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Memorandum M-1603

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Digital Computer Laboratory  
Massachusetts Institute of Technology  
Cambridge 39, MassachusettsSUBJECT: GROUP 61 BI-WEEKLY REPORT, August 15, 1952

CLASSIFICATION CHANGED TO: Auth: <i>DD 254</i> By: <i>L.R. Everett</i> Date: <i>2-1-60</i>
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2.0 EQUIPMENT ENGINEERING

(N. Alperin)

The present Light Gem used for target and interceptor initiation is being redesigned; simple circuitry and better target resolution are the desired goals.

A new amplifier and pulse generator has been designed and tested. The results are very satisfactory.

(H. J. Kirshner)

The second SDV receiver was delivered by Group 24 on August 4th. Although sufficient time for complete checking was not available, the receiver was connected to Whirlwind and operated satisfactorily. Further checking will take place after the move to Room 222 has been completed.

The antenna for a standby V.H.F. transceiver will be erected at the Whittemore Building next week.

A high frequency receiver and transmitter have been received from Group 22. This equipment will be used in conjunction with AAA tests.

A trip was made to LINCRO at North Truro to discuss air defense center communications equipment with Mr. Enticknap of Group 21.

(J. H. Newitt)

During the past bi-weekly period, the schedule of WWI new equipment has been brought up to date and a 2nd liaison report issued to accompany it. The composite report is the subject of an M-note (M-1589). Comments on this latest report are urgently solicited from all project members since it is felt that the present tentative schedule is now in a position to be finally frozen within the next few weeks. Any errors or uncertainties should be brought to my attention as soon as possible.

The past bi-weekly period was also devoted to the interviewing of representatives from air conditioning concerns. It was necessary to discuss our requirements with them and show them our present facilities. It became necessary to issue a purchase order on the primary air-distribution ductwork for Room #156 in order to ensure its completion ahead of the rack installation work which is scheduled to start on Sept. 1st.

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2.0 EQUIPMENT ENGINEERING (Continued)

(F. Sandy)

Meetings were held Monday and Tuesday mornings, Aug. 11 and 12, at which time the final design for the Room 156 power supply control was decided upon. Also decided were: what components should go on each panel; where each panel should be located; and the power distribution to Room 156.

Room 156 has been painted and all holes for the floor cut but three. This Saturday, Aug. 16, the sills for the racks are to be laid down. Completion of this should take less than one week.

(A. V. Shortell, Jr.)

The installation of display scopes and associated equipment in Room 222 is expected to begin on Monday, August 18, and should be completed by the end of that week.

The first nine days of the past bi-weekly period were spent on vacation.

3.0 BEDFORD EXPERIMENT

(D. R. Israel)

A good deal of time has been put into the organization and preparation of material in connection with the rewriting of computer programs and in connection with several changes in our methods of keeping Program, Flight Test, Ampex, and Magnecorder Tape Records. Memos M-1444, M-1588, and M-1598 cover these subjects. During the week of August 11 all Magnecorder Tapes deemed worth saving were re-recorded on Ampex Tapes. Recordings will only be made on the two-channel Ampex unit during future flight tests.

During the week of August 18, when equipment will be moved from Rm. 224 to Rm. 222, it is hoped that several Navy and Air Force films can be obtained for showing to new staff members. Trips to the Bedford and Scituate radar sites and the Manchester GOC Filter Center are also being lined up for interested staff members during that week. Phil Bagley is engineering all details in connection with these activities.

Consideration of the problem of preventing the computer from associating the same piece of data with both aircraft during the final few scans of a collision-course interception — this difficulty arising in part from lack of radar data — seems to indicate that the best solution is merely to reduce the search area for both aircraft when the aircraft are less than four miles apart. Other procedures considered give only slightly more favorable results at the expense of a good deal of complication in programming.

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3.0 BEDFORD EXPERIMENT (Continued)

(D. R. Israel) (Continued)

On Friday, August 15, our first test was held with a B-25 aircraft equipped with a APG-33 airborne radar. Several head-on intercepts were attempted with manual vectoring (the computer was shut down). The results indicated satisfactory pick-up on a B-17 target at a range of approximately nine miles. The radar observer in the aircraft thought that this performance was about as good as could be expected, although he acknowledged that the set needed maintenance.

A report by the Cornell Aeronautical Laboratories in connection with their work on fleet air defense was recently read. This report describes the formulation of a mathematical model for an intercept and the application of a probability method for determining some figures regarding errors arising in various parts of the process. It becomes apparent on reading this and in discussing various tactical problems in connection with the final phase of an intercept that we need to obtain some more information regarding this subject. Investigations in regard to this matter will be undertaken immediately.

(A. P. Hill)

During the period from August 4th through August 15th a total of thirty-one aircraft hours were scheduled; however, only twenty-two aircraft hours were flown. Reasons for change in schedule are shown below.

BREAKDOWN OF FLIGHT TEST SCHEDULE

Date	Scheduled Test	Actual Test Held	Reason for Change in Schedule
Aug. 4	1000-1100 (Israel) Jet on Piston Interception Two Aircraft	Cancelled	Due to Weather
	1100-1200 (Israel) Antiaircraft One Aircraft	As Scheduled	_____
Aug. 6	1000-1100 (Israel) Two Aircraft Interception	Cancelled	Due to Weather
	1100-1200 (Israel) Antiaircraft One Aircraft	Cancelled	Due to Weather
Aug. 7	1300-1500 (Israel) Beacon Test One Aircraft	Take-Off Initiation Two Aircraft	Aircraft Beacon Inoperative

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3.0 BEDFORD EXPERIMENT (Continued)

(A. P. Hill) (Continued)

BREAKDOWN OF FLIGHT TEST SCHEDULE (Continued)

Date	Scheduled Test	Actual Test Held	Reason for Change in Schedule
Aug. 8	1000-1100 (Israel) Two Dimensional Inter-ception Two Aircraft	As Scheduled	
	1100-1200 (Israel) Antiaircraft Guidance One Aircraft	As Scheduled	
	1300-1600 (Israel) Two Aircraft Interception For Visitors	Cancelled	No Visitors
Aug. 11	1300-1500 (Israel) Take-Off Initiation Two Aircraft	As Scheduled	
Aug. 12	1730-1930 (Israel) Ground Observer Test One Aircraft	Cancelled	Due to Weather
Aug. 13	1300-1500 (Israel) Beacon Test One Aircraft	Jet (F-80) Coverage in Cape Cod Area	Aircraft Beacon Inoperative
Aug. 14	1300-1500 (Israel) Jet (F-94) Coverage Test	As Scheduled	
Aug. 15	1300-1500 (Israel) Two Aircraft Interception Using Airborne Radar	As Scheduled	

Results of the flight tests held are:

Aug. 4 1100-1200 Antiaircraft Guidance  
see section by J. Cahill (Section 6.0)

Aug. 7 1300-1500 Take-off Initiation  
Seven take-offs were made at headings of 015° up to 360°, after take-off, aircraft climbed to 5,000 feet and remained on course for approximately 5 minutes. Tracking on the first four take-offs was fair, the last three take-offs -- poor.

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3.0 BEDFORD EXPERIMENT (Continued)

(A. P. Hill) (Continued)

A new system was used: two F-51's were used in relays, one landing and taking off while the other F-51 served as the observer relaying the times of take-off. This seems to be the best system for this type of a test, as seven take-offs were recorded in only one hour and twenty minutes.

- Aug. 8 1000-1400 Two-Dimensional Interception  
Three runs were made using an F-51 as the interceptor, and a B-29 as the target, in all cases the interceptor started at Grenier, and the target at a position 15 miles east of Rockport.
- Run #1 Interceptor passed 500 feet ahead of the target
- Run #2 Interceptor passed 700 feet ahead of the target
- Run #3 Interceptor passed 1000 feet ahead of target —  
(had to keep re-initiating on the interceptor).
- Aug. 8 1100-1200 Antiaircraft Guidance  
See section by J. Cahill (Section 6.0)
- Aug. 11 1300-1500 Take-off Initiation  
The same test that was held on Aug. 7th was repeated; however, results were poor on all take-offs, probably due to 7/10 cloud coverage in the area.
- Aug. 13 1300-1500 Jet (F-80) Coverage Test (Cape area)  
Using an F-80, which flew from Bedford to Otis (Cape Cod) to Quonset Pt. and back to Bedford. Coverage was fair to poor on all legs, due to heavy cloud clutter.
- Aug. 14 1300-1500 Jet (F-94) Coverage Test  
The F-94 was tracked on a course from Bedford-Concord-Sanford-Newburyport, back to Concord. In general the tracking was very good, except at the higher altitudes, (13-15,000 feet - tracking was poor). Indicated air-speed during most of the test was 400 M.P.H.
- Aug. 15 1300-1500 Two Aircraft Interception, with Airborne Radar  
This was to test the range of the airborne radar (without the computer).  
The interceptor on each run started at Concord N.H., and the target at York, Me. The aircraft were given headings so that they would intercept "head-on".  
The airborne radar picked up the target at 11 - 9 - and 5 miles.

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3.0 BEDFORD EXPERIMENT (Continued)

(M. Brand)

Beacon Response. The beacon response program, successfully run in conjunction with T-176-6, will now be incorporated as a modification to the basic two-aircraft interception program and the final-phase guidance program. I am now awaiting completion of the writing and rewriting of these programs.

Aided-Smoothing Studies. This smoothing program in which velocities are not smoothed but computed from a known a/c speed and a trigonometric function of the a/c heading was originally going to be tested on PWTFT-3. I found that this program didn't lend itself to this type of smoothing, in that the heading angle which is used to compute velocity is, in turn, itself computed by an arctangent of x and y velocities. Present plans are to include this smoothing system as modifications to the new interception programs. In this case the heading angles (of the interceptor) are a function of the relative positions of the two aircraft and not a function of one aircraft alone. I am awaiting the completion of these programs so they may be modified.

A/C Selection of One Piece of Data as a Best Fit. Work was reactivated on this program which was originally written to modify T-314 so that either the target or the interceptor, but not both, could accept a given piece of data as a best fit. It was decided that before more extensive work be done on this project a "quick-fix" be used to solve the problem. This quick method, which will be incorporated into the new interception programs, will decrease the search areas of both the target and interceptor to one and a half miles when they are four miles apart or closer.

(P. O. Cioffi)

I have studied the reports issued to date on the In-Out System being installed.

A small number of certain programs of interest are being revised consistent with the proposed In-Out scheme.

(C. Gaudette)

Sue Knapp's Sixteen Aircraft Tracking Program is now operating satisfactorily. The program automatically deinitiates on a track that has had five consecutive misses. The program must now be modified for the new In-Out System.

C. Zraket and I have completed a flow diagram for the new Final Phase Interception Program. C. Grandy and J. Nolan will help in the coding of this program.

C. Zraket, P. Cioffi and I are rewriting the basic two aircraft interception program to minimize storage and incorporate the new In-Out System.

3.0 BEDFORD EXPERIMENT (Continued)

(C. A. Zraket)

Work on the Final Phase Interception Program has progressed considerably and the program should be ready the early part of September. J. Nolan is now working with C. Gaudette and myself on this problem.

P. Gioffi, C. Gaudette and myself have decided to write a new basic 2 a/c Interception Program in lieu of modifying the present program (T-1000-5) for the new In-Out System.

Other programs which are not to be discarded are being modified to conform with the new In-Out System.

4.0 DATA SCREENING

(W.S. Attridge, Jr.)

A large part of the past bi-weekly period has been spent preparing the Data Screening section of the Lincoln Summary Report.

Study of the new In-Out System and conversion of programs to the system is continuing with assistance of new members of the group.

(P. R. Bagley)

Clutter Rejection. The most recent stationary clutter rejection program (T-1334) was run several times. The associated filtered data recording program (T-1400) has been checked out. Both of these programs will be modified to conform to the new in-out orders.

(W. A. Clark)

In collaboration with J. Ishihara, work has continued on the evaluation of schemes for the reduction or removal of redundancy in overlapping radars. One very promising possibility involving coordinate transformations and associated bookkeeping techniques has been investigated in some detail and is being incorporated into a muldar correlation program by Ishihara.

(D. Goldenberg)

## 1. Size and center of search area:-

At a meeting with several members of this group, a summary of my work and some preliminary conclusions were presented. I stated that since an aircraft might make a  $180^\circ$  change in heading within one scan without the present smoothing formulae indicating a change in heading of more than  $6^\circ$ , the last data should be considered to be the center of the search area. The size of the search area should be the vector velocity in miles per scan plus some quantity due to quantization and radar errors about the center of the area. This is equivalent to positional tracking.

4.0 DATA SCREENING (Continued)

(D. Goldenberg) (Continued)

During the discussion which followed, it became apparent that I had not presented sufficient evidence and analysis to sustain my conclusions. In addition, several suggestions were made which bear consideration. One of these was that the center of the search area be located at some point between the last smoothed position and the full-scan predicted position. The investigation of this problem is being continued along the lines of this suggestion and my stated conclusion.

## 2. Time analysis of sorting processes:-

A time analysis has been partially completed of the five methods of sorting data listed in the bi-weeklies of 6 and 23 June. For up to 20 pieces of data, it was found that sorting by successively finding the smallest data consumed the least time. Beyond 20, the method of sorting by addresses and then compressing the table consumed the least time, the time being markedly smaller than all methods. The main disadvantages of this latter method are that duplicates in data are lost and that the number of registers required (112) is from  $1\frac{1}{2}$  to 3 times that required by the other methods.

(J. Ishihara)

Overlap study of the Muldar system indicates that any breakdown of tracks by radar sets is a highly redundant process. Thus as an alternative "box" method a program which "pre-sorts" tracks once per field-switch into non-overlapping "boxes", whose combined areas include the entire system, has been written for study. Such a method requires the added breakdown of returns but correlation time (estimated) is less than that required for a radar-quadrant scheme. W. A. Clark's suggestion for programming this process has aided appreciably in reducing operating time. Adding a "box" to radar set correspondence to the program does not seem feasible.

Modification of Muldar Tracking Program #1 has been completed, as well as a "box" presort correlation program using three sets and the tracking program of MTP#1.

(N. S. Potter)

The differential correction heading angle computation was operated, the average deviation from the correct heading, as determined by the iterative method under present use, being less than four degrees. More data will have to be obtained and a number of minor alterations in the computational procedure made if the scheme is deemed worthy of further consideration.



5.0 TRACKING AND CONTROL

(J. Arnow)

The second set of terminal equipment was delivered during the first week of this period. It was used briefly with a few of the two-radar programs and seemed to operate in a reasonably satisfactory manner. Further use of the gear will have to wait until the computer is back in operation. It did however prove its usefulness by indicating a few minor programming errors that were contained in the programs tested.

The Rockport 584 is being moved to Halibut Point, and all programs operating with live data will have to be modified so that the co-ordinate separations correspond to the new location.

(M. Frazier)

The first part of the past bi-weekly period was spent on vacation. The second part of the past bi-weekly period has been spent in study of the new In-Out System and bringing two programs up to date with respect to it.

A new Bedford-Rockport (or Scituate) tracking program is being written; at present it is in the flow diagram stage.

(W. Lone)

The TRASACT program which correlates with the closest radar is operating successfully and has been run with six of the simulated data tapes. All data from my three operating TRASACT programs has now been plotted.

The first week of this bi-weekly period was spent on vacation.

(A. Mathiasen)

Trouble with the short two-radar tracking program occurred when unexpectedly small ranges at north appeared in the data input.

A minor error was discovered in a test of the live-data TRASACT I. Otherwise it seems to be working well.

A test of the TRASACT program which treats the two radars as one in correlation failed. A storage printout revealed an unrecognizable program.

A test of the Rockport tracking program on simulated data using NLS-1, 2, 2b, 2c showed no differences significant enough to warrant using other than the simplest method. The various non-linear smoothing methods will be tried with the two-radar programs to confirm or deny this assertion.

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5.0 TRACKING AND CONTROL (Continued)

(B. R. Stahl)

Since the computer shutdown, data from the TRASACT test have been distributed to the computer operators for plotting. These plots should soon be available for quick comparison and analysis of different smoothing techniques.

Other programs (both working and experimental) are being adapted for use in the new In-Out System.

6.0 AIR DEFENSE CENTER OPERATIONS

(D. R. Israel)

Work in connection with the installation of new equipment in Rm. 222 continues. Acknowledgement is made of the fine cooperation and assistance of various sections of the Digital Computer Laboratory staff. The exact layout of equipment in Rm. 222 has been decided upon and movement of the gear from 224 will be undertaken during the week of August 18. Arrangements have been made to place a computer-controlled Flexowriter printer-punch unit in 222.

The initial layout of equipment in 222 has taken up a good deal more room than had previously been expected. As soon as this initial installation has been completed and the equipment put into operation, investigations will be undertaken of the possibility of securing custom-built cabinets and tables for much of the gear. A point of particular interest in connection with Rm. 222 is the ability to display and post information in a darkened room. It presently appears that through the use of fluorescent paints and crayons and ultra-violet light illumination, a satisfactory scheme can be obtained. The Plexiglass boards for this have already been constructed, and arrangements are now being made to obtain the fluorescent material and the proper light fixtures.

A one-day trip was made to the Lincro installation (Group 21 -- "Quick Fix") at North Truro. Discussions with Mr. Enticknap concerning various types of communications facilities for operations centers proved to be extremely interesting, and he offered Kirshner and me several valuable suggestions.

Preliminary thinking in connection with the return-to-base (RTB) problem indicates that the existing final-phase guidance procedure is one which could very well be used in guiding an interceptor back to the GCA gate at its home field. This scheme will be tried out -- as soon as the computer returns to operation -- in a flight test in which we will ignore altitude considerations but will attempt to vector an aircraft and instruct it to make a turn such that it finally lines up with one of the runways at Grenier Air Force Base.

(M. Brand)

GOCSACT. GOC Single Aircraft Tracking programs GOCSACT-M and GOCSACT-W have been completed. M is for use with the Manchester area, while W is for use with the White Plains area.

GOC Exercises. I have written a memo M-1597 which analyses the results of two joint Group 61 - Manchester Filter Center exercises held on 7/15/52 and 7/29/52.

Radar Tracking Correlation. I have started work on a system which will correlate reports received from GOC, commercial flight plans, and overlap data with aircraft which are being tracked on the computer.

6.0 AIR DEFENSE CENTER OPERATIONS (Continued)

(J. J. Cahill, Jr.)

The writer was on vacation for 3 days of the past bi-weekly period.

Approximately 5 hours were spent in the computer room assisting at flight tests. Additionally, about 10 hours were spent at the AA installation at Nahant, supervising two AA Guidance flight tests.

With the exercises of the week of Aug. 3, the present phase of AA tests was concluded. Results, unfortunately, were inconclusive, due to an apparent fault in the radar installation at Nahant. The fault has not been diagnosed as yet, but the artillery people have the problem under advisement. The difficulty takes the form of inability of the AA people to correlate true Georef locations with the Georef overlay on their radar scope.

The active and intelligent cooperation of Capt. Aborjaily, Btty. C. O., Lt. Johnson, Gunnery Officer, and all the E. M. of the plotting and radar groups must be noted. The cooperation of Group 61 in the matter of obtaining A/C for radar calibration purposes has been offered, and ways and means are presently being considered by AA Group Hq.

An error was detected in the modification of T-1100 made to enable it to display range from Rockport in miles, and has been corrected. The fault was not found in time to run the program before the shut-down.

A memo on the errors introduced by lack of height information in two-radar problems is in preparation, and will shortly be presented.

(F. A. Webster)

The first week was spent on vacation, while the second was devoted to assembling, revising, and illustrating the report on "manual tracking" under the Ground Observer Corps (GOC) system.

7.0 ASSOCIATED STUDIES

(W. Linvill)

During the last period we have been writing reports on the work we have done so far on interceptor guidance and are starting to work on background for the correlation problem. Bob Sittler has been teaching elementary probability theory to our group.

(P. R. Bagley)

In-Out System. The majority of this period has been spent in studying the new In-Out System and incorporating the pertinent information in a revised version of the WWI Order Code. The Order Code,

7.0 ASSOCIATED STUDIES (Continued)

(P. R. Bagley) (Continued)

effective September 1, 1952, has been published. Also published was M-1551, Supplement #1, containing a list of the in-out equipment planned for September with the appropriate selection addresses. A correction and an addition to M-1551 are included. The Order Code applicable to the final system (with many explanatory notes) has been written in rough draft and is being checked.

Records and Procedures. In cooperation with P. Cioffi and W. Lone, M-1558, "Group 61 Records and Procedures" was published, delineating the current procedures for Group 61. It covers program files, preparation of modifications and parameters, assignment of computer time, responsibilities of computer operator, records of program operation, and preparation of bi-weekly reports.

(G. Cooper)

The rough draft of M-1492, Limit-Mean Smoothing, has finally been completed.

A rough draft of a thesis proposal, "Design of Optimum Non-Linear Filters by Inverse Probability Methods", is about  $\frac{1}{4}$  done.

(J. W. Craig)

The typing of the shortened form of John Salzer's thesis was completed, and a copy was sent to him for comments and criticisms.

A summary of the "Mark 65" reports was started.

(W. Lone)

Compilation of the Subroutine Library is being continued. The first week of this bi-weekly period was spent on vacation.

(I. Mann)

The Special Input Program has been adapted to the new computer orders. It now occupies the last 34 registers of storage. A memorandum has been written giving a brief description of it.

(W. I. Wells and R. W. Sittler)

Mathematical analysis of the dynamical problems associated with the final approach phase of the interception problem has proved non-feasible in all but the simplest and most nonrealistic cases. For this reason a type of graphical procedure has been resorted to to determine the optimum behavior of target and interceptor aircraft. This procedure consists of a game in which two players move imaginary target and interceptor respectively, holding as close as possible to a realistic set of

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7.0 ASSOCIATED STUDIES (Continued)

(Wells and Sittler) (Continued)

restrictions. The object of the target is to evade radar contact by the interceptor; while the object of the interceptor is to effect this contact. Such "paper chases" have produced definite, though unfortunately non-precise ideas on such things as necessary interceptor radar range, data smoothing procedures, and target evasive tactics.

Study is beginning on correlation and the handling of data. The initial approach is being made through a probability analysis of some very simplified mathematical models.

8.0 COMPUTER OPERATIONS

(J. Arnow)

The computer was used only during the first half of the past bi-weekly period due to the shut down for installation of the in-out system.

The following is a tabulation of time used during the first week:

MEW Tracking and Control	4.5 hours
Data Screening	3.0
Multiple Radar Tracking	8.25
Air Defense Center Operations	0.5
Indoctrination	2.25
Miscellaneous	5.75
Subtotal	24.25
Flight Tests	4.0
Not Used	4.0
Lost	<u>3.75</u>
Total	36.0 hours

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9.0 PUBLICATIONS

(M.R. Susskind)

The following material has been received in the Library, Whittemore Building, and is available to Laboratory personnel:

LABORATORY REPORT

1. "Group 61, Bi-Weekly Report, August 1, 1952," M-1583, pp. 1-17.  
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2. "Whirlwind II Meeting of June 13, 1952," M-1585, pp. 1-6.  
CONFIDENTIAL
3. "Group 61 Records and Procedures," M-1588, pp. 1-4.  
RESTRICTED

TECHNICAL REPORTS

1. "Performance of Ground Radars from the Operational Viewpoint," Digby, J.F., Kappler, M., Rand Corporation, Santa Monica, California, Rand M-472, Lib. No. 1960.  
CONFIDENTIAL
2. "Affects of Penetration Distance on Fighter Effectiveness for Steady-State Attack Conditions," Sturdevant, C.U., Rand Corporation, Rand M-795, Lib. No. 1961.  
CONFIDENTIAL
3. "The General Problem of Reliability in Missile Systems," Carhart, R.R., C.U.S. Air Force, Project Rand, Rand Corporation, Rand 5-4, July 9, 1951, Lib. No. 1967.  
CONFIDENTIAL
4. "Recent Developments in Components," Morris, A.L., T.R.E. Technical Note, Gt. Malvern, Worcs., England, August, 1950, Lib. No. 1979.  
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