Rascal Air-to-Ground Guided Missiles

BELL AEROSPACE CO BUFFALO NY

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BELL *Aircraft* CORPORATION

PROJECT RASCAL

CONTRACT W33-038 ac14169

BI-MONTHLY PROGRESS REPORT

APRIL 30, 1947

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DATE April 30, 1947

BELL Aircraft CORPORATION

AIR BELL CRAFT

TITLE

RASCAL AIR-TO-GROUND GUIDED MISSILES

SIXTH BI-MONTHLY PROGRESS REPORT

NO. OF PAGES 75

CONTRACT NO. W33-038 ac-14169

MODEL MX-776

PREPARED BY John K Curran

APPROVED BY B Hamlin

APPROVED BY

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1. PURPOSE OF PROJECT

Project MX-776 is a one-year study and research program covering engineering studies, research, design, laboratory and flight testing for the practical design of an air-to-surface supersonic (M = 1.6) guided missile. It is to be carried and launched from an altitude of 20,000 to 45,000 feet by a B-29 series aircraft against stationary targets and maneuvering water-borne targets at flight distances up to 100 miles from the launching point. The controlling aircraft must be able to take evasive action in any direction while controlling the missile and must be able to execute control from a distance of at least 60 miles. Seventy-five percent hits within 500 feet of a stationary target and seventy-five percent direct hits on a water-borne target are required. The warhead must contain an explosive equivalent to at least 3,000 pounds of present TNT.

April 29, 1946 - July 1, 1947

2. SUMMARY OF WORK CONDUCTED DURING PERIOD - FEB. 28 - APRIL 30, 1947

a. Engineers have visited outside organizations to discuss subjects pertinent to our research program:

Activity Visited	Date	Subject Discussed
Raytheon Mfg. Co. Waltham, Mass.	3/10/47	Radar Relay
Laboratory for Electronics Boston, Mass.	3/11/47	K-Band Rapid Scan System
Cambridge Field Station Cambridge, Mass.	3/11/47	Clearances
M.I.T. Cambridge, Mass.	3/11/47	Search Antenna
Stevens Arnold Co. Boston, Mass.	3/11/47	Ultrasonic Trainers
Cal. Tech. and Johns Hopkins	3/11-12/47	Free Flight Symposium
Wright Field Dayton, Ohio	3/18-19-20	Contracts and Equipment
Wright Field Dayton, Ohio	3/26-27/47	Radar Receivers
Stevens Arnold Co. Boston, Mass.	3/31/47	AN/APQ-13T Trainer
Laboratory for Electronics Boston, Mass.	3/31/47	K-band Rapid Scan System
Sylvania Electric Corp. Boston, Mass.	4/1/47	Missile Search System
Workshop Associates Boston, Mass.	4/1/47	K-band Rapid Scan System
Williard Storage Battery Cleveland, Ohio	4/16/47	One Shot Batteries
Philco Corporation Philadelphia, Pa.	4/17/47	Radar Receivers
BuShips, Navy Dept. Washington, D.C.	4/18-21	Subminiature Tubes
Radio Corp. of America Camden, New Jersey	4/21/47	Pulse Altimeters

Activity Visited	Date	Subject Discussed
Navy Research Laboratory Washington, D.C.	4/22/47	Radar Receivers

b. Personnel of outside organizations visited this contractor to discuss problems pertaining to Project "Rascal":

Visiting Activity	Date	Subject Discussed
Air Materiel Command	3/7/47	Project Status
Sylvania Electric Products	3/7-8/47	Missile Search Radar

Discussions pertaining to a subcontract are still in progress with the Laboratory for Electronics. Completion of negotiations are held up pending procurement of test equipment to be used in prosecution of the subcontract.

At M.I.T. a study of dielectric lenses has indicated that a limited aperature will be obtained and hence a study of zoned lenses can be made. It was brought out that, contrary to the conclusions of A.I.L., satisfactory azimuth patterns may be obtainable over a range in elevation of ±10 degrees or greater. Further study will be undertaken to ascertain if such is the case.

Ultrasonic trainers were discussed at Stevens Arnold Company. Several types of ultrasonic trainers have been developed, the most flexible of which is the most recent type for the Navy, the AN/APS-T3. Other types are represented by the APQ-7T1, APQ-13T1 (Mark III and VI) and APQ-13T1A (Mark IV). The AN/APS-T3 is capable of providing conical scan and tilting reflectors; the tilt control is located at a central station. Stevens Arnold felt that the APQ-13T1 was the best suited for our needs. This opinion conflicted with a recommendation of AMC that our choice should be the APQ-13T1A. The -13T1A was obtained and a consultant from Stevens Arnold brought in to aid in setting it up. Further details on our use of this equipment is contained in this report.

At California Institute of Technology and Johns Hopkins University we attended a symposium concerned with problems of free flight testing of full size and scale model missiles.

At Wright Field the subject of auxiliary power supplies was discussed. It was suggested that a symposium on this subject for all missile contractors and battery and generator manufacturers be held in May or June at which the requirements of the missile field would be aired to industry in general.

Workshop Associates' facilities were inspected as a possible subcontractor. Their organization is small, but they have adequate shop facilities for building model shop versions of antennas in a comparatively short time. Their present test equipment is limited to X, S, and the lower frequency bands. They specialize in final development of antennas rather than research and early development.

Our power requirements for equipment operation were given to Willard Storage Battery Company in an effort to obtain an expendible one-shot battery. The results of this inquiry are expected in the very near future.

Philco Corporation has determined that their logarithmic i.f. amplifiers are quite successful on the ground, but flight tests have not yet been made. The sub-miniature tubes used in conjunction with this equipment have proved quite satisfactory; however, it is felt that their general use cannot be possible until tooling for mass production is completed by the manufacturer. It becomes evident as a result of this Philco effort that weight, space and power can be conserved, proving a great advantage to the missile field.

Further studies have been made of the effect of ogival nose angles on missile range. A basic missile of the weight and size comparable to the Rascal rocket missilea wae selected for study. Overall length, fuselage diameter, space for equipment and payload were held constant, and the ogival nose angle varied from 20 to 60 degrees. Basicelly the problem reduced to eelecting a compromise fuselage configuration which would carry a maximum amount of fuel for a minimum of nose drag. A curve of range versue ogive nose angle wae plotted which indicates en optimum renge for an angle of 35 degrees. An angle of 44 degrees which we had previously selected euffers approximately only seven miles loss in range over the optimum indicating the realisticness of our choice.

A Constant Incident Angle Radome was offered in BMPR-4 as a missile nose configuration, which constituted a reasonable compromise between aerodynamics end guidance requiremente. In that vain, another nose configuration is presented in thie report which we have called a "Faired Radome". It is eesentially a hollow disk containing a "pill box" antenna inserted into the nose of the missile in an attempt to segregate the guidance requirements and the aerodynamic requirements into individuel nose shapes and thereby (1) reduce the nose drag, (2) make possible a most favorable antenna radome design, and (3) reduce to an absolute minimum the structural problems associated with the radome. Wind tunnel tests are now needed to clarify the extent of the destabilizing effect which aerodynamic analysis has revealed for this configuration. Tests were requested for May 1, 1947.

From a wing deeign study it was determined that 45 sq. feet of horizontal wing area would permit an 8 g pull-out et 5,000 feet with 20 per cent fuel for a Rascal miseile groseing 11,500 pounds, and that this area with a delte planform, end double wedge airfoil is desirable from the standpoint of structure end the minimum weight of fuel required to overcome the drag of the wing plus the wing weight. A minimum section thickness of 2 per cent was shown to be satisfactory, but other consideretions dictated that 5 per cent is more realistic. This study has taken into account structural, aerodynamic, and production considerations; flutter was touched on lightly, but missile atebility was intentionelly ignored for simplicity. Because of this letter omission this anelysis cannot be considered conclusive but only indicetive of wing design parameters with which to work.

The Missile Relay Antenne and Missile Carrier Relay Antenna Stabilized Pletforms shown in BMPR-5 ere undergoing modification.

Of the guidance end control equipment under development, the azimuth computer is complete except for the decoder and its esseciated servo. The AN/APQ-7 radar is being modified in the laboratory to include e triple-tone circuit because it has become apparent that for attacks on land targets some form of target discriminatory circuit is essential. The small ten inch diemeter conical radome described in BMPR-5 is etill being tested et Wright Field; in the meantime, a large twenty inch diemeter 18 degree conicel radome is being fabricated. It is intended thet thie latter radome will also be tested at Wright Field. Sylvania is now active in a miesile search redar system development, which has produced to date preliminary sketches locating the complete K-band system in the specific missile deeign previously mentioned.

In the lapse of time between the last report, the flight simulator has undergone chenges which appear to offer considerable improvement over the earlier system. Also an AN/APQ-13-T1A Training Set has been obtained and set up for modificetion into a flight simulation device.

A recapulation of our flight test reeulte is contained in this publication. We have epproached the problem by reviewing the original "Rascal" Guidance Scheme that was present in BMPR-1 and commenting on each of the items therein. We have covered the objectives and procedure of the television air-to-air link, the missile search radar system, radar tracking and guiding of missiles, the use of a P-80 and B-25 airplanes as missile flight test vehicles, and the equipment required. In general the status of the flight test program can be summed up as proceeding as planned with the one exception of material procurement.

3. AERODYNAMICS

a. A Study of the Effect of Ogival Nose Angles on Range:

To continue with the program of an optimum nose configuration selection which we have pursued in the preceding progress report periods, a short study has been made to determine the effect of the magnitude of the ogival nose angle on the total range of the missile. Being short and limited in nature, it gives only an indication of the desirable latitudes of ogival nose angles in which to work, but it does further substantiate our original selection of 44 degrees.

For purposes of comparison, a basic missile of the weight and size comparable to the Rascal rocket missiles was selected. Overall length and fuselage diameter are held constant. Space for motors, guidance equipment, and warhead is fixed, and the configuration is further restricted by the location of the search antenna, the position of which is maintained at a point where the diameter of the ogive is 90 per cent of the fuselage diameter. Fuel cannot be stored forward of the search antenna and, therefore, the amount of fuel which a missile can carry becomes a function of the ogival angle and in turn, the antenna location. The problem reduces to selecting a compromise fuselage configuration which will carry a maximum amount of fuel for a minimum of nose drag. The ogival nose angle was varied from 20 to 60 degrees.

Since the effect of nose angle variation was the desired objective in this short study, the calculations were simplified by making assumptions which eliminated several of the usual performance computations: (1) The missile was assumed to be able to fly with no lifting surfaces, which eliminated the form drag, attitude drag, and skin friction drag calculations on these surfaces. (2) The missile was assumed to reach M = 1.6 after 30 seconds of boosted flight and was considered to fly at M = 1.6 at 40,000 feet until the fuel was exhausted.

With the total fuel for unaccelerated flight known, the ranges for unaccelerated flight of the various missile configurations were calculated.

Table 3:1 gives a comparison of gross weights, total fuel, and range for the various nose angles selected, and Figure 3:1 shows the variation of range with these nose angles.

Table 3:1

Range Performance for Various Ogive Nose Angles at 40,000 feet

θ Ogive (Deg.)	Missile Wetted Area (sq. ft.)	Gross Vol. (cu.ft.)	Total Fuel Wt. (lbs.)	Cruising* Fuel (lbs.)	Drag at M = 1.6 (lbs.)	Range (mi.)
60	254.5	145.3	6586	4801	1690	161
45	249.5	136.5	6000	4300	1320	185
30	239.0	125.0	4841	3301	976	192
20	224.0	103.7	3021	1746	798	124

* Fuel remaining after deducting fuel used to boost the missile from 300 mph to M = 1.6 in 30 seconds.

Figure 3:1 provides a means of selecting an optimum basic body for the Rascal missile. However, it should be emphasized that no attitude, form, or skin friction drags of the lifting surfaces were included in this study, and that with increasing nose angle and the consequent increase in gross weight, these drag components all increase and tend to counteract any benefits derived from greater fuel capacity.

It would seem, therefore, that for the complete missile, the optimum point on the curve (namely, at an angle of 35 degrees) would move toward the left. This indicates that the final selection of an optimum nose angle can be made only after a more detailed investigation.

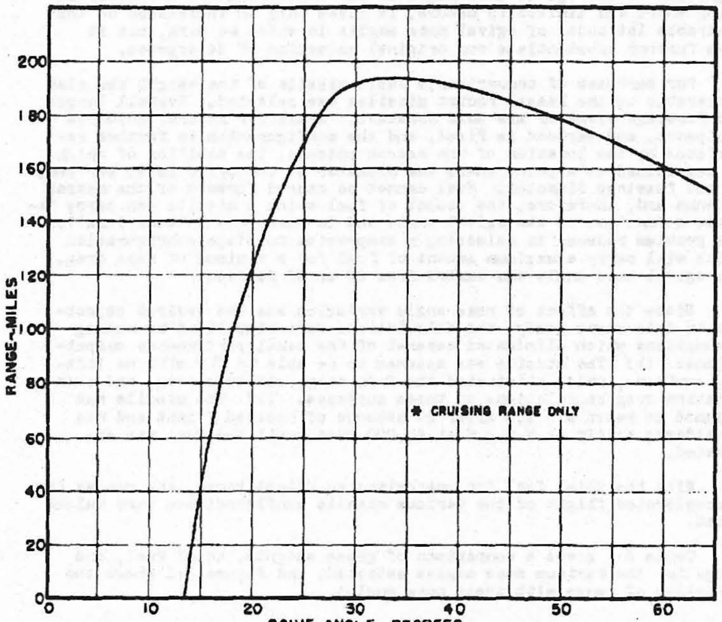


FIG. 3:1 RANGE* VS. OGIVE NOSE ANGLE FOR A MISSILE OF GIVEN LENGTH AND DIAMETER AT 40,000 FEET

b. General:

Aside from the Ogive Angle Study presented in 3,a. above, the recent investigations in the aerodynamic phase of the Rascal Project have pertained chiefly to the problems concerned with the preliminary design of a specific missile. These include designing and locating aerodynamic surfaces for satisfactory static longitudinal and directional stability at both subsonic and supersonic speeds, and having made a wing selection, investigating briefly the longitudinal characteristics of the missile. The ranges attainable when launched at various attitudes and altitudes were then determined for performance study. To complete the picture, rates of control surface deflection, power requirements and missile responses were investigated for given pull-out specifications. Further details will be published in a special report covering the whole of the specific missile design.

c. Faired Radome:

A constant 10 degree incidance angle radome was presented in BMPR-4, in which the calculated nose radoma contour with respaot to rays emanating from .9 of the body radius, was closely approximated by an ogive, i.e., by arcs of circles. This nosa shape resultad in an includad tangent nose angle of 44 degrees, which from the standpoint of aerodynamics is rather blunt. From a consideration of microwave transmission, a much more blunt nose would be preferred. Preliminary results of still incomplete tests being made by Mr. Behrens, AMC, indicate that the 18 degree nose angle, straight-sidad plexiglas cone may exhibit acceptable transmission characteristics. At any rate, the critical compromise between aerodynamics and electronics in respect to the forward portion of Rascal supersonic body remains indeterminate at this time.

In view of the uncertainty of this situation, it has been decided to explore the possibility of solving this crucial problem using a different approach. Accordingly, a design as indicated in Figure 3:2 has been proposed and investigated insofar as possible without the aid of wind tunnel information. Since the search antenna is conceived as a rotating mechanism sweeping a 28 inch diameter "disc" about 4 inches deep, it is proposed to move this "disc" forward in the missile nose until the antenna radiating area extends outside the missile contour. Effectively, this configuration attempts to segregate the incompatible aerodynamic and electronic characteristics. The antenna radome frontal area has now been reduced to a minimum. Thus a blunt radome shape will not so seriously affect the aerodynamic characteristics, since the major portion of the frontal area may be disposed favorably by the dictates of aerodynamics, which means a longer, smaller-included-angle nose shape.

It was hoped that this arrangement, referred to as a "faired radome" would (1) increase the usable volume within the fuselage, (2) reduce the nose drag, (3) make possible a most favorable antenna radome design, and (4) reduce to an absolute minimum the structural problems associated with the radome. Preliminary work indicates that the "usable" fuselage volume remains unaltered, due to the reduced "total" fuselage volume resulting from the longer, sharper nose, the fuselage length being limited by bomb-bay dimensions.

Aerodynamic investigation revealed that the resulting destabilizing horizontal area at the forward fuselage location poses a serious stability problem. In respect to this and drag, a reasonable estimate is not possible in that satisfactory theory for 3-dimensional supersonic flow has not been evolved, and no tests of a similar nature have been performed insofar as this contractor has been able to determine from technical information both in this country and in Germany.

For these reasons it was considered imperative to investigate this type of nose shape in a supersonic wind tunnel, and to that end a request for one day's testing in the Aberdeen tunnel on or about May 1st was requested in a letter to AMC dated March 6, 1947. To date, no wind tunnel time has been assigned.

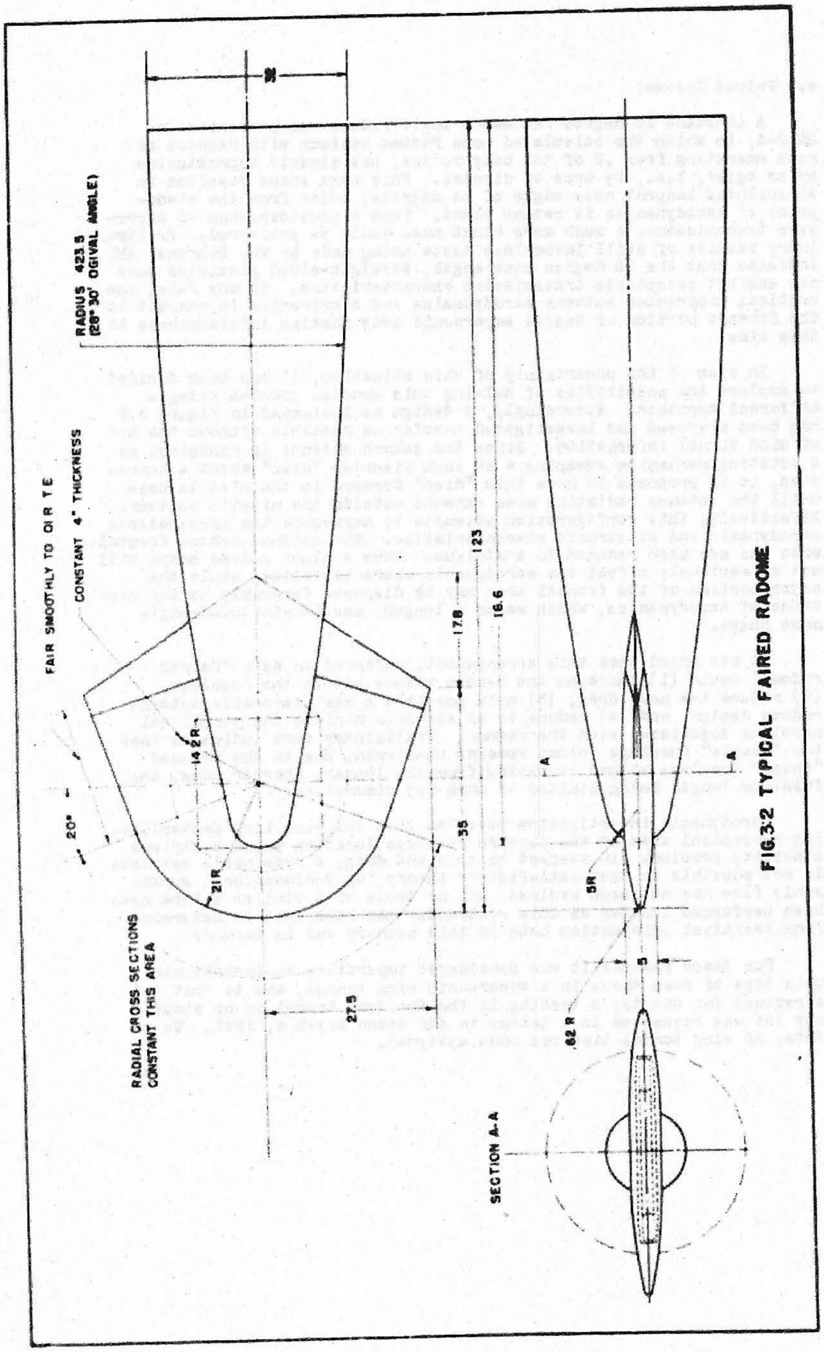


FIG. 3-2 TYPICAL FAIRED RADOME

4. STRUCTURES

Rascal Wing Dasign Study:

Selection of a suitable horizontal wing for the Rascal missile involves, among othar thinge, consideration of the saction profile, planform, and wing area to give a minimum waight of fual to overcome the drag plue wing weight, and a wing area to accomplish tha raquired maneuvers.

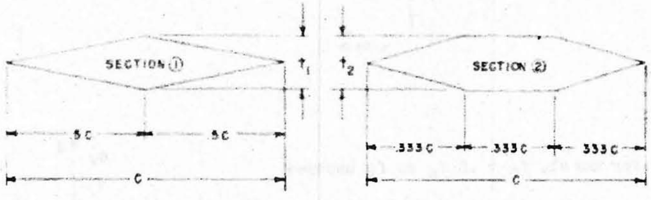
A specification has been established for the missila for this particular etudy as follows:

1. Gross weight at launching .... 11,500 lbs.
2. Averaga gross weight over the flight path ...... 8,000 lbs.
3. Launching altitude .... 40,000 ft.
4. Cruising altitude .... 40,000 ft.
5. Range .... 100 mi.
6. Speed for 60% of tha range .... 1.6 M
7. Maneuver in Pitch (20% fuel & 5000 ft.) .... 8 g

This specification only approximates the missila under consideration at present.

Structural, aerodynamic, flutter, and production considerations are among tha more important planform criteria on which a wing design is to be based. Structurally, it must be analyzed with respect to (1) spanwise banding moment, (2) deflection, and (3) torsional stiffness. Aerodynamically, minimum profila drag is desirad. Minimum washout dua to spanwiae deflection of a sweptback wing, and pointed tip within a trailing edge Mach cona are additional aerodynamic considarations. Flutter characteristics have baen touched on lightly, although it is believed that thay are of prime importance aven to the point of determining wing ehape. Since we are working on an axpendable vehicle, the desirability of production-ease influences tha dasign in size and straight element development. Wing area was based on the minimum weight of fuel necaeeary to overcome wing drag plus wing weight and the minimum to accomplish the requirad maneuvars.

a. Structural Comparison of a Wedge (Diamond) Section Airfoil With a Flat Hexagon Saction:



Given the above sections which have the eame chord but different t's (both sections are solid), it is desired to compare the drag, strength, weight, and deflection of these sections.

Section Properties			
Section	(1)	(2)	
A	$.5\ Ct_1$	$.666\ Ct_2$	$= \frac{2 \times .333\ Ct_2}{2} + .333\ Ct_2$
I	$.0208\ Ct_1^3$	$.0416\ Ct_2^3$	$= 2 \times .333\ C \times .0208\ t_2^3$
I/y	$.0416\ Ct_1^2$	$.0832\ Ct_2^2$	$+ .0832 \times .333\ Ct_2^3$

A beam, in bending, will fail at a stress which calculates to be higher than the ultimate of the material, provided all of the material is not concentrated at the extreme fibers. This is true because the material undergoes some plastic flow and therefore the classical beam bending formulae break down. The apparent stress at which the beam fails depends on the shape of the beam cross-section, or on a "form" factor.

The following information comes from an article in the Institute of Aeronautical Sciences Journal, May 1943, by Cozzone, "Bending Strength in the Plastic Range".

Apparent $f_b = f_m + f_o\ (K-1) = \frac{My}{I}$

K = form factor

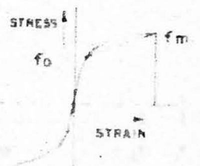
= 1.5 for a rectangular cross-section

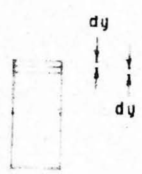
= 2.0 for a wedge section

f_b = bending stress

f_m = ultimate tension or compression stress

f_o = interception, with stress axis, of a trapezoid drawn on a stress-strain diagram such that the trapezoid covers the same area as that under the stress-strain curve. One peak of the trapezoid is at f_m:

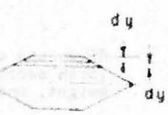




For dural, $f_o = .5\ f_m$ so f_b becomes

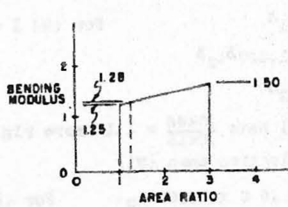
$$f_b = f_m + .5\ f_m\ (K-1) = f_m\ (.5 + .5K)$$

The beam does not ever reach the apparent stress. Instead, considering two elements of area at the extreme fiber, when the outer-most area reaches the ultimate stress, there is some plastic flow, and before it fails the next area reaches the ultimate, and so on until no more flow is possible and the beam breaks. It can be seen from the accompanying sketches that the ratio of the area of the inner increment to the outer increment, for the rectangular section is



1:1; for the diamond 3:1. A scale drawing of the hexagon being considered gives a ratio of 1.22:1.

Plotting the bending moduli against the area ratio for extreme fibers, gives a bending modulus = 1.28 for the hexagonal section.



The strengths of the two beams, wedge and hexagon, will now be made equal. The strength of any beam would depend on the bending modulus times the I/y.

$$1.5 \times .0416\ Ct_1^2 = 1.28 \times .0832\ Ct_2^2$$

$$t_1 = 1.307\ t_2$$

The wing drag is made up of three parts, skin friction, attitude drag, and profile drag. Of these, only the latter will vary with the two sections under consideration. For the profile drag, the only varying factor is $K_a(t/C)^2$.

Drag Properties

Section	(1)	(2)
Profile drag form factor = K_a	4	6
$\frac{t^2}{C^2}$	$\frac{t_1^2}{C^2} = \frac{1.307^2 t_2^2}{C^2} = \frac{1.71\ t_2^2}{C^2}$	$\frac{t_2^2}{C^2}$
Profile drag factor = $K_a\left(\frac{t}{C}\right)^2$	$\frac{4 \times 1.71\ t_2^2}{C^2} = \frac{6.84\ t_2^2}{C^2}$	$\frac{6\ t_2^2}{C^2}$

From this table it can be seen that the increase in profile drag caused by using the wedge section is $\frac{6.84}{6}$ times that for the hexagon, providing that the strengths are equal.

It has been found, very approximately, from a previous analysis of a similar airframe that the wing drag = 1/2 total drag, profile drag = skin friction, and the attitude drag = 2 x profile drag (or skin friction).

Then letting the profile drag = A
wing drag = 4A
and airplane drag = 8A

the increase in total airplane drag from using a wedge shape 30.7%

thicker than a hexagon shape

$= \frac{.64}{6} A - .8A = .013$ or 1.3% (This is negligible, being within the limits of error of the method).

For comparing deflections of the above two sections, as designed for equal strength, the moments of inertia may be compared.

For (1) $I = .0208\ Ct_1^3$ For (2) $I = .0416\ Ct_2^3$

$= .0208\ C\ 1.307^3 t_2^3$

$= .0466\ Ct_2^3$

Or (1) will have $\frac{.0466}{.0416} = 1.12$ more rigidity or 12% less deflection than (2).

For (1) $A = .5\ Ct_1 = .5\ C \times 1.307\ t_2$ For (2) $I = .666\ Ct_2$

$= .653\ Ct_2$

Or A (or weight of (1)) $= \frac{.653}{.666} \times A_2$

$= .980\ A_2$ (or weight of (2))

To summarize:

Item	Wedge (1)	Hexagon (2)
Allowable Load	L	L
t/c	1.307 x	x
Airfoil Weight	.98 W	W
Total Airplane Drag	D	D
Wing Deflection	δ	1.12 δ

b. Planform Selection:

Since deflection becomes very serious with small thickness airfoils, a study was made to determine the best planform; that is, the planform which, for a given aspect ratio, thickness ratio, and area, has the least tip beamwise deflection.

Assume, for simplicity, the following wing:

Constants:
- Aspect Ratio or b (= semi span of exposed area)
- S (= area of 1/2 exposed wing)
- W (= load on S)
- 50% chord ⊥ airplane
- w = uniform loading

$C = C_t + \frac{X}{b}(C_R - C_t)$

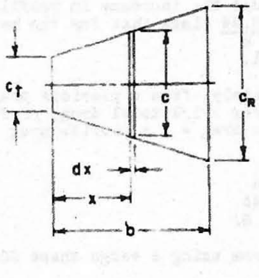
I = Moment of Inertia

$= .0208\ Ct^3$

$= .0208\ Z^3 C^4$

where $Z = \frac{t}{C}$

$= .0208\ Z^3 (C_t + \frac{X}{b}[C_R - C_t])^4$



The moment at any point, X, = $(\frac{X^2C_t}{6} + \frac{X^2C}{3})$, which formula can be arrived at by calculus or, more simply, by geometrical calculations.

The tip deflection is equal to the moment, about the tip, of the area under the M/EI curve.

$$\delta_{tip} = \int_0^b \frac{(\frac{X^2C_t}{6} + \frac{X^2C}{3})\, X\, dX}{E\ .0208\ Z^3(C_t + \frac{X}{b}[C_R - C_t])^4}$$

Let $K_1 = \frac{w}{E\ .0208\ Z^3}$

$$\delta_{tip} = K_1 \int_0^b \frac{C_t\ X^3\ dX}{6(C_t + \frac{X}{b}[C_R - C_t])^4} + K_1 \int_0^b \frac{X^3\ dX}{3(C_t + \frac{X}{b}[C_R - C_t])^3}$$

Upon integrating this and substituting in the limits, the following equation is found:

$$\delta_{tip} = \frac{K_1C_t\ b^4}{18(C_R-C_t)}\left[-\frac{1}{C_R^3} + \frac{1}{(C_R-C_t)^3}\left(\log\frac{C_R}{C_t} + \frac{4\ C_tC_R - C_t^2}{2\ C_R^2} - 1.5\right)\right]$$

$$+ \frac{K_1b^4}{6(C_R-C_t)}\left[-\frac{1}{C_R^2} + \frac{3}{(C_R-C_t)^3}\left(C_R - 2\ C_t\log\frac{C_R}{C_t} - \frac{C_t^2}{C_R}\right)\right]$$

But $S = \frac{C_t + C_R}{2}b$ or $C_R = \frac{2\ S}{b} - C_t$

And C_t can be put into terms of $\frac{2\ S}{b}$ or $C_t = K\frac{2\ S}{b}$

$$\delta_{tip} = \frac{K_1\ Kb}{18(1-2K)}\left[-\frac{1}{(\frac{2S}{b})^3(1-K)^3} + \frac{1}{(\frac{2S}{b})^3(1-2K)^3}\ x\right.$$

$$\left.\left(\log\frac{1-K}{K} + \frac{2K-2.5K^2}{(1-K)^2} - 1.5\right)\right]$$

$$+ \frac{K_1b^4}{6\ \frac{2S}{b}(1-2K)}\left[-\frac{1}{(\frac{2S}{b})^2(1-K)^2} + \frac{3}{(\frac{2S}{b})^3(1-2K)^3}\ x\right.$$

$$\left.\left(\frac{2S}{b}[1-K] - 2K\frac{2S}{b}\log\frac{1-K}{K} - \frac{K^2\frac{2S}{b}}{1-K}\right)\right]$$

Setting the first derivative of this equation, with respect to K = 0, would give the optimum wing planform from a deflection standpoint on the minimum deflection. However, this is a long tedious process and it is simpler to substitute a given condition or given values of b and $\frac{2S}{b}$. Then different values of K can be assumed and a curve of δ_{tip} plotted. The minimum deflection point can be found directly on this curve.

Using a typical wing, b = 36", S = 1330 sq.in., the following results are obtained:

K	δ_{tip}/K_1
.01	1.299
.05	1.222
.10	1.216
.20	1.351

The curve, Fig. 4:1, plots these values and shows the optimum point to be K = .075.

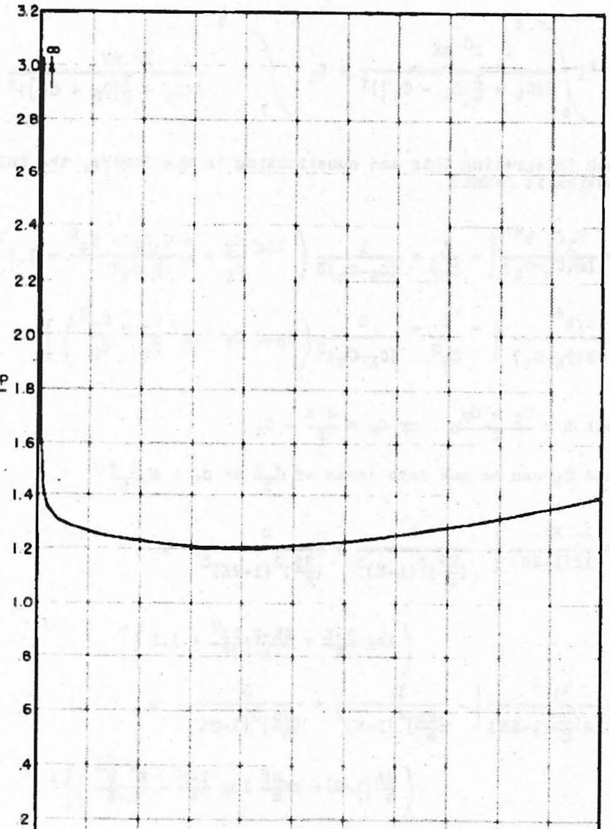


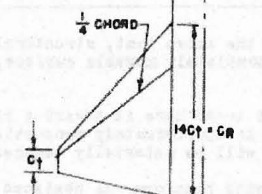
FIG. 4:1 WING DEFLECTION AS A FUNCTION OF PLANFORM

Then $C_t = .075 \frac{2S}{b}$

$C = \frac{2S}{b} \quad .075 \frac{2S}{b} \quad .925 \frac{2S}{b}$

or $\frac{C_R}{C_t} = \frac{.925 \frac{2S}{b}}{.075 \frac{2S}{b}} = 12.33:1$

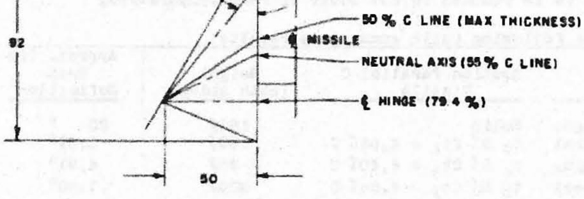
By previous considerations the optimum sweepback angle has been found to be 45°, for the quarter chord line, at M = 1.6. The ratio 12.33:1 is along the neutral axis. For the above condition the ratio of the root chord to the tip chord, for the chords parallel to the line of flight is found to be 14:1.



Optimum Wing Planform

For Minimum Deflection

The torsional twist of a 2.3% solid magnesium surface of the following planform was studied. The trailing 20.6% of the surface was considered to be an elevator. On the basis of preliminary estimates, the fixed surface loading was assumed to be 8.3 psi (limit) and the elevator 2 x 8.3 = 16.6 psi.



Torsion was taken about the elastic axis (which was assumed to coincide with the neutral axis). The pressure distribution over the wing was assumed uniform. Since the twist decreased the angle of attack, α, the effective wing area was lowered, or more exactly, the C_L along the span was lowered. A plot of the chord x $\frac{\alpha-\theta}{\alpha}$ against the span compared with a plot of chord x span showed an effective decrease in wing area of about 30%. (The elevator was assumed to have four hinges.)

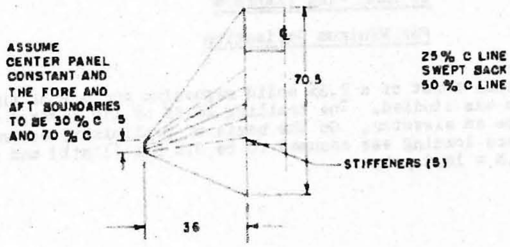
	Approximate Twist (θ) in % of α						
% Exposed Semi-Span	0	17.5	35.1	52.6	70.2	87.8	100
θ (% α)	0	.103	.207	.331	.600	1.00	1.36
$\alpha - \theta$	1	.897	.793	.669	.400	0	0*

*Actually the surface would never twist more than α.

It can be seen from the above that, structurally, it would be very desirable to use a completely movable surface, rather than an elevator.

However, the present trend here is toward a 5% section. Since the torsional deflection is approximately proportional to the cube of the thickness, the twist will be materially reduced.

A wing of the following planform was designed (1) as solid magnesium, (2) hollow dural, (3) hollow magnesium, and (4) hollow steel.



The wings were designed for a design loading of 12.8 psi. Temperature was considered to be 250°F, at which the E, and UTS are considered to be reduced to 80% those of room temperature.

The following table summarizes results:

Wing	Section Parallel C Missile	Weight (both sides)	Approx. Tip Beam Deflection
2.3% Magn.	Solid	185#	20 "
5% Dural	t_o 5% Ct_i = 4.56% C	109#	3.39"
5% Magn.	t_o 5% Ct_i = 4.40% C	95#	4.91"
5% Steel	t_o 5% Ct_i = 4.64% C	226#	1.68"

t_o = outside thickness at 50% C line.
t_i = inside thickness at 50% C line.
Deflection is at limit load.

From the foregoing analysis it can be seen that the double wedge section compares very favorably with the hexagon in weight, drag, and wing deflection. In planform, the delta configuration with a $\frac{C_R}{C_t}$ equal to 12.33:1 proves to be the most desirable structurally. Optimum sweepback for minimum profile drag is approximately 40° at M equal to 1.6 design speed. (Ref. BAC 02-942-071). Since the attitude drag is appreciably less with higher angles of sweepback, an angle of sweepback of 45 degrees has been arbitrarily chosen as a reasonable compromise. A delta planform wing is proposed to minimize the decrease in lift caused by washout. This becomes apparent when one considers the case of a sweptback rectangular planform wing where the washout is induced progressively toward the tip in proportion to the amount of spanwise deflection. The delta configuration offers less area to be affected by washout toward the tip and therefore less adverse effect of washout due to tip deflection. Production considerations have influenced the selection of a planform to one of straight leading and trailing edges.

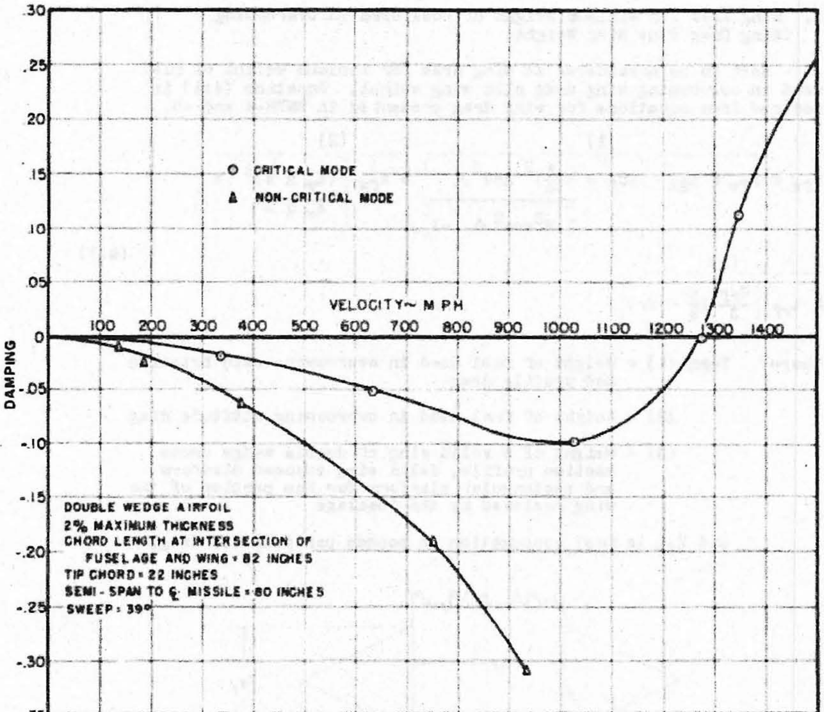


FIG. 4:2 VELOCITY VS. DAMPING
SUBSONIC INCOMPRESSIBLE FLOW COEFFICIENTS
(SWEEP BACK NEGLECTED)

A simplified flutter analysis has been made for a wing similar to the one in question to anticipate aero-elastic problems which will influence the design of lifting elements. It was believed that high subsonic speeds might be most critical, and therefore the analysis was made assuming subsonic incompressible flow. No compressibility corrections were made for the two dimensional bending-torsion flutter considered. A spot check of points in the supersonic region indicates no flutter for these check points, but a complete supersonic analysis has not been made. A two percent and three percent wing were considered:

Wing Thickness	Bending	Torsion
2%	650 cycles/min.	2500 cycles/min.
3%	760 cycles/min.	3250 cycles/min.

For either wing the ratio of torsion to bending is sufficiently high to indicate that no flutter problem will be anticipated. A plot of velocity versus damping, Fig. 4:2, indicates that damping in the high subsonic region is inherent.

c. Wing Area for Minimum Weight of Fuel Used in Overcoming Wing Drag Plus Wing Weight:

Next to be considered is wing area for minimum weight of fuel used in overcoming wing drag plus wing weight. Equation (4:1) is derived from equations for wing drag presented in BMPR-4 and -5.

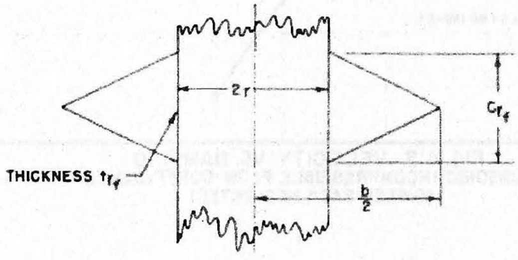
$$W_{fw} = \overbrace{K_{fw}\, q\, S_{EX}\left[2C_f + \frac{4\left(\frac{t}{c}\right)^2 \cos^3\Lambda}{\sqrt{M^2\cos^2\Lambda - 1}}\right]}^{(1)} + \overbrace{K_{fw}\left[\frac{(K_w \times W)^2}{A_w\, q\, S}\right]}^{(2)} + \overbrace{\delta\, t_{rf}\left[\frac{C_{rf}}{3}\left(\frac{b}{2} + 2r\right)\right]}^{(3)} \qquad (4:1)$$

Where: Term (1) = Weight of fuel used in overcoming skin friction and profile drag

(2) = Weight of fuel used in overcoming attitude drag

(3) = Weight of a solid wing of double wedge cross section profile, delta wing exposed planform and rectangular planform for the portion of the wing enclosed by the fuselage

and K_{fw} is fuel consumption in pounds per pound of drag.



This study is based on a missile average weight of 8,000 lbs. and a canard arrangement where the aft horizontal surface is assumed to contribute two thirds of the total horizontal wing lift.

Values of S were assumed and corresponding values of W_{f_w} were calculated. A plot of the individusl terms as a function of "S" with the exception of term (3) is presented in Fig. 4:3.

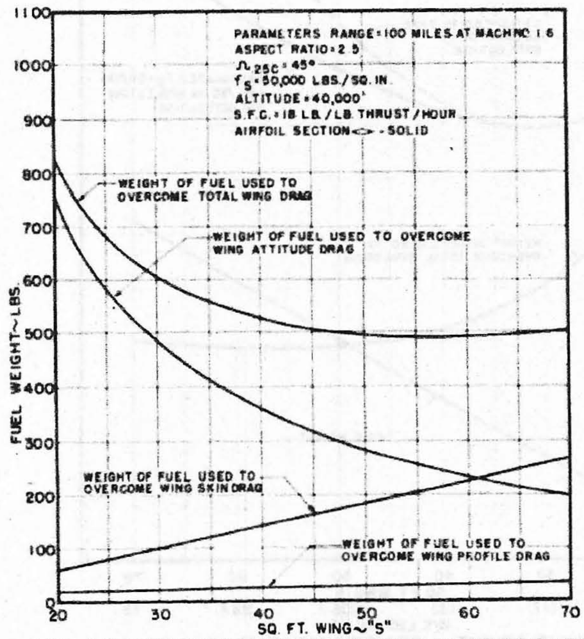


FIG. 4:3 WEIGHT OF FUEL USED TO OVERCOME WING DRAG

Fig. 4:4 is the aggregate of the fuel required to overcome wing drag plus wing weight. An estimated curve (dash line) has been added merely to emphasize the fact that these curves were prepared on the basis of equal stresses (50,000 psi) which gives excessive tip deflections for the larger surfaces.

From Fig. 4:4 an area of 30 sq. ft. is selected as the optimum for the horizontal aft wing. The corresponding total horizontal wing area is equal to 30 x 2/3 = 45 sq. ft. To determine the maneuver accelerations possible with this area, Fig. 4:5 was plotted. Forty-five square feet will permit the missile to pull 8 g at altitudes of 16,125 feet under full gross weight and 27,500 feet under a 20 per cent fuel condition.

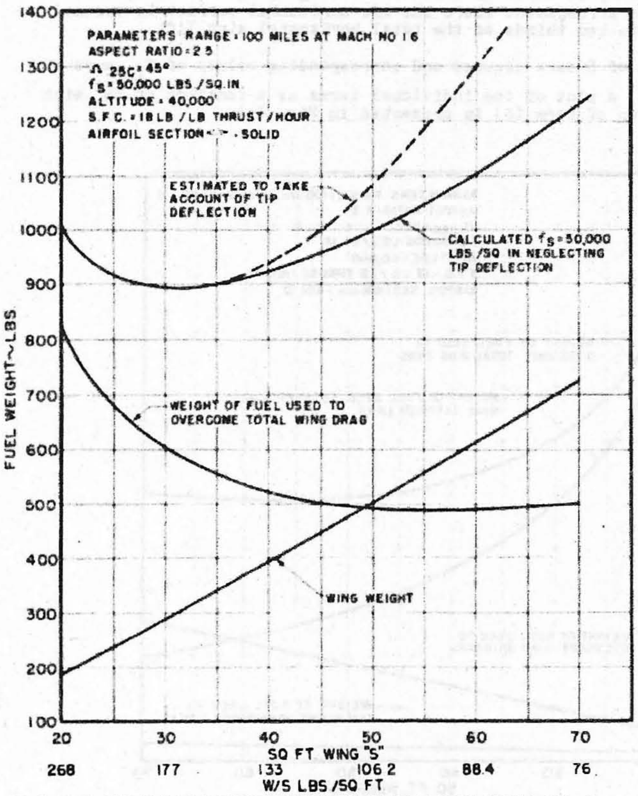


FIG. 4:4 WEIGHT OF FUEL USED TO OVERCOME WING DRAG PLUS WING WEIGHT VS. WING AREA

From this study it has been determined that horizontal wings of delta planform, double wedge cross section, and 45 sq. feet total area, are satisfactory from the standpoint of structure and the minimum weight of fuel required to overcome the drag of the wing plus the wing weight. The area is more than sufficient to fulfill the requirement of an 8 g pull out at 5,000 feet with 20 per cent fuel. A minimum section thickness of 2 per cent is shown to be satisfactory, but engineering judgment dictates that 5 per cent is more reasonable. This study, because of its incompleteness can be considered only preliminary, giving limiting criteria on which a design can be based. It is realized that the wing design will finally be selected only when stability requirements are considered with those above.

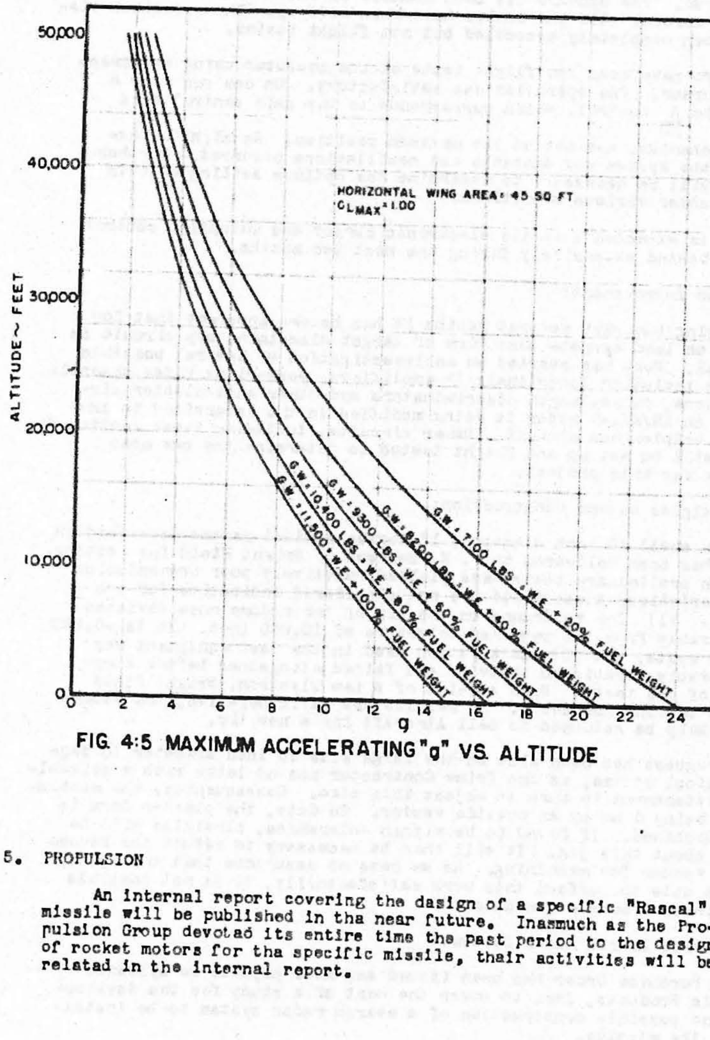


FIG. 4:5 MAXIMUM ACCELERATING "g" VS. ALTITUDE

5. PROPULSION

An internal report covering the dasign of a specific "Rascal" missile will be published in tha near future. Inasmuch as the Propulsion Group devotad its entire time the past period to the design of rocket motors for tha specific missile, their activities will be relatad in the internal report.

6. GUIDANCE AND CONTROL

a. Azimuth Computer:

The Azimuth Computer is complete except for the decoder and associated servo. The Synchro has been mounted on the antenna but has not yet been zeroed. All the cables have been made up. The autopilot tie-in has been completely assembled but not flight tested.

There have been two flight tests of the computer using the mechanical cursor. The operation was satisfactory. On one run over a target the $\frac{A}{\Delta D}$ control, which corresponds to the gain control of a servo-mechanism, was set at its maximum position. As might be expected, the system was unstable and oscillations occurred. Further flights will be necessary to determine the optimum setting of this control under various conditions.

It is expected that the electronic cursor and autopilot control will be tested extensively during the next two months.

b. Radar Improvement:

During the past several months it has become apparent that for attacks on land targets some form of target discriminatory circuit is essential. Work has started on an investigation of several possible circuits including logarithmic IF amplifiers, peak-rider video channels, triple-tone, pulse-length discriminators and other anti-clutter circuits. An AN/APQ-7 radar is being modified in the laboratory to include a triple-tone circuit. Other circuits, including those mentioned above, will be set up and flight tested to determine the one most suitable for this project.

c. Plexiglas Radome Construction:

The small 10 inch diameter, 17 degree conical radome described in BMPR-5 has been delivered to F. H. Behrens of Wright Field for testing. Although preliminary tests have yielded relatively poor transmission characteristics, these tests are not considered indicative for two reasons: (1) The tolerance on the tip of the radome nose deviates considerably from the required tolerance of ±0.005 inch. It is -0.020 inch in spots, and (2) The klystron used in the test equipment was considerably erratic in behavior and failed altogether before completion of the tests. Upon receipt of a new klystron, Wright Field intends to continue tests. If results are still negative, the radome will likely be returned to Bell Aircraft for a new tip.

Progress has been slow on the large size 20 inch diameter 18 degree conical radome, as the Prime Contractor has no lathe with a suitable taper attachment to turn an object this size. Consequently, the machining is being done by an outside vendor. To date, the plaster form is being machined. If found to be within tolerances, plexiglas will be formed about this jig. It will then be necessary to return the radome to the vendor for machining. As we have no assurance that the vendor will be able to perform this work satisfactorily, it is not possible to estimate a completion date.

d. Missile Search Radar System:

A Purchase Order has been issued and made payable to Sylvania Electric Products, Inc. to cover the cost of a study for the development and possible construction of a search radar system to be installed in the missile.

Exhibit "A" of this Purchase Order lists the activities included in this study and are reproduced as follows:

1. Follow pertinent developments at the plant of the Buyer.
2. Construct a wooden mock-up of a proposed radar receiver-transmitter unit.

3. Do miscellaneous laboratory testing of proposed materials and schemes.
4. Visit Wright Field and Naval Research Laboratory to secure aid in conducting said study.
5. Study especially the receiver-transmitter unit, but give some attention to antenna and indicator problems, and automatic operation requirements.
6. Submit brief monthly reports of Seller's studies and progress.
7. Write a set of specifications for a proposed development contract.
8. Submit by April 1, 194?, a preliminary estimate of weight, size and shape of components, and power requirements of the complete system (assuming power supply of 28 volts d.c. and 400 cycles 115 volts a.c.).
9. Submit a final report showing in detail the study, work, results and recommendations of the Seller. Such report shall include reproducible copies of all drawings made and used in the performance of such study and work.

A preliminary estimate of weight, size and shape has been received per Item 8 and is as follows for a K-band system.

Total estimated weight (less cables) .... 95 lbs.
Total estimated volume .... 1.8 cu.ft.
Power consumption ..... 300 watts of 115V a.c. and 2 amps of 24V d.c.

The K-band system includes synchronizer, modulator, transmitter, all receiving components including AFC, receiver with anti-clutter features and all power supplies. It does not include the antenna.

Preliminary sketches have been made locating the complete K-band system above the search antenna in the missile nose. Additional sketches place only the r.f. components above the antenna, the other components having been removed to the missile mid-section.

Similar sketches including weight, size and space requirements are being prepared for the K_a-band.

e. Flight Simulator:

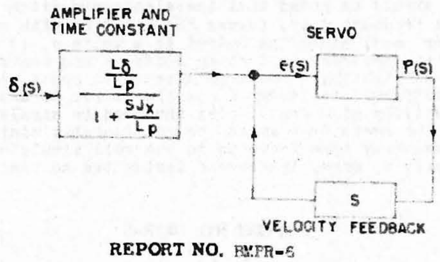
In the previous progress report (BMPR-5) the aerodynamic equations for pitch and roll were developed and a servo system indicated for providing a mechanical solution for the aerodynamic equations. Another method of simulation has been devised which may offer certain practical advantages in providing good simulation.

<u>Roll Simulator</u>

$$J_x \ddot{\phi} + L_p \dot{\phi} = L_\delta \delta$$

$$\frac{\phi(S)}{\delta(S)} = \frac{L_\delta}{S(L_p + J_x S)} = \frac{\frac{L_\delta}{L_p}}{S\left(1 + \frac{SJ_x}{L_p}\right)}$$

The following block diagram shows the approximate solution of this equation in terms of practical components.



$$\epsilon(S) = \delta(S)\frac{\frac{L_\delta}{L_p}}{\left(1+S\frac{J_x}{L_p}\right)} - S\,\varphi(S)$$

$$-\frac{\epsilon(S)}{\delta(S)\,S} = \frac{\varphi(S)}{\delta(S)} - \frac{\frac{L_\delta}{L_p}}{S\left(1+S\frac{J_x}{L_p}\right)}$$

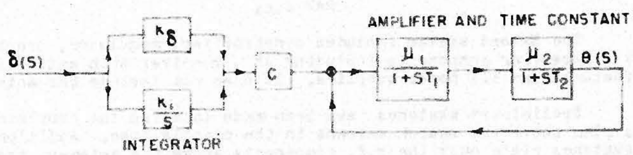
Thus the accuracy of solution of the equation is determined by the integral of the servo error.

Pitch Simulator

$$K_a\ddot{\theta} + K_r\dot{\theta} + K_p\theta = K_\delta\,\delta + K_i\int_0^t \delta\,dt$$

$$\frac{\theta(S)}{\delta(S)} = \frac{K_\delta + \frac{K_i}{S}}{K_p + K_r S + K_a S^2} = \frac{K_i + K_\delta S}{S(K_p + K_r S + K_a S^2)}$$

The following bloc diagram shows an electronic method of solving the equation (the interrator may be electronic or mechanical).



In order to determine the variables 1, 2, T_1, T_2 and C, we establish the relationship:

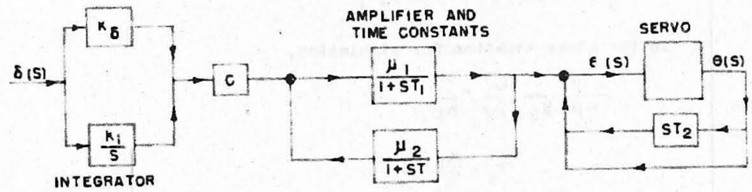
$$\frac{1}{K_p + K_r S + K_a S^2} = \frac{\frac{\mu_1\mu_2}{(1+ST_1)(1+ST_2)}}{1+\frac{\mu_1\mu_2}{(1+ST_1)(1+ST_2)}} = \frac{C\mu_1\mu_2}{(1+ST_1)(1+ST_2)+\mu_1\mu_2}$$

$$\frac{\frac{1}{K_p}}{1+\frac{K_r}{K_p}S+\frac{K_a}{K_p}S^2} = \frac{C\frac{\mu_1\mu_2}{1+\mu_1\mu_2}}{1+\frac{S(T_1+T_2)}{1+\mu_1\mu_2}+\frac{T_1T_2S^2}{1+\mu_1\mu_2}}$$

$$\frac{K_a}{K_r} = \frac{T_1T_2}{T_1+T_2} \qquad \frac{K_a}{K_p} = \frac{T_1T_2}{1+\mu_1\mu_2} \qquad \frac{1}{K_p} = C\frac{\mu_1\mu_2}{1+\mu_1\mu_2}$$

This provides three equations in five unknowns permitting the various time constants and amplifications to be adjusted to meet other requirements. It should be noted that the electronic pitch simulator, although including a feedback loop, solves the equation with no inherent error. On the other hand, since the output is a voltage, it cannot be used directly with gyroscopes and other guidance and control equipment. To avoid this difficulty, a position type servo could be utilized but it is rather difficult to design a position servo to accurately respond to the relatively high frequencies involved in simulation of a missile airframe. The servo problem can be considerably minimized if we convert to a velocity type servo as in the roll simulator, or if we are able to supply a large, true error derivative to the servo.

A block diagram showing a method utilizing error derivative follows:



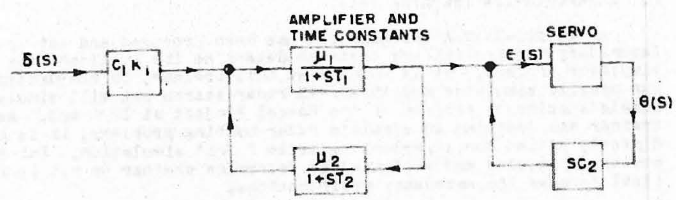
$$\frac{\mu_1}{1+ST_1}\left[\delta(S)\left(K_\delta+\frac{K_i}{S}\right)C-\left(\frac{\mu_2}{1+ST_2}\right)\left(\epsilon(S)+[1+ST_2]\,\theta(S)\right)\right]=\epsilon(S)+\theta(S)(1+ST_2)$$

$$\left(\frac{\mu_1}{1+ST_1}\right)\delta(S)\,C\left(K\delta+\frac{K_i}{S}\right)=\left[\frac{(1+ST_1)(1+ST_2)+\mu_1\mu_2}{(1+ST_1)(1+ST_2)}\right]\left[\epsilon(S)+\theta(S)(1+ST_2)\right]$$

$$\frac{\theta(S)}{\delta(S)}-\frac{\left(K\delta+\frac{K_i}{S}\right)\frac{C\mu_1}{1+\mu_1\mu_2}}{1+\frac{S(T_1+T_2)}{1+\mu_1\mu_2}+\frac{S^2\,T_1T_2}{1+\mu_1\mu_2}}=-\frac{\epsilon(S)}{\delta(S)(1+ST_2)}$$

As before, the accuracy of simulation is determined by the magnitude of the servo error.

A velocity type servo can be utilized if the $\frac{K_i}{S}$ integrator is dispensed with as follows:



$$\frac{\mu_1}{1+ST_1}\left[K_i\,C_1\,\delta(S)-\frac{\mu_2}{1+ST_2}\left(\epsilon(S)+C_2\,S\theta(S)\right)\right]=\epsilon(S)+\theta(S)SC_2$$

$$\frac{\mu_1}{1+ST_1}\,C_1\,K_i\,\delta(S)=\left[\frac{(1+ST_1)(1+ST_2)+\mu_1\mu_2}{(1+ST_1)(1+ST_2)}\right]\left[\epsilon(S)+\theta(S)\,SC_2\right]$$

$$\frac{\theta(S)}{\delta(S)} = \frac{\left(\frac{\mu_1}{1+\mu_1\mu_2}\right) C_1 K_1 (1+ST_2)}{SC_2\left(1+\frac{S(T_1+T_2)}{1+\mu_1\mu_2}+\frac{S^2 T_1 T_2}{1+\mu_1\mu_2}\right)} = -\frac{\epsilon(S)}{SC_2\,\delta(S)}$$

In the above equation for simulation,

$$\frac{\mu_1}{1+\mu_1\mu_2}\,\frac{C_1}{C_2} = \frac{1}{K_p}$$

$$T_2 = \frac{K_\delta}{K_1}$$

$$\frac{T_1 T_2}{T_1+T_2} = \frac{K_a}{K_r}$$

$$\frac{T_1 T_2}{1+\mu_1\mu_2} = \frac{K_a}{K_p}$$

The appearance of the number C_2 in the error expression merely means that the servo loop gain should be as high as possible for accurate simulation.

Although the general angular simulation methods outlined in this description have not been completely evaluated, a few inherent advantages are readily apparent.

(1) The system requires no mechanical counterpart of the airframe inertia, nor does it require any acceleration measurements.

(2) The feedback quantities associated with the servo can be determined primarily from the standpoint of best servo performance. As a result, no compromise of servo performance need be experienced because of changing aerodynamic constants.

(3) Since velocity signals are available to feed the servo, considerably better performance can be expected than if positional information alone were available.

f. AN/APQ-13-T1A Training Set:

An AN/APQ-13-T1A Training Set has been procured and set up in the laboratory for preliminary tests to determine its applicability to our simulator program. It is hoped that this trainer, in conjunction with our missile simulator and AN/APQ-13 radar search set will simulate the complete guidance program of the Rascal Project at 1200 mph. As this trainer was designed to simulate radar bombing problems, it is not directly suited for supersonic missile flight simulation. But it is now being studied and evaluated to determine whether or not is is practical to make the necessary modifications.

For example, the present maximum horizontal velocities of 400 mph for the airplane and 75 mph wind must be increased to 1200 mph and 200 mph by increasing the X and Y velocities of the trolley. The maximum vertical velocity must be increased from 30 mph to 850 mph by changing the altitude drive in the trolley. There is excessive backlash in almost all the gearing that must be reduced to a minimum or eliminated. The azimuth drive servo system will not follow a 5 cycle per second, plus and minus 45 degree sector scan rate, which means a change in the azimuth drive gearing and/or motor. As the present motions of the simulator antenna are the same as though the antenna was stabilized in the missile, it is desirable to move the antenna to simulate an unstabilized antenna in the missile. To accomplish this on the trainer will require major modification in the trolley antenna system.

As the diving portion of the flight is the only part that needs to be simulated, the maximum slant range will be 20 miles at 50,000 feet to a slant range of 1 mile, which is near the present range of the trainer. This will enable us to determine target recognition and reaction times at supersonic velocities. As beam pattern study necessitates grinding new glass reflectors, the optimum target recognition time may not be determined.

g. Raytheon Relay:

The video relay equipment has been completed and has passed electrical type tests satisfactorily. During vibration tests it was found that several minor modifications were necessary in order to insure proper operation under flight conditions. These modifications have been made on the "missile" equipment which is now being set up in the Bell electronics laboratory.

Considerable trouble was experienced in the launching airplane parabolic antenna due to vibration. A new and much stronger antenna has been constructed and is now ready for vibration testing. Upon satisfactory completion of these tests, the antenna and its associated receiver will be shipped to Bell for our tests.

The command link from the launching airplane to the missile is now scheduled for completion at the end of May. Two different receivers are being supplied for the missile end of this link. One is a conventional superhetrodyne using 60 mc. i.f. and the other a crystal video receiver.

The crystal video receiver will have two sections of tuned pre-selector cavities feeding into two separate crystals. The pre-selector cavities have a bandwidth of approximately 10 mc and will be tuned so one will receive the search radar frequency and the other the command link frequency. This receiver is much smaller and lighter than the conventional i.f. receiver.

h. Dive-Angle Computer:

In BMPR-4 a computer called "Elevation Computer" was introduced; it was further described in BMPR-5. This computer is now being called "Dive-Angle Computer" in order to permit assigning "Elevation Computer" to an item better suited to that name.

The Dive-Angle Computer is of the Range-Altitude variety. Its purpose is to determine the proper dive angle for the missile path, and to combine this angle with the actual missile pitch angle as measured by a vertical gyro. If the missile is not on the correct course in pitch, these two angles will not cancel and there will be a correction to the autopilot.

The modified Dive-Angle Computer is shown in block diagram form in Figure 6:1. The major recent additions are the incorporation of an autopilot converter, and provisions for utilizing an APG-5 range unit for tracking altitude automatically.

The computer may be divided into two parts; the calculator, which determines the dive angle, θ; and the mixing system, which censures the original calculation by combining the dive angle with the pitch angle, and sends the result to the autopilot.

The calculator works on the equation, $R_s \sin\theta - H = 0$.

where: R_s is slant range
θ is the dive angle
H is altitude

This equation is set up by conventional means, utilizing potentiometers and a servo loop. The desired solution is the angle called "θ". In order to track altitude and range, some means must be on hand to determine when the potentiometers are at the correct position. In order to accomplish this, linear potentiometers are ganged to the range and altitude potentiometers, across which a direct voltage is impressed. This voltage feeds into a circuit which has the property of developing a marker, delayed in direct proportion to the applied voltage. By this method altitude and range pips are placed on the P.P.I. screen. With the "R " servo motor driving the range potentiometer and APG-5 servo driving the altitude potentiometer, the operator need adjust only the elevation angle (sine potentiometer) to furnish complete information to the computer.

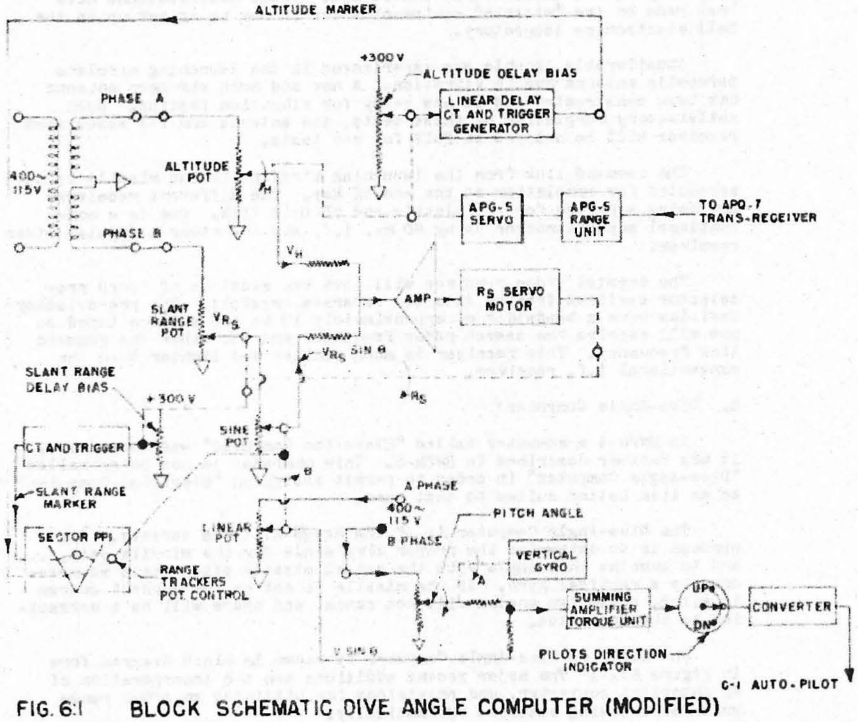


FIG. 6:1 BLOCK SCHEMATIC DIVE ANGLE COMPUTER (MODIFIED)

Ganged on the arm of the sine pot is a linear pot with an alternating voltage impressed across it. This voltage is then combined with an out of phase voltage from a vertical gyro. The combination of these two voltages is fed into a summing amplifier and then to an autopilot-converter. The converter then goes directly to the C-1 autopilot. If the sum of these voltages is zero, the missile will be on the desired course.

7. FLIGHT TEST

a. Review of Flight Testing Program:

In the first bimonthly progress report, BMPR-1, dated June 29, 1946, pages 21 through 25, a flight testing program was outlined. This program has been followed, with minor revisions, for ten months. It is the purpose of this review to analyze our progress in following the program, which is as follows:

"1. Television Link, Air-to-Air

A. The objectives are:

(1) To demonstrate that an air-to-air television link is feasible."

Two types of air-to-air video links have been investigated; the Block 3 Television System and the Raythson Video Relay Link. The Block 3, used to transmit a television picture, has been demonstrated air-to-air at ranges in excess of 100 nautical miles. A link for transmitting a radar picture, manufactured to our specifications on a subcontract, has been designed and built, as a breadboard, and is being installed in the flight test vehicles.

"(2) To develop a method of synchronization.

This refers to synchronization of a radar picture transmitted over a video link. A method of sweep synchronization has been developed and demonstrated and a method of azimuth synchronization is in work.

"B. Procedure:

(1) Obtain and install microwave transmitter and receiver. (Block 18 or X-Band); adapt to sector PPI (APQ-7) scanner and indicator."

Block 18 has not been available so Bell Aircraft let a subcontract to Raythson who has delivered a breadboard Video Relay Link which operates in the X-Band region. It is being bench tested prior to installation. In addition, a Block 3 television link was obtained, installed, tested, and modified for air-to-air transmission of television pictures at ranges of 60 to 100 nautical miles. The Video Relay Link has yet to be flight tested.

"(2) Design, build, and install gyro stabilized transmitter antenna."

The antennas for the Video Relay were supplied by the subcontractor. Bell Aircraft has designed, built, and is now bench testing gyro stabilized platforms to support these antennas. In addition, a yagi antenna was designed, built, and installed with the Block 3 transmitter in order to attain long range operation. The Video Relay Antennas have yet to be flight tested.

"(3) Study effect of ground reflections, phase interference (fading) and time delay (ghosting)."

Thus far, fading and ghosting tests have been made air-to-air with Block 3 transmission. Tests have indicated that fading, if present, is not evident, and that ghosting, very much evident for certain conditions at short ranges, is not troublesome at ranges in excess of 60 nautical miles. Similar tests are scheduled for the Video Relay Link.

"(4) Test various methods of sweep synchronization."

A method employing a microsecond pulse coder and decoder has been developed and tested in the laboratory for use with the Video Relay Link. The Block 3 supplies its own sweep synchronization. Synchronization signals sent over the Video Relay Link have yet to be flight tested.

"2. Missile Search Radar System

A. The objectives are:

(1) To obtain first-hand experience and data on the optimum relations which exist between missile speed, scanning rate, resolution of scanning system, time required at various ranges to find and track various targets, etc."

Efforts to accomplish these objectives have been numerous. An Eagle (AN/APQ-7) search radar system has been flown as a narrow (0.4°) beam radar, and a bombing (AN/APQ-23) search radar system, as a wide (1.4°) beam radar for terminal guidance. The M.I.T. K-Band Rapid Scan Search Radar has been resurrected and is being put in shape by a subcontractor for future installation and dive tests. A Projection Terminal Guidance Analyzer is being assembled to project films of both television and radar presentations taken during dive tests. The films will be projected at increased speed so as to simulate conditions at 1200 mph, for analyzing a human operator's ability to read the presentations at supersonic speeds. An Ultrasonic Terminal Guidance Analyzer is being made from a modified AN/APQ-13T1A bombing trainer to simulate 1200 mph terminal guidance conditions. These various projects will cover all of the objectives quoted above.

"(2) Effect of rapidly varying aspect on target recognition."

Roll and pitch variations have intentionally been introduced during dive tests. Large magnitude variations confuse the presentation, but variations associated with normal course corrections are not objectionable. More data is to be obtained from the Terminal Guidance Analyzers.

"(3) Requirements and usefulness of offset techniques."

Offset points giving distinctive radar return have been used visually for initially locating less prominent targets. However, more attention will be directed to this problem when direct target approaches have been investigated more thoroughly.

"(4) Distance to begin search; maximum range required."

This is a function of airspeed and target characteristics, of which more will be learned with the Terminal Guidance Analyzers. At B-17 speeds, 20 miles is sufficient for average targets.

"(5) Desirable range scale variation for tracking method chosen."

It has been found that continuous range scale expansion, so as to keep the target two-thirds of the way from the bottom of the PPI sector, gives an easily readable picture with present tracking methods.

"(6) Evaluation of alternative methods of tracking and computing."

Various methods of tracking and computing have been considered and breadboard models for both the azimuth and pitch problems are being flight tested and revised as the tests progress.

"(7) Frequency and continuity with which scope must be checked, for these alternatives."

Tests to date indicate continuous observation and tracking of the scope presentation to be preferable, and aided tracking to be desirable.

"(8) Requirements for roll and pitch stabilization of search antenna."

B-17 tests included pitch changes of five degreas, at retas allowable with the aircraft, which showed little or no adverse affect. Rolls which were nsceesary for B-17 turns in correcting the coursa to target tended to confuee ths radar picture but do not rssult in loss of target. However, for these teste the target could not be along the roll axis of the aircraft because of the antenna configuration. It is axpected that tha K-Band Rapid Scan System will provide bettar data.

"(9) Stability and suitability of the range-altitude system for computing tha approach glids angle."

A model of such a computing system ie being flight tasted and has been suitable in initial tests. Tests ara continuing to determine limitations and to improva tha modal.

"(10) Faasibility of steering to collision at 600 mph relativa velocity by constant bearing principle (optical and radar) sighting, with baacon carrying plana as target."

Such air-to-air tests have not baen attempted, nor ars they presently intanded. Tha contract has been changed to raquire 1200 mph, which would raqu..e two aircraft flying 600 mph reciprocal headings. Instead, an AN/APQ-13T1A bombing trainer is being modified to attack the problem under simulated 1200 mph conditions, as a Terminal Guidance Analyzar.

"B. Procedure:

(1) Fly with APQ-7 and APQ-16 systems to becoma familiar with operation and application possibilities."

Repaatad attampte to obtain demonstration flights with APQ-16 have been uneuccessful. APQ-7 familiarization was accomplished aftar we procured an installation.

(2) Study desirabla methods for obtaining data modificatione appropriata to Q-7, layout program."

This study and planning was accomplished prior to recaipt of an AN/APQ-7 system.

"(3) Modify Q-7 syetam to provide optimum (variable) range scalas, PRR, scopa spot siza, etc., for flight sxperimantation."

These and othsr modifications wsre triad on a bench setup of AN/APQ-7 befora ths flight installation arrived. Laboratory work has continuad since then, interlaced with flight tests ae needed.

"(4) Install Q-7 in B-25."

Such an installation was investigated and startsd, but then eliminated in favor of an AN/APQ-7 alrcady installed in a B-17.

"(5) Flight teeting: directed toward above objectives."

Mors than 30 flights have baen accomplished since the flight test vehicla was receivad in January.

"(6) Further study and appropriata flight tasting."

Flight testing and laboratory work are continuing in a coordinated program to study the Rascal Guidanca Schema and to provide information for the final design. The present AN/APQ-7 model will be rsplaced or supplemented with the K-Band Rapid Scan System when the latter is available for flight tests.

"(7) Check item (10) of objectives as early as possible (a) with just two airplanes; (b) with Eagle with or without a beacon in target."

This has yet to be checked and is presently assigned to the Ultrasonic Terminal Guidance Analyzer as stated above.

"3. Radar Tracking and Guiding of Missile

A. The objectives are:

(1) To demonstrate the error in determing relative location of a beacon-carrying missile or airplane and target, at a range of 60-100 miles."

Tests have shown that either a target or beacon can be located within ±1 degree and ±1000 yards at these ranges. However, these data are not yet available in usable form for the guidance scheme. Data in usable form is available at much less accuracy.

"(2) To demonstrate the accuracy with which missile may be steered to target using various methods of tracking and computing steering signals: must scope be tracked continuously?"

Many different methods have been considered and a simple method is being tested. It involves instantaneous reading of bearing from missile to target and relaying it as a compass heading to the missile.

"(3) To demonstrate probable maximum angles between missile heading and launching plane-to-target line during (2) for use in determing required television antenna pattern."

Tests have indicated that the guidance scheme imposes minor limitations on this angle. The major limitations on the relay link (formerly called television) antenna pattern are imposed by the aerodynamic turning response of the missile and the aerodynamic limitations on antenna size and shape.

"B. Procedure:

(1) Become familiar with APQ-23 (and APQ-24) operation."

The APQ-23 was bench checked before installation and APQ-24 developments have been followed at Wright Field.

"(2) Modify, if necessary, and install Q-23 in a B-17, and beacon (APN-11) in missile."

The AN/APQ-23 was modified for simultaneous beacon and radar operation and both AN/APQ-23 and AN/APN-11 were installed.

"(3) Install also in the B-17:

(a) Television receiver and indicator."

Block 3 television and its indicator have been installed and used with the missile having television "eyes". A video relay link receiver and indicator have yet to be installed for use with the missile having radar "eyes".

"(b) Tracking system and computer."

Tracking systems and computers have been constructed in breadboard fashion and installed where needed. In order to simplify the layout, the computing system has been divided so that some components are in the mother and some in the missile. Work on computers is continuing.

"(c) Control Transmitter."

A radio transmitter has been installed for controlling the missile with television "eyes". The missile with radar "eyes" will be controlled over the two-way video relay link.

"(d) Antennas."

Antennae have been installed as necessary. In addition to the GFE antennas supplied, a video relay link antenna has been designed and is being gyro stabilized.

"And in the missile:

(e) Autopilot-servo system with directional gyro and/or compass."

In the B-25 television missile, an autopilot which is slaved to compass has been installed and adapted to remote control. In the B-17 radar missile, an autopilot which came installed in the aircraft is slaved to a directional gyro, and is being adapted to remote control.

"(f) Television transmitter and antenna."

Block 3 television has been installed in the B-25 missile and a new antenna designed and installed for 100 nautical mile transmission ranges. The B-17 radar missile will have a video relay link installed between it and the B-17 mother. Its antenna has been designed and is being gyro stabilized.

"(g) Control receiver."

A control receiver has been installed in the B-25 television missile. The two-way video relay link will carry control signals to the B-17 radar missile when it is installed.

"(h) Miscellaneous control equipment (including APQ-7)".

AN/APQ-7, the Eagle radar, came installed in the missile B-17, which was a major factor for using such a large aircraft to simulate a missile. Other equipment has been installed as needed.

"(4) Flight Testing:

(a) Relative position error, missile seen from B-17."

Both air-to-ground and air-to-air tests have been made using the missile beacon and the Mother search radar at ranges of 60 to 100 nautical miles. Tests have indicated that relative positions are determined within accuracy of reading search radar presentation. With 100 miles, full scale range, the error is in the order of plus or minus one mile in range and plus or minus one degree in azimuth. Using range delay and short range scale, the range accuracy can be increased, but a map presentation no longer exists. These tests are essentially complete.

"(b) Error when guided by various systems (APQ-23 only)."

A desired missile heading may be determined from the Mother search radar by determining relative positions of Mother, missile, and target, with errors as mentioned in the paragraph above. These errors combine to make the inaccuracies in the computed missile heading increase as the missile nears the target. The results of the combined errors have yet to be determined.

Determining a desired missile course correction requires, in addition to the above, the plotting of a preset missile course. This alternate system of guiding does not look promising but may be tried should the first system prove difficult.

"(c) Stability of various guiding systems (APQ-23 only)."

With the system of guiding which is presently being worked out, only two fixed missile headings are determined by the Mother search radar: one at the time of launching and another when the missile is about 20 miles from the target. Here there is no stability problem involved. Should an alternate system be tried later, which requires that the missile course corrections be determined from the Mother search radar system, then the stability problem will enter.

"(d) Time required for control (continuous or intermittent)(APQ-23 only)."

As presently planned control will be intermittent, requiring two course determinations. For the first, prior to launching it is necessary to determine the wind and compute a corrected heading to get the proper missile course to the target. Tests have indicated that wind determinations, either radar or optical, take about 15 minutes, after which the calculation consumes a negligible one minute.

It is expected that the second missile course determination, when the missile is about 20 miles from the target, can be read directly from the Mother search radar, this operation requiring about one minute set-up time. However, further tests are required to measure the time for the second determination.

"(e) Error in cruising preset."

A series of flights have been made with the Mother B-17 during which it determined, at 100 miles from the target, a wind corrected missile course. The Mother B-17 then flew this course simulating the missile after launching. Of course the B-17 flew the launching-point-to-target course at about one sixth of 1200 mph, thereby effectively increasing the actual wind factor by six times for the simulated case. Tests made were with winds up to 50 mph, which multiplied by six would simulate winds up to 300 mph. Errors in the cruising preset course were a maximum of twelve nautical miles, a minimum of less than 1000 feet, and an average of two or three nautical miles to one side or the other of the desired course for a 100 nautical miles distance. The maximum error was caused by a wind shift associated with a weather front and would have required a 3½ degree correction at 20 miles from target. Average errors indicate the course correction just prior to terminal guidance will often be unnecessary, being of the order of 5 to 9 degrees. More data will be forthcoming from two aircraft missions which will simulate conditions with separate missile and Mother aircraft.

"(f) Accuracy of first course correcting signal."

This refers to the course correction just prior to terminal guidance, which is determined in the mother and relayed to the missile. Initial tests have indicated difficulty in determining the proper correction from the Mother search radar. With suitable antennas for the missile radar beacon, it is possible to get positive identification of missile position. With suitable changes to the Mother search radar, it is possible to read both beacon and the search radar map simultaneously. However, the problem of sharp target definition 100 nautical miles away, from direct radar return or from offset target return, is still being investigated for necessary improvements.

"(g) (b), (c), and (d) with radar-television systems (i.e., with complete system)."

The complete system of guidance from the Mother prior to terminal guidance is presently having its initial tests. Terminal guidance is included in these tests with only television missile "eyes." Results are not yet significant. After completion of the radar relay, the complete system will be tested using radar "eyes" for terminal guidance.

"(h) Time to yaw missile and lateral acceleration."

It has been found in flight tests that the time elapsed between determining a correction from the Mother search radar and the execution of the correction by the missile is serious even at the speeds of the present flight test vehicles. The problem is presently in work.

"(i) Observe maximum angles of missile heading and launching plane-to-target line during above tests.

These tests are in the initial stage, with the angles yet to be determined.

"4. P-80 or B-25 'Missile'

Three possible uses are:

(1) As missile with target seeker and autopilot. Such a system we are considering only in case the radar television scheme proves impracticable."

Instead, the program is using both a B-25 and a B-17 as missiles. Television is used as the "eyes" for terminal guidance in the B-25 and radar is used in the B-17. Target seekers have been considered, but have not yet been used because of their inherent tactical limitations. They require that the target have some light, heat, or radar reflecting characteristic which is different from the surrounding area.

"(2) As a beacon-carrying missile, radio-controlled and guided only by APQ-23 information, as in 3-B, 4-b, c, d."

AN/APN-11 beacon equipment is used in the B-25 missile in conjunction with the APQ-23 Mother search radar to provide a course correction to target just prior to terminal guidance. One of the functions of the Video Relay Link in the B-17 missile will be to provide a similar beacon signal.

"(3) As missile in full television system."

The B-25 and B-17 missile are being used in working towards two complete systems, one using television "eyes" in the missile and the other using radar "eyes".

"5. Equipment Required

(1) GFE as requested in letters to Wright Field, References (c) and (e)."

A time lag of from three to nine months existed in obtaining the major portion of the initial requests. Since then a system has been worked out with which the time between request and receipt of GFE items is usually kept down to a minimum, which is primarily the time consumed in freight shipments. Express shipments would alleviate this condition. This lag in receipt of equipment has been a major difficulty at times and continues to be troublesome.

"(2) Additional test equipment and material."

It has been obtained or substituted for as needed.

"(3) Additional GFE: Command Link and auxiliaries, etc."

Additional GFE continues to be requested as the need arises, and in due time it usually arrives.

"(4) X-Band television link.
(5) X-Band command link."

For the television missile, two separate GPE systems have been procured and used. For the radar missile, the Video Relay Link built to our specifications by Raytheon on a subcontract is expected to perform both functions.

"(6) Antennas:

(a) Missile Search gyrostabilized.
(b) Command and Television Receiver for B-17."

The missile search antenna has not been gyrostabilized because of the obvious difficulty to be encountered with the Eagle antenna. Tests to date indicate little advantage in stabilizing present flight test models. The Video Relay Link antennas, however, are being stabilized.

"(7) Interim Search Radar for Missile, perhaps 3-4 mm. or 9 mm. system."

The closest available system is the K-Band Rapid Scan System which is being resurrected by a subcontractor.

"(8) Research on 3-4 mm. radar system."

Aircraft Radiation Laboratory started to initiate this work, but when the program did not materialize, subcontracts were let to study possibilities for the missile search radar. These subcontracts are presently in work.

"(9) Range-altitude computer system for glide path control."

A model of this computer has been built and flight tested. Improvements are now in work.

"(10) Other computers:

(a) For first course correction.
(b) GPI system.
(c) Accelerometer system."

The first course correction is presently being attempted by a method which does not require computation. However, a GPI system, such as AN/APA-44 might be adapted to materially aid the case; hence, the accuracy of the correction. Accelerometers have been studied and a model built, but as yet they have not been incorporated into the computers presently being developed for the missile.

"(11) Telemetering proportional control, for television and command systems."

Two types of proportional control are in work. One, being installed in the B-25 missile, operates from an off-on signal with a 10 cycle per second fundamental frequency. The other, being developed to work over the Video Relay Link, uses microsecond pulses and a time base of the order of milliseconds.

"(12" Timers"

As yet the problem of timers has had only preliminary investigation. Timers have not yet been necessary in the flight test program.

b. Flight Test Summary:

A total of 43 flights have been completed during the period of this report. Of these flights, 6 were dual missions pertaining to the Mother and Television Missile; 10 were by the Mother alone; 4 by the Television Missile alone, and 23 by the Radar Missile alone.

Of the 16 Mother test flights, 9 were for preset guidance checks, 2 were beacon antenna pattern and maximum range checks, 3 were television ghosting and maximum range checks, and 2 for complete Mother-Missile missions.

The 9 preset guidance flights (50-38, 53-41, 57-43, 57-44, 58-45, 59-46, 59-47, 61-48, 62-49) made up a series in which the AN/APQ-23 equipped airplane served as both Missile Carrier and Missile; i.e., served as Missile Carrier in navigating to the launching point, determined windage and proper heading from the launching point to the target, and flew the course the Missile would have flown from the launching point to the target. Optical and radar wind determination procedures were compared and evaluated, and accuracy of preset courses determined. It was found that radar determined winds are reliable and that 100 nautical mile runs on preset courses to targets could be flown with an average accuracy of about 2 to 3 miles lateral miss. In one extreme case, in which a weather front was encountered, a wind change of 17 degrees in direction and 65 per cent in magnitude gave a lateral error of 12 miles. This test is not considered serious, since errors caused by weather fronts could be expected and compensated for by careful perusal of available meteorological data.

The beacon horn antenna beam width, in the horizontal plane was determined on flight 48-36 in which the beacon-equipped B-25 remained on the ground while the radar-equipped B-17 was airborne. The width was 50 degrees at a nominal range of 60 nautical miles and at an altitude of 19,000 feet. The beam width was measured again during flight 53-42 in which both ships were airborne. The beam width was 35 degrees at a separation distance of 90 nautical miles range and an altitude of 10,000 feet. Also on this flight a maximum beacon range of 150 nautical miles was obtained, in which reception was intermittent and not considered reliable. However, consistently good return was had at 130 nautical miles, and this is considered the reliable maximum range.

Flights 49-37, 50-39, 51-40 were flown in conjunction with television testing and the beacon was used to furnish ranges between the two aircraft. Beacon ranges up to 110 nautical miles were obtained on these flights.

The Mother-Missile missions are mentioned later in connection with television.

The twenty-three flights made while testing the AN/APQ-7 (Eagle) radar can be broken down into several categories.

Satisfactory results were obtained on flights 50B-(16) and 56B-(23) from a mechanical azimuth computer whose indications were fed into a PDI on the flight panel. Development of an electronic azimuth cursor is proceeding in the laboratory. Tie in with the C-1 autopilot azimuth control awaits completion of laboratory tests.

On flights 52B-(18), 57B-(24), 59B-(27), 59B-(28), and 60B-(29) flight test and design analysis of the range altitude computer have satisfactorily solved the problem of accurate corrected missile angles to targets. With the computer output feeding a meter indicator on the flight panel, simulated collision runs on selected targets were successfully completed. Since these flights were made, work has progressed toward coupling the computer output directly to the C-1 autopilot elevation control.

A modified triple tone target discriminator circuit was flight tested on flights 55B-(22) and 62B-(33), and found to give unsatisfactory results. A circuit, redesigned on the basis of observed results, is now awaiting test.

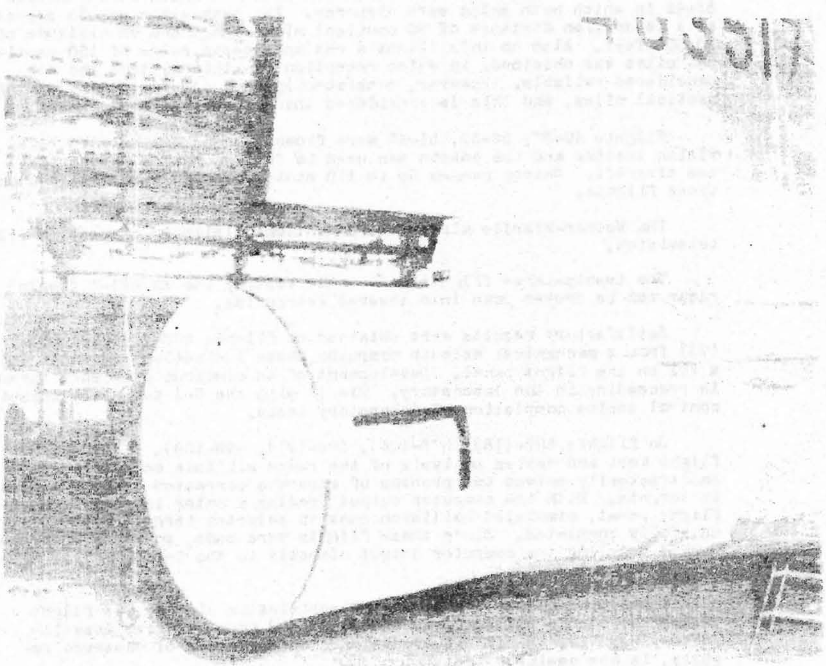
Several flights, 62B-(31), 62B-(32) and 62B-(35), at 20,000 feet level have been completed in order to observe the operating limitations of target location and approach. Consistent results have not been obtained; therefore, further tests at this altitude and above are indicated.

Simulated collision approaches, flights 47B-(13), 49B-(14), 4?B-(15), 51B-(17), 53B-(19), 54B(21), 58B-(26), to observe the effect of various range sweep modifications were tested and satisfactorily improved operation was obtained. This improved operation was obtained as a result of the flight analysis and redesign of various systems.

On flights 53B-(20), 57B-(25) and 61B-(30) the operating limitations of target location were observed in simulated missile drops from 17,000 feet at ranges of 20 to 25 miles. Evaluation of the data obtained has indicated a reliable accuracy within specification limits.

Photographic radar scope recordings have been made on several flights. Due to erratic camera operation, satisfactory films have not been attained. Since the fault appears to be inherent in the camera design, another type of camera has been ordered.

Preparations for installation of the relay link, together with associated AN/APQ-7 synchronizing components are proceeding as rapidly as laboratory development and the arrival of components will permit. The installation of additional power facilities in the B-17 awaits arrival of GFE equipment. Figure 7:1 shows the new tail modifications for housing the relay link.



In the course of the 10 B-25 airplane flight tests performed during this period, the first air-to-air television transmissions were performed since the B-25 aircraft was equipped as a missile.

On 10 March (flight 49A-(19)) the television transmitting equipment was given its first air check since the AXT-3 modifications had been made. By this change, it was possible to choose a picture of the terrain ahead of the aircraft, or a picture of a bank of flight meters set in a photo-panel. Operation was satisfactory at 60 statute miles. On the next flight (flight 50A-(20)) and on the following one (flight 51A-(21)) it was found that ghosting would offer no trouble at ranges beyond 60 statute miles and that signals were readable up to 125 statute miles. These limitations were acceptable in view of the fact that the mother plane will operate at 60 to 100 nautical miles from the target.

The B-25 missile was grounded on 13 March to allow installation of the F-1 Bendix autopilot in as short a time as possible. During this period the image orthicon television camera received its final check-out in the laboratory and was placed in the B-25 nose on a specially designed shock mount. The mount was so constructed that the operator, by a choice of switches, could vary its position in pitch and yaw, or cause it to be stabilized by wind vanes mounted on booms in the nose of the ship.

On 10 April, air checking of the autopilot was begun (flight 63A-(23)). Adjustment of the various controls continued in flight 64A-(24) and the new image orthicon was given its initial air check. In the next flight (65A-(25)) the F-1 autopilot installation proved satisfactory and required no further adjustment; the image orthicon, however, developed a fault and failed to operate. With the image orthicon repaired and working satisfactorily, flight 66A-(26) illustrated the camera's high degree of usefulness when it produced a picture of such clarity that the television observer in the B-25 could guide the ship into five direct hits. In this flight the F-1 control head was operated from the television station, simulating conditions under radio control.

In flight 67A-(27), flown in conjunction with 67-(50), a preliminary flight was made, controlling the B-25 verbally from the B-17, with all units installed except the tie-in from radio control to autopilot. Control was maintained by oral instructions to the B-25 pilot. In two of the three dives attempted, the television operator failed to distinguish any target at all. This was caused by a mist in one case and by an error in previous "aiming" of the missile in the other. The third dive, on Niagara Falls Airport, showed distinguishing landmarks at five miles range, from which point the missile was successfully directed over the target.

On 24 April, flights 68A-(28) and 68-(51) yielded useful data on the performance of the entire television system. In four controlled dives, the average range at which large objects, shorelines, etc., could be distinguished clearly was ten to fifteen nautical miles. Absolute target identification was quite difficult, and could be adjudged completely reliable only within five miles. In the case of a ship on the water, or a target located near a band in the river, hits should be scored consistently from ten miles.

In the line of conclusions and results, no difficulty has yet been experienced with the television equipment from cross wind effects. Any chosen object on the television screen can be hit within limits. The problem of distinguishing a specific target from such a thing as a field is much more difficult, however, and will require a great deal of experience on the part of the operator as well as a thorough familiarization with the terrain. This need for experience and familiarization is likewise true for operation of the radar equipment, since a marked improvement in the operator's ability to "see" targets has been manifested since this flight testing program was originated.

c. Autopilot Evaluation:

No further evaluation of the F-1 Bendix Autopilot has been realized as components removed from the P-63 have been in use in the laboratory Radio Control mock-up and B-25 Azimuth Control programs.

Evaluation of the Sperry A-12 has been discontinued in the interests of economy, but the following performance and limitations were observed:

(1) The particular vertical gyro supplied, developed minor mechanical difficulties but after these were corrected performed perfectly as a source of pitch and roll intelligence within the limits of its design. Tumbling occurs at approximately 85 degrees pitch or roll with re-erection requiring about two minutes. No means of caging is provided and therefore, it is not adaptable to high maneuverability gyropilot configurations.

(2) Two servo sizes are available with four power gear ratios optional, thus allowing for a wide range of servo speeds. Six ratios of repeatback gear clusters are also available to match the response characteristics of the aircraft. In addition to the gear cluster changes por 'ile, a simple change of voltage divider values in the repeatback network allows additional latitude of adjustment. Application of surface at all times was exceptionally smooth.

(3) The A-12 Gyropilot was primarily designed for multi-engined craft where no torque problem is presented and coordination is accomplished by zeroing rudder servo output. Coordination of this type should be satisfactory also for jet and rocket powered vehicles, but was definitely unsatisfactory for the P-63 where torque varies proportional to air speed and certain conditions may require left rudder for right turns. A yaw intelligence pick-off from a Ball-Bank indicator or a pendulous mass could be devised to accomplish coordination under torque conditions.

(4) Altitude control can be made to maintain altitude in level flight or turns to plus or minus fifty feet even under turbulent conditions at low altitudes.

(5) The Sperry system of rate derivation from displacement errors provides a wide range of rate changes by simple voltage division that can be carried still further if integration components are altered.

In the interests of economy the proposed program of recording response to transients injected in series with gyro intelligence was cancelled and all evaluation was made by observation of pilot and engineer.

d. Radio Control Adaptation:

The Bendix Radio Control Program is to proceed with a complete check of functions by laboratory mockup and installation in the P-63 airplane. Work on the basic radio control configuration plus Azimuth selection by proportional control is to be the first objective with research of altitude control, rate of climb control and acceleration limiting held in abeyance.

Analysis of the Lear Autopilot is awaiting the receipt of design data and autopilot components.

BELL Aircraft CORPORATION

APPENDIX I

(FLIGHT TEST REPORTS)

REPORT NO. BMPR-6

40-A

BY: E. Gorin DATE: 3/7/47	**BELL** Aircraft CORPORATION	MODEL: B-173	PAGE:
CHECKED: E. Gorin DATE: 3/25/47		AIRPLANE: 44-93439	REPORT:

FLIGHT TEST REPORT

PROJECT: MX-770 **PLACE:** Niagara Falls Airport **FLIGHT #:** 48 (36)

PURPOSE: To determine the maximum range and beam width of the beacon horn antennas at maximum and intermediate ranges.

TEST EQUIPMENT: AN/APQ-23 installed in B-173
AN/APN-11 installed in B-25J

CHANGES SINCE LAST FLIGHT: None

PILOT:	H. A. Dow	**GROSS WGT.:**	48,534
CO-PILOT:	J. Frits	**FLIGHT TIME:**	2:15
TEST ENGINEER:	E. Gorin	**TOTAL TIME:**	55:33

WEATHER: Overcast and scattered at 3000 feet

TAKE-OFF TIME: 13:53

PRE-FLIGHT TESTS:

Receiver Sensitivity (With simultaneous operation of Radar and Beacon local oscillators).

Radar:	101 -DBM
Beacon:	84 -DBM
Power Output:	42 +DBM

1. Method of Testing: The B-25J parked on the Bell Aircraft Ramp was aligned by radio compass with its tail (containing the beacon horn antennas) in line with and directed toward CHML (900 kc) at Hamilton, Ontario. The B-173 then flew over the B-25J on a course to Hamilton and began a climb so as to reach an altitude of 20,000 feet when 100 nautical miles from the B-25J. The maximum beacon range and the beam widths were to be determined along this flight path.

2. Results: At a range of [illegible] nautical miles from the B-25J, the beacon signals fluctuated for a few moments and then disappeared completely. The B-173 turned and headed back toward the B-25J while the beacon equipment was being checked. At 60 nautical miles from the B-25J, the beacon again became operative. The B-173 then resumed its original course.

At 90 nautical miles the beacon failure recurred, and the B-173 headed back toward the B-25J while maintaining altitude. When the beacon became operative once again, at a range of 65 nautical miles, time did not permit a further attempt at determining the maximum range; instead, the beam width at a nominal range of [illegible] nautical miles and at an altitude of 19,000 feet was determined.

BY: E. Gorin DATE: 3/7/47	**BELL** Aircraft CORPORATION	MODEL: B-173	PAGE:
CHECKED: E. Gorin DATE: 3/25/47		AIRPLANE: 44-93439	REPORT:

FLIGHT #48 (36)

2. Results: (Continued)

Since the heading to the B-25J was 110 degrees magnetic, the transverse headings taken to find the beam width were 20 degrees and 200 degrees magnetic. The beacon signals disappeared at a relative bearing of 112 degrees on the 20 degree heading, and at a relative bearing of 242 degrees on the 200 degree heading. The beam width, therefore, was 50 degrees at a nominal range of 60 nautical miles and an altitude of 19,000 feet.

3. Conclusions: An average maximum beacon range could not be determined due to the beacon failure; however, the appearance of the signals at 90 nautical miles indicated that the previous maximum range of 122 nautical miles might have been duplicated.

Post-flight investigation revealed that a loose tube in the beacon receiver had caused the intermittent beacon failure.

It is intended to make further beacon width tests at various ranges to determine the useful beacon antenna pattern.

EG:emh

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REPORT NO. BMPR-6

-42-

BY: E. Gorin	DATE: 3/10/47	BELL Aircraft Corporation	MODEL: B-17G
CHECKED: E. Gorin	DATE: 3/14/47		AIRPLANE: 44-83439

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 49 (37)

PURPOSE: Test operation of television and Radar beacon equipment at short range in air-to-air transmission.

TEST EQUIPMENT: AXT-3 television transmitter installed in B-25, and AXR-1 television receiver installed in B-17. APN-11 installed in B-25, and APQ-23 installed in B-17.

CHANGES SINCE LAST FLIGHT: None

PILOT:	R. H. McNiece	**GROSS WGT.:**	48,534
CO-PILOT:	None	**FLIGHT TIME:**	:50
TEST ENGINEER:	J. Newman, Television E. Gorin, Radar Beacon	**TOTAL TIME:**	56:20
WEATHER:	Scattered clouds 3000 to 7000 feet.		

TAKE-OFF TIME: 15:25

PRE-FLIGHT TESTS:

APQ-23 Receiver Sensitivity (Radar-Beacon Combined)
Radar: 101 -DBM
Beacon: 82 -DBM
Power Output: 42 +DBM

1. Method of Testing: The B-25 and the B-17 were climbed to an altitude of 10,000 feet, and both set a course east over Lake Ontario with a differential speed of 120 mph until the B-25 was 70 miles in the lead. The television and Radar beacon were operated alternately to determine television and beacon performance at exact ranges as determined by the beacon.

2. Results: Television - Reception in the B-17 showed erratic transmitter operation in the early part of the flight. At 45 statute miles separation, performance improved when transmitter was retuned. From that point to 70 statute miles the picture received was clear and readable. Switching operation from one conversion unit to another in the B-25 worked satisfactorily.

Radar Beacon - Operation was satisfactory, although weaker than air-to-ground operation, up to 60 nautical miles, when due to lack of time, the flight was terminated.

3. Conclusions: Television - The short range transmission was satisfactory. The equipment is now ready for determining maximum range of the AXT-3, for comparison with the range obtained with the AXT-2.

Beacon - Operation will probably give no difficulty, and a range of over 100 nautical miles appears probable.

EG:emh

Form 84-41

BY: E. Gorin	DATE: 3/11/47	BELL Aircraft Corporation	MODEL: B-17G
CHECKED: E. Gorin	DATE: 3/14/47		AIRPLANE: 44-83439

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 50 (38)

PURPOSE: Make a preliminary familiarization flight to determine accuracies of pre-set simulated missile courses to targets.

TEST EQUIPMENT: APQ-23 Installed in B-17G

CHANGES SINCE LAST FLIGHT: None

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PILOT:	R. H. McNiece	**GROSS WGT.:**	48,534
CO-PILOT:	J. Fritz	**FLIGHT TIME:**	2:35
TEST ENGINEER:	E. Gorin	**TOTAL TIME:**	58:55
WEATHER:	Overcast from 2000 to 9000 feet		

TAKE-OFF TIME: 10:15

PRE-FLIGHT TESTS:

Receiver Sensitivity: 101 -DBM
Power Output: 42 +DBM

FLIGHT CONDITIONS:

True Airspeed 220 MPH
Wind 15 MPH from 240 Degrees
Altitude 10,000 Feet

1. Method of Testing: Target identification, position of aircraft, and headings to targets were all determined from the North Stabilized Radar PPI Scope, simulating overcast conditions. The B-17 was set over a launching point, a heading to the target read from the scope and given to the pilot, who immediately set the B-17 on this heading. When over the launching point, a mechanical cursor line was set to intersect the target, and the reading of this line on the scope compass rose was the heading given the pilot. The ranges from initial launching points to targets were between 70 and 100 miles. After the B-17 flew about 10% of these ranges, or enough to indicate on the scope (target moving to the right or left of the cursor line) that a course correction was necessary, a correction was given the pilot. This correction was taken as the angle between the cursor line and the target, and was a first approximation for the wind drift angle. The time of this correction was taken as the actual launching point, and the heading from there was held constant into the target by the B-17 simulating a missile. Three runs were made, with the center of Erie, Pa., Buffalo, N.Y., and Humber Bay, Toronto, as targets.

Form 84-40

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FLIGHT #50 (38)

2. Results: Run No. 1 - The eastern edge of Erie about 1 mile from its center was hit.

Run No. 2 - The center of Buffalo about 2 miles south of the Niagara River was hit.

Run No. 3 - The center area of Humber Bay was hit.

3. Conclusions: The accuracies of these simulated missile pre-set courses are considered good. However, the wind was small, being about 7% of true airspeed, based on the pilot's estimate of the wind. The first approximation drift used was sufficient to give good results, but it is desired to determine accuracies of pre-set courses for 100 mile ranges using only one course setting. This precludes determination of wind direction and magnitude prior to setting the B-17 on simulated missile courses.

A series of future flights is indicated at this point, in which the B-17 mother will initially play the role of mother up to the launching point, and then assume the role of missile from launching point to target. That is, it will determine wind, and navigate to the launching point; determine the heading based on the wind and after reaching the launching point, it will fly that heading to the target as if it were the missile itself. This will include a comparison of optically and Radar determined wind, the testing of one or two Radar wind determination procedures, and the determination of the accuracy of the resultant pre-set courses based on these winds.

This will then prepare the way for dual mother-missile flights, in which the transition to the terminal guidance phase of directing the missile to the target will be tested, limitations determined, and technique developed.

Thus, the general scheme to be followed in future flights is indicated above, and should be borne in mind when reading the Flight Test Reports which will be associated with them.

EG:emh

BY E. Gorin DATE 3/11/47 BELL Aircraft CORPORATION MODEL B-17G PAGE
CHECKED E. Gorin DATE 3/12/47 AIRPLANE 44-83439 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 50 (39)

PURPOSE: Test operation and maximum range of television and Radar beacon equipment in air-to-air transmission.

TEST EQUIPMENT: AXT-3 television transmitter in B-25J; AXR-1 television receiver in B-17G. APN-11 in B-25 and APQ-23 in B-17.

CHANGES SINCE LAST FLIGHT: None

PILOT: J. A. Cannon
CO-PILOT: J. Fritz
TEST ENGINEER: J. Newman, Television
E. Gorin, Radar Beacon
WEATHER: Overcast to 5000 feet

GROSS WGT.: 48,634
FLIGHT TIME: 1:46
TOTAL TIME: 60:40

TAKE-OFF TIME: 15:03

PRE-FLIGHT TESTS:

APQ-23 Receiver Sensitivity (Radar-beacon Combined)
Radar: 101 -DBM
Beacon: 83 -DBM
Power Output: 42 +DBM

1. Method of Testing: The B-25 and the B-17 were climbed to 6500 feet and flew east over Lake Ontario with a differential speed of 150 mph until the B-25 was 30 nautical miles ahead of the B-17. The B-17 circled to increase range quickly, then tests were continued as range changed from 70 to 110 nautical miles.

2. Results: Television - The flight was performed over water to investigate "ghosting" under the worst conditions. Only a slight unobjectionable "ghosting" effect was noted at low range, which soon disappeared. Television reception was good out to the maximum range tested, which corresponds to about 125 statute miles. Beyond 80 statute miles noise was bothersome, but signal strength was consistently high enough for instruments to be read without difficulty. Weather prevented use of the conversion unit located in the nose of the B-25; therefore, the instruments were used as a "target" throughout the flight.

Radar Beacon - Satisfactory return was obtained on beacon operation alone out to a range of 110 nautical miles, when due to lack of time, the flight was terminated. Compared to previous air-to-ground operation, the return was weaker but definitely identifiable. Low beacon crystal current indicates improvement may be had by crystal and beacon local oscillator tuning.

FLIGHT #50 (39)

3. Conclusions: Television - Because of the slight presence of "ghosts", the next flight should investigate their effect for various possible altitudes and ranges, in order to determine whether they can be ignored. The range obtained confirms previous observations as to adequate performance of the yagi antenna.

Radar Beacon - Beacon return at 110 nautical miles, although faint, indicated a further possible range of 10 or more miles. On future flights attempts should be made to determine the maximum range of Radar beacon return.

RJ:emh

FLIGHT TEST REPORT

FLIGHT #: 51 (40)

PROJECT: MX-776 **PLACE:** Niagara Falls Airport

PURPOSE: Investigate "ghosting" effects on television signal so that antennas may be relocated if necessary, or effect ignored in future tests if interference is negligible.

TEST EQUIPMENT: AXT-2 television transmitter in B-25; AXR-1 television receiver in B-17; APN-11 beacon in B-25; APQ-23 Radar in B-17.

CHANGES SINCE LAST FLIGHT: None

GROSS WGT.: 48,534
FLIGHT TIME: 2:10
TOTAL TIME: 62:50

PILOT: J. A. Cannon
CO-PILOT: J. Fritz
TEST ENGINEER: E. Gorin & J. Newman

WEATHER: CAVU

TAKE-OFF TIME: 14:40

1. Method of Testing: In an air-to-air transmission the signal may go directly from aircraft to aircraft, or reflect from aircraft to ground to aircraft. The second signal gives an "echo" effect, which is known as "ghosting" because of the double pattern which results. The two aircraft were flown at various altitudes and ranges so that the presence of "ghosts" might be tabulated for various cases. Beacon and Radar were used to determine range.

2. Results: In general no trouble was found at short ranges. For each altitude there existed a range zone where "ghosting" was apparent. Beyond a certain range "ghosting" disappeared again. Results are tabulated below:

No.	Altitude	Range in Miles 1/2	1	3	5	10	25	35	45
1	1,000	-	-	-	-	-	-	-	-
2	2,000	1/8"F	-	-	-	-	-	-	-
3	5,000	-	-	1/4"S	1/8"S	1/16"F	-	-	-
4	10,000	-	-	-	1/2"F	3/8"S	1/8"F	-	-
5	15,000	-	-	-	-	3/4"F	3/8"S	1/4"F	-
6	20,000	-	-	-	-	-	-	-	1/4"F

NOTE: S - Strong. F - Faint.

When viewing meters it was at all times possible to "read through" the "ghosting", which destroyed the clean appearance of the picture but did not alter legibility of meter faces. The distrubance was quite serious when viewing terrain, however; the picture could not be readily interpreted.

BY E. Gorin	DATE 3/12/47	BELL AIRCRAFT CORP. NIAGARA FRONTIER DIVISION BUFFALO, N.Y.	MODEL B-17G	PAGE
CHECKED E. Gorin	DATE 3/18/47		SHIP 44-83439	REPORT

FLIGHT #61 (40)

3. Conclusions: "Ghosting" in the present television installation is present to an annoying degree in a narrow zone of ranges which vary with altitude. Inasmuch as the missile eyes are required to operate only beyond a 60 mile range from the Mother aircraft, which places it beyond all trouble zones, there does not appear to be any danger from this type of interference. To verify this statement, however, an additional flight should be performed in which "ghosting" is observed while flying at the ceiling of each aircraft and also while the B-25J missile is in a dive. If results of this flight are thereby confirmed, the present antenna locations need not be altered.

EG:emh

BY E. Gorin	DATE 3/17/47	BELL Aircraft CORPORATION	MODEL B-17G	PAGE
CHECKED E. Gorin	DATE 3/18/47		AIRPLANE 44-83439	REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 PLACE: Niagara Falls Airport FLIGHT #: 53 (41)

PURPOSE: Determine accuracy of a pre-set course to a target set from 100 nautical miles or more distance.

TEST EQUIPMENT: APQ-23 in B-17G

CHANGES SINCE LAST FLIGHT: None

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PILOT:	R. H. McNiace	GROSS WGT.:	48,534
CO-PILOT:	W. E. Gorin	FLIGHT TIME:	3:05
TEST ENGINEER:	E. Gorin	TOTAL TIME:	65:55

WEATHER: Overcast and scattered at 2000 to 6000 feet.

TAKE-OFF TIME: 10:15

PRE-FLIGHT TESTS:

Radar Receiver Sensitivity: 101 -DBM
Power Output: 42 +DBM

1. Method of Testing: Three runs were made, consisting of obtaining optical wind data (Run #1) and making two pre-set course runs (Run #2 and #3). Toronto, Ontario was the launching point and Mayville, N.Y., on the northwest tip of Lake Chautauqua was the target for Run #2. In Run #3, Erie, Pa., was the launching point and Montour Falls, N.Y., two miles south of Lake Seneca, was the target.

The B-17 mother determined wind and navigated to the launching points, and from launching points to targets flew as a missile on pre-set courses.

2. Results: The wind was computed, from the data determined in Run #1, to be from 258 degrees at 18 mph.

The target, Mayville, N.Y., in Run #2, was missed by 3 miles to the left.

In Run #3, the target, Montour Falls, was passed about 1 mile to the left.

3. Conclusions: The results were within the accuracy of the navigational instruments used, although less than the accuracy of Flight #60 (38), where the course to the target was set by Radar tracking of the target at a distance of over 75 miles from it.

Had the course of Run #2 been flown by a missile, it would have needed a 7 degree right correction at a range of 20 nautical miles from the target in order to have intercepted the target.

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BY E. Gorin DATE 3/17/47 | BELL Aircraft CORPORATION | MODEL B-17G | AIRPLANE 44-83439 | PAGE | REPORT
CHECKED DATE 3/17/47

FLIGHT #53 (41)

3. Conclusions: (Continued)

On Run #3, where the off-course error was less than a degree, at 20 nautical miles from the target missile would have required less than 2 degrees course correction to intercept the target.

From these results, it is seen that a missile "eye" would require a width in azimuth of at least 14 degrees with no intermediate course correction. However, more flights with higher winds will be flown to obtain more complete data.

EG:emh

BY P. Steck DATE 3/17/47 | BELL Aircraft CORPORATION | MODEL B-17G | AIRPLANE 44-83439 | PAGE | REPORT
CHECKED DATE 3/19/47

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 53 (42)

PURPOSE: Determine maximum operating range and usable azimuth beam of APN-11 beacon in air-to-air tests.

TEST EQUIPMENT: APQ-23 in B-17G - APN-11 in B-25J

CHANGES SINCE LAST FLIGHT: None

GROSS WGT.: 48,534
FLIGHT TIME: 1:35
TOTAL TIME: 67:30

PILOT: J. A. Cannon
CO-PILOT: H. E. Davis
TEST ENGINEER: P. Steck

WEATHER: Overcast - Scattered clouds 2000 to 8000 feet.

TAKE-OFF TIME: 14:50

PRE-FLIGHT TESTS:

Power Output (Average):	42 +DBM
Radar Receiver Sensitivity:	101 -DBM
Radar Receiver Sensitivity (Beacon):	85 -DBM

1. Method of Testing: Both the B-17G and the B-25J were flown at 10,000 feet on reciprocal headings until beacon signal was lost on APQ-23 Radar. The B-17G then turned and flew on the same heading as the B-25J until beacon signal was again picked up. When signal was obtained the B-25J increased speed so as to increase range until beacon again faded.

The B-17G and the B-25J flew toward each other until approximately 85 miles apart. At this point the B-25J turned on the same heading as the B-17G. With beacon signal well defined on scope, the B-25J made a slow flat turn to the left until signal faded. Amount of turn made by B-25J was determined with directional gyro. After the B-25J returned to correct heading, a right turn was made until signal faded. Difference in headings of B-25J when beacon signals faded indicated usable beam width of beacon antenna.

2. Results: As distance between the aircraft increased, first fading of beacon signal was noticed at 110 nautical miles. This occasional fading continued out to 135 nautical miles, when signal dropped out completely. When the aircraft closed to 130 miles signal was again picked up. Signal appeared to be of same strength, but there was no indication of fading. Range was increased to 142 nautical miles when fading was again noticed, and at 150 nautical miles signal was intermittent and weak to the extent that this range was considered the maximum.

BELL Aircraft CORPORATION

By: E. Stack	Date: 3/17/47	BELL Aircraft Corporation	Model: B-173
Checked: [illegible]	Date: 3/19/47		Airplane: 44-83433

FLIGHT #53 (42)

2. Results: (Continued)

When the aircraft were 90 nautical miles apart, the B-25J made a right and then a left turn. The beacon signal dropped out at headings of 65 degrees left and 100 degrees right, which gave a usable beam width of 35 degrees at that range. It was impossible to make these measurements at other ranges due to lack of time.

3. Conclusions: This test indicates that air-to-air transmission and reception of beacon is reliable and consistent out to 133 nautical miles, where it is possible to pick up the beacon after it has faded out. Ranges further than this are entirely possible, but not to the same reliable degree. Ranges obtained also check with previous air-to-ground tests.

The 35 degree usable beam width at 90 nautical miles differs considerably from 50 degrees at 60 nautical miles obtained on a previous test. It should be noted that the 50 degree beam width was determined in a different manner in air-to-ground tests; however, it is expected that the usable beam width will decrease with increasing range. It is desirable to obtain further data in the same manner as that described in this report to establish usable beacon beam width at other ranges.

ES:emh

By: E. Gurin	Date: 3/31/47	BELL Aircraft Corporation	Model: B-173
Checked: E. Gurin	Date: 4/1/47		Airplane: 44-83439

FLIGHT TEST REPORT

PROJECT: MX-776 PLACE: Niagara Falls Airport FLIGHT #: 57 (43)

PURPOSE: Compare two Radar methods of wind determination with optical method for use with pre-set missile courses.

TEST EQUIPMENT: AN/APQ-23 and optical drift meter in B-173

CHANGES SINCE LAST FLIGHT: None

PILOT:	P. H. McNiece	GROSS WGT.:	48,534
CO-PILOT:	Wm. Davis	FLIGHT TIME:	1:05
TEST ENGINEER:	E. Gurin	TOTAL TIME:	64:25

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WEATHER: Light scattered clouds.

TAKE-OFF TIME: 10:00

PRE-FLIGHT DATA:

Receiver Sensitivity: 101 -DBM
Power Output: 42 +DBM

1. Method of Testing: The first Radar method used consisted of correcting heading of the aircraft from the Radar presentation until a collision course with some Radar target was being flown. The angle between the heading marker and the target was the wind drift angle for that heading. The ground speed is measured simultaneously on this heading. From the ground speed, drift, and true airspeed, the wind was computed.

The second Radar method used, consisted of recording ranges and azimuths to any Radar target, and then plotting them on the rectangular grid section of an E6B dead-reckoning computer. With zero wind, the "track" of the Radar target would be parallel to the heading of the plane. With wind, this "track" would not be parallel to the heading of the plane, but would be at an angle to the heading equal to the drift angle at that heading. The length of the track would be the ground distance flown by the aircraft, and this distance divided by the time of track would give the ground speed. From the drift angle, ground speed and true airspeed, the wind was computed.

Drifts were measured by the optical drift meter simultaneously with the Radar methods.

2. Results: No drifts were obtained by Radar using the first method, due to the erratic behavior of the fluxgate compass, and what appears to be an inherent lack of accuracy in this method. The variation in area and shape of the target with range presents difficulty in selecting a point on the target for reference. [illegible] it appears that a small drift angle may not be measurable, or would be highly inaccurate.

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BY E. Gorin DATE 3/31/47 CHECKED C. Gorin DATE 4/7/47 | BELL Aircraft CORPORATION | MODEL B-17G AIRPLANE 44-83439 PAGE REPORT

FLIGHT #57 (43)

2. Results: (Continued)

The wind measured by the second method compared favorably with the one obtained on the optical drift meter:

Method	Wind
Optical	279 degrees at 28 mph
Radar	271 degrees at 30 mph

3. Conclusions: The first Radar method for determining wind data depends on the accuracy of the drift measured. Since these drifts could not be measured with any accuracy, at least for the ranges to the targets used (under 20 miles), it is indicated that longer ranges are necessary. This method will be tried once more in a future flight, using longer ranges to targets, but is presently considered inferior to any other.

The second Radar method, in addition to comparing favorably with the optical results, requires no heading changes of the aircraft, no separate ground speed measurements, and no special limitations on location of target with respect to the aircraft.

EG:emh

Form 94-1

BY E. Gorin DATE 3/31/47 CHECKED E. Gorin DATE 4/7/47 | BELL Aircraft CORPORATION | MODEL B-17G AIRPLANE 44-83439 PAGE REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 57 (44)

PURPOSE: Make further optical and Radar wind observations; to observe effect of a wind shift on a pre-set course to a target.

TEST EQUIPMENT: AN/APQ-23 and optical drift meter installed in B-17G

CHANGES SINCE LAST FLIGHT: None

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PILOT: R. H. McNince
CO-PILOT: Wm. Davis
TEST ENGINEER: E. Gorin

GROSS WGT.: 48,634
FLIGHT TIME: 2:00
TOTAL TIME: 71:25

WEATHER: Scattered and overcast over Toronto-Lake Erie Region - Overcast over Erie, Pa., Region

TAKE-OFF TIME: 14:05

PRE-FLIGHT TESTS:

Receiver Sensitivity: 101 -DBM
Power Output: 42 + DBM

1. Method of Testing: Drift readings were taken north of Toronto by the optical drift meter. Radar drift readings were also attempted, but were in error and not usable. From the wind determined north of Toronto, a course was set and flown to Erie from Toronto.

Due to a large wind change, another set of drift readings were taken over Erie, and from this wind, a course was set and flown to Buffalo.

2. Results: The Radar method of determining drift by flying a collision course to a target and measuring the relative bearing between the heading marker and the target, gave large drift reading errors. This was for target ranges from 30 to 40 miles. A fairly accurate drift by this method would be obtained if the target range were well over 50 miles and if time were available, under actual conditions, to fly about 30% of this range in order to set the aircraft on a collision course.

The wind, calculated from optical drifts measured north of Toronto, was 322 degrees at 30 mph at an altitude of 8100 feet. The true course to Erie from Toronto is 199 degrees, and the zero-wind heading is 206 degrees using 7 degrees west variation. The heading flown, correcting for wind, was 213 degrees. At 37 miles range the bearing to Erie was 15 degrees right, and at the end of the run, the B-17 was 12 miles east of Erie and its true course was 7 degrees left of the Toronto-Erie course.

Form 94-1

BELL Aircraft CORPORATION

CONFIDENTIAL

BY: E. Gorin DATE: 3/31/47 | CHECKED: E. Gorin DATE: 4/7/47 | BELL Aircraft CORPORATION | MODEL: B-17G | AIRPLANE: 44-83439

FLIGHT #57 (44)

2. Results: (Continued)

Another set of drift readings were taken west of Erie, and the wind was computed to be 305 degrees at 50 mph. Since there was a weather front, just west of Erie, moving east, the wind shift was to be expected.

Had a missile flown this course it would have required a 6 degree right correction to just bring the target into view of the television missile's "eye" (which has a 17 degree beam width) when it was at 20 miles range to the target.

Using the 305 degree, 50 mph wind, a course was set and flown to Buffalo. The center of Buffalo was the point aimed at. At 20 miles from Buffalo the bearing to the target was 10 degrees right, and the true course flown was 4 degrees left of the Erie-Buffalo course. A point approximately 3 miles north of the center was passed over at the end of the run.

3. Conclusions: Since drift determinations by the Radar collision course method gave poor results, they will be made in the future using the second Radar method, as outlined in Flight Test Report #57 (43).

An idea of the accuracy of a pre-set course to a target has been obtained from this and similar flights of this nature. In the future, simulated missile B-25 flights directed and observed from the B-17 Mother airplane will be made.

EG:emh

BY: E. Gorin DATE: 4/1/47 | CHECKED: E. Gorin DATE: 4/7/47 | BELL Aircraft CORPORATION | MODEL: B-17G | AIRPLANE: 44-83439

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 58 (45)

PURPOSE: Check comparison of wind determination methods for use with pre-set missile courses.

TEST EQUIPMENT: AN/APQ-23 and optical drift meter installed in B-17G

CHANGES SINCE LAST FLIGHT: None

CONFIDENTIAL

PILOT: J. A. Cannon
CO-PILOT: W. Davis
TEST ENGINEER: E. Gorin

GROSS WGT.: 48,534
FLIGHT TIME: 1:45
TOTAL TIME: 73:10

WEATHER: Overcast - Scattered Rain

TAKE-OFF TIME: 14:25

PRE-FLIGHT TESTS:

Receiver Sensitivity: 101 -DBM
Power Output: 42 +DBM

1. Method of Testing: Drift readings were taken optically, and the wind computed.

The wind was also computed by the second Radar method described in Flight Test Report #57 (43).

2. Results: The winds computed from the optical and Radar data compared favorably.

It is worth mentioning here that wind shifts were noted when flying over the lake shore. An overcast and rain squall were moving in at that time, which would account for wind changes.

3. Conclusions: From the tests made to date, it can be concluded that computation of the wind aloft from Radar data will enable pre-set courses to be flown with the same accuracy as with winds computed from optical drift data.

EG:emh

BELL Aircraft CORPORATION

CONFIDENTIAL

BY E. Gorin DATE 4/3/47 | **BELL** *Aircraft* CORPORATION | MODEL B-173 | AIRPLANE 44-83439

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 59 (46)

PURPOSE: Develop technique and determine limitations in obtaining Radar wind data.

TEST EQUIPMENT: AN/APQ-23 and optical drift meter installed in B-173

CHANGES SINCE LAST FLIGHT: None

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PILOT: A. M. Johnston **GROSS WGT.:** 48,534
CO-PILOT: R. H. McNiece **FLIGHT TIME:** 1:55
TEST ENGINEER: E. Gorin **TOTAL TIME:** 75:05

WEATHER: CAVU

TAKE-OFF TIME: 13:05

PRE-FLIGHT DATA:

Receiver Sensitivity: 101 -DBM
Power Output: 42 +DBM

1. Method of Testing: At an altitude of [illegible] feet and a constant airspeed, wind drifts were measured by optical and Radar methods on several headings. Fluxgate compass and magnetic compass readings were observed for comparison.

2. Results: The winds aloft over the Lake Erie-Lake Ontario regions were of a continually varying nature, and were small in magnitude. As a result, neither the optical wind data nor the Radar wind data were consistent. Also, the fluxgate compass differed from the magnetic compass by as much as 10 degrees on some headings, and would vary up to 4 degrees on a single heading. Thus, the drifts determined by the Radar method, which depended upon the fluxgate orientation of the Radar scope, were in error. The method can, however, be accomplished with fluxgate stabilization off. One such run was made giving a wind from [illegible] degrees at 12 mph. The optically determined wind was from [illegible] degrees at 12 mph. Considering the wind shifts encountered over the period and distances flown, this is a favorable comparison. Azimuth stabilization is expected to be used under actual launching conditions, and hence it is desired to perform all operations with azimuth stabilization on.

3. Conclusions: It is intended to continue making flights of this nature to improve technique and eliminate error sources, such as fluxgate compass errors.

EG:emh

Form 86-41

BY E. Gorin DATE 4/3/47 | **BELL** *Aircraft* CORPORATION | MODEL B-173 | AIRPLANE 44-83439

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 69 (47)

PURPOSE: Develop technique and determine limitations in obtaining Radar wind data. This flight is to confirm impressions of previous flight regarding sources of error.

TEST EQUIPMENT: AN/APQ-23 and optical drift meter installed in B-173

CHANGES SINCE LAST FLIGHT: None

CONFIDENTIAL

PILOT: R. H. McNiece **GROSS WGT.:** 48,534
CO-PILOT: None **FLIGHT TIME:** 1:20
TEST ENGINEER: E. Gorin **TOTAL TIME:** 76:25

WEATHER: CAVU

TAKE-OFF TIME: 14:45

PRE-FLIGHT TESTS:

Receiver Sensitivity: 101 -DBM
Power Output: 42 +DBM

1. Method of Testing: At an altitude of [illegible] feet and a constant airspeed, wind drifts were measured by optical and Radar methods on several headings. Fluxgate compass and magnetic compass readings were observed for comparison.

2. Results: The variations of the fluxgate compass from the magnetic were observed on different headings, and found to be inconsistent.

The wind was negligible, being under 10 mph and varying in direction over short distances.

3. Conclusions: The compasses, fluxgate and magnetic, will both be checked and swung before any more flights are made.

EG:emh

Form 86-41

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BELL *Aircraft* CORPORATION

REPORT NO. BMPR-3

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CONFIDENTIAL

By E. Gorin Date 4/9/47	BELL Aircraft Corporation	Model B-17[illegible]	Page
Approved [illegible] Date [illegible]		Airplane 44-[illegible]439	Report

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 61 (48)

PURPOSE: Compute wind and fly a simulated pre-set missile course to a target from Radar data only.

TEST EQUIPMENT: AN/APQ-23 installed in B-17

CHANGES SINCE LAST FLIGHT: None

CONFIDENTIAL

PILOT: [illegible]. Walton
CO-PILOT: J. A. Tannon
TEST ENGINEER: E. Gorin

GROSS WGT.: 48,[illegible]54
FLIGHT TIME: 1:45
TOTAL TIME: 7[illegible]:10

WEATHER: Haze - Visibility 5 to 15 miles

TAKE-OFF TIME: 14:3[illegible]

PRE-FLIGHT TESTS:

Receiver Sensitivity: 1[illegible]1 -DBM
Power Output: 42 +DBM

1. Method of Testing: With no visual reference to ground, the B-17 mother determined wind, navigated to the launching point, and flew a simulated missile course to the target from the launching point. The Radar was also used to measure the distance by which the target was missed. For a close miss, less than a mile, this can only be an estimate. The wind was computed from data taken on the heading to Toronto (the first launching point).

The first pre-set course was flown with Toronto as launching point and Erie as target. The second pre-set course was flown with Erie as launching point and Niagara Falls Airport as target.

2. Results: The wind computed was from 274 degrees at 3[illegible] mph, at an altitude of 7[illegible] feet.

The small harbor entrance at Erie was the target point, and was missed by less than 1/4 mile to the left.

The Niagara Falls Airport was missed by less than 1/4 mile to the right.

3. Conclusions: For both of these runs no course correction from the mother aircraft would have been necessary for a missile, had it flown these courses.

A similar flight at higher altitude and in stronger winds will be made.

[illegible]

By [illegible] Date [illegible]/47	BELL Aircraft Corporation	Model [illegible]	Page
Approved [illegible] Date [illegible]/47		Airplane 44-[illegible]	Report

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 62 (4[illegible])

PURPOSE: Compute wind and fly a simulated pre-set missile course to a target from Radar data only, using line of flight wind determination method.

TEST EQUIPMENT: APQ-23 installed in B-17[illegible]

CHANGES SINCE LAST FLIGHT: None

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PILOT: [illegible]
CO-PILOT: [illegible]
TEST ENGINEER: [illegible]

GROSS WGT.: 48,[illegible]4
FLIGHT TIME: [illegible]
TOTAL TIME: [illegible]

WEATHER: Scattered and overcast at 1[illegible],[illegible] feet.

TAKE-OFF TIME: 1[illegible]

PRE-FLIGHT TESTS:

Receiver Sensitivity: 101 -DBM
Power Output: 42 +DBM

1. Method of Testing: Procedure of flight number 61 (48) was duplicated, except that this run was flown at [illegible] feet altitude and the final run to Niagara Falls Airport was terminated in a dive begun at [illegible] miles range from [illegible].

2. Results: The wind computed, [illegible] the Radar scope [illegible], was from [illegible] degrees at 42 mph. [illegible] at [illegible] mph.

The target point at Erie was passed directly over, as determined from the Radar scope. This [illegible] of the order of [illegible] target point.

In the run to Niagara Falls Airport from Erie a let-down or dive was begun at [illegible] miles from the Airport. The B-17 missed the Airport by [illegible] miles to the [illegible]. The target was not identifiable at [illegible] miles [illegible] the [illegible] in the [illegible].

3. Conclusions: This flight gave results consistent with the previous flights made under different conditions of altitude and wind, and using different wind [illegible]. From these flights, it is now evident that accurate [illegible] of a pre-set course to a target. The maximum miss distance from a [illegible] was [illegible] miles, and was due to a large increase in the [illegible] component of the wind. The average miss distance was about 2 miles, and was [illegible]. [illegible], if at [illegible] degrees either side of the [illegible].

BELL Aircraft CORPORATION

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CONFIDENTIAL

BY E. Gorin	DATE 4/9/47	BELL Aircraft CORPORATION	MODEL B-17G
CHECKED C. Gorin	DATE 4/11/47		AIRPLANE 44-83439

FLIGHT #62 (49)

3. Conclusions: (Continued)

20 miles from the target the relative bearing between the missile's heading and the target is less than 9-1/2 degrees, then terminal guidance can begin, based on the missile's "eye" television presentation. It is expected that this will be the average case pending actual tests.

The courses that were flown using winds determined from Radar data were found to be in error in the same order of magnitude as those flown using optical wind data.

EG:cmh

BY E. Gorin	DATE 4/23/47	BELL Aircraft CORPORATION	MODEL B-17G
CHECKED C. Gorin	DATE 4/28/47		AIRPLANE 44-83439

FLIGHT TEST REPORT

PROJECT: MX-778 **PLACE:** Niagara Falls Airport **FLIGHT #:** 67 (50)

PURPOSE: Make a preliminary investigation flight with the mother and missile aircraft, consisting of guiding missile into a target using the Radar-beacon combination and television. Test vibration of B-17G tail and nose sections. Test air-to-air operation of radio control transmitter and receiver.

TEST EQUIPMENT: APQ-23 Search Radar, AN/AXR-1 Television Receiver, AN/ARW-18 Radio Control Transmitter, and Velocity Pick-Up and Recording Oscillograph Installed in B-17G.

CHANGES SINCE LAST FLIGHT: Radome substituted for plexiglas nose. ARW/AM-33 power amplifier and antenna added to complete the AN/ARW-18 radio control transmitting equipment.

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PILOT:	J. A. Cannon	**GROSS WGT.:**	46,534
CO-PILOT:	J. Frits	**FLIGHT TIME:**	2:30
TEST ENGINEER:	E. Gorin - Radar-Beacon	**TOTAL TIME:**	82:40
	J. Newman - Television. R. Deagan - Vibration Test.		
WEATHER:	High thin overcast - visibility 15 miles in light haze.		

TAKE-OFF TIME: 10:10

PRE-FLIGHT TESTS:

Receiver Sensitivity (Radar):	101 -DBM
Receiver Sensitivity (Beacon):	84 -DBM
Power Output:	42 +DBM

1. Method of Testing: Three runs were made. The wind was measured enroute to the first launching point. Flight conditions were as follows:

B-17G	B-25J
Altitude - 10,000 feet	Altitude - 10,000 feet
I. A. S. - 200 mph	I. A. S. - 220 mph

The two aircraft flew formation to the launching point.

Headings from launching point to target and time of launching were given the B-25J pilot by VHF radio. When launched, the missile flew at constant speed and altitude until Radar screen indicated it to be 20 miles from target. Then by observing relative position of missile to target, the first course correction was given as the missile began its dive at rate of descent necessary to intercept target. Further corrections were made as necessary until the beacon was turned off and television turned on. As soon as the target became identifiable to television operator in B-17G, he gave necessary heading and pitch corrections to B-25J to continue the dive directly into the target.

Run #1 - The launching point was Jamestown, New York, and the target was Toronto Island, Toronto, the distance between the two being 91 nautical miles. After launching, the B-17G cruised so as to be between 60 and 100 nautical miles from the target at all times, and to be pointing toward the missile's tail for the final guiding into target by television.

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BELL Aircraft CORPORATION

BY K. Gorin	DATE 4/23/47	BELL Aircraft CORPORATION	MODEL B-17G	PAGE
CHECKED	DATE		A. F. SER. 44-83439	FLIGHT

FLIGHT #67 (50)

1. Method of Testing: (Continued)

Run #2 - The launching point was Toronto and the target was the small harbor entrance to Erie, Pa., the distance between the two being 84 nautical miles. In order to save the time of the B-17G flying to Toronto from its position at the end of Run #1, the heading corrected for wind from Toronto to Erie was given the B-25J by VHF radio, and the B-25J then flew this heading. The B-17G then flew to be in position for the final guiding of the missile, i.e., between 60 and 100 nautical miles from Erie, and pointing towards the tail of the B-25J.

Run #3 - The launching point was Erie and the target was the Niagara Falls Airport. The distance between the two being 80 nautical miles. Since time was short, the B-25J began its given heading to target from about 2000 feet in a climb to reach 10,000 feet enroute, rather than gain proper altitude over launching point. The B-17G flew to be in proper position for terminal guiding of missile.

2. Results: The wind was from 289 degrees at 58 mph, and was found to have decreased in magnitude to 34 mph when checked at the end of Run #3.

Run #1 - On the run to Toronto the fluxgate compass inverter failed, and the drifting of this compass was not noted until gyros had slowed down. At the time the missile was at 20 nautical miles from the target, the target was not clearly identifiable on the Radar scope and no heading correction was made. Instead, the beacon was turned off and the television turned on, and the dive begun. At no time during the dive was the target area visible to television operator due to a heavy mist in the vicinity. The B-25J overshot and passed about 10 miles to the west of the target.

Run #2 - When the missile was 20 nautical miles from the target, a new heading without wind was given simultaneously with the order to enter its dive. One more correction was given, and then television turned on. The B-25J undershot the target, and the television gave no indication of the position of the target during the run. The B-25J passed 5 miles west of the target. On this run there was time lost in transmitting, hence, in executing the course correction which was about 40 degrees. This accounts for passing 5 miles west of target.

Run #3 - From over 70 nautical miles distance, the Niagara Falls Airport could not be distinguished as an individual target on the Radar scope. Its position on the screen was estimated with relation to Buffalo, and a new heading given the B-25J when it was told to dive at 15 nautical miles from the Airport. The pilot of the B-25J saw this was insufficient, and made another heading correction visually. At 5 miles from the target the television gave good indication of the target, and the television operator in the B-17G was able to guide the B-25J by aural radio instructions directly over the Airport.

The radio control receiver and transmitter gave satisfactory operation. It was found, however, that radio control transmission interfered with television reception.

The vibration tests revealed there were no peak-to-peak vibration amplitudes greater than 0.001" in the floors and bulkheads of the tail and nose sections of the B-17G.

BY K. Gorin	DATE 4/23/47	BELL Aircraft CORPORATION	MODEL B-17G	PAGE
CHECKED	DATE		A. F. SER. 44-83439	FLIGHT

FLIGHT #67 (50)

3. Conclusions: The results of Run #1, target Toronto, cannot be evaluated because of the fluxgate compass failure during that run. The duration of its failure and the error in course thus introduced are not known.

In general, the difficulties to be overcome consist of: Positive target identification at ranges of 60 to 100 nautical miles on the APQ-23 scope; allowance for time delay in transmitting course corrections and their execution by B-25J pilot, (especially if repeating of instructions is necessary,) since correction angle of course increases rapidly with time when missile is close to a target; a change of wind between two runs or between launching point and target, which may at least require a wind check between runs.

For the present initial phase mother-missile flights, only Radar targets positively identifiable at 60 to 100 nautical miles will be used until time is available to develop method and technique for use of offset points in target identification. Greater flight altitude will help. As for overcoming the time element in giving course corrections, an estimated over-correction will be tried and further corrections made as necessary for the time when the missile is between 20 and 10 nautical miles from the target. The rechecking of wind will depend on accuracy of first run made in a flight.

The effect of mist or poor visibility on limiting the television's identification of target and target areas will have to be compensated for by more accurate Radar-beacon guiding of missile in close to the target. At present, simultaneous operation of the beacon and television equipment is not possible due to triggering of the beacon by the television. This requires time lost in switching between the two. An investigation to eliminate this difficulty is under way.

To prevent interference from radio control in television receivers, it will be necessary to relocate antennae and perhaps separate the units.

The vibration tests will be repeated for different power settings and speeds of the B-17G, other than cruising, in future flight.

EJ:emh

BY J. Newman DATE 4/24/47 CHECKED [illegible] DATE 4-28-47	BELL Aircraft CORPORATION	MODEL B-173 PAGE AIRPLANE 44-33439 REPORT

FLIGHT TEST REPORT

PROJECT: MX-775 **PLACE:** Niagara Falls Airport **FLIGHT #:** 68 (31)

PURPOSE: Perform the second in a series of preliminary flights, guiding the missile into several targets by air-to-air transmissions.

TEST EQUIPMENT: APQ-23 Radar
AN/AXR-1 Television Receivers

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CHANGES SINCE LAST FLIGHT: Second television receiver mounted in nose of B-173. Receiver light shields modified to provide three observers' posts, plus one operator's post.

PILOT: A. M. Johnston
CO-PILOT: F. Walton
TEST ENGINEER: E. Corin & P. Stack - Radar-Beacon
J. Newman - Television

GROSS WGT.: 49,334
FLIGHT TIME: 1:15
TOTAL TIME: 83:56

WEATHER: CAVU

TAKE-OFF TIME: 14:50

1. Method of Testing: Original plans called for guiding the missile from the launching point to the target 100 miles away by beacon and then television. Immediately after takeoff, however, the magnetron of the APQ-23 Radar failed, thereby preventing use of the beacon signal. It was decided, therefore, that the missile B-25 should be piloted visually to within 20 miles of the target, then put into a dive and be given any necessary course corrections by the television operator in the B-17, who would be in contact with the B-23 pilot by VHF radio.

Four dives were made at an average distance of 20 nautical miles, an altitude of 10,000 feet, and a speed of 270 mph I.A.S. The mother B-17 stayed 60 to 70 nautical miles behind the B-25 in all cases, on the same heading, at an altitude of 10,000 feet.

The targets were the shoreline of Toronto, Canada, Albion, N.Y., Brockport, N.Y. (both small towns), and a tanker underway in Lake Ontario.

2. Results: The dive on Toronto was a direct "hit" on the opening in the breakwater. The target could be seen as a dark line at the beginning of the dive; it could be positively identified at a distance of about 2 nautical miles. The next two dives (on small towns) were not successful. In each case the operator (between 20 and 15 nautical miles) chose a spot of high contrast which was not identified until about 1 nautical mile from completion of the dive. The first was an empty field, and the second a small pond. Each was located about 2 miles outside the small towns. The fourth attempt resulted in a second direct "hit". The ship was discernible as a dark spot on the water, as seen on the television screen, at the start of the 15 mile dive; it could be positively identified as a ship at about 2 miles.

Vibration during the dives caused the picture to be out of focus about one-third of the time. This greatly increased the difficulty of identification.

BY J. Newman DATE 4/24/47 CHECKED [illegible] DATE 4-28-47	BELL Aircraft CORPORATION	MODEL B-173 PAGE AIRPLANE 44-33439 REPORT

FLIGHT #68 (31)

2. Results: (Continued)

At no time was it found difficult to direct the aircraft into the chosen spot on the television screen. Yaw and pitch stabilizing circuits eliminated errors in those axes, and no effect of crosswind was observed.

3. Conclusions: Several steps must be taken to decrease the difficulty of target identification:

(1) Investigation and reduction of vibration.
(2) A change of guiding technique whereby more attention is paid to identification of surrounding areas and less to the exact spot at which the operator has chosen to direct the aircraft.
(3) More extensive pre-flight briefing for familiarization with the target area, preferably with large scale maps.
(4) Experience and practice in identifying television targets from the air. This is probably the most important point, and will require a series of training and practice flights.

JN:cah

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BELL Aircraft CORPORATION

By J. Newman Date 3/10/47 | BELL Aircraft Corporation | Model B-25J | Airplane 44-30470

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 49A (19)

PURPOSE: Test operation of television and Radar beacon equipment at short range in air-to-air transmission.

TEST EQUIPMENT: AXT-3 television transmitter, using two conversion units and yagi antenna. APN-11 beacon installed in B-25.

CHANGES SINCE LAST FLIGHT: Replaced AXT-2 with AXT-3 to allow choice of either of two conversion units (pick-up tubes): one for aircraft instruments and one for terrain.

PILOT:	A. M. Johnston	**GROSS WGT.:**	25,259
CO-PILOT:	H. A. Dow	**FLIGHT TIME:**	1:00
TEST ENGINEER:	J. Newman & J. Sedona	**TOTAL TIME:**	24:45

WEATHER: Scattered clouds 3000 to 7000 feet.

TAKE-OFF TIME: 15:25

This flight was performed in conjunction with Flight No. 49 (37) of B-17? Serial No. 44-83439. All essential information is contained in Flight Test Report for that flight.

JN:emh

Form 96-41

By J. Newman Date 3/11/47 | BELL Aircraft Corporation | Model B-25J | Airplane 44-30470

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 50A (20)

PURPOSE: Check operation and maximum range of television and Radar beacon equipment in air-to-air transmission.

TEST EQUIPMENT: AXT-3 Television Transmitter With Yagi Antenna. APN-11 Beacon.

CHANGES SINCE LAST FLIGHT: None

PILOT:	A. M. Johnston	**GROSS WGT.:**	25,259
CO-PILOT:	F. H. McNiece	**FLIGHT TIME:**	1:50
TEST ENGINEER:	J. W. Hampton	**TOTAL TIME:**	26:35

WEATHER: Overcast - Clear at 6000 Feet

TAKE-OFF TIME: 15:00

This flight was performed in conjunction with Flight No. 50 (39) of B-17? Serial No. 44-83439. All essential information is contained in Flight Test Report for that flight.

JN:emh

Form 96-41

BELL Aircraft CORPORATION

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BY J. Newman DATE 3/12/47 | BELL Aircraft CORPORATION | MODEL B-25J | PAGE
CHECKED J. Newman DATE 3/12/47 | | AIRPLANE 44-30470 | REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 51A (21)

PURPOSE: Investigate "ghosting" effects on television signal so that antennas may be relocated if necessary, or effect ignored in future tests if the interference is negligible.

TEST EQUIPMENT: AXT-2 television transmitter. APS-11 beacon.

CHANGES SINCE LAST FLIGHT: None

PILOT: M. A. Dow
CO-PILOT: J. Fritz
TEST ENGINEER: J. Newman & R. Kempton

GROSS WGT.: 25,259
FLIGHT TIME: 2:30
TOTAL TIME: 28:35

WEATHER: CAVU

TAKE-OFF TIME: 14:40

This flight was performed in conjunction with Flight No. 81 (40) of B-17G, Serial No. 44-83439. All essential information is contained in Flight Test Report for that flight.

JN:mh

Form 84-41

BY F. Steck DATE 3/17/47 | BELL Aircraft CORPORATION | MODEL B-25J | PAGE
CHECKED F. Steck DATE 3/17/47 | | AIRPLANE 44-30470 | REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 53A (22)

PURPOSE: To determine maximum operating range and usable azimuth beam of APS-11 beacon in air-to-air tests.

TEST EQUIPMENT: APS-11 in B-25
APG-23 in B-17

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CHANGES SINCE LAST FLIGHT: None

PILOT: A. M. Johnston
CO-PILOT: R. Neiswander
TEST ENGINEER:

GROSS WGT.: 25,259
FLIGHT TIME: 1:50
TOTAL TIME: 30:25

WEATHER: Overcast and scattered at 2000-4000 feet

TAKE-OFF TIME: 14:56

This flight was made in conjunction with B-17 plane, 44-83439, and all data and results will be found on Flight Report No. 53 (42).

FS:ek

Form 84-41

BY G. Beck DATE 4/10/47 CHECKED [illegible] DATE [illegible]

BELL *Aircraft* CORPORATION

MODEL B-25J PAGE
AIRPLANE 44-30470 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 63A (23)

PURPOSE: Air check of F-1 auto pilot. Adjustment of controls for proper follow-up ratios in each axis. In the remaining time, to begin adjustment of control head for coordinated turns.

TEST EQUIPMENT: Bendix F-1 Auto Pilot

CHANGES SINCE LAST FLIGHT: Installed Bendix F-1 Auto Pilot

PILOT: J. A. Cannon
CO-PILOT: J. Fritz
TEST ENGINEER: G. Beck

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GROSS WGT.: 25,259
FLIGHT TIME: :45
TOTAL TIME: 31:10

WEATHER: Ceiling 10,000 feet - visibility unlimited.

TAKE-OFF TIME: 15:43

1. Method of testing: At 8000 feet the auto pilot was engaged. Each axis was set up separately by introducing a transient with the airplane's controls. The follow-up ratio was adjusted until the airplane returned to the proper line of flight without overshoot or undershoot.

A series of turns, banks, and dives were then made to ascertain the performance of the aircraft under auto pilot control.

Ground installation work delayed this flight until late afternoon, so that there was no time to adjust for coordinated turns after the follow-up ratios had been set.

2. Results: Follow-up ratios and rate ratios were found to be satisfactory in all three axes. It was observed that adjustments would be required to coordinate the turns, but there was insufficient time to complete the adjustments.

3. Conclusions: The control head must be adjusted in the next flight to properly coordinate turns and hold elevator in turns.

Follow-up and rate ratios are now satisfactory for proper operation of the auto pilot.

Form 90-31

GB:emh

BY J. Newman DATE 4/11/47 CHECKED J. A. Cannon DATE 4/18/47

BELL *Aircraft* CORPORATION

MODEL B-25J PAGE
AIRPLANE 44-30470 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 64A (24)

PURPOSE: Adjust F-1 auto pilot control head for coordinated turns. Preliminary check of television installation.

TEST EQUIPMENT: Bendix F-1 Auto Pilot; AN/AXT-5 television transmitter with image orthicon camera installed in the nose.

CHANGES SINCE LAST FLIGHT: New camera mount installed in nose, which will provide both yaw and pitch stabilization. Regular iconoscope television camera replaced with RCA-loaned image orthicon camera.

PILOT: J. A. Cannon
CO-PILOT: None
TEST ENGINEER: G. Beck & J. Newman

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GROSS WGT.: 25,259
FLIGHT TIME: 1:00
TOTAL TIME: 32:13

WEATHER: Ceiling 6000 feet - visibility 2 to 5 miles in light rain.

TAKE-OFF TIME: 15:30

1. Method of testing: Auto Pilot - At 5600 feet the auto pilot was engaged and a series of turns to left and right were made, during which the control head was trimmed to maintain coordinated turns.

Television - Transmitter was operated during entire flight, and presentation noted on monitor scope. Pitch and yaw stabilizing operation noted and adjusted.

2. Results: Auto Pilot - Turns to the right were adjusted satisfactorily by compensator in the control head. In left turns it was impossible to obtain sufficient up elevator signal to prevent loss of altitude. Follow-up and rate ratios were satisfactory in all axes.

Television - The television picture of the ground was poor, the rain making the ground nearly invisible to the naked eye. The picture was readable, however, indicating the superiority of this camera over the regular iconoscope camera, which would have yielded no picture at all in such low light level conditions. The new stabilized shock mount operated properly in both yaw and pitch stabilization. Very little vibration was noted in the camera itself, which is supported in the plane of the center of gravity.

3. Conclusions: Auto Pilot - It will be necessary to ground check the auto pilot control head and adjust to give greater up elevator signal in turns prior to the next flight. No further adjustments need be made to the amplifier settings.

Television - The television installation, using the image orthicon camera, will apparently prove satisfactory. It is recommended that the mount be tested for vibration in rougher weather, and that the image orthicon be tested more in flight before approved as satisfactory. In this test, operation of the image orthicon failed to disclose any faults.

Form 90-31

JN:GB:emh

REPORT NO. EMPR-6

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BELL *Aircraft* CORPORATION

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BY J. Newman DATE 4/14/47 | CHECKED J. A. Cannon DATE 4/18/47

BELL Aircraft CORPORATION

MODEL B-25J PAGE
AIRPLANE 44-30470 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 65A (25)

PURPOSE: Air check of F-1 auto pilot for correct elevator signal in turn. Air check of television performance.

TEST EQUIPMENT: Bendix F-1 Auto Pilot.
AN/ART-5 Television Transmitter, using image orthicon camera.

CHANGES SINCE LAST FLIGHT: Control head of F-1 adjusted for greater up elevator signal in turns.

CONFIDENTIAL

PILOT: R. M. Stanley
CO-PILOT: J. A. Cannon
TEST ENGINEER: T. Beck & J. Newman

GROSS WGT.: 25,253
FLIGHT TIME: :45
TOTAL TIME: 32:56

WEATHER: Ceiling 5000 feet - visibility 5 to 8 miles.

TAKE-OFF TIME: 15:05

1. Method of Testing: Auto Pilot - Complete series of maneuvers executed under auto pilot control, with special notice paid to performance in turns.

Television - Equipment failed to operate.

2. Results: Auto Pilot - Auto pilot performance was satisfactory in all respects. Altitude is held closely in both left and right turns.

Television - Although pre-flight ground check showed proper operation, the image orthicon signal could not be obtained in the air. Observed symptoms indicated a probable component failure.

3. Conclusions: Auto Pilot - No further adjustments need be made. Ready for radio control link.

Television - Image orthicon camera must be removed to the laboratory, repaired, and reinstalled for the next flight.

JN:JAC:esh

BY J. Newman DATE 4/15/47 | CHECKED DATE

BELL Aircraft CORPORATION

MODEL B-25J PAGE
AIRPLANE 44-30470 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 66A (26)

PURPOSE: Conduct diving tests on several targets by means of television picture and auto pilot control.

TEST EQUIPMENT: Image orthicon television camera and monitor unit installed in nose of B-25J. F-1 auto pilot control head mounted by television operator.

CHANGES SINCE LAST FLIGHT: Auto pilot control head removed from cockpit to a position near the television operator in the nose. Image orthicon checked in laboratory and replaced in aircraft.

PILOT: J. A. Cannon
CO-PILOT: F. Walton
TEST ENGINEER: J. Newman

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GROSS WGT.: 25,259
FLIGHT TIME: 1:10
TOTAL TIME: 34:06

WEATHER: Scattered clouds at 7000 feet - visibility unlimited.

TAKE-OFF TIME: 11:50

1. Method of Testing: Five successive dives were made - three at [illegible], one at a highway intersection, and one at the South Grand Island Bridge. Dive conditions: Starting altitude 5000 feet; distance 10 miles; speed 270 mph. The auto pilot was clutched in at straight and level flight. The television operator chose a target by visual observation through the plexiglas nose, then observed only the television presentation on the monitor scope as he brought the aircraft into alignment and dove on the target. At 500 feet the pilot unclutched the auto pilot and regained altitude.

2. Results: At the beginning of each dive, only the general outline of the target could be distinguished. It was possible, however, to keep the crosshairs centered on that outline until contrast increased to the point where specific recognition was possible. All five dives were successful, each resulting in a direct hit. The crosswinds encountered were small, and their effect easily neutralized by experimenting with the turn control until the target remained stationary on the screen. The auto pilot responded well to all signals, so that it was not difficult to follow the target all the way in. When turn errors were cranked in, it was necessary to estimate the proper time to straighten out, because the airplane's attitude in a turn caused the target to appear off to one side of the screen. This effect caused little trouble, however, and the experience gained in those dives was sufficient to allow the operator to compensate for the effect.

Some trouble was experienced from violent vibrations in the dive, which momentarily destroyed the electrical focus and obscured the picture. This added greatly to the difficulty of tracking.

The pitch stabilization circuit operated properly. Yaw stabilization developed a fault, and the camera remained fixed in azimuth.

Operation of the image orthicon was normal throughout the flight.

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FLIGHT #66A (26)

3. Conclusions: Little, if any, piloting experience is needed to guide the aircraft into a target from 5 miles with the present installation. The effect of violent crosswinds must still be studied. It will be necessary to increase the rigidity of the deck supporting the camera mount and to repair the yaw stabilization system to lessen camera vibration. The television and auto pilot are now ready for radio control. It is suggested that, following the installation of the radio control, these dives be repeated on the next test, making use of radio control of the auto pilot and transmission of the television signal to the Mother airplane.

JN:emh

BY J. Newman	DATE 4/23/47	BELL Aircraft CORPORATION	MODEL B-26J	PAGE
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FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 67A (27)

PURPOSE: Make a preliminary investigation flight with the mother and missile aircraft, consisting of guiding missile into a target using the Radar-beacon combination and television. Test air-to-air operation of radio control transmitter and receiver.

TEST EQUIPMENT: ARN-11 Beacon Transponder, AN/AXT-3 Television Transmitter, and AN/APW-1 Radio Control Receiver

CHANGES SINCE LAST FLIGHT: AN/APW-1 radio control receiver installed and ground-checked.

PILOT: F. Walton
CO-PILOT: A. M. Johnston
TEST ENGINEER: W. Hampton

CONFIDENTIAL

GROSS WGT.: 26,259
FLIGHT TIME: 2:20
TOTAL TIME: 36:25

WEATHER: High thin overcast - visibility 15 miles in light haze.

TAKE-OFF TIME: 10:05

This test was made in conjunction with Flight No. 67 (50) of B-17G. Consult flight test report on that flight for methods and results.

JN:emh

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BY	J. Newman	DATE	4/24/47	BELL Aircraft CORPORATION	MODEL	B-28J	PAGE	
CHECKED	J. Newman	DATE	4-28-47		AIRPLANE	44-30470	REPORT	

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 68A (28)

PURPOSE: Perform the second in a series of preliminary flights, guiding the missile into several targets by air-to-air transmission.

TEST EQUIPMENT: APN-11 Beacon
AN/AXT-3 Television Transmitter, with image orthicon camera

CHANGES SINCE LAST FLIGHT: None

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PILOT: J. A. Cannon **GROSS WGT.:** 25,259
CO-PILOT: J. Fritz **FLIGHT TIME:** 1:30
TEST ENGINEER: W. Hampton **TOTAL TIME:** 37:55

WEATHER: CAVU

TAKE-OFF TIME: 14:45

This test was made in conjunction with Flight #68 (51) of B-17G. Consult Flight Test Report on that flight for methods and results.

JN:cmh

Form 66-45

BY	H.W. Ackerman	DATE	2/28/47	BELL Aircraft CORPORATION	MODEL	B-17G	PAGE	
CHECKED		DATE	3-3-47		AIRPLANE	44-83517	REPORT	

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 46B (12)

PURPOSE: Flight Check of AN/APQ-7 System Components

TEST EQUIPMENT: AN/APQ-7 Installed in B-17G

CHANGES SINCE LAST FLIGHT: Completed range sweep modifications of auxiliary scope; replaced receiver IF strip; repaired antenna cables.

PILOT: J. A. Cannon **GROSS WGT.:**
CO-PILOT: J. Fritz **FLIGHT TIME:**
TEST ENGINEER: H. W. Ackerman **TOTAL TIME:**

WEATHER: Instrument Flight Conditions

TAKE-OFF TIME: 10:45

PRE-FLIGHT TESTS:

Receiver Sensitivity Measured: 96 -DBM (2/27/47)
Power Output (Average): 43 +DBM "

1. Method of Testing: Overall system functioning of the AN/APQ-7 was flight tested on a utility flight to Rome, New York, and return. Usual test Radar approaches had to be abandoned because of solid undercast and less than one mile visibility.

2. Results: Overall system operation on all ranges was good; no defects or breakdowns were noted. An improved method of scope observation was tried by having the operator wear red polaroid night adaption goggles at all times when not actually observing the scope.

3. Conclusion: Minimum delay in dark adaption and improved target definition and contrast may be achieved by filtering all external light at the Radar operator's position.

4. Recommendation: It is recommended that all externally illuminated transparent surfaces adjacent to Radar operator's positions in both the control and the missile B-17's be covered with polaroid dark adaptor (non polarising) 8AF filters. (Several sheets of red cellophane would serve as effectively.)

Form 66-45

HWA:cmh

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BY W. Ackerman DATE 3/6/47
CHECKED [illegible] DATE 3-?-47

BELL Aircraft CORPORATION

MODEL B-17? PAGE
AIRPLANE 44-83517 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 47B (13)

PURPOSE: To demonstrate system operation on short range collision headings.

TEST EQUIPMENT: AN/APQ-7 installed in B-17

CHANGES SINCE LAST FLIGHT: Short-range sweep circuits modified.

PILOT:	A. M. Johnston	**GROSS WGT.:**	46,750
CO-PILOT:	J. Frits	**FLIGHT TIME:**	:45
TEST ENGINEER:	W. Ackerman	**TOTAL TIME:**	23:35
OBSERVERS:	Capt. Westenhoff, Mr. Oyster, Mr. Zimmerman, P. Robertson		

WEATHER: Limited visibility, overcast 3-7,000 feet

TAKE-OFF TIME: 14:35

PRE-FLIGHT TESTS:

Overall system operation checked 3-5-47 and aligned.

1. Method of Testing: Simulated collision approaches were run on the north end of the North Grand Island bridge from 18 to 9 mile ranges, and from 3500 to 7500 feet flight levels.

2. Results: Three runs were made, the first from 9 miles north, from 4500 feet flight altitude at 150 IAS. The autopilot aileron function oscillated during the approach making control difficult. However, the B-17 passed about 1000 feet left of the target at 500 feet altitude. The second run, from 12 miles south and 3500 feet at 150 IAS, again was hampered by the autopilot. This time the operator called his shot as the middle of the bridge when 500 feet above and exactly over it. A third approach was made from 1? miles east and 7500 feet. Again the autopilot hampered the approach, the hit was 500 feet above the center of the bridge and the operator called the hit as such. The third run was of sufficient length so that scope pictures were taken.

3. Conclusions: The runs were limited by the overcast and hampered by autopilot malfunction, but were otherwise satisfactory. Ease of tracking during the last part of the approach could be improved with further range expansion.

WA:ek

Form 96-61

BY W. Ackerman DATE 3/10/47
CHECKED [illegible] DATE 3-10-47

BELL Aircraft CORPORATION

MODEL B-17? PAGE
AIRPLANE 44-83517 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 49N (14)

PURPOSE: Test simulated short range collision approaches using modified AN/APQ-7 sweep expansion.

TEST EQUIPMENT: AN/APQ-7 installed in B-17G

CHANGES SINCE LAST FLIGHT: None

PILOT:	J. A. Cannon	**GROSS WGT.:**	46,750
CO-PILOT:	J. Frits	**FLIGHT TIME:**	1:05
TEST ENGINEER:	W. Ackerman & R. Robertson	**TOTAL TIME:**	24:40

WEATHER: Scattered Clouds - Visibility 20 to 30 Miles

TAKE-OFF TIME: 10:25

PRE-FLIGHT TESTS:

Checked overall system operation 3/10/47.

1. Method of Testing: Simulated collision approaches were run on the north Grand Island Bridge from 10,000 feet at 150 mph IAS and 10 miles slant range. Two approaches were run from the east and one from the west. Pullouts were made at 500 feet. Azimuth was controlled by Radar operator during dives.

2. Results: Target was tracked all the way in, and for all runs when the Radar operator reported "over target", the aircraft was 500 feet above and less than 500 feet away from the target.

3. Conclusions: Satisfactory tracking and homing operations of the AN/APQ-7 can be realized on well defined targets; however, during the last mile of the approach the Radar presentation is more difficult to read.

WA:amh

Form 96-61

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BY W. Ackerman DATE 3/10/47 | BELL Aircraft CORPORATION | MODEL B-17G PAGE
CHECKED [signature] DATE 3-15 | AIRPLANE 44-83517 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 498 (15)

PURPOSE: Test simulated short range collision approaches using modified AN/APQ-7 sweep expansion.

TEST EQUIPMENT: AN/APQ-7 Installed in B-17G

CHANGES SINCE LAST FLIGHT: None

PILOT: J. A. Cannon
CO-PILOT: J. Fritz
TEST ENGINEER: W. Ackerman & R. Robertson
OBSERVERS: R.M.Stanley, J. Stricklar, & L. Faneuf
WEATHER: Undercast and haze - Visibility 3 to 5 Miles

GROSS WGT.: 46,750
FLIGHT TIME: 1:00
TOTAL TIME: 25:40

TAKE-OFF TIME: 14:25

PRE-FLIGHT TESTS:

Checked system operation on previous flight.

1. Method of Testing: Simulated collision approaches were run on the north Grand Island Bridge from 10,000 feet at 150 mph IAS and 10 miles slant range. Two approaches were run from the east and one from the west. Pullouts were made at 500 feet. Azimuth was controlled by Radar operator during dives.

2. Results: Target was tracked all the way in, and for all runs when the Radar operator reported "over target", the aircraft was 500 feet above and less than 500 feet away from the target.

3. Conclusions: Satisfactory tracking and homing operations of the AN/APQ-7 can be realized on well defined targets; however, during the last mile of the approach the Radar presentation is more difficult to read.

WWA:emh

Form 84-61

BY W. Ackerman DATE 3/11/47 | BELL Aircraft CORPORATION | MODEL B-17G PAGE
CHECKED [signature] DATE | AIRPLANE 44-83517 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 508 (16)

PURPOSE: Test flight operation of mechanical azimuth computer coupled to AN/APQ-7 Radar

TEST EQUIPMENT: Mechanical computer installed in connection with AN/APQ-7 in B-17

CHANGES SINCE LAST FLIGHT: Completed installation of mechanical azimuth computer at Radar operator's position

PILOT: F. A. Dow
CO-PILOT: J. A. Cannon
TEST ENGINEER: W. Ackerman & T. Witherby

GROSS WGT.: 46,750
FLIGHT TIME: 1:05
TOTAL TIME: 26:45

WEATHER: Solid overcast 3000 to 6000 feet, becoming broken near end of flight. Wind at flight level southwest at estimated 10-15 mph.

TAKE-OFF TIME: 10:40

PRE-FLIGHT TESTS:

System operation verified on ground prior to takeoff. Computer was aligned at 0 degrees. (3/11/47)

1. Method of Testing: Selected well defined Radar targets were approached from 10 to 15 miles range at constant altitude and IAS of 150 mph. Drift variation was fed to the computer manually by the Radar operator, and the aircraft was flown in azimuth corresponding to the computer pointer position by a test engineer operating the remote auto pilot control.

2. Results: The first approach was rendered difficult by the many mechanical operations required by the Radar operator in maintaining azimuth setting on the computer and auto pilot while operating the range expansion and gain settings of the AN/APQ-7.

The second target approach was made as outlined in "Method of Testing" above. The drift angle averaged 7 degrees left; flight altitude was 8000 feet. The aircraft was flown in azimuth according to computer indications. No apparent final target tracking error was observed. Operation of the auto pilot could not be made to follow at the same rate as the computer indications if the latter required large turn moments.

The third approach was in all respects a duplicate of the second, except that the target approach was from the opposite direction (east). Average drift 4 degrees right. Flight altitude was 8500 feet. Results were as noted before.

Form 84-61

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BELL Aircraft CORPORATION

BY W. Ackerman	DATE 3/11/47	BELL AIRCRAFT CORP. NIAGARA FRONTIER DIVISION BUFFALO, N.Y.	MODEL B-17G PAGE
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FLIGHT #608 (16)

3. Conclusions: The mechanical azimuth computer was found to operate without appreciable error; however, it was demonstrated that direct computer connection to the auto pilot is desirable. Rate stabilization of turn, proportional to error angle, will also be required for smooth operation. Development of a complete electronic azimuth cursor is indicated to adequately meet existing system requirements of the AN/APQ-7.

WA:eah

BY W. Ackerman	DATE 3/12/47	BELL Aircraft CORPORATION	MODEL B-17G PAGE
CHECKED	DATE		AIRPLANE 44-83517 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 618 (17)

PURPOSE: Determine the operating characteristics of the AN/APQ-7 on short range simulated collision approaches.

TEST EQUIPMENT: AN/APQ-7 installed in B-17G.

CHANGES SINCE LAST FLIGHT: Removed mechanical azimuth computer.

PILOT: H. A. Dow
CO-PILOT: J. L. Fritz
TEST ENGINEER: W. Ackerman

GROSS WGT.: 46,780
FLIGHT TIME: 1:35
TOTAL TIME: 29:20

WEATHER: CAVU - Wind Southwest 25-30 MPH

TAKE-OFF TIME: 10:40

PRE-FLIGHT TESTS:

System operation checked on external power source prior to takeoff.

1. Method of Testing: A transportation dump on an abandoned airfield approximately 10 miles southeast of Brentford, Ontario was selected as a general target area. Simulated collision approaches on individual targets within the general target area were run from varying altitudes and ranges. The Radar operator guided the aircraft in azimuth. Let-down speed was 150 mph IAS.

2. Results: Target was first identified visually and a course of 270 degrees from target was followed. At approximately 15 miles from target the heading was changed to 90 degrees, and let-down from 10,000 feet began at 10 miles Radar range. A cluster of automotive equipment near the northern edge of the field was selected and homed on to 500 feet altitude over the target. No observable error was noted in passing directly over the target.

The second approach was made on a heading of 270 degrees from 24 miles Radar range. Let-down began at 10,000 feet and 16 miles Radar range. Target was chosen as area between Hangars 3 and 4 of a group of six broadside to the approach course. The aircraft passed an estimated 20 yards to the left of the selected target at 500 feet.

The third approach was made on a heading of 170 degrees from 5000 feet altitude and 17 miles. Let-down was begun at 10 miles on a single target estimated at 100 yards beyond the east-west runway area. Target was tracked until over the target at 500 feet altitude. No observable error was noted.

3. Conclusion: Direct target approaches, leveling out over the target, can readily be made by the AN/APQ-7 Radar on secondary point targets, provided orientation with other well defined targets is maintained.

WFA:erh

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 62B (18)

PURPOSE: Flight test altitude-range computer used as a component of AN/APQ-7 Radar.

TEST EQUIPMENT: AN/APQ-7 and associated computer installed in B-179.

CHANGES SINCE LAST FLIGHT: Completed installation of altitude-range computer.

PILOT:	H. A. Dow	**GROSS WGT.:**	46,750
CO-PILOT:	J. Fritz	**FLIGHT TIME:**	2:10
TEST ENGINEER:	W. Ackerman & N. Spencer	**TOTAL TIME:**	30:30

WEATHER: Haze - Visibility 10 miles.

TAKE-OFF TIME: 10:55

PRE-FLIGHT TESTS:

System operation checked prior to takeoff on external power supply.

1. Method of Testing: Operation of the range-altitude computer was observed on a utility flight to Rome, New York, and return. The azimuth control of the aircraft was at all times under full control of the Radar operator, except for take-off and landing. Approach was made on Rome Army Air Base from 5000 feet, and let-down began at 10 miles Radar range. Similar approaches on the return flight were made on targets at Oswego, Rochester, and Niagara Falls Airport. Computer was calibrated over varying terrain from 246 feet (Lake Ontario) to 1500 feet.

2. Results: Radar altimeter, using ground return of an "A" scope, was tried out and found to have the following characteristics:

(a) The range of initial ground return varied with sweep of antenna, the variation increasing with altitude. It was noted that the main transmitter pulse remained stationary.
(b) The initial ground return became very indistinct around 7500 feet, and continued so until around 2000 feet, at which point it again became possible to track.
(c) On the 5 micro-second sweep of the TS-34, altitude had to decrease about 100 feet before any scope change became noticeable. This effect was noticed at different points and over water so as to discount the effect of hills.
(d) Due to relative insensitivity, mountains had very little noticeable effect.

Calibration of the computer assembly was then undertaken. A curve is being drawn to indicate relation between shaft position and elevation angle.

BY W. W. Ackerman DATE 3/13/47 | CHECKED [illegible] DATE [illegible] | BELL AIRCRAFT CORP. NIAGARA FRONTIER DIVISION BUFFALO, N.Y. | MODEL B-179 PAGE | SHIP 44-63517 REPORT

FLIGHT #62B (18)

2. Results: (Continued)

Tracking a target from a range of 10 miles to zero was attempted, using constant altitude, and indicated very satisfactory performance of servo-amplifier and motor.

Sensitivity did not radically decrease as the target was approached. High gain in servo amplifier overcame this expected result.

Normal Radar operation enabled the operator to guide the aircraft on course direct from Niagara Falls to the Rome Army Air Base, by using known reference targets. Approach was made from 10 miles Radar range to 500 feet altitude over target. Observed error appeared to be 20 yards to left of the end of the north-east runway intersection. On the return flight a Radar approach was made on a bridge target at Oswego from 5000 feet, ten miles Radar range. Target was confused by misalignment of trace, and bridge was missed by an estimated 1/2 mile to the right. At 700 feet level out the aircraft passed directly over a large grain elevator. A target in Rochester was tracked from 55 miles and homed on from 10 miles Radar range from 5000 feet to 500 feet. The northern end of the target was selected as the objective and the aircraft was guided to within an estimated 20 yards to left of a factory building. Apparent external Radar interference from another transmitter was noted at intervals during this approach. The anti-jamming circuit in the APQ-7 was successful in eliminating a major part of the interference, although with some loss of signal return. Final approach was made on Niagara Falls Airport from 5000 feet and ten miles Radar range, leveling off at 1000 feet. Selected target was northeast end of the test cells. The aircraft passed directly over target, but operator called the range 1/2 mile short.

3. Conclusion: Redesign of components of the TS-34 to enable faster sweep is indicated. The components of the range-altitude computer, which were tested, are considered satisfactory; however, the computer was not tested in its entirety, and variation in the range of the initial ground return indicated that it was not an altitude signal, but a slant range signal.

Normal Radar operation of the AN/APQ-7 enables completely reliable point-to-point navigation within range of the equipment. The addition of elevation control fed electronically to the auto pilot should enable accurate collision approaches to any selected target.

WWA:emh

BY: H. W. Ackerman DATE: 3/17/47	BELL Aircraft CORPORATION	MODEL: B-17G PAGE:
CHECKED: [signature] DATE: 3-18-47		AIRPLANE: 44-83517 REPORT:

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 53B (19)

PURPOSE: Practice and photograph simulated collision approaches on point targets under AN/APQ-7 guidance.

TEST EQUIPMENT: AN/APQ-7 and O-5 camera installed in B-17G.

CHANGES SINCE LAST FLIGHT: None

PILOT:	H. A. Dow	**GROSS WGT.:**	46,750
CO-PILOT:	J. Fritz	**FLIGHT TIME:**	:55
TEST ENGINEER:	W. A. Ackerman	**TOTAL TIME:**	31:25

WEATHER: Scattered clouds - Limited visibility in target areas.

TAKE-OFF TIME: 10:25

PRE-FLIGHT TESTS:

System operation was checked in pre-flight engine warm-up.

1. Method of Testing: One run was made on the north Grand Island Bridge from a northeast direction, letting down from 7500 feet to 800 feet from 10 miles until over target.

2. Results: Due to auto pilot failure the run was made by manual pilot control at the direction of the Radar operator. Approach was made to 300 feet altitude and ended an estimated 750 yards to the south of the Bridge. IAS was 160 mph and an estimated 25 to 30 knot crosswind was encountered. Other target areas appeared to be obscured; therefore, runs were discontinued.

3. Conclusion: It was found difficult to direct manual pilot target tracking in a crosswind approach. No trouble has been experienced in previous approaches when the auto pilot functioned properly.

Form 38-31

WWA:emh

BY: H. W. Ackerman DATE: 3/17/47	BELL Aircraft CORPORATION	MODEL: B-17G PAGE:
CHECKED: [signature] DATE: 3-18-47		AIRPLANE: 44-83517 REPORT:

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 53B (20)

PURPOSE: Locate targets and navigate in conditions of limited visibility entirely under AN/APQ-7 guidance.

TEST EQUIPMENT: AN/APQ-7 installed in B-17G

CHANGES SINCE LAST FLIGHT: Repaired auto pilot

PILOT:	H. A. Dow	**GROSS WGT.:**	46,750
CO-PILOT:	J. Fritz	**FLIGHT TIME:**	1:35
TEST ENGINEER:	W. A. Ackerman	**TOTAL TIME:**	33:00

WEATHER: Low overcast and snow flurries - Visibility 5 miles.

TAKE-OFF TIME: 14:45

1. Method of Testing: The aircraft was flown at flight altitudes of 2000 to 2500 feet under full guidance of the Radar operator. Selected course was Niagara to Hamilton, Long Point, and return to Niagara Falls Airport.

2. Results: No difficulty was encountered in maintaining course to Hamilton, although snow flurries occasionally caused zero pilot visibility. An attempt was made on the second leg to locate the transportation dump used as a target in previous flights; however, it was passed to the west and not observed. A Radar fix established by reference to a small lake and the coastline of Lake Erie established the turn point for the third leg. Because of the Radar returns from the ice pack in the vicinity of Long Point, this target was never positively identified, although a complete circle of 15 miles diameter was made. Strong returns were noted from Buffalo and Tonawanda at 50 miles. Final course was set by establishing a heading to the Grand Island Bridge from 40 miles. The R.F. antenna switch became inoperative for the entire approach to Grand Island, causing mirror images of the right sweep; however, it was found possible to maintain correct heading. The bridge was crossed at 1000 feet and less than 100 yards to the south. The R.F. switch again became operative and a short run from the northeast from 9 miles was made on the upper Grand Island bridge. This approach ended over the northern end of the span at 1000 feet. No azimuth error was observed. The Radar was used as assistance to the pilot in locating Niagara Falls Airport, which was blotted out by snow flurries.

3. Conclusion: Overland navigation at flight altitudes of 2000 feet with AN/APQ-7 was found to be very difficult because of the failure to positively identify the many Radar returns. Coastline and large city Radar returns provide ready reference points for fixes; however, reliable navigation in a completely land locked area would require flight altitude in excess of 10,000 feet and a knowledge of approximate location and compass heading. Individual target identification from low flight altitude requires positive known reference points.

Form 38-31

WWA:emh

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BY R. Ackerman DATE 3/12/47 | **BELL** Aircraft CORPORATION | MODEL B-17G | AIRPLANE 44-83517

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 54B (21)

PURPOSE: To practice and photograph simulated collision approaches from short range.

TEST EQUIPMENT: AN/APQ-7 installed in B-17. Gun Camera.

CHANGES SINCE LAST FLIGHT: Replaced operator's indicator

PILOT: J. A. Cannon
CO-PILOT: C. Fritz
TEST ENGINEER: R. Ackerman
[illegible] Shoults, Sizgron, Roberts[illegible]

GROSS WGT.: 44,780
FLIGHT TIME: 2:00
TOTAL TIME: 74:00

WEATHER: CAVU. Flight winds 30-26 m.p.h. [illegible]

TAKE-OFF TIME: 13:15

1. Method of Testing: Simulated collision approaches on the North Grand Island Bridge were made from 8500 ft. to 800 ft. from 10 mi. Radar range at 16 [illegible]

2. Results: First approach was made on a heading of 270° using normal technique of reducing receiver gain as target was closed. At level out, target was observed visually to be an estimated 50 yards off course.

Second approach was made on a reciprocal heading of the initial approach. The anti-jam circuit was used in an effort to improve target definition and was found very successful. It was also noted that an antijam gain setting could be used and no further adjustment made in the approach. Target was passed over at approximately the same error noted in the first approach.

Final approach was made from approximately 10 mi. N.E. of Niagara Falls. Some difficulty was encountered in identifying the target due to the many radar returns in the scope. The anti-jam circuit was again used and target was readily identified. Course made good was a parabola to the target, due to incorrect original course alignment and a variable cross wind. The aircraft passed an estimated 75 to 100 yds off target.

3. Conclusions: Further investigation of the anti-jam circuit to enable target approaches without varying the receiver gain is considered desirable. Flight test of duplicate approaches to other previously used targets with present receiver gain is indicated.

RA:ak

Form 84-41

BY R. Ackerman DATE 3/21/47 | **BELL** Aircraft CORPORATION | MODEL B-17G | AIRPLANE 44-83517

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 55B (22)

PURPOSE: Test operation of triple-tone target discriminator circuit used with AN/APQ-7

TEST EQUIPMENT: AN/APQ-7 Radar and mock-up of triple-tone target discriminator circuit installed in B-17G.

CHANGES SINCE LAST FLIGHT: Installed modified operator's indicator.

PILOT: J. A. Cannon
CO-PILOT: C. Fritz
TEST ENGINEER: T. Netherty & R. Ackerman

GROSS WGT.: 46,730
FLIGHT TIME: 2:30
TOTAL TIME: 76:30

WEATHER: Scattered clouds, increasing to solid overcast and 1 mile visibility near end of flight.

TAKE-OFF TIME: 09:25

PRE-FLIGHT TESTS:

Average Power Output: 66 +DBW (3/20/47)
Receiver Sensitivity: 97 -DBW (3/20/47)

1. Method of Testing: Flight plan was set up to seek remote targets by offset techniques and Radar-controlled navigation. Selected course was from East Aurora to railroad yards southeast of Hornell in mountainous area having varying elevation to 2100 feet. Second leg was to a target indicated as a power station on the west shore of Seneca Lake near Dresden. Third leg was to a factory target in northwest Rochester. Final target was the North Grand Island Bridge. The first leg was flown at 10,500 feet, and the remainder at 8500 feet. Let-down was begun at 10 miles at 160 mph IAS. The existing anti-jam circuit in the APQ-7 and the triple-tone target discriminator were used in test separately.

2. Results: Radar operation was initially faulty, producing a spoking effect in the sweep. Fault was later established as an intermittent ground in the filament supply to the triple-tone circuit.

A level run was made over the Grand Island Bridge to tune the target discriminator. Course was then set for Hornell and departure taken over East Aurora at flight altitude.

Estimated positions were established by reference to elapsed time, radio range, and Radar return. By use of the discriminator, terrain returns were well defined; however, individual targets were blended in the general Radar return. On this leg the course was judged to be correct, but target was passed over and not identified by Radar. A 180 degree turn was made and target was identified visually after returning 8 miles on a reciprocal of the original course.

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REPORT NO. BMPR-5

BY W. Ackerman DATE 3/21/47	BELL Aircraft CORPORATION	MODEL B-173	PAGE
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FLIGHT #568 (22)

2. Results: (Continued)

Excellent land painting was observed on the second leg to Dresden Power Station by using triple-tone circuit; however, again individual target definition was not apparent, and approach was ended some ten miles north of target. A turn was made and a visual run was made over target by the pilot. The Power Station was located approximately 200 yards from the lake shore and passed over directly, but no apparent Radar return was discernible.

The third leg was run on a selected factory target in northwest Rochester using normal Radar operation, except for intermittent test of the triple-tone discriminator. Every attempt to use the discriminator circuit resulted in a general blending of the target signals with the terrain returns. Approach was made from 53 miles, letting down to 500 feet over target. No error in homing was observed.

Final run was made on the Grand Island Bridge, letting down to 1000 feet over target from ten miles range. The triple-tone discriminator was used and found effective in controlling contrast on this approach. No change in gain or video level was required after the initial optimum value was set at the beginning of the approach. No error in homing was observed.

3. Conclusion: Redesign of the triple-tone target discriminator is necessary to improve point target definition. It is useful in its present form in identifying targets by their configuration as in the case of bridges or other over-water objects; however, it caused complete loss of normally identifiable land targets. The triple-tone circuit mock-up showed no improvement over the existing anti-jam circuit in the AN/APQ-7.

WWA:cmh

BY W.W.Ackerman DATE 3/27/47	BELL Aircraft CORPORATION	MODEL B-173	PAGE
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FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 569 (23)

PURPOSE: Test operation of mechanical azimuth computer used with AN/APQ-7 Radar in simulated collision approaches.

TEST EQUIPMENT: AN/APQ-7 Radar Installed in B-173

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CHANGES SINCE LAST FLIGHT: Installed mechanical azimuth computer and P.D.I.

PILOT:	A. M. Johnston	**GROSS WGT.:**	46,750
CO-PILOT:	None	**FLIGHT TIME:**	1:45
TEST ENGINEER:	W. W. Ackerman	**TOTAL TIME:**	38:16

WEATHER: Scattered clouds - Wind Southwest - 35 mph

TAKE-OFF TIME: 09:55

PRE-FLIGHT TESTS:

Overall system operation checked on external power supply prior to takeoff.

1. Method of Testing: Airplane was flown on selected headings to targets near Brantford, Erie, and Grand Island. Flight altitude was 8000 feet. Let-down from 10 miles range to 500 feet over target at 150 mph IAS was used on approach to the Brantford and Grand Island targets. Pilot followed the PDI meter in each approach.

2. Results: Initial course was set to transportation dump 10 miles southeast of Brantford. Target was identified at 43 miles and the azimuth computer zero set on desired heading. Pilot followed PDI meter and Radar operator continued to align cursor on target. Let-down began at 10 miles and ended 500 feet over target. No azimuth error was observed. Pilot reported minor corrections were applied to maintain target heading.

The second approach was made on a selected target at Erie at flight altitude. Approach was made without let-down. Computer was aligned as in previous approach. It was estimated that target was passed over at flight altitude; however, positive visual evidence was lacking due to cloud cover.

The third approach was made on a selected heading to Port Maitland. Too high a rate drive was set in the computer, which caused the PDI to oscillate, and target was lost within the last 20 miles of approach. Heading was altered to Grand Island and approach to the north bridge was attempted from 10 miles range, letting down to 500 feet over target. The bridge was passed approximately 100 yards to the north, which error was believed due to faulty zero setting of the computer.

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BY H.T. Ackerman DATE 3/27/47 | BELL AIRCRAFT CORP. NIAGARA FRONTIER DIVISION BUFFALO, N.Y. | MODEL B-17? PAGE
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FLIGHT #6?B (23)

2. Results: (Continued)

Final approach was made on Grand Island Bridge from 22 miles east of target. An estimated 14 degree left drift was encountered. The approach was ended at 500 feet directly over target after let-down from 10 miles.

3. Conclusions: No difficulty was encountered by the pilot in homing on a target by following the PDI fed from the azimuth computer, except when the Radar operator used too high a rate correction. It is recommended that an auxiliary PDI be located adjacent to the Radar operator's position to enable initial computer alignment on the desired target heading.

WEA:esh

BY H.T. Ackerman DATE 3/31/47 | BELL Aircraft CORPORATION | MODEL B-17? PAGE
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FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 67B (24)

PURPOSE: Test operation of range elevation computer with AN/APQ-7

TEST EQUIPMENT: AN/APQ-7 Installed in B-17?

CHANGES SINCE LAST FLIGHT: Completed installation of range and elevation computer components in B-17?

PILOT:	A. V. Johnston	**GROSS WGT.:**	46,750
CO-PILOT:	J. Fritz	**FLIGHT TIME:**	1:30
TEST ENGINEER:	N. Spencer	**TOTAL TIME:**	39:40
	W. Ackerman		

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WEATHER: Scattered clouds - Generally CAVU

TAKE-OFF TIME: 09:50

PRE-FLIGHT TESTS:

System operation tested prior to takeoff.

1. Method of Testing: Components were tested and aligned in flight. Aircraft was flown at 7500 feet flight altitude on headings to Brantford, Erie, Port Maitland, and Grand Island. Let-down from 10 miles range to 500 feet altitude over target at 150 mph I.A.S. was used in approach to Brantford, Port Maitland, and Grand Island. Erie was passed over at flight altitude.

2. Results: The vertical gyro was zeroed in level flight, and after a few trial runs to observe the tracking procedure, the pilot attempted to fly the indicated meter course in elevation. Meter sensitivity was found too great. Flight attitude changes due to wind were enough to produce full meter deflection.

Let-down on targets was attempted. It was found impossible to follow meter indications because of off-scale readings. Approaches were continued, using normal let-down procedures and targets were passed over with no observable error in azimuth.

An attempt was made to track the target with the range marker on three of the runs. No difficulty was encountered in following target to seven miles, at which time the marker became erratic and oscillated up and down the sweep. From 4 miles to over target the range marker could not be kept on the signal return. This is believed due to zero adjustment error.

The ground return pulse was not apparently improved or stabilized by the use of a directional horn which fed a portion of the R.F. energy from the transmitter in a beam directed perpendicular to the aircraft's longitudinal axis.

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CHECKED DATE 4-4-47 — SHIP 44-83517 REPORT

FLIGHT #57B (24)

2. Results: (Continued)

The rate drive on the expanded sweep from 30 to 2 miles was operated and found non-linear from approximately 7 miles to minimum range. Switching operations were a source of confusion and delay in quickly changing ranges.

3. Conclusion: Modification of the elevation meter is necessary to reduce sensitivity. The range marker control requires modification to enable it to follow a target to minimum range. (It has a further disadvantage of obscuring the signal return on relatively small targets.) The rate drive needs modification to accomplish linear range expansion throughout full scale operation. The R.F. horn connected to alternate taps of directional coupler produced no observable improvement in altitude return.

EEA:emh

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CHECKED DATE 4-4-47 — AIRPLANE 44-83517 REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 57B (25)

PURPOSE: Evaluate and practice pin-point target location and navigation with AN/APQ-7

TEST EQUIPMENT: AN/APQ-7 Radar Installed in B-17G

CHANGES SINCE LAST FLIGHT: None

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PILOT: A. M. Johnston **GROSS WGT.:** 46,750
CO-PILOT: P. B. Foster **FLIGHT TIME:** 2:00
TEST ENGINEER: E. E. Ackerman **TOTAL TIME:** 41:25

WEATHER: Broken clouds and overcast during first and second flight legs.

TAKE-OFF TIME: 14.10

PRE-FLIGHT TESTS:

System tested on external power supply prior to takeoff.

1. Method of Testing: Pre-determined targets were selected and homed on by the Radar operator, using the remote auto pilot azimuth control. The pilot controlled takeoff, landing, and elevation. Throughout the entire flight all headings were controlled by the Radar operator. Selected courses follow: (1) Niagara Falls to East Aurora, climbing on course to 10,000 feet flight level. (2) Take departure East Aurora to railroad yards southeast of Hornell. (3) Hornell to Power Station at Dresden. (4) Dresden to selected target in northwest Rochester. (5) Rochester to Grand Island bridge.

2. Results: Radar operator directed climb on approximate heading to East Aurora, and corrected the final course by observing Radar return.

Turn was made over East Aurora to approximate heading to Hornell. The first 15 miles was directed on course by Radar returns from identifiable terrain configurations, after which positive identification by Radar alone became impossible, and selected target was passed over.

The directional horn which had been connected in previous flight was disconnected at this time in an effort to improve Radar returns. Signal returns from beyond 30 miles range then gave a marked improvement in intensity.

Orientation was finally established by Radar near Elmira and the corrected heading for Dresden was taken up. Target was identified and tracked from 43 miles. Let-down began at 10 miles Radar range and ended 500 feet over target. The aircraft passed approximately 100 yards to right of the Power Station.

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BY W.W. Ackerman	DATE 3/31/47	BELL Aircraft CORPORATION	MODEL B-17G
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FLIGHT #567B (26)

2. Results: (Continued)

The approximate heading to the selected Rochester target was flown, and the aircraft climbed to flight altitude. At 50 miles Radar range what was believed to be the selected target was observed, and course set for collision heading. At 45 miles target proved to be a ship close in shore, and at 40 miles two ships were apparent on divergent courses. Heading was altered to the larger ship target, and approach was made from 10 miles, letting down to 500 feet over target. At 8 miles the ship altered course and steamed a zigzag pattern which was clearly evident on the Radar scope. The return from the wake was nearly of the same magnitude as that from the ship. The aircraft passed directly over the ship (appeared to be 5000 ton lake freighter) at 500 feet.

Approximate course for Niagara Falls was set and return to flight altitude of 10,000 feet was made. Niagara Falls Airport was tentatively identified and tracked from 60 miles. Course to Grand Island Bridge was corrected at 40 miles and approach began at 10 miles, letting down to 500 feet over bridge. No error was observed.

3. Conclusions: The AN/APQ-7 can be successfully used to direct homing on point targets that are readily identifiable by reference to other known returns and on ship targets. Targets shadowed by high terrain require a more positive return than is apparent from the Radar alone for identification.

WWA:emh

BY W.W. Ackerman	DATE 4/1/47	BELL Aircraft CORPORATION	MODEL B-17G
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FLIGHT TEST REPORT

PROJECT: VX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 598 (26)

PURPOSE: Test operation of rate drive sweep expansion component of AN/APQ-7

TEST EQUIPMENT: AN/APQ-7 Installed in B-17G (Rate Drive Sweep Expander)

CHANGES SINCE LAST FLIGHT: None

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PILOT: J. A. Cannon
CO-PILOT: J. Fritz
TEST ENGINEER: W. Ackerman & E. Evans

GROSS WGT.: 44,750
FLIGHT TIME: 1:35
TOTAL TIME: 43:20

WEATHER: High clouds 9000-10,000 feet - Visibility 8-10 miles

TAKE-OFF TIME: 10:10

PRE-FLIGHT TESTS:

System operation tested on warm-up.

1. Method of Testing: Standard simulated collision approaches were made under Radar operator control on targets near Brantford, Erie, Port Maitland, and Grand Island from 9,000 foot flight altitude to 500 feet over target. Let-down began at 10 miles Radar range.

2. Results: Approach was made on transportation dump near Brantford from 10 miles Radar range. Target was initially identified at 35 miles, and was tracked to 30 miles, at which time the rate drive sweep expansion was turned on. Rate was adjusted to keep target in upper 2/3 of scope, and required no further attention until target range became 10 miles. From 10 to 6 miles expansion became very slow, until at 3 miles a sharp increase in rate occurred which required a large adjustment of the rate control. Continuous rate adjustment was necessary to minimum range.

Second approach was on a grain elevator at Erie. The same procedure and results were observed as noted in previous run.

Third approach was made on a dam approximately 7 miles northwest of Port Maitland. Manual sweep expansion was used to its normal limit of 10 miles, and then the rate drive was switched in the circuit. Target was immediately confused until the rate drive expanded the sweep to approximately the 10 mile range. At 5 miles and below the effects previously noted occurred.

Final approach was made on the North Grand Island Bridge. Rate drive sweep expansion was used with the same results as in the earlier runs.

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BY E. E. Ackerman DATE 4/1/47 | **BELL** Aircraft CORPORATION | MODEL B-17? PAGE
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FLIGHT #59B (26)

3. Conclusions: Modification of the rate drive is necessary to produce linear expansion to minimum range. The addition of a slew control to permit rapid change in sweep expansion is desirable. The Radar operator does not have positive, fast-acting range expansion control in the present mock-up.

VA:emh

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FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 59B (27)

PURPOSE: Test operation of range-elevation computer.

TEST EQUIPMENT: AN/APQ-7 Installed in B-17? (Range-Elevation Computer)

CHANGES SINCE LAST FLIGHT: Computer components modified.

PILOT: J. A. Cannon
CO-PILOT: C. Fritz
TEST ENGINEER: E. E. Ackerman & K. Spencer
WEATHER: CAVU

GROSS WGT.: 46,750
FLIGHT TIME: 2:00
TOTAL TIME: 45:20

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TAKE-OFF TIME: 09:40

PRE-FLIGHT TESTS:

System operation and zero alignment tested on ground on external power.

1. Method of Testing: Diving approaches on pre-selected targets were attempted from 10 miles Radar range to 500 feet over target. The pilot tried following the elevation meter in controlling descent. Three Radar operators were required: one to track target range, one to track elevation, and the third to direct the aircraft in azimuth to target.

2. Results: Five runs were made using the Range-Altitude Computer. The indicated approach angle appeared to be correct on the initial approach, but the succeeding four approaches were too high. Flight altitude was 7500 feet at the beginning of each approach except number 3, which was started from 5000 feet. Investigation showed that the potentiometer controlling altitude was running off of the resistance element. The navigator's scope had erratic sweep operation. Intermittent interference from a high powered ground Radar was also apparent. These three factors made range tracking difficult, resulting in inaccurate elevation angle solution.

3. Conclusions: Modification of the altitude tracking potentiometer is required. The antenna horn made no apparent difference in altitude return.

EEA:emh

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BY W.W. Ackerman DATE 4/3/47 | CHECKED [signature] DATE 4-7-47

BELL Aircraft CORPORATION

MODEL B-17G | PAGE | AIRPLANE 44-83517 | REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 59B (28)

PURPOSE: Test operation of range-altitude computer with AN/APQ-7 Radar

TEST EQUIPMENT: AN/APQ-7 Installed in B-17G (Range-Altitude Computer)

CHANGES SINCE LAST FLIGHT: Altitude potentiometer modified. Yevscope potentiometer replaced.

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PILOT: A. W. Johnston **GROSS WGT.:** 46,750
CO-PILOT: None **FLIGHT TIME:** 1:15
TEST ENGINEER: W. W. Ackerman & N. Spencer **TOTAL TIME:** 46:35

WEATHER: CAVU

TAKE-OFF TIME: 14:35

PRE-FLIGHT TESTS:

System operation tested on external power supply.

1. Method of Testing: Shuttle runs were made on the Grand Island Bridge and a dam at Dunville, Ontario. Approaches were made from 7000 feet, 8000 feet, 10,000 feet, and 5,000 feet flight levels from 12 miles Radar range. The pilot followed the elevation meter indications in each let-down.

2. Results: Four approaches were attempted. On the first run the range tracking operator became confused as to target and approach was ended 700 feet high. On the second and third runs, from 8000 and 10,000 feet respectively, the elevation meter indicated the correct approach angle to target. The fourth run, from 5000 feet, was slightly high due to slipping of the clutch on the range control.

3. Conclusion: Operation of the range altitude computer in solving the problem of dive angle to target is considered satisfactory. Refinement of control is indicated to simplify operation of this unit.

WWA:emh

BY W.W. Ackerman DATE 4/4/47 | CHECKED [signature] DATE [illegible]

BELL Aircraft CORPORATION

MODEL B-17G | PAGE | AIRPLANE 44-83517 | REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 60B (29)

PURPOSE: Test operation of Range-Altitude Computer with AN/APQ-7 Radar

TEST EQUIPMENT: AN/APQ-7 Installed in B-17G (Range-Altitude Computer)

CHANGES SINCE LAST FLIGHT: None

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PILOT: A. W. Johnston **GROSS WGT.:** 46,750
CO-PILOT: J. Fritz **FLIGHT TIME:** 1:00
TEST ENGINEER: R. Robertson, N. Spencer, & W. W. Ackerman **TOTAL TIME:** 47:35
OBSERVER: R. P. Whitman
WEATHER: Haze - 8 to 10 miles visibility - ceiling 6000 to 8000 feet.

TAKE-OFF TIME: 10:15

PRE-FLIGHT TEST:

System operation tested during warm-up of engines.

1. Method of Testing: Three runs were made on the Grand Island Upper Bridge from 8000 feet flight level from 10 miles Radar range. The pilot followed elevation meter indications in let-down.

2. Results: All target runs were considered successful. The pilot reported no difficulty in following the meter indications. Approaches ended 5[illegible] feet above target.

3. Conclusion: Satisfactory dive angle indications to selected targets can be maintained from 10 miles Radar range using the Range-Altitude Computer component of the AN/APQ-7 Radar.

WWA:emh

BY N.N.Ackerman DATE 4/8/47
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BELL Aircraft CORPORATION

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AIRPLANE 44-83517 REPORT ____

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 61B (3D)

PURPOSE: Observe and practice target location from 20 - 25 miles range using AN/APQ-7 Radar.

TEST EQUIPMENT: AN/APQ-7 Installed in B-17G

CHANGES SINCE LAST FLIGHT: Replaced operator's indicator; removed range-altitude computer.

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PILOT:	F. Walton	**GROSS WGT.:**	48,750
CO-PILOT:	J. A. Cannon	**FLIGHT TIME:**	2:00
TEST ENGINEER:	N.N.Ackerman	**TOTAL TIME:**	43:35
RADAR OPERATOR:	J. Donovan		
WEATHER:	CAVU except for light haze.		

TAKE-OFF TIME: 10:10

PRE-FLIGHT TESTS:

System operation tested on external power supply before takeoff.

1. Method of Testing: Selected targets were approached by manual pilot control to within 20 to 25 miles range, and within 25 degrees of the aircraft heading. At the pilot's signal, let-down began. The Radar operator attempted to correct for collision course to target, and direct closing by remote auto pilot azimuth control. Prior to signal from the pilot the Radar was set in normal operation on the 30 mile range, but the scope was not observed except as necessary in aligning controls. All runs were made from 10,000 feet at 180 mph I.A.S.

2. Results: The first target selected was the railroad yards east of Hornell, which are located in a valley between mountains ranging from 2000 to 2500 feet elevation. The aircraft heading at the start of descent was 140 degrees magnetic. Target was tentatively identified at 23 miles as a thin bright line on the scope. Heading was altered 10 degrees right to maintain a collision course. The aircraft passed directly over the railroad yards.

Second target selected was the Corning Glass works at Corning, New York. Aircraft heading was 192 degrees magnetic. After 3 minutes on course the Radar operator directed a correction 18 degrees right to target observed at 16 miles. Run ended over a railroad bridge and highway approximately 8 miles northeast of Corning. Operator had failed to note heading at the beginning of descent, and ignored the Radar return from Corning in the mistaken belief that it was Elmira.

Third selected target was a Power Station at Dresden on the west shore of Lake Seneca. Aircraft heading was 023 degrees magnetic. Initial range was 24 miles at 25 degrees to the left of the aircraft heading. The operator confused the location in relation to Lake Seneca, and target passed to the left of the

BY N.N.Ackerman DATE 4/8/47
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BUFFALO, N.Y.

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FLIGHT #61B (3D)

2. Results: (Continued)

Radar beam coverage. A second attempt was started on a heading of 203 degrees magnetic. Faulty operation of the AFC and misalignment of the video and gain level again caused confusion and loss of target.

The final selected target was Lockport, which was approached on a heading of 284 degrees magnetic. Positive identification of target was never accomplished, and the run was unsuccessful.

3. Conclusion: Positive target identification requires accurate knowledge of location and heading at the time the Radar is turned on. Approach to the target cannot be parallel to areas which are shadowed by returns from high terrain. Operator experience is a major requirement for successful operation.

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REPORT NO. EMR-6

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BY T. J. Ackerman DATE 4/9/47 | CHECKED [illegible] DATE [illegible] | BELL Aircraft CORPORATION | MODEL B-17 [illegible] | AIRPLANE 44-85817 [illegible] | PAGE | REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** (28) (31)

PURPOSE: Observe and practice target location from 20,000 feet flight level with AN/APQ-7

TEST EQUIPMENT: Standard AN/APQ-7 installed in B-17?

CHANGES SINCE LAST FLIGHT: Aligned [illegible] circuit

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PILOT:	F. Talton	**GROSS WGT.:**	46,760
CO-PILOT:	J. Fritz	**FLIGHT TIME:**	1:15
TEST ENGINEER:	T. J. Ackerman	**TOTAL TIME:**	60:50

WEATHER: Overcast 4200 to 8000 feet; vertical development

TAKE-OFF TIME: 13:50

PRE-FLIGHT [illegible]:

System operation tested on external power supply; Klystron tuned 4/8/47.

1. Method of Testing: An attempt was made to locate and home on pre-selected targets from off-course headings up to [illegible] degrees from 20,000 feet and 25 to 30 miles range.

2. Results: Solid overcast in all operating areas caused tests to be discontinued. Radar was used as an aid in returning to base.

3. Conclusions: Flight must be repeated when safe operating conditions [illegible].

TJA:ech

Form 96-61

BY T. J. Ackerman DATE 4/10/47 | CHECKED [illegible] DATE [illegible] | BELL Aircraft CORPORATION | MODEL B-17G | AIRPLANE 44-85817 | PAGE | REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 63B (32)

PURPOSE: Observe operating limitations of AN/APQ-7 used for point target location from 20,000 feet flight altitude.

TEST EQUIPMENT: AN/APQ-7 installed in B-17G

CHANGES SINCE LAST FLIGHT: None

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PILOT:	F. Talton	**GROSS WGT.:**	46,760
CO-PILOT:	J. Fritz	**FLIGHT TIME:**	2:10
TEST ENGINEER:	T. J. Ackerman	**TOTAL TIME:**	63:00

WEATHER: CAVU except for light ground haze.

TAKE-OFF TIME: 09:50

PRE-FLIGHT TESTS:

System operation tested on external power supply.

1. Method of Testing: An attempt was made to locate and home on targets from off-course headings up to 25 degrees from 20,000 feet and 25 to 30 miles Radar range. Descent to 500 feet over target was made at 150 mph I.A.S.

2. Results: Initial target was the railroad yards at Hornell. Aircraft heading was 184 degrees M. Target was immediately identified at 21 miles Radar range, and heading was corrected 3 degrees right. At 3000 feet flight level and 11 miles Radar range the target became confused in the land return and was never re-established, although the aircraft passed over target.

Second attempt was made on a Power Station at Dresden. Target was tentatively identified 8 degrees right of a heading of 062 degrees M. at 23 miles. Radar return from the far shore of Lake Seneca was very strong, and the near shore was not well defined. An attempt to establish target reference to a point of land on the opposite far shore was unsuccessful, and the approach ended over a small town 1½ miles southeast of the selected target.

Final run from 20,000 feet flight level was attempted on a factory target in northeast Rochester. Tentative identification was immediately established 3 degrees left of a heading of 311 degrees M. at 26 miles. Positive identification was completed at 9 miles, and the run ended directly over target at 500 feet.

Outside air temperatures ranged from +11°C on the ground at Niagara to -16°C at 20,000 feet flight level. Radar operation appeared to be normal.

Form 96-61

BY W.W. Ackerman	DATE 4/10/47	BELL Aircraft CORPORATION	MODEL B-17G
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FLIGHT #638 (32)

2. Results: (Continued)

Radar scope returns observed on the first two runs did not agree with similar approaches on the same targets from 10,000 feet flight level at approximately one-half the range. No apparent difference was noticed on the final target.

3. Conclusion: A re-flight from 20,000 feet flight level on the same targets is considered desirable. Temperature inversions over the mountains near Hornell and over Lake Seneca may account for the apparent change in angle of Radar reflection.

WWA:emh

BY W.W. Ackerman	DATE 4/10/47	BELL Aircraft CORPORATION	MODEL B-17G
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FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 638 (33)

PURPOSE: Observe and test in flight the operation of the modified Triple-Tone Target Discriminator.

TEST EQUIPMENT: AN/APQ-7 (Triple-Tone Target Discriminator) Installed in B-17G.

CHANGES SINCE LAST FLIGHT: Installed modified operator's indicator in B-17G

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PILOT: F. Walton
CO-PILOT: R. B. Foster
TEST ENGINEER: W. W. Ackerman & T. Witherby

GROSS WGT.: 46,750
FLIGHT TIME: 1:30
TOTAL TIME: 54:30

WEATHER: Overcast 6000 to 8000 feet.

TAKE-OFF TIME: 14:30

PRE-FLIGHT TESTS:

System operation tested on external power supply.

1. Method of Testing: Aircraft was flown at medium flight level over varied ground targets in an attempt to observe on the Radar scope the discriminator action of the modified triple-tone circuit.

2. Results: The triple-tone circuit did not give satisfactory contrast between targets and landmass.

3. Conclusion: Redesign of the triple-tone target discriminator is necessary. Elimination of manual controls to achieve contrast is desirable.

WWA:emh

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REPORT NO. BMPR-6

BY W.W. Ackerman DATE 4/14/47 CHECKED [signature] DATE 4-18-47 — BELL Aircraft CORPORATION — MODEL B-17G AIRPLANE 44-85517 PAGE REPORT

FLIGHT TEST REPORT

PROJECT: MX-776 **PLACE:** Niagara Falls Airport **FLIGHT #:** 65B (35)

PURPOSE: Test operation and limitations of AN/APQ-7 Radar.

TEST EQUIPMENT: AN/APQ-7 Installed in B-17G

CHANGES SINCE LAST FLIGHT: Replaced crystal and tuned local B.F.O.

CONFIDENTIAL

PILOT: F. Walton
CO-PILOT: J. Fritz
TEST ENGINEER: W. Ackerman
RADAR OPERATOR: J. Donovan
WEATHER: CAVU - Winds southeast 55-60 mph at flight level.

GROSS WGT.: 46,750
FLIGHT TIME: 2:40
TOTAL TIME: 63:50

TAKE-OFF TIME: 10:15

PRE-FLIGHT TESTS:

Tested system operation and aligned operating voltages on aircraft's power supply prior to takeoff.

1. Method of Testing: Attempts were made to locate and let-down on targets from 20,000 feet flight altitude at 25 miles and 30 miles Radar range. Ground speeds were determined by timing the interval to close 10 miles on Radar returns on course headings. Attempts were also made to determine the maximum angle at which the Radar target return could still be identified in flying level at 2 miles altitude and at 1 mile altitude. The latter tests were made by having the Radar operator indicate the instant the target was lost in the altitude return on the scope, while a second observer noted relation to the target as it appeared in the optical drift sight, which is mounted perpendicular to the aircraft longitudinal axis.

2. Results: Downwind approaches on selected targets at Dresden and Rome from 20,000 feet flight level from 25 mile and 35 mile ranges, respectively, were unsuccessful. The aircraft was unable to descend fast enough. Dresden was lost at 10 miles range, and Rome was tracked to 2 miles, at which time the run was ended 6000 feet over the Field. A normal approach was then made.

Ground speeds were determined in level flight and in descent with no apparent error.

Radar angle to target in level flight at 2 miles and 1 mile level, appeared to approach 90 degrees from the horizon as observed optically. Computation of Radar slant range data at the time target merged with the altitude return is inconsistent with the optical observation. Error is believed due to operator's estimation of Radar indicated range.

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3. Conclusion: Detailed analysis of selected target in respect to Radar shadow areas, missile approach angle, and missile drift will be necessary to utilize the "eyes" for successful collision approach on target. Apparently the "Eagle" antenna will "see" the target until very nearly directly above it in level flight. Rate and range of descent must be governed by ground speed in order not to overshoot target at low angles of approach in conventional aircraft.

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Evans, John H. AUTHOR(S)	DIVISION: Guided Missiles (1) SECTION: Design and Description (12) CROSS REFERENCES: Missiles, Guided - Design (62909); Missiles, Guided - Range (63550); Missiles, Guided - Structural design (63700); Rascal (62909);*	054000	ATI- 4573 ORIG. AGENCY NUMBER BMPR 6 REVISION U

AMER. TITLE: Rascal air-to-ground guided missiles - Sixth bi-monthly progress report

FORG'N. TITLE: Guided Missiles, Radar Guidance (OVER)

ORIGINATING AGENCY: Bell Aircraft Corp. AN/APQ-7

TRANSLATION:

COUNTRY	LANGUAGE	FORG'N.CLASS	U.S.CLASS.	DATE	PAGES	ILLUS.	FEATURES
U.S.	Eng.		Secr.	Apr'47	79	14	photos, diagrs, graphs

ABSTRACT

Design of supersonic guided missile with range up to 100 miles is discussed. Studiee are continued on effect of ogival nose angles on missile range and curve of range versus angle indicated optimum range for 35 degrees. Concerning suitable nose configurations, new design based on structural, aerodynamic, and production considerations, are outlined for Rascal missile grossing 11,500 pounds. AN/APQ-7 radar will include triple-tone circuit deemed essential for attacks on land targets. Flight test reports are appended.

* Target seekers, Electromagnetic (92000)

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