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Date: OCT 1 1 2012

NATIONAL BUREAU OF STANDARDS

Quarterly Progress Report No. 2
For Period Ending March 31, 1947
on Project

KINGFISHER

5-20 11:00

ATI No. 4611

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NATIONAL BUREAU OF STANDARDS

Quarterly Progress Report No. 2
For Period Ending March 31, 1947
on Project

KINGFISHER

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U. S. DEPARTMENT OF COMMERCE
W. Averell Harriman, Secretary

NATIONAL BUREAU OF STANDARDS
E. U. Condon, Director

NATIONAL BUREAU OF STANDARDS
Quarterly Progress Report No. 2
For Period Ending March 31, 1947
on Project

KINGFISHER

Submitted to
Bureau of Ordnance
and
Bureau of Aeronautics
NAVY DEPARTMENT

Approved for the National Bureau of Standards
Hugh L. Dryden, Chief of Project
E. U. Condon, Director

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TABLE OF CONTENTS

PAGE

II. AIRFRAME

B. CURRENT PROGRESS

III. NAVIGATION

B. CURRENT PROGRAM

IV. INTELLIGENCE

B. CURRENT PROGRESS

V. PROPULSION

VI. STABILIZATION AND CONTROL

B. CURRENT PROGRESS

VII. POWER SUPPLY

VIII. INSTRUMENTATION

U-27101

I. INTRODUCTION

The KINGFISHER is a radar-controlled, subsonic, self-homing, airborne guided missile designed to deliver an explosive charge below the waterline against floating targets. It is intended that KINGFISHER will be released from an aircraft well beyond the range of conventional antiaircraft fire originating at the target. The KINGFISHER, in turn, will release a torpedo at some distance short of the target. An exception is the Type E KINGFISHER, which is intended for submarine targets and is to be released from shipboard.

Project KINGFISHER is an outgrowth of the PELICAN and BAT Projects, which were carried out, during the war, at the National Bureau of Standards under the sponsorship of the National Defense Research Committee and the Bureau of Ordnance of the Navy Department. Supporting radar development work was done by the Radiation Laboratory of the Massachusetts Institute of Technology. First design consideration was given to KINGFISHER in September 1944, but active development work on the Project did not begin until after the end of World War II. The Project was originally under the cognizance of the Bureau of Ordnance, but during the current quarter, the assistance of the Bureau of Aeronautics was enlisted, and Project KINGFISHER is now controlled jointly by these two Bureaus of the Navy Department. Technical direction of the Project is the responsibility of the National Bureau of Standards. The organization chart for the KINGFISHER development project is shown in Figure 1.

As of January 1, 1947, consideration was being given to five KINGFISHER types: A and B, which were gravity-powered (glider), and C, D and E, which were jet-powered missiles. During the current quarter, at the direction of CNO, the glider types, A and B, were abandoned because of lack of an operational demand. A new type, Type F, was added, which is essentially a powered version of the former Type B. Currently, the four types of KINGFISHER missiles, designated for development, are as follows:

Type C: A power-driven missile having a 20-mile range when launched from an aircraft at low altitude; total weight of the unit to be about 4,000 lbs., including the payload, which is a power-driven homing torpedo having a 350-lb. warhead charge. The Type C KINGFISHER is being designed to be released from currently available aircraft and to use currently available torpedoes (in particular, the Mk 13 and Mk 25).

Type D: A power-driven missile having a 20-mile range when launched from an aircraft at low altitude; total weight of the unit to be about 3,000 lbs., including the payload, a light-weight power-driven homing torpedo (not yet developed) having a 200- to 400-lb. warhead charge.

Type E: A power-driven missile having a 10- to 20-mile range when launched from a surface ship; the total weight of the unit to be about 3,000 lbs., including the deep-diving homing torpedo (Mk 35) now in the research stage.

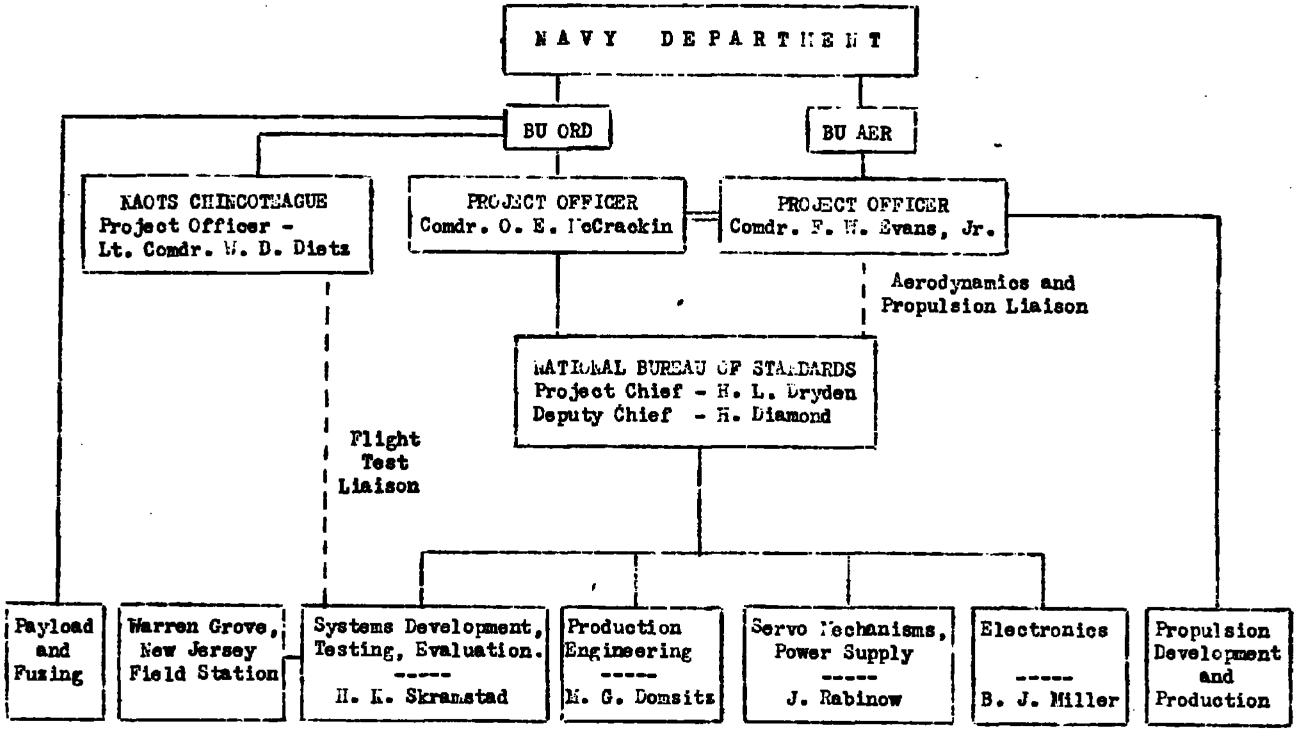


FIGURE 1

ORGANIZATION CHART FOR KINGFISHER DEVELOPMENT

Type F: A power-driven vehicle having a 20-mile range, aircraft launched; the total weight of the unit to be about 1,000 lbs., including the payload, which will be a non-powered, non-homing bomb torpedo of about 350-lb. weight, similar to the German BT. The payload has not yet been developed.

Major effort is being put on Type C KINGFISHER, although the other three types, particularly Type F, are being given serious attention. Because of the fact that powered missiles, even the interim design, will not be available for flight testing until 1948, an extensive test program is under way with glider missiles in order to facilitate the development of the other essential components.

The progress and status of development of KINGFISHER is presented, in the following sections of this report, under headings of Airframe, Navigation, Intelligence, Servo Systems, Propulsion, Electrical Power Supply, and Instrumentation. Under each heading is a brief summary of the over-all status followed by a more detailed resume' of current progress. The applicability of the various developments to different KINGFISHER types is considered separately in each section.

II. AIRFRAME

A. STATUS OF DEVELOPMENT

Most of the work to date on KINGFISHER airframes has been on glider versions in order to have vehicles available for immediate field testing. However, in wind tunnel tests and design studies, the required modifications on the airframe to convert it to the powered version have been carefully noted.

The airframe used in current field tests is designated Mark 15 and is, to some extent, a modification of the BAT airframe. An improved glider version airframe, designated as the wing-attached model, dispenses with the body structure of the Mark 15 and attaches the wings directly to the torpedo body. These two airframes were shown as Figures 2 and 3 in Quarterly Progress Report No. 1. Extensive wind tunnel tests on a model of the wing-attached glider have been made and have yielded design data for an airframe possessing excellent aerodynamic properties.

Wind tunnel tests for a Type C KINGFISHER airframe have shown that optimum location for the propulsion unit is aft of the torpedo shroud ring. The tests have given data on lift and drag coefficients, L/D ratio, and preferred trim angles.

In all KINGFISHER models, it is planned that the intelligence system be mounted in a housing on the forward end of the torpedo. Zero controls will probably be located in the wing structures.

B. CURRENT PROGRESS

1. Mark 15 Airframe

Four Mark 15 airframes were prepared for field test during the current quarter for the purpose of obtaining additional data on the aerodynamic properties of the missile during homing flight, particularly in regard to determination of best decalage setting. In the first two units, the decalage (angle between the chord of the main wing and the chord of the horizontal tail surface) of one was set at 3°, and of the other, at $3\frac{1}{2}^\circ$. Mark 1 (PELICAN) radar equipment was used and arranged for homing on an AN/APN-7 transponder used as a beacon.

Flight data obtained in the two previous tests (Flights K-23 and K-24) showed that the failure of these units to reach the target was due to the effect of the large roll-hunt amplitude on the action of the pitch gyro. In order to correct this condition, the angle of the turn gyro was increased from 15° to 25°. Also, tail elevators similar to those in use on the Mod 0 BAT were installed, and the setting of the pitch gyro increased from 2°/sec to 6°/sec.

One unit (Flight K-25) was dropped in a 29-knot crosswind and landed 140 feet to the left and 89 feet over the beacon. The flight records obtained from the nose camera showed a yaw oscillation of about 7° amplitude. The flight as a whole, however, was very good.

The other unit was destroyed when it was accidentally dropped on the runway at the Test Station.

Two additional units were tested to attempt to reduce the yaw oscillation obtained in the previous flights. These units were equipped with Mark 2 (BAT) radar equipment and were dropped against a corner reflector. Six-inch extensions were provided on the vertical tail surfaces to provide greater directional stability.

The first unit (Flight K-26) had a decalage of 3°. The glider camera records indicated that, although the radar was calling for a glide signal, the elevons moved to an average position half way to full glide. The yawing motion was not noticeably affected by the increased area of the vertical stabilizer. Homing control was apparently lost during the flight; the landing point was 1,700 feet short and 1,250 feet to the left of the corner reflector.

The second unit (Flight K-27) had a decalage of $3\frac{1}{2}^{\circ}$. The pitch and yaw hunt amplitudes of this test were very similar to K-26 except that, about 12 seconds after release, the flight became very steady for 6 to 10 seconds. During this period, the elevons were at full glide limit. The flight was good, the unit landing 146 feet short and 18 feet to the left of the corner reflector.

Comparison of the flight characteristics of the three missiles indicated that the $3\frac{1}{2}^{\circ}$ decalage setting was superior, although the data were not sufficient to be conclusive. Missiles for future tests will be prepared with the $3\frac{1}{2}^{\circ}$ decalage setting.

Torpedo Release - Test Flight K-10 (reported previously) was made for the purpose of testing a mechanism to release the torpedo from the Mark 15 airframe. Analysis of the photographs was made during the current quarter, and the results show satisfactory operation of the mechanism. The operation of the torpedo release is shown in a series of photographs in Figure 2.

2. Wing-Attached Glider

Extensive aerodynamic tests of the glide version of the wing-attached airframe were conducted in the NBS' 6-foot wind tunnel. Measurements were completed on approximately fifty different configurations of the model. The model with the desirable position of the wing and tail is shown in Figure 3. Tables 1, 2, 3, 4, 5 and 6 list the trim angle at zero pitching moments for the various positions of the wing, the tail, and the center of gravity when the control flaps are set at -30°, 0°, and +30° to the neutral. The positions of the wing, the tail, and the center of gravity are listed as ratios to the root chord of the main wing. It is noteworthy that for the optimum configuration, the angle of trim is within ±1° to the flight path for the full range of the control flap settings (see Table 6). The diagram for use with Tables 1 to 6 is shown in Figure 4.

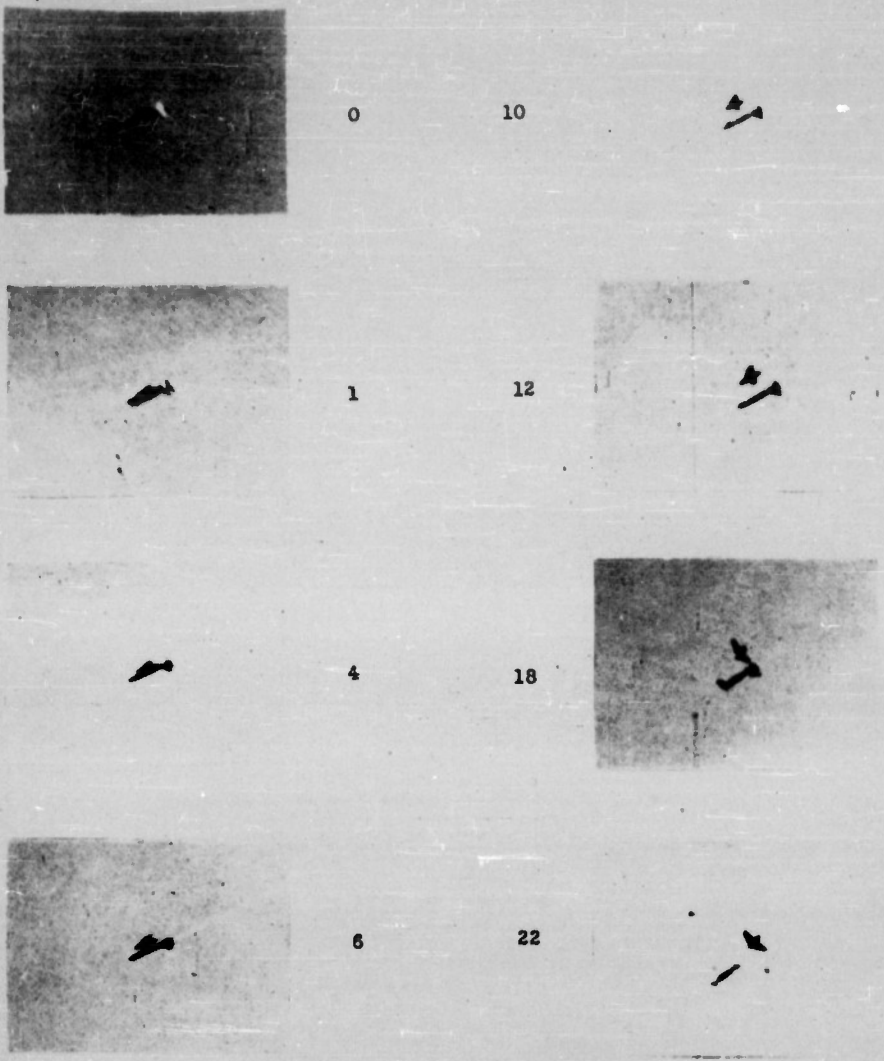


FIGURE 2

TORPEDO RELEASE BY KINGFISHER MISSILE

(The above sequence of pictures shows the separation of the torpedo and Kingfisher airframe in an actual flight test. The pictures were taken at a speed of 64 frames per second, and the numbers adjacent to the various views represent the number of frames after the release mechanism functioned. This functioning is identified by a flash of light, shown in the view labeled 0.)

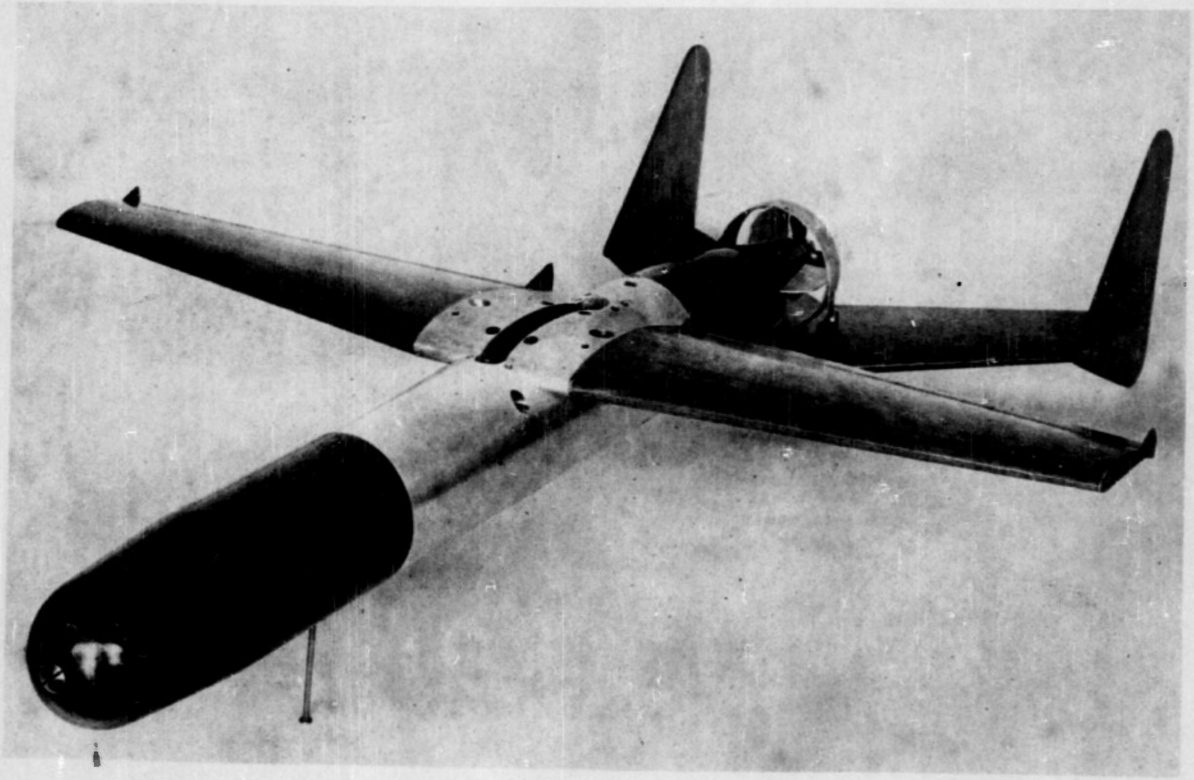


FIGURE 3

SCALE MODEL OF THE WING-ATTACHED GLIDER-VERSION KINGFISHER AIRFRAME USED IN WIND TUNNEL TESTS

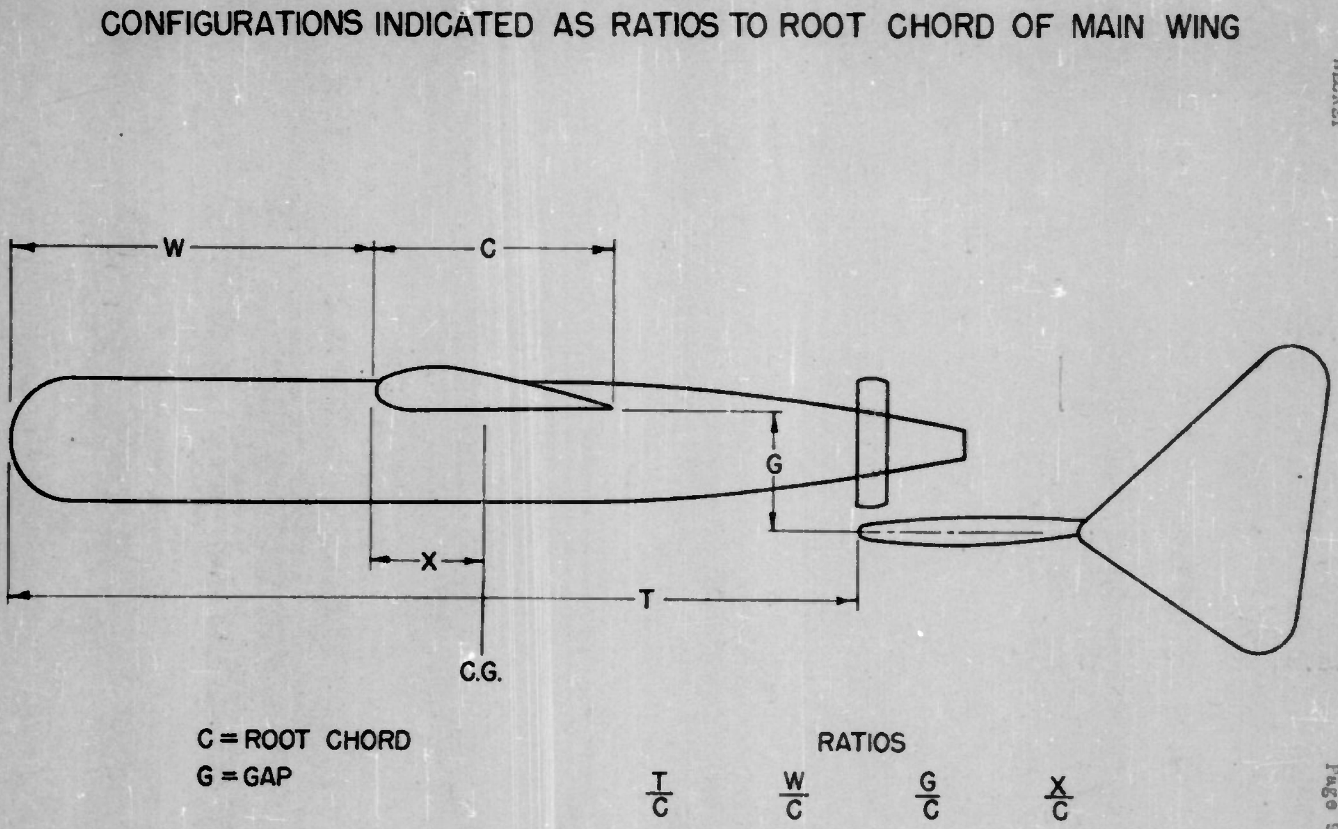


FIGURE 4
SCHEMATIC DIAGRAM OF KINGFISHER AIRFRAME INDICATING
THE VARIABLES INVOLVED FOR DIFFERENT CONFIGURATIONS
AND THE RATIOS USED IN TABLES 1 TO 6

TABLE 1

TRIM ANGLES OF THE WING-ATTACHED AIRFRAME FOR ZERO PITCHING MOMENT FOR VARIOUS FLAP SETTINGS AND SPECIAL CONFIGURATIONS

Flap Settings	Trim Angle	Ratios				Ratio Tail Area Main Wing	Tail Section
		W/C	X/C	G/C	T/C		
-30	-1	2.21	0.43	0.59	4.28	0.36	NACA .0012
0	+2.5	2.21	0.43	0.59	4.28	0.36	NACA .0012
30	+6	2.21	0.43	0.59	4.28	0.36	NACA .0012
30	0	2.28	0.43	0.59	4.28	0.36	NACA .0012
0	+3.5	2.28	0.43	0.59	4.28	0.36	NACA .0012
30	+6	2.28	0.43	0.59	4.28	0.36	NACA .0012
30	0	2.36	0.43	0.59	4.28	0.36	NACA .0012
0	+3.5	2.36	0.43	0.59	4.28	0.36	NACA .0012
30	+6	2.36	0.43	0.59	4.28	0.36	NACA .0012
30	-9	2.36	0.43	0.59	4.28	0.36	NACA .0012
0	-4	2.36	0.43	0.59	4.28	0.36	NACA .0012
30	+3.5	2.36	0.43	0.59	4.28	0.36	NACA .0012
30	-5.5	2.36	0.43	0.59	4.28	0.36	NACA .0012
0	+1	2.36	0.43	0.59	4.28	0.36	NACA .0012
30	+5	2.36	0.43	0.59	4.28	0.36	NACA .0012
30	-2.5	2.44	0.36	0.59	4.28	0.36	NACA .0012
0	-2	2.44	0.36	0.59	4.28	0.36	NACA .0012
30	+1	2.44	0.36	0.59	4.28	0.36	NACA .0012
30	0	2.44	0.36	0.59	4.28	0.36	NACA .0012
0	+ .25	2.44	0.36	0.59	4.28	0.36	NACA .0012
30	+3	2.44	0.36	0.59	4.28	0.36	NACA .0012
30	0	2.36	0.36	0.59	4.28	0.36	NACA .0012
0	+ .25	2.36	0.36	0.59	4.28	0.36	NACA .0012
30	+3.5	2.36	0.36	0.59	4.28	0.36	NACA .0012

The ratios in the center column of the table refer to special configurations and are explained in Figure 7. The optimum settings are shown in Table 6.

TABLE 2

TRIM ANGLES OF THE WING-ATTACHED AIRFRAME FOR ZERO PITCHING MOMENT FOR VARIOUS FLAP SETTINGS AND SPECIAL CONFIGURATIONS

Flap Settings	Trim Angle	Ratios W/C	Ratios X/C	Ratios G/C	Ratios T/C	Ratio Tail Area / Main Wing	Tail Section
30	0	2.28	0.40	0.59	4.28	0.36	NACA .0012
0	+2	2.28	0.40	0.59	4.28	0.36	NACA .0012
30	+5.5	2.28	0.40	0.59	4.28	0.36	NACA .0012
30	0	2.28	0.40	0.52	4.28	0.36	NACA .0012
0	+3	2.28	0.40	0.52	4.28	0.36	NACA .0012
30	+6	2.28	0.40	0.52	4.28	0.36	NACA .0012
30	0	2.28	0.36	0.52	4.28	0.36	NACA .0012
0	+1	2.28	0.36	0.52	4.28	0.36	NACA .0012
30	+4	2.28	0.36	0.52	4.28	0.36	NACA .0012
30	+ .50	2.36	0.28	0.52	4.28	0.36	NACA .0012
0	- .50	2.36	0.28	0.52	4.28	0.36	NACA .0012
30	+ .50	2.36	0.28	0.52	4.28	0.36	NACA .0012
30	+ 1	2.36	0.28	0.52	4.28	0.36	NACA .0012
0	0	2.36	0.28	0.52	4.28	0.36	NACA .0012
30	+ 1	2.36	0.28	0.52	4.28	0.36	NACA .0012
30	+ 1	2.36	0.32	0.52	4.28	0.36	NACA .0012
0	+ .50	2.36	0.32	0.52	4.28	0.36	NACA .0012
30	+ 2.50	2.36	0.32	0.52	4.28	0.36	NACA .0012
30	+ 1	2.36	0.36	0.52	4.28	0.36	NACA .0012
0	+ 1.50	2.36	0.36	0.52	4.28	0.36	NACA .0012
30	+ 4	2.36	0.36	0.52	4.28	0.36	NACA .0012
30	- 1.50	2.36	0.36	0.52	4.28	0.36	NACA .0012
0	- .50	2.36	0.36	0.52	4.28	0.36	NACA .0012
30	+ 2.50	2.36	0.36	0.52	4.28	0.36	NACA .0012

The ratios in the center column of the table refer to special configurations and are explained in Figure 7. The optimum settings are shown in Table 6.

TABLE 3

TRIM ANGLES OF THE WING-ATTACHED AIRFRAME FOR ZERO PITCHING MOMENT FOR VARIOUS FLAP SETTINGS AND SPECIAL CONFIGURATIONS

Flap Settings	Trim Angle	Ratios				Ratio Tail Area Main Wing	Tail Section
		W/C	X/C	G/C	T/C		
30	- .50	2.28	0.37	0.52	4.28	0.36	NACA .0012
0	+ .50	2.28	0.37	0.52	4.28	0.36	NACA .0012
30	+3.50	2.28	0.37	0.52	4.28	0.36	NACA .0012
30	+3.50	2.44	0.36	0.59	4.28	0.36	NACA .0012
0	+3.50	2.44	0.36	0.59	4.28	0.36	NACA .0012
30	+4.50	2.44	0.36	0.59	4.28	0.36	NACA .0012
30	+3.50	2.28	0.32	0.52	4.28	0.36	NACA .0012
0	+2.50	2.28	0.32	0.52	4.28	0.36	NACA .0012
30	+4	2.28	0.32	0.52	4.28	0.36	NACA .0012
30	+2	2.28	0.32	0.52	4.36	0.36	NACA .0012
0	+1	2.28	0.32	0.52	4.36	0.36	NACA .0012
30	+3.50	2.28	0.32	0.52	4.36	0.36	NACA .0012
30	+2	2.36	0.30	0.52	4.36	0.36	NACA .0012
0	+1	2.36	0.30	0.52	4.36	0.36	NACA .0012
30	+2.50	2.36	0.30	0.52	4.36	0.36	NACA .0012
30	+1.50	2.36	0.32	0.52	4.36	0.36	NACA .0012
0	+1	2.36	0.32	0.52	4.36	0.36	NACA .0012
30	+3	2.36	0.32	0.52	4.36	0.36	NACA .0012
30	+2	2.36	0.34	0.52	4.36	0.36	NACA .0012
0	+2	2.36	0.34	0.52	4.36	0.36	NACA .0012
30	+4	2.36	0.34	0.52	4.36	0.36	NACA .0012
30	-1.50	2.28	0.36	0.52	4.28	0.36	NACA .0012
0	- .50	2.28	0.36	0.52	4.28	0.36	NACA .0012
30	+2.50	2.28	0.36	0.52	4.28	0.36	NACA .0012

The ratios in the center column of the table refer to special configurations and are explained in Figure 7. The optimum settings are shown in Table 6.

TABLE 4

TRIM ANGLES OF THE WING-ATTACHED AIRFRAME FOR ZERO PITCHING MOMENT FOR VARIOUS FLAP SETTINGS AND SPECIAL CONFIGURATIONS

Flap Settings	Trim Angle	Ratios W/C	X/C	G/C	T/C	Ratio Tail Area Main Wing	Tail Section
30	-1.50	2.28	0.32	0.52	4.28	0.36	NACA .0012
0	-1.50	2.28	0.32	0.52	4.28	0.36	NACA .0012
30	+1	2.28	0.32	0.52	4.28	0.36	NACA .0012
30	- .25	2.28	0.32	0.52	4.28	0.36	NACA .0012
0	- .25	2.28	0.32	0.52	4.28	0.36	NACA .0012
10	+ .50	2.28	0.32	0.52	4.28	0.36	NACA .0012
20	+1	2.28	0.32	0.52	4.28	0.36	NACA .0012
30	+2	2.28	0.32	0.52	4.28	0.36	NACA .0012
30	-1	2.36	0.43	0.52	4.28	0.36	NACA .0012
0	+3.50	2.36	0.43	0.52	4.28	0.36	NACA .0012
30	+6	2.36	0.43	0.52	4.28	0.36	NACA .0012
30	-9	2.36	0.43	0.52	4.28	0.36	NACA .0012
0	-3.50	2.36	0.43	0.52	4.28	0.36	NACA .0012
30	+4	2.36	0.43	0.52	4.28	0.36	NACA .0012
30	0	2.28	0.40	0.52	4.28	0.36	NACA .0012
0	+2.50	2.28	0.40	0.52	4.28	0.36	NACA .0012
30	+5.50	2.28	0.40	0.52	4.28	0.36	NACA .0012
30	- .25	2.28	0.38	0.52	4.28	0.36	NACA .0012
0	+2	2.28	0.38	0.52	4.28	0.36	NACA .0012
30	+4.50	2.28	0.38	0.52	4.28	0.36	NACA .0012
30	+ .50	2.21	0.46	0.52	4.28	0.36	NACA .0012
0	+4.50	2.21	0.46	0.52	4.28	0.36	NACA .0012
30	+7.50	2.21	0.46	0.52	4.28	0.36	NACA .0012

The ratios in the center column of the table refer to special configurations and are explained in Figure 7. The optimum settings are shown in Table 6.

TABLE 5

TRIM ANGLES OF THE WING-ATTACHED AIRFRAME FOR ZERO PITCHING MOMENT FOR VARIOUS FLAP SETTINGS AND SPECIAL CONFIGURATIONS

Flap Settings	Trim Angle	Ratios W/C	Ratios X/C	Ratios G/C	Ratios T/C	Ratio Tail Area Main Wing	Tail Section
30	0	2.36	0.34	0.52	4.28	0.50	Large Flat
0	+1.25	2.36	0.34	0.52	4.28	0.50	Large Flat
30	+4	2.36	0.34	0.52	4.28	0.50	Large Flat
30	0	2.36	0.30	0.52	4.28	0.50	Large Flat
0	+1	2.36	0.30	0.52	4.28	0.50	Large Flat
30	+3	2.36	0.30	0.52	4.28	0.50	Large Flat
30	-2	2.36	0.30	0.52	4.28	0.50	Large Flat
0	- .50	2.36	0.30	0.52	4.28	0.50	Large Flat
30	+1.50	2.36	0.30	0.52	4.28	0.50	Large Flat
30	-1.25	2.44	0.23	0.52	4.28	0.50	Large Flat
0	-1	2.44	0.23	0.52	4.28	0.50	Large Flat
30	0	2.44	0.23	0.52	4.28	0.50	Large Flat
30	-1.25	2.44	0.23	0.52	4.28	0.50	Large Flat*
0	-1	2.44	0.23	0.52	4.28	0.50	Large Flat*
30	0	2.44	0.23	0.52	4.28	0.50	Large Flat*
30	-1.50	2.44	0.24	0.52	4.28	0.50	Large Flat
0	-1	2.44	0.24	0.52	4.28	0.50	Large Flat
30	+ .50	2.44	0.24	0.52	4.28	0.50	Large Flat
30	-3	2.28	0.24	0.52	4.28	0.50	Large Flat
0	0	2.28	0.24	0.52	4.28	0.50	Large Flat
30	+4	2.28	0.24	0.52	4.28	0.50	Large Flat
30	-3	2.28	0.24	0.52	4.36	0.50	Large Flat
0	0	2.28	0.24	0.52	4.36	0.50	Large Flat
30	+4	2.28	0.24	0.52	4.36	0.50	Large Flat
30	-3	2.28	0.24	0.52	4.36	0.50	Large Flat
0	0	2.28	0.24	0.52	4.36	0.50	Large Flat
30	+4	2.28	0.24	0.52	4.36	0.50	Large Flat

* Without torpedo propellers.

The ratios in the center column of the table refer to special configurations and are explained in Figure 7. The optimum settings are shown in Table 6.

TABLE 6

TRIM ANGLES OF THE WING-ATTACHED AIRFRAME FOR ZERO PITCHING MOMENT FOR VARIOUS FLAP SETTINGS AND SPECIAL CONFIGURATIONS

Flap Settings	Trim Angle	Ratios				Ratio Tail Area Main Wing	Tail Section
		W/C	X/C	G/C	T/C		
30	-2	2.36	0.32	0.52	4.36	0.50	Large Flat
0	- .50	2.36	0.32	0.52	4.36	0.50	Large Flat
30	+2	2.36	0.32	0.52	4.36	0.50	Large Flat
30	-1.50	2.44	0.24	0.52	4.36	0.50	Large Flat
0	-1	2.44	0.24	0.52	4.36	0.50	Large Flat
30	+1.50	2.44	0.24	0.52	4.36	0.50	Large Flat
30	+1	2.44	0.24	0.52	4.32	0.50	Large .0012
0	+ .50	2.44	0.24	0.52	4.32	0.50	Large .0012
30	+2	2.44	0.24	0.52	4.32	0.50	Large .0012
30	+1	2.44	0.24	0.52	4.28	0.50	Large .0012
0	+1	2.44	0.24	0.52	4.28	0.50	Large .0012
30	+2.50	2.44	0.24	0.52	4.28	0.50	Large .0012
30	+1	2.44	0.24	0.52	4.28	0.50	Large .0012
0	+ .50	2.44	0.24	0.52	4.28	0.50	Large .0012
30	+2	2.44	0.24	0.52	4.28	0.50	Large .0012
30	0*	2.44	0.24	0.52	4.36	0.50	Large .0012
0	0*	2.44	0.24	0.52	4.36	0.50	Large .0012
30	+1*	2.44	0.24	0.52	4.36	0.50	Large .0012
30	-1	2.44	0.24	0.52	4.36	0.50	Large .0012
0	-1	2.44	0.24	0.52	4.36	0.50	Large .0012
30	0	2.44	0.24	0.52	4.36	0.50	Large .0012
30	+1	2.44	0.24	0.52	4.36	0.50	Large .0012
0	+1	2.44	0.24	0.52	4.36	0.50	Large .0012
30	+2	2.44	0.24	0.52	4.36	0.50	Large .0012

* Optimum

The ratios in the center column of the table refer to special configurations and are explained in Figure 7.

The structure for the optimum configuration was analyzed for stresses under wing loadings of 500 lbs. per sq. ft. Detail design of this structure was completed for one set of full-scale wings and the models were constructed. The full-scale wind tunnel tests will not, however, be made because of divergence of effort from the glider version.

3. Powered Airframe (Type C)

With the shift of emphasis from glider to powered versions of KINGFISHER, wind tunnel tests were modified to provide design information for powered airframes. Many of the glider data, as well as the wind tunnel models, have proved useful in this other application. In particular, studies were made to determine the relative merits of various single- and twin-engine motor arrangements using the glider model. In Fig. 5 are listed the relative drags for the various arrangements of the propulsion unit. It is noted that the optimum position of the motor was found to be aft of the torpedo and in line with its axis. This desirable configuration for the wind tunnel model is shown in Figure 6. With this arrangement, however, a slight reduction in propulsive efficiency is expected, but the aerodynamical advantage should more than offset this reduction.

A wind tunnel model (1/6 size) for the Type C KINGFISHER was prepared. Measurements were made to determine the lift and drag coefficients, the L/D ratio, and the trim angles for zero pitching moments at control flap settings of -40°, -30°, -20°, -10°, 0°, $+10^\circ$, $+20^\circ$, $+30^\circ$, and $+40^\circ$. These quantities were determined for various positions of the center of gravity and for four different wing sections. Figures 7 and 8 give the comparison of these quantities for the wing sections tested. These wing sections varied mainly in the degree the trailing edge was raised above the chord line of the basic wing. The ordinates affected were aft of the 50% chord station. The X/C ratio shown in Figure 4 equals 31%.

These reverse cambers are listed as a percent of the root chord. A ratio of 2% was chosen to satisfy the lift coefficient required for horizontal flight for a missile of approximately 3,300 lbs. weight.

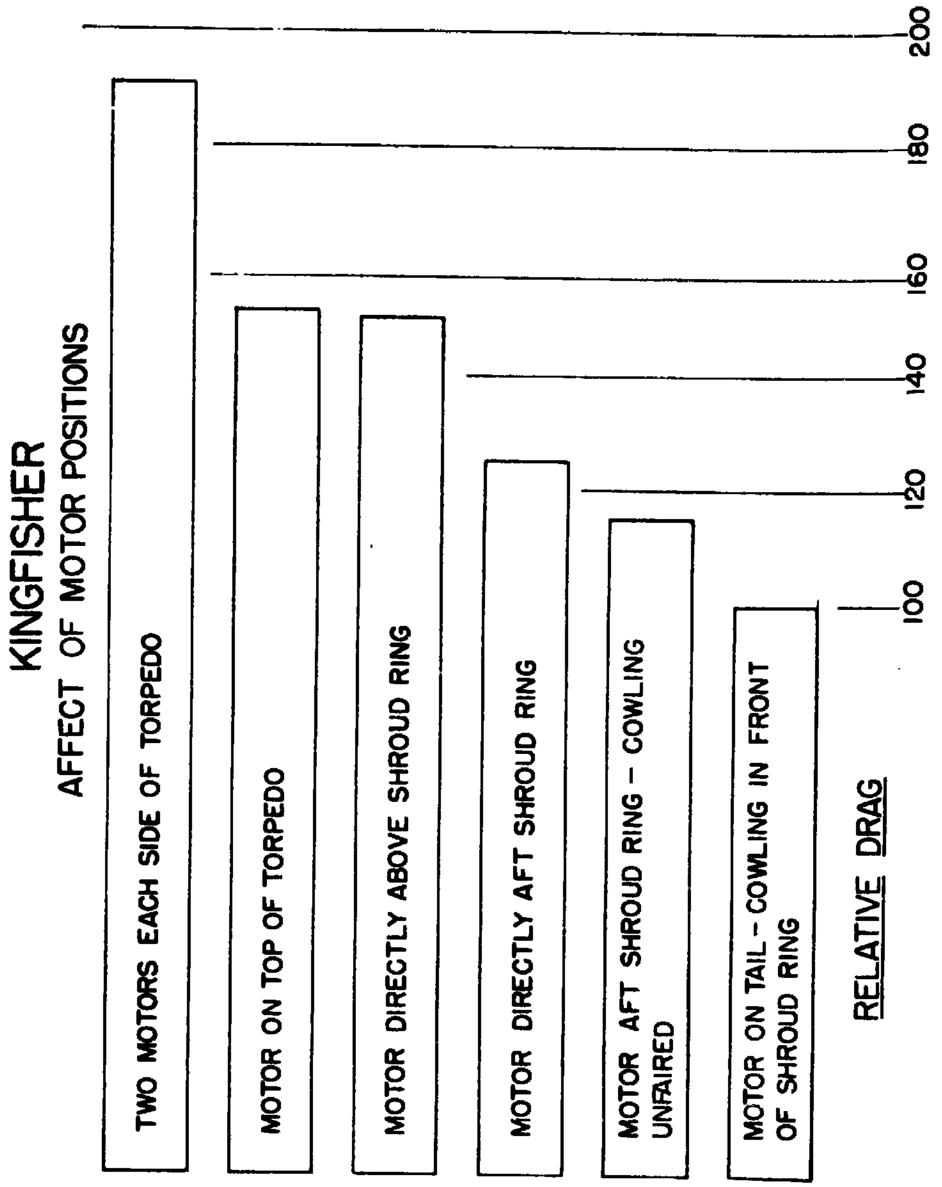
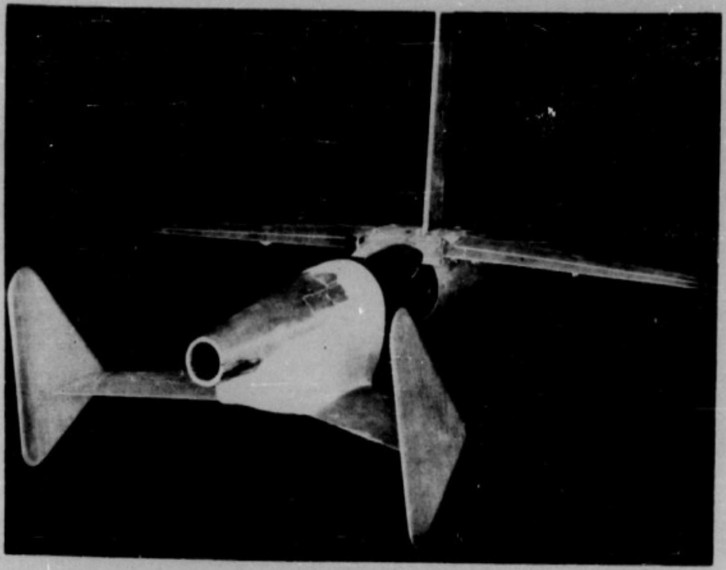


FIGURE 5
RELATIVE DRAG ON KINGFISHER AIRFRAME FOR RELATIVE POSITIONS OF THE PROPULSION UNIT



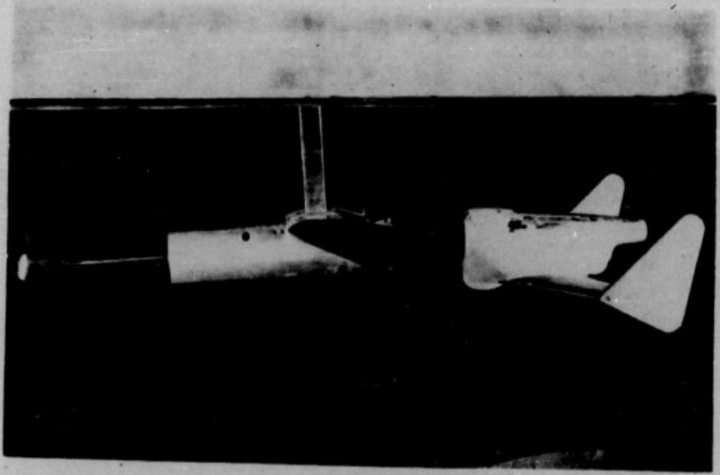
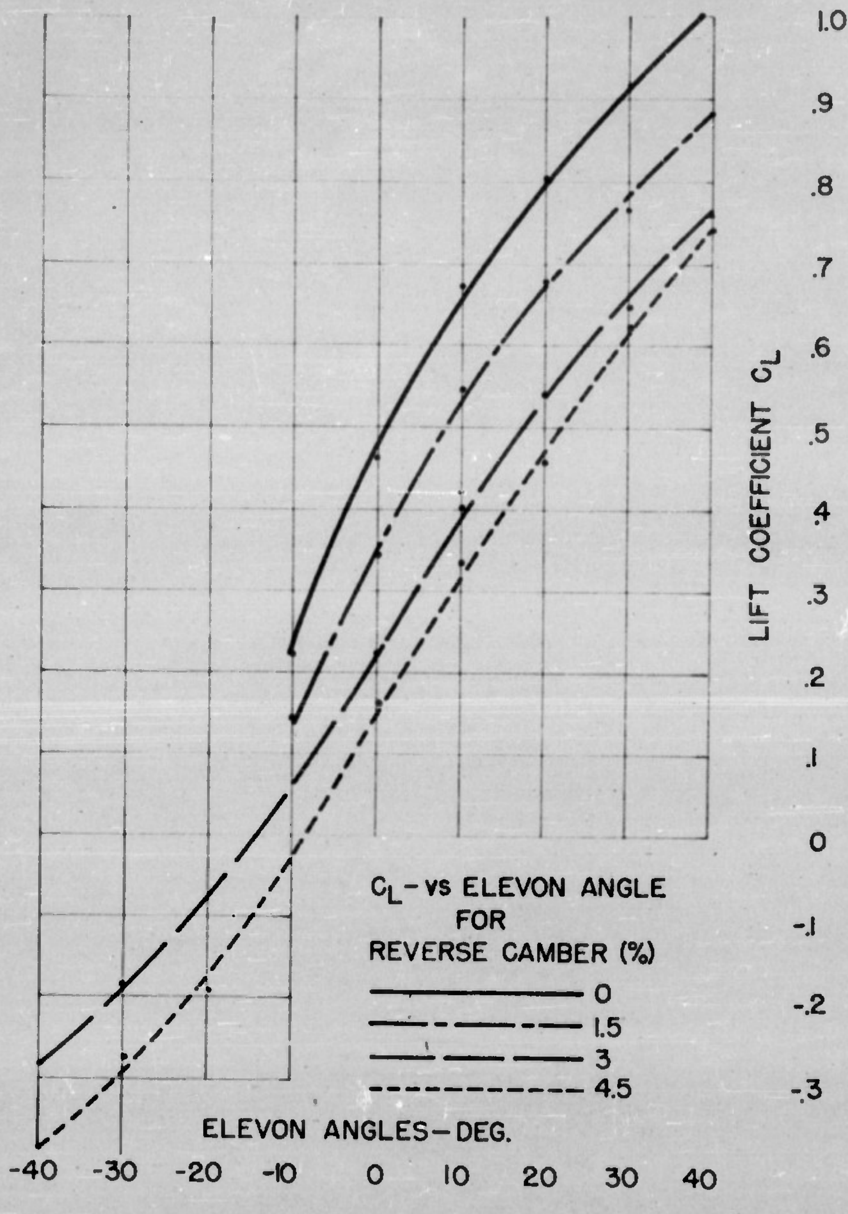


FIGURE 6

TWO VIEWS OF THE WIND TUNNEL MODEL OF THE KINGFISHER AIRFRAME SHOWING OPTIMUM LOCATION FOR THE PROPULSION UNIT

FIGURE 7

LIFT COEFFICIENTS FOR TYPE C KINGFISHER AIRFRAME



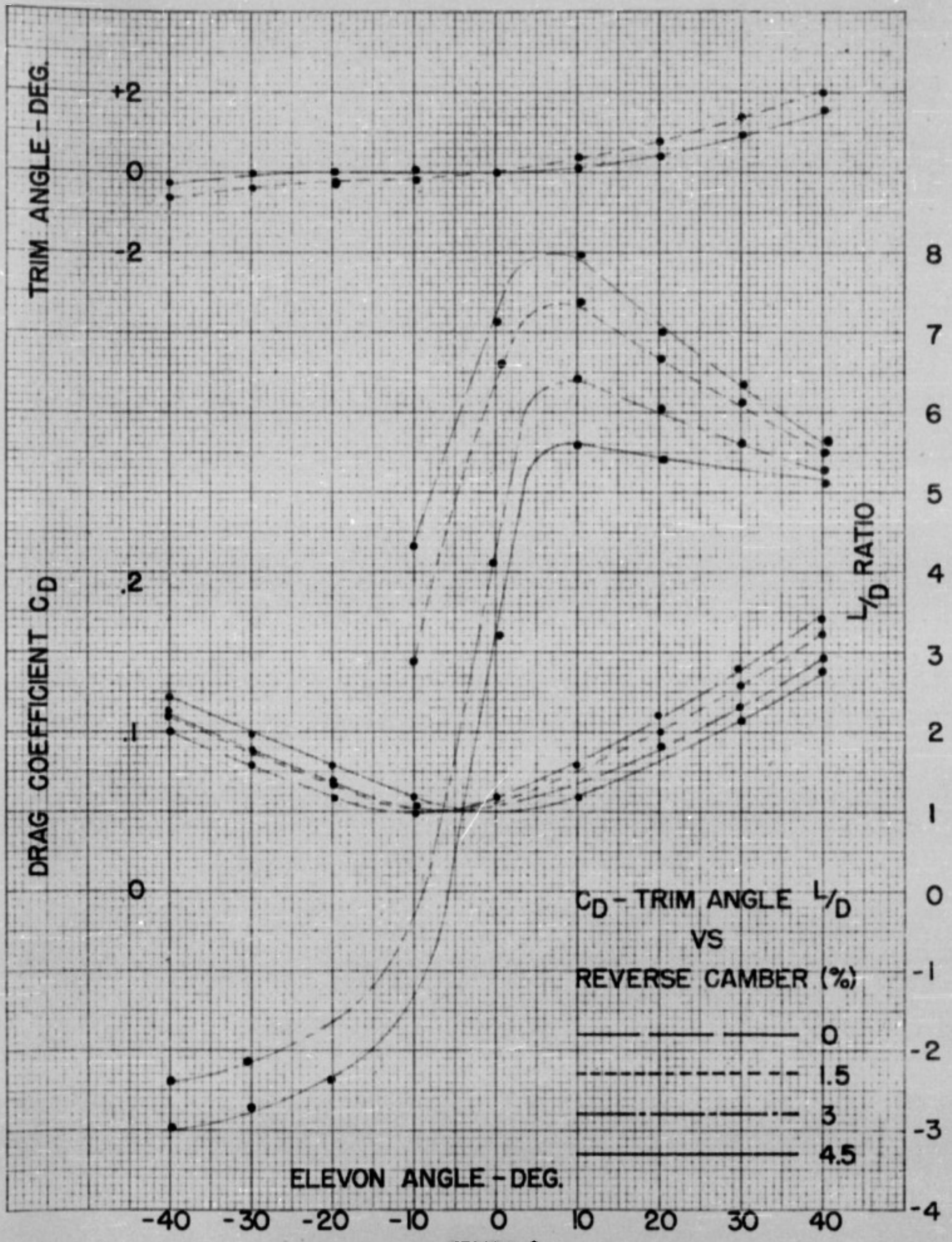


FIGURE 8
DRAG COEFFICIENTS, TRIM ANGLES, AND
L/D RATIOS FOR TYPE C KINGFISHER AIRFRAME

III. NAVIGATION

A. STATUS OF DEVELOPMENT

The pursuit-course type of homing employed in BAT is considered inadequate for use against fast-moving targets. This conclusion is based on experience with BAT, as well as on numerous mathematical studies. Accordingly, various types of course navigation are being investigated for KINGFISHER. Any type of navigation which causes the missile to fly a course differing from pursuit must cause the missile to fly at an angle to the line-of-sight path. Therefore, the homing reference axes will be variable with respect to the missile axes, and a major design consideration will be to provide adequate separation between homing signals and stabilization signals. The importance of this separation has been well established in actual flight tests and in simulated flight tests.

Flight tests against moving targets have been made with KINGFISHER and modified BAT missiles at the Warren Grove, New Jersey, Field Station. The results of these tests have showed that with a fixed azimuth offset on the radar axis, made as a predetermined lead computation, increased accuracy was obtained. However, when the offset was variable (some fraction of the angle between the line-of-sight and missile axis), the results were erratic. Apparently long-period yaw oscillations of missiles produced appreciable azimuth error. This effect has been fully verified in tests with the flight simulator, details of which are reported below.

Currently, the most favored system is to stabilize the radar axis along the line-of-sight, independently of any reference axes in the missile. Radar error signals, caused by target or missile translation, would then provide navigation signals for the axes of the reference gyro of the missile. This system has not yet been tested on the flight simulator. An important requirement of this system is that the natural drift rate of the reference gyros be low.

For the applications where low trajectories throughout the flight are expected, consideration is being given to a navigation system in which pitch homing is supplemented with altitude control.

B. CURRENT PROGRAM

1. Flight Simulator Tests

A series of tests with the KINGFISHER flight simulator comparing the performance of the control systems of the Mod 0 and the Mod 1 BATS revealed no significant difference between the two systems in respect to their accuracy in pitch. However, the Mod 1 system exhibited better characteristics in right-left performance. With the Mod 1 system, smaller right-left dispersions in paths were obtained for flights made under identical conditions, and there was less tendency for large amplitude, long period (10- to 15-second) oscillations to develop.

Following the above-mentioned tests, it was decided that investigations of different navigation systems, with a view toward determining the optimum "navigation factor" for KINGFISHER, should have priority over other simulator tests. Considerable modifications of the simulator were required before these investigations could be undertaken. A small stabilized mount for the photoelectric homing head was built and installed on the inner platform of the rotation simulator. This mount is shown in the center of Figure 9. The mount is stabilized in yaw and pitch by a small servo system. Signals for controlling the homing head servos may be derived from gyro references or other sources. At present, the mount is caused to turn in yaw and pitch by some proportion of the angles turned through by the yaw and pitch gimbals of the simulator. This proportion can be caried continuously from 1 to 0, thereby covering the complete range of courses between the collision and pursuit courses. The navigation courses which will result from this arrangement of the simulator are the same as those which would result in actual flight if perfect free gyros were used as a reference for the homing head servos.

A number of tests with the simulator, using the stabilized homing head, along with the Mod 0 BAT control system, made it apparent that before any "navigation factor" at all could be used to advantage, a very effective means must be found for damping out long-period homing oscillations which become worse as the amount of navigation is increased. A very effective means of damping out this oscillation is to introduce a lead into the homing signals. A lead of about 40° has been found to be very effective on the simulator.

The fact that the long-period homing oscillation becomes less damped as the distance of the glider from the target is lessened makes it possible to use the distance at which the oscillation becomes undamped as a measure of the damping. When measuring the damping on the simulator, the translation target carriage is allowed to oscillate at a fixed distance from the rotation simulator. In successive trials, this distance is lessened until a point is found where the yaw oscillation becomes undamped. For any given circuit configuration, this distance has been found to be critical.

Tests of the navigation system in which the radar axis is independently stabilized will be made when a stabilized antenna mount becomes available.

2. Altitude Control

With the emphasis of the KINGFISHER program shifted from glider to powered missiles, provision for low flat trajectories becomes increasingly important. For such trajectories, altitude control may be preferred to pitch homing with radar signals reflected from the target. The problem of altimeter control has been analyzed, and the results presented in Report OD-8-2M.[1] Conclusions from this report follow:

(a) Altimeter control offers no appreciable advantage for a gravity-powered missile.

(b) Altitude information is probably essential for at least the early portion of the flight of powered missiles.

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[1] See Reference 1, Bibliography, Section IX.

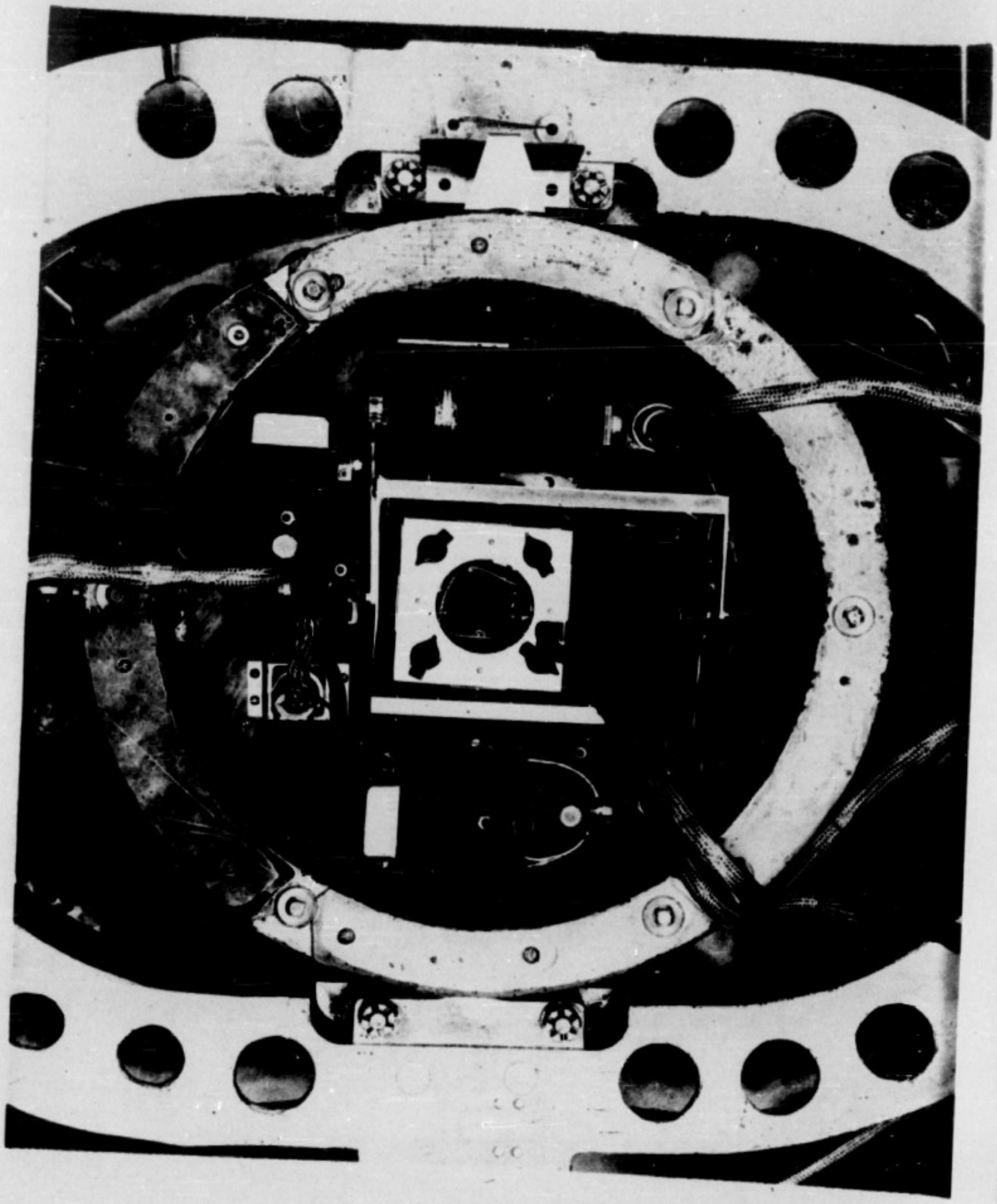


FIGURE 9

FLIGHT SIMULATOR WITH PHOTOELECTRIC HOMING HEAD MOUNTED IN THE CENTER OF THE PLATFORM

(o) Altimeter design depends in part on the altitude at which powered missiles are intended to fly. This latter is conditioned by the desire to avoid detection by staying low, and also by the requirements for torpedo release. It may be necessary to release the torpedo from an altitude between 500 and 1,000 ft. Further consideration of this topic will depend on more specific formulation of the technique of torpedo release.

IV. INTELLIGENCE

A. STATUS OF DEVELOPMENT

The intelligence system under development for Types C, D and F KINGFISHER is X-band radar providing homing signals for azimuth and pitch. Assembly of the first model for flight and other tests has been completed. This model was originally intended for Type A KINGFISHER but is readily adaptable to Type C.

Miniaturization of various components of the intelligence system, an essential requirement for Type F, is in process.

Development of an FM altimeter to replace pitch homing in the case of low-altitude trajectories has been initiated.

The salient features of the first prototype intelligence system for Type C KINGFISHER are as follows:

(1) Antenna system: four-horn model pictured in Quarterly Progress Report No. 1; sequential scanning.

(2) R-f system: 2J55 or 2J56 magnetron; 1/4 microsecond pulse; measured power about 35 kw peak; 2,000-cycle repetition rate.

(3) Modulator: pulse-forming line, hydrogen thyratron (4C35), pulse transformer.

(4) Receiver: unbalanced mixer, fixed-tune 60 mc i-f amplifier, as described in Quarterly Progress Report No. 1. The pre-mixer attenuator, required for crystal protection at minimum range, has not yet been included.

(5) AFC Unit: as described in Progress Report No. 1.

(6) Video Unit: as described in Quarterly Progress Report No. 1.

(7) Electronic Power Supply: An electronic power supply has been designed to operate with a 115-volt input at either 400 or 800 cycles. A mockup was constructed for 60-cycle operation, scaling up the filter time constants and using larger tubes in place of certain T5½ tubes in short supply. Commercially available transformers were used, in some cases of only approximately correct voltage ratios. As a result, some of the regulating tubes run over their specifications, with resulting short life, but with reasonably good performance during the early portion of the life. It was subsequently found possible to operate this supply at 800 cycles. This last feature permits flight tests without awaiting the winding of special transformers, since inverters are available from the BAT program for converting the 24-volt d.c. airplane supply to 115 volts, 800 cycle a.c.

B. CURRENT PROGRESS

1. Type C Prototype

(a) Laboratory Tests

Switch Tube Performance - The ignition voltage was found to be somewhat higher than was hoped for, necessitating a modification of the switch tube gating circuit to supply the higher voltage without exceeding gate tube specifications.

The tube life was found to be quite low, with the average life less than 50 hours and with some tubes failing in an hour or two. New modifications are being prepared to extend the life, some of which involve also extending the recovery time. The latter, however, will be tolerable in the present system, since the switch tubes are not fired as TR's by the transmitted pulse, due to non-duplexing and loose receiving-transmitting antenna coupling. Thus, the switching can be initiated sufficiently in advance of the expected echo to allow switch tube recovery. Three tubes with a new filling have been received, which require only about 1/3 to 1/4 the amount of control current, and presumably have a much longer life. A recovery time of 20 microseconds is characteristic of these tubes.

System Performance - The transmitter has been checked for peak power output, frequency, and frequency spectrum, and found satisfactory.

The transmitter coupling to the AFC converter has been adjusted for proper AFC action.

The switching section (that portion of the r-f plumbing where the three receiving horns converge, through the switch tube, into the common converter channel) was checked for insertion loss viewed from each of its three inputs. Certain differences between switch tube and TR box characteristics were noted, which required a slightly different location of the parts. This relocation will be in future antenna assemblies but cannot be installed in the test model. As a result, a loss of about 3 to 4 decibels through the present switch section is observed, rather than the approximately 1.5 decibels obtainable with the modified design.

The local oscillator injection was found to vary slightly, according to which switch tube was open. The effect has no serious consequences but is to be eliminated in the untuned mixer now being designed by the use of directional couplers as injecting elements. This latter measure is expected also to accomplish a considerable reduction in the amount of main bang coupling into the signal crystal via the AFC crystal and local oscillator. Tests have shown that this channel is now responsible for most of the main bang disturbance of the receiver.

The over-all signal-equal-noise sensitivity was observed to be about -107 dbw. Allowing for excessive switch section losses, this is still somewhat less than can be achieved without elaborate precautions. Modifications of the crystal coupling circuit and the i-f input stage are in process and show promise.

A number of "radar-width" curves (curves of output error signal versus target or signal generator deflection) have been taken and are reproduced in Figures 10, 11, 12 and 13. The degree of linearity was found to be adequate. (The sensitivity, or the angle at which saturation occurs, is adjustable by means of a directional sensitivity control.) The fact that no reversals of the sense of the information were observed out to large error angles was particularly gratifying. Figures 10 and 11 are for air path only.

Figure 12 shows the distortion of the radar width curve due to the interposition of a plane polystyrene window in the path. The window was almost exactly 1/4 wavelength thick, so that reflections from the two faces interfered constructively.

Figure 13 shows how the distortion is removed by doubling the polystyrene thickness, for destructive interference. All curves were taken by rotating the antenna relative to the window with the antenna mouth plane about 1 foot from the window. Thus, reflected wave phase relations change very rapidly with angle, and the test is quite rigorous.

These tests are of importance on several scores. First, they represent the first over-all test of the intelligence system. Second, they indicate that with a properly designed radome, radome shapes other than spherical may be permitted if the aerodynamic properties are improved thereby. Third, they suggest that the radome now mounted in the experimental airplane may not be suitable. This radome has a thickness of 5/32 inch, which is approximately 1/5 wavelength (in the dielectric). This thickness is quite close to 1/4 wavelength and may well give rise to phenomena similar to those observed with the single window. The effect may be reduced to tolerability by the fact that the radome-antenna spacing is greater in the airplane. Measurements are planned, but various factors have prevented their completion at this time.

The apparatus has been mounted in a specially equipped airplane for flight tests. Two views of the apparatus, less antenna, are shown in Figure 14. The antenna was shown in the last Progress Report. In the first test, good tracking was obtained on ship targets, but not good directional information. The latter effect may have been due to switch tube misbehavior; one tube failed about 1/2 hour after the tests. Also, radome effects may have contributed to this end. Ranges observed on this test were limited to 6 or 7 (nautical) miles on ships, 9 miles on a fairly large hangar. It was subsequently observed that the sensitivity of the receiver was approximately 17 decibels below normal, due to a faulty crystal (mixer) and a maladjustment of the i-f input circuit.

In subsequent tests in the airplane, a series of minor difficulties with power supplies, broken connections, etc., prevented further tracking experience, or much more accurate range determination. However, very strong echoes have been received from unidentified land objects at ranges out to 20 miles, under circumstances such that failure to observe them at greater ranges was coincidental.

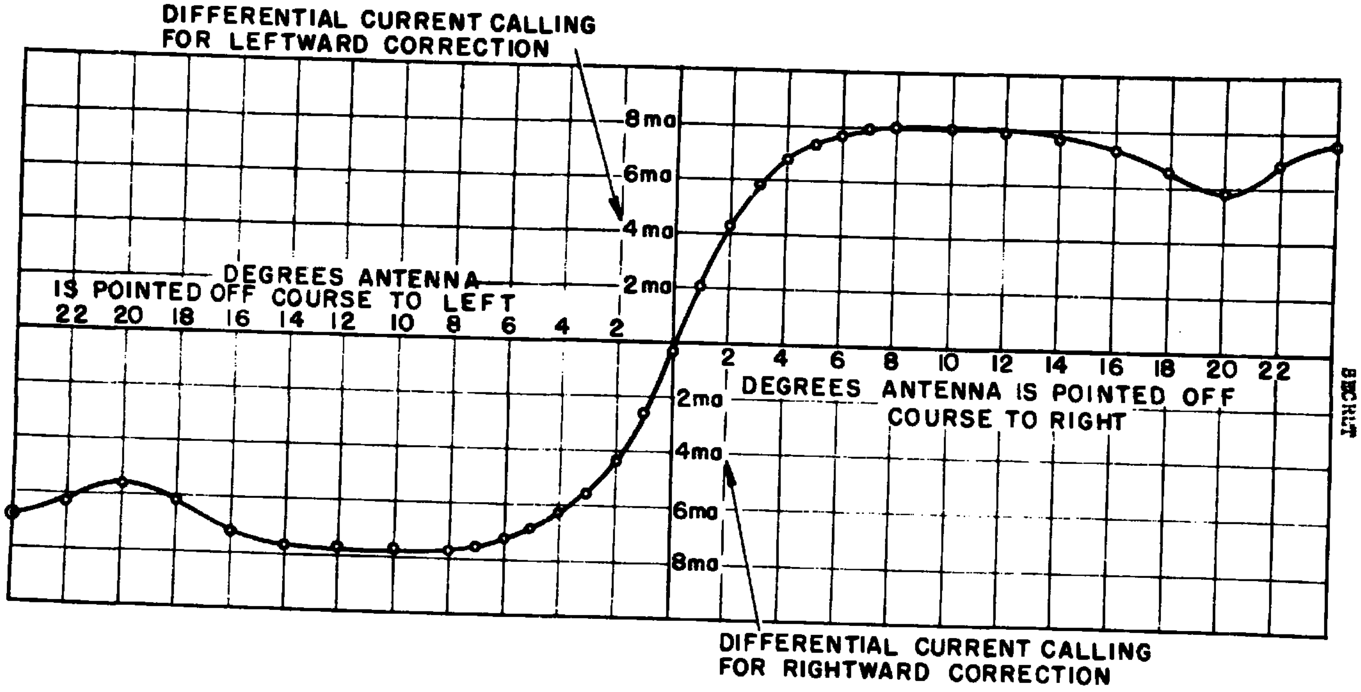


FIGURE 10

RADAR WIDTH CURVE, IN AIR, FOR RIGHT-LEFT DIRECTIONS

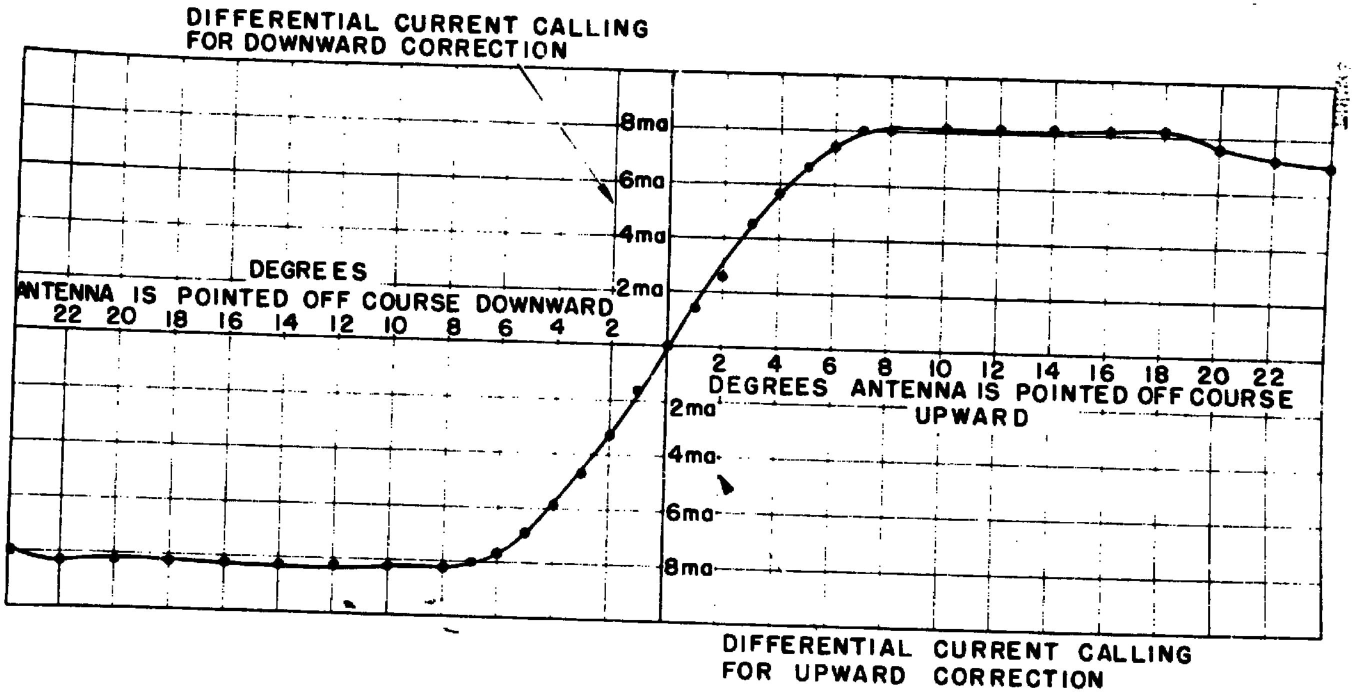


FIGURE 11

RADAR WIDTH CURVE, IN AIR, FOR RIGHT-LEFT DIRECTIONS

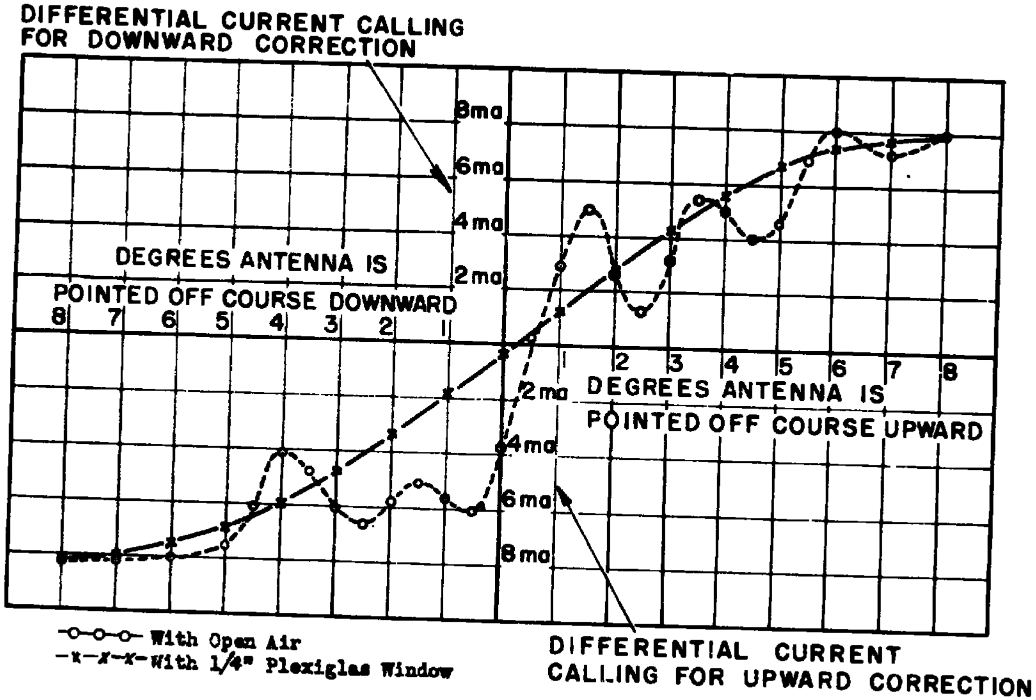


FIGURE 12

RADAR WIDTH CURVE FOR UP-DOWN DIRECTIONS
AND THROUGH QUARTER-INCH PLEXIGLAS WINDOW

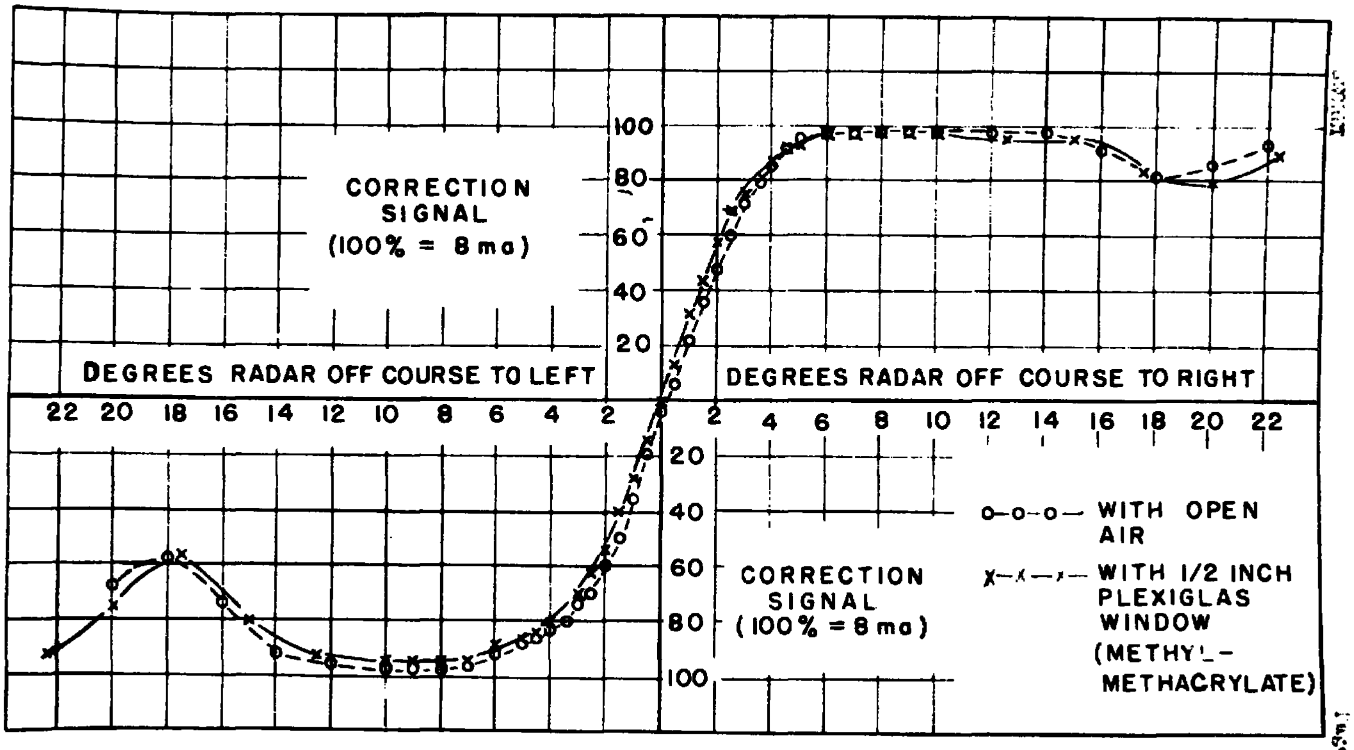
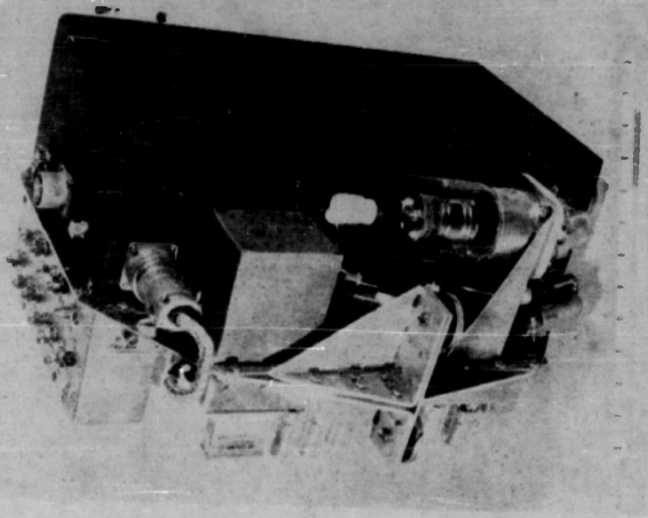


FIGURE 13

RADAR WIDTH CURVE FOR UP-DOWN DIRECTIONS
AND THROUGH HALF-INCH PLEXIGLAS WINDOW



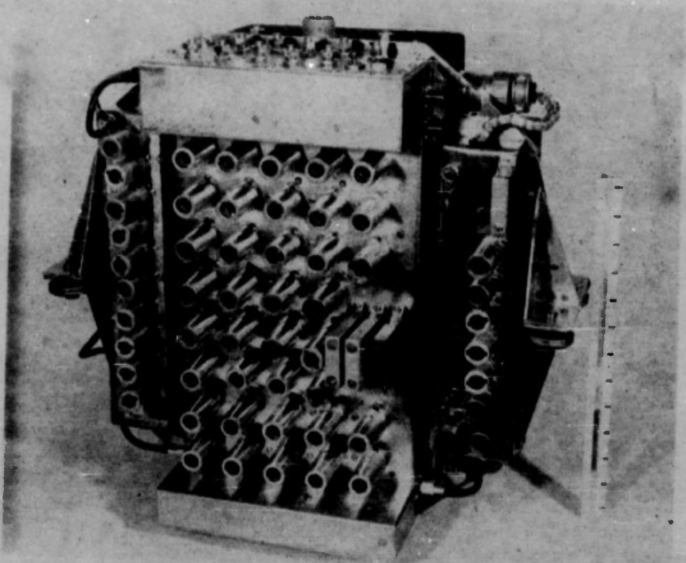


FIGURE 14

TWO VIEWS OF THE FIRST PROTOTYPE MODEL
OF THE RADAR INTELLIGENCE SYSTEM

2. Miniaturisation and Development of Improved Components

(a) R-f Development

A refined switch section was developed for lower insertion loss.

Development of the untuned mixer with directional couplers for local oscillator injection is proceeding.

New antenna development is being expedited. The recent shift of emphasis to powered versions and smaller versions has affected the course of this development. Since the powered versions will probably not employ pitch homing, scanning is required only in azimuth. Consequently, attention is now concentrated on development of a smaller antenna of higher gain. Information on the multiple feed for a lens or dish is now being assembled, but less is expected of this type than of a second, now being investigated. The second type is a polyrod array as a primary radiator, with rapid scan obtained by switching the point of feed. A second array is to be used for transmission in initial designs, at least, to avoid firing the switch tubes with the transmitted pulse. This last effect would be harmful to minimum range performance because of switch tube recovery time.

2K45 klystrons (the thermal tuned variety) have been received and their properties have been noted. The AFC unit is to be redesigned to accommodate their thermal time lags without oscillation. The new mixer will be "packaged" on the assumption that these tubes will be employed rather than the 2K25. The 2K45 is now the preferred tube; in addition, it will not be necessary to provide access to a mechanical tuning adjustment. 2J51 magnetrons (tunable from 8,500 to 9,600 mc; otherwise similar to 2J55-2J56 tubes) have been received but not experimented with. Sufficient 2J55 and 2J56 tubes are available for present experiments; it will presumably be some time before the tunable feature is required.

First experiments on the possible use of the 3C45 in place of the 4C35 as the modulator thyratron show that present tubes cannot be expected to have a long life under such severe overload conditions. However, the fact that a life of 60 hours was observed with one tube and 74 hours with another indicates that sufficient life may be attainable with only slight modification. A very considerable size reduction would, of course, be obtained in this case.

(b) I-F Developments

Effort in the i-f field was directed toward locating and eliminating the cause of feedback in the commercially made i-f strips and toward modification of the input circuit for lower noise figure. Some progress was made in the further development of miniature amplifiers.[2] The printed circuit approach for miniaturization is now being reopened.

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[2] See Reference 2, Bibliography, Section IX.

(c) Video Development

Several items are under simultaneous consideration in the video circuitry. Receipt of iron-cored coils of high Q apparently makes possible the construction of a 2,000-cycle master oscillator, with a net space saving over the 8,000-cycle master oscillator and scale of four counter now used to establish the 2,000-cycle repetition rate. New scanning gate generators based on counting rings are being studied as more economical replacements for the present gate generator. Use of a peak voltmeter rather than an energy meter to measure the information content of the gated control amplifier is being studied. The peak voltmeter would eliminate or reduce jitter in the directional information due to oscillation in the relative position of the gate and the target echo.

Miniaturization of the video circuitry is proceeding on lower priority, this priority to be advanced when further types of miniature tubes are available.

Performance of a 60-cycle version of the electronic power supply was found adequate, and the packaging of 800-cycle (or 400-cycle; the supply is designed to work on either) version has been assigned to a service contractor.

3. Altimeter

The development of an FM altimeter has been started at the Emerson Radio and Phonograph Corporation. The apparatus will develop a voltage proportional to altitude. Flyover tests have been completed to obtain data on the sensitivities required and on optimum antenna arrangement.

V. PROPULSION

A. STATUS OF DEVELOPMENT

Plans for the development of a propulsion unit for KINGFISHER were initiated during the current quarter. The Bureau of Aeronautics will supervise the development of this unit. As an interim device for the Type C missile, the liquid-fuel rocket motors of Project LARK are being considered. A net thrust of 800 lbs. is required.

VI. STABILIZATION AND CONTROL

A. STATUS OF DEVELOPMENT

It is planned to stabilize the antenna of KINGFISHER radar along the line-of-sight to the target. Stabilization to within $\frac{1}{4}^{\circ}$, without hunt, is desired. The antenna assembly, which will weigh approximately 30 lbs., will be free to move, with respect to the missile, ±45° in azimuth and ± 20° in pitch. It is planned to effect the stabilization by means of a free gyro and to precess the gyro as the line-of-sight changes by means of the radar error signal developed.

Tentatively, it is planned to stabilize the missile in pitch and roll by means of a gyro vertical. The position of the reference axes is to be controlled by radar error signals. Control of direction in yaw motion will not be necessary because the KINGFISHER turns by banking. An alternative system being given consideration is to stabilize in pitch and yaw by means of a free gyro spinning on the axis of roll and to stabilize in roll by means of an angular accelerometer.

It is estimated that a servo system which will provide stabilization of the missile must be capable of delivering 1/3 H.P. to each flap of the bird.

Progress on the development of components for the stabilization system is reported below.

B. CURRENT PROGRESS

1. Antenna Stabilization

The double, or "Piggy Back", gyro system of antenna stabilization which was described in the last progress report has been abandoned. Tests indicate that nutation of the large gyroscope resulted in violent oscillations of the antenna. The large size and weight of the wheel, plus the need for a large motor, were other objection to its use.

Three other systems of motivation for the antenna stabilizer are well along in their development.

In the first system, the antenna is bound rigidly to the airframe at all times through gear and worm drives and a clutch mechanism. This system is under development by the Raymond Engineering Laboratories, Inc., and employs a refined version of the differential clutch shown in the previous Progress Report. In the later model of this clutch, both discs are driven at constant speed at all times, the differential gears are eliminated, and the tilting roller is attached to the output shaft so that it will rotate in either direction, dependent on the direction of roller tilt, and at a speed corresponding to the degree of tilt. The tilting action is controlled by a rod projecting through a hollow central shaft. Thus, the only mass which is reversed is the small roller and its arm, which have a relatively low inertia and are rotating at low speeds. A schematic diagram of this device is shown in Figure 15, and a photograph of this device is shown in Figure 16.

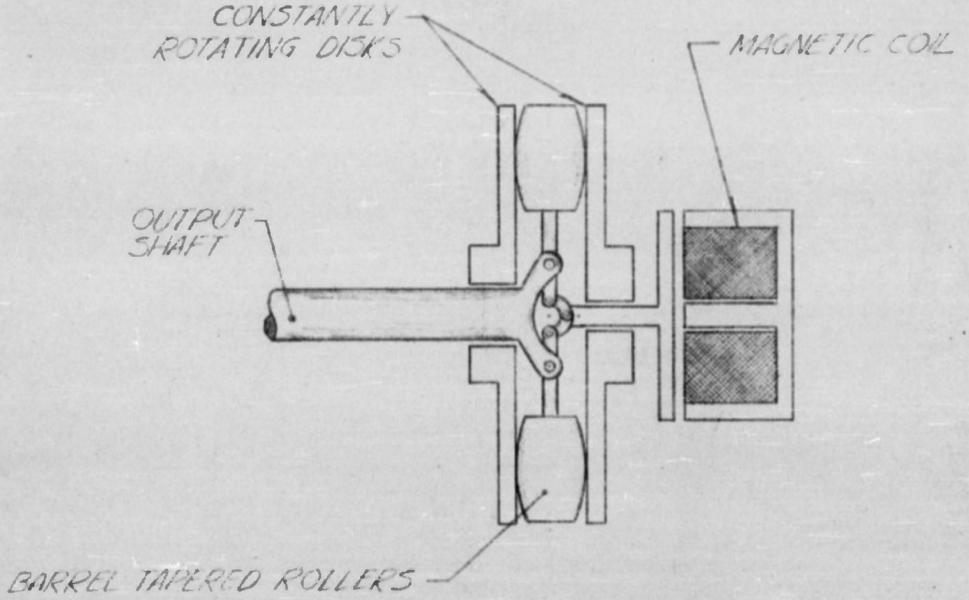

FIGURE 15

SCHEMATIC DIAGRAM OF NEW MODEL DIFFERENTIAL CLUTCH

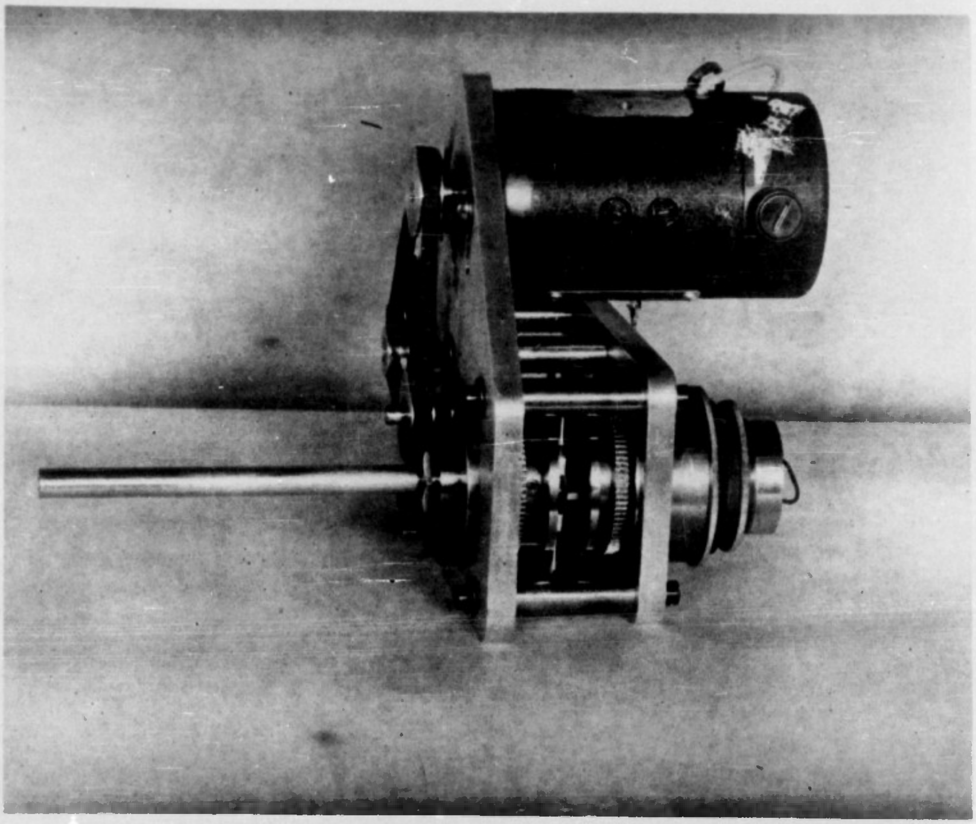

FIGURE 16

PHOTOGRAPH OF THE DIFFERENTIAL CLUTCH
SHOWN SCHEMATICALLY IN FIGURE 15

In the second system, the antenna is bound to the airframe only through the stiffness of the radar cables and the friction of the gimbal bearings. Disc clutches are being used. If the proper materials are chosen for the clutch faces, the coefficient of friction can be kept at a constant value, independent of the speed. The output of such a clutch can be considered to be a pure torque whose value is independent of the antenna position. In this manner, the inertia of the antenna helps to hold it steady. The anti-hunt mechanism must depend on the space angular velocities of the antenna and not on its velocities relative to the airframe. The F. H. Shepard Laboratories are developing this system.

The third system, which is being built at NBS, is intermediate to the other two systems in the degree of rigidity with which it is attached to the airframe. It employs small, high-speed, low-inertia, two-phase motors which are geared to the antenna. The antenna is then free by the ratio of its inertia of the motors multiplied by the square of the gear train ratio. The chief virtue of this system is the space economy which it makes feasible. The motors (and possibly the amplifiers) can be mounted directly on the antenna gimbal, thus freeing valuable airframe space for other equipment. As a test of whether this conventional system was applicable to antenna stabilization, it was applied to an artificial antenna and airframe in the laboratory. Anti-hunt was applied by mixing the output of a small generator with the error signal. This generator was geared to the antenna, so that its voltage was proportional to velocity. With the proper ratio of this inverse feedback to the error signal, the whole system could be made "dead beat." Tests conducted by rocking the artificial airframe in one plane through a constant angle, at various velocities, showed that the antenna held its space orientation within $\pm\frac{1}{4}^\circ$ for accelerations up to one radian per second squared, and within $\pm\frac{1}{2}^\circ$ for accelerations of five radians per second squared. Figure 17 is a photograph of a full-size dummy antenna mounted in a gimbal and the forward frame in such a way as to permit the antenna to look 25° both up and down, and 60° both to the port and starboard. Provision has also been made for mounting a free gyro on the side of the antenna and allowing it to project through the gimbal frame. Sufficient space is available towards the stern of the antenna for the radar gear, and the whole assembly will fit into the present BAT radome.

Each of the three antenna stabilization systems employs a free gyro as a space reference, in which the error information is picked up by photoelectric means. Work has been progressing on modifications to the Mark 18 gunsight gyro for this purpose. In Figure 18 are shown two modifications to the Mark 18 gyro. This method has the advantages of not imposing any precessional forces on the gyro and of giving a high order of sensitivity and a high voltage output. The gyro on the left employs a single phototube which is scanned by a rotating light beam reflected from the gyro mirror and swung in a circular path by an offset rotating mirror. Directional information is obtained by means of a commutator on the shaft of the rotating mirror. The gyro on the right employs four miniature phototubes illuminated directly by the light beam reflected from the gyro mirror. This eliminates the rotating mirror and the commutator but increases the number of tubes necessary in the difference and amplifier circuits. Experiments have indicated that, by use of this modified gyro, it should be easy to slave the antenna to the radar. All that is necessary is to rewind the precession coils already in the Mark 18 unit and couple them to the radar output through conventional diodes.

FIGURE 17

FRAME FOR MOUNTING ANTENNA ASSEMBLY

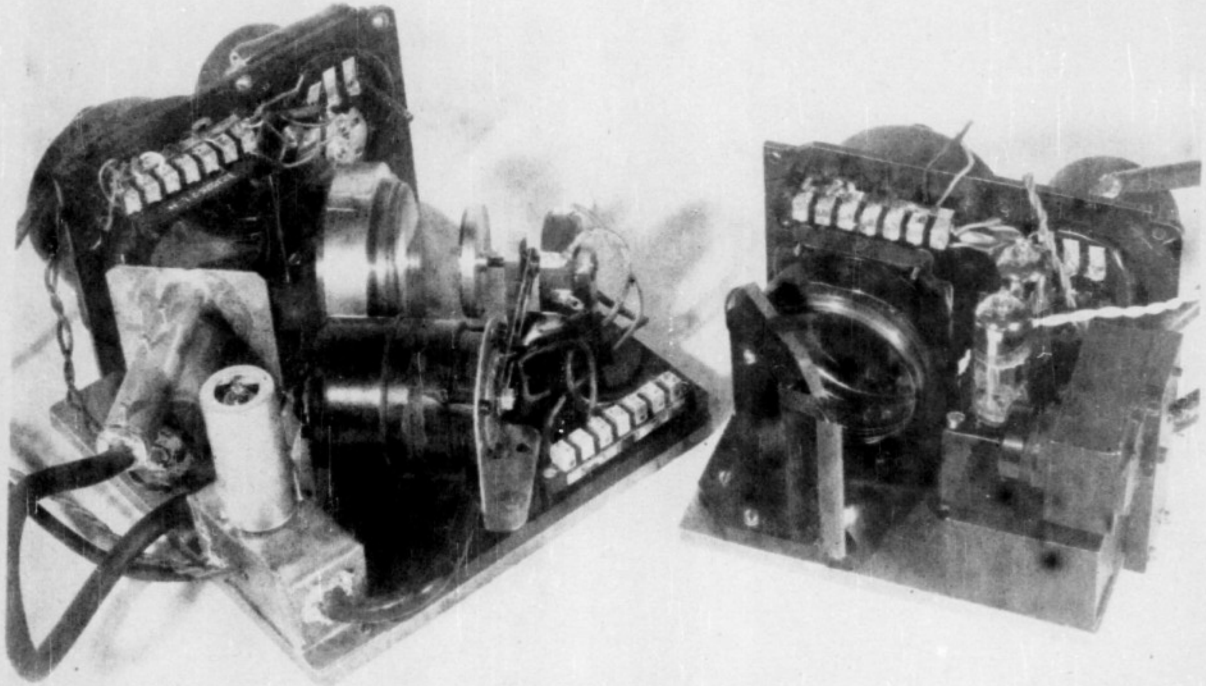

FIGURE 18

TWO MODIFICATIONS OF THE MARK 18 GUNSIGHT GYRO USING PHOTOELECTRIC PICK-OFFS

A pitch and yaw simulator for testing the antenna stabilizer is now under construction. It consists of a large gimbal in which the whole forward assembly (including the antenna, its gimbal, the free gyro, and the servo mechanism) can be mounted. This can then be made to pitch and yaw, either simultaneously or independently, by means of variable speed drives, and the stability of the antenna measured. It is intended to compare the three systems of stabilization now under development.

2. Main Control Servo

Two driving mechanisms are under development for the operation of the main control surfaces. The first of these is a refinement of the rapidly meshed gear clutch first employed by NBS for the BAT. Friction drive wedge or "V" gears are employed rather than the toothed gears formerly used. Two female gears are constantly driven in opposite directions and a centrally located male gear is engaged to one or the other by means of a solenoid, energized from the gyro and radar amplifier circuits. This central gear then drives a lead screw and nut which operates the control arm. It is hoped that proportioning control may be obtained by allowing some slippage of the wedge gears.

The second method is being studied by the Raymond Engineering Laboratories, Inc., and employs a further modification of the differential clutch. In one version, three or more tipping rollers are used in an arrangement similar to that described for the antenna stabilization. In another version, the roller arm is hinged and has a roller on each end, one end engaging a conical disc and the other a flat disc, and by tipping the roller on the conical disc, differential action over a large speed range is obtained.

Some preliminary consideration and design calculations have also been made on the development of a self-contained hydraulic unit which would be completely sealed and installed as a package.

Considerable progress has been made in the development of the angular accelerometer as a pickup for roll stabilization. Progressive models are shown schematically in Figure 19. The first model, previously described, employs a spring to center the inertia element. Angular acceleration causes a slight motion of this element relative to the frame which, in turn, unbalances a differential transformer by movement of the iron core. In the second model, the spring was replaced by the magnetic force between the armature attached to the inertia element and the central leg of an "E" core differential transformer with the primary in the center. This moving element also changes the area of the air gap between it and the outer legs of the transformer, thus unbalancing the secondary voltages. Using a similar principle, a much smaller instrument (Model 3 in Figure 19) was developed. This model is only three inches long in its greatest dimension. It, too, employs magnetic centering, but the output is obtained by varying the lengths of the outer air gaps by a rocking motion about a bearing in the inertia element.

Since the accelerations involved are of the order of one radian per second squared, the forces applied to the instrument are very small. However, the first model had a sensitivity of 10 mv per radian per second squared, the second model gave up to 100 mv, while the miniature model has an output of 50 mv for the same acceleration.

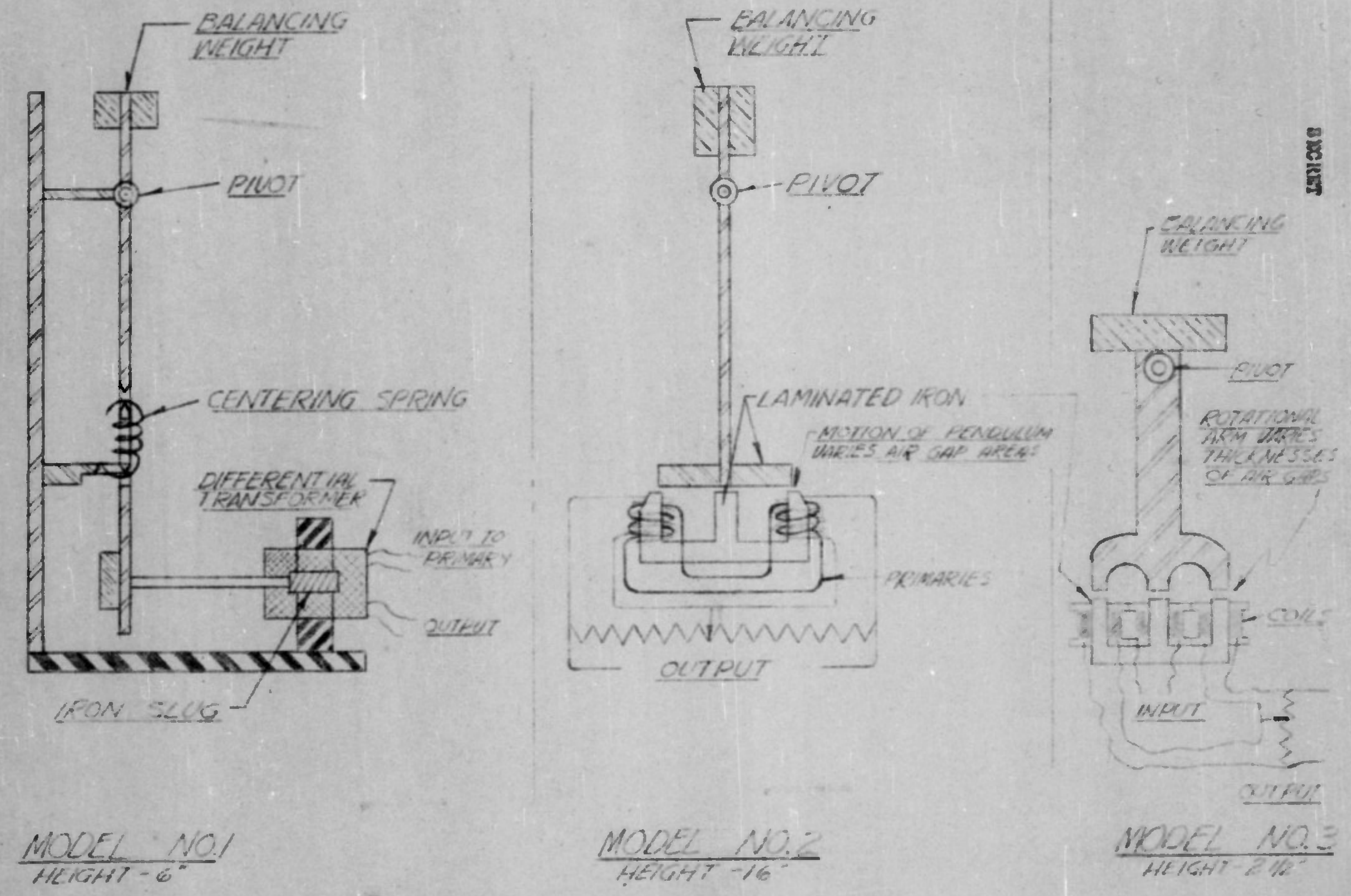

FIGURE 19
THREE MODELS OF ANGULAR ACCELEROMETERS

VII. POWER SUPPLY

A. STATUS OF DEVELOPMENT

The primary source of energy both for the radar and the two stabilization systems is the air stream. Two generators, driven by one or two variable-pitch constant-speed windmills, are to be used. The radar generator will supply approximately 1 kw at 400 cps; the servo generator will have similar capacity, but the exact form of the output awaits further definition of servo requirements.

First models of the power supply have been built and found satisfactory in laboratory tests.

B. CURRENT PROGRESS

The constant-speed windmill and the a-c/d-c generator converted from the Eclipse Type 800-1-D motor generator, which were both described in Quarterly Progress Report No. 1, were assembled and tested in the high-speed 12-inch wind tunnel. Figure 20 is a photograph which shows the complete power supply in the wind tunnel. Oscillographic records were made of the outputs over a wide range of load conditions. Regulation of the a-c voltage and interaction between the d-c and a-c sides were both good.

The speed regulation characteristics of the constant-speed windmill were within ±7% under all load conditions. However, an air velocity of 280 knots was required before the windmill could drive the generator under full load. A new model of this windmill has been designed with 8 blades instead of 5 and with a larger hub diameter. This unit should be capable of delivering more than sufficient power for any generator load now envisaged. Pitch limit stops have also been incorporated to remove any chance of reversal when starting under load. An order has been placed for limited production of this latest design.

The generator previously described was capable of sufficient power output and has good regulation. The frequency of the a-c side was 800 cps and the speed of rotation was 8,000 rpm. It is felt that a lower speed is more desirable for operation with the windmill drive, and that 400-cycle a.c. is more desirable with presently available control motors and gyroscopes. Hence, a new modification of the Eclipse Motor Generator Type 800-1-D has been made. This machine has new windings throughout except for the d-c armature and has the following ratings:

	A.C.	D.C.
Volts	125	12
Amperes	7.5	60
Speed	4,000 rpm	

The machine will withstand considerable overload. Alternating voltage regulation is achieved by saturating the field of the a-c generator. As a result, so long as there is a constant load on the a-c generator, large load changes in the d-c load result in very little change in a-c output voltage. Since this method eliminates the use of carbon pile regulators and a rectifier, further tests are under way to determine the suitability of this as a final design.

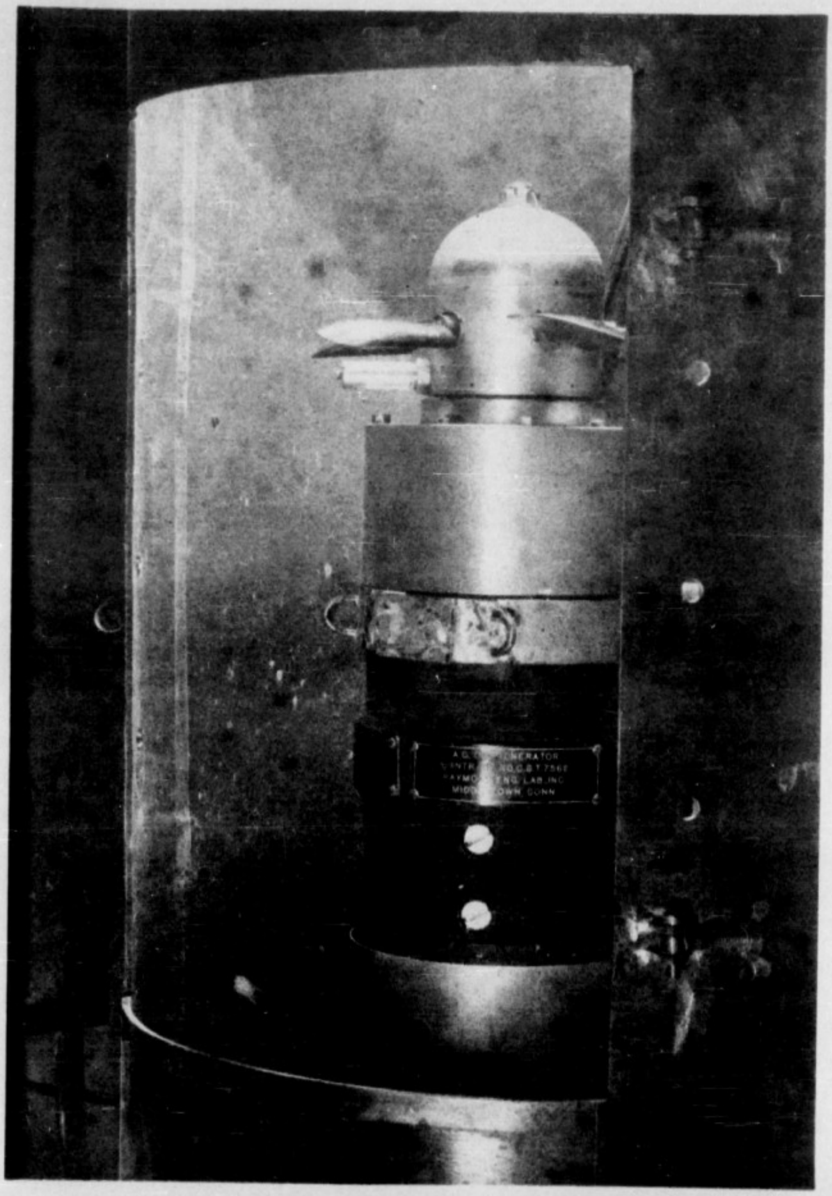

FIGURE 20

ELECTRICAL POWER SUPPLY MOUNTED FOR TEST
IN 12-INCH HIGH-SPEED WIND TUNNEL

VIII. INSTRUMENTATION

A. STATUS OF DEVELOPMENT

The instrument system developed for BAT, with some improvements, is being used for KINGFISHER flight tests. This system includes two recording cameras within the missile and two ground stations for obtaining trajectory data by optical methods. The cameras within the missile are enclosed in rugged cases to preserve the records from damage caused by impact. One camera photographs an instrument panel and the other, the view directly ahead of the missile.

Consideration is being given to telemetering systems to supplement the present photographic record system.

B. CURRENT PROGRESS

A number of existing telemetering systems have been studied but none of these will handle the small voltages from strain gages (such as might be used to measure hinge moments) without the addition of d-c amplifiers or other devices to raise the low voltage to an adequate modulating level. It has been found that the pulse-time telemetering system under development at NBS can be used to handle strain gage outputs directly by using saturable reactors as phase modulators. It appears that a considerable saving in space and complexity is possible by use of this scheme.

Receiving systems for telemetering have been investigated with the object of simplifying the field installation required. A simple reliable system appears to be as follows. In the receiver, the reference pulse triggers a horizontal switch on a cathode-ray oscillograph. The channel intelligence pulses are applied to the intensity grid and appear on the screen as a succession of dots, each of which may be moved laterally by appropriate modulation in the corresponding channel. A film moving vertically records the channel signals. This recording system is much simpler than many others which require electronic switching for channel separation and power amplification for driving recording oscillograph elements. In this receiver, the effect of noise pulses is not as serious as is the case with some other systems. It is necessary to separate the reference pulses from the channel intelligence pulses, but a certain amount of random noise can be tolerated since there is no electronic switch to be thrown out of synchronization. As long as the horizontal sweeps are properly synchronized, the channel sequence is not disturbed. Another pronounced advantage in this receiver is that failure of any one or more channels does not affect the remaining channel synchronization.

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ABSTRACT:

Development of radar-controlled, subsonic, self-homing, air-borne missiles designed to deliver explosive charge below water line of floating targets is discussed. Missiles are to be rocket-propelled with a range of 10 to 20 miles and varying in weight from 1000 to 4000 lb. Power-driven, homing torpedo separates from missile some distance short of target. One model to be ship-launched, carrying deep-diving homing torpedo for submarine targets. Discussion of flight simulator, and wind-tunnel and flight tests.

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28 JAN 2013

Subject: OSD MDR Case 12-M-1569

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We have reviewed the enclosed document in consultation with the Department of the Navy and have declassified it in full. If you have any questions, contact me by e-mail at Records.Declassification@whs.mil or by phone at 571-372-0483.

Sincerely,

Robert Storer

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Chief, Records and Declassification Division

Enclosures:
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