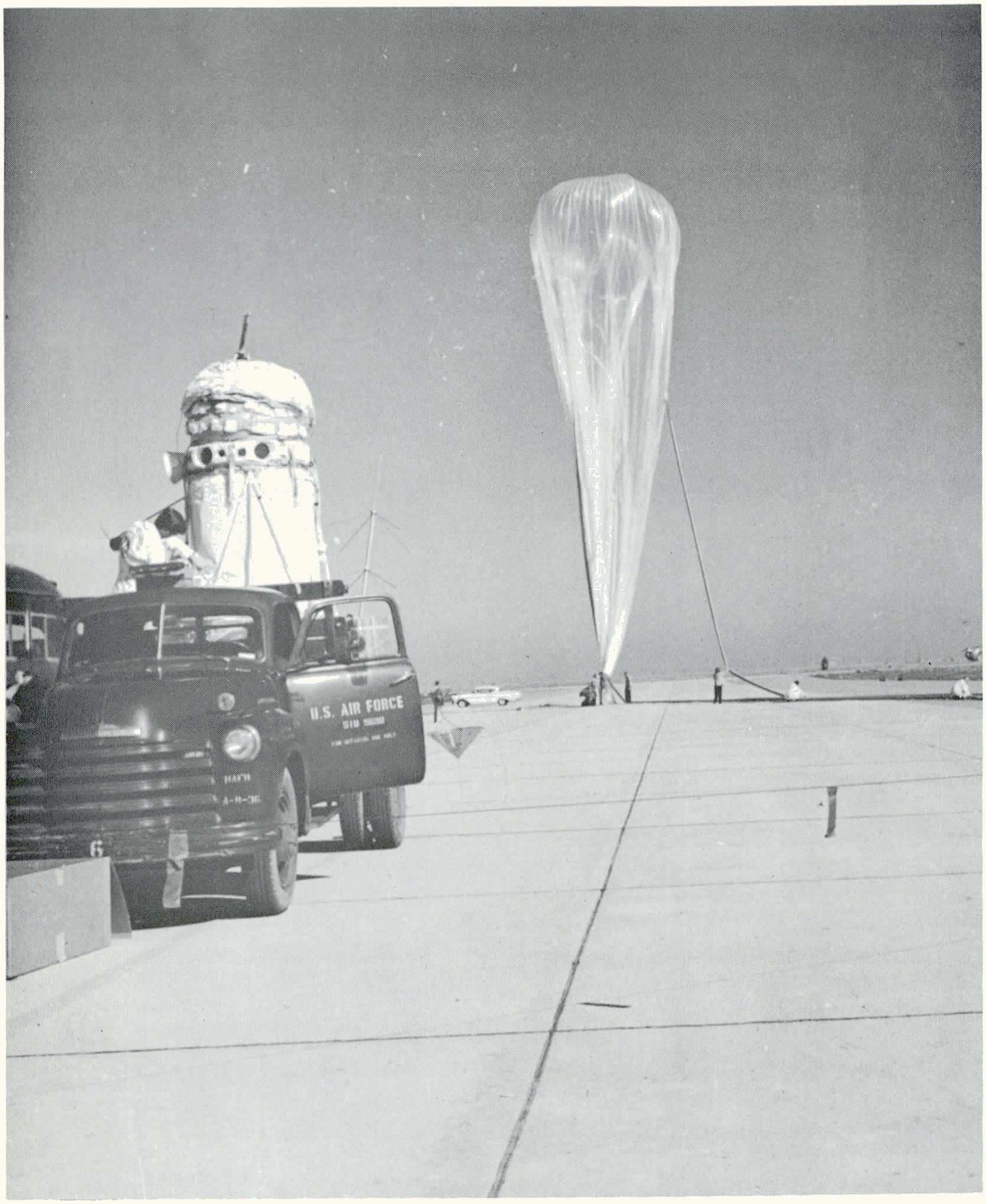
Starting with a group of experiments launched from Pierre, South Dakota, in October and November 1953, the Holloman Balloon Branch was no longer in charge of conducting the northern flights. Instead, flights were managed under contract by crews either of General Mills or of Winzen Research, Incorporated. However, the Balloon Branch continued to render special advice and assistance when needed, and it played a definite role in Project Man-High, the series of high-altitude manned ascents that brought the Aeromedical Field Laboratory's space biology balloon flights to a stirring climax in 1957-58.

Early in 1957 the Balloon Branch conducted low-level manned flights, for Man-High pilot training.[2] Among those who received the training was the Balloon Branch's own Mr. Bernard D. Gildenberg, who at one point was scheduled to serve as pilot on the Man-High (I) ascent--the same flight that was finally made by Captain Joseph W. Kittinger, Jr., after Gildenberg had been eliminated because of rib injuries. Both the first and second of the actual Man-High flights, in June and August 1957, were launched in Minnesota by Winzen Research crews, but some Balloon Branch personnel always went along to help. Indeed Mr. Gildenberg, one of whose specialties is to predict high-altitude winds with uncanny accuracy, was on hand each time as chief meteorologist for the Man-High project.[3]

The Man-High (III) flight of 1958 was also scheduled, originally, to be launched in Minnesota. However, the project was plagued by so many mishaps and delays that the period of suitable weather in the northern plains was over for the year before the Man-High capsule left the ground. By the end of September, the prospect was that the Man-High capsule--if it could still be launched at all in Minnesota--would drift into northern Canada or out over the Atlantic Ocean. The alternatives, therefore, were either to postpone the flight indefinitely or to launch somewhere else.

On 1 October the decision was made to move to Holloman. By 7 October, everything was ready at the new location, and the first attempted launch took place. Unfortunately, the launch operation was slowed by unexpected difficulties, and rising winds finally caused it to be aborted. Early the next morning, 8 October, the attempt was made again with complete success. The flight reached a near-record altitude of 99,900 feet, although it was terminated ahead of schedule that afternoon when the Man-High capsule became dangerously overheated.[4]

Even at Holloman, the Man-High (III) flight was launched by a Winzen crew, whose services had been contracted before the change in plans. An obvious drawback of the move, from the research standpoint, was the lesser cosmic ray exposure at the



Man-High (III) Balloon Launch: October 1958 more southern location. Yet Project Man-High, as it finally evolved, had to do with research on much more than just cosmic rays; and even in this one respect a flight from Holloman had potential value as a "control" experiment, whose results might suggest useful comparisons with those obtained at higher latitudes.

Moreover, Holloman had some other distinct advantages. The huge 3,000,000-cubic-foot Man-High balloon was launched at Holloman on the second try and, with a minimum of complications, from one of the regular base runways--whereas in Minnesota the plan had been to launch from a deep mine pit to obtain needed protection from surface winds. The favorable wind conditions prevailing at that time in the Holloman area were also responsible for the fact that the flight could go on for twelve hours and still land within the boundaries of the military test range, which greatly simplified both tracking and recovery. In addition, the tracking facilities of the dense range instrumentation network were far superior to what would have been available in the northern plains--or anywhere else for that matter. Flight altitude was measured by cinetheodolites from the ground, with accuracy of plus or minus twenty feet, whereas the official altitude-measuring equipment carried on the Man-High (II) flight, which had been supplied by the Fédération Aéronautique Internationale, was accurate only to plus or minus several hundred. All other services of the Air Force Missile Development Center were also made available as needed, naturally including a more extensive participation by the local Balloon Branch than on the two previous Man-High flights.

More prosaic than experiments with human or animal subjects, but considerably more numerous, have been the continuing flights launched at Holloman by the Balloon Branch to measure physical and chemical properties and phenomena of the upper atmosphere. Even the biological flights normally carried nuclear track plates to record the physical nature and intensity of cosmic radiation, although their primary objective was to discover possible effects of radiation on living specimens. In other cases, balloon flights have been launched in which direct cosmic ray measurements were the principal objective. Balloons have also been sent aloft to obtain data on the general composition of air samples; on concentrations of ozone, carbon dioxide, carbon fourteen, and nitrous oxide, at altitudes up to and exceeding 100,000 feet; on isotope ratios of oxygen and nitrogen; and on the presence of radioactive dust from nuclear blasts.[5]

One of the more unusual experiments in atmospheric chemistry was a so-called "artificial moonlight" test, designed to investigate the amount of natural sodium present at high altitude. This sodium at times causes illumination in the night sky; scientists therefore decided to eject a known quantity of sodium vapor from a balloon at roughly 89,000 feet, measure the illumination it caused, and then, from the relation they discovered between the amounts of sodium and illumination, calculate how much of the chemical must be present to cause the observed natural illumination. Like quite a few balloon flights, this test was a duplication of other experiments carried out with similar equipment but at higher altitude in Aerobee rockets. It proved successful; but when another balloon experiment was conducted, attempting to cause artificial illumination with nitric oxide instead of sodium, the equipment failed to function properly.[6]

Still other programs of upper-atmospheric research have used balloon-borne instruments at Holloman to study atmospheric sound channel transmission, by means of acoustically sensitive radio equipment; the solar constant and sky brightness, measured from altitudes in the neighborhood of 100,000 feet; solar spectra, using a "sun-seeker" device that keeps instrumentation pointed constantly at the sun; the earth's albedo as measured from 93,000 feet; atmospheric conductivity; and atmospheric thermal radiation. Two typical recent additions to the Air Force research efforts making use of Holloman balloon flights are Wright Air Development Center's Project 4603, Radio Propagation Research, which aims to measure refractive index, signal strengths, and temperature in the upper air; and the same Center's Project 5043, Infrared Seeker

Development, which needs accurate measurements of infrared backgrounds, at 40-100,000 feet.[7]

Thanks partly to these balloon-borne atmospheric and related studies, "the air over [the Air Force Missile] Development Center has been measured more thoroughly than any other portion of the earth's atmosphere."[8] Taken as a group, they can be regarded as an outgrowth of the earliest atmospheric sampling flights that began at Holloman as far back as September 1948, with rubber-type balloons. Those original flights were conducted for the former Watson Laboratories of Air Materiel Command. In later years the Air Force Cambridge Research Center has been the leading sponsor of this type of research at Holloman, although in many cases balloon flights were performed for academic scientists doing research under Air Force (normally Cambridge) contract. Denver, New York, Northwestern, Ohio State and Rhode Island Universities have all been represented in this manner.

Wright Air Development Center, in addition to requesting balloon flights for Projects 4603 and 5043, has sponsored sky brightness experiments, which were of special interest to the Vision Unit of its Aero Medical Laboratory.[9] The Atomic Energy Commission was responsible for high-altitude flights to measure carbon dioxide, carbon fourteen, and radioactive dust particles.[10] Last but not least, such items as cosmic ray track plates have often been "hitchhiked" by individual researchers. In this last

Intricate "Sunseeker" Payload Being Readied for Launch procedure, small research packages are accepted on a non-interference basis to be included on flights organized primarily for some other objective.

Items of experimental equipment have also been "hitchhiked" on Holloman balloon flights.[11] Indeed, one major category of flights by the Balloon Branch has been concerned with the development of instrumentation or other equipment, just as some of the very earliest balloon flights launched at Holloman were designed to test the tracking capability of radar equipment. Holloman balloons have continued to prove useful in radar testing and calibration, for range instrumentation development and for the Army's Nike missile project at White Sands Proving Ground (now White Sands Missile Range). The Balloon Branch has flown an Aerobee rocket beacon for environmental testing and Aerobee nose cone for calibration; guidance equipment for North American Aviation, Incorporated; and an optical target for film calibration, on behalf of the Flight Determination Laboratory (now Range Instrumentation Development Division), a White Sands (Army) agency that is physically located at Holloman Air Force Base and serves all users of the tri-service integrated test range.[12]

The same agency has used balloons for other purposes as well. A miss-distance indicator that it was developing for use in missile testing was held aloft by captive (tethered) balloon while high velocity aircraft rockets (HVARs) were fired in the vicinity. When this agency wanted to determine the optical properties of various special paints, it originated Project Stove Pipe, in which painted stove pipes were strung out beneath a balloon and studied through ground instrumentation.[13]

A flight was made for White Sands Proving Ground's Project 060021, in order to place experimental sounding equipment in the area of a missile as it re-entered the tropopause and then estimate the point of impact from the recorded shock waves. Still other experimentation in the field of sound detection, using the balloon as instrument carrier, has been performed for the Rome Air Development Center.[14]

A significant number of flights have been concerned with high-altitude photography, including the development of photo-reconnaissance systems. Holloman balloons have carried equipment to photograph the horizon from 95,000 feet, for missile attitude calibration by scientists of Aberdeen Proving Ground, and have obtained photographs of parachute motions at 90,000 feet for the Aeromedical Field Laboratory. More recently photographs were obtained, by means of a ballistic camera, of flares that were being flown and tested at high altitude for the Air Force Ballistic Missile Division of the Air Research and Development Command.[15]

Holloman balloon flights have played a part in the development of special instrumentation for the United States' satellite program. One example is the testing, from a balloon platform, of an all-sky camera being developed by the Air Force Cambridge Research Center for satellite tracking. Another is the publicized experiment of 27 August 1958 in which a balloon gathered basic research data on cosmic radiation and telemetered the information continuously for over eight hours to a ground station at the Air Force Missile Development Center. The cosmic ray data are valuable, but the special interest of the flight, which was launched at a distance of several hundred miles so that winds would carry it toward rather than away from the ground station, lay in its use of new telemetry techniques that are under development by a subsidiary of the Martin Company and will be applicable to satellite work.[16]

Some of the most interesting of Holloman balloon flights have been conducted in support of Project 6665, Plastic [formerly Constant Level] Balloon Components and Techniques, or simply Balloon Components for short. This is another activity of the Air Force Cambridge Research Center and represents a continuing effort to improve balloon equipment and techniques. It has led to flights at Holloman for testing of balloon navigation systems, as well as tests of the airborne deployment of extremely long (3,000-foot)balloon load trains. Balloons have even been successfully launched from aircraft at

Holloman as part of the same project effort. This technique is "being developed to satisfy a broad spectrum of Air Force requirements, both in the developmental support and operational areas." The principal application discussed so far is to use air-launched balloons for floating and gathering data in the "eye" of severe tropical storms. The balloon is packed together with its own cylinder of lifting gas and is carried and released in about the same manner as an ordinary bomb. After release, it inflates itself, and the gas cylinder then drops away.[17]

Not all flight testing of balloon techniques is carried on under Project 6665. Often a particular research and development project will have some special requirement for launching awkward or unusual payloads, for an unusually long or complex trajectory, or for some other technical innovation. In that case, the Balloon Branch may need to conduct preliminary test flights, perhaps with dummy loads, in order to perfect or merely check out the required new techniques; and such flights may simply be charged against the project in question. Furthermore, numerous flights have been made in connection with the development of balloon-borne missile targets and balloon-rocket combinations, two topics that will be discussed in detail in a later chapter.

A project that has required a great number of balloon launchings for the testing and improvement of flight techniques is one commonly referred to as High-Dive, an activity of the Aero Medical Laboratory of Wright Air Development Center. As originally conceived, the objective was to stage a series of live bailouts from a balloon gondola at altitudes ranging up to approximately 100,000 feet, as part of a study of high-altitude escape procedures. In practice, no manned experiment has yet taken place, but starting in the spring of 1953 the project was responsible for many gondola tests, dummy drops, and other preparatory flights at Holloman Air Force Base. These flights produced some important data on the suitability of different launch techniques and balloon vehicles for use with heavy loads (up to 3,000 pounds, not counting the balloon), as well as data on parachute operation, gondola performance, and free-fall characteristics of anthropomorphic dummies.[18] In addition, the Balloon Branch borrowed a blimp hangar at Moffett Naval Air Station, Sunnyvale, California, in November 1953 to conduct static tests of balloon performance for the Wright Field program. Three-mil polyethylene balloons of various designs were inflated in the hangar and observed for twenty-four hours. Data were obtained on balloon capacity and fatigue as well as on the functioning of balloon harness lines.[19]

High-Dive was relatively inactive, as far as Holloman test flights were concerned, during 1958. But as it turned out, the project plans were being revised, not cancelled. Indeed there are now several distinct Wright Field programs that seek to conduct human (and dummy) balloon flights at Holloman Air Force Base. One closely related effort goes under the name of High-Chair and aims to test the special X-15 ejection seat and allied equipment. The program is supposed to culminate in a manned seat-drop experiment from nearly 100,000 feet, with the test subject riding all the way up in the seat itself rather than in a balloon gondola. The Holloman Balloon Branch was scheduled to conduct several tests in the High-Chair program during 1958, but these were delayed while awaiting results of high-speed track tests of the X-15 escape system at Edwards Air Force Base, California, where track vibrations created some unexpected difficulties.[20]

The Air Force Missile Development Center's own Aeromedical Field Laboratory has also used balloons for work on aircraft escape problems. In the spring of 1957, the Balloon Branch conducted a rather unusual series of tests amid the dunes of nearby White Sands National Monument for Colonel John Paul Stapp, then head of the laboratory. "Jump balloons" were used to explore whether or not it would be feasible and advantageous for a pilot to ride an ejection seat all the way down to earth. Seats were attached to small plastic balloons that were filled with just enough gas to rise up off the ground at a push of the test subject's toe. The subject soared briefly upward, then came down again with the balloon simulating the role of a parachute.[21]

In late 1957 and early 1958, some more anthropomorphic dummies were dropped by the Balloon Branch for the Aeromedical Field Laboratory's Space Biology Branch, which was headed by Lieutenant Colonel Simons. These tests were related only indirectly to Project Man-High, the laboratory's manned-balloon program that in turn was an outgrowth of Simons' earlier space biology experiments with animal subjects. The dummies were attached to aircraft ejection seats. However, the purpose was not so much to evaluate escape equipment as to work out test procedures for the laboratory's Task 78502, Descent and Recovery (Re-entry), whose ultimate research program was supposed to feature the launching from balloons of special re-entry test vehicles. However, soon after the first wholly successful flight the task itself was abandoned, largely because of duplication of research objectives with those of the Aero Medical Laboratory at Wright Field.[22]

Then there have been various flights made for strictly miscellaneous objectives. Demonstration launches for Armed Forces Day are one example of this category.[23] Another is the series of flights made for Twentieth Century Fox in the fall of 1955 for inclusion in the motion picture "Threshold of Space," which also featured shots of rocket-track experiments at Holloman Air Force Base. The Balloon Branch's contribution to this endeavor included launches of a simulated manned gondola and high-altitude photographs taken by a balloon-borne camera. These shots included the picture of a warm front moving in, as seen from 93,000 feet, which was one of the most spectacular pictorial demonstrations of a weather system ever obtained---in color, too, and later converted by Fox to broad-screen cinema-scope.[24]

One flight with an extremely specialized, if slightly trivial, objective was performed for the Navy test facility at White Sands and has sometimes been referred to as "Man-Low." The problem was to remove a defective anemometer perched on top of a tall pipe beside the Navy's Aerobee tower. The pipe was held in place by guy wires, which precluded the use of scaffolding, and the Air Force doubted that a helicopter could hover in exactly the right position long enough to do the job. Therefore, the Holloman Balloon Branch sent a human "subject" (provided by the Navy) aloft by tethered balloon to bring the instrument down.[25]

Still another unusual flight sought to obtain accurate data on the altitude and latitude of two meteor stations operated by Sacramento Peak Observatory, an installation high in the Sacramento Mountains that is directed by Air Force Cambridge Research Center but attached to the Air Force Missile Development Center, at Holloman Air Force Base, for various support purposes. The cost of a ground survey would have been unduly high, so the solution was to send up a balloon, with flashbulbs attached, on a moonless night. This vehicle was positioned at 40,000 feet over a triangle formed by the two meteor stations--one at Sacramento Peak and one at Mayhill, New Mexico--plus a third point on the integrated test range; and, when the series of flashes went off, simultaneous photographic coverage from the three locations gave far more accurate data than those obtained in any previous survey.[26]

Finally, there was Project Moby Dick. This one activity antedated most of the projects discussed already, but it also required a broader range of services from the Holloman Balloon Branch than any other project, and it can thus properly be saved for last. It was initiated in 1951 by the Air Force Cambridge Research Center for the study of weather conditions above the tropopause, especially high-altitude winds. It was much the most ambitious balloon-borne research activity up to that time, requiring an unprecedented number of flights, constant-level trajectories of several days' duration, and instrument payloads too heavy for normal meteorological sounding balloons. Routine, daily launchings were envisaged, even in bad weather conditions. Cross-country tracking was needed too, although instrument recovery, while clearly desirable, was not essential.[27]

A great many organizations besides the sponsoring Cambridge

Center took part in this undertaking, among them Holloman Air Force Base. People of the local Balloon Branch, plus assorted newcomers and visitors from Cambridge, were commissioned to help in the development of flight techniques; to supervise the establishment of three new launch sites on the West Coast from which "operational" Moby Dick flights would be made; and to train other Air Force personnel who were to man those sites and to launch the actual research flights. Work at Holloman began in September 1951, and gathered momentum during the fall of that year with a series of test flights paying special attention to the improvement of launch techniques.[28]

Technical development flights continued through the greater part of the following year, 1952, and in the course of this work Holloman balloon specialists made some significant contributions to the art of research ballooning. The best known of these is the so-called "covered wagon" balloon launcher, permitting inflation and release of balloons in winds of twenty to twenty-five knots. The following chapter will discuss this and other technical innovations resulting from work on Moby Dick. At the same time, numerous records were being set even in the preparatory stages of the project. For instance, in February 1952 a Moby Dick balloon was successfully tracked northeastward from Holloman for ninety-two hours, setting what was then a new record for sustained constant-level flight.[29]

In the second half of 1952, equipment and personnel began moving from Holloman to the West Coast to set up the three operational launch sites. These were located at Edwards Air Force Base and Vernalis Naval Air Station, California, and Tillamook Naval Air Station, Oregon. The training phase of Holloman's Moby Dick effort naturally reached its peak when whole groups of officers and airmen of the Air Resupply and Communications Service--which had primary responsibility for manning these sites--were brought through for a course of lectures and demonstrations. Three distinct "classes" visited Holloman between September 1952 and February 1953 and were exposed to a curriculum that included "balloon history and theory," Moby Dick instrumentation, launch techniques, and such related topics as "base policies." Not all the graduating specialists went directly to the Moby Dick launch sites, although the main reason for setting up this special training program was to prepare Moby Dick launching personnel.[30]

Even before the final class of trainees left Holloman, the "operational" phase of Moby Dick began. From January 1953 to August 1954 640 Moby Dick balloons were launched either at the three original western sites or at additional launch points established later in Missouri and Georgia. This scale of operation caused the Commerce Department to fear that the project was a hazard to aircraft, but the Air Force replied that a Moby Dick balloon was really the safest vehicle in the air, setting the odds against one colliding with a plane at 800,000,000 to one. (The odds against an individual on the ground being hit by a descending Moby Dick instrument package were not quite so favorable.) In any case, the role of Holloman's Balloon Branch gradually tapered off after the start of the operational phase, although Holloman continued for a while to serve as a clearing house for recovered instrument packages and to perform other miscellaneous functions.[31]

In Project Moby Dick the Holloman Balloon Branch at one time or another performed every type of service related to research ballooning except to compile and publish the end product--a product that filled ten volumes with the title Compilations of Meteorologically Useful Data from Project Moby Dick.[32] However, Air Force Cambridge Research Center, which ~~inherited~~ no! originally was the Cambridge Field Station ~~the role~~ of Watson Laboratories, and their contractor New York University in developing balloon techniques for the United States Air Force, was the ultimate directing agency for the project. It has continued ever since to be the responsible agency within the Air Force for "development of plastic balloons and associated components."[33] This function is entrusted specifically to a subdivision of the Cambridge Center's Geophysics Research Directorate, whose scientists have also been the leading consumers, over the years, of atmospheric research data obtained on Holloman balloon flights.

The Cambridge Center further maintains a small balloon-launching capability of its own at the former Vernalis, California, Moby Dick launch site, but this is used essentially for development testing of balloon components and techniques rather than for actual research flights. It is not even used for all technical development flights sponsored by the Cambridge Center, since its major advantage--the fact that Cambridge technicians have the Vernalis balloon facility all to themselves--is offset by the lack of any extensive recovery organization or range instrumentation. Thus Cambridge has conducted a significant portion of its technical development flights at Holloman, which offers a highly developed recovery capability, direct access to the world's most thoroughly instrumented testing range, and other conveniences besides. An obvious example is the series of Holloman test flights in the Cambridge Center's Balloon Components program.[34] Indeed, for launch, tracking and recovery of research and development balloon flights the primary Air Force agency continues to be Holloman--or more precisely, the Balloon Branch of the Air Force Missile Development Center.

Other organizations that are regularly engaged in flying research balloons are the United States Navy, which even provides launch facilities on shipboard; the University of Minnesota, which maintains a balloon-flying capability for the sake of its own cosmic ray physicists and has also engaged in basic research and development on balloon performance and techniques under contract for all three armed services; and the private firms that manufacture plastic balloons, namely, General Mills and Winzen Research of Minneapolis, Raven Industries of Sioux Falls, South Dakota, and the G. T. Schjeldahl Company of Northfield, Minnesota.[35] New York University, however, is no longer active in the balloon-flying business.

The private balloon firms conduct flights under contract for a variety of customers, including both Navy and Air Force agencies if military balloon organizations cannot handle the workload, or if for any special reason contract arrangements seem advisable. Their balloon crews have even worked at Holloman for the Man-High (III) flight. Several years earlier, General Mills sent a crew to Holloman to conduct certain balloon launches in connection with work the company was doing under contract for Wright Air Development Center.[36] These are unusual examples, however. And, though private contractors sometimes expedite matters simply by avoiding government red tape, they cannot expedite such things as weather, in which sun-baked New Mexico has a distinct advantage over most other locations for balloon-flying purposes. According to Holloman estimates, moreover, contract services cost about twice as much on the average as the same services performed by the local Balloon Branch. In this calculation allowance is made for the pay of Balloon Branch airmen, for aircraft and ground vehicle operation, but not for the fixed costs and overhead of a specialized test center such as Holloman, which would be virtually as great even if the Balloon Branch did not exist.[37]

One more Air Force organization with a special mission in the field of balloon operations is the 1110th Balloon Activities Group. Formerly known as the 1110th Air Support Group, this unit is a dependency of Headquarters Command but is centered at Lowry Air Force Base, Colorado, where it maintains a plotting and control facility for "coordinating Air Force balloon activities." It also has its own detachments "to conduct independent balloon operations" as and where directed. Among other things, it finally took over the Moby Dick program, and it has continued down to the present to conduct Moby Dick-type balloon operations for long-range weather reconnaissance and similar purposes.. But it does not perform specialized balloon support of research and development testing, and thus in practice its functions do not seriously overlap those of the Holloman Balloon Branch.[38]

The precise relationship between the local Balloon Branch and the balloon specialists of Air Force Cambridge Research Center is somewhat more complex. There has been close and cordial cooperation among the individual members of the two organizations, but the Holloman unit has not always been satisfied with the assignment to Cambridge of exclusive Air Force responsibility for balloon systems development. In 1953, in fact, the Balloon Branch submitted a formal proposal for a new development project to be conducted under its own immediate direction, with research and development funds, and entitled Balloon Facility Development. On later occasions, too, attempts were made to enlarge the official mission of the Balloon Branch in much the same direction. But always the request has been turned down at Headquarters, Air Research and Development Command on the ground that development was a Cambridge affair, whereas the Balloon Branch was to fulfill a basic support function, merely performing flight services as required for approved projects.[39]

From the standpoint of avoiding duplication, the attitude of higher headquarters was perfectly logical. The only trouble is that the Cambridge balloon staff, as its own members readily admit, has neither the time nor the resources to take care of all the requirements for technical development and assistance arising within the United States Air Force. Accordingly, some admittedly valid requests must go unfilled; and at Holloman, at least, the Balloon Branch has then tried usually to get the job done itself, by one means or another. An instructive example is the introduction of target balloons, to be discussed in detail in the next chapter. This was clearly balloon systems development, and Cambridge certainly helped. But the major part of the effort was accomplished through independent work at Holloman, by the Balloon Branch, with some additional assistance from the Hughes Aircraft Company.[40]

For that matter, as already mentioned, a certain amount of technical development is necessarily carried on at Holloman in connection with many research balloon flights. If a special need arises which Cambridge cannot meet in time, then the development of procedures or equipment is likely to be carried out at the local level, with local people and resources, and with "support" funds. If the work can be classed as merely "improving the Balloon Branch facility"--that is, perfecting its standard balloon-flight services--then no conflict of jurisdiction arises. But it is often hard to draw the line, and if the development required is a minor one there is really no reason to bother Cambridge in the first place. And so, in practice, a quite satisfactory relationship has grown up: less clear-cut than pure logic or official mission statements would require, but amply realistic.

The mere fact that the Balloon Branch is drawn into a limited amount of independent development work should not, of course, obscure its primary function as a support organization.

In this capacity, it has played an essential role not only in the development of balloon systems, as carried on principally under auspices of the Cambridge Center itself, but also in the collection of basic and applied research data for both Air Force and other organizations. The versatility of the plastic balloon for use in research and development testing is one major explanation for the post-war renaissance of balloon operations, and nowhere has this versatility been more fully exploited than at the Air Force Missile Development Center. It will be documented further in the following chapter.

NOTES

1. For a fuller account of these flights, see The Beginnings of Research in Space Biology at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1946-1952 (Historical Division, AFMDC, January 1958), pp. 14-21 and Major Achievements in Space Biology at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1953-1957 (Historical Division, AFMDC, March 1958).

2. High Altitude Test Division, AFMDC, "Historical Data...1 January-31 March 1957," p. 4.

3. Interview, Mr. Bernard D. Gildenberg, Chief, Balloon Control Section, Balloon Branch, AFMDC, by Dr. David Bushnell, AFMDC Historian, 24 September 1958; Alamogordo Daily News, 2 June 1957.

4. On the Man-High (III) flight, statements are based on personal observations of Dr. Bushnell, on 7 and 8 October 1958, and discussions with personnel of the Balloon Branch and members of the scientific "panel of experts" that came to Holloman Air Force Base to take part in the experiment.

5. Bernard D. Gildenberg, "A Brief Summary of Seven Years of AFMDC Balloon Branch Experiments," September 1958; HAFB, Quarterly Progress Summary Report on U.S.A.F. Guided Missile Test Activities (slightly varying titles), July-September 1950 to April-June 1952, passim; 6580th Missile Test Group, HADC, Monthly Report on USAF Guided Missile Test Activities at Holloman Air Development Center, October 1952 to September 1953, passim; High Altitude Test Division AFMDC, "Historical Data" reports, passim.

6. Interview, Mr. Gildenberg by Dr. Bushnell, 24 September 1958; High Altitude Test Division, "Historical Data...1 January-31 March 1957," p. 3.

7. Sources cited in footnote 5 above; Major Lawrence M. Bogard, Chief, Balloon Branch, AFMDC, Center Briefing 18 August 1958 (prepared tables and summaries); R & D Project Card (DD Form 613), Project 5043, 8 July 1957.

8. History of Air Force Cambridge Research Center, Vol.

XXII (January-June 1955), Part 1, p. 161.

9. 6580th Missile Test Group, Monthly Report...August 1953, p. 34.

10. Gildenberg, "Brief Summary of Balloon Branch Experiments;" Project R-114-13 (MX-1277), Balloon Flights for Atomic Energy Commission, Weekly Test Status Report, 12 April 1955.

11. For instance, experimental altimeters (Lt. Charles H. Steinmetz, Experimental Material Flown on Aeromedical Field Laboratory Balloon Flights 46 Through 71, HADC Technical Note 56-2, pp. 6, 10).

12. Gildenberg, "Brief Summary of Balloon Branch Experiments."

13. Balloon Branch, Test Report on the Parmis Miss-Distance Indicator, Number 1, 3 May 1956; Test Facilities Division, HADC, "Semiannual Progress Report," July-December 1955, p. 6.

14. Interview, Mr. Gildenberg by Dr. Bushnell, 24 September 1958; High Altitude Test Division, "Historical Data...1 April-30 June 1957," p. 3; Bogard, Center Briefing 18 August 1958, p. 5.

15. Gildenberg, "Brief Summary of Balloon Branch Experiments;" High Altitude Test Division, "Historical Data...1 April-30 June 1958," p. 4.

16. Interview, Mr. Gildenberg by Dr. Bushnell, 26 September 1958; Holloman Rocketeer, 19 September 1958; below, p. 96.

17. R & D Project Card (DD Form 613), Project 6665, 1 January 1958; Management Report (ARDC Form 111), Project 6665, 2 July 1958; Test Facilities Division, "Historical Report," January-March 1956, p. 2; High Altitude Test Division, "Historical Data...1 October-31 December 1956," p. 4; Gildenberg, "Brief Summary of Balloon Branch Experiments."

18. Major Achievements in Biodynamics: Escape Physiology, at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1953-1958 (Historical Division, AFMDC, June 1958), pp. 30-32; High Altitude Test Division,

"Historical Data...1 July-30 September 1957," p. 3; Everett E. Beson, "Design Considerations of a Balloon-Borne Pressurized Capsule for High Altitude Bailout Study," Journal of Aviation Medicine, Vol. 29, pp. 516-525 (July 1958).

19. Bernard D. Gildenberg, Capacity and Fatigue Tests on Three Mil Polyethylene Balloons (HADC Technical Note 55-4, June 1955).

20. Major Achievements in Biodynamics: Escape Physiology, pp. 31, 32; interviews, Maj. Bogard by Dr. Bushnell, 24 September and 29 October 1958.

21. Major Achievements in Biodynamics: Escape Physiology, p. 29; Alamogordo Daily News, 21 April 1957.

22. Research Accomplishments in Biodynamics: Deceleration and Impact, at the Air Force Missile Development Center, Holloman Air Force Base, New Mexico, 1955-1958 (Historical Division, AFMDC, October 1958), pp. 16-19; interview, Lt. Col. David G. Simons, Aeromedical Field Laboratory, AFMDC, by Dr. Bushnell, 13 January 1959.

23. Cf. High Altitude Test Division, "Historical Data...1 April-30 June 1957," p. 3.

24. Test Facilities Division, "Historical Report," July-December 1955, p. 10; interview, Mr. Gildenberg by Dr. Bushnell, 25 September 1958; Major Achievements in Biodynamics: Escape Physiology, pp. 14, 31.

25. Interview, Capt. Milton M. Hopkins Jr. and Mr. Ernest F. Sorgnit, Aero Research Administrator, High Altitude Test Division, by Dr. Bushnell, 23 September 1957.

26. USAF Research & Development Quarterly Review, Summer 1956, p. 68; interview, Capt. Hopkins and Mr. Sorgnit, 23 September 1957.

27. History of Air Force Cambridge Research Center, Vol. XV (July-December 1951), Part 1, p. 40, Vol. XX (January-June 1954), Part 1, pp. 101-109, Vol. XXII (January-June 1955), Part 1, p. 171; Quarterly Report on USAF Guided Missile Test Activities at Holloman Air Force Base...April-June 1951, p. 39.

28. History of Air Force Cambridge Research Center, Vol. XV July-December 1951), Part 1, pp. 41, 42; Quarterly Report on USAF Guided Missile Test Activities at Holloman Air Force Base...July-September 1951, pp. 31, 39, 40; Summary Report Project Moby Dick, Holloman Air Force Base ...6 November-20 November 1951.

29. Summary Report on Project Moby Dick Covered Wagon Balloon Launcher Development and Test Results 6 December 1951 to 15 September 1952 (HAFB, 12 December 1952); History of Air Force Cambridge Research Center, Vol. XVI (January-June 1952), Part 1, p. 35.

30. Historical Report...Holloman Air Force Base, New Mexico, 1 September 1952-31 December 1952, p. 150; 6580th Missile Test Group, HADC, Monthly Report on USAF Guided Missile Test Activities at Holloman Air Development Center... October 1952, pp. 22, 26, Monthly Report...November 1952, p. 28, and Monthly Report...January 1953, p. 36; 6580th Missile Test Group, Summary Report Training of ARCS Personnel in Balloon Launching Techniques (HAFB, 15 May 1953).

31. History of Air Force Cambridge Research Center, Vol. XX (January-June 1954), Part 1, pp. 104-106 and Part 2, Appendix 60; 6580th Missile Test Group, Monthly Report... March 1953, p. 38 and Monthly Report...May 1953, p. 34; Geophysics Research Directorate, AFCRC, "Pre-Briefing Report No. 2, For the Panel on Geophysical Research, Scientific Advisory Board, USAF," October 1953.

32. History of Air Force Cambridge Research Center, Vol. XX, Part 1, p. 108.

33. Ltr., Brig. Gen. Marvin C. Demler, Asst. Dep. Cmdr./ Technical Operations,ARDC, to Cmdr., WADC, subj.: "Plastic Balloon Vehicles," 29 April 1955.

34. Interview, Mr. Charles Tilton and Mr. Thomas W. Kelly, Atmospheric Devices Laboratory, AFCRC, by Dr. David Bushnell, 8 July 1958.

35. Interviews, Prof. Edward P. Ney, Department of Physics, University of Minnesota, and Mr. Joseph C. Groth, Winzen Research, Inc., by Dr. Bushnell, 1 July 1958; interview, Mr. Gildenberg by Dr. Bushnell, 12 January 1959.

36. Ltr., Maj. Richard H. Braun, Chief, Balloon Development Laboratory, AFCRC, to Cmdr., AFMDC (attention: Dr. Bushnell), subj.: "Air Force Missile Development Center Balloon Launching History," 15 January 1959.

37. Bogard, Center Briefing 18 August 1958, p. 7; interview, Maj. Bogard by Dr. Bushnell, 24 September 1958.

38. Air Force Regulation 23-7, 23 May 1957; Headquarters Command, USAF, Regulation 20-3, 1 July 1957; History of Air Force Cambridge Research Center, Vol. XX, Part 1, Appendix 60.

39. Interview, Maj. Milton M. Hopkins, Jr., Chief, Operations Section, Balloon Branch, by Dr. Bushnell, 7 May 1958; ltr., Col. Clarence L. Elder, DCS/O, HADC, to Cmdr., ARDC, subj.: "Holloman Air Development Center Annual Progress Report," 31 July 1954.

40. Interview, Maj. Hopkins by Dr. Bushnell, 7 May 1958; interview, Mr. Tilton and Mr. Kelly by Dr. Bushnell, 8 July 1958.

CHAPTER III

BALLOONS AS MISSILE TARGETS AND ROCKET LAUNCHERS

The use of balloons as missile targets and the development of balloon-rocket combinations are two areas in which the work of the Balloon Branch corresponds most closely to the official title and primary mission of the Air Force Missile Development Center. Target balloons represent a significant portion of the total launched by the Holloman unit since 1955 and are, moreover, a distinctive local contribution to the art of missile testing. Use of the balloon for a rocket-launching platform goes back some years earlier, and is primarily a Navy development. But the Air Force Missile Development Center has still made important contributions to this highly promising branch of rocket technology.

The Development of Target Balloon Systems

The entry of the Balloon Branch into the field of missile testing was a direct result of the Air Force's "continuing requirement for air-to-air missile targets at altitudes in excess of 40,000 feet."[1] At the start of 1955 this requirement was already becoming acute, and drone targets then in use simply lacked the necessary altitude capability. Obviously balloons could not compete in speed with even the slowest of drones, but they could easily go two to three times as high. A precedent for their use as targets was the development of parachute targets, which have been extensively used by all three services on the integrated White Sands Missile Range. But most parachute targets have needed an aircraft to drop them, and their altitude capability was limited accordingly. The Navy's recently developed Pogo-Hi parachute target, which is rocket-launched from the ground, can go high enough but is limited in its duration at altitude and in its payload capability.

Mr. Gilbert Moore of the New Mexico College of Agriculture and Mechanic Arts at Las Cruces (now New Mexico State University) was apparently the first to propose use of the balloon as an alternate for the parachute target. The idea was taken up by the Hughes Aircraft Company, which maintains a test facility for its Falcon missile program at the Air Force Missile Development Center.[2]

Specifically, Hughes proposed early in 1955 the development of a suitable balloon target for the Falcon program, and this led to a successful endeavor in which several different organizations took part. The Air Force Cambridge Research Center, with over-all responsibility within the Air Force for development of new balloon systems, was naturally consulted, and it was able to provide important help. But the Cambridge

Center's balloon specialists could not give their full attention to this one problem, which in any case had to be worked out chiefly in the light of special local conditions. The Hughes Company also took part, for instance providing certain supplies and equipment that no Air Force agency working through channels could have obtained as easily. In the last analysis, however, most of the effort was accomplished by the Balloon Branch itself.[3]

The original objective was to develop a target for use with radar-guided missiles, and standard balloon materials had poor radar-reflective qualities. However, a possible solution was to apply laminated aluminum to the thin polyethylene plastic of a balloon cell. Laminated balloons had been made before for other specialized applications, and Air Force Cambridge Research Center prepared specifications for applying the technique to balloons of proper size and shape for target use. An alternative method, introduced later, was to use an ordinary polyethylene balloon with a radar beacon attached to it as payload.[4]

The really critical problem, however, was not to provide the target itself but to get it to a particular point above the missile testing range, and at just the right time for a particular mission. This was an extremely intricate maneuver, requiring accurate prediction of all the factors--especially wind velocity and ascent rate--that affect a balloon trajectory. Once these factors were established, it would be necessary to calculate the exact point on the ground from which a free-floating balloon should be launched in order to make its appointed rendezvous with a Falcon missile. Three things that made a successful outcome possible were the accumulated experience of the Balloon Branch in flight operations, the exceptional regularity of Holloman area weather conditions, and the reservoir of data on those weather conditions built up during nearly ten years of military research and development testing.

Finally, after a series of experimental target launchings, the first use of a balloon target in missile testing was accomplished on 26 August 1955. The balloon was thirty-one feet in diameter, and like other target balloons was of polyethylene plastic. In this case it was laminated with aluminum foil. Launch had to be off-range, to permit ascent into the desired area. In fact the balloon started out near the intersection of United States Highways 54 and 70, just outside Alamogordo on the way to Holloman Air Force Base, with a police road blockade holding back traffic at the moment of launch. It reached a mean floating altitude of 52,099 feet, as compared with planned altitude of 51,000, and passed only 1.2 miles horizontally from the center of a preselected target area.[5]

Soon afterward, work began on a balloon target system for missiles using infrared guidance. This involved hanging flares beneath a balloon and igniting them by radio command signal, and it was a more complicated operation. The awkward load train used with early infrared target balloons posed serious difficulties at the time of launch, which were overcome by such methods as tethering the balloon until its load train was entirely free of the ground. Other difficulties were likewise overcome, and before long the infrared targets were in operational use.[6]

Both radar- and infrared-type balloon targets were originally developed for the Hughes Falcon project, but their obvious advantages caused them to be adopted for use in some other missile projects too, including the Air Force Sidewinder project. The highest target flights to date have been in the neighborhood of 70,000 feet, which still does not fully exploit the superior altitude capability of balloons as compared with other target systems. Balloons are also much easier to obtain--and more expendable--than high-performance drone targets. They are relatively inexpensive, since the "operational" net cost of a radar target flight is less than $1000 and that of an infrared balloon target slightly more than $2000.[7] What is more, the balloon vehicle functions as a convenient carrier for miss indicators and other test instrumentation.[8]

In fact, balloons have been used for some target flights in which high-altitude capability was not required at all. The better to perform low-altitude target missions, the Balloon Branch at one point experimented with a helium-air mixture to lower the floating altitudes of existing manufactured balloons. It has also requested Air Force Cambridge Research Center to investigate balloon designs suitable for low-floating target trajectories.[9]

The secure place that balloon targets have won in missile testing is shown by the ratio of target flights to total polyethylene balloon flights launched by the Holloman Balloon Branch. In fiscal year 1955 they were four out of a total of seventy; in fiscal 1956, seventy out of 132; in fiscal 1957, 164 out of 242; and in fiscal 1958, 151 out of 215.[10] Some of the target flights, including all those listed for fiscal year 1955, were experimental flights launched for the development or improvement of balloon target systems; but most were operational flights, and a sizeable majority of these provided acceptable targets. For the first 154 target flights, up to December 1956, the rate was sixty-five percent successful.[11] However, this rate has sometimes fluctuated widely. There have also been balloons that failed to get off the ground, and target missions cancelled prior to launch because of difficulties of balloon support.[12]

Problems are especially numerous in the winter months. Roughly from October to May prevailing winds make it necessary to launch target balloons some fifty to ninety miles west of

Holloman Air Force Base. This means that they are launched not merely off-range but usually in the rough, sparsely-settled country west of the San Andres Mountains. Remote, unfavorable launch sites thus combine with the longer target trajectories to make operations unusually difficult during this part of the year. There have been cases when the ideal launch site was wholly inaccessible, and either the mission had to be cancelled or a less suitable point used instead. Or perhaps the chosen site simply could not be reached in time by the launch crew, especially if there was some late change in project plans.[13]

The remote-launch procedure, though not an entirely new idea,[14] first came into regular operational use for target flights. Since then it has been used increasingly for research flights as well, when special positioning over the range is desired for instrumentation, mission safety, or other reasons. The uncertainties and inconveniences inherent in the procedure were reduced somewhat--though scarcely eliminated--by organizing what is almost a miniature Balloon Branch in Truth or Consequences, New Mexico, and using that city as a central base for off-range operations. During the off-range launching season, crews would normally arrive on Monday and remain until Friday. Originally they took their heavy equipment back and forth with them each week, but starting early in 1958 vehicles and launch equipment were left over the weekend at the Truth or Consequences police station, thus saving both time and wear and tear.[15]

One thing that cannot be saved is a certain amount of duplication in both personnel and material resources made necessary by remote-launch operations. In fact the mere addition of target flights--whether launched remotely or otherwise--to its workload was enough to put the Balloon Branch in a difficult situation with respect to manpower.[16] The manpower problem was ultimately overcome, and in fact gave way to a manpower surplus for the Balloon Branch during the first part of 1958. But sharp manpower cuts ordered later in the year are supposed to be absorbed mainly at the expense of target operations.[17]

The Inspector General of Air Force Missile Development Center, in a special study of balloon operations completed early in 1958, pointed out further problem areas affecting target flights. One of these was poor performance of a special radio command package that was supplied, along with heavy launch equipment and other material assistance, by the Hughes Aircraft Company. This difficulty was corrected in large measure when the Balloon Branch developed another package of its own for target missions.[18] Some poor coordination was found, also, in the matter of balloon target scheduling, as insufficient attention was sometimes paid to the Balloon Branch's own capability for a particular day and type of mission. It has even happened that the Balloon Branch became aware that it was expected to provide a missile target only by reading about it in the published daily range schedule.[19] Despite temporary lapses, however, the over-all trend from 1955 to the present has been toward increasing proficiency in balloon target operations. Thus there were numerous complaints over the prospect of a cutback in these operations, as a consequence of recent reductions in Balloon Branch funding and authorized manpower. No fully satisfactory alternative yet exists for getting missile targets to high altitude.[20]

The Hi-Fly Target Development

If altitude capability was the most conspicuous single advantage of balloon targets, the most conspicuous drawback was their relative lack of speed. To be sure, the very slowness of a balloon target can have compensating advantages. Such a target dutifully remains in place, more or less, if for any reason a missile test should be delayed. When wind conditions are right, it is theoretically possible for the same balloon target to remain in place for different tests both morning and afternoon. On the other hand, the notion of a balloon target as just hovering over the range, waiting for some missile to come and shoot it down, is not always technically accurate. Even after they reach floating altitude, balloons move with the air currents, and on occasion target balloons have been observed drifting along at a healthy clip of more than 100 knots.[21]

Nevertheless, balloon targets were often seriously limited in their usefulness by lack of speed. The Sidewinder project office at the Air Force Missile Development Center, headed by Captain Thomas U. McElmurry, therefore desired to work out an improved system in which the balloon would serve essentially as launching vehicle for a high-velocity target rocket.[22] Target rockets in missile testing are most often fired straight ahead of the same aircraft that carries the missile, thus giving the latter an unfair advantage. By launching the rocket from a balloon, the missile could be made to work harder, and neither would target altitude be dependent in any way on the aircraft ceiling.

The work of developing the proposed target system--which came to be known as Hi-Fly--was essentially an "in-house" effort by Captain McElmurry's Sidewinder Branch, plus the Fighter Missile Test Branch and the Evaluation Division, which are other units of the Center's Directorate of Aircraft Missile Test. There was no missile contractor company to help out, since the Sidewinder project is entirely military, with the assigned task of testing the Navy-developed Sidewinder missile for Air Force use. Higher headquarters originally gave no money or other assistance, and the Holloman Balloon Branch, while providing a command package and offering help on any problems related to the balloon phase of the operation, was in no position to construct other elements of the target system.

Direction of the Hi-Fly target development was assigned at first to Lieutenant Edward J. Bauman of the Evaluation Division, but numerous other officers and airmen pitched in with enthusiasm, often as an extra-duty chore. Design standards were influenced not merely by the mission to be performed but also, for lack of funds, by what odds and ends happened to be lying around at Holloman available for scrounging. The propulsion system turned out to be the 2.75-inch-diameter high-velocity aircraft rocket (HVAR), because there was a surplus of these on base. The balloon-borne launching platform was originally made of plywood. Finally, on 19 February 1958, the first air launch was attempted. It was not successful, but the system still showed promise.

Over the next few months, as work on Hi-Fly continued, the design improved steadily. Lieutenant Bauman left Holloman, but he was succeeded as Hi-Fly project officer by Master Sergeant Elmer B. Tixier, Noncommissioned Officer in Charge of the Fighter Missile Test Branch. Tixier was succeeded in turn by Lieutenant

Gerald E. Weinstein, another member of the Evaluation Division, although in fact Tixier also worked closely on Hi-Fly with both Bauman and Weinstein. Many airmen continued to help, including Staff Sergeant James McClure, who designed an aluminum launch platform ("McClure launcher") in place of the earlier plywood contraption. Finally, on 17 July, there was the first "perfect" test, from the standpoint of target performance; and on 5 September the first successful firing of a Sidewinder missile against a Hi-Fly target.

As now developed, the target is an aluminum-winged, dart-shaped affair. It is automatically positioned by a compass which keeps it pointing true north until ready to be fired. The Hi-Fly system includes two flares that are lit by command signal just before the Sidewinder missile is launched from the test aircraft. Since the Sidewinder uses infrared guidance, it begins to home in on the heat generated by the flares--at which point the target itself is fired away on a ballistic trajectory, and the missile (if all goes well) corrects its own trajectory to follow after.

Though further improvements can be expected, the Hi-Fly system is now operational, with a capability even for providing three targets on a single mission. Once its practicability was established, moreover, material support was obtained for the target program. No great amount of money is involved, since Hi-Fly resembles other balloon target systems in being quite inexpensive; but at least there is now a backlog of Hi-Fly equipment in readiness for future flights. So far, Hi-Fly has been excepted from the general Balloon Branch cutback in target operations. Indeed, the Balloon Branch's plastic flight number 1000, on 18 December 1958, was a successful Hi-Fly mission.[23]

Balrok

The Hi-Fly target system is only one of the balloon-rocket combinations that have been flown by the Balloon Branch at the Air Force Missile Development Center. Other balloon-launched rocket systems, however, have been intended for research rather than for target use and represent a type of activity in which the Balloon Branch has long been interested, but in which the United States Navy is the acknowledged pioneer. As mentioned in the first chapter of this history, some of the Navy's earliest experimentation in this field received miscellaneous support from units at Holloman Air Force Base. The end result was the Rockoon system, which has since attained operational status and has played a major role in recent upper-atmosphere research.

Navy Rockoons have carried scientific instruments, especially for cosmic ray research, to altitudes much higher than those attainable with balloons alone. At the same time, launching from a balloon platform above the bulk of the earth's atmosphere has brought great economy in rocket fuel requirements and generally improved rocket performance. Peak altitude with a payload of thirty pounds is normally 300,000 feet. Launchings have been made from shipboard, away from inhabited land areas and from commercial air and sea lanes. This procedure allows a wide variety of test sites and serves to minimize the danger to innocent bystanders, in case a rocket should go astray. A ship can also minimize surface wind conditions at the time a balloon is launched by moving in the same direction as the wind and with the same velocity. On the other hand, tracking is more difficult at sea than on a land range, and recovery of any part of the balloon-rocket combination is next to impossible.[24]

So far, the closest Air Force approximation to the Navy's Rockoon activity has been the ill-fated Operation Farside. This project was sponsored by the Air Force Office of Scientific Research and sought to fire a research rocket from a balloon to an altitude of about 4,000 miles. Six attempts were made, in September and October 1957, with a General Mills crew providing the necessary balloon launch and flight services. In only one case were both balloon and rocket performance more or less satisfactory. The tests were conducted from Eniwetok atoll rather than from shipboard, but for most purposes this was about the same as a high-seas launching.[25]

The Air Force Missile Development Center's prime contribution to balloon-launched research rocketry--a program that came to be known as Balrok--was rather different in some respects from both the Navy program and Operation Farside. Probably the most important difference was that flights were to be conducted over a land testing range. This meant better possibilities for instrumentation, tracking, and recovery but also required greater precision in balloon and rocket performance because of safety considerations.

Balrok was conceived as a means of increasing the performance range of "a large variety of rockets, depending on test requirements."[26] However, the two-stage HTV (hypersonic test vehicle) was the rocket selected for "proof testing," and also the one that has figured in most preliminary studies and discussion of the Balrok program. The HTV was developed by the Aerophysics Development Corporation, under contract with the Aeronautical Research Laboratory of Wright Air Development Center, as "a low-priced rocket-propelled carrier for test instrumentation, upper air research and [producing] hypersonic flow conditions."[27] Its unique quality is the almost instantaneous achievement of hypersonic velocity, even at relatively low altitudes.

The HTV was brought to Holloman for test firings by the Center's Rocket Sonde Branch starting in the fall of 1954. It found an enthusiastic reception among the Center's scientific staff, which was then headed by Dr. Ernest A. Steinhoff as Chief of the Technical Analysis Division. The Center hoped to establish a regular HTV facility for hypersonic research testing, similar to the balloon and Aerobee facilities already existing, and in March 1955 it initiated a new Project 6879 to be entitled Hypersonic [Free] Flight Testing. The project as written was concerned principally with support of HTV ground firings, but one of its tasks had to do with development of a balloon-launch capability for the HTV.[28]

The project, with this task included, was finally approved by Headquarters, Air Research and Development Command to begin work in fiscal year 1957;[29] but the first real effort on Balrok was delayed even after 1 July 1956 when the fiscal year began. Captain Gerald J. Klecker, who had promoted the Balrok concept as head of the Center's Test Facilities Division, was now in a new assignment. Mr. Ernest F. Sorgnit, who had worked closely with him in this matter, was on "loan" from division level to a higher echelon, helping work out organization problems involved in setting up the new Directorate of Ballistic Missile Test of which the Test Facilities Division (renamed High Altitude Test Division) formed part.

In due course, however, Sorgnit returned to active service with the Division and got down to work on Balrok. His chief move was to let a contract with Aerophysics Development Corporation for a "design study...of balloon-rocket launching facility." This contract--AF 29 (600)-1202--was initiated on 12 October 1956, with justification emphasizing the potential role of Balrok flight-testing in the Air Force's ballistic missile program. The contract was signed on 25 February 1957, and the finished report was dated 30 August of the same year.[30]

The Aerophysics contract called for preliminary design of a balloon-borne rocket-launching platform, plus a study of the balloon handling techniques, command systems, and all equipment needed for "launching solid-propellant, single and multistage rockets weighing up to 2,500 lbs. within the region of 40,000 to 100,000 feet over the Integrated HADC-WSPG Range."[31] For reasons of both safety and instrumentation, the actual rocket trajectory was to be aimed at a particular target area on the range, and so accurate balloon positioning had to be combined with accurate control of the rocket's launching attitude. It was assumed that off-range balloon launchings would often be necessary, which was an added complication. However, the Aerophysics report concluded that Balrok operations were perfectly feasible, and it offered a set of technical recommendations and design criteria. Some sections were naturally more useful than others, and some have already been superseded by state-of-the-art developments, but by and large the report was a valuable contribution.[32]

Aerophysics later prepared a separate classified study, dealing with possible classified applications of the Balrok system.[33] Still another contract effort related to Balrok was a study entrusted to the Midwest Research Institute "to determine the type of direction finding system to be used for azimuth determination of high-altitude balloon-borne transmitting equipment."[34] This was a matter of obvious importance for tracking and recovery of balloons in general. However, it would be of very special importance in dealing with any balloon whose cargo was a "hot" research rocket, above all when the balloon was off-range, and on this basis the Midwest Research contract was funded under the Balrok phase of Project 6879.[35] Institute engineers made a thorough study of all direction-finding systems currently available, and recommended the techniques and equipment that appeared best suited for Holloman operations.

Additional studies were conducted "in house," at the Air Force Missile Development Center, on probable Balrok performance. Some of the results were published in a technical note entitled Performance of the Balloon Launched Hypersonic Test Vehicle, HTV I, in Vertical Descent, by Mr. Hermann O. F. Scharn, an aeronautical research engineer assigned to the Center's Directorate of Ballistic Missile Test. This note calculated the mach and reynolds numbers obtainable in downward launchings of the HTV from a balloon carrier, at altitudes up to 125,000 feet and with different time delays between release and ignition of the rocket motor. It showed that, for the trajectories studied,[36]

> The highest Mach number is $M = 9.5$. It can be reached by a release altitude of 125,000 feet and an ignition-time delay of 60 seconds. In this case we have Reynolds numbers in the interval $7.10^6 < Re/l < 1.5 \cdot 10^7$. Maximum Reynolds number is 2.10^7 in the Mach number interval $4.5 < M < 8.0$. For a release altitude $h_o = 80,000$ feet we have $M_{max} = 9$ in the Reynolds number interval $10^7 < Re/l < 2.10^7$.

These and other calculations indicated about a forty percent increase in performance for the HTV when launched from a balloon rather than at ground level.[37]

Early in 1958, the first Balrok test mission took place. This was not a "hot" firing but rather a dummy drop, which was successfully accomplished on 27 February after one previous failure. On this mission, additional photographic tracking was provided by members of the 1352nd Motion Picture Group, of Lookout Mountain Laboratory, California. Release altitude for the 230-pound dummy HTV was 93,000 feet; thirty-two seconds later, after falling to 76,638 feet, the test vehicle attained mach one; and roughly mach 1.5, with a peak of mach 1.51, was attained for thirteen seconds beginning about 50,000 feet. The main purpose of the test was to see what kind of stability

Hypersonic Test Vehicle Ready for Free Ride to Altitudes of Minimum Drag the HTV would have following release at high altitude and to check equipment for use in the Balrok program. However, it was also an impressive achievement merely to develop such high velocity in a test vehicle without expending one drop of fuel.[38]

The success of this preliminary test paved the way for a live firing later in the year, although there were naturally details that had to be taken care of first. The Center's Missile Flight Safety Branch still had some qualms about launching a rocket with the HTV's performance capability from a balloon floating over the range, but the degree of reliability shown in the February drop test was a powerful argument for the safety of Balrok operations. Thus in the end full approval was obtained. It was also necessary to find some more money for internal instrumentation of the bird itself. With considerable effort, funds were rounded up and transferred to Wright Air Development Center, which arranged for the work to be done through an open contract with Aerophysics Development Corporation. Then, too, a balloon-borne rocket launcher had to be fabricated for the full-scale live test. This was expertly done in the base shops, under the watchful care of Mr. Sorgnit and Lt. Reed B. Jenkins, HTV project officer.[39]

There were other problems, too. A firing scheduled for 26 June was postponed due to temperatures of minus seventy-six degrees centigrade in the tropopause, which would have caused the polyethylene balloon material to become brittle and very probably burst.[40] Finally, in the pre-dawn darkness of 8 August 1958, the Balrok system was launched from a site three miles north of Tularosa, New Mexico. The balloon ascended to 87,000 feet while drifting onto and over the range, but alas the rocket refused to release from the launcher. Thus rocket and launcher were both cut down together and recovered by parachute. The cause of the failure was later traced to a severed wire inside the rocket.[41]

The damage suffered by the launcher and rocket in the recovery process was relatively unimportant, although the internal recording equipment was in need of a fairly extensive job of recalibration. Everyone concerned with the Balrok effort--in the Balloon Branch, the Rocket Sonde Branch, or at division level--was naturally anxious to try again. But unfortunately all the available funds, which were never very plentiful, had now been exhausted.[42]

Command headquarters has promised a substantial new increment of funds for fiscal year 1960. However, many people--and not just at Holloman--would like to see something done even before then. Officials at Wright Air Development Center indicated that they might be able to give some financial assistance, and included pleas for the Balrok program in briefings made both to Headquarters, Air Research and Development Command and (in mid-September 1958, with Command encouragement)to the Defense Department's Advanced Research Projects Agency. Wright Field scientists stressed the fact that Balrok will permit inexpensive "duplication of certain missile, boost-glide, and other re-entry trajectories." They pointed out the possible application of Balrok to aero-thermodynamic studies for the Air Force Dyna-Soar program, and observed further that "near-horizontal firings" with the Balrok system could be used to reproduce "sustained-flight conditions" in the upper atmosphere.[43]

Indeed the list of possible applications for Balrok is extremely long, ranging from use in target missions,[44] in the manner of Hi-Fly, to upper air sounding rocket flights of the Rockoon variety.[45] A recent article by a member of the Holloman Balloon Branch aptly compared the Balrok system, used in downward firings, to[46]

> ...a vertical high-speed track, roughly twenty miles long. The launching segment is located in a region where 99% of the atmosphere has been expended, and primary cosmic radiation exists. The central portion splits the heart of the ozonosphere. Thus, the system provides both high speeds, and authentic environment.

The same article noted that for re-entry studies Balrok has[47]

> ...four prime advantages over [alternative test] vehicles.
>
> a. Optimum efficiency: 100% of the rocket fuel is employed in the act of re-entry, and no fuel of any kind is required to attain peak altitude.
>
> b. Outstanding economy: No sophisticated

programming is required of the rocket, and the vehicle can therefore be relatively simple and inexpensive. The usefulness of the giant plastic research balloons has always been augmented by their low cost....

c. Solid data reliability: The usual re-entry vehicle descends over an area which is difficult to predict accurately, and at tremendous ranges from tracking stations. The 'Balrok' technique provides a descent directly over a highly concentrated range network...The telemetering transmitter can be low-powered, due to the proximity of the ground stations. Optics and radar are present to back up telemetry....

d. Fine control of parameters: Achieved by adjustment of drop [and firing] altitude.

The "Cree" Missile Cluster

Still another research vehicle that has been launched from Holloman balloons is one specially developed by Cook Research Laboratories for parachute testing. It is used in the work of Project 6065, Parachute Performance at High Mach Numbers, which is directed by Wright Air Development Center with Cook in the role of contractor. Parachutes capable of operation "at high mach numbers" will prove useful for various purposes, but the most interesting application, without much doubt, is for manned re-entry. Some re-entry proposals envisage the use of metal parachutes; Cook, however, believes that cloth parachutes, in series, will do the trick.[48]

Project plans call for the deployment of experimental

Cree Missile Cluster, Especially Developed for Parachute Experimentation, Being Prepared for Balloon Drop Test parachute systems from a balloon-launched "Cree" cluster of three missiles, used either in free fall or in rocket-boosted flight. Tests at Holloman began officially in May 1958, and so far only free-fall vehicles have been used. But at least the project is not simply engaged in evaluating its own test procedures--the stage in which Balrok is still bogged down--and is accumulating actual research data on parachutes. Even for unpowered tests, the requirements are extremely complicated. Seven separate radio command channels are used, as against the five-channel system used so far on Balrok. An unusual amount of telemetering is also required, to record missile temperature and other needed parameters.[49] Last but not least, two recent flights for this project, on 14 November and 16 December 1958, each made use of a 3.75-million-cubic-foot, 1500-pound balloon. There had been no previous military launch of a plastic balloon this size, which is the largest operational size in existence. These balloons were actually launched from a remote site off-range, by a launch crew under the direction of Staff Sergeant Grady Cole.[50]

Balloon operations for Project 6065 are, in short, a far cry from the primitive launch and flight services performed at Holloman Air Force Base in earlier years, when support of research ballooning first became a part of the local Air Force mission. They have been made possible, moreover, by the truly spectacular improvements in balloon technology that have taken place over the intervening period. Some of these same improvements will be discussed more fully in the next chapter.

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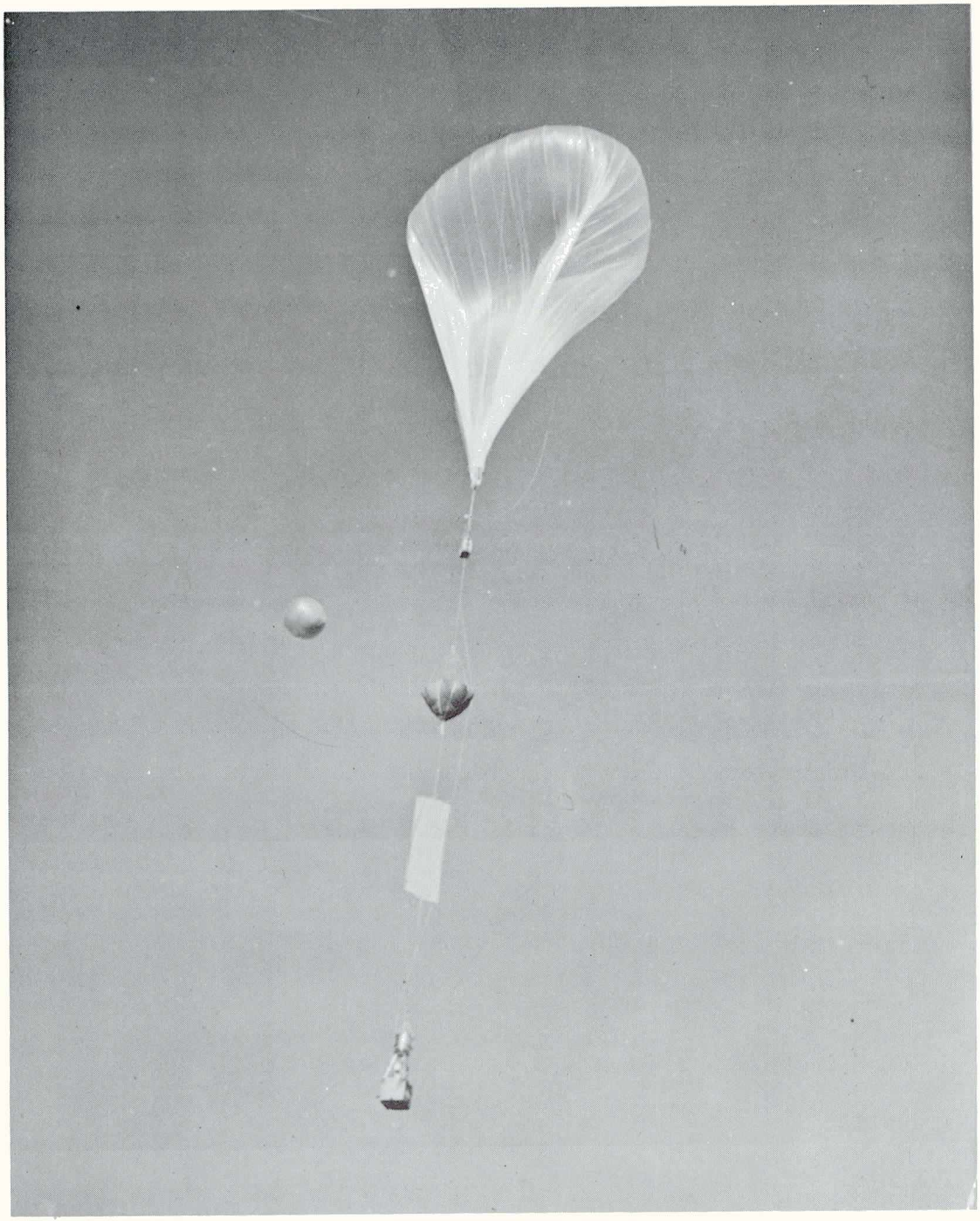
CHAPTER IV

TECHNICAL ADVANCES IN BALLOON OPERATIONS

The research accomplishments described in other chapters of this history were made possible, in considerable part, by the steady advances in balloon manufacturing and in the techniques of launch and flight operations that have occurred during the same years. These advances are the product of research and development on the part of government agencies, universities and private industry. The Balloon Branch of the Air Force Missile Development Center has duly contributed its share--and in turn has benefited from many of the technical improvements devised elsewhere.

Some of the most basic changes have been in the balloons themselves, which have grown both bigger and better. To be sure, only recently have balloons again been built that could equal in sheer size the rubberized-fabric vehicles used for manned stratosphere ascents in the 1930's. The Explorer II balloon that took Captains Albert Stevens and Orvil A. Anderson to a record altitude of 72,000 feet in 1935 had a volume of 3,700,000 cubic feet--and weighed over three tons. Cost and logistics precluded the use of such balloons for unmanned research flights, which had to rely instead on small rubber balloons that carried a minimum payload.[1]

The giant fabric balloons are now gone and forgotten.



Plastic Balloon Flown at Holloman in 1949: Inverted Parachute to Limit Ascent Rate, Banner for Stability made of non-extensible material and is flown with the appendix open or with side ducts. As it rises, the gas inside it (normally helium) expands, gradually filling the volume of the cell. At a point which can be accurately predetermined by adjustment of balloon volume and gross load, any excess ("free") lift is ejected through the open appendix or ducts. The system is then in equilibrium, with just enough lift to support the balloon plus payload, and assumes a constant-level trajectory which can be maintained for extended periods by occasional dropping of ballast. While at float, the balloon is subject to remarkably little in the way of either vertical oscillations or rotational movement.

By supporting the payload primarily on a skeleton of strong tapes, and only secondarily on the plastic film itself, polyethylene balloons have been able to exceed all standard sounding rockets in lifting capacity. The tapeless models, which were introduced later, cannot support quite as much payload as the taped balloons but are still far superior in this respect to rubber balloons. At the same time, polyethylene is relatively inexpensive. The cost of a polyethylene balloon, in dollars, runs about ten times the balloon diameter as measured in feet (referring to diameter when the balloon is fully inflated at ceiling altitude). For roughly the price of a B-58 bomber, enough of these balloons could be purchased to lift a half ton

Rubber balloons (including those made of neoprene and other synthetic rubber-type products) are still in regular use for weather sounding purposes, and were widely used in early research flights at Holloman. Their small cargo-carrying capacity was partly offset by flying them in clusters. But for most research and development operations they have been superseded by polyethylene plastic. The clear superiority of this material was established in the late 1940's by the Aeronautical Laboratories of General Mills, for which Mr. Otto C. Winzen was originally chief balloon designer, and by the New York University balloon project that used Holloman Air Force Base as one alternative launch point.[2] The Holloman Balloon Branch itself did not launch a polyethylene research balloon, with its own Air Force personnel, until July 1950. It is worth noting, however, that the Balloon Branch's official list of numbered flights begins with this first plastic launching.[3] Rubber-type balloons were occasionally used on research flights even after July 1950--on flights to measure atmospheric conductivity and ozone concentration[4]--but they are not included in the official count.

The polyethylene research balloon has been aptly described as "nothing but a rather profoundly engineered vegetable bag."[5] Unlike a conventional rubber balloon, which keeps expanding as it rises until finally it bursts, the polyethylene balloon is of scientific payload to 110,000 feet once a day for seven years.

A further advantage, or disadvantage, of plastic balloons is that from a distance they look remarkably like flying saucers. When floating at ceiling altitude, their configuration is somewhat saucer-shaped; and they can either hover for a week over much the same spot or cruise at 250 miles an hour in the jet stream. They can be seen with unaided eye glistening at altitudes above 100,000 feet and at horizontal distances up to eighty miles; in the interval from ground sunset to balloon sunset, while the balloons are still illuminated by the sun, they may be seen at even greater distances. In addition, metallic masses of more than a ton may be lifted by these vehicles, thus giving radar returns not usually associated with balloons.

In the early days of plastic ballooning, in fact, it was sometimes possible to track a long-distance flight from Holloman or from some other center of balloon operations such as Minneapolis-St. Paul[6] simply by following flying saucer reports in the daily papers. One classic example is Holloman's plastic balloon flight number 175, launched 27 October 1953, which appears to have been both sighted visually and tracked by radar over England on 3 November. English accounts of the incident contained such statements as "tremendous speed," "practically motionless," "circular or spherical and white in color," "emitting or reflecting a fierce light." Altitude was reported as 61,000 feet--and as no research balloon had recently been sent up from Britain, there was ample room for local saucer enthusiasts to claim the "unidentified flying object" as proof of their theories.[7] A much likelier explanation, however, is that this was really the balloon launched at Holloman Air Force Base on 27 October.

Naturally, there have been steady improvements even within the general category of polyethylene balloons. Since their introduction, they have tended to grow in size, strength and load-carrying ability, while diminishing in thickness and therefore in weight for any given size. The very first polyethylene balloons flown at Holloman, by the New York University project in July 1947, measured only seven feet in diameter. Ten of them flown in a cluster still supported a payload of less than fifty pounds.[8] By August 1956, when the Balloon Branch launched its 500th plastic vehicle, the average diameter was 128 feet.[9] Cluster flights with plastic balloons had been discontinued by then in view of the increased dimensions and performance of the single balloons, and the danger of abrasion damage when cluster balloons rub together. Still more recently, the Balloon Branch has flown balloons as much as 217 feet in diameter, with a capacity of 3,750,000 cubic feet. The plastic film in these balloons was two mils thick, as compared with the five- to seven-mil thickness that was normal when the polyethylene balloons were introduced approximately twelve years ago.[10] On the other hand, the Balloon Branch has not yet flown balloons made of the even thinner mylar plastic, which has surpassed polyethylene in altitude capability. A quarter-mil mylar balloon flown by the University of Minnesota rose to a record 143,000 feet. Unfortunately, mylar still presents certain problems that must be worked out, while for any balloon material the payload capability drops off sharply at altitudes above the 100,000-foot level, where there is only a trace (roughly one percent) of atmosphere left in which to float.

The Evolution of Balloon Launch Techniques[11]

The earliest techniques for launching constant-level plastic balloons go back slightly before the start of balloon operations at Holloman Air Force Base. The original balloon cells ranged from seven to twenty feet in diameter and were usually inflated inside hangars. They were simply laid out on a ground cloth and walked up to a vertical position as the lifting gas was applied. The lift was checked by balancing off the payload plus a shot bag equal in weight to the free lift. After completion of inflation, the cell was walked out on the downwind side. The actual release was negotiated at some distance away from the hangar in order to avoid back-lash eddies. The Holloman Balloon Branch used this method on some of its early flights, launching from hangars in the North Area of the base.

However, the introduction of larger balloon sizes, plus the requirement for operations from remote areas not equipped with hangars, called for the development of outdoor launch techniques. One solution was the launch platform, first devised in 1947 as a system affording minimum wind exposure in addition to providing gross lift readings. A platform scale was positioned under the ground cloth at the calculated base of the gas bubble. (The bubble is that upper portion of the balloon which would be filled by the gas prior to launch.) The ground cloth was tucked over the rest of the balloon and shot bags placed on top of the section lying on the platform scale. An opening was left for the inflation tube which entered through the balloon appendix and extended into the bubble. The gross lift, at any time, was the decrease in indicated weight on the platform scale, plus the weight of the bubble material.

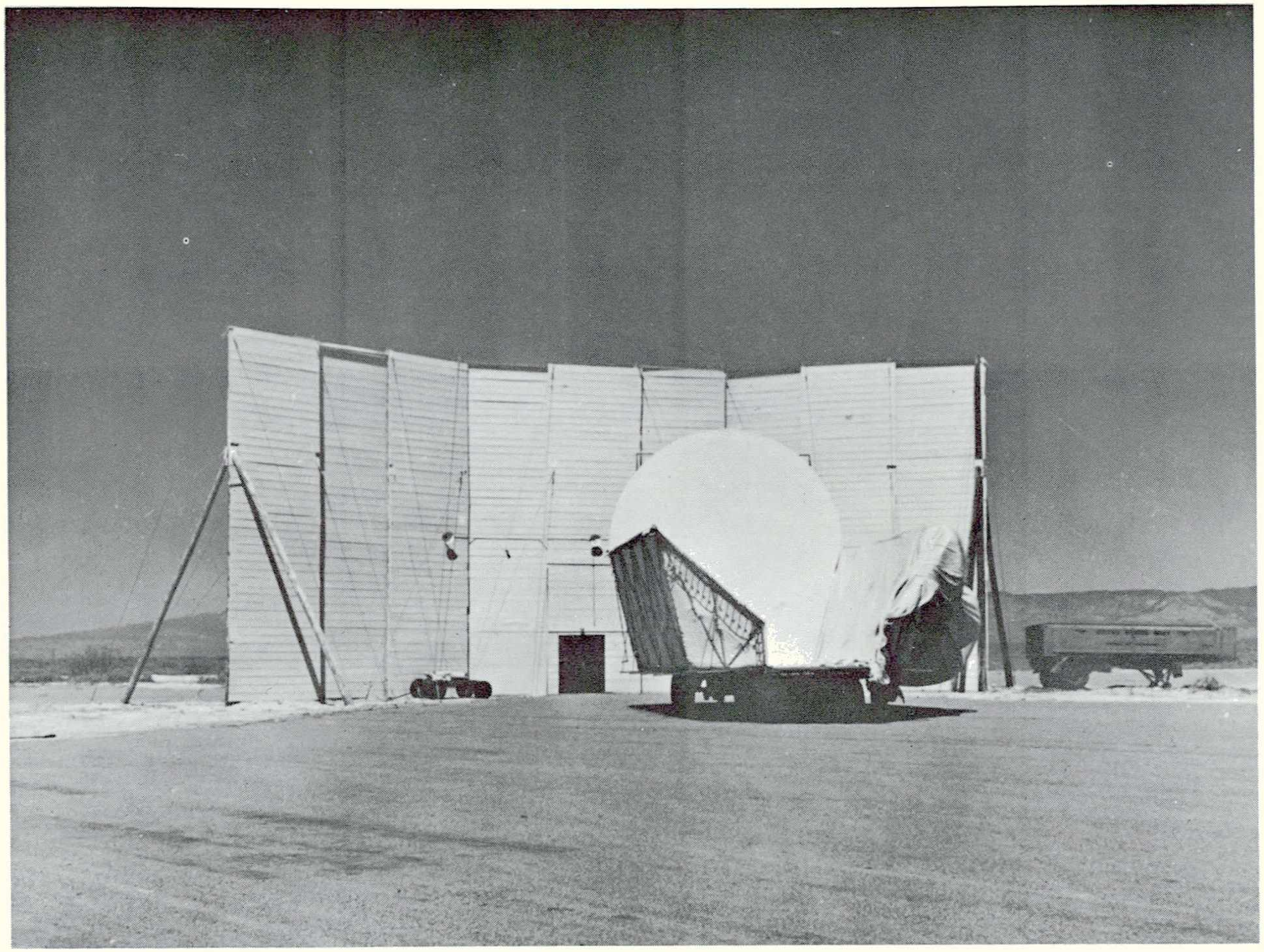
The primitive launch platform provided protection from surface winds by exposing a minimum of balloon material until launch time. The versatility was soon increased by replacing the shot bags with a pair of clamping arms. This last type of unit was employed by the Balloon Branch to launch its plastic balloon flight number one, in July 1950.

As the plastic aerostats gradually surpassed brontosaurian dimensions, the length of the bubble above the fixed launch arms became as great as the total vertical height of the earlier balloons. This dilemma was solved by converting to a single arm which rolled freely and attaching the inflation tube near the apex of the balloon. Throughout the inflation, therefore, the bubble could be restricted to minimum size. The Balloon Branch adopted roller arms in 1955.

An airborne version of the launch-arm method, developed by the Air Force Cambridge Research Center, was tested at Holloman in 1952 for Project Moby Dick. Although the launch arms could give protection during inflation, in winds up to ten knots, the transition to a vertical attitude just before release caused total exposure to the wind. The Cambridge proposal therefore involved winding up the balloon material about a large geared reel, excluding the bubble and the harness. A tight configuration was presented consequently, through inflation and the actual launch. At a few thousand feet above the ground, the slack plastic would be unreeled and the reel lowered to the ground on a smaller balloon. The complicating factor of the supplementary balloon, in addition to the unwieldy reel configuration required for larger balloons, soon terminated this line of attack, although similar reels were employed in more recent years for the airborne deployment of load lines up to 3,000 feet in length.

Another technique developed for Moby Dick was the "covered wagon" launcher. This was an invention of Balloon Branch personnel at Holloman, and bore a strong resemblance to the old-style Conestoga wagon. The balloon was completely contained within the "wagon" during inflation and until the moment of launch, at which point a canvas cover was mechanically released on one side and along the headboard, and the balloon was sent on its way. Extended delays in scheduled launch time, and changes of wind direction,were much less serious when a launch was conducted in this manner. Above all, balloons could be launched without damage in winds as high as twenty to twenty-five knots.

Covered wagon units were sent to all three of the West Coast launch sites used in the operational phase of Moby Dick. The method was also employed on Air Force Cambridge Research Center's Flying Cloud project, which used the same sites but a different set of wagons, and on numerous research flights from Holloman. One covered wagon was constructed by Hughes Aircraft Company especially for use in off-range target balloon launchings by the Holloman Balloon Branch. However, the method has fallen into disuse at Holloman since 1956. Primary disadvantages are small-scale abrasions which prevent its use with any but balloon material of two-mil thickness or greater, and the limited volume of existing covered wagon launchers, which cannot accommodate today's large-size balloons. A 116-foot-diameter cell was the



Wind Screen and Covered Wagon Launcher

largest ever launched from a covered wagon, and 750 pounds is the highest gross inflation achieved with this method. It would be theoretically possible, of course, to make bigger and bigger wagons, but this does not appear a practical solution, especially in view of the abrasion problem.

A non-movable structure that was designed, like the covered wagon launcher, to give protection against winds was a forty-foot-high wooden windscreen completed early in 1953. It was located in the North Area, close to the Aeromedical Field Laboratory, and had a ready room in the center. It was originally intended for use in simple vertical inflations, serving as a kind of semi-hangar and bringing to mind the portable fabric windscreen sometimes used at Holloman by New York University crews. Because of the unfortunate lag between design and construction, by the time the wooden screen was built a majority of the plastic balloons used at Holloman stood higher than it did. Nevertheless, the screen provided moderate protection for a few years, when employed in conjunction with launch arms. With further increase in balloon sizes, the screen finally became a hindrance and was disassembled in 1955.

Despite the use of launch arms, reels, and covered wagons, the vertical inflation method was not wholly abandoned. It had the advantage of simplicity, at least originally, even though it was suitable mainly for use inside a hangar or in a near-perfect calm. Moreover, the capabilities of the vertical method gradually increased through the introduction of various new gadgets and appendages. One of the most important of these, introduced by the General Mills balloon group in 1950, was the reefing sleeve. Constructed of polyethylene, it extended from the base of the gas bubble down to the balloon appendix. As gas was valved into the cell, the sleeve was pulled gradually downward, always maintaining a tight gas bubble for minimal wind drag profile. This reefing sleeve actually evolved from the primitive ground-cloth launch platform technique.

Balloon hold-down lines were devised also about the same time, by General Mills. Their function was to combat twisting of the balloon while it was in the vertical position, which tended to choke off the appendix inflation tubes employed in earlier years.

The Holloman Balloon Branch performed its first vertical launch with a large balloon on 24 September 1952. Only the polyethylene reefing sleeve was employed. The attempt was successful, but it was obvious that this system was only adequate in a wind of two knots or less. On 2 October 1952, the Balloon Branch tried out two innovations that it had devised especially for launches of this type:

1. The aerostat was inflated while tied into a C-2

wrecker boom. As soon as the gas would lift the material, the balloon was walked up to a vertical position. This method made it easier to work around the balloon during inflation and allowed launch crews to reposition the balloon both during and after the inflation.

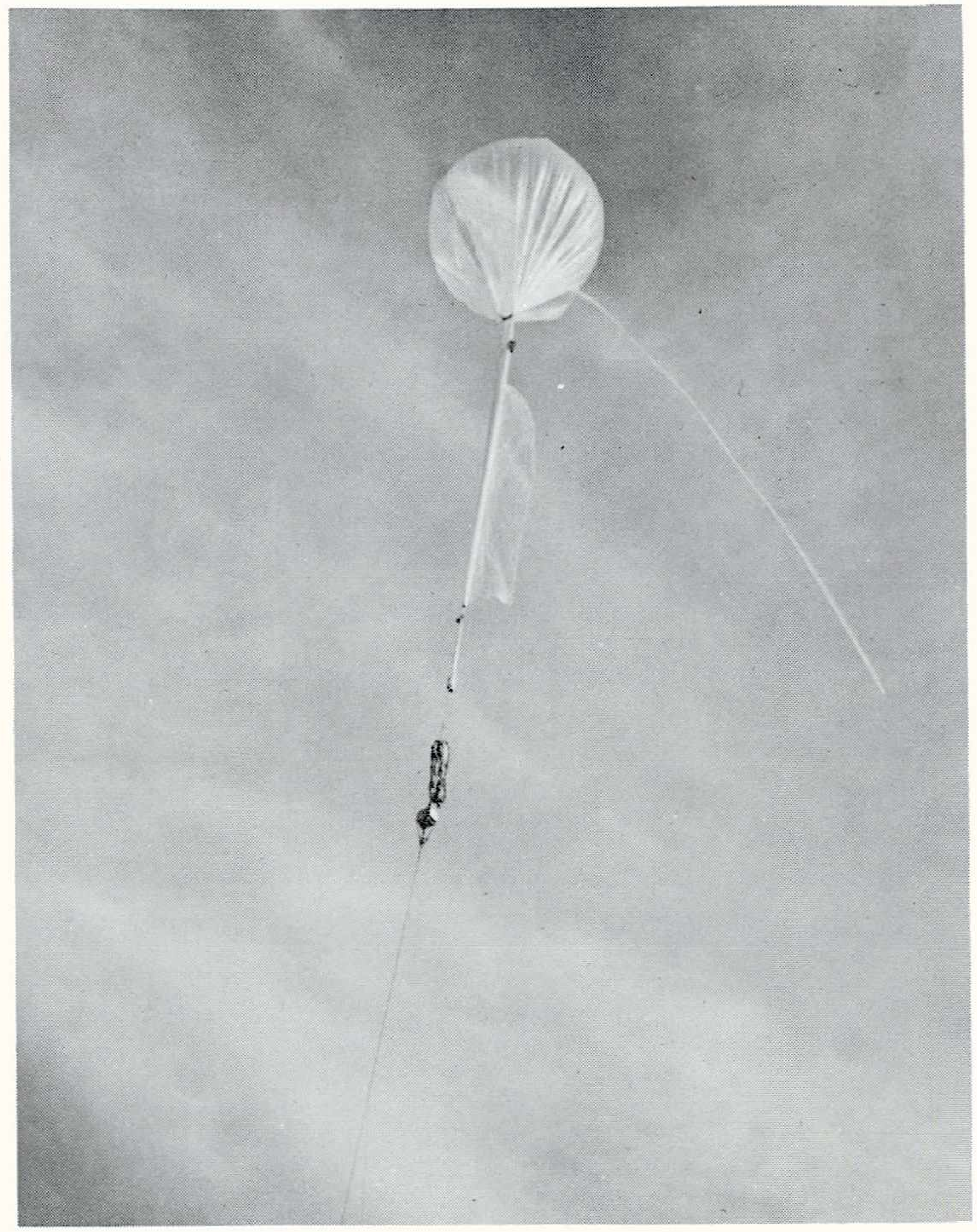
2. A re-usable canvas reefing cloth was introduced. Buckles were used for the shedding process.

The General Mills system of balloon hold-down lines was checked at Holloman in 1953, in an effort to find a suitable launch technique for Wright Air Development Center's High-Dive program. It demonstrated a four-knot limitation with seventy-two-foot-diameter balloons. The general approach seemed promising, however, and led the Balloon Branch to the development of the shroud-cap system. A hemispherical canvas cap was placed on top of the bubble, and the bubble was gradually nursed to the vertical position by use of hold-down lines attached to the perimeter of the cap. A canvas reefer was used in conjunction with the cap. Although developed primarily for High-Dive, the shroud-cap method was used for other research projects as well. Some twenty-five flights were made employing this system in 1953-1954. It showed a capability up to seven knots but was later abandoned because of the complexity of releasing the huge cap, the advent of the unsymmetrical tapeless balloons for which the system was not suitable,and the introduction of other improved launch techniques.

The Holloman technique of tying a balloon during inflation to a crane or wrecker boom, as tested originally in October 1952, was in some cases used in combination with the shroud cap. Starting in November 1954, it was used with the launch-arm system instead. Inflation was completed before the balloon was actually "captured" on the crane; the payload was then tied in, the boom raised to maximum elevation, and the flight sent on its way. However, this procedure was abandoned after twenty-five flights, for various reasons including the deceleration shock acting upon the cell at the moment of capture. It gave way to the crane-downwind method, which was first tested by the Balloon Branch in February 1956 and was still used for some flights in 1958. Instead of capturing the aerostat after it leaves the launch platform, the crane proceeds downwind until the balloon is almost vertical and at this moment releases the payload, which has previously been suspended from the crane. This technique has been successfully used even with three-million-cubic-foot balloons (and light loads).

The semi-crane-capture technique is one presently employed for heavy-load launches and rocket payloads and would be well suited for manned flights. It is unique in the field of balloon operations, and the Balloon Branch, which devised it, considers it a superior system. The cell is first partially inflated

Vertical Inflation Using Shroud Cap



May 1958 Launch Showing "Choker" in Use

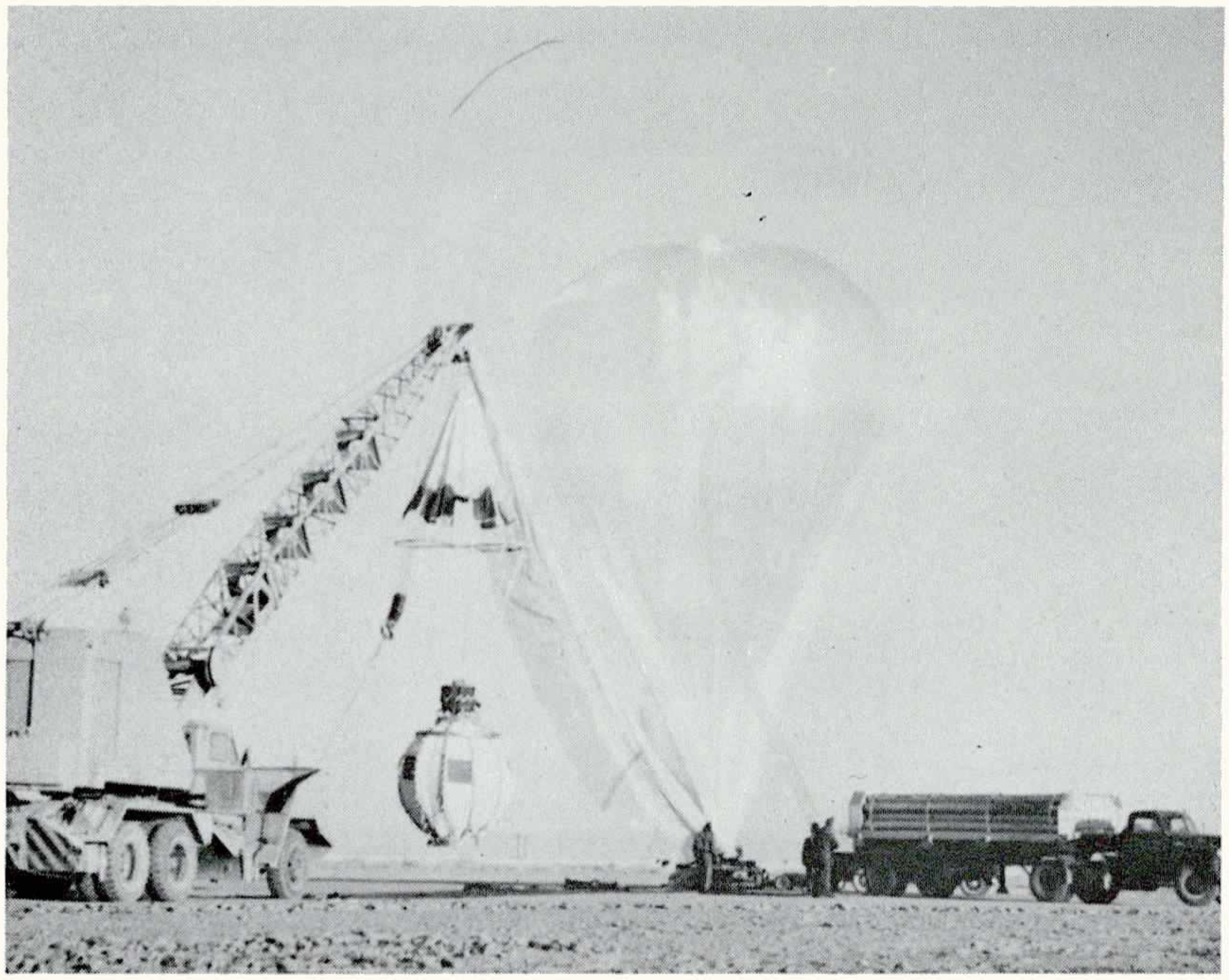
using a roller-arm launch platform. The amount of gas initially inserted is proportioned to the prevailing wind speed. Next the balloon is captured on the crane and inflation completed with the cell in vertical attitude. The crane is moved downwind if necessary at launch, but the displacement is usually minimal.

A simple complement to crane launch methods--and various other launch methods--which has recently been under development is the choker. Like the Moby Dick reel, it attempts to contain the balloon in a better drag configuration not merely during inflation but through the actual launch. Basically, the choker is a short reefing cloth, just below the base of the bubble, which is released after launch by aneroid or radio-command techniques.

Although the Balloon Branch has had good service from the crane as a launch tool, one useful alternative is the so-called Fisher Launcher. This was first tested in the summer of 1955 by crews of the Air Force's balloon operations unit at Lowry Air Force Base, Colorado, and was really an outgrowth of a fork-lift launcher proposed by technicians of the Air Force Cambridge Research Center as a substitute for the Holloman crane. It is a fast-accelerating, maneuverable truck, with a more stable and sophisticated release mechanism than either the crane or the fork-lift launcher. The Fisher Launcher is one of the devices currently used by the Holloman Balloon Branch, and experienced airmen show remarkable dexterity with it.

In addition to the launch techniques that have been discussed, the Balloon Branch has experimented with many other combination systems and launch innovations. These include a system of tie-down lines developed in 1951 to guide the motion of the balloon toward a pre-selected load pickup point; the shroud cap used in conjunction with launch arms; a small balloon to hold the major cell erect; an inflation method in which the apex of the cell was tied to Holloman's Aerobee tower; and an uncovered covered wagon, used in the early part of a shroud launch. Some of these miscellaneous launch techniques--and more could easily be listed--proved useful on a limited number of flights. Others were never used at all, on any operational basis.

Basically, the experimentation at Holloman with so many different launch techniques reflects both the desire of the Balloon Branch to improve its launch capability and the fact that it is called upon to handle an extremely wide variety of flight-train configurations. No launch technique is equally satisfactory for all balloon missions. Nevertheless, for balloons up to 2,000,000 cubic feet in size, the launching is now considered one of the most reliable operations. And,



Crane Launch of Dummy Gondola

Fisher Launcher

in general, conditions for balloon launching are more favorable in New Mexico's Tularosa Basin, where Holloman Air Force Base is situated, than at any other permanent center of constant-level plastic balloon operations in the United States. Low cloudiness and generally favorable surface winds are supplemented by careful micro-surface wind forecasting. Correct forecasting, together with precise timing of launch procedures, often results in successful missions even with weather systems close by.

The favorable launch conditions in the Holloman area were dramatically illustrated by the successful laumching of the Man-High (III) balloon flight in October 1958 without benefit of an open mine pit, as used in launching Man-High (II) from a site in Minnesota. This feat has since been exceeded by the launching of 3,750,000-foot plastic balloons--the largest size anywhere in operational use--for another research project, again without benefit of pit and from relatively unimproved off-range sites. The growth of off-range launching, described principally in the preceding chapter, is one of the notable developments in Holloman balloon operations in recent years. Moreover, it could easily be extended to include the New Mexico equivalent of the Minnesota pit-launch technique, when and if this should become necessary as a result of the steady increase in balloon sizes. The Balloon Branch has already begun to calibrate some of the magnificent mountain canyons in the neighborhood, which appear to have dimensions superior to Minnesota's mining pits.

Balloon Instrumentation, Tracking and Recovery

Progress made in balloon instrumentation has been just as important as the introduction of new launch methods, although sometimes even harder to convey in non-technical language. Much the same can be said regarding the steady improvement of tracking and recovery techniques, which are closely bound up with developments in instrumentation *per se*. Indeed a large part of the instrumentation used in balloon operations is designed specifically to help with tracking and recovery functions.

In the general vicinity of Holloman Air Force Base, optical tracking by means of theodolites has always played an important part in balloon missions. Radar tracking has also been available as needed, through the integrated range instrumentation network. Unfortunately, neither conventional radar tracking nor theodolites are adequate for long-distance flights. Any kind of optical tracking is also severely limited by bad weather and by night-time conditions, although the Balloon Branch has experimented intermittently with a flashing-light system for night tracking.[12] For these reasons it is desirable to have a radio transmitter included in the balloon equipment, for direction-finding purposes; and in fact such a transmitter was often flown in the early stages of instrumentation development. The same transmitter normally sent back coded altitude data during the flight, and could be used for still other telemetering requirements.

Various transmitters have been used by the Balloon Branch, and numerous improvements made from time to time by "in-house" effort. In 1957, a special study of alternative direction-finding systems was made for the Balloon Branch under contract by the Midwest Research Institute. The study touched on radar methods but dealt mainly with other radio tracking techniques. Specific recommendations made by the study did not always appear most practical for Holloman operations, for reasons of cost among other things; but a great deal was learned nevertheless.[13]

Radio tracking has supplemented rather than replaced other tracking methods. And the balloon-borne transmitter is, of course, only one part of a radio tracking system. Receiving equipment is installed both at Holloman Air Force Base and in tracking aircraft, which are also used for visual tracking of balloon flights. The role of aircraft is especially important near the conclusion of a flight, in order to direct the following recovery operation. In the early days of Holloman ballooning, both B-17 and C-47 aircraft were used; and on some flights even B-17's from Wright Air Development Center would pick up Holloman-launched balloons for tracking after they had traveled halfway across country. This last procedure was used on Project Gopher, which involved sending heavy specialized equipment on flights lasting up to two and a half days.[14]

Since 1953-1954, special ground vehicles with both theodolites and radio equipment have been extensively used in balloon tracking and recovery, performing some of the tasks formerly assigned to aircraft and at much less cost. At about the same time, B-17's disappeared from the standard roster of tracking aircraft. C-47's have continued down to the present to share in tracking of the longer balloon flights, but specially-equipped L-20's came to be recognized as the "primary [aircraft] support" of the Balloon Branch. Indeed, an L-20 was involved in the major accident of Holloman balloon operations--and worst aircraft accident of recent Holloman history--when it crashed into an Arizona mountainside on a balloon hunt in August 1955. All three persons aboard were killed. L-20's were replaced in turn, in 1957-1958, by L-27 aircraft, which had superior performance in many respects but were also more in demand for combat readiness training and other non-balloon purposes. The best vehicle for all-around support of balloon operations is really the H-21 helicopter, but one of these is not always available, and in practice the Balloon Branch must take whatever it can get from one day to the next.[15]

A considerable amount of outside help has been received in balloon tracking. The Federal Communications Commission has taken part, with its far-flung radio direction-finding network,

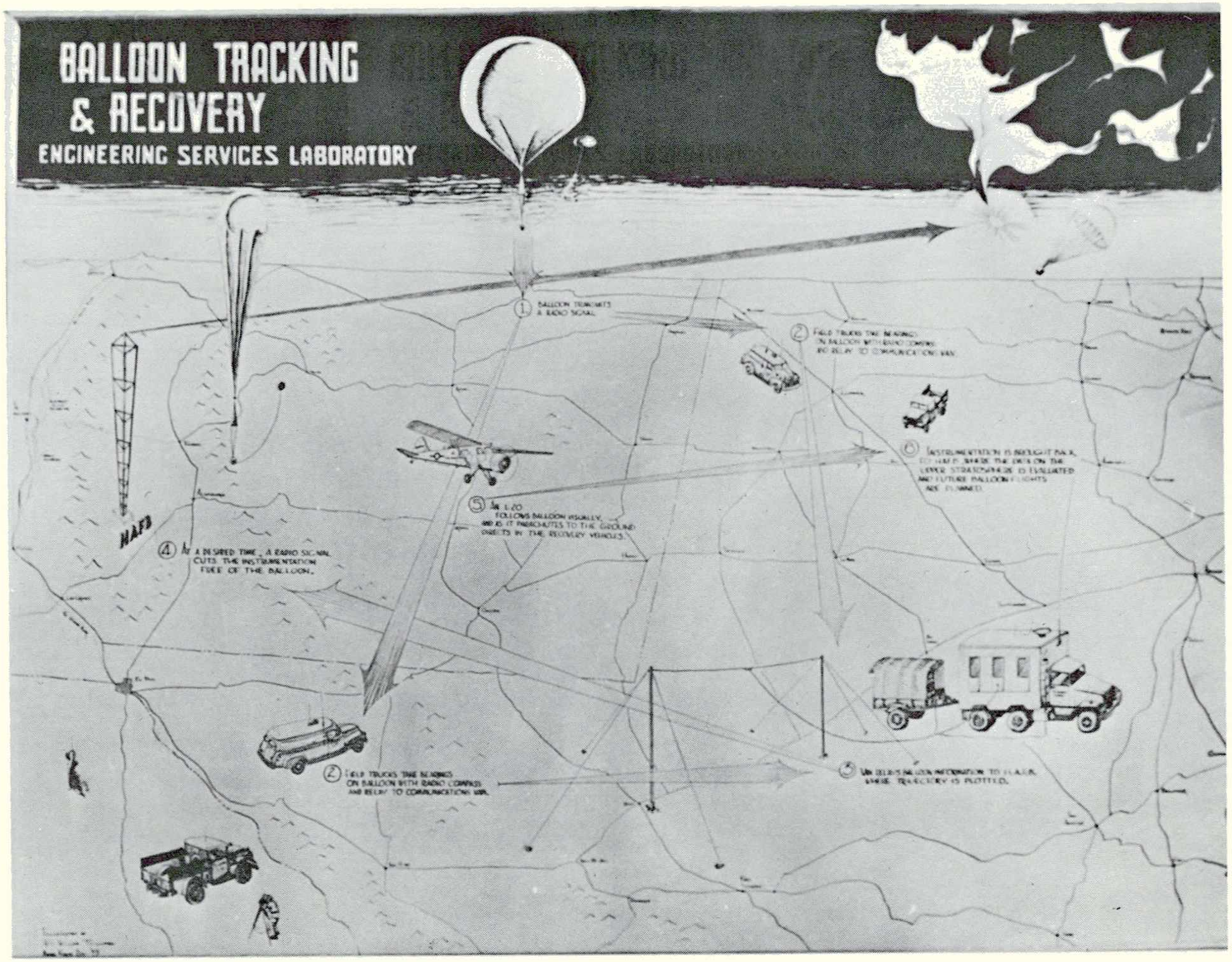
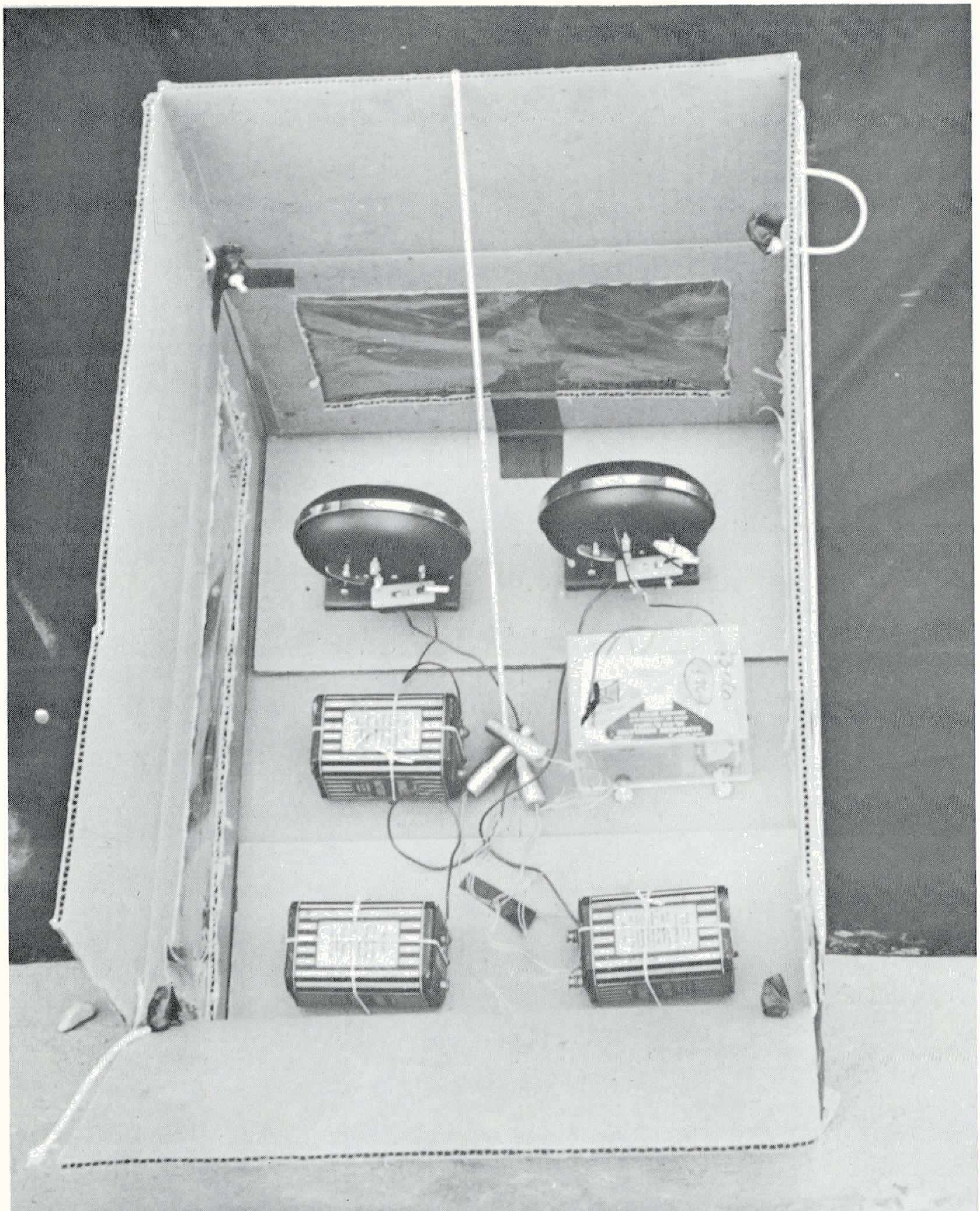


Illustration of a Tracking and Recovery Operation: About 1955 and the 34th Air Division, Albuquerque, New Mexico, has given help in the form of radar tracking. Then, too, the missile counter-measures group at the Air Force Missile Development Center has often tracked balloon flights by radar as a training measure; and still other tracking services have been available. By and large, however, the varied tracking activities on a balloon mission are coordinated from a single control center at Holloman Air Force Base (with the balloon itself sometimes serving as radio relay station between the base and tracking vehicles in the air or on the ground). The present control room, which features a wall-size plotting board, is modelled after those of operational air commands and is located in the same building (number 850) that houses the Balloon Branch offices. This building, which also has theodolites poised on its roof, was completed in 1953 expressly for high-altitude research units.[16]

Another distinct category of balloon instrumentation is that designed for purposes of flight control, meaning principally ballasting and separation. One early method of ballasting was to send aloft something like kerosene or anti-freeze fluid that steadily dripped from its container, but this system offered no real control, merely compensating for a continuous loss of lift. Yet loss of lift is not in fact continuous, occurring mainly at night due to cooling of the gas in the balloon. At present an improved system is used, which was developed originally for the Moby Dick project. Fine dust-like steel shot is metered through a valve, which can operate either by automatic aneroid control or by radio-command signal. Recently, ballast was dropped from a balloon floating above a point near Dallas, Texas, merely by pressing a button at the Air Force Missile Development Center.[17]

On some missions there is no need for ballasting. Almost always, however, there is a need for special instrumentation to end the mission by separating the payload and other balloon-borne equipment from the vehicle itself, after which the equipment is parachuted back to earth. On some early flights the separation devices were flown simply in a cardboard box and included batteries, one or two cheap alarm clocks, and some weather balloon equipment modified to actuate barometrically if (after a reasonable ascent period) the balloon fell below 30,000 feet. The latter figure was chosen so that the balloon would not descend slowly through the air lanes and constitute a flight hazard. Both the clocks and the aneroid equipment worked by energizing squibs, which in turn severed the line between the balloon and its cargo. This class of instrumentation was not always reliable: alarm clocks, for instance, were unduly sensitive to launching jolts.[18]

In due course, cardboard boxes gave way to insulated



Balloon Instrumentation: 1950

containers (which of course held more than just separation devices). Better clocks and other timers were obtained, and mechanical cutters were added as a backup for the squibs. But in the matter of separation mere reliability was not enough. If some complication arose that made it pointless to continue a flight for the planned duration, tracking crews and equipment would still be committed until a preset cut-down occurred. Furthermore, timing or aneroid devices, if left to operate automatically, might terminate a flight just when it was on top of a thunderstorm or over terrain where ground recovery crews would have trouble entering--a mountain peak, for instance, or a dense forest. A result such as this was especially undesirable for the aeromedical animal flights, which required prompt and reliable recovery to protect the test subjects' physical and mental well-being. There is a case on record in which a balloon-borne hamster package launched at Holloman evaded tracking crews, landed in Florida, and was not opened for six days after impact--and all the hamsters were found alive and apparently normal. But most animal subjects are less hardy. Nor are living specimens the only payloads that require unusually prompt recovery. Certain film emulsions and delicate scientific equipment can also be damaged by heat and other environmental factors if not found right away.[19]

For all these reasons, the Balloon Branch developed an early interest in radio-command separation. The idea was not necessarily to take the place of timing and aneroid devices, but to have some means of ending a flight sooner if it seemed advisable. One command cut-down system developed by Holloman's own Electronic and Atmospheric Projects Section was given checkout tests in 1951 and appeared successful. Another command cut-down system, flight-tested at Holloman in 1953, had been developed by the Aero Medical Laboratory of Wright Air Development Center. This last system was duly adopted not only for many aeromedical research flights but for other missions as well. In fact on some flights it is still being used. The main drawback of this as of most other command cutdown systems was vulnerability to interfering radio signals: there is one case in which a Holloman balloon flight cut down apparently in response to the playing of "Tiger Rag" on a local radio station.[20]

A different means of expediting post-flight recovery, developed experimentally at Holloman during the pre-polyethylene days of the Balloon Branch, was the "locator balloon," a small weather-type balloon rigged to descend along with the other flight equipment. Its function was to remain floating above the New Mexico brush after impact and act as guide to recovery parties. The method showed some promise but never came into regular use.[21] Various smoke generators have also been used, to give out signals both during descent and after landing.[22]

More important was the steady improvement of balloon antenna systems, to the point that they could continue to give out reliable radio signals during and after descent. Antenna developments officially received the greatest share of credit for a sharp increase in the "prompt recovery" rate from thirty-eight percent in fiscal year 1953 to eighty-eight percent in fiscal 1954. "Prompt" in this case was defined as meaning one week or less. In both years, about ten percent of the payloads were not recovered at all.[23] However, many of the packages recovered late or not at all were flown for projects in which physical recovery of equipment was not essential, or the trajectory was unusually long and difficult, or both.

Recovery rates have continued to improve, thanks not only to the use of advanced techniques but also to effort beyond the call of duty on the part of recovery crews. By the end of 1958, at least ninety-five percent of balloon packages were being recovered within a week. Almost none were being lost--and "lost" packages of years gone by were still turning up.[24]

One Balloon Branch recovery team had an unusual incentive to do its work well when it was sent to Arizona to recover a series of flights launched from Holloman in the summer of 1955.

Forced to remain out in the hot, dusty countryside for days on end, the men were reduced to bathing in the nearest irrigation ditch, but at least they had the benefit of special delivery mail service direct from home. Letters from their wives back in New Mexico were attached to the balloon equipment at launch, and it was then up to the men to go find them! Another Holloman recovery crew once managed to combine official duty with a visit to one of the nation's scenic wonders, when a balloon package conveniently landed at the bottom of the Grand Canyon.[25]

To be sure, recovery for Holloman balloon missions is not the exclusive responsibility of the Balloon Branch, or of the Air Force Missile Development Center. When the adjoining test ranges of Holloman Air Force Base and of the Army's White Sands Proving Ground were integrated by Defense Department order in 1952, the Army was put in charge of range recovery, and it organized a facility of its own with ground crews and light aircraft to do the job. The Army unit was geared chiefly for missile recovery, but balloon packages landing on-range came within its jurisdiction. Outside the range boundaries the Air Force--meaning essentially the Holloman Balloon Branch--retained its former responsibility. However, this distinction between on-range and off-range recovery has not been strictly maintained. Balloon Branch personnel have picked up many a package on-range even after range integration, as well as performing instrumentation and tracking functions that lead up to the final act of recovery. Similarly, the Army on its part has frequently given help off-range.[26]

The general public also shoulders a definite share of balloon recovery work, in response to the $25 reward notices that are flown attached to the equipment. There was a Mexican who found a Holloman balloon package south of the border and retrieved it on burro back, with a request not only for the posted reward but also for an extra something to cover food eaten by his burro during the trip. On another memorable occasion a balloon package was clearly seen as it came in to land but had simply disappeared when Air Force recovery crews reached the impact point. As it turned out, a nearby Indian had reached the package first and hidden it under a pile of brush with a view to producing it later on and claiming his $25![27]

At one extreme, a balloon package has been found just outside Alamogordo and delivered to the base by a cowboy on horseback; at the other extreme, packages have been returned all the way from overseas. Two stock examples of the latter concern flights launched at Holloman and recovered in Norway and Algeria respectively. These two flights were launched by the former New York University balloon project at Holloman, but balloons launched by the Balloon Branch itself have also been known to cross the Atlantic.[28]

One distinct category of balloon instrumentation that remains to be discussed is data recording. The amount of data recorded, and the means of recording it, vary widely from one project to another, but progress has been made in this field also. In-flight recorders, however, are normally supplied by the project (rather than the Balloon Branch) and are flown with the other project equipment. An exception is the barograph that has sometimes been supplied by the Balloon Branch to preserve a continuous record of flight altitude.

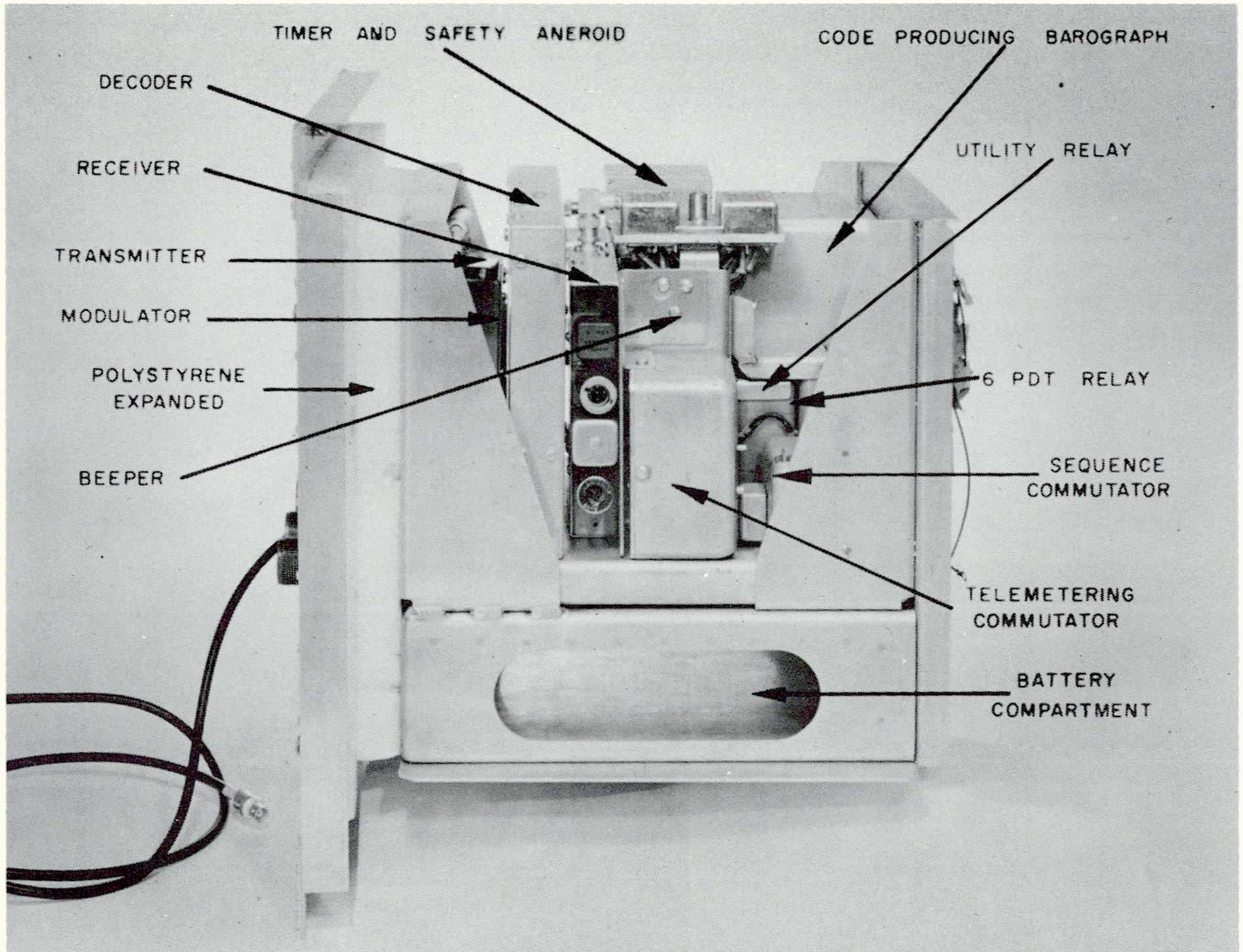
The Balloon Branch also makes available telemetry channels so data can be radioed from the balloon back to ground. Even long-range balloon telemetry, for distances up to and beyond 500 miles, has been successfully practiced for several years. The data most frequently telemetered--altitude measurements--are wanted by the Balloon Branch itself for purposes of tracking and flight control, but additional data can be telemetered as desired by the project. An interesting example is the flight of 27 August 1958, already mentioned in a previous chapter, in which a balloon transmitted cosmic ray data back to Holloman as it floated at twenty miles altitude over central Texas and New Mexico. The data transmission, by frequency-modulation telemetry, was continuous for over eight hours.[29]

Improvements in balloon instrumentation at Holloman and elsewhere have often come haphazardly. However, in recent years there has been increasing emphasis on the development of "integrated" balloon instrumentation, principally meaning a standardized flight package with all the components needed for tracking, telemetering, multiple command functions, and so forth. Design specifications for one such package were drawn up by the Center's instrumentation specialists, and a contract awarded to Cook Electric Company to produce the resulting "integrated" system. The latter received the name "Ballooncode" and was delivered early in 1956. Unfortunately, much of the hardware produced under the Cook contract turned out to be unusable. But valuable knowledge and experience were gained in the course of this effort, and to that extent the state of the art of balloon instrumentation was advanced. Nor can the failures be charged simply to the Cook organization, which incidentally lost money on the contract. Instrumentation people at Holloman still had much to learn at that time, and thus allowed the work to be based on unsatisfactory specifications.[30]

Another step forward was the creation, in 1956, of the Balloon Branch's own instrumentation section. Henceforth, balloon instrumentation work was to be centralized in this one unit, whereas previously it was performed by technicians who were not assigned to the Balloon Branch itself. The section is currently headed by Mr. David S. Willard and entitled Communications and Electronics Section.[31]

Willard and his co-workers have contributed a long list of improvements, both major and minor. They developed a special control package for target balloon flights, when one supplied for this purpose by the Hughes Aircraft Company proved unsatisfactory.[32] But the greatest single achievement of the instrumentation section has been preparing specifications for and then monitoring a contract with Radiaphone Corporation for still another "integrated" system. The contract was awarded in the spring of 1957; the first installment of hardware was accepted in mid-1958, and most had been delivered by the end of the year.[33]

Probably the most notable aspect of the new system is the radio command equipment. It has five channels, but by sequencing of commands or flying more than one command decoder on the same mission the number of separate commands available is almost unlimited--whereas a few years earlier just one command function was possible on a single flight. It has outstanding reliability also, with not one failure attributable to the command equipment itself since it was first flown. The odds against receiving a false command--for instance from static, or from interference of



COMPONENTS OF BALLOON COMMAND INSTRUMENTATION SYSTEM (SIDE VIEW)

Radiaphone Instrumentation System

a broadcasting station--are estimated in excess of one million to one. And it is more difficult than with other equipment for a ground technician to give a false command simply by pressing the wrong button, although this is not theoretically impossible. An interesting recent example of such a mishap occurred, with different command equipment, during a test that also served as a demonstration for Brigadier General Daniel E. Hooks, soon after his arrival to take command of the Air Force Missile Development Center in July 1958. Plans called for a low-level smoke flare to be released from the balloon, but an airman mistakenly pressed the cut-down button instead, and everything fell to earth making a great mess not far from the official party.

The degree of reliability offered by the new command equipment is particularly important for the launching of rockets and missiles from balloons, a type of activity that was described in the preceding chapter. Then, too, the multiple-command capability of the new system not only facilitates the operation of more complicated project payloads but increases the extent to which an unmanned balloon can become a directed rather than a free-floating vehicle. Command ballasting is one established technique for controlling a balloon's trajectory from the ground, but it has not always been reliable, and for lack of sufficient command channels it has not always been feasible to practice it on a given flight. Now both reliability and versatility of the command equipment are more than adequate. Similarly, the new equipment will be of great help in developing techniques of command valving, to lower a balloon's altitude in flight by release of gas from the valve at the top of the cell and also to provide more flexibility in launch operations by allowing the injection of increased free lift that can be valved out during ascent by command signal. The first operational use by the Balloon Branch of radio-controlled apex valving occurred on 12 June 1958, with an Air Force Cambridge Research Center "sun-seeker" payload that was floated first at 95,000 and then at 65,000 feet.[34] In future this procedure will become steadily more frequent.

Command equipment is of course only one part of the "integrated" Radiaphone instrumentation system. There are other units, too, such as a mechanical timer which can terminate a flight and also perform other functions at preset intervals. The separate units are generally lighter and more compact than those formerly in use, and they are designed to be easily plugged in or left out depending on the requirements of a mission. Unlike the former Cook contract, which called for very little in the way of associated ground equipment, the Radiaphone contract included such things as a complete ground checkout apparatus--not to mention the ground-based transmitter used with the new command system. The Radiaphone equipment even has some virtues that were not wholly anticipated. Specifications called for the units to be able to withstand thirty g's, but in practice they have successfully taken impacts on the order of 150 g's.

The end result is a complete instrumentation system that is still less than perfect, and still has not been adapted for every use of every project, but is in general far superior to other equipment available. Naturally, instrumentation people in the Holloman Balloon Branch and elsewhere will continue devising new techniques and improving old ones. In fact progress in this field is likely to be even more rapid in coming years, thanks to the advent of space satellites. Balloons and satellites both demand instrumentation with minimum size and weight and with other similar characteristics. Hence balloon instrumentation pioneered some instrumentation techniques of the type now used in satellite work, and it will no doubt continue to do so; but at the same time, borrowing has already begun from satellite work to balloons in radio direction-finding concepts and in the use of transistorization.

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2. Winzen Research, Inc., "Otto C. Winzen--Biographical Information;" above, pp. 1, 2.

3. 6580th Test Squadron (Special), Flight Summary, Non-Extensible Balloon Operations...June 1950 to October 1954.

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5. The quotation is from Gildenberg, "Some Properties of a Remarkable Vehicle," in Holloman Monthly News Bulletin, March 1958, p. 6. Except as otherwise indicated, the discussion of plastic balloons that follows is essentially a combination and condensation of the same published article, a longer unpublished version of it, and Gildenberg, "AFMDC Flying Saucer Nest" (n.d.).

6. Cf. Winzen, "Ten Years of Plastic Balloons," loc. cit., p. 438.

7. "British Radar, Plane Spot 'Flying Saucer,'" El Paso Herald-Post, 17 December 1953.

8. Above, p. 2.

9. Alamogordo Daily News, 31 August 1956.

10. Interview, Mr. Gildenberg by Dr. Bushnell, 12 January 1959.

11. The following discussion of launch techniques is essentially a condensation, by Mr. Gildenberg, of four technical reports he has written, with other material that he has added to

bring it up to date. For further details, see Gildenberg, Summary Report, Project Moby Dick, Covered Wagon Balloon Launcher, Development and Test Results 6 December 1951 to 15 September 1952 (HADC Report No. HDT-21, 17 December 1952); Techniques Developed for Heavy Load Non-Extensible Balloon Flights (HADC Technical Note 54-3, March 1954); Development of Shroud Inflation Techniques for Plastic Balloons (HADC Technical Note 54-4, April 1954); and Crane Launch Techniques for Polyethylene Balloons (HADC Technical Note 57-3).

12. Cf. David G. Simons, Stratosphere Balloon Techniques for Exposing Living Specimens to Primary Cosmic Ray Particles (HADC Technical Report 54-16, November 1954), p. 54.

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15. Gildenberg, Techniques Developed for Heavy Load Non-Extensible Balloon Flights, p. 7; Test Facilities Division, HADC, "Semi-Annual Progress Report," July-December 1955, p. 12; History of Flight Support, Holloman Air Development Center, 1946-1957 (AFMDC Historical Branch, July 1957), p. 103; Operations Division, DCS/O, AFMDC, "Historical Data ... 1 July-31 October 1957;" interview, Mr. Robert G. Blankenship, Recovery Operations Unit, Balloon Branch, by Dr. Bushnell, 24 September 1958; interview, Capt. Jack H. Patterson, Aircraft Allocations Officer, DCS/O, AFMDC, by Dr. Bushnell, 10 February 1959.

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1954), Part 1, p. 103; ARDC Newsreview, October 1958, p. 5.

18. Willard, "Progress in Balloon Instrumentation Techniques at Holloman Air Development Center" (August 1955), pp. 3-4; interview, Mr. Willard by Dr. Bushnell, 29 October 1958.

19. Willard, "Progress in Balloon Instrumentation," p. 4; Simons, Stratosphere Balloon Techniques, pp. 7-9, 19-24, 54.

20. HAFB, Quarterly Progress Summary Report on U.S.A.F. Guided Missile Test Activities, July-September 1951, pp. 31, 32; Simons, Stratosphere Balloon Techniques, pp. 27, 39; interview, Mr. Willard by Dr. Bushnell, 29 October 1958.

21. HAFB, Progress Summary Report on U.S.A.F. Guided Missile Test Activities, 1 December 1949, p. 53; interview, Capt. Milton M. Hopkins, Jr., Asst. Chief, and Mr. Ernest F. Sorgnit, Aero Research Administrator, High Altitude Test Division, AFMDC, by Dr. Bushnell, 23 September 1957.

22. Simons, Stratosphere Balloon Techniques, p. 54; Test Facilities Division, "Historical Report," January-March 1956, p. 5.

23. "Major FY 54 Accomplishments: Improved tracking and recovery techniques for high altitude balloon research," incl. 10 to DF, Lt. Col. Wilbur D. Pritchard, Cmdr., 6580th Test Squadron (Special), to Plans and Programs Division, DCS/O, HADC, subj.: "Summary Letter, FY 54," 30 June 1954; ltr., Col. Clarence L. Elder, DCS/O, HADC, to Cmdr., ARDC, subj.: "Holloman Air Development Center Annual Progress Report," 31 July 1954.

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26. History of Flight Support, pp. 28, 32, 33, and Appendix B; interview, Mr. Blankenship by Dr. Bushnell, 24 September 1958; Holloman Rocketeer, 19 September 1958.

27. Interview, Mr. Gildenberg by Dr. Bushnell, 30 September 1957.

28. *Rocketeer* (*HAFB*), 5 May 1950; *Alamogordo News*, 26 April 1951; *Alamogordo Daily News*, 31 August 1956; interview, Mr. Gildenberg by Dr. Bushnell, 30 September 1957.

29. Willard, "Progress in Balloon Instrumentation," pp. 4, 5; interview, Mr. Willard by Dr. Bushnell, 5 December 1958; *Holloman Rocketeer*, 19 September 1958; above, p. 19.

30. Willard, "Progress in Balloon Instrumentation," *passim*; interviews, Mr. Willard by Dr. Bushnell, 29 October and 5 December 1958.

31. See below, pp. 106, 107.

32. High Altitude Test Division, "Historical Data...1 January-31 March 1958," p. 3.

33. Except where otherwise indicated, the discussion that follows of the Radiaphone equipment is based on interviews by Dr. Bushnell, with Mr. Willard, 24 September, 29 October, and 5 December 1958, and with Mr. Ernest F. Sorgnit, Aero Research Administrator, Technical Services Division, AFMDC, 16 September 1958.

34. High Altitude Test Division, "Historical Data...1 April-30 June 1958," p. 6.

CHAPTER V

ADMINISTRATIVE PROBLEMS AND PRESENT OUTLOOK

The steady expansion of balloon operations at the Air Force Missile Development Center has naturally been reflected in the organization and administration of the Balloon Branch. It has grown in size as well as in renown, and has undergone its full share of growing pains in the process. It has also been affected by manpower and funding problems that were beyond its own control, and to a considerable extent even beyond the control of the local Center. But its future prospects appear bright, despite some recent setbacks.

For some time after a separate Holloman balloon unit was created, within the framework of the former Electronic and Atmospheric Projects Section, it was a relatively small and informal organization. In due course, however, the Holloman Balloon Branch not only became a clearly defined unit but had recognized subdivisions of its own. By 1 September 1955, for instance, it had an Operations Section immediately in charge of conducting balloon flights, and a Technical Guidance Section to provide "technical services, information and advice relative to balloon activities." The following year an Instrumentation and Communications Section was added, providing services formerly obtained from specialists outside as well as within the Balloon

Branch. In 1958 a Projects Section was formally created, essentially for administrative work; but was almost immediately abolished as a result of manpower cuts.

Only the short-lived Projects Section was immune to the constant name changes that are seemingly an inescapable feature of life at the Air Force Missile Development Center. At the time of writing (February 1959), the three surviving sections were known as the Operations Section, Balloon Control Section, and Communications and Electronics Section. Of these, the first had reverted to its earlier name, after bearing at least one other designation in between, but it was now concerned just with launch operations. Tracking and recovery functions were assigned to the Balloon Control Section, which otherwise was simply the latest form of the earlier Technical Guidance Section; while Communications and Electronics was an easily recognizable variant of Instrumentation and Communications.[1]

The chain of command between the Balloon Branch and other Holloman activities has undergone numerous changes also. To give only the principal arrangements since Holloman became a part of the new Air Research and Development Command, in April 1951, the Branch has formed part of:

1. Electronics and Atmospheric Unit, Development and Test Section, 6540th Missile Test Group, 6540th Missile Test Wing;

2. Test Section, 6580th Special Test Squadron, 6580th Test Group, Holloman Air Development Center;

3. Test Facilities Division, Directorate of Laboratories, Holloman Air Development Center;

4. High Altitude Test Division, Directorate of Ballistic Missile Test, Holloman Air Development Center; and currently

5. Technical Services Division, Directorate of Advanced Technology, Air Force Missile Development Center.[2]

All through these reorganizations the Balloon Branch at least had the steady companionship of the Rocket Sonde Branch, which has always been subordinate to the same next higher unit. For that matter, the life and work of the Branch have not been too greatly disturbed by alterations in the chain of command above or beyond it. As with so many military reorganizations, one could usually apply the familiar French saying: the more it changes, the more it's the same thing.

One element of stability has been the continued service of certain key civil service employees. An obvious example is Mr. Bernard D. Gildenberg, Chief of the Balloon Control Section of the Balloon Branch. After visiting Holloman Air Force Base for the first time with a New York University balloon team in 1948, he joined the Balloon Branch itself on a permanent basis in 1951. Another example is Mr. Herbert G. Markley, who took part in high-altitude rocket research as a lieutenant in the Electronic and Atmospheric Projects Section, changed to civil service status in 1950, and continued working on instrumentation problems at Holloman. At one point he joined an aircraft company, but he soon returned to Air Force employment and is now Assistant Chief of the Balloon Branch. Mr. David S. Willard, Chief of the Communication and Electronics Section, has worked on balloon instrumentation at Holloman in one capacity or another since June 1954. Then there is Mr. Ernest F. Sorgnit, who at present is a research administrator at division level--that is, working directly under the Chief of the Technical Services (until recently High Altitude Test) Division--but who has been closely associated with balloon operations since he came to Holloman in January 1953.[3]

Among military personnel--always a substantial majority of the total Balloon Branch staff--there has of course been greater turnover. However, a single Air Force officer, Major (now Lieutenant Colonel) Edward A. Doty, was able to guide the branch through most of its formative stage, during a tour at Holloman lasting nearly five years. Doty came to Holloman as a captain about the beginning of 1948 and was assigned to the Electronic and Atmospheric Projects Section. There he was directly concerned with the section's various balloon activities, including the establishment of what is now the Balloon Branch. After a brief absence for advanced training, he returned to Holloman and remained until November 1952. At that time he was formally head of the Balloon Sonde Sub-Unit, then the name of the Balloon Branch, which over the previous year had been undergoing a period of exceptionally rapid growth, chiefly reflecting the impact of Project Moby Dick.[4]

After the departure of Major Doty, the branch was briefly headed first by Lieutenant Charles C. Johnson and then by Lieutenant Romain C. Fruge, Jr. Lieutenant Jack Cahoon, Jr., assumed command in August 1953, and, with time out for Air Command and Staff School, remained as chief until succeeded by Captain (later Major) Milton M. Hopkins, Jr., in mid-1955. Lieutenant Cahoon returned to head the branch in May 1956, when Captain Hopkins moved on to become chief of the entire High Altitude Test Division. Starting in August 1956, the branch was headed in quick succession by three officers--Captain Jed B. Woolley, Lieutenant Donald A. Neal, and Captain James D. Miller--until the arrival of the present chief, Major Lawrence M. Bogard, in September 1957.[5]

This rapid turnover in branch chiefs seems less serious if one bears in mind that the same officer might fill other positions in the branch before becoming chief, and might also continue within the branch in a new capacity after a higher-ranking officer arrived to take command. Lieutenant Cahoon, for instance, served his apprenticeship under Major Doty and, between two terms as branch chief in his own right, was assistant under Captain Hopkins. Likewise Hopkins was still concerned with the Balloon Branch as Chief (and later, with the arrival of a higher-ranking officer, as Assistant Chief) of the High Altitude Test Division; and before finally leaving Holloman in June 1958, he returned to the Balloon Branch as head of its Operations Section.[6] Hopkins' career at the Air Force Missile Development Center--where he was promoted to major just before his reassignment--is an unusually clear example of the automatic functioning of rank and date-of-rank. It has parallels elsewhere in the Center, where many important missile projects were at one point headed by captains and lieutenants, until suddenly the backlog of vacancies in field-grade military spaces was filled, and the former chiefs were lowered automatically to assistant chiefs. Thus, rapid turn-over in key positions is by no means extraordinary in a military organization. Nevertheless, this situation may have at least something to do with the miscellaneous administrative deficiencies[7] that have sometimes been charged against the Balloon Branch.

There have also been problems with respect to enlisted personnel, whose number has fluctuated widely and sometimes unpredictably. At different periods in the past the Balloon Branch has been actually undermanned.[8] On the other hand, in the spring of 1958 it received a sudden and frankly unexpected increment of some sixty-five new airmen, which was more than the entire number previously assigned and left the branch decidedly overmanned as compared with its authorized strength. Needless to say, these new arrivals were not all balloon specialists. In fact it has never been easy to obtain airmen already familiar with balloon techniques, this being a rather limited field within the Air Force as a whole. And when the sixty-five airmen mentioned above turned up, a complete cross-training program had to be conducted before they could fully participate in the work of the branch. Formal classes were organized and conducted by Technical Sergeant Lonny B. Moss, who had just returned to Holloman himself from the Noncommissioned Officers Academy.[9]

Another difficulty that existed formerly but which has since been largely overcome concerned the classification and advancement of Balloon Branch airmen. At one point there simply was no recognized Air Force specialty code (AFSC) corresponding to the work performed by most members of the unit. For advancement, they had to qualify in such fields as heavy equipment operator, radar operator, or weather observer. Of these three fields, the first represented only one limited aspect of balloon operations, while the other two required considerable training outside the unit.[10] Subsequently a balloon-launcher specialist code was set up, although it did not entirely fit the work done at Holloman in particular. For instance, it called for experience in instrumentation techniques that at Holloman were largely the responsibility of civilian employees. However, once it was established that upgrading in this career field could be by board action rather than by a standardized written examination, it became possible to stretch the formal specifications slightly and in effect reward worthy candidates on the basis of the work they were doing.[11]

This solution was finally obtained about a year ago, but while the classification and advancement problem lasted, as can be imagined, it was not very good for morale. In periods of manpower shortage, morale has also been hurt in some instances by overwork. For off-base launch crews, in particular, the work day has been known to last as much as thirteen hours, without bringing exemption from kitchen police, charge of quarters, and miscellaneous squadron duties. As of February 1958 it was pointed out that no reenlistment had ever occurred in the Holloman Balloon Branch,[12] although some Balloon Branch airmen, having left Holloman, later sought and obtained reassignment to their old unit.

Since February 1958 there has been a decided change in the reenlistment situation. Similarly, a substantial majority of the airmen who received Sergeant Moss's training course expressed a desire to continue in balloon work.[13] But how many of them will be able to do so is an open question, for the Balloon Branch is one of the units that were adversely affected in the series of manpower cuts, crises, and readjustments that have afflicted the

Air Force Missile Development Center, like other Centers of the Air Research and Development Command, since the second half of 1957.

A Command-level survey recommended in April 1958 that the Balloon Branch lose twenty-one manpower spaces out of seventy-nine then authorized. This cut was less drastic than that recommended by the same group for the Center's Directorate of Research and Development, and most of it could have been absorbed without curtailing essential functions. However, the April recommendation was not allowed to stand. Following still another review of the Center manpower situation, the Balloon Branch learned in August 1958 that it was to be cut to a mere twenty-nine spaces--as compared with seventy-nine spaces authorized, 136 people actually assigned--by the end of the fiscal year. The airman category was to suffer much the sharpest reduction. This new cut threatened elimination of two of the three existing launch crews, virtual elimination of target balloon flights (to be replaced principally by the Pogo-Hi parachute target system), plus a distinct cutback in research flights.[14]

The new and more severe reduction was determined primarily at Center, not Command level, and aimed basically to save spaces for the use of other Center units. The decision was undoubtedly influenced by the hope that it might never have to be fully carried out. With relatively few openings existing within the

Air Force for the balloon-launcher career specialty, there was a chance that some of the affected Balloon Branch airmen would in practice be allowed to continue on an overage basis. Also, many things might happen before the end of the fiscal year. However, some airmen have already been transferred, for instance to other activities at the Air Force Missile Development Center. The situation with regard to civil service employees was also serious: few were actually threatened with dismissal, but the prospect of a reduction in force is normally more damaging to civilian than to military morale. And, finally, the operating funds of the Balloon Branch were cut at the same time.[15]

Nor was it only hope that the manpower cuts would not be fully carried out that led the Center to adopt them. The fact is that the Balloon Branch has enjoyed relatively low Center priority--and not merely in manpower matters but also in the distribution of other resources. Technically speaking, it has the same priority for any given requirement as does the project it is supporting at the moment, but this policy is not always clearly understood or easily implemented.[16] Even on a project-for-project basis, some of the research activities served by the Balloon Branch have a relatively low Air Force priority; and thinking at Center level is naturally colored, rightly or wrongly, by the fact that so many of these are activities of other Centers and sometimes even other agencies rather than of the local Center.

Nevertheless, the importance of all these and other difficulties should not be exaggerated. Manpower authorizations and the like are seldom wholly satisfactory to anyone. In the present situation of the Balloon Branch, moreover, various concrete sources of relief have been suggested,including the possible assignment of airmen to the Holloman unit on temporary duty from the 1110th Balloon Activities Group, Lowry Air Force Base, Colorado.[17] Certainly the "customers" of the Balloon Branch are generally anxious that some form of relief should be forthcoming. Not only have some misgivings been expressed with regard to the adequacy of promised substitutes for balloon targets, but there is the danger that important research flights either will not be accomplished or will have to be conducted elsewhere, through private contractual services and at greater cost to the government. There is even a considerable waiting list of projects which have valid requirements for the services of the Balloon Branch but which have not yet flown their research equipment. These projects include recent additions with very high priority; and the waiting list would undoubtedly be longer if many other project scientists did not feel that it was useless to apply.

This unabated interest in ballooning may at first glance seem anachronistic in the age of research satellites. Yet balloons, far from being superseded by satellite developments, have an important role to play in pretesting of satellite equipment and procedures. There are also things a balloon can do of which no true satellite is yet capable: it can operate at low and medium as well as high altitudes; weather permitting, it can hover for extended periods above a single area; and it can return its cargo of scientific instruments safely to earth. Development of recovery systems for satellite use is obviously just a matter of time, but it is doubtful that satellites will ever come close to rivaling balloons in economy. Thus the next few years are likely to see a continued growth in balloon-borne research and dev lopment activities. And certainly no agency in the United States, or in the world for that matter, is better qualified to take part in this expansion than the Holloman balloon organization, which has been flying balloons steadily for over ten years and in addition enjoys unique advantages in such matters as weather, tracking, and recovery. Its members even harbor the ambition to go on temporary duty themselves--to launch balloons on Mars, whose atmosphere is admirably suited for this type of vehicle.

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2. 6540th Missile Test Wing, "Functional Organizational Chart, Holloman Air Force Base, Approved 5 July 1951;" Comptroller, HADC, Organization and Functions, June 1953, p. 81; Manpower and Organization Division, Organization and Functions, revisions of 1 September 1955 to present.

3. Alamogordo Daily News, 2 June 1957; files of Civilian Personnel Division, AFMDC.

4. Progress Summary Report on U.S.A.F. Guided Missile Test Activities (HAFB, published monthly 1 November 1947-1 June 1950); Roster of Officers Assigned (HAFB), 10 March 1950-31 October 1952.

5. Roster of Officers Assigned, 30 November 1952 to present; High Altitude Test Division, AFMDC, "Historical Data...1 October-31 December 1956," p. 1.

6. Roster of Officers Assigned, 30 November 1952 to present.

7. Cf. report, Lt. Col. William F. Haizlip, Inspector General, AFMDC, to Chief of Staff, AFMDC, subj.: "Balloon Support for Project Mission Accomplishment," 4 February 1958.

8. Cf. ltr., Col. Clarence L. Elder, DCS/O, HADC, to Cmdr., ARDC, subj.: "Holloman Air Development Center Annual Progress Report," 31 July 1954.

9. Interviews, Maj. John R. Patterson, Chief, Technical Services Division, AFMDC, and Maj. Lawrence M. Bogard, Chief, Balloon Branch, AFMDC, by Dr. David Bushnell, AFMDC Historian, 24 September 1958; High Altitude Test Division, "Historical Data...1 April-30 June 1958," pp. 2, 5 and "Historical Data...1 July-31 August 1958," p. 5; interview, M/Sgt. A. D. Vizcarra, Sergeant Major, Military Personnel Division, AFMDC, by Dr. Bushnell, 6 January 1959.

10. Ltr., Col. Elder to Cmdr., ARDC, subj.: "HADC Annual Progress Report," 31 July 1954.

11. Interview, Maj. Milton M. Hopkins, Jr., Chief, Operations Section, Balloon Branch, by Dr. Bushnell, 7 May 1958; High Altitude Test Division, "Historical Data...1 January-31 March 1958," pp. 6, 7.

12. Report, Col. Haizlip to Chief of Staff, subj.: "Balloon Support," 4 February 1958; interview, Mr. Bernard D. Gildenberg, Chief, Balloon Control Section, Balloon Branch, by Dr. Bushnell, 18 December 1958.

13. Interview, Maj. Bogard by Dr. Bushnell, 24 September 1958.

14. Ltr., Lt. Gen. S. E. Anderson to Cmdr., AFMDC, subj.: "Functional Overmanning Inspection," 28 April 1958; DF, DCS/Operations, AFMDC, to various units, subj.: "Change in AFMDC Organization and Manning," 27 August 1958; interview, Maj. Hopkins by Dr. Bushnell, 7 May 1958; interview, Maj. Bogard by Dr. Bushnell, 24 September 1958; interview, S/Sgt. Grady Cole, Balloon Branch, by Dr. Bushnell, 8 December 1958. On Pogo-Hi, see above, p.41.

15. Interview, Mr. Ernest F. Sorgnit, Aero Research Administrator, Technical Services Division, AFMDC, by Dr. Bushnell, 16 September 1958; interview, Maj. Bogard by Dr. Bushnell, 24 September 1958.

16. Report, Col. Haizlip to Chief of Staff, subj.: "Balloon Support," 4 February 1958, and 1st ind. to same, Col. Richard C. Gibson, DCS/O, AFMDC, to Chief of Staff, 28 February 1958.

17. Interview, Maj. Bogard by Dr. Bushnell, 18 December 1958.

GLOSSARY

AFB	Air Force Base
AFCRC	Air Force Cambridge Research Center
AFMDC	Air Force Missile Development Center
ARCS	Air Resupply and Communication Service
ARDC	Air Research and Development Command
Cmdr.	Commander
DCS/	Deputy Chief of Staff for
DCS/O	Deputy Chief of Staff, Operations
DD	Department of Defense
DF	Disposition Form
FY	Fiscal Year
Hq.	Headquarters
HADC	Holloman Air Development Center (re-designated Air Force Missile Development Center as of 1 September 1957)
HAFB	Holloman Air Force Base
HTV	Hypersonic Test Vehicle
HVAR	High-velocity aircraft rocket
Incl.	Inclosure
Ind.	Indorsement
Ltr.	Letter
NCOIC	Noncommissioned Officer in Charge

n. d.	No date
R & D	Research and Development
Subj.	Subject
USAF	United States Air Force
WADC	Wright Air Development Center
WSMR	White Sands Missile Range
WSPG	White Sands Proving Ground

GAZETTEER

Aberdeen Proving Ground	An Army Ordnance Department test installatinn, about twenty-five miles east of Baltimore, Maryland.
Air Force Cambridge Research Center	A major unit of the Air Research and Development Command, with headquarters located at Hanscom Field, Bedford, Massachusetts. Its mission lies primarily in the two fields of electronics and geophysics.
Air Force Missile Development Center	A major unit of the Air Research and Development Command, formally established in 1952 and located at Holloman Air Force Base, New Mexico. Its mission is chiefly related to guided missiles, upper atmospheric investigations, bio-astronautics, and other aspects of space technology such as orbital mechanics. Until 1 September 1957 it was known as Holloman Air Development Center.
Alamogordo, New Mexico	The closest settlement to Holloman Air Force Base, Alamogordo is located at the edge of the Tularosa Basin, about ten miles to the east of the military installation and ninety miles north of El Paso, Texas. Founded in 1898 as a railroad water-point, it grew slowly until after the establishment of the Alamogordo Army Air Field (later renamed Holloman) in 1942. It is the county seat of Otero County and has a current population of more than 20,000.
Edwards Air Force Base	Air Research and Development Command installation, approximately seventy-five miles northeast of Los Angeles, California. It is the site of the

	Air Force Flight Test Center.
Eniwetok	Circular Pacific atoll fifty miles in circumference composed of forty islets totaling about two square miles of surface. Part of the Ralik Chain of the Marshall Islands complex, Eniwetok was captured in 1944 by United States forces. Since 1948, it has been the test site for atomic and hydrogen weapons. The Air Force Special Weapons Center maintains permanent installations on the atoll.
Holloman Air Development Center	Official designation of the present Air Force Missile Development Center during the period from October 1952 until 1 September 1957.
Holloman Air Force Base	Known until 1948 as Alamogordo Army Air Field, Holloman Air Force Base is located in the Tularosa Basin ten miles southwest of Alamogordo, New Mexico. It is now the location of the Air Force Missile Development Center.
Las Cruces, New Mexico	A college and agricultural center in the Rio Grande valley, seat of Dona Ana County and nearest urban center to the headquarters area of the White Sands Missile Range (and of the Army Missile Development Center).
Lowry Air Force Base	An Air Training Command installation at Denver, Colorado. It is the location of Headquarters, 1110th Balloon Activities Group, which is a dependency of Headquarters Command.
Mayhill, New Mexico	Small community in the Sacramento Mountains, about thirty miles due east of Alamogordo.
Minneapolis, Minnesota	Largest city of the northern Mississippi Valley, and the leading

	world center of plastic ballooning. This last distinction reflects the presence of two firms engaged in balloon manufacturing and flight operations--General Mills and Winzen Research--and also the close association of University of Minnesota scientists with balloon research developments.
Moffett Naval Air Station	Naval installation located at Sunnyvale, California, in the San Francisco bay area.
North Area	One of the three principal, non-contiguous areas into which Holloman Air Force Base is divided. This three-area arrangement was adopted from the outset, according to specifications of the Royal Air Force, which was originally expected to use the base, in World War II, as a British overseas training installation. The North Area is the site of the Aeromedical Field Laboratory, the Aerobee launch tower, and the captive-missile test track.
Pierre, South Dakota	Capital city of South Dakota, located approximately in the middle of the state. Served as a launch site in 1953 for Holloman research balloons.
Rome Air Development Center	One of the Centers of Air Research and Development Command, with a mission in the field of electronics research. It is located at Griffiss Air Force Base, Rome, New York.
Roswell, New Mexico	One of New Mexico's major cities, seat of Chaves County and the main business center of the Roswell Artesian Basin. Walker Air Force Base is located four miles south of the city.

Sacramento Mountains	Range of mountains constituting the eastern border of the Tularosa Basin. Their highest peak, Sierra Blanca, rises over 12,000 feet.
Sacramento Peak Observatory	Officially known as the Upper Air Research Observatory of the Air Force Cambridge Research Center. Specializing in solar research, it is located high in the Sacramento Mountains southeast of Alamogordo, New Mexico, and is attached for support purposes to the Air Force Missile Development Center.
San Andres Mountains	Range of mountains in south-central New Mexico, roughly marking the western boundary of the Tularosa Basin and of the integrated White Sands Missile Range. They are distinctly lower than the Sacramento Mountains which run parallel about fifty miles to the east.
Tillamook Naval Air Station (Auxiliary), Oregon	Naval installation in the northwestern part of the state, about seventy-five miles from Portland.
Truth or Consequences, New Mexico	City in the Rio Grande valley, situated roughly one-third of the way from Las Cruces to Albuquerque. Seat of Sierra County and a focus of off-range balloon operations by the Air Force Missile Development Center's Balloon Branch.
Tularosa, New Mexico	Second largest community in Otero County, twelve miles north of Alamogordo. An established center of irrigated agriculture, which has received a recent influx of residents commuting to the Air Force Missile Development Center.
Tularosa Basin	The northern extension of the Chihuahua Desert, this broad, flat basin is bounded by the

San Andres and Sacramento mountain chains. Within it are contained both the White Sands Missile Range and the military ranges belonging to Fort Bliss, Texas. The flatness of the basin floor, the many convenient instrumentation sites on surrounding peaks, the ideal testing climate and the sparseness of population make the basin unusually valuable for military research and development programs.

Vernalis Naval Air Station — Naval installation located inland from San Francisco, in northern California.

White Sands Missile Range — A military testing range that occupies a major part of New Mexico's Tularosa Basin. It was formed under Defense Department order, in 1952, by combining the range of Holloman Air Force Base with that of White Sands Proving Ground and part of the ranges belonging to Fort Bliss, Texas. Immediate responsibility for range administration is vested in the Army, but use of the range is shared by the Air Force Missile Development Center and the smaller Naval Ordnance Missile Test Facility.

White Sands National Monument — A recreation area, famous for its dunes of pure gypsum, in the middle of the Tularosa Basin. Operated by the National Park Service, it is wholly surrounded by the White Sands Missile Range.

White Sands Proving Ground — A military installation established by the Army in 1945, in the western part of the Tularosa Basin. Its testing range was integrated with that of Holloman Air Force Base to form the present White Sands Missile Range. The Army's own research and development complex, which shares the use of the integrated range, has recently been designated Army Missile Development Center.

Wright Air Development Center — The largest of all the Centers in Air Research and Development Command, located at Wright-Patterson Air Force Base, near Dayton, Ohio. Its research and monitoring functions touch upon virtually all aspects of the development of weapon systems.

Wright Field — A short designation often used in referring either to Wright-Patterson Air Force Base, Ohio, or to the Wright Air Development Center. Strictly speaking, the latter is a tenant organization at the base, which is under the jurisdiction of (and contains the headquarters of) Air Materiel Command.

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