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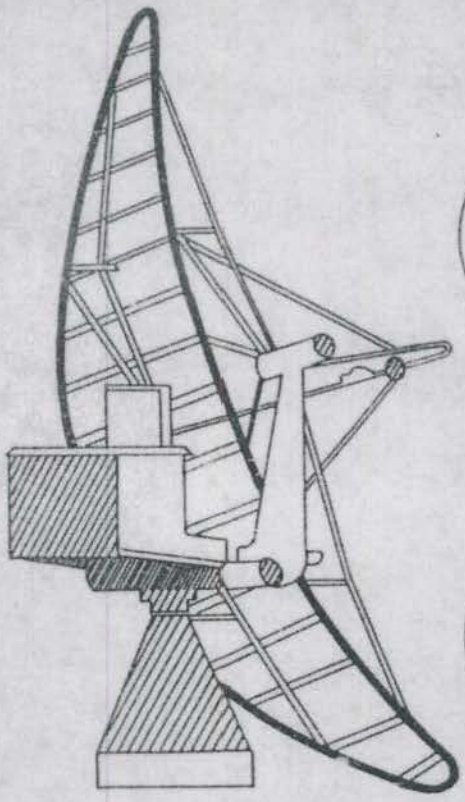
HISTORY

Rome Air Development Center
Air Research & Development Command
United States Air Force



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H I S T O R Y

OF

RCAS AIR DEVELOPMENT CENTER

GRIFFISS AIR FORCE BASE

NEW YORK

1 July - 31 December

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VOLUME I

NARRATIVE

Approved By:

[redacted]

DONALD P. GRAUL
Brigadier General, USAF
Commander

Prepared By:

[redacted]

Center Historian

AIR RESEARCH AND DEVELOPMENT COMMAND
United States Air Force

Control No. 57-8193

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FOREWARD

During the confusion which abounded in the first weeks of World War II, the very real need for military historical programs to furnish wartime leaders with a better perspective and broader understanding of their problems had become apparent. For this reason President Roosevelt directed in 1942 that each of the war agencies prepare an administrative record of its wartime activities. It is from this date that the Air Force historical program takes its beginning. Later, after the Air Force became a separate establishment, the history program was strengthened further by the publication of Air Force Regulation 210-3(1948) which defined the mission and policy of the program. Subsequent presidential directives have served to emphasize again the value of maintaining historical records.

A Center history is of value locally in orienting new personnel rapidly and efficiently and in providing administrators, scientists and engineers, most of whose time is claimed by their own responsibilities, with a broader understanding and a greater awareness of the total Center effort. At Headquarters, Air Research and Development Command, the Center history supplies pertinent facts, statistics and analyses necessary to the establishment of a Command-wide historical perspective for use at Headquarters and at other centers of the Command. Copies of the Center history are also forwarded to Air University where they are available for special studies of various kinds.

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The first two chapters of this history and the collection of documents concerning them were prepared and assembled by the former Center Historian, Mr. Robert P. Piper. The present Center Historian is also indebted to Mr. Piper for notes, suggestions and collections of documents which have facilitated the writing of the remainder of the history. The Historian is pleased to acknowledge the excellen cooperation he has received from Major John Kiernan, formerly Information Services Officer, and from Lt. George Alexander the present Information Services Officer. He also wishes to thank Mrs. Betty Zuicko for her patience and care in correcting and typing the final manuscript. Finally the Historian wishes to recognize the invaluable aid he has received from the members of the staff, laboratory and section chiefs and engineers who have placed records at his disposal and given of their time to make possible the history which follows.

Philip A. Knachel
Center Historian

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CHRONOLOGY

1 July 1956 - Directorate of Communications activated.

22-23 August 1956 - Conference on Acquisition Radar.

12-13 September 1956 - Conference of Navarho Advisory Panel.

15-16 September 1956 - Symposium on Passive Detection in Air Defense.

16 September 1956 - Colonel Daniel M. Harvey assigned as Director of Communications.

1 October 1956 - Colonel Howard Burhanna, Jr., assigned as Director of Procurement.

22-26 October 1956 - ARDC Conference for Personnel Specialists.

23-24 October 1956 - Conference on Infrared Countermeasures.

29 October 1956 - Presentation of Final Report of WSEG to Defense Department.

31 October-1 November 1956-Conference on Single Sideband.

1 November 1956 - Major John Kiernan assigned as Adjutant.

7-8 November 1956 - Conference on Crash Locator.

28-29 November 1956 - Symposium on Air Force Global Communications System.

21 December 1956 - Conference on Texas Towers Interference Test Program.

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CHAPTER I

CENTER BRIEFING

There was continued emphasis by the Air Research and Development Command on the development of electronic systems and components that would assure the United States Air Force performance superiority essential to its mission. The mission of the Rome Air Development Center was precisely defined within certain general requirements which included applied research and development of those systems and components related to the ground electronic environment. This meant continued effort in areas of detection, control, identification, countermeasures, navigation, communications, data transmission, and radio-intelligence collection and processing. Research and development was also extended to the development of ground-based intelligence and reconnaissance systems and components, and the operation of an electronic countermeasures test facility (ECM) that was to be used to support all Air Research and Development centers or other agencies as headquarters might direct. (UNCLASSIFIED)

There were very few changes of personnel on the staff and directorate level. Major General Stuart P. Wright continued as the Commander of the Center and Colonel Daniel B. White remained as the Deputy Commander. The Scientific Director, formerly called the Technical Director, was Mr. Harry Davis. As previously reported,

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Robert V. Decker became acting director of the Directorate of Procurement following the transfer of Colonel John B. Turner. On the 1st of October 1956 Colonel Howard Burhanna,Jr. was assigned as the Director of Procurement. The new Center Directorate of Communications that became active on the 1st of July 1956 was headed by Joseph Vogelman until a permanent director was selected. On the 17th of September 1956 the position of Director was assigned to Colonel Daniel M. Harvey and Joseph Vogelman remained the Technical Director of the Communications Directorate. On the 1st of November 1956 Major John P. Kiernan assumed the position of Adjutant that was left vacant through the transfer of Captain Walter Falk,Jr. Lieutenant George A. Haskins who had been acting Adjutant was assigned as Squadron Commander on the 26th of December,1956.* (UNCLASSIFIED)

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* On the 31st of December 1956 the Commander's staff and directors of Center agencies were as follows:

Mr. James Wayman	Inspector General
Lt. Melvin A. Bailey	Office of Information Services
Major John P. Kiernan	Adjutant
Lt. George A. Haskins	Headquarters,Squadron Section
Lt.Col. Woodrow Smith	DCS/Personnel
Col. John R. Hoover	DCS/Operations
Lt.Col. Leo E. Fielder	DCS/Materiel
Col. John B. Donley	DCS/Comptroller
Col. Howard Burhanna Jr.	Directorate of Procurement
Col. Otto Quanrud	Directorate of Control & Guidance
Col. James Anderson	Directorate of Intelligence & Electronic Warfare
Mr. Oliver Tallman	Directorate of Technical Services
Major Robert E. Barney	Directorate of Flight Test
Col. Daniel M. Harvey	Directorate of Communications

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Inspector General

The Inspector General's Office carried out its dual role of responsibility for the security of the Center and inspection of Center operations that was directed to improving the productivity and management of Center agencies and organizations. Inspections were performed on the request of the Commander, Vice Commander, Scientific Director, staff officers, and directors. Separate from these were "problem area" inspections that were defined as those that were made after analysis of individual inspection reports indicated a Center-wide condition existed that needed correction or solution. The emphasis on all inspections was to obtain management improvement rather than merely to secure compliance with regulations.[1] (UNCLASSIFIED)

Adjutant

The Office of the Adjutant continued to perform many vital services for the Center. It was the staff agency that in a sense controlled paper work, regulated its storage, and final disposal. All correspondence entering, leaving and circulating within the Center was handled by this office. This required particular attention to the very detailed procedures necessary to control all classified mail and documents. Another assigned task was to act as the "clearing house" for all Center travel including overseas assignments. To aid travelers the Adjutant's Office

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published a brochure entitled, "So You Are Going Overseas (On TDY)," that contained the instructions imposed by regulations and relevant information suggested by Personnel, Inspector General, Intelligence, and Administrative Services. (UNCLASSIFIED)

The Reproduction Branch of the Adjutant's Office was faced with increasing demands for printing and duplicating service at the same time it was presented with a reduced operating budget. The budget allocation was established by the Air Research and Development Command at $9,000. This amount was increased to $13,500 by the 31 December 1956.[2] Plans were made to increase the working area of the mail room. This action was considered to be very necessary to improve the work room area that was too congested to permit really efficient operation. (UNCLASSIFIED)

Personnel

As has been reported in other histories the Rome Center depends for its manpower needs on the base Civil Service Office. Its successful acquisition of the scientists, engineers, administrative, technical, and clerical personnel depends on joint effort of the base and Center personnel functions. A well organized and concentrated "drive" was made to recruit professional people into working for the Center. Although the loss of professional employees to private industry or other callings was severe it was possible for the Center to avoid any serious manpower problems. The Rome Center Personnel System continued to operate

with unusual success in meeting the requirements of promotion that required a different approach in a scientific center. The system was studied by the Air Research and Development Command and by representatives from other centers for possible adaptation to their own needs. (UNCLASSIFIED)

Materiel

For the remainder of fiscal year 1957 construction was expected to begin on an electronic tube laboratory. The budget allocation for this construction, including two experimental stations, amounted to $650,000. There was $4,500,000 appropriated for the construction of an operations building for the down range site on the island of Trinidad. [redacted]

Comptroller

The Center budget for fiscal year 1957 was increased slightly over that previously reported.[3] Based on a teletype, dated the 14 of January 1957, various items in budget exclusive of personnel services were increased to $4,377,800 or to a total of $11,801,935. A copy of the budget authorizations based on this additional money may be noted in the appendix. (UNCLASSIFIED)

The Center budget including research and development funds are of course much larger. These are allocated as either P-600 funds or non P-600 funds. The P-600 funds are to cover expenditures for studies, test and analysis of theories and techniques, research facilities of non-profit institutions, preliminary designs,

and [illegible] vehicles. Also included in this fund category are the costs of detailed design and fabrication, experimental models of various kinds, flight tests, feasibility tests, engineering expenses [illegible] to cover engineering changes.(UNCLASSIFIED)

Non P-600 funds are to cover the costs involved in the development of prototype models, test models, test engines, engine components and related types or groups of equipment. Other costs that may be included in this classification are those incurred for detailed design, fabrication, flight test by contractor, functional and performance testing, engineering and engineering changes and the costs involved in providing development facilities.(UNCLASSIFIED)

The funds available are continually changing but this was their status by the end of 1956: the Center had available a total of $26,100,000 in P-600 funds and $25,700,000 in non-P-600 funds or a total for research and development of $51,800,000. In reference to particular directorates this was to be distributed as indicated in the following amounts: The Directorate of Control and Guidance had available a total of $19,491,000 in P-600 funds and a total of $13,689,000 in non P-600 funds or a total of $33,180,000 was available to this Directorate. The Directorate of Communications had available a total of $1,579,000 in P-600 funds and $4,620,000 in non-P-600 or a total of $6,199,000. The Directorate of Intelligence and Electronic Warfare was granted $11,179,000 in P-600 funds and $11,372,000 in non P-600 funds or

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a total of $22,513,000. The Directorate of Technical Services was allowed $2,188,000 in P-600 funds and $495,000 in non P-600 funds or a total of $2,683,000.[4] (UNCLASSIFIED)

The mathematics headquarters of the Rome Center was in the Statistical Services Division of the Comptroller's Office and was headed by Julius Widerwitz. This provides through electronic computers a variety of services for the Center. To utilize the potential services of the equipment available, various organizational schemes were tried. By the 1 December 1956 the Division contained a Scientific Computing Branch, Methods Mechanization Branch and the Statistical Production Branch. This arrangement permitted the Division to assume a more relevant role. Problems are accepted in whatever form they may be presented and then if necessary the problem is reduced to mathematical terms that permit the problem to be solved through the use of the computing equipment that is available. There are four major types of equipment in operation. The analog facilities included an electronic differential analyzer produced by Reeves called the REAC, a computer particularly adapted to ". . . the study of problems in mechanical vibration, control systems, chemical process systems, aircraft flight dynamics and many other time varying problems."[5] The digital facilities includes the Elecom 120 which is a high speed digital calculator and a Bendix digital differential analyzer called the Bendix D-12. The fourth type

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of equipment permits data reduction from film strips. This is performed through the use of a Boscar Model A which is a ballistic film analyser and recorder. As applied in this installation the input is 35mm film, which is projected on a screen along with a spot of light. The light spot, in some way that is only clear to a mathematician, derives information in terms ". . . of the X-Y coordinate system at the screen plane."[6] The other equipment used was the Oscar Model E, an oscillograph analyzer and reader. This machine reads data from traces recorded on oscillographs, data that may be of extreme value in engineering and scientific applications. (UNCLASSIFIED)

Along with the non-routine problem solving, the Statistical Production Branch performs audits and control functions and contains as well the electronic accounting machine section that has reduced the financial and statistical activity of the Center to punched cards. This accumulated data was kept current and may be sorted and tabulated as the needs of the Center and headquarters require. This is the main source of information for the data transmission line to Baltimore headquarters. (UNCLASSIFIED)

The final equipment was installed in December to permit a direct connection between the Center and headquarters statistical services in Baltimore. Formerly statistical information was forwarded in mailed reports or transcribed on tape that was handled through Griffiss Air Force base headquarters and then

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sent on to Baltimore. This arrangement often resulted in delay. The equipments placed in service were a Western Union teleprinter and IBM 860 transceivers. The teleprinter may not be used for conventional messages but to indicate the type of intelligence to be transmitted. The transceiver receives the punched cards, tabulates the data and forwards the data to Baltimore where the same process is performed in reverse.(UNCLASSIFIED)

The Accounting Division under the direction of Earl Towne continued to improve its service to the Center. During October of 1956 a new accounting procedure was started of reporting on a semi-monthly schedule the cash status of such funds as travel, dollar commitments and obligations. This report was circulated to the Commander, each staff office and directorate. In addition to this, accounting information on weekly changes in the budget are summarized and reported to a weekly meeting on the budget attended by staff officers and directors.(UNCLASSIFIED)

Another area of financial accounting that must be guarded very carefully are the funds for research and development. There is an Air Force regulation (AFR 177-16) that prohibits any obligation of government funds in excess of that clearly defined by contract or permitted by proper authority and procedure. A violation of this regulation is a serious matter. To insure proper understanding of this regulation, the Accounting Division

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required all personnel associated with contractural activity to indicate their awareness and understanding of this regulation.(U)

Conferences

Possibly it might be stated as an axiom that the more complex an intellectual discipline the greater the necessity for communication of ideas. Scientific meetings and conferences fill this need to generate and stimulate advances in a particular art. There were numerous conferences at the Rome Center that were devoted to discussions of complex electronic theory, reviews of the current state-of-the-art, requirements for or the uses of particular equipments within the Air Force, contractor proposals for the solution of Air Force problems and conferences between contractors and Center project engineers to solve their engineering problems. In addition to these conferences, several times a year there are meetings of professional groups that include in their memberships most of the professional electronic engineers and scientists working at the Rome Center.(UNCLASSIFIED)

The Rome-Utica, New York, Chapter of the Institute of Radio Engineers met in Utica on the 8th and 9th of October 1956 as a sponsor of the second annual national symposium on aeronautical communications. The meeting emphasized the needs of the expanding civil and military aviation for a reliable and safe system of communications. There were over 600 engineers, scientists and communications executives present at this meeting. On the 10th of October 1956

a classified session was held that was addressed by Joseph Russ from the Rome Center on the subject of the Air Force Time Division Data Link.[8] (UNCLASSIFIED)

In addition to this address by Joseph Russ engineers from the Rome Center presented several scientific papers to the delegates. Joseph Berliner and John Augustine read their paper on the "Results of Ultra High Frequency Mutual Environment Test Program at RADC." This report surveyed the results of tests performed with ultra high frequency equipments to determine the mutual interference problems that are present when a number of transmitters and receivers are operated together under various conditions.[9] (UNCLASSIFIED)

"Air Force Communications Problems and the Future Air Force Operational System," was presented by C. K. Chappuis. A paper on "A One Kilowatt High Level Modulated UHF Amplifier with Low Distortion" was presented by G. R. Weatherup, C. R. Ellis from General Electric Company and K. E. Owen from McIntosh Electronics. This was reported to be a much needed development for certain military applications and would have the effect of increasing the range and efficiency of presently used transmitters such as the AN/GRC-27. Weatherup was particularly interested in describing the Air Force development and test program for this equipment.[10] (UNCLASSIFIED)

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In reference to the Center, the primary purpose of conference activity was to maintain liaison with other commands of the Air Force and to keep in close touch with industry and research laboratories. On the [illegible] and 6 July 1956, the Intelligence Laboratory was visited by the Reconnaissance Systems Panel of the Scientific Advisory Board. The membership that was present included Dr. C. Overhage associated with Project Lincoln, Dr. D. MacDonald from Boston University, George Garrett from the Directorate of Intelligence, United States Air Force and Dr. Baker from Harvard University. On the 24 and 25 July 1956, Ramo-Wooldridge Corporation presented the results of their design study of an Integrated Air Force Intelligence Data Handling System. Representatives at this conference were from the Army, Navy, Central Intelligence Agency, National Security Agency, National Science Foundation, Massachusetts Institute of Technology, University of Michigan, Syracuse University and Rand Corporation.[11] (UNCLASSIFIED)

During August 1956 there was a joint Center and Technical Training Air Force conference which has become an annual briefing conducted by the Center to keep the Technical Training Command completely up-to-date on new electronic developments. Some of the items included in the discussion concerned Automatic Ground Controlled Approach, Navarho, new bomb scoring techniques, data transmission features, automatic trackers, communications equip-

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ments including the ultra-high frequency kilowatt transmitter, troposphere scatter, single sideband, radio relay, Rafax Kink, Two Wheels and electronic countermeasures equipment. The Rome Center was also host during the month of August to a conference on counter-countermeasures that included representatives from the Royal Canadian Air Force, United States Air Force and Headquarters, Air Research and Development Command.[12] (UNCLASSIFIED)

On the 11 September 1956, representatives from the Air Defense Command, Strategic Air Command, Air Proving Ground, Air Research and Development Command, United States Air Force listened to a presentation by engineers from the Rome Center's Electronic Warfare Laboratory on the Distributed Area Jamming system. A two day symposium on passive detection in the air defense situation was held on the 15th and 16th of September 1956. This was attended by representatives from Air Research and Development Command, Kelper Incorporated, Westinghouse Corporation, General Electric, Bendix and Weapons Systems Evaluation Group. A conference of the Navarho Advisory Panel was held on the 12th and 13th of September. At this conference were representatives from the National Bureau of Standards, United States Coast Guard, Headquarters, United States Air Force, Air Research and Development Command, Civil Aeronautics Authority, Navy Bureau of Aeronautics and Wright Air Development Center.[13] (UNCLASSIFIED)

It was previously mentioned in this chapter that the Rome Center recently pioneered in the development of a personnel promotion system. The plan worked so successfully that the Air Research and Development Command called a command-wide conference for personnel specialists to meet at the Rome Center to consider among other personnel agenda items the Rome Personnel System. The conference was held from the 22nd through the 26th October 1956. One result of the conference was, there will be a general adaptation of the essential features of the plan in other command centers.[14] (UNCLASSIFIED)

On the 23rd and 24th October there was an Air Research and Development sponsored conference at the Rome Center on infrared countermeasures. This was a technical symposium that included representatives from the Strategic Air Command, Wright Air Development Center, Rand Corporation, Stanford University, John Hopkins University and the Rome Center.[15] (UNCLASSIFIED)

A development that the Air Force has been pursuing for several years was the purpose of conference held on the 7th and 8th November. The crash locator system was covered at this conference that was attended by representatives from a large number of Air Force commands. Following the presentation of information concerning the operation and development of this system, the conference representatives made recommendations for future actions to be forwarded to Headquarters, United States Air Force.[16] (UNCLASSIFIED)

The plans of the Air Force Global Communications System were at the preliminary stage of soliciting ideas and proposals from industry. A conference was held of representatives of the communications industry to inform them of the needs and requirements of the total Air Force communications system. The conference was held on the 28th and 29th November and there were about 300 people present.[17] (UNCLASSIFIED)

December was a low month on conferences. A conference was called on the 21st December to consider the Texas Towers interference test program. The contractor performing interference research, Collins Radio Company, was represented at the Conference along with representatives from Cambridge Research Center, Rome Air Force Depot and Rome Center personnel. Joseph Perlitzer was the Center engineer on this project.[18] (UNCLASSIFIED)

Publications

Center engineers and scientists continued to report advances in their various specialized fields. Lieutenant Richard E. Hartow reported the findings of an investigation of the utility of reduced-voltage starting for Motor Generator Set PU-219/TPS-1CD when limited capacity engine generator sets are used as prime power sources.[19] Lieutenant Edward J. Chapin, Jr. reported a study made of the application of Signal Data Recorder Set AN/FXH-4(XW-1) to radar signals. Tests indicated that the recorder is not feasible unless the signal to noise ratio is at least three to one. The main

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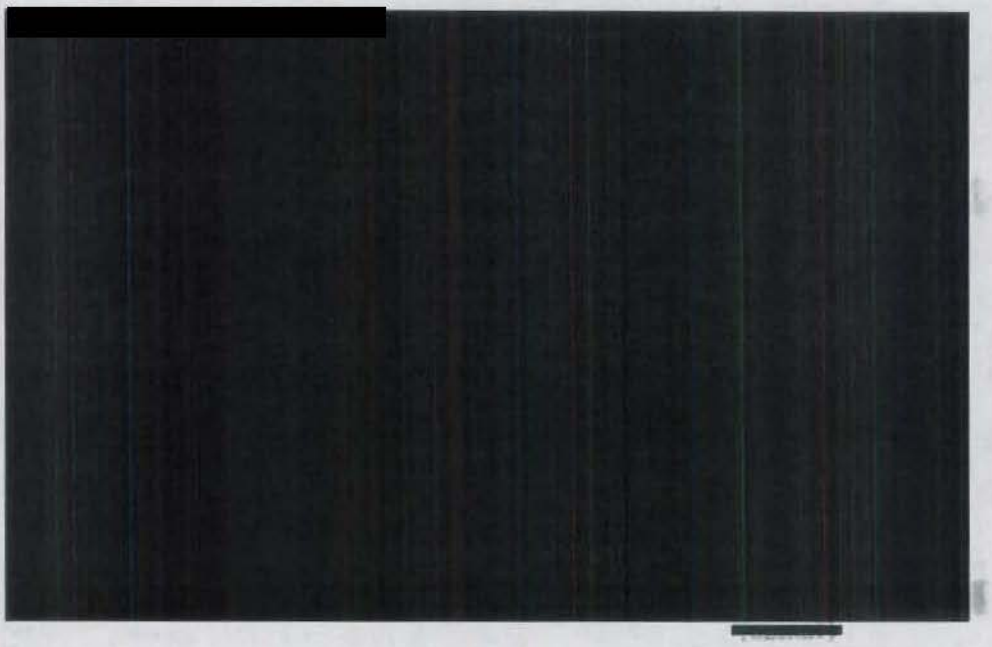
advantage of the device proved to be the immediate availability of the visual record without the need of later processing. A further conclusion was that both low and high speed records can be employed to add to the performance of passive detection stations.[20] (UNCLASSIFIED)

Fred L. Diamond analyzed the complex relationships in the

relation between certain electronic components of the radar set.[21] (UNCLASSIFIED)



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components in order to identify the differences between the bacterial species.[22] (Secret)

Charles R. Miller and Lieutenant Charles L. Noules produced a report of the data processing of passive detection signals. This was performed by equipment (Signal Data Comparator Group OA-686 TIQ-3) designed to process pertinent parameters of intercepted signals. The report included information on the design of the main elements and the operation of the computer as well as method of proper maintenance.[23] (Confidential)

A technical study was completed by Lieutenant John M. O'Connell that was a study of the performance of the Interim Ground Based Electronic Counter Measures System QRC T-19. This equipment provides for passive detection and communications jamming for the Tactical Air Command. The full capability of this equipment was determined to be radar alerting, radar assisting, communications jamming and intelligence.[24] (Secret)

Sidney Rosenberg completed evaluation of the various factors involved in selecting an all-weather, general-purpose, enroute type of navigation system for all aircraft at a long distance from ground based transmitters. This was a thorough study involving consideration of the performance of proposed radio navigational aids for long range operation in relation to the most recent requirements of the Air Coordinating Committee and the International Civil Aviation Organization. An optimum radio frequency of 60 kilocycles was recommended based on the ratio

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of [illegible] requirements. A comparison was made of the various techniques [illegible] available for signal transmission of [illegible] data. [illegible] all these considerations the system best meeting [illegible] these demands was judged to be that designated as Navarho.[25]

(UNCLASSIFIED)

[illegible] Kaulor and Robin [illegible], mathematics specialists, [illegible] a report on the use and preparation of a [illegible] tables for a method of analysing linear and nonlinear systems.[26] (UNCLASSIFIED)

A technical report was prepared by Lieutenant A. VanPutten on the design of microwave low pass filters using a stripline technique. This study, primarily of interest only to highly trained specialists, reported the development of a new technique for increasing the frequency of the spurious responses for a stripline low pass filter and a new formula important to the use of this technique. Six stripline low pass filters were designed, fabricated, tested and the details of their design was given.[27] (UNCLASSIFIED)

Major Lawrence R. Wilcox produced a technical report on a series of experiments covering eye reactions within a short period following the cessation of adapting luminances. Specially designed apparatus and three subjects with normal vision were used to obtain measurements of the probability of seeing as a function related to light intensity.[28] (UNCLASSIFIED)

Directorate of Flight Test and Instrumentation

Electronic wonders developed by the laboratory must be finally subjected to the stress of actual operations. These may include communications systems, systems for automatic landing of aircraft

in any weather, electronic navigation of aircraft from ground tracked targets and automatic jammers that "blind" airborne radars. Testing these varied equipments may require devices and skills as complex as those employed in developing the item to be tested. Aircraft must be modified and properly instrumented. Pilots must have an adequate understanding of electronics in order to work successfully with the engineers in testing out the hardware. (UNCLASSIFIED)

The testing program carried on by the Directorate required flying in all weather conditions or on long over water flights to test navigation equipment. Project "Hi-Life" required 20 ground control approach patterns to be flown during heavy rain. There were flights to such distant points as Piarco, Trinidad; Albrook Air Force Base, Panama; and Kindley Air Force Base, Bermuda.[29] An important assignment was running flight tests to determine antenna pattern measurements at the Laredo Test Site radar installation.[30] These and other flights resulted in an accumulation of 2994 hours of flying test time between 1 July and 31 December 1956.[31] (UNCLASSIFIED)

This total of flying time was accomplished without serious accident. The hours flown were in excess of those allocated to the Directorate although there continued to be a serious pilot shortage. On the 15 of August 1956 there were 27 pilots authorized and 15 assigned for duty. Of these 15 three were leaving the

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service within a month. Four were on temporary duty for periods ranging from two to four months and two were in the process of changing their permanent duty stations. During the subsequent months there was an average of 10 pilots available for flight test missions.[32] (UNCLASSIFIED)

In contrast to this problem there was an improvement in the quality of aircraft available for flight test use. An increasing number of C-131 aircraft were placed in service and the overage B-29's and C-47's were in the process of gradual retirement. The largest and most modern aircraft acquisitions were two B-47's that arrived during the last part of December.[33] (U)

The organization and mission of the Directorate remained unchanged. Major Robert E. Barney continued as the director. The three main divisions of the Directorate were Flight Test Electronic Instrumentation Division headed by Major Dow Evelyn, Flight Test Maintenance Division directed by Major Harold Patrick and Flight Test Operations Division headed by Captain John Milkowski. (U)

Weapons System Evaluation Group

During the summer months of 1956 the Air Force established a special advisory group that was staffed by eminent scientists under the chairmanship of Dr. Hill. Called the Weapons System Evaluation Group (WSEG), they met during the summer of 1956 and undertook to survey, particularly in respect to the application of electronics, the demands that adequate defense will place on weapons systems that are now being planned. Anticipated threats

were evaluated and based on these assumptions it was possible to determine the weapons that would be needed to counter these future threats. These weapon demands were then compared to current developments. Selected improvements were recommended and new programs were projected. (UNCLASSIFIED)

A member of this group was Mr. Harry Davis, Scientific Director of the Rome Center. A final report of the work of this group was presented to the Department of Defense on the 29 of October 1956. The report will, of course, influence the research and development program of the Rome Center. This will effect the Frequency Diversity Radar Program, planning for passive detection, electronic countermeasures, and possibly other radar developments.[34] (UNCLASSIFIED)

NOTES

Chapter I

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(2)GCA including lightweight mobile equipment. [redacted]

(3)GCA (FPI).

(4)Other navigation aids plus visual operation.[redacted]

The Wright Center indorsement also recommended that the Rome Center modify its one or more experimental AN/GSN-2 or AN/MSN-3 equipments to include changing the ground or airborne system equipment to conform with the design philosophy outlined by Wright Center engineers. All equipment under production by Gilfillan Brothers should be cancelled to the extent of the maximum monetary saving to the government. The equipment in the possession of Rome Center or to be produced should be modified to perform as directed by the Wright Center.[20] (UNCLASSIFIED)

The Rome Center in a fifth Indorsement signed by Major General Stuart P. Wright, Commander, stated that the recommendations and actions reported in the fourth Indorsement were based on incomplete information. It was pointed out again that the development of the system was not delayed but that the delay in testing out the system was due to the unavailability of data links. It was recommended that an attempt be made to resolve the controversy through a joint presentation by both Centers before General Bryan and General Wright, and that later a presentation be made before General Wood and General Boyd of the Air Research and Development Command.[21] (UNCLASSIFIED)

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The conference that was recommended by General Wright as a means of determining future planning for the system was held on the 12th of April 1956. A summary of the status and the problems of the system was given before General Farman, Headquarters, Air Research and Development Command, General Bryan of the Wright Center and General Wright. At this conference it was concluded that Automatic Ground Control Approach would not meet the needs of the Air Force during the period from 1958 to 1964 or after 1964 under the TRACALS system. This action required that the five sets under procurement from Gilfillan brothers be reduced to one or two sets and the system would not be placed on the Air Force buying list.[22]

There was agreement that the action was necessary because of the primary deficiency of the airborne data link equipments. Future programming indicated that by 1959 there would be about 3500 aircraft equipped with data links and of these only about 700 would be capable of using automatic approach control information. There would be about 1800 that would be capable of using approach information as a semi-automatic system similar to the instrument landing system (ILS) and with wiring changes these could be converted to a fully automatic approach system. The remaining 1000 aircraft would probably lack a coupler between the data link and the flight control system.

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The retrofitting of the aircraft equipped with frequency division to time division data link would also require refitting of the ground data link AN/URA-2 housed in the AN/MSN-3 trailer.[23] [redacted]

It was decided that for the period to 1964 the instrument landing system would be the automatic phase and that ground controlled approach would be used for traffic and control monitoring during the approach and landing phase. Automatic landings would be possible with the use of a device for measuring height above the ground referred to as the AN/APN-9A with flare out altimeter. An important consideration was that the equipment items necessary for instrument landing systems and ground controlled approach systems be readily available. The majority of Air Force bases already have ground control approach installations.[24] (UNCLASSIFIED)

The complications of closing out the Gilfillan Brothers production on service test models was made more complicated by the termination order the Rome Center was required to follow.[25] The order was later modified to permit Gilfillan Brothers to complete delivery of the first service test model without touch-up and to take delivery of a second AN/MSN-3 in accordance with the provisions of the existing contract.(UNCLASSIFIED)

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The Home Center was continuing its development of landing systems through contracts with Hughes Aircraft Corporation, General Electric Company and Gilfillan Brothers.[26] These were competitive design studies to investigate frequency scan monopulse radar and track-while-scan techniques under these contracts. Upon the completion of these studies in late 1956 a single technique which seemed to be most feasible was selected for further development into an experimental model, and then a developmental model would follow that was to be tested out prior to 1962.(UNCLASSIFIED)

Automatic Landing System

In the meantime two possible interim solutions to the development of an automatic landing system were under investigation. These were studies conducted by Bell Aircraft Corporation of a conical scan system and an inertial aided automatic ground control approach system that would be a refinement of the automatic approach system developed by Gilfillan Brothers.[27] (UNCLASSIFIED)

About 1950 the Navy in its search for an improved all weather landing system for aircraft carriers, contracted with Minneapolis-Honeywell Company and with the Bell Aircraft Corporation to produce a breadboard model of an automatic landing system. Tests indicated the superiority of the Bell System referred to as the AN/SPN-10. In the meantime the Air Force established a requirement for an automatic landing system

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equipment that was called AN/SGN-5, and made a part of system 438L of the Air Force Traffic Control Approach and Landing System consortium (TRACALS). The Bell system appeared capable of meeting the AN/SGN-5 requirements and the Air Force assigned to the Rome Center the responsibility of thoroughly testing out the equipment.[28] (UNCLASSIFIED)

A series of tests were conducted at Griffiss Air Force Base beginning in October 1955 using a Navy F3D aircraft that performed 147 landings using the Bell system.[29] An evaluation of the test results indicated appreciable technical advances along with necessary changes that would have to be made to adapt the system to Air Force requirements.[30] (UNCLASSIFIED)

There are differences between Navy and Air Force landing requirements. Navy aircraft drop more quickly to the carrier deck in a harder landing than Air Force aircraft are designed to take. The system's radar would be less disturbed by ground clutter than would be the case in many land based airstrip locations. The system required the use of a corner reflector to reinforce the radar return, an additional piece of equipment that the Air Force was not too interested in adding to its aircraft. This was a reflective surface about 8" x 10" that could be made retractible by making it a part of the landing gear. With the conclusion of the flight evaluation program during the fall of 1955 and the first of 1956 it was decided

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to use the cell system in producing a modified and improved [illegible][32] (UNCLASSIFIED)

The equipment is similar to that employed with the Automatic Ground Control Approach system. There are also essential differences. A precise radar, or as required in the first service test model a completely automatic acquisition radar, will pick up the aircraft as it approaches the entry gate three miles from the end of the runway. The radar will determine the position of the aircraft in terms of X, Y, Z coordinates and send this information through the computer that will determine the error of the aircraft deviation from the required flight path. The signals are sent through the data link and transmitted to the aircraft that must be equipped with an autopilot and data link. (U)

The tests pointed up a possible limitation of the system in rain and that the key component in the system was the automatic pilot. The performance of the computer, radar, data link, and the autopilot were thoroughly analyzed. With the use of a high performance autopilot it was demonstrated, during the summer of 1956, that an F86A aircraft could be brought in to a smooth accurately flared landing that was equal to the best performance of a skilled pilot. Without a high performance autopilot the landings had more impact than Air Force aircraft were equipped to take as a steady diet.[32] (UNCLASSIFIED)

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During 1956 flight testing was directed to determine the capability of the AN/ASN-5 system as it worked with other types of fixed navigation systems, and to establish procedures for combined operations. The greatest interest was determining the use of TACAN with the Bell system, and secondarily with conventional ground controlled approach surveillance radar equipment. The test procedure required the pilot to use TACAN or GCA to position his aircraft at the gate three or four miles from the end of the runway and from there the aircraft would be placed under automatic control for a landing. The aircraft was equipped with necessary TACAN instrumentation, and at Griffiss Air Force base the off base Jervis Site TACAN transmitter was used along with a mobile TACAN transmitter in order to fix the TACAN entry gate location. A total of 78 TACAN approaches was made. Automatic touchdowns followed 25 of these approaches. There were seven approaches using the CPN-18 ground control approach (GCA) CPN-18 surveillance radar and the AN/ASN-5 equipment to satisfactory touchdowns. The final testing was performed using an aircraft equipped for instrument landings, but without data link as the pilot served the function of the data link in this instance, taking data from the ILAS indicator and applying the information to aircraft controls. The tests using instrument landing system equipment were regarded as inconclusive but sufficiently encouraging to warrant additional investigation.[33] (UNCLASSIFIED)

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As a result of the favorable test evaluation it was decided to award the Bell Aircraft Corporation a contract to produce one complete mobile AN/USM-4 unit at a cost of $1,646,700. The contract was signed on the 19 September 1956 and delivery of the equipment was scheduled for two and a half years later. The equipment was to include two radars that will alternate in landing an aircraft and picking up another at the same time, and three trailers that were to contain the radars, operations center, and power supply.[34] (UNCLASSIFIED)

Short Range Navigation

The Rome Center continued to support the TACAN program as the recognized Air Force short range navigation system. A general description of this system and its technical characteristics was previously reported.[35] By the 1st July 1957 the Air Force was to install 270 ground stations within the Zone of Interior and there were to be 12,000 airborne sets installed on F86D and F94 aircraft within the same time period.[36] (U)

Modifications to improve the equipment were continually underway. More advanced transmitters were to be produced by the Federal Electric Corporation that were to utilize a tube that increased the power output from five kilowatts to ten kilowatts. Continuous wave amplification was to be used in lieu of pulse amplification in the interest of greater transmitter efficiency.[37] (UNCLASSIFIED)

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The program to fit TACAN into a common navigation system for both civilian and military aircraft was not moving as rapidly. The Rome Center had proved the feasibility of operating TACAN at the same site as the civilian Omni-directional Radio Range (VOR) installation without creating mutual interference; however, there was a serious lack of TACAN ground transmitters for such installations. Another problem was the development and production of a low priced TACAN receiver. An airborne receiver costs approximately $5,000 and with this there would be relatively high maintenance costs. Airborne receivers at half this cost would still create a problem for many civilian aircraft owners. In any event the Air Force expected that the target date of 1960 for full operational use of TACAN as a short range navigational system would be reached.[38] (UNCLASSIFIED)

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CHAPTER III

THE MISSILE PROGRAM

Reflection of the phenomenal advance in missile designs in the post World War II period could be observed at the Rome Air Development Center by the continuing high priorities assigned to missile defense and missile guidance programs. As to be expected Rome directed its effort to the highly complex and crucially important ground electronic environment associated with missile offensive and defensive systems. Though perhaps less dramatic than development of the missile itself, this work could be considered as equally vital. (UNCLASSIFIED)

Ballistic Missile Warning System

Greatest concern at the Center somewhat naturally arose from the much publicized "ultimate weapon" - the intercontinental ballistic missile. In fact the three most urgent projects at Rome in late 1956 were tied in one way or another to this weapon.[1] From a defensive point of view, the thought of ballistic missiles hurtling toward American soil at the incredibly high speed of four miles a second, two thousand miles above the earth's surface, from bases as far as 5,500 miles away was a thoroughly frightening prospect. Existing radar warning networks simply could not cope with this new weapon and could certainly not provide the twelve to twenty minutes advance warning deemed a bare minimum for passive

defense measures to be carried out and for a retaliatory force to become airborne.[2] A warning system which could furnish those essential few minutes of alert, indicate the area to be struck, the time of impact and the density of the attack would be eminently useful.[3] To prevent the morale sapping effects of frequent false alarms, however, the system would have to possess a high degree of reliability.[4] [redacted]

The Air Research and Development Command selected Rome to let three six month study contracts as a preliminary step toward establishment of an adequate warning system by 1960. These studies begun by General Electric, Hughes and Sylvania in March of 1956 were completed some five months later in July.[5] A follow-up conference held at Rome the 16th of July allowed representatives of the three companies to present orally the results of their studies.[6] Two days later the Air Force Source Selection Board composed of representatives of Headquarters, Air Research and Development Command, Air Material Command and the Rome Center convened at Rome to analyze the presentations, and to recommend the letting of a contract to the firm with the best plan.[7] No decision in that sense was reached though, because of questions and doubts raised by the studies themselves. Subsequent review and analysis of the problem by the Air Research

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and Development Command, the Air Defense Command and by Headquarters United States Air Force, made it clear by September of 1956 that the target date of 1960 for an operational warning system was impractical; this original objective was, therefore, abandoned.[8]

This is not to say that the 1960 goal was entirely visionary. However, the cost of producing the system by that date would probably have surpassed the dizzy height of one billion dollars. There were also disturbing unknowns in the relatively unexplored field of propagation research that could have reserved serious trouble for the radars of the system.[9] All in all, further work in technical development and experimentation seemed the wiser course before investing in a costly and possibly premature operational system.[10]

Confirmation of this new line of thought came in the form of a System Development Directive dated 19 October 1956 which fixed responsibility for the planning and conduct of the experimental program on Rome.[11] In anticipation of this move Rome had already drafted the month before a tentative plan to be followed in the technical development of such a system.[12] This same plan, slightly modified, was accorded official sanction by the Air Research and Development Command and Rome was notified of the action in a letter of General Parman, October 30, 1956. Specifically spelled out in the plan was Rome's responsibility for management of experimental sites at Trinidad and in the Arctic

to support the program as well as for the research and development effort required for what was now titled "System 219L."[13]

The obvious complexity of System 219L suggested to Rome leaders the desirability for a more than average team play. An Advisory Committee under the chairmanship of the Rome Air Development Center, but consisting of representatives from other government agencies and nonprofit organizations, was established to review accomplishments and advise Rome on improvements in the program.[14] Inside the Center similar effort was exerted to pool and consolidate experience through the creation of an "Anti-intercontinental ballistic missile office" in November 1956. Major Raymond W. Booth was selected as its head and Mr. Karl F. Filer was named as the project engineer. This team was to consist of eighteen full time engineering personnel who could be called upon to support System 219L work. For some time, however, the Anti-intercontinental ballistic missile office remained a paper creation and did not function as intended.[15] Strong representations by Major Booth coupled with a warning that the Rome effort would be severely handicapped unless the office did function, brought official recognition and support in late January 1957.[16] Close liaison was also established with the Air Materiel Command. Even though the operational date for System 219L was uncertain, eventually the Air Materiel Command

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would be called upon to act as executive agent for the system. Considerable difficulty had been experienced previously in the Distant Early Warning, Semiautomatic Ground Environment and White Alice projects because of a lack of liaison with the Air Materiel Command in the early stages of planning. Hoping to profit from these past mistakes General Clyde H. Mitchell directed the Rome Air Force Depot to assign one of its procurement and production officers for liaison work with the Rome Air Development Center on this program.[47] [redacted]

Much of the work at the Rome Center in this period concerned the test sites chosen for the program, particularly the "Down Range" site at Trinidad. The U.S. Naval Station at Trinidad had already been picked in April of 1956 as the best place from which to observe missiles fired from the Patrick

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Since some forty missile firings were planned from Patrick in fiscal year 1957 and more than double that number in fiscal 1958, this would furnish excellent opportunities for radar

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drawings were completed during December of 1956, but a lack of

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construction funds prevented prompt awarding of a contract. The resultant slippage was expected to cause postponement from the original date of January 1958 for operational use of the site.[21] In the meantime Rome did award a letter contract to General Electric on November 12, 1956 to study the experiments to be performed at the "Down Range" site and to establish the design parameters of the equipment. General Electric was expected to complete the study in February of 1957.[22]

Studies were also in progress at the Rome Air Development Center to determine the feasibility of using a northern arctic site or a shipborne site for radar testing. Interest here related particularly to the problem of propagation within the earth's atmosphere. To what extent would auroral and meteoric echoes affect the efficiency of radars? Would attacking missiles be sufficiently masked by these spurious returns that they could penetrate a warning system undetected? These are examples of doubtful areas which needed clarification. Propagation research and meteor analysis had been conducted previously at the University of Alaska, Cornell University, Stanford University and at the Laredo test site in Texas in support of System 219L, but it was hoped that even more could be done in this important research field.[23] In-the-house studies at Rome

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Underlying most of the 1956 activity in System 222A were the three study contracts which had been let in September 1955 to three teams of contractors with allocations of approximately one half million dollars for each contract.[34] These studies were completed in December of 1956 as anticipated. Plans were formulated to send a group of Rome Center personnel along with other representatives of the Air Research and Development Command in January 1957 to the contractors for visits of several days each in order to evaluate more thoroughly the results of the studies.[35] Quarterly progress reports in the meantime as well as visits had enabled Rome representatives to follow closely the somewhat different directions being taken by the three contracting teams.[redacted]

A third quarter fall presentation by the contractors at the Wright Air Development Center had stressed these differences. Convair/RCA were devoting considerable attention to the countermeasure decoy problem; Bell Telephone/Douglas Aircraft continued their previous studies to build up conventional radar equipments; while Lockheed/Raytheon seemed to have abandoned this more conventional approach and were exploring possibilities of an area defense capability using new techniques.[36] In any event none of the three study programs had yet come forward in the fall of 1956 with a clear cut plan for a ground electronic environment.[37] [redacted]

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Consequently, no firm all round systems design specifications could be drawn at this time. There were, however, some major components needed in any active system and requiring long lead time whose development could be undertaken.[38] A first priority item of this sort was the "acquisition" radar. An acquisition radar in System 122A had duties that clearly differentiated it from the early warning radar envisaged for System 219L. While the acquisition radar had to operate at long ranges, it had also to predict with exceeding accuracy the site of missile impact and supply data of such precision that a local tracking radar could lock on to the incoming missile. The probability that an attack would be massive, postulated a radar with large traffic capacity as well.[39]

In July of 1956 it was estimated that roughly one million dollars could be made available in fiscal 1957 for this development of what was termed "one of the most critical problem areas to be explored..." in missile defense.[40] Upon direction from the Air Research and Development Command,[41] the Rome Center concluded arrangements to hold a conference August 22-23, 1956 at Rome on the acquisition radar. Representatives from the Air Research and Development Command, from Headquarters United States Air Force, and other organizations attended.[42] From this two-day conference it emerged that "brute force" techniques of "beefing-up" conventional radars to do the more exacting job

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of an acquisition radar probably could succeed though at great expense. Of greater promise though, appeared an entirely new technique which was discussed at the conference.[43] At the conclusion of the conference Rome was instructed to draft a work statement for the proposed project. After first soliciting suggestions on a tentative work statement, Rome submitted a final work statement October 30, 1956 to Baltimore for what was called a "coherent array radar."[44] (Secret)

The coherent array radar, it was hoped, would represent the "ultimate in flexibility." It would utilize a large number of low powered radar equipments in such a way that a powerful radar beam could be projected and steered electronically without need to turn the antenna physically. It would cover an area with tremendous power and high resolution and yet because of its construction from a large number of low powered units, achieve a high degree of reliability. It was expected to possess a frequency agility which would prove useful in jamming environments as well as in selecting the best frequency for the particular object under observation. Perhaps more important still, it would have an extremely high traffic capacity. Its advantages, thus, were many.[45] Final approval and permission to go ahead was granted by the Air Research and Development Command on January 18, 1957 for what was estimated to be a thirty-six month project.[46] (Secret)

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Tracking Range

A third missile project of highest priority was the support given by the Rome Air Development Center to the WS-107A program. Rome had been requested by the Western Development Division to construct an optical tracking range of great precision for the testing of missile guidance systems. This program whose beginning stages have been described in some detail in the previous Center history[47] was far enough along in late 1956 to permit operational use for various flight tests requested by the Western Development Division and the General Electric Company. While the data obtained was of varied quality, it was believed adequate to meet the requirements set by the Western Development Division. This variation of quality was not unexpected since the range had been constructed on an accelerated basis.[48] [redacted]

By November of 1956 a number of minor modifications were planned to improve the capabilities of the range. A month later in December announcement could be made of modifications in progress covering highly technical items such as improved film magazines and theodolite drive assemblies as well as better communication facilities at the master site for enhanced performance by the AN/MSQ-1 acquisition radar.[49] (UNCLASSIFIED)

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CHAPTER II

CONTROL AND GUIDANCE

The Directorate of Control and Guidance was now organized to fully implement the resources of the Center in the research and development of ground controlled navigation and landing systems for aircraft and to support the missile program for the Air Force. The head of the directorate, Colonel Otto Quarm, was assisted by Lieutenant Colonel W. Mannon of the Executive Office, Dr. John Burgess head of the Radar Laboratory, Mr. Wilbur Combs in charge of the Missile Support Laboratory, and Mr. Ernest Storrs the director of the Control Laboratory. (UNCLASSIFIED)

The Control Laboratory was mainly interested in the development of new systems and equipment for manual and automatic flight control in aircraft navigation, approach, and landings. The systems and techniques that grew out of this research program resulted in equipment capable of performing automatic ground controlled approach for aircraft (AGCA), automatic landings as developed for the Air Force AN/GSN-5 system, and improvements to the TACAN system to adapt it for Air Force and civilian use as a common system. (UNCLASSIFIED)

Automatic Ground Controlled Approach

The search for an electronic system that would automatically guide an aircraft near enough to the runway to permit the pilot to

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make a [illegible] landing was started in 1946. Watson Laboratory [illegible] were interested in pursuing this research in the direction suggested by the success of the Ground Controlled Approach system.[1] (UNCLASSIFIED)

Gilfillan Brothers, Incorporated, of Los Angeles was awarded the first experimental contract to produce equipment that would have the desired capability. It was decided to convert the Ground Controlled Approach (GCA) radar into an automatic operation. This was to be accomplished by the addition of tracking and computing circuits for the generation of suitable control signals which were to be transmitted to the aircraft for the use of the automatic pilot. By adapting the automatic pilot to accept signals that would guide the aircraft up and down and left and right through the approach pattern to the runway, the aircraft could be brought in safely in any weather.[2] (UNCLASSIFIED)

Since 1946 five experimental models of the automatic system were produced. These were gradually improved, tested and modified. The testing was accomplished at Wright Patterson Air Force Base and at the Air Proving Ground, Eglin Air Force Base, Florida. During the history of the project there were several Center engineers who were placed in charge of the project. Among those who worked on its early development were Harry Davis and Stanley Rush. During the later phases

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of the project Lenais I. Zulch, Stanley J. Tepper and Robert L. Waite were the responsible engineers. (UNCLASSIFIED)

The early tests brought many engineering problems but continued effort and redesign proved that the system was capable of operational use. The test series beginning in 1952 at the Air Proving Ground Command were particularly productive in indicating direction of improvements and design changes. As a result it was definitely established that six aircraft could be safely controlled during the final approach phase of landing and brought in to the runway with a minimum spacing of 30 seconds.[3] (UNCLASSIFIED)

The Air Force was concerned about obtaining such a system. The requirements of an automatic approach system were indicated in a letter from the Strategic Air Command, dated 21 December 1949, to Headquarters, United States Air Force that stated the "Requirements for Engineering and Operational Evaluation of the Automatic Ground Approach System (AGCA)." The requirement was stated to be for a system that would automatically control six aircraft spaced 30 seconds apart while on "the final approach phase under all weather conditions." This was followed by later requirements issued by the various aircraft navigational authorities. Technical Requirement No. 66, dated 4 November 1954, raised the sights of technical accomplishment for aircraft to land and take off under conditions of zero visibility and zero ceiling and at

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a rate of 120 to 300 aircraft per hour." (CONFIDENTIAL)

The technical approach decided upon was to obtain aircraft positional information from a standard ground control radar such as the AN/FPN-16. Angular position outputs of the radar are fed into the ACCA equipment and six sets of trackers convert the data into acceptable information for use in the flight path computer. Control commands are transmitted via the data link transmitter to the aircraft. The data link monitor converts the information being sent to the aircraft and displays it on dials and on the same type presentation as in the aircraft. A standard Ground Control Approach display with some additions is presented on a scope for traffic monitoring as well as providing a capability for standard Ground Control Approach talk down procedures. The output of the receiver is fed to the converter which transforms the digital data into parallel information. Five primary control outputs of the converter are fed to the coupler. The coupler outputs to the autopilot are bank and pitch changes. The coupler also gives outputs of heading and pitch commands to a crosspointer indicator and range to a distance indicator. (U)

The ground elements of the system were produced in stationary and mobile models. The fixed installation was designated the AN/GSN-2 Radar Course Directing Central and included the CA-134/GPN Computer Group and the AN/GSA-2 Flight Control Group. These components were to work with the

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AN/FPN-40 Ground Controlled Approach (GCA) radar. This equipment was to fit in with a remotely located traffic control center that would include communications facilities and information from a terminal area surveillance radar. The equipment would be operated by suitable commercial power. (UNCLASSIFIED)

The airborne equipment included a radio receiver, a data link converter, a data link coupler, the automatic pilot and suitable airborne instrumentation for pilot information. The pilot may observe all the positional aircraft information coming in from the ground on visual indicators. Should there be any indication of poor control information or malfunction of any of the airborne equipment, warning flags are displayed. A warning is also displayed when the minimum altitude is reached, specified by instrument flying rules.[5] (UNCLASSIFIED)

As indicated above, the ground console was particularly well engineered. It was equipped with aircraft instrumentation similar to that in an approaching aircraft which permitted the operator to monitor data being transmitted to the aircraft over any one of the six channels. The aircraft video and the surrounding gates of the channel tracking the aircraft were displayed on a screen indicator (SCA) presenting both azimuth and elevation information. During operation the letter designation of the tracking channel appears between the azimuth and elevation information. The letter moves on the screen in

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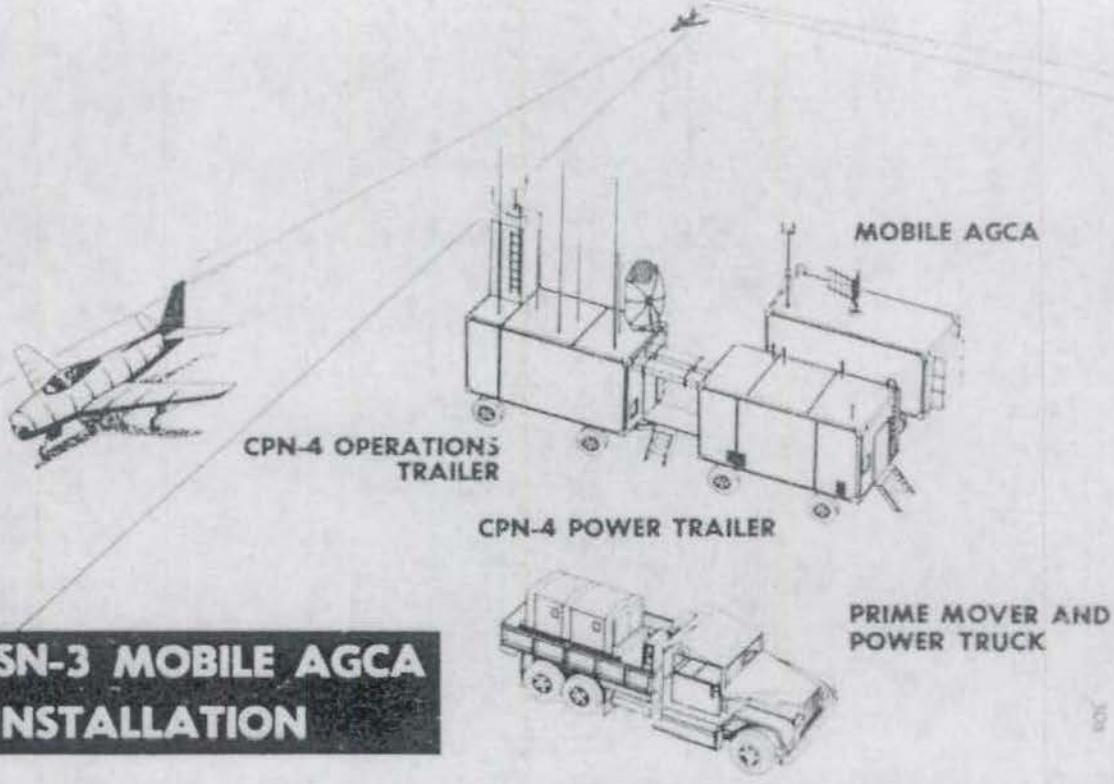

AN/MSN-3 MOBILE AGCA INSTALLATION

six aircraft simultaneously, but they provided experience in operation and maintenance of the equipment. There was an accumulation of a great deal of engineering information covering basic design philosophy of an automatic approach system. From the Eglin tests and the engineering improvements developed there, it was decided to contract with Gilfillan Brothers for five service test models of the automatic approach system.[8] (UNCLASSIFIED)

The tests discovered development weaknesses in equipment associated with the operation of the automatic approach system. Data link equipment was inadequate and it was necessary for Gilfillan Brothers to produce data links and couplers between the data links and the automatic pilots in order to test out the system. (UNCLASSIFIED)

It was necessary to plan a new test series beginning with the first of the service test models to be produced by Gilfillan Brothers. On the 15th of July 1955, Headquarters, Air Research and Development Command, issued a test directive that specified the types of aircraft to be used in the testing schedule and assigned Wright Air Development Center primary responsibility in the projected testing program.[10] (UNCLASSIFIED)

The Flight Control Laboratory of Wright Air Development Center had been associated with the Rome Center in testing the automatic approach landing system. They did not entirely

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approve of the general concept of the automatic approach system and more specifically at this particular point Lieutenant Colonel Doolittle, Chief of the Engineering and Special Projects Branch, Test Operations Division, directed Wright Air Development Center to cancel the test program and suggested to the Rome Center that the entire system program needed a complete review.[11] The Rome Center was directed to"...cancel all flights and the flight test program until a comprehensive flight test program based on a firm Research and Development program ..." was worked out.[12] (UNCLASSIFIED)

It was necessary to arrive at a new understanding about the testing program. On the 18th October 1955 a conference was held at Baltimore that was attended by representatives from Headquarters, Air Research and Development Command, Wright Center, and the Rome Center. Engineers from the Rome Center presented a briefing on the current status of the automatic approach system. The meeting resulted in an order from Headquarters directing that flight tests scheduled for November with Wright Center aircraft would continue as scheduled. The order also directed that improved coordination be achieved with Wright Center Flight Control Laboratory on the procurement of airborne equipment from Gilfillan Brothers, and that the Laboratory be kept informed of the latest system requirements. The order also directed that new documentation

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be prepared for multiple aircraft flight tests that were to begin June 1956.[13] (UNCLASSIFIED)

Arrangements were continued in respect to the contract for five service test equipments from Gilfillan Brothers. Additional requirements to include the automatic landing system as a system requirement of the F-105 and F5W aircraft were received at the Home Center and were also reported to the Commander, Wright Air Development Center, on the 31st of October 1955. This memorandum cites a reference to system requirement amendments that directed the development of an appropriate airborne data link receiving system similar to the AN/ARR-39 and a flight control coupler, that would have the capability of receiving and converting data commands to the autopilot.[14] These were airborne components that were the development responsibility of the Wright Center.

The spread of opinion on the actual operating capabilities of the automatic system was widening. At the Wright Center a conference was held on the 29th November 1955 between engineers of the Flight Control Laboratory and the TRACALS group. During this conference it was suggested the Flight Control Laboratory summarize its views of Automatic Ground Controlled Approach as an operating system. The report stated that the Laboratory was ". . . . convinced that certain discrepancies exist in the AGCA program as it stands today. . ." The program should be

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redirected to modify ground equipment so as to limit its function to that of determining good positional information and transmitting this data to the aircraft. (UNCLASSIFIED)

This report was studied carefully by engineers at the Base Center. Joseph Ryerson, Chief, Systems Integration Section, Control and Guidance Laboratory, prepared a report that summarized the technical problems involved in system development and the engineering reasons for the particular approach that was used.[15] It was necessary for Center engineers to design equipment that would process positional data on the ground into steering signals because of the absence of airborne flight control systems capable of accepting position and positional rate information. Ryerson stated that the Center engineered automatic system was an extremely simple one" . . . and therefore no modification of the automatic approach system need be made." The deficiencies pointed out by the Wright Center were admitted, but it was believed these deficiencies came about through historical reasons rather than technical. At the beginning of the development it was necessary for Center engineers to process positional data on the ground into steering signals because of the absence of airborne flight control systems capable of accepting position and positional rate information. There was no disagreement with the statement of the ideal control elements for an automatic ground controlled approach system.

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The problem of airborne rate determination is generally applicable to all air vehicle guidance systems and it was necessary for Center and contractor engineers to develop specialized techniques for this specific program. There is yet no integrated vehicular rate sensing system that utilizes positional data. This problem must be solved if Century series aircraft are to be controlled on either the proposed automatic approach system or the instrument landing system (ILS). Ryerson also stated that the proposed system uses both a guidance loop and a traffic control loop that permits spacing and scheduling of six aircraft by remote control and that this performance met 3CR 133 CC-la-1-64, dated 9 January 1956, on traffic control demands.[16] [redacted]

Headquarters, United States Air Force, on the 25 August 1955, addressed an inquiry to the Commander of Air Research and Development Command in reference to "AGCA Airborne Configuration." This was referred to Wright Air Development Center and to the Rome Center for relevant information. The third indorsement added by the Rome Center to the request for a report on "AGCA Airborne Configuration" was dated the 31 October 1955 and it provided information on the projected delivery schedule of the five service test models from Wilfillan Brothers. There was also included a reference to the planned use of the system for the F-105 and the F84F and the necessity of developing an airborne data link receiving system.[17] [redacted]

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The fourth indorsement prepared by the Flight Control Laboratory of Wright Air Development Center over the signature of Brigadier General Thomas L. Bryan, Commander, was a reply to the third indorsement. The indorsement stated that the delays in the system program were such that the F84F was not going to be equipped with Automatic Ground Controlled Approach capability. The F-105 was to be configured for automatic instrument landing system (ILS) with the possibility that technical considerations might result in automatic approach system capability being added later. There was expressed ". . .concern about the protracted development progress of the AGCA program." And again, "At this date after repeated slippages in the program there appears no assurance that the most recent test program will progress rapidly or result in a completely successful equipment." An admission was made that the data link was a problem and that the change from frequency division to time division data link complicated the timing for introducing the system.[18] In consideration of these various objections it was recommended that:[19] [redacted]

> Further consideration of AGCA as an approach system be discontinued. Operational and weapon system planning for the time period from the present through 1958-1960 should be based on above choice of the following types of operation.
>
> (1) Automatic or manual ILS with improved cockpit instrumentation (flight director) extended to touchdown by airborne devices, with a GCA monitor.

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In addition to these top three programs, Rome assisted a variety of lesser priority missile projects. Among them was the TALOS ground-to-air missile system for short range (100 miles) use. Originally a U. S. Navy enterprise, the Air Force had since 1955 been assigned primary funding and administrative responsibility in order to integrate the TALOS missile into the continental defense system.[50] Rome Air Development Center had been summoned to work on the necessary electronic ground environment and was particularly interested in the guidance system, communications and anti-jamming techniques against ground equipments. This project was organized and broken into specific tasks after receipt of a directive dated the 10 August 1956.[51] (Secret)

Unfortunately the project was hampered in various ways by the lack of unified direction. The Air Force, for example, had commitments to purchase four TALOS systems identical to that under development by the Navy. Rome Center personnel learned, however, that the Navy was not monitoring the communication system being developed by the Radio Corporation of America, contractor, and would apparently accept anything which the contractor produced. This, in turn, meant that the Air Force must string along with the same equipment unless in the meantime it could persuade the contractor to incorporate Air Force requirements into the design. Skimpy travel funds for Rome engineers restricted liaison

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with the contractor and brought to pass a situation where costly retrofits could be anticipated.[52] In December of 1956 Rome learned unofficially that the Defense Department contemplated eliminating both the Navy and the Air Force from the program and tossing the whole TALOS project into the Army's lap.[53] The rumor later proved correct and Rome terminated its support of TALOS in May of 1957.[54] (SECRET)

But before this new transfer of responsibility for TALOS, considerable work had been accomplished by Rome in late 1956. As previously indicated, communications had loomed up as a particularly weak link because of the contractor's ignorance of problems to be faced in integrating the equipment into an Air Force operational environment. After months of effort, Rome succeeded in bringing about a redesign of communications central equipment which would have provision for radio tie-in, voice recording and expanded wire capability in the aim of supplying greater flexibility. While still greater flexibility was desired, progress had definitely been realized.[55] (SECRET)

A wide variety of studies undertaken at Rome, some at the request of the Radio Corporation of America and others at the initiative of the Center, were producing recommendations for other important changes in the TALOS ground environment. A few examples may serve to illustrate. Rome completed a feasibility study of research done at the Applied Physics Laboratory of Johns Hopkins University and recommended to the Weapons System Project

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Office that a CW homing system be included to increase the probability that TALOS could achieve kills at low altitudes. A Center study of the tracking radar indicated necessary changes to be made resulting from an Air Defense Command decision altering the original target area specifications for TALOS from [redacted] counter measure study of this tracking radar suggested modifi- [redacted] capability as a protection against jamming. Studies of various sorts were also in progress in reference to compatibility of TALOS with the Semi Automatic Ground Environment system.[56] [redacted])

BOMARC

The somewhat longer range (300 miles) BOMARC ground-to-air missile also received its share of attention from Rome in 1956. Rome was assisting the Weapons System Project Office in evaluating the ground electronic components of this system for use with and without the Semi Automatic Ground Environment system.[57] Long a problem, Headquarters USAF chose to emphasize again in a letter of December 17, 1956 the importance attached to assuring compatibility of BOMARC with the Semi Automatic Ground Environment. Rome was convinced at the close of 1956 that a thorough systems analysis of equipment requirements for integration with the Semi Automatic Ground Environment would be necessary. This would permit trouble shooting the problem areas in sufficient time to allow programming

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of the associated research and development projects.[58] [redacted]

Meanwhile Rome was supplying information on components to contractors engaged in the BOMARC program. The Boeing Aircraft Company benefited from Center supplied information regarding the data link system for BOMARC and both the Burroughs Corporation and Westinghouse were similarly aided on the Mark X "identification friend or foe" system.[59] [redacted]

Since BOMARC squadrons would probably be activated before the Semi Automatic Ground Environment system could be installed in some areas, it had previously been proposed to use the AN/GPA-35 radar with the Ground Control Interceptor stations. Rome investigated this area to assemble data needed for operation of the AN/GPA-35. Modification Kits were also developed to improve the performance of auxiliary equipments needed in the system.[60] [redacted]

Missile Guidance Techniques

Somewhat more general in scope was the investigation of missile guidance techniques at the Center. The goal here was to overcome some of the deficiencies apparent in the electronic guidance systems for missiles. Range extension, greater reliability and reduced vulnerability to electronic countermeasures were obvious areas for improvement. [redacted]

Study contracts with Melpar Incorporated and Lear Incorporated had been let by Rome to determine the best

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combination of ground guidance and air guidance equipment for extension of missile range. These studies were completed by the end of 1956, but had to await thorough evaluation by the Center before recommendations could be forwarded to the Air Research and Development Command. For research in the realm of countermeasures vulnerability, the Center secured an MTW-2 experimental NIKE monopulse radar and had begun work on a target simulator. The Center planned to evaluate the radar in the presence of various countermeasures without the benefit of anti-jamming techniques. The equipment was also to be employed in analysis of targets in complex formations where countermeasures were utilized. 61 [redacted]

Additional studies and investigations of drone ground support equipment rounded out the rather considerable effort which the Rome Air Development Center had mustered in support of numerous Air Force missile programs. (UNCLASSIFIED)

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CHAPTER IV

TRENDS IN RADAR DEVELOPMENT

Radar development carried out during 1956 in the Directorate of Control and Guidance with the assistance of other Center groups covers so large an area running as it did from radars in the early planning stages to others ready for production that only a few of the high spots can be included here. One of the programs of more than usual interest in the directorate was that devoted to frequency diversity radars.(UNCLASSIFIED)

Frequency Diversity Radars

A multimillion dollar frequency diversity radar program had been set in motion in 1955 under sponsorship by the Rome Center to provide the Air Defense Command with radars in new frequency bands. As explained in the Center history for 1955, existing radars were bunched together in the same frequency areas and so greatly simplified the task of electronic jamming for the enemy.[1] Frequency diversity radars on the other hand would operate at widely scattered frequencies and force the enemy to spread his total available jamming power over the widest possible spectrum.[2] But the program was not one of dressing up old radars to work at a new frequency. It was clearly understood from the beginning that each of the frequency diversity radars was to offer

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unique functions apart from a different frequency.[3] (Secret)

As outlined in the previous Center history, several of the frequency diversity radars were dropped, at least temporarily, from the program in mid 1956. This included the AN/FPS-25, an [redacted] the AN/FPS-29 in the same frequency band. Funding complications were at the root of this decision.[4] General Wright, then the Home Air Development Center Commander, was particularly disturbed at losing the AN/FPS-25. In a letter of October 5th, 1956 to General Demler, Deputy Commander of Research and Development in the Air Research and Development Command, he stressed the vital role awaiting the AN/FPS-25. The radar was planned, he remarked, as the height finder to provide the increased range and altitude coverage necessary for compatibility with the new low frequency radars. Elimination of the AN/FPS-25 would drastically limit the Ground Control Intercept capability of these radars. Since General Wright felt the decision not to fund the AN/FPS-25 was based on monetary considerations rather than technical or operational ones, he requested a review of available funds to determine whether five million dollars could not be earmarked for this task.[5] (Secret)

General Wright learned from General Demler's reply of November 1,1956 that the AN/FPS-25 could not be funded, however, until fiscal year 1958. Originally, he was informed, it had been

proposed to fund the entire frequency diversity program over a period of three fiscal years, but Headquarters of the United States Air Force overruled it and required that funds for each radar be allocated entirely in one fiscal year. Consequently the Air Force selected the five frequency diversity radars which seemed to hold the greatest chance of pay off in the shortest time at the least cost[6] and as the program stood at the close of 1956 the number of radars still in the program remained at five. But even for those radars still programmed, funding remained the weak link of the chain throughout 1956 and funding difficulties were largely responsible for the slippages which occurred. Hardware contracts for these radars which were placed in August and September 1956 should, according to the original timetable, have reached this stage in January, 1956.[7] [redacted]

At the outset of the program, it had been understood that the frequencies employed by the radars would encroach upon those allocated for commercial, amateur and other military uses[8] and in 1956 this had assumed the proportions of a major problem. Headquarters United States Air Force reassured the Rome Center on October 1st, 1956 that it was actively engaged in studies to solve the frequency allocation dilemma expected to result from use of frequency diversity radars[9] and the same problem was further discussed at Headquarters of the Air Research and Development Command on 24 October 1956 with representatives of

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Rome in attendance.[10] Nevertheless on December 10,1956 Colonel Quanrud, director of Control and Guidance at the Center, warned the Air Research and Development Command that the desirability of continuing with radar [redacted] seemed highly dubious unless a frequency allocation for it could be obtained. This reflected the view held at Rome that the frequency diversity program had merit only if the radars under development were followed by production quantities.[11] The issue was particularly cloudy for the AN/FPS-27 because communication services essential to defense already crowded this frequency band.[12] Although the radar was not cancelled, frequency allocation had not been finally settled in the 1956 period. [redacted]

Search and Height Finding Radar

Another big step away from traditional radar conceptions was the AN/FPS-7 "three dimensional radar." Effective radar warning against air attack, of course, requires three dimensional coverage. Range and azimuth data must be combined with a determination of the height of air targets to provide this coverage. Unfortunately good range finding radars were generally poor height finders and the reverse was equally true. During and after World War II it had been customary to maintain two separate radar sets, the one specializing in range the other in heightfinding. Dual installations of this kind understandably proved awkward and costly to operate and the increased speeds and altitudes of postwar aircraft and missiles only accentuated the inadequacy of of these dual installations.[13] [redacted]

Attempts had been made to build into one radar set the desired three dimensional capability. The CPS-6B was an example of this. However this set required two separate fan beams for its operation and this, in turn, entailed the use of 5 transmitters. In other respects too it was regarded as unfit to handle the job efficiently.[14] Another approach of greater promise was undertaken by the United States Navy in the development of what was called a "stacked beam" radar (SPS-2).[15] Briefly stated, the stacked beam radar sends out only one transmitting beam; this beam, however, merges into seven vertically stacked beams during the receive cycle which are used to catch and compare the echoes to obtain simultaneous range and height data.[16] [redacted]

So promising in fact did the stacked beam radar appear that the Air Force decided to build an experimental L-band model of its own patterned on the Navy SPS-2. A contract was let in May 1950 to the General Electric Company and in November 1952 the set, an experimental AN/FPS-7 (XW-1), was completed and accepted by the Rome Air Development Center for flight testing. Flight tests turned up a number of weaknesses in the set. The magnetron transmitting system proved inadequate and a number of deficiencies particularly those affecting heightfinding capabilities would have to be corrected. The Center did not lose confidence, though, and informed the Air Research and Development Command that with some modifications and additional funds, both the search and height-

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finding capabilities of the system could be improved. Accordingly Rome was authorized to let an improvement contract to the General Electric Company. [redacted]

The early promise of the AN/FPS-7 lay not only in its simultaneous range and height finding capabilities, but in the superior ranges and altitudes to which it might reach and to its excellent anti-jam features. In 1954 it was anticipated that F-86 type aircraft could be reached by the [redacted]

anti-jam features including anti-jam console display, azimuth and vertical gain reduction were first tried out on this radar. Thus, leaving aside the heightfinding potential of the AN/FPS-7, it was attracting serious attention simply on its two dimensional searching quality and anti-jam merit[redacted]

The Rome Center insisted on these selling points as the AN/FPS-7 came in for critical attention for several reasons during the course of 1956. For one thing the heightfinding capability of the set was not entirely sure. While Colonel Quanrud, director of Control and Guidance at the Center, reported in September 1956 that as a result of the improvement contract with General Electric the heightfinding portion of the system had been "vastly improved", nevertheless he was obliged to admit that the antenna was expected to pose a major

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problem.[21] Colonel Quanrud consequently endorsed a previous recommendation that height finding not be incorporated into the production sets of the AN/FPS-7 until flight tests, then scheduled to begin in June 1957, could be thoroughly analyzed.[22]

Meanwhile the Air Defense Command was reported unhappy with the AN/FPS-7 in part because they felt the equipment could not maintain a twenty-four hour operating capability. It was even reported that Headquarters, United States Air Force, was considering utilization of other equipments to meet the operational requirements for which the AN/FPS-7 had been designed. Rome stressed the increased high altitude and anti-jam features which were inherent in the stacked beam radar to offset these objections.[23] Other questioning of the set concerned its compatibility with the Semiautomatic Ground Environment. Although it had long been anticipated that the set would be compatible[24], Headquarters of the Air Research and Development Command requested additional study of this aspect from the Cambridge Center in March of 1956. Cambridge replied July 2, 1956 that in effect more testing would have to take place, particularly in reference to the height finding capabilities, but in general Cambridge assumed a tone of cautious optimism regarding the set.[25] Approximately two weeks later in a meeting at Syracuse, New York, of representatives of the contractor and of the Cambridge and Rome Centers, it was agreed that the AN/FPS-7 was compatible in all respects with the data transmission equipment (AN/FST-2) of the Semiautomatic Ground Environment.[26] Nonetheless after a review of

the evidence, Headquarters of the Air Research and Development Command felt that a lack of complete experimental and field test data on the AN/FPS-7 left its status in the Semiautomatic Ground Environment obscure. Consequently Cambridge with the cooperation of the Rome Center was directed to initiate plans which would turn up the answers to this important question.[27] [redacted]

In the meantime development of the AN/FPS-7 went ahead at Rome and those working on the project maintained a close rapport with other stacked beam radar projects. The United States Navy was in the process of redesigning its SPS-2 and SPS-13 stacked beam radars and the Air Force was also trying out the stacked beam principle at the Rome Center in such projects as the AN/FPS-27 of the frequency diversity program and the AN/MPS-20. The closest cooperation was maintained in the AN/FPS-7 development both with the United States Navy and with the other Air Force stacked beam radar projects. Visits, exchanges of information from all sides brought clear benefit to all and demonstrated once again the value of teamwork in research.[28] [redacted]

The schedule of the AN/FPS-7 underwent some slippage in this period. In September of 1956 it was estimated that flight test evaluation of the first Service Test AN/FPS-7 would begin in June 1957.[29] In October, a month later, flight testing of the first Service Test radar was not planned until September 1957.[30] Design

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changes were accounted in large part responsible for the delay.[31]

Radars Readied for Production

Also to the credit of the Center in 1956 were a number of radars brought through the development stages successfully and ready for production. The AN/FPS-20 was a radar of this category. Begun essentially as an improvement over surveillance radar AN/FPS-3, the AN/FPS-20 grew out of a number of high power modification kits. This improved set was intended for use as a search radar to provide range and azimuth information to the Air Defense Net. Operating at

improved duplexing system and improved receiver to mention a few of its advantages. All of the components for the AN/FPS-20 were designed to be air transportable. Development of this improved radar was completed in August 1956 and quantity production began at the close of the year.[32]

Several radars intended for use in the Distant Early Warning Line were also successfully developed in 1956. The AN/FPS-19 was a search radar which incorporated substantial improvements over the AN/TPS-1D. Production of the AN/FPS-19 including antenna system, radar components and console was completed in September 1956. The AN/FPS-23 was developed to provide low altitude coverage for the Distant Early Warning Line. This radar whose production was completed

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in October 1956 differed in several respects from conventional pulsed type scanning radars. Its transmitter and receiver with associated antennas were designed to be separated by from thirty to ninety miles. Using the Doppler principle, this radar provided automatic low altitude coverage with a high detection capability and a minimum of false alarms. The equipment made no attempt to supply range information, however, and indicated in only a general way the direction of enemy penetration. Preliminary flight tests and calculations demonstrated that the equipment fully met the Distant Early Warning line requirements and would fill the gap between two adjacent AN/FPS-19 radars down to two hundred feet over land and fifty feet over water on aircraft comparable to a B-47.[33] [redacted]

Several Center developed mobile equipments were also readied for production by the last half of 1956. An improved AN/MPS-7 named the AN/GPS-4 which had been developed and successfully flight tested by January 1956 was rolling off the production assembly lines the following November of that year. The set, [redacted] search radar for the Tactical Air Command. Both the radar and trucks for carrying it were all transportable in C-124 aircraft without need to remove any units from the vehicles.[34] [redacted]

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[redacted]

Another mobile radar, the AN/MPS-16, was intended as a lightweight heightfinder whose equipment could be transported in four 2 and 1/2 ton M-35 trucks or by airlift. Delivery of the production model AN/MPS-16 began in December 1956.[35] [redacted]

[redacted]

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CHAPTER V

COMMUNICATIONS

Entrusted with world wide responsibilities, the United States Air Force had for some time remarked the inadequacy of its communication network to carry this newly borden. Air Force leadership viewed with even greater concern the widening gap which was leaving communication facilities ever further behind the supersonic weapons they were supposed to weld together. Rapid integrated communication over short and long distances among units of various types on ground and in the air, capacity to accept large volumes of traffic swiftly, expeditiously, reliably and with security, ability to transmit teletype, voice and graphic data - this was a list of qualities which everyone agreed were necessary, but which unfortunately could not be found packaged in one global communication system. (UNCLASSIFIED)

Global Communications

Perhaps the most basic need on the list was the global communication network itself. Newly erected radar warning systems, missile launching bases and other programs involving large expenditures of money obviously would have to be fused into a master communication system. Unless some provision was made for this integration in the early stages of these

programs, the result would be inadequate performance and costly retrofit for eventual integration. Thus it was that the Rome Air Development Center had been alerted to this far reaching problem and had adopted an active role to solve it since 1954.[1] The task promised to be a gigantic one. A new global system might cost as much as two billion dollars even though some parts of the old system would be salvable. Without the proper advance planning contemplated by the Rome Center, the bill could mount considerably higher than that.[2] (UNCLASSIFIED)

The Bell Telephone Laboratories had begun a study on contract from Rome in August of 1955 designed to provide a long range investigation for a complete world wide communications system. While the study was in progress, Rome was obliged to inform Bell in the spring of 1956 of new Air Force requirements calling for an improved world wide communication system by 1962.[3] Bell consequently abbreviated its investigation somewhat inorder to present recommendations that could be submitted in time to aid in development of a 1962 communication system. The Company completed its report with recommendations in November 1956. Further effort by Bell in this direction was blocked after November by lack of funds.[4] [redacted]

Meanwhile, in-the-house thinking at Rome emerged clearly from a communications symposium sponsored by the Center November 28-29, 1956. A paper presented by Mr. G.K. Chappuis of the Center outlined the needs of the program and the special areas that

would claim intensive research and development.[5] (UNCLASSIFIED)

During this period Rome endeavored to draft plans acceptable to the Air Research and Development Command for the new global communication system (System 456L).[6] Proposed tasks included such varied items as multiplex systems study, automatic switching equipments and development of long distance communication through reflections of signals off the Moon. Developments which were then in progress and would be finished before 1962 were also to be integrated into the system. This included a microwave radio relay equipment integrated with a family of power amplifiers to form new tropospheric scatter stations and communication anti-jam techniques to cite but a few.[7] [redacted]

By January of 1957 Headquarters of the Air Research and Development Command had still failed to approve the plan and the Rome Center continued to revise and revamp the original draft plan. Although Rome had no systems development directive from Baltimore, informal work along the general lines of the proposed system was yielding fruit. Rome's coordination with the White Alice project, for example, was expected to save several million dollars in terms of retrofit for eventual world wide communication integration.[8] [redacted]

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Rome also pushed a "quick fix" type of support for the program in the last half of 1956 in a project titled "Global Communications Equipment." Originally the Center had intended to let one or more contracts to obtain an evaluation of equipments then making up the Air Force communication system, but restriction of funds limited this to an in-the-house analysis of a small number of selected items of equipment.[9] (UNCLASSIFIED)

Project interest also focused on development of an automatic correction system which would introduce error free teletype communications. In-the-house studies at the Center revealed that existing commercial error correction systems were not adaptable to the Air Force and a contract was, therefore, awarded to Melpar Incorporated for development of the necessary new technique.[10] By December 1956 Rome had received a final report from Melpar, delayed because of technical difficulties, recommending construction of a prototype marginal error correcting system employing a five unit code or an alternate system using a six unit code.[11] If a correct mark or space came through the system, the equipment would take no action. But if an error occurred, it would ask for a repetition of the last three characters.[12] The production phase was held in abeyance, however, pending results of a meeting in January 1957 to resolve certain differences of technical opinion between Melpar and the Airways and Air Communication System about the duplex features

which Melpar proposed to include.[13] (UNCLASSIFIED)

To step up teletype traffic capacity, a predicted wave radio teletype system was constructed by the Collins Radio Company for the Center. It was hoped that the technique would open the way to communication on forty channels in the normal voice channel. This compared with the twelve channels available for standard teletype use. The first set fabricated by Collins Incorporated only a twelve channel capacity, but this was done to permit preliminary testing before construction of an equipment capable of working at the forty channel level. Rome planned to test the predicted wave radio teletype between Hawaii and Leal, New Jersey, sometime in 1957.[14] (UNCLASSIFIED)

The Center had also drawn up specifications for a new type microwave antenna tower for use at strategic communication system sites. The improved design would reduce the number of tower types required for heights between forty and eighty feet. The Center recommended to the Air Research and Development Command that the tower be procured on a development production basis since the item could be fabricated utilizing "state-of-the-art" manufacturing techniques.[15] (UNCLASSIFIED)

In coordination with the U. S. Navy, Rome monitored navy progress on transistorized multiplex equipment for the project. Testing of it (the AN/UGC-1) in Airways and Air Communication System circuits produced generally satisfactory

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results. At a joint services meeting held in Washington, D. C. the 18-19 December 1956, a number of minor problems associated with it were resolved and repackaging of the equipment agreed upon. It was marked for extensive employment in the strategic communication system.[16] (UNCLASSIFIED)

Single Sideband Development

In a sense all communication projects at the Center could be considered related to the general task of perfecting a global communication network. But within that over-all framework, there remained the traditional areas of communication development. Here, long distance radio communications naturally claimed keen attention and a sizeable portion of the Center Directorate of Communications was assigned to projects in this field. Single Sideband was one of the promising new techniques benefiting from Center support in 1956.[17] (UNCLASSIFIED)

Single Sideband was but one of several long distance communication systems under development in this period and pressure had built up by the summer of 1956 for a merging of some of these programs - particularly Single Sideband with Long Arm. Following instructions from Headquarters of the Air Research and Development Command, engineers from the Centers at Rome and at Wright-Patterson met August 7th 1956, to consider the combination of Single Sideband and Long Arm. After thorough discussion, the two Centers agreed that a combination of the two systems was impractical at that time,

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out it was felt that there should be ultimate utilization of a common Radio Frequency component for the Single Sideband, Long Arm and Quick Silver programs.[18] [redacted]

Actual work on the research and development of a single sideband aeronautical system for the Air Force had already started in June 1955 with a contract to the Collins Radio Company. A review of the technical principles upon which the single sideband technique is based can be consulted in the July-December 1955 History of the Rome Center. The immediate goal for the project was set at a ground-to-air operating range of 2,000 miles with an eventual extension of the range to 7,500 miles.[19](UNCLASSIFIED)

Several obstacles threatened in the summer of 1956 to delay prompt completion of the project. As a matter of fact, Collins let it be known July 16, 1956 that a slippage of six months seemed likely. Officially Collins attributed the delay to unexpected technical problems which had appeared and to revisions of contract scope and requirements introduced by the Air Force and by Collins itself.[20] It was noted at Rome, however, that Collins had accepted two similar tasks from the U. S. Navy and that this was certainly a factor in the slow down.[21] (UNCLASSIFIED)

It would seem though, that the project speed was cut to some extent because of uncoordinated Air Force requests for

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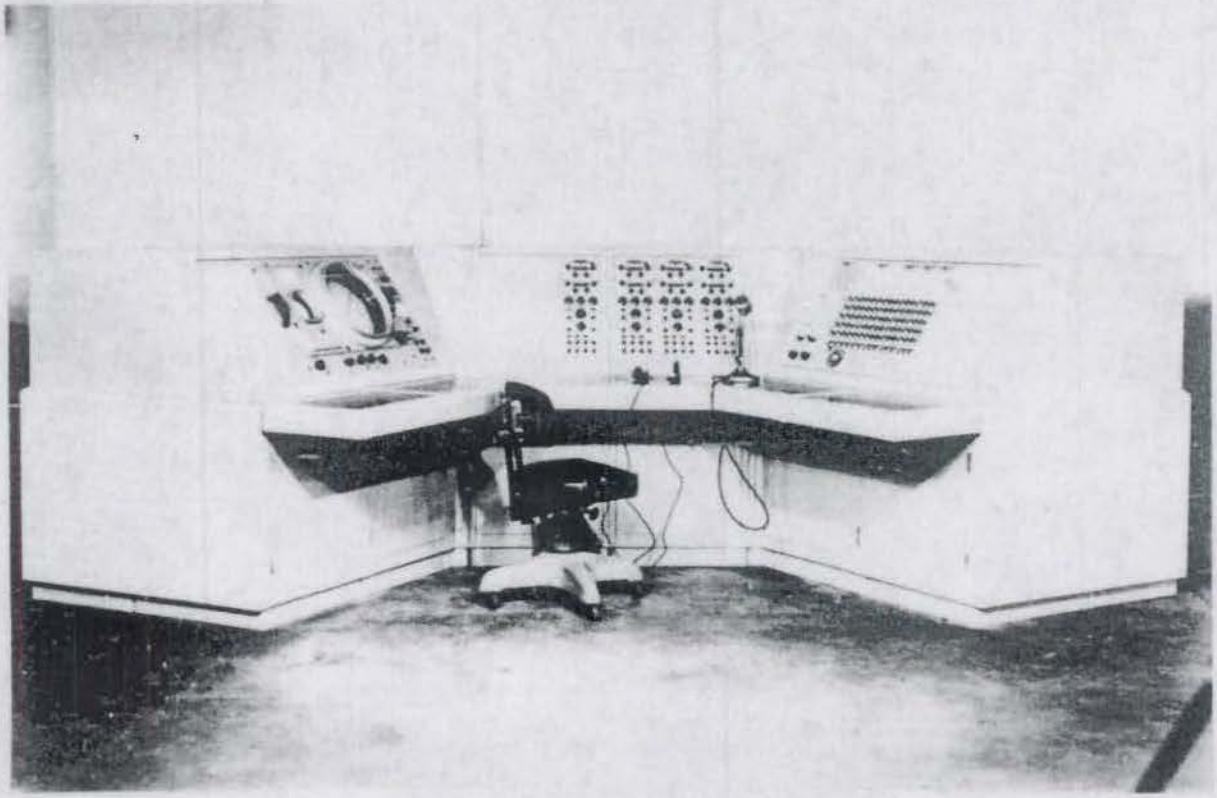

design changes. Rome observed July 13th 1956 that the status of the airborne single sideband equipment [AN/ARC-58] was so extended that changes in basic design concepts were sure to slow the program - perhaps as much as twelve to eighteen months.[22] Yet two months later, September 13th 1956, the Directorate of Procurement at Rome was apprised that other agencies within the Air Force were going directly to Collins to effect changes in the single sideband equipment. Center representatives specifically directed Collins to consider no such changes without obtaining the permission of Rome.[23] [illegible]

In a follow up attack on the same problem Rome invited representatives from other Air Force agencies to be present October 31st - November 1st 1956 for a detailed presentation of the single sideband program. In substance those at the conference were invited to criticize and suggest changes they felt necessary; but no major dissatisfaction was forthcoming. This meeting effectively ended any further difficulty on that score.[24] To reduce the chance of misunderstanding between Collins and Rome itself, the Center undertook to redefine more closely the requirements of the contractor. The new contract was completed by January 1957 and worked out very well.[25] Unfortunately as these problems were being set straight, the project incurred a heavy overrun. Collins Radio

estimated that approximately $4,100,000 over and above the original contract price of approximately $5,434,000 would be needed to complete work.[26] (UNCLASSIFIED)

An important part of the single sideband project consisted of a complex test program for which the Rome Air Development Center was in part responsible. A precise delineation of responsibilities was set down after a meeting between representatives of the Air Proving Ground Command and Center personnel October 30th, 1956.[27] As previously outlined in a directive by the Chief of Staff dated August 8th, 1956, nine fixed, ground, single sideband stations would be scattered across to both sides of the North Atlantic in addition to airborne and transportable single sideband equipments. Among the fixed ground sites selected was the Stockbridge/Ava, New York site - the particular interest of the Rome Center. However, Rome was providing financial assistance for the sites at Thule, Greenland and Elkhorn/Scribner, Nebraska and was providing the one Kilowatt equipments at Sidi Slimane (French Morocco), Lajes (Azores), Croughton (England), Keflavie (Iceland), Harmon (New Foundland) and at Andrews Air Force Base. These locations had been selected because it was in the North Atlantic area where radio frequency assignments were most difficult due to the congested spectrum and to the auroral effects experienced there.[28] (UNCLASSIFIED)

Synchronous Detection

A different though related technique known as synchronous detection was also under investigation at Rome for long range communication. In this approach although the carrier wave was suppressed just as in single sideband transmission, both sidebands were employed instead of only one as with single sideband. A comparison with single sideband indicated certain potential advantages as well as disadvantages. For example synchronous detection, or double sideband as it is sometimes called, offered greater assurance that a signal would get through in the event of interference with one of the sidebands. The transmitter portion of synchronous detection was simpler than that of single sideband, but synchronous detection brought these advantages at the cost of a bandwidth twice that of single sideband and increased receiver complexity.[29] (UNCLASSIFIED)

In 1956 no "best" modulation technique could be discerned. It was assumed that the development engineer's task was to choose the best system for a given situation. Responsible leaders at the Center considered the competition among the various modes of modulation a healthy one and believed it would purchase the "most Air Force per dollar" after impartial investigation and testing.[30] (UNCLASSIFIED)

Synchronous detection was a technique which had been much advanced by Dr. John P. Costas of the General Electric Company.

logically, then, General Electric, with this advantage over its competitors, won the Air Force contract for its further development.[32] (UNCLASSIFIED)

The completion date of December 1956 attached to this contract had to be moved back to March 1957 because of technical difficulties. Two cost overruns during the course of 1956 likewise clouded the picture, but Rome recommended acceptance of the delay and the cost overruns in the interest of obtaining satisfactory equipment.[33] Plans had been formulated in the fall of 1956 for an extensive system test program involving a one kilowatt suppressed carrier transmitter and synchronous receivers to be located at several ground stations and in an aircraft.[33] (UNCLASSIFIED)

Tropospheric Scatter

For development of point-to-point long distance radio communications, scatter techniques, a comparatively new field, opened the door to fresh advance. In general these new techniques relied on bouncing or refracting part of a signal transmitted high above the earth's surface to a receiving station located some distance away. Normal microwave radio transmission was limited to line-of-sight distances - distances in the neighborhood of thirty miles - because the earth's curvature prevented a receiving antenna from capturing the signal much further away than that. Scatter transmission made it possible to go out to 250 miles or even to a

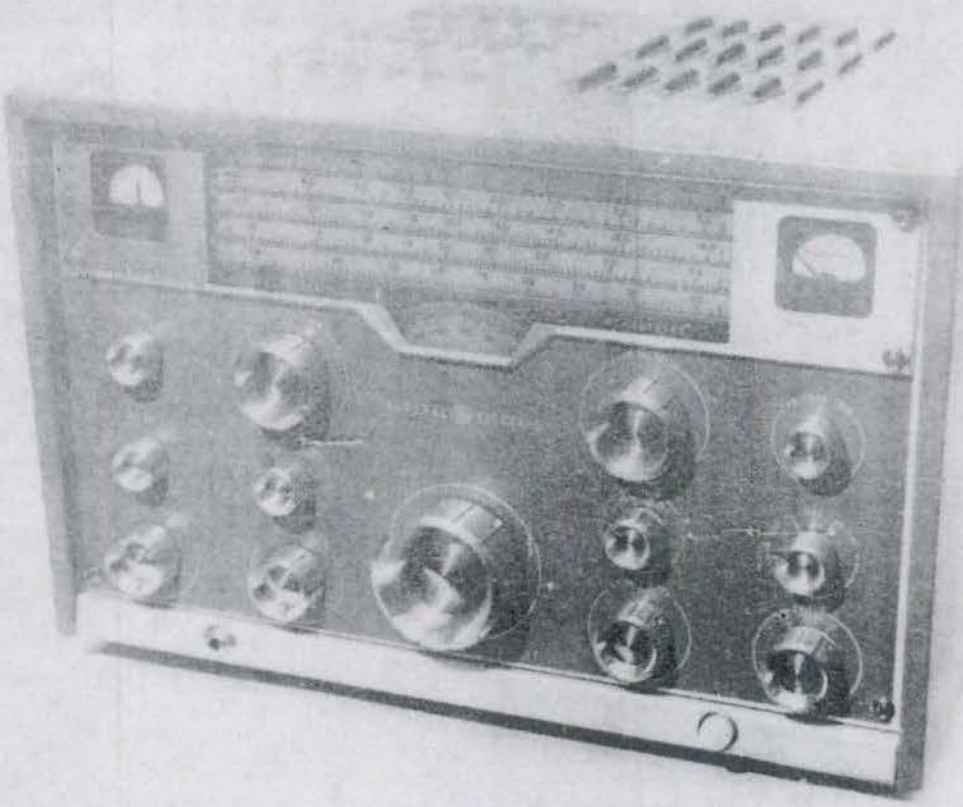

Figure 13 - The AN/URR-48 (XA-1) Receiver

theoretical 1,200 miles (using meteoric scatter) between stations. What this could mean in terms of communication to inaccessible areas of the Far North, desert areas and islands at sea is obvious. Elimination of many of the stations needed in traditional microwave relay would bring reduced costs and a need for fewer operating personnel.[34] (UNCLASSIFIED)

It was during the ten years following World War II and in part from the experience of the Korean War that evidence accumulated which demonstrated that weak radio signals in the Ultra High Frequency and Super High Frequency ranges could be received at great distances. Previous to this period communications equipment had ordinarily not been capable of picking up these very small scatter signals and the value of scatter propagation was ignored. Scatter techniques thus required back up first from high power transmitters, super sensitive receivers and high gain directional antennas.[35] (UNCLASSIFIED)

Tropospheric scatter, as the name suggests, was one of these new techniques which sought to capitalize on the bending of radio beams in the troposphere. Tropospheric equipment had already been programmed for installation in the Pole Vault and White Alice northern communication systems as the value of this technique came to be appreciated.[36] In fact by early 1956 the Air Force was anxious to develop tropospheric equipment as a standard item and the Rome

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Air Development Center was called in to monitor and supervise the project.[37] [redacted]

A contract was let to the Radio Corporation of America in the spring of 1956 for construction of AN/FRC-39(V).[38] This equipment, intended as a standard production item in the [redacted] proposed as a development item, but the urgency of achieving operational dates caused this phase to be eliminated. Acceptance tests were to take place at the contractor's plant.[39] The AN/FRC-39(V) was to function at point-to-point ranges up to 200-250 miles with a twenty-four hour communication reliability. Important anti-jam features also figured in its anticipated performance capabilities.[40] [redacted]

During the spring and summer of 1956 work on AN/FRC-39(V) was hampered because of the contractor's interest in similar equipments ordered for the White Alice line. However, by August 1956 testing of White Alice gear had terminated and key personnel at the contractor's plant were freed for this project.[41] Some difficulty occurred too because of a misunderstanding between Center personnel and the contractor. It had been the impression of the Rome Center in all discussions that continuous tuning would be engineered into the set, but in March 1956 it was evident that the Radio Corporation of America had failed to include this feature.[42] The contractor later calculated that an

additional $100,000 would have to be supplied for its inclusion and that a two and one half to three month slippage in production would probably ensue.[43] Final delivery was then set for approximately January of 1958 and by late 1956 it appeared that this goal could be met as construction moved on schedule in this four million dollar contract.[44]

Other Scatter Techniques

Other scatter techniques beyond the troposphere were studied too at the Rome Air Development Center including ionospheric and meteoric scatter. No formal project for ionospheric scatter was yet underway in 1956, but the Center was engaged in the necessary preliminary planning.[45] Similar study took place in the intriguing field of meteoric scatter. In this latter technique radio signals would be reflected back to earth from the ionized trails left by meteors in the upper atmosphere. In order for the technique to function properly, the meteor had to be fairly large, moving in the right direction and in the correct location. But since there were millions of meteors in a band ten miles wide some sixty miles out from the earth, enough meteors could fulfill the requirements to allow transmission approximately five percent of the time. With accelerated data handling equipments operating at perhaps twenty times the normal rate of speed during meteor bursts, normal rates of exchange of binary information was possible. What interested Center

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scientists particularly were the long ranges possible - up to 1200 nautical miles for ground stations. The planning and study for both of these scatter techniques in 1956 were the necessary first steps before the more concrete work which followed in 1957.[46] (UNCLASSIFIED)

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37. Report, subj:(U) Brief History of FRC-39 Procurement in Files of Mr. Lewis Javarone RCUERS, Project Engineer, 26 April 56, pp.1-3.

38. Ibid, pp.1-2.

39. ARDC Form 171, subj:(U) Radio Set AN/FRC-39A, 15 Nov 56. See also Ltr, Mr. Jospeh H. Vogelman Technical Director, Dir Comm to Comdr ARDC, subj:(U) Status of Equipment Development, 14 Sept 56.

40. Interview by the author with Mr. Lewis Javarone RCUERS, Project Engineer, 12 Sept 57.

41. Memo for Project File AN/FRC-39, subj:(U) Trip to REL, 7 Jun56.

42. Report, subj:(U) Brief History of FRC-39 Procurement, from Files of Mr. Lewis Javarone RCUERS, Project Engineer.

43. Ibid.

44. RADC Form 145, subj:(U) Radio Set AN/FRC-39, 30 Nov 56.

45. Interview by the author with Mr. David L. Coddington ROGERS, Project Engineer, 13 Sept 57.

46. Interview by the author with Mr. Thomas G. Knight RUSELL, Project Engineer, 13 Sept 57.

CHAPTER V

INTELLIGENCE AND ELECTRONIC WARFARE

The rapid pace of modern war is often visualized in terms of supersonic aircraft and missiles with the maze of electronic ground equipments which seem, for some, to augur an age of push button warfare. Even the most rabid push button enthusiast would probably agree nonetheless that machines cannot eliminate a need for human decisions of all kinds at all levels. Decisions, however, require access to information and that, in turn, means immediate access in order to keep up with the capabilities of newly developed weapons. (UNCLASSIFIED)

Minicard

The Directorate of Intelligence and Electronic Warfare at the Rome Air Development Center had been entrusted by the Air Research and Development Command to streamline the horse and buggy filing methods then in use to store and classify intelligence data of all kinds. Baltimore wanted an Intelligence Data Handling System for file information for immediate retrieval and it wanted the system operational by 31 December 1959.[redacted]

An important part of the system (System 438L) for which Rome was assigned responsibility, was the Minicard Intelligence and Information Handling equipment. Minicard was to function as the

basic library storage unit of the system. Technical details on the characteristics of this equipment can be reviewed in the previous Rome Center history.[2] Briefly, however, Minicard may be described as a unit capable of storing and filing intelligence information of various kinds on microfilm strips which can be retrieved when needed in a matter of seconds.(UNCLASSIFIED)

The contract for the basic developmental Minicard equipment had been awarded to Eastman Kodak Company in June of 1954. Originally this equipment had been scheduled for delivery in January 1956, but by late 1956 a slippage of approximately 15 months had set back the date to March 1957. The magnitude of the work involved on the project and the tight schedule were accounted to blame for this slippage by the Center project engineer, Mr. Al DeLucia. It was anticipated that the equipment would then be integrated into a working system and that a Minicard system test of approximately one year duration could then be set in motion. Invaluable experience was expected to result which could be of aid in the design of new data handling systems.[3] (UNCLASSIFIED)

At first, sights were limited to procurement of one set of Minicard equipment, but after a meeting on August 9th, 1956 at Headquarters U. S. Air Force, a request by the Air Research and Development Command was approved which increased the number to six. High cost estimates by Eastman Kodak in

conjunction with a shortage of available service test funds cancelled out this plan for the time being. On 26 December 1956 Rome received eight million dollars to allow for procurement of a total of four Minicard installations.[4] (UNCLASSIFIED)

Plans to include a camera and enlarger for aerial photographs received a set back when Eastman Kodak, the contractor, informed Rome in July of 1956 that the original delivery date for this item (June or July 1956) could not be met and that the completion date would fall a year later in June of 1957. A large overrun of funds anticipated for the equipment decided Rome to cancel the contract in September 1956.[5] (UNCLASSIFIED)

Not all work on this project fell to Eastman Kodak. Several contracts had been let to other firms for support equipments. Skiatron Electronics had completed approximately fifty percent of the design for a remote televiewer for Minicard under a contract begun in May of 1955. Magnavox had begun the design and fabrication of an automatic dissemination control for Minicard after having completed the study phase of the contract in June 1956.[6] (UNCLASSIFIED)

Increases in the equipments supporting Minicard obliged a re-design of the layout for the Minicard prototype equipment in late 1956. This was a problem which brought help from the Human Factors Laboratory of the Directorate of Technical Services at Rome. The Human Factors Laboratory had in fact closely

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coordinated with the contractor and the Directorate of Intelligence and Electronic Warfare to incorporate design changes which seemed advisable at previous stages of Minicard development.[7] (UNCLASSIFIED)

Language Translation

Utilization of information in a foreign language was another area in which Rome believed a significant improvement could be registered in intelligence operations. Specifically, the Center through its own in-the-house studies and through the contracts it monitored, brought machine language translation closer to reality. This project which aimed first at translating scientific Russian into English was well underway by the end of 1956. The nature of the equipments proposed for this task have been treated in the previous history.[8] (UNCLASSIFIED)

The International Telemeter Company had been engaged to produce the photoscopic disc which, as the memory storage device, was the key to success for the equipment. By the end of 1956 the design for the required disc and the attendant paper work had been completed and actual fabrication was in progress at the beginning of 1957. This work of International Telemeter incurred a heavy overrun of funds, however, in the course of this progress. As early as July of 1956 the contractor informed the Rome Center that an overrun would result because of unanticipated technical difficulties. After investigation,

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Rome concurred that the overrun was justified and in spite of a substantial amount of money involved, recommended that the contract not be terminated. It was felt that the contractor was close to solution of the technical difficulties and that a successful issue could be foreseen. Consequently arrangements to make up the overrun through periodic installment payments to the contractor had been ironed out during the closing days of 1956.[9] (UNCLASSIFIED)

Meanwhile the University of Washington subcontracted for a language analysis study to clarify the language relationships basic to the translating equipment. This was, of course, unexplored territory and various approaches seemed to offer promise. Although University of Washington linguists were confident that their own line of attack would be a successful one, Rome maintained in-the-house investigations of its own to check the feasibility of other linguistic theories. The combined work under contract to International Telemeter Company and the University of Washington for this project cost the Air Force approximately $45,000 a month.[10] (UNCLASSIFIED)

Essentially Rome was engrossed during 1956 in the first phase of the machine language translation project. This phase anticipated human operators to type Russian text into flexowriters. After then passing through various automatic steps in the equipment the English text would be typed out by the output flexowriter. The second phase proposed an electronic scanner

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which would eliminate the need for a human operator to type the text and would instead scan the text and automatically type the Russian text into the flexowriter. The finished translation would be reproduced by a high speed printer. During 1956 no contracts were awarded for the phase II refinements as Center effort concentrated on solving the more basic problems.[11] (UNCLASSIFIED)

As Rome became more involved in questions associated with language translation, related topics of significance to intelligence work were encountered. It was noted that ordinary texts contain a considerable amount of redundant verbage requiring precious time for the abstracting of really essential information. If machines could be built to translate from one language to another, was it not also possible to construct equipment which could "translate" from an English text into a filing code for more efficient classification and storage of information and more rapid access to it later? Modern research gave promise that scientific word patterns and relationships could be devised, something on the order of the word classification relationships worked out in Roget's Thesaurus, which with appropriate electronic equipment could perform these tasks. To help build up the essential theoretical background, Rome allocated $20,000 to the Cambridge Language Research Unit of Cambridge University in England for

a study of automatic information data processing involving mechanical abstracting. These funds for a one year contract has been transferred by the Rome Center to the National Science Foundation in order to procure the services of Cambridge.[12] (UNCLASSIFIED)

Jamming Techniques

These are but a few examples of what could be and was being done by the Rome Center to revolutionize intelligence activities of the future. This same directorate which undertook to improve facilities for intelligence operations devoted a no less considerable portion of its attention to the problems of electronic warfare. Ironically enough, a particularly important segment of the electronic warfare effort at Rome consisted of projects whose task was to blind or baffle the same powerful radars being developed just a few hundred yards down the road by the Directorate of Control and Guidance. Active countermeasure equipments like electronic jammers and passive countermeasure developments such as radar reflectors and radar absorbant materials all came under the careful scrutiny of Center personnel in 1956.

In the active field of radar jamming equipments, it had been apparent to specialists at Rome for some time that improved

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Jammer design was not enough in itself to match radar development in the Post Korean War period. Clearly it seemed, a whole new philosophy of jamming would have to be forged - without which the balance would swing inexorably against radar countermeasures in the forseeable future.[13] [redacted]

Previous jamming has relied on high powered equipment with narrow beam antenna which had to be aimed at the target radar and tuned to the appropriate frequency to blank out a desired area. During World War II it required anywhere from thirty to sixty seconds to train and tune the jammer. If the enemy then changed frequency, a new adjustment of the jammer to the corresponding frequency would have to be repeated. This period of jammer adjustment allowed approximately twelve to twenty-four scans by the enemy radar before interference by the jammer resumed. Since it was estimated that a good bombardier required but five scans to obtain sufficient information to place his bombs on target, the weakness was a real one. Modern radars with rapid automatic tuning devices could convert old style jamming into a nuisance rather than a serious deterrent.[14] [redacted]

Newer jammers of the KIC series improved the countermeasure balance somewhat since they could be adjusted to follow enemy frequency changes in from five to ten seconds. However, skillful operation of the enemy radar set could still result in a 180 degree scan if only a one second gap were left in jammer

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adjustment. Repeated evasive tactics by the enemy radar operator could thus provide enough data for successful bombardment. Time of adjustment was manifestly one of the critical weaknesses in traditional jamming equipments.[15] [redacted]

Yet assuming that this problem could be properly resolved, the enemy had still another string to his bow. Instead of trying to pick out the target in the jammed sector, the enemy radar could train on a landmark or "Offset Point" near the target, but outside the jammed area. Then using an offset bombing technique on the basis of this information, bombs could be dropped on the desired target. This was why it appeared to the Rome Center that not only improved jamming equipment, but a new philosophy of jamming was imperative.[16] [redacted]

The Rome Air Development Center, therefore, turned to a new concept, Distributed Area Jamming, as a way out of the dilemma. Under this system a number of jammers would be situated in a given area in such fashion that the enemy's target and every landmark which might be used to locate the target would be masked by a jammer. The jammers to be employed would be low powered equipments considerably cheaper to produce than the old fashioned high power jammer. Quantity production of the new jammer would set a price of approximately $25,000 a piece compared to the $350,000 that went into the building of an MIQ type jammer. While the new system would require a number

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of jammers, the cost of the program would be far less than might first be supposed. The system would greatly lessen the effectiveness of off set bombing techniques.[17] [redacted]

To prove out the feasibility of the distributed area concept, eight ULT-1 low power jammers were ordered from the Farnsworth Company. These equipments contracted for in December of 1953 and delivered in February of 1955 indicated that the distributed area concept was sound. However, the magnetron tube used in the sets had a frequency coverage too limited to permit following the evasive frequency changes which could be anticipated from enemy radars. Happily, a newly developed French tube, the Carcinotron, which could tune over a broad frequency range, held out high promise. A new equipment, the AN/ULT-2 based on the distributed area jamming concept and incorporating the Carcinotron tube was accordingly programmed by the Rome Center.[18] [redacted]

The Carcinotron tube to be designed for the AN/ULT-2 could be tuned 800 megacycles per microsecond through a frequency range of 3,000 megacycles. It had been hoped that the jammer would be entirely omnidirectional as well for greater speed. It was discovered, however, that this feature would have to be purchased with too much power for effective operation. Instead, a compromise was effected in which two antennas were called for. An omnidirectional antenna composed

of eight horns pointed at eight equidistant points around the compass would receive the radar signal and analyze the beam for frequency. Then by switching from the receiving antenna to a transmitting antenna similarly composed of eight horns, the jamming signal would be transmitted. The horn pointed in the appropriate direction would be the one selected for transmitting the jamming signal at high gain.[19] [redacted]

Time of course would be consumed in switching from one antenna to another but using comparatively "crude" mechanical methods this could be accomplished in one and three quarters milliseconds. In short, with the carcinotron tube and the double antenna system, the AN/ULT-2 could complete the total operation of receiving a radar signal, analyzing it and transmitting a properly tuned and directed jamming signal in approximately two milliseconds. Enemy radars needed far more time than this to acquire necessary data.[20] [redacted]

Contracts to fabricate one experimental model each of the AN/ULT-2 were let by Rome in the course of 1955 to Farnsworth, Melpar and Airborne Instruments Laboratory. Then on March 30th, 1956 Farnsworth and Melpar were awarded contracts for four preproduction AN/ULT-2's each. As the summer months wore on, additional units for testing purposes were added to the list for Farnsworth. In all, exclusive of experimental models, Farnsworth had authorization to build twenty-six and Melpar four AN/ULT-2's by the close of 1956.[21] Farnsworth had

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acquired the lion's share of this order because of their substantially lower bid for the last twenty equipments. Their estimate of cost figured at $300,000. As it turned out, though, this optimistically low bid was quite unrealistic. In December 1956 Farnsworth talked of overrun and by early January 1957 the Center learned the bad news that a whopping $680,000 overrun would be incurred. Only the urgency of the project prevented cancellation of the contract.[22]

Need for this relatively large number of AN/ULT-2 equipments stemmed from a conference held at Rome the 11th September 1956. Representatives of the Strategic Air Command, the Air Defense Command and the Air Proving Ground Command conferred upon this occasion with Rome Center personnel to commence arrangements for a Distributed Area Jam System test. Rome was given the responsibility of drafting the over all test plan following the guide lines laid down at the conference. The conferees chose the Springfield, Massachusetts area as the site of the test program scheduled to begin July 1, 1957.[23]

The 1957 test program in Massachusetts was intended to deploy the jammers in such a way as to conceal points which could be used in the bombing phase of the simulated attack. In the event that this method proved less successful than hoped, another branch of the Rome Center, the Human Factors

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Laboratory of the Directorate of Technical Services, supplied assistance to the project by investigating another aspect of approach in distributed area jamming. Human Factors people were interested in denying the navigational landmarks which the enemy would pick up on his radar screen to position himself before ever beginning the bombing phase of the attack. By denying navigational data any initial navigation errors of the enemy would be compounded to an extent that might spell mission failure.[24]

Human Factors conducted a study of maps and radar screen photographs of the test area to locate the most likely navigational radar returns. A total of some 93 returns were ranked in four categories depending on their prominence. It was felt that 272 jammers could mask them sufficiently for navigational purposes. A bombing trainer for tests utilizing this method was acquired by Bone and the complex work necessary to simulate the test area for the trainer began. Although technical difficulties delayed full scale simulation tests on the trainer in 1956, several interesting experiments were carried out. For example, it was asked, would a regular geometric jam pattern or a selected area jam pattern which blocked out the most vital segment of the radar return confuse the enemy more? Static tests carried out by Human Factors personnel demonstrated that the selected jamming

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technique was the more effective.[25] (Confidential)

Passive Reflectors

Passive countermeasure projects against radar also received their due share of attention at the Center. The "corner reflector" could be classified in this category. During World War II radar "corner reflectors" had been set up to create artificial or unexpected radar echo returns in order to confuse enemy radar operators. At that time the full potentialities of these reflectors could not be realized for lack of sufficient theoretical and empirical research. Conversely, however, a number of techniques could be developed of considerable utility in air defense. Reflectors might be placed in the immediate vicinity of the target to distort its contour. In areas where the bomb had to be dropped within critical limits to cause damage, enough error might be introduced in this way to result in failure of the bombardment. Or again reflectors might be placed at various points to camouflage the navigational check points which enemy planes could be expected to use to arrive on target. Finally a military installation might be simulated in a number of reflector decoy complexes with the result that the enemy bombardier could not determine which area was the true target and which the decoy complex.[26] (Confidential)

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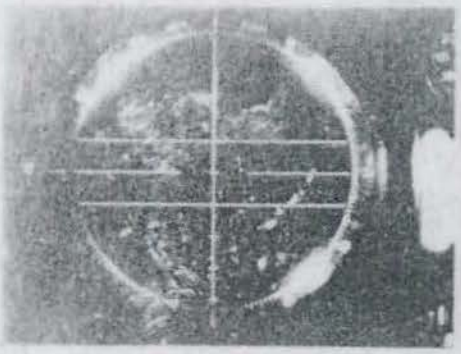

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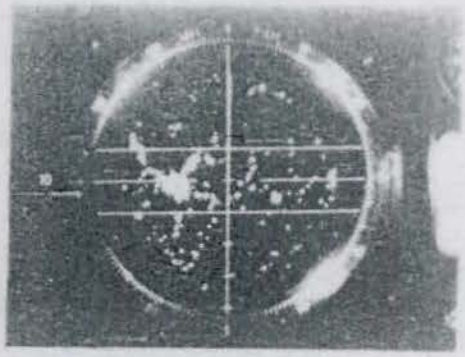

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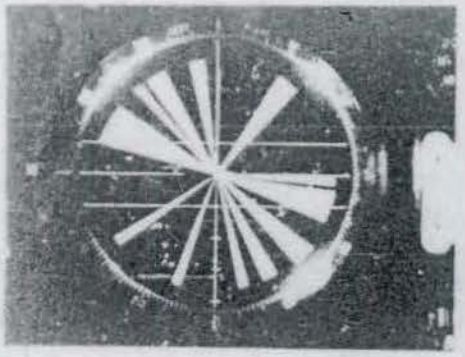

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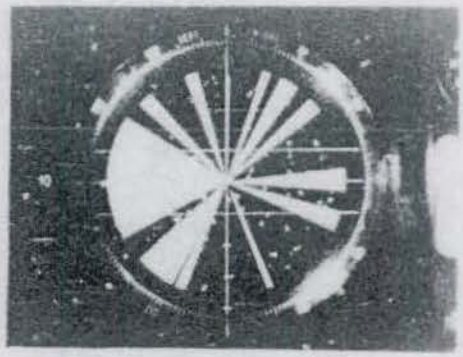

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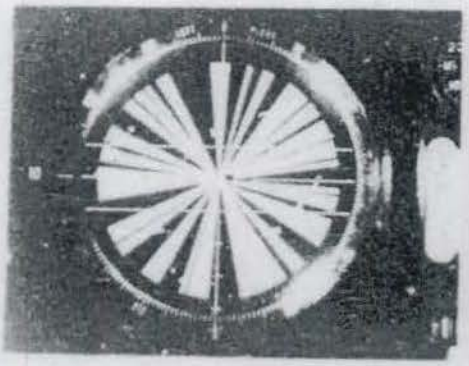
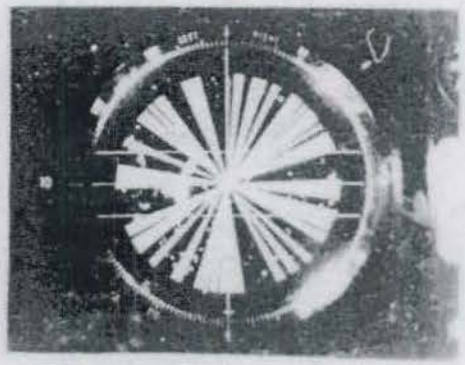


Geometric Deployment
Problem #1



Geometric Deployment
Problem #2

It was to investigate the latter technique that Rome scheduled a series of tests at the Eglin Air Force Base in Florida in early 1956 to simulate the Eglin radar complex with corner reflectors. This involved careful preliminary studies of the area through aerial photographs and photographs of the airborne Position Plotting Indicator radar scope before setting up the reflectors.[27] In these tests which lasted from February through April of 1956 a total of 249 reflectors of varying types were employed.[28] A B-47 type aircraft equipped with an AN/APS-64 radar flying at an altitude of 40,000 feet viewed the complex at various ranges. Test results were reported highly gratifying. (Secret)

The complex was visible at slant ranges of from 150 to 175 nautical miles and did not disappear until a slant range of under 1½ miles.[29] In the case of the Eglin complex, it was demonstrated that only forty to seventy corner reflectors were actually needed. Assuming the average cost of $250 per reflector, the entire complex could be simulated for around $20,000. Once erected the decoy complex would require no field maintenance. It was thus economically as well as operationally feasible.[30] (Secret)

Admittedly in the Eglin test, the simulated complex was so arranged that the enemy would have to approach on a particular track, plus or minus fifteen degrees. A 360 degree complex

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could be erected, but would necessitate seven times as many reflectors. It was this narrow beam limitation of the corner reflector which led to Center interest in "Luneberg Lens" spherical reflectors. These improved reflectors would increase the viewing angle from 30 degrees to 120 degrees. They would also be simpler to erect and yet be of a cost comparable with old style corner reflectors.[31] A contract for Luneberg Lens reflectors was let to Scientific Associates June 30, 1956. These reflectors were to have a maximum diameter of thirty six inches, the largest lens considered practical to manufacture and utilize operationally. Delivery of the reflectors was expected in the Spring of 1957 for evaluation by Rome to determine their reflective characteristics.[32] Even with the most advanced techniques, Center engineers admitted that it was economically impractical to duplicate with reflectors the radar complex presented by large cities such as Chicago and Pittsburgh. However, Rome did feel that protections of Strategic Air Command sites and other military installations was quite within the limits of current reflector development.[33] [redacted]

Radar Absorbent Materials

Radar absorbent materials to eliminate or at least diminish electronic echoes were the concern of a related Center project in the field of radar countermeasures. One of the substances which attracted particular attention at Rome in 1956 was a

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[redacted]

cost to the United States Air Force for evaluation. Rome worked through the European office of the Air Research and Development Command in acquiring the material.[34] [redacted]

A variety of tests both in and out of doors were undertaken

[redacted]

July 16, 1956 for experiments conducted later in the month at Wright-Patterson Air Force Base.[35] Environmental and mechanical testing of the substance also took place in the late summer and fall of 1956 and yielded encouraging results. Whatever the electrical properties of the material might be, it was clear that it had many desirable practical qualities to recommend it. It could be coated or sprayed on the object to be masked, revealed good durability and a facility to adjust to various environmental and mechanical stresses.[36] [redacted]

Rome's prime interest was to develop a substance to conceal

[redacted]

in the interest of rigorous testing, the Center resolved to continue

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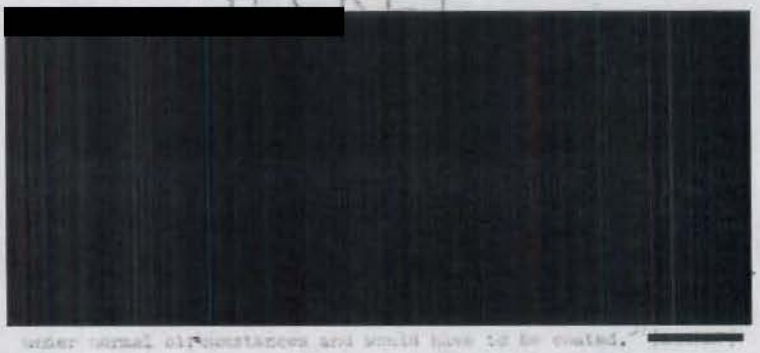
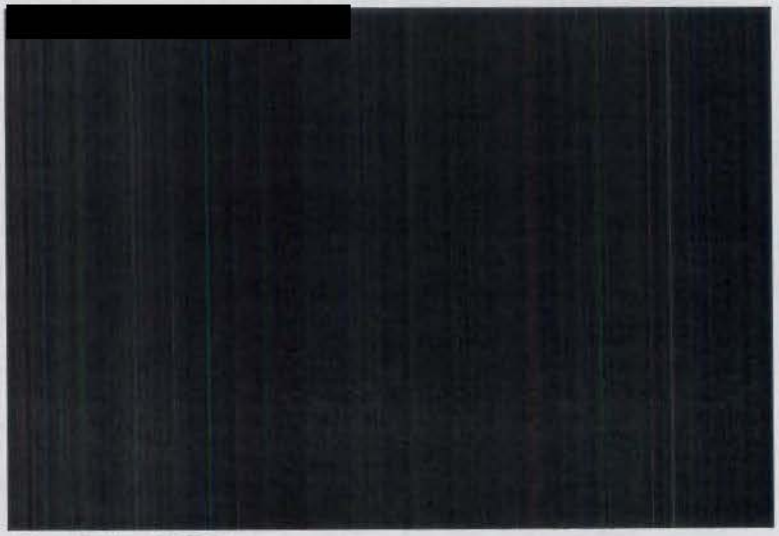


under normal circumstances and would have to be coated.

Initial flight testing of the partially coated F-4 began at Edwards Air Force Base in December 1948 under supervision of the Rome Center. The plane suffered no appreciable aerodynamic loss because of the substance, but the electrical result was

[redacted]



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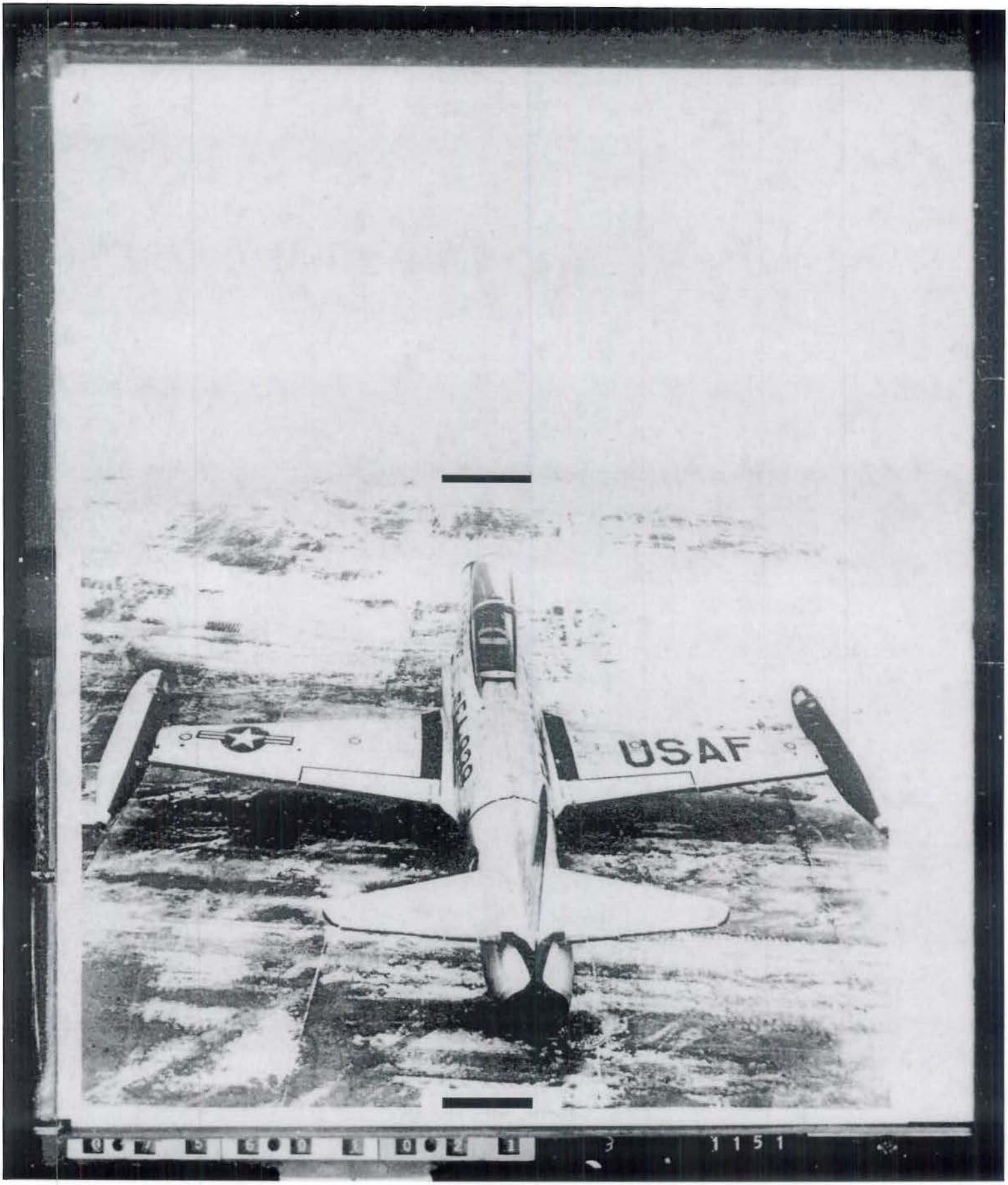
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NOTES

Chapter VI

1. DD Form 613, subj:(U) Minicard Intelligence and Information Handling Equipment, 31 Dec 56, p.1.

2. Rome Air Development Center History 1 Jan 56 - 30 Jun 56, pp. 91-94.

3. Interview by the author with Mr. Al [illegible], Project Engineer, 23 Sept 57. Also DD Form 613, subj:(U) Minicard Intelligence and Information Handling Equipment, 31 Dec 56, pp.[illegible].

4. DD Form 613, subj:(U) Minicard Intelligence and Information Handling Equipment, 31 Dec 56, pp.[illegible].

5. Ibid, p.179

6. Ibid, p.[illegible].

7. Progress Report, Intelligence Branch, Human Factors Laboratory, Directorate of Technical Services RADC, Dec 56, 14 Jan 57, pp. 1-2.

8. Rome Air Development Center History 1 Jan 56 - 30 Jun 56, pp.

9. Interview by the author with Mr. George Shiner RCWIPS, Task Engineer, 23 Sept 57.

10. Ibid.

11. Ibid.

12. Ibid.

13. Interview by the author with Mr. Irving Zitchow RCWRC, Chief, Countermeasures and Deception Branch, 24 Sept 57.

14. Ibid.

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16. Ibid.

17. Ibid.

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19. Ibid.

20. Ibid.

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23. Minutes of a Meeting at RADC, subj:(U) Jamming Test Program, 11 Sept 56.

24. Interview by the author with Mr. William J. Doherty RCSSW, Task Engineer, 3 Oct 57.

25. Ibid.

26. Draft Report, subj:(U) Technical Report on Phase II of the Corner Reflector Test Program, by 1st Lt George F. Shivley Jr, 7 Feb 57, p.2.

27. Ibid, pp.2-3.

28. Interview by the author with Mr. Roger Ringlund RCWESD, Project Engineer, 30 Sept 57.

29. Draft Report, Technical Report on Phase II of the Corner Reflector Test Program, by 1st Lt George F. Shivley Jr, 7 Feb 57, pp.5-7.

30. Activity Report, Research and Development Report RADC, vol.3, no.11, 25 Nov 56, pp.2-3.

31. Draft Report, Technical Report by 1st Lt George F. Shivley Jr, 7 Feb 57, p.12.

32. Interview by the author with Mr. Roger Ringlund RCWESD, Project Engineer, 30 Sept 57.

33. Draft Report, Technical Report by 1st Lt George F. Shivley Jr, 4 Feb 57, p.19.

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34. Interview by the author with Mr. Louis F. Moses RCWECD, Project Engineer, 13 Sept 57.

35. Ltr, Col James W. Anderson Jr, Div of Intell & EW to Comdr WADC, subj:(U)Microwave mass remnants of coated sphere, 18 Jul 56 and 1st Ind thereto by Lee W. Cunningham WADC to Comdr RADC, 1 Aug 56.

[redacted]

37. Interview by the author with Mr. Louis F. Moses RCWECD, Project Engineer, 13 Sept 57. See also Memo, David F. Barber RCWECD to Col Hoover, DCS/Operations in files of Mr. Louis F. Moses RCWECD.

38. Memo for Project File 4504, subj:(U) Report of trip to Air Force Flight Test Center, Edwards Air Force Base, 24 Jan 57. SD-43.

[redacted]

40. Ibid, p.68.

CHAPTER VII

Technical Services

Help of many kinds for the electronic projects at the Rome Air Development Center could be credited to the Directorate of Technical Services, but an obviously important phase of that activity concerned the testing of equipments developed by other directorates and described in preceding chapters. Logically enough the test facilities of the Directorate of Technical Services had to keep step with the greater demands made by new Center projects if the caliber of testing assistance was to be maintained. (UNCLASSIFIED)

Test Facilities

In this connection the Center constructed among other things a microwave dark room (Radio Frequency Anechoic Chamber) in the summer of 1956 for simulated free space tests. Study of antenna patterns, interaction of microwave radiation on dieletric and magnetic materials were some of the research and development areas that benefited from the new facility. The chamber, which was lined with Hairflex absorbing material, measured ninety feet in length, twenty feet in width and fifteen feet in height.[1] (UNCLASSIFIED)

Much testing had to be carried on outside the laboratory, however, and to supply the electronic measurements necessary for field testing of Center developed equipments a mobile interfence measurement laboratory (AN/MSM-7) was designed and fabricated

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by the Networth Manufacturing Corporation for Rume[2] on a contract initiated January 15, 1955.[3] The laboratory area of the truck was specially shielded to prevent entry of unwanted radiation which might throw off the delicate measuring devices contained in the mobile laboratory. Living quarters in the truck permitted accommodation of a crew for extended tests.[4] The unit, delivered to the Center in July of 1956 at a cost of approximately $32,000, proved extremely useful in later field tests of electronic equipments.[5] (UNCLASSIFIED)

The Directorate of Technical Services did not by any means limit its back up support of other Center projects to the performance of tests. Work accomplished by the Human Engineering Laboratory of the directorate and touched upon in previous chapters was evidence of this. But still another illustration of a different sort might be taken using the Manufacturer's Drawing Analysis Section of the directorate. (UNCLASSIFIED)

Manufacturer's Drawing Analysis

After equipment had been developed and proved out for the Air Force, standard practice dictated the letting of production contracts "per performance specifications." This was a textual or detailed verbal performance guide to be followed by future contractors in producing the same equipment. It might happen, though, that ten manufacturers making their own drawings on the basis of the performance specifications might fabricate

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equipments which did everything called for in the specifications and yet which differed considerably among themselves as to parts and construction. If, however, contractors in the second round of production procurement were required to build "per drawings", uniformity must result since room for individual interpretation was eliminated. This method of procurement "per drawings" looked especially attractive after the development and first production procurement stages had been passed when presumably the "bugs" had been worked out of the equipment.[6] (UNCLASSIFIED)

To make possible procurement "per drawings", the Manufacturers' Drawing Analysis Section, first set up in 1954, reviewed the original manufacturer's drawings of an equipment to determine if they were technically satisfactory for use as production drawings. If not, the Center succeeded in some cases in obtaining revised drawings from the manufacturer and in others the section drew up supplementary drawings of its own. The small number of personnel in the section could not, of course, review all equipments under development for the Center, but selected those projects which seemed to offer the most room for dollar savings either because of the large quantity of items intended for procurement or because of the very high cost of the units to be acquired. As a result of its effort, the section effected very substantial savings in the projects it chose to assist. In fact, it was estimated that construction "per drawings" would lop off around fifty percent of the cost of selected production contracts which could employ this method. This was possible because smaller

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companies unable to maintain elaborate and expensive engineering staffs to evaluate the traditional performance specifications and go through the complex work involved in making their own drawings could not compete with the larger companies. If they were supplied with the necessary drawings, however, then they could compete on terms much closer to equality with their larger rivals. Increased competition for Air Force procurement contracts naturally tended to force the contract price down. This plus the elimination of design costs in reprocurement permitted the saving of hundreds of thousands of dollars to the Air Force not to mention the uniformity of equipment parts and construction which was added to the bargain.[7] (UNCLASSIFIED)

Reliability Program

Technical Services staked out yet another vital area in which to aid other Center projects. At question this time was the dependability or reliability of the equipments being developed and later procured for Air Force use. An equipment which passed its performance tests with ease in the laboratory, but which might break down at any odd moment, was of dubious value. And yet the complex communication and radar systems with their thousands upon thousands of vacuum tubes were bringing the failure factor to a critically high point. Radio equipment was in trouble 14 percent of the time - radar equipment 9½ percent of the time. Evidence like this made it clear that equipments would have to meet standards of reliability as well as of performance. Fortunately theoretical

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work in this field in the early 1950's helped set the stage for the promising programs to follow.[8] (UNCLASSIFIED)

The Department of Defense had established an Advisory Group on Reliability of Electronic Equipment to recommend a program for purchasing electronic equipment on a reliability basis. During the period 1955-1956 military and industrial representatives on the group met to draft recommendations for submission January 1957.[9] Three representatives of the Rome Air Development Center served with the group and brought the Rome Center very actively into this stream of thought.[10] (UNCLASSIFIED)

Long before the report was completed, though, Rome had already taken steps to set up its own reliability program. What might in fact be considered a preliminary phase of the program dated even before this. This refers to the automatic maintenance equipment program which was coming up with devices built in to an equipment that could automatically and continuously monitor the more critical parameters and display the results so that a deterioration of performance could be quickly noted and corrected. Performance monitors had been built into a large number of radars by January 1957 and retrofit kits were under development for others. Construction of automatic fault locators for simpler maintenance and of failure prediction indicators which would measure critical voltages and predict imminent failure were more advanced stages of this project.[11] (UNCLASSIFIED)

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Useful as these devices might be, they do not reveal the basic scope of the reliability program. The real objective was not so much to check on equipment performance after fabrication, as to see to it that predictable standards of reliability were built into an equipment in the first place. Throughout 1956 manufacturers had given little beyond lip service toward achievement of higher standards of reliability and it was believed that little would be done until the manufacturer was presented with quantitative reliability figures which he must meet as a part of his contract.[12] It was this thinking which led the Center to award a contract to the Radio Corporation of America December 18, 1956 to evolve a technique by which an engineer could rapidly analyze an equipment design and predict the quantitative reliability that the equipment would achieve in the field.[13] This would make it possible to ascertain quickly enough whether an equipment under design would live up to the specified reliability figure. The Radio Corporation of America was instructed to analyze several representative items of ground electronic equipment and predict their reliability. These predictions would then be correlated with figures from laboratory life tests and from Air Force field failure reports on these same items. Through constant correlation and modification of technique to tally more closely with the actual life of an item, it was hoped that an accurate technique could be made available.[14] (UNCLASSIFIED)

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In-the-house studies at Rome fitted together other pieces of the picture. The Center investigated the attractive possibility of using parallel or redundant circuits to attain high reliability with unreliable components. While the Tactical Air Command and the North East Air Command voiced some alarm that circuit redundancy might end in cumbersomely heavy and bulky equipments,[15] Rome observed that for ground electronic equipments these factors were of less importance than in the case of airborne or shipboard units. Center leadership felt that a reasonable amount of redundancy might well buy a great increase in reliability.[16] In-the-house effort also strove to improve the Air Force field failure reports in order to make accessible more useful information for the reliability program.[17] Certainly, by January of 1957 the Center reliability program was in full swing with many new tasks to come. (UNCLASSIFIED)

Radomes

In many instances the Directorate of Technical Services and particularly its General Engineering Laboratory undertook the development of rather elaborate equipments in their own right. Among these latter, radomes figured high in importance. Radomes, either rigid or air supportable, were the coverings for protection of radar antennas in areas of extreme weather conditions. Rome had long played an active role in the development of radomes for ground antennas; however radome research was not a monopoly of the Center and the task of coordinating radome development in

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the Air Research and Development Command constituted a serious problem by the summer of 1956.[18] Several months later a number of Air Force groups interested in the radome program sent representatives to a meeting January 11, 1957 for the purpose of arranging closer coordination. One of the significant results of the conference was agreement on a charter for a committee on Air Force ground radomes. Rome, charged with responsibility for the program, was named permanent chairman of the committee which would number representatives from the Cambridge Center and Lincoln Laboratory as well as from Rome in its active membership. Observers from other commands were also invited to attend. The committee was "to discuss and record the plans, actions, problems, and status of the radome development efforts of each participating agency." It would further act in advisory capacity to Headquarters of the Air Research and Development Command.[19] (UNCLASSIFIED)

One of the radomes under test in the rigid field was the deiceable CW-392(XW-1) developed by Zenith Plastics Company for use with AN/FPS-4 and AN/DPS-1D radars. It was to serve in the development of still larger radomes in the deiceable category and was delivered to Rome for evaluation.[20] Electrical tests were conducted at the Newport Antenna Test site at both the X and L band frequencies.[21] While the radome operated satisfactorily with the AN/DPS-1D, performance was poor with the AN/FPS-4. The trouble stemmed from the joint design. A request to the contractor

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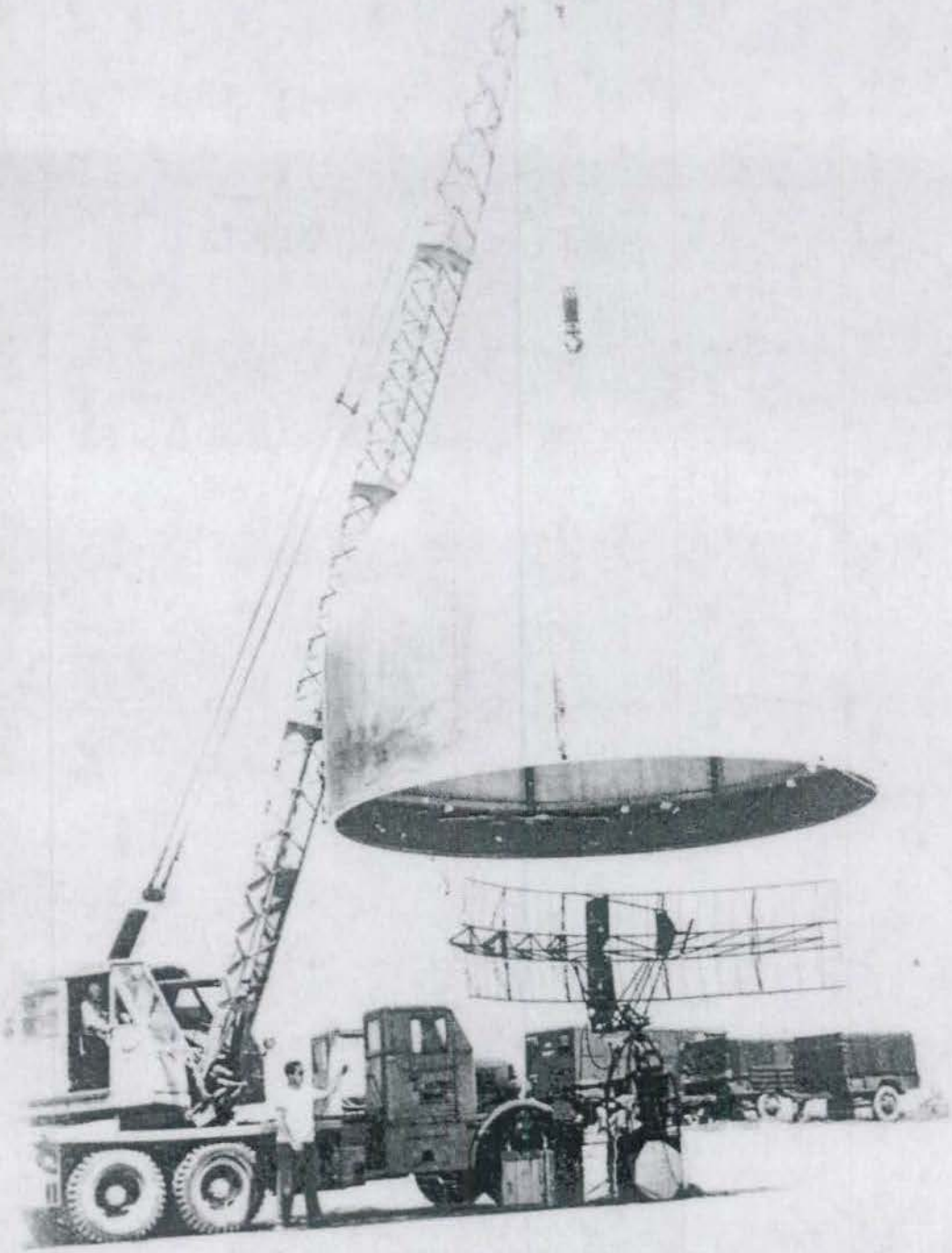

[illegible] modification of the joints brought only slight improvement in a report sent in August 1956. The Center decided to drop this type radome - especially since its main selling point, the demountable feature, was no longer considered as important as previous planning had indicated.[22] (UNCLASSIFIED)

The change of heart regarding icing dangers had come about in part after a meeting July 10, 1956 at Rome with representatives of the Royal Canadian Air Force.[23] Under discussion was the radome icing data which had been collected the previous winter at Lac St. Denis in Canada. The experience seemed to demonstrate that at a majority of Air Defense Command sites demountable type radomes would not be required even though the installations might be arctic.[24] This is not to imply that Rome suddenly entertained no further interest in deicing. As late as January 1957 investigations were still being pointed toward the realm of radome or large structure deicing.[25](UNCLASSIFIED)

The Center prepared specifications in the last few months of 1956 for a variety of rigid radomes. One of the most unusual of these was the "Cyclodrome", designed to eliminate the radome joints which frequently interfered electrically with the radar. According to this design, the antenna and radome would rotate together on a common platform. A Radio Frequency window in front of the antenna would pass the radar signals and the rest of the radome could then be of any material strong enough to support itself. Rome planned to construct a fifty five foot engineering

model although the design was intended primarily for ground radomes 150 feet in diameter and larger. Naturally a big advantage was a minimum pattern distortion for the radar. High among others was reduced construction cost since the largest part of the radome could be fabricated of a material not requiring low dielectric quality.[26] (UNCLASSIFIED)

In general the Center tended to emphasize rigid radomes in its programming as compared to the air supportable type. Rigid radomes demanded less ancilliary equipment, were less vulnerable to damage and required less effort to maintain. Nevertheless air supported structures could fill certain assignments more efficiently and their continued development was not neglected by the Center.[27] (UNCLASSIFIED)

In this area one of the top projects concerned the development of a light weight thirty-five foot Dacron-Hypalon radome for the Rome Center by DeBell and Richardson, Incorporated.[28] The Dacron fabric and its Hypalon coating combined to give an unusually strong material having a unit strength of roughly thirty five pounds per inch per ounce and yet weighing half as much as the ordinary air supportable radome.[29] Naturally these were properties of interest to the Tactical Air Command. It had been planned to ship the radome to Alaska for evaluation of its operational suitability; however preliminary testing indicated

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a need for further development in September 1956.[30] It was then erected at the Rome Center, instead, for weathering evaluation. Subsequent reports of its performance through 1956 were favorable.[31] (UNCLASSIFIED)

On the other hand a dual wall radome delivered on contract by the Goodyear Tire and Rubber Company and erected at the Center June 19, 1956[32] did not measure up to expectations in the evaluation undertaken later in 1956. A radome constructed on this principle seemingly had the advantage of requiring no internal pressurization and would eliminate the need for special tower, pressure lock and assorted paraphernalia called for with air supportable radomes. Unfortunately the technical problems encountered on this project were so great that the program was dropped.[33] (UNCLASSIFIED)

In work closely allied to air supportable radomes, Rome hoped to supply the Air Force and particularly the Tactical Air Command with air supported shelters for protection of ground radar equipments. Shelter S-93(MIS-7) of light weight and low bulk, originally contracted for by the Bendix Company, had been delivered to the Rome Air Development Center in the summer of 1956 and awaited only construction of a suitable platform at the Center for the beginning of its tests.[34] (UNCLASSIFIED)

[redacted]

Security Alarm Devices

In another quite different project area the directorate continued past efforts to develop security alarm devices of various categories. One of the early preoccupations of this project had been an aircraft security alarm system to warn of intruders in an area where aircraft were located. The previous Center history has already outlined some of the background of this project.[35] By August of 1956 the three study contracts which had been let by the Rome Air Development Center in this field were finished and the Center could evaluate the results. The infrared fence type detection system submitted for consideration by the Polarad Company failed to win favor because it appeared impractical, but the system recommended by the other two contractors, General Mills Incorporated and Ralph M. Parsons Company, which was based on changes in capacitance that could be detected when a human body moved into a given area, did seem well within practical limits. Specifications were prepared by the Center for this latter system, the AN/GSS-2,[36] and by November of 1956 the Center was ready to initiate procurement. Lack of funds, however, held up all action for the rest of 1956 and well into 1957.[37] [redacted]

In the latter half of 1956 serious attention focused on the need for indoor alarm systems as well. The Air Research and Development Command had queried Rome August 24, 1956 whether the

[redacted]

Center believed practical indoor systems could be developed. Rome had answered in the affirmative and announced its readiness to assume development of such a system. In November 1956 Rome was instructed to participate in a conference at Headquarters United States Air Force for further exploration and discussion of the problems likely to be encountered in indoor alarm systems. From that conference it emerged notably that responsibility for the indoor system would be delegated to Rome.[38](UNCLASSIFIED)

In addition to these and other tasks connected with security alarms, Rome was called in to participate in the service test program conducted by the Wright Air Development Center of a perimeter fence for the Strategic Air Command at the MacDill, Lincoln and March Air Force Bases. Rome's responsibility in this test program was steadily widened, indicative of the pre-eminent role the Center was to fill in the development of Air Force security devices in 1957.[39]

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NOTES

Chapter VII

1. Activity Report, Research and Development Report, vol.2, no.8, 25 Aug 56, p.11.

2. Activity Report, Research and Development Report, vol.2, no.11, 25 Nov 56, p.7.

3. Interview by the author with Mr. Robert Powers RCUACM, Project Engineer, 27 Sept 57.

4. Activity Report, Reser sh and Development Report, vol.2, no.11, 25 Nov 56, p.7.

5. Interview by the author with Mr. Robert Powers RCUACM, Project Engineer, 27 Sept 57.

6. Interview by the author with Mr. Charles B. Breece RCSGDM, 2 Oct 57.

7. Ibid.

8. Technical Note, subj:(U) Air Force Ground Electronic Equipment Reliability Improvement Program by Joseph J. Naresky, Jul 57, p.1.

9. Ibid, pp.3-4.

10. Interview by the author with Mr. Joseph J. Naresky RCSGP, 3 Oct 57.

11. Technical Note, subj:(U) Air Force Ground Electronic Equipment Reliability Improvement Program by Joseph J. Naresky, Jul 57, pp.6-12. See also DD Form 613, subj:(U) Ground Radar Calibration and Monitoring Equipment, 1 Jul 57.

12. Interview by the author with Mr. Joseph J. Naresky RCSGP, 3 Oct 57.

13. Ibid.

14. Technical Note, subj:(U) Air Force Ground Electronic Equipment Reliability Improvement Program by Joseph J. Naresky, Jul 57, p.17.

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15. Notes from Project 4561 in Files of DCS/Operations at RADC.

16. Technical Note, subj:(U) Air Force Ground Electronic Equipment Reliability Improvement Program by Joseph J. Naresky, Jul 57, pp.18-19.

17. Ibid, pp.16-17. Also Interview by the author with Mr. Joseph J. Naresky, RCSGP, 3 Oct 57.

18. Ltr, Lt Col H.A. Huskey RCSS, Chief, Engineering Services Division to Comdr ARDC, subj:(U) Transmittal of AFCRC Exhibit, 26 Jul 56 - see note for record in files of Mr. Charles S. Beal RCSGES.

19. Charter of the Committee on USAF Ground Radomes, 11 Jan 57. SD-52.

20. Interview by the author with Mr. Charles S. Beal RCSGES, Project Engineer, 2 Oct 57.

21. RADC Form 3, subj:(U) Project 4158, 26 Jun 56.

22. Interview by the author with Mr. Charles S. Beal RCSGES, Project Engineer, 2 Oct 57.

23. RADC Form 3, subj:(U) Project 4158, p.2.

24. ARDC Form 111, subj:(U) Project 4158, 12 Sept 56, pp.1-2.

25. Minutes, subj:(U) USAF Ground Radome Committee Meeting, 11 Jan 57, p.6. SD-51.

26. Interview by the author with Mr. Charles S. Beal RCSGES, Project Engineer, 2 Oct 57. See also Report in files of Mr. Charles S. Beal RCSGES, "Cyclodome" and also the Minutes of the USAF Ground Radome Committee Meeting, 11 Jan 57, pp.3-4.

27. Interview by the author with Mr. Charles S. Beal RCSGES, Project Engineer, 2 Oct 57.

28. Report, subj:(U) Antenna Housings and Air Supported Structures for USAF Ground Electric Equipment, 13 Jul 56.

29. Management Report, subj:(U) Development of Lightweight Dacron-Hypalon Radome, no date, in files of Mr. Charles S. Beal RCSGES.

30. RADC Form 3, subj:(U) Antenna Housings, 17 Sept 56.

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31. Interview by the author with Mr. Charles S. Beal RCSGES, 2 Oct 57.

32. RADC Form 3, subj:(U) Project 4158, p.2.

33. Interview by the author with Mr. Charles S. Beal RCSGES, 2 Oct 57.

34. Ibid. See also ARDC Form 111, subj:(U) Antenna Housings and Air Supported Structures for USAF Ground Electronic Equipment, 12 Sept 56, p.2.

35. Rome Air Development Center History 1 Jan 56 - 30 Jun 56, pp.63-65.

36. DD Form 613, subj:(U) Security Alarm Devices, 2 April 57, pp. 15-16.

37. Interview by the author with Mr. Richard Nelson RCSOII, Project Engineer, 2 Oct 57.

38. Ibid.

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GLOSSARY

AF	Air Force
AFCRC	Air Force Cambridge Research Center
AFR	Air Force Regulations
AGCA	Automatic Ground Controlled Approach
AICBM	Anti Intercontinental Ballistic Missile
AMC	Air Materiel Command
APGC	Air Proving Ground Command
ARDC	Air Research and Development Command
Asst	Assistant
BMD	Ballistic Missile Defense
Brig Gen	Brigadier General
Col	Colonel
Comdr	Commander
Comm	Communications
DCS	Deputy Chief of Staff
DD	Development Directive
Dep	Deputy
Dir	Director or Directorate
ECM	Electronic Countermeasures
EW	Electronic Warfare
GAFB	Griffiss Air Force base
GCA	Ground Controlled Approach
GE	General Electric Company
Gen	General
GOR	General Operation Requirement
ICBM	Intercontinental Ballistic Missile
ILS	Instrument Landing System
Ind	Indorsement
Intell	Intelligence
Lt	Lieutenant
Ltr	Letter
Maj	Major
Memo	Memorandum
Msg	Teletype
MTI	Moving Target Indicator

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DICTIONARY (2)

No.	Number
PPI	Position Plot Indicator
RADC	Rome Air Development Center
RAFD	Rome Air Force Depot
R and D	Research and Development
RCA	Radio Corporation of America
RCE	Directorate of Control and Guidance
RCEA	Directorate of Control and Guidance, Missile Support Laboratory
RCEAD	Directorate of Control and Guidance, Ballistic Missile Detection Branch
RCEASA	Directorate of Control and Guidance, Advanced Development Section
RCEASI	Directorate of Control and Guidance, Implementation Section
RCEB	Directorate of Control and Guidance, Control Laboratory
RCEBS	Directorate of Control and Guidance, Special Devices Branch
RCENT	Directorate of Control and Guidance, Control Laboratory
RCENW	Directorate of Control and Guidance, Control Laboratory
RCER	Directorate of Control and Guidance, Radar Laboratory
RCERHH	Directorate of Control and Guidance, Height Finding Section
RCERMM	Directorate of Control and Guidance, Medium Range Surveillance Section
RCHH	Office of Information Services, Historical Branch
RCO	DCS/Operations
RCOOT	DCS/Operations, Operations and Training Branch
RCS	Directorate of Technical Services
RCSG	Directorate of Technical Services, General Engineering Laboratory
RCSMEN	Directorate of Technical Services, Manufacturers'Drawing Analysis Section
RCSSES	Directorate of Technical Services, Structural Engineering Section
RCSSII	Directorate of Technical Services, Systems Instrumentation Section

GLOSSARY (3)

RASDP	Directorate of Technical Services, Applied Physics Branch
RDEEW	Directorate of Technical Services, Electronic Warfare Branch
RCU	Directorate of Communications
RCDA	Directorate of Communications, Advanced Development Laboratory
RCUACH	Directorate of Communications, Interference Specification and Measurement Section
RCUAT	Directorate of Communications, Transmission Branch
RCUE	Directorate of Communications, Equipment Laboratory
RCUEM	Directorate of Communications, Terminal Equipment Section
RCUEL	Directorate of Communications, Long Distance Branch
RCUELI	Directorate of Communications, Long Distance Communications Section
RCUFIS	Directorate of Communications, Single Sideband Equipment Section
RCW	Directorate of Intelligence and Electronic Warfare
RCWEC	Directorate of Intelligence and Electronic Warfare, Deception Branch
RCWECD	Directorate of Intelligence and Electronic Warfare, Deception Section
RCWID	Directorate of Intelligence and Electronic Warfare
RCWIPS	Directorate of Intelligence and Electronic Warfare, Storage and Retrieval Section
REAC	An electronic differential analyzer computer
RRL	Radio Electronics Laboratory
Rpt	Report
S	Secret
SD	Supporting Document
SJ	Staff Journal, Rome Air Development Center
SR	System Requirement
Subj	Subject
TDY	Travel Duty
TR	Technical Report

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GLOSSARY (4)

U	Unclassified
UHF	Ultra High Frequency
USAF	United States Air Force
Vol.	Volume
VOR	Omnidirectional Radio Range
WADC	Wright Air Development Center
WSEG	Weapons System Evaluation Group
WSPO	Weapons System Project Office

G A Z E T T E E R

Albrook Air Force Base, Balboa, Canal Zone
Andrews Air Force Base, Camp Springs, Maryland
Ascension Island, South Atlantic Ocean
Ava, New York

Baltimore, Maryland
Boston, Massachusetts

Cambridge, England
Cambridge, Massachusetts
Chicago, Illinois
Croughton, Northamptonshire, England

Deal, New Jersey

Edwards Air Force Base, Edwards, California
Eglin Air Force Base, Valparaiso, Florida
Elkhorn, Nebraska

Griffiss Air Force Base, New York

Harmon, New Foundland

Keflavic, Iceland
Kindley Air Force Base, St. George, Bermuda

Laredo, Texas
Lajes, Azores
Lincoln Air Force Base, Lincoln, Nebraska

MacDill Air Force Base, Tampa, Florida
March Air Force Base, Riverside, California
Munich, Germany

Newport, New York

Patrick Air Force Base, Florida
Piarco, Trinidad
Pittsburgh, Pennsylvania

Rome, New York

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GAZETTEER (2)

Scribner, Nebraska
Sidi Slimane, French Morocco
Springfield, Massachusetts
Stockbridge, New York
Syracuse, New York

Thule, Greenland
Trinidad, British West Indies

Utica, New York

Washington, District of Columbia

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APPENDIX A

Civilian Personnel Status as of December 31,1956 *

Total Permanent Authorization	1461	
Total Assigned Personnel	1417	
Percentage of Engineers Assigned	2%	
Percentage of Engineering Aids Assigned	9%	
Percentage of Engineering Technicians Assigned	5%	
Percentage of Administrative & Clerical Assigned	43%	
Percentage of Wage Board Assigned	19%	
Number and Percentage of Promotions	64	4.5%
Number and Percentage of Gains	29	2%
Number and Percentage of Loss	32	2%
Downgrades	0	
Rate of Turnover	2.5%	
Total Permanent & Temporary Position Vacancies	226	
Total Established Authorized Permanent Position Vacs	154	
% Assigned of Authorized (Engineers)	82%	
% Assigned of Authorized (Engr Aids)	87%	
% Assigned of Authorized (Engr Techns)	96%	
% Assigned of Authorized (Admin & Clerical)	95%	
% Assigned of Authorized (Wage Board)	90%	

* Statistics Taken from a Report of the Office of DCS/Personnel of 31 Dec 56.

A P P E N D I X B

Distribution of Personnel* as of C.O.B.

31 December 1956

Activity	Distribution of Authorized Personnel Spaces: Authorized Class Act	W.E.	Total	Distribution of Assigned Personnel: Assigned Emprs	Aids	Tech	Admin	Total	W.E.	Grand Total
ROD	1	-	1	-	-	-	1	1	-	1
RCST	3	-	3	2	-	-	3	5	-	5
RCT	21	-	21	-	-	-	20	20	-	20
RDD	45	-	45	17	-	1	25	43	-	43
RDS	69	39	108	1	-	-	67	68	42	110
RDP	9	-	9	2	17	-	19	38	-	38
RDA	34	13	47	-	-	-	33	33	13	46
RDT	3	-	3	-	-	-	2	3	-	3
RDC	94	-	94	10	1	-	89	100	-	100
RDA	47	-	47	-	-	-	51	51	-	51
RDP	8	108	116	-	-	-	7	7	96	103
RDW	9	4	13	1	-	-	8	9	3	12
RDWE	104	23	127	39	14	5	28	84	22	106
RDWT	75	5	80	34	2	6	19	61	4	65
RDE	2	-	2	1	-	-	1	2	-	2
RDEA	5	-	5	-	-	-	4	4	-	4
RDEC	55	7	62	25	11	5	14	55	5	60
RDER	79	9	88	43	8	8	19	78	8	86
RDWA	85	24	109	35	15	9	19	78	25	103
RDS	7	-	7	1	-	-	6	7	-	7
RDSO	132	5	137	53	31	12	25	121	4	125
RDSS	119	5	124	5	12	2	91	110	5	115
RDST	43	27	70	11	10	12	8	41	26	67
RDSH	22	1	23	15	-	-	6	21	1	22
RDU	3	-	3	2	-	-	1	3	-	3
RDUB	4	-	4	-	-	-	4	4	-	4
RDUO	9	-	9	7	-	-	3	10	-	10
RDUA	26	4	30	12	2	2	7	23	3	26
RDUE	61	13	74	24	7	13	18	62	13	75
Total	1174	287	1461	340	130	75	597	1142	270	1412
(31 Dec 55)	1066	258	1324	353	122	52	500	1027	261	1288
(31 Dec 54)	928	236	1164	310	100	36	437	883	234	1117

*Statistics Taken from Report of Office of DCS/Personnel

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APPENDIX C

Military Personnel Status as of January 3,1957 4

Strength	Authorized	Assigned
Officers	168	184
(R & D Officers)	81	101
Pilots	27	29
Observers	5	6
Airmen	82	145
Airmen Auth Overstrength Space	66	
Special Category	N/A	4

Average Monthly Assigned Strength

Officers:	184
Airmen	145
Total	329

4 Statistics Taken from Monthly Personnel Status Report Issued by Office of DCS/Personnel, 7 Jan 57.

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[redacted] CONFIDENTIAL

APPENDIX D

Status of RF-590 Fund as of January 11 '57

ITEM	BUDGET AUTHORIZATION
Pay of Personnel	$7,402,853
Travel	500,337
Supplies and Equipment	2,576,992
Transportation	35,000
Printing	13,000
Training	85,782
Awards	20,000
Maintenance	5,500
Laredo Guns	7,540
Laredo Utilities	1,600
Repair and Rehab Facilities	50,000
Test and Evaluation	1,225,000
Other	36,000
Total - Less Personnel Pay	
Total	$ 13,701,975

[redacted] CONFIDENTIAL

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[illegible]

PRODUCTION

ITEM	BIDDER	TYPE OF BID	BASED ON	AMOUNT BID	SAVING TO DATE
A. CABIN AN/GRC-27	COLLINS RADIO 3 SMALL LOCAL CONTRACTORS	SOLE SOURCE COMPETITIVE	PERFORM SPEC. MFG. DWG.	$72,000.00 $28,000.00	$44,000.00
B. RADIO RACKS AN/GRC-30	LAVOIE LABORATORY KNOWLAND CORPORATION	SOLE SOURCE COMPETITIVE	PERFORM SPEC. MFG. DWG.	$28,000.00 $ 8,000.00	$20,000.00
C. TOWER AB-256/FPS-6	GENERAL ELECTRIC CO. IDECO BLAW-KNOX	SOLE SOURCE COMPETITIVE COMPETITIVE	PERFORM SPEC. MFG. DWG. MFG. DWG.	$15,089.00 $ 8,027.00 $ 7,236.00	$ 7,651.00
D. RADAR RACKS AN/GPN-4	GILFILLAN BROS. SYSTEMS DEV. LAB.	SOLE SOURCE COMPETITIVE	PERFORM SPEC. MFG. DWG.	$150,000.00 $ 89,000.00	$61,000.00
E. AN/GPS SERIES SHAFTS	GENERAL ELECTRIC CO. L. W. WHEELER CO.	SOLE SOURCE COMPETITIVE	PERFORM SPEC. MFG. DWG.	$ 10,000.00 $ 1,000.00	$ 9,000.00
				Not in Total	
MT-1173/FPN TURNTABLE	CRAIG MACHINE	COMPETITIVE	SPEC. DWG.	$16,000.00 $11,990.00	TOTAL SAVING
				Not in Total	$141,851.00
CABINET	FLORENCE STOVE	COMPETITIVE	SPEC. & DWG. DWG.	$ 198.00 $ 89.23	

APPENDIX E

I N D E X

Accounting Division:9
Acquisition Radar: 60
Adjutant: 2,3,4
Administrative Services: 4
Advisory Committee: 52
Advisory Group on Reliability of Electronic Equipment: 131
Airborne Instruments Laboratory: 115
Air Coordinating Committee: 17
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