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U. S. NAVAL TECHNICAL MISSION TO JAPAN
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DECLASSIFICATION OF WWII RECORDS

31 December 1945

RESTRICTED

From: Chief, Naval Technical Mission to Japan.
To: Chief of Naval Operations.

Subject: Target Report - Japanese Guided Missiles.

Reference: (a) "Intelligence Targets Japan" (DNI) of 4 Sept. 1945.

1. Subject report, dealing with Target O-02 of Fascicle O-1 and E-27 of Fascicle E-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Lt. Comdr. E.L. Delmar-Morgan, RNVR, assisted by Lt. (jg) D.H. Jackson, USNR.

C. G. Grimes

C. G. GRIMES
Captain, USN

30633

RESTRICTED

O-02

JAPANESE GUIDED MISSILES

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945

FASCICLE O-1, TARGET O-02,

DECEMBER 1945

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ORDNANCE TARGETS

JAPANESE GUIDED MISSILES

A through investigation of Japanese guided missiles was made by the Air Technical Intelligence Group. The subject of infra-red devices for the control of guided missiles was explored by NavTechJap, and a report has been submitted under the title "Japanese Infra-Red Devices, Article 1 - Control for Guided Missiles", Index No. X-02-1.

After discussions with representatives of ATIG it was decided that its reports, which have been given a limited distribution, should be reproduced in full in this report to insure dissemination to all interested naval activities. This has been done. Further research on the part of NavTechJap was not considered necessary.

TABLE OF CONTENTS

LIST OF ENCLOSURES

LIST OF ILLUSTRATIONS

REFERENCES

Related Reports:

NavTechJap Report - "Japanese Infra-Red Devices, Article 1 - Control for Guided Missiles", Index No. X-02-1.

ATIG Report - "Japanese Heat Homing Bombs", No. 146.

ENCLOSURE (A)

AIR TECHNICAL INTELLIGENCE GROUP
ADVANCED ECHELON FEAF
APO 925

REPORT No. 262
12 December 1945

SUBJECT: Heat Homing Bomb, Fuze System

REFERENCE: Hdqtrs AAF "Air Staff Intelligence Requirements in the Far East" dated 25 July 1945. Section III Alc, and Section IIIAlg.

PERSONS INTERVIEWED: Maj. Tetsuo SHIRAKURA, Army Ordnance Hq. and Capt. Takeo AKIBA, 1st Army Technical Laboratory

INTERVIEWING OFFICERS: Lieut. Ernest G. OXTON, ATIG and Mr. H.H. MOORE, NAVTECHJAP

BRIEF OF MATERIAL DISCUSSED:

The fuzing system of the heat homing bomb, KEGO, consisted of four air-armed initiating trains, two instantaneous for deck impact and two with 0.3 to 0.5 second delay for underwater explosion.

The two instantaneous initiating trains fired one booster located in the rear of the main explosive charge, and each of the two delay trains fired its own booster, similarly located.

Material discussed included the operation of the fuzing system, composition of explosive trains, and research leading to the modifications of the standard fuzes used.

CONCLUSION OF INTERVIEWING OFFICER:

Fuzing system looks good on paper but is difficult to evaluate because no heat homing missile with live charge was tested against a solid target.

RECOMMENDATIONS:

Similar dual detonating systems, including water discriminating, simple, shear pin type fuze should be studied for use in VB ' nd VB-6.

EQUIPMENT, LOCATION, AND DISPOSITION:

All of the fuzes were claimed by officers interviewed to have been destroyed. No samples have yet been found.

PREPARED BY: Earnest G. Oxton
2nd Lieut., Air Corps

APPROVED: F.O. Carroll
BRIG. GEN.

ENCLOSURE (A), continued

APPENDIX "A"

DETAILED DESCRIPTION

Arming: Firing pins of the two initiating trains to the instantaneous booster protruded beyond the heat seeking nose and were armed by means of vanes which were spun off three to five seconds after the arming wire was pulled, assuming a wind velocity of 40 meters per second (131 ft/sec).

The two delay fuzes were armed by means of Robinson cup anemometers which extended into the wind stream on the dorsal and ventral surfaces.

(NOTE: Because of language difficulties these Robinson cup anemometers were referred to as "Robinson Couples" in the overall report on KEGO, the Japanese Heat Homing Bomb, ATIG report no. 146.)

Operation: The delay fuzes for underwater explosion were standard Model 4 (1944) which had been modified by the addition of a 0.3 to 0.5 second, pressed black powder delay. Primer, detonater, and booster were all self-contained in the two fuzes which were located in the tail of the main charge.

Water discriminating initiators for instantaneous explosion at deck impact were made from standard Model 12 (1933) fuzes modified with an iron shear pin to hold the firing pin away from the primer. This shear pin had an experimentally determined diameter, 1.2mm (.472 in.), such that water impact would not fire the fuze but the greater force of impact with a deck would cause instantaneous detonation in the following manner:

Firing pin would shear the shear pin and strike the mercury fulminate primer (Raikoo) which exploded, setting off a detonating mixture (Boofun) of two parts mercury fulminate, five parts potassium chlorate, and five parts antimony sulfide. This mixture in turn fired a booster (Melayaku) of tetra nitro methyl aniline which set off a detonating cord (Syoei) with a burning rate of four to five thousand meters per second (4400 to 5500 ft/sec). Each of the two initiators was connected by a detonating cord to the middle booster in the tail of the main charge. The detonating cord entering the main charge first set off another tetra nitro aniline booster which fired a charge of molded picric acid (1st Tanooyaku), and that finally exploded the main charge of picric acid.

Tests: Tail fuze was tested and found satisfactory on 10 kg (22 lb) bombs and on live heat seeking missiles (uncontrolled) dropped into the water 20 or 30 miles off the coast of HAMAMATSU.

Shear pins of various diameters were tested for the instantaneous fuze. Nineteen kg (42 lb) test shells were fitted with test fuzes and fired from a 120mm (4.7 in) mortar. Specifications for the pin required that it shear at terminal velocities of not more than 100 meters per second (327 ft/sec) upon ground impact and not less than 200 meters per second (654 ft/sec) upon water impact.

Key Personnel: Capt. Takeo AKIBA, 899 3 Cho-me, Setagaya-Ku, TOKYO, an engieering graduate of Tokyo Imperial University in 1942; assigned to fuze Section, First Army Technical Laboratory.

Maj. Tetsuo SHIRAKURA, 3629 Nerima-Minimachi-2 Itabashi-Ku, TOKYO, graduated from the Tokyo Military Academy in 1937; assigned to Army Ordnance Headquarters.

ENCLOSURE (A), continued

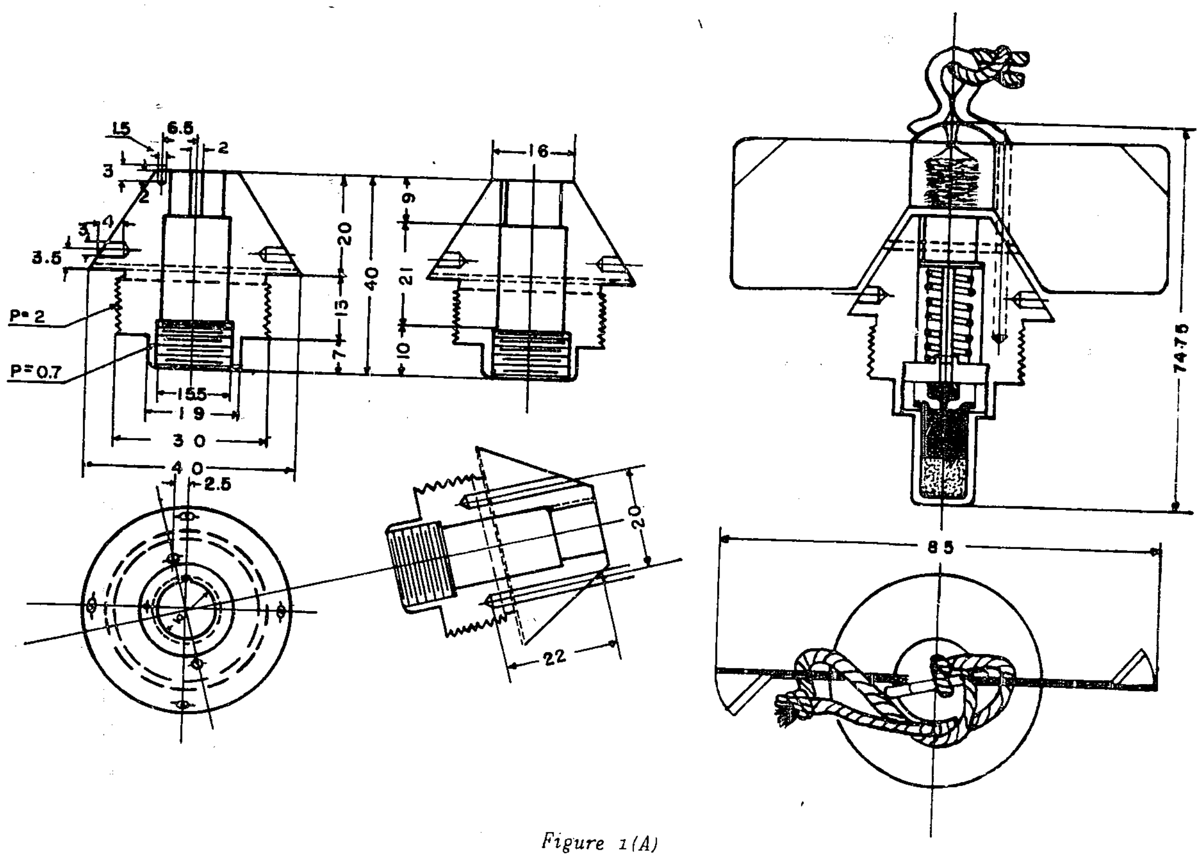

Figure 1(A)

STANDARD MODEL 12 (1933) FUZE

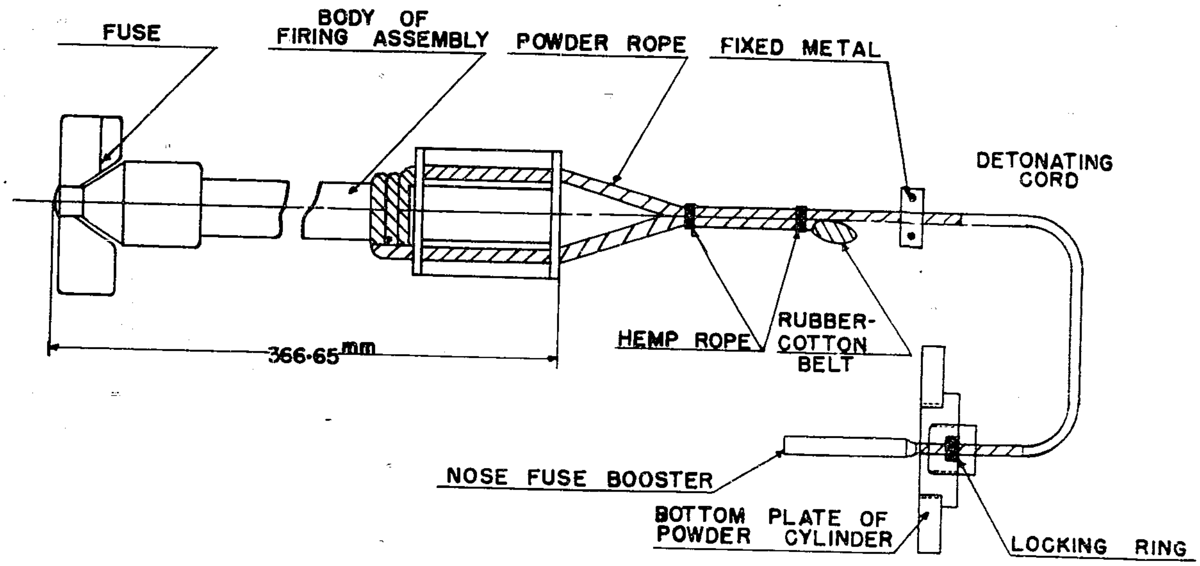

Figure 2(A)

NOSE FUZING SYSTEM

ENCLOSURE (A), continued

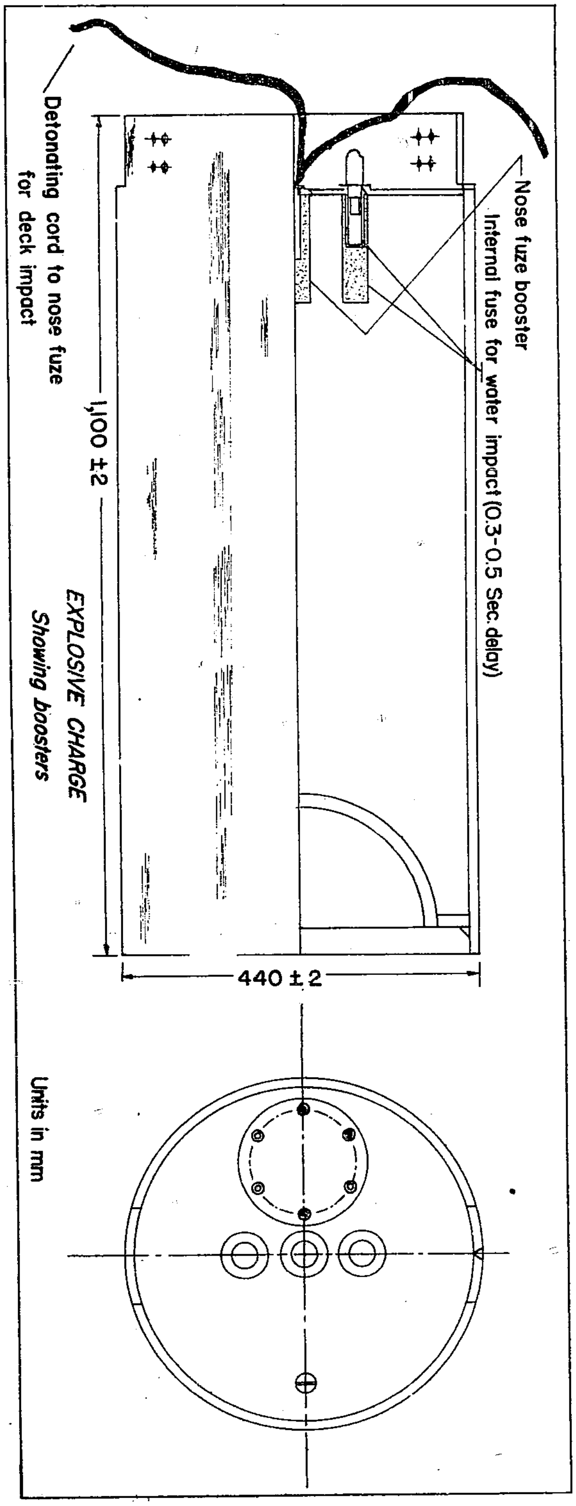

Figure 3(A)
EXPLOSIVE CHARGE

ENCLOSURE (B)

FF12-5(25)/F32
Serial No. 101

AIR TECHNICAL INTELLIGENCE GROUP
ADVANCED ECHELON FEAF
APO 925

REPORT NO. 32
2 November 1945

SUBJECT: Control Systems for Pilotless Aircraft.

REFERENCE: Hdqtrs. AAF, "Air Staff Intelligence Requirements in the Far East, dated 25 July, 1945, Section III (A) (g).

PERSONS INTERVIEWED: Mr. T. HAYASHI (B.S., Physics)
Mr. K. NAGAMORI (B.S., E.E.)
Lieutenant (E.C.) K. RIDA, I.J.A.
Lieutenant (E.C.) S. NIIKURA, I.J.A
Mr. T. DOI

INTERVIEWING OFFICER: Lieutenant Commander R.F. DEIBEL, Jr., U.S. Navy.

BRIEF OF MATERIAL DISCUSSED:

1. HAYSAHI and NAGAMORI were design engineers with the Sumitomo Communication Industry Co., Ltd., of TOKYO. The former designed the auto pilot system, and NAGAMORI, the transmitter and receiver circuits for the radio-controlled flying missile, "I-go B". Both were intelligent and most cooperative and rather annoyed by the Army's attitude of indifference toward civilian engineers.

RIDA and NIIKURA, both Army technical Lieutenants, were attached to the Army Test Flight Group at FUSSO as radio and auto pilot engineers, respectively.

DOI was the Chief Engineer at the Gifu plant of the Kawasaki Aircraft Co., and in this capacity had general cognizance of production of "I-go B".

For three-view and inboard profile of "I-go B", see A.T.I.G. Report No. 28. (These illustrations have been extracted from Report No. 28 and are attached hereto as Figures 3(B) and 4(B).

2. To date the "I-go" series (A and B) is the only flyable result of pilotless missles found in JAPAN, and this was an Army-sponsored program. It included the most elementary radio and auto-pilot control system.

3. Complete test results will be included in a later report by the Aircraft Section, A.T.I.G., but preliminary data indicates that about 150 missiles were constructed by the Gifu Plant of the Kawasaki Aircraft Co., ten "Mother" planes (Ki-67), modified, and a total of about 17 missiles actually test-flown. Of this total of about 17 missiles flown, about 70% to 80% were considered effective hits. The missile was not free from control defects, the major item being the servo motors, which were considered by HAYASHI to be of inferior quality and design, and which was estimated as resulting in the production of only 20% defect-free autopilot systems.

4. The Sumitomo Co. manufactured about 220 receivers. The transmitter was a modified TOBI 4 which was a standard Army plane-to-plane VHF set operating at about 48 mcs. NAGAMORI stated that the major modification was the change from crystal to non-crystal operation. The transmitter operated in a frequency range of from 35 to 58 mcs., with an intermediate frequency of 600 to 700 kcs. There were four audio control frequencies of 3000 (right), 2600

(left), 2200 (up), 1800 (down). The carrier frequency was on only when control was applied by a "stick" in the "Mother" plane.

5. The gyro system included electric gyros and servo motors with mechanical linkage to the control surfaces. One gyro and two servos controlled rudder and aileron throw (10 degrees maximum) simultaneously with application of right or left "stick" in the "Mother" plane. A second gyro and third servo controlled stabilizer throw (25 degrees down and five degrees up maximum), with application of down or up "stick" in the "Mother" plane.

6. In operation, about one minute prior to launching, current was applied to the filaments in the receiver tubes by electrical leads from the "Mother" plane. Just prior to launching, the gyros were started using the same power source, and in about four seconds reached maximum speed of seven to ten thousand RPM. (Upon launching, and when the power leads to the "Mother" plane were broken, all power was then off the gyro rotors, and no power was applied to the rotors during flight of "I-go B". Useful sensitivity control was about two minutes after which gyros tumbled because of loss of speed.) During flight, power to the tube filaments was supplied by dry cells connected in series parallel capable of supplying six ampere at 24 volts for five minutes.

7. While in flight, application of right "stick" in the "Mother" plane effected full rudder and aileron throw in "I-go B" and a maximum course change of 25° could be obtained, at which time "I-go B" righted itself and straightened out on the new course. If the "stick" were then moved to the neutral position, "I-go B" would assume its original course. (See Fig. 1(B).) Actually, then, course changes were effected by steps right and left, the resulting lateral movement of "I-go B" in space being determined by the length of time of application of right or left "stick".

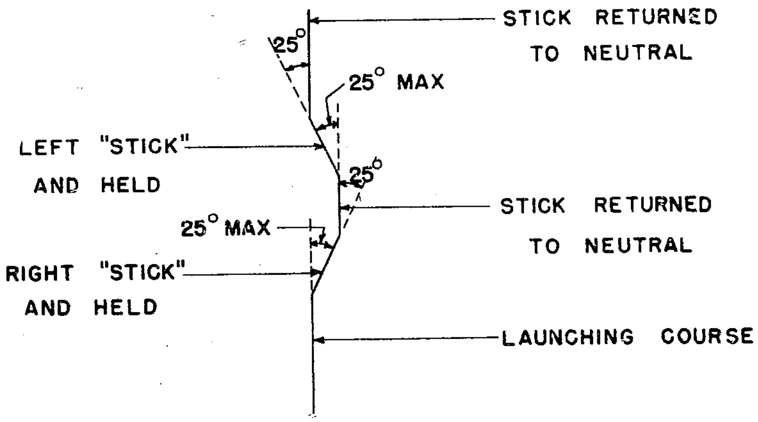

Figure 1(B)

CONTROL OF "I-go B" IN HORIZONTAL PLANE

ENCLOSURE (B), continued

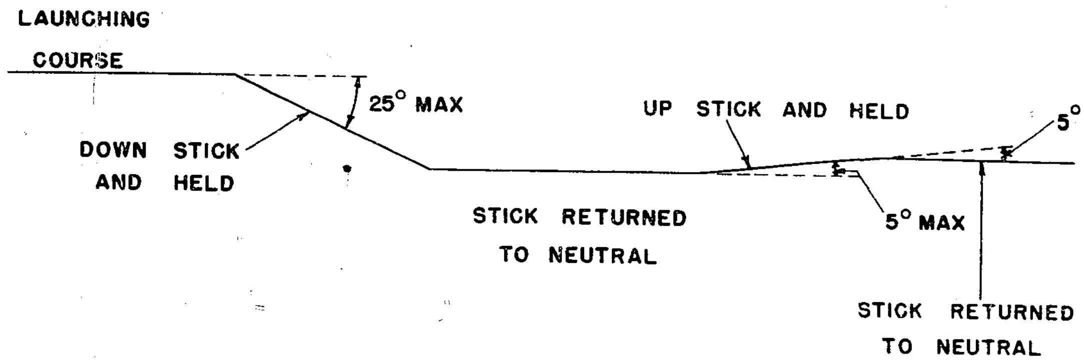

Figure 2(B)

CONTROL OF "I-go B" IN VERTICAL PLANE

Note that the figures for change of course, dive, and climb are the theoretical figures to which the control system was designed. Actual in-flight figures were not known.

9. When the "stick" in the "Mother" plane was moved in any direction, the resulting signal transmitted was received in "I-go B" and placed a fixed resistance in the gyro-selsyn circuit, shifting the zero point. As the gyro sought the new zero point, the selsyn was actuated, which in turn actuated the control surfaces. When the "stick" in the "Mother" plane was returned to neutral, the fixed resistance was removed from the circuit, the zero point shifted to its original position, and the plane returned to its original course. Use of proportional control had not been considered. No consideration was given to the installation of repeat-back equipment in "I-go B".

10. The total weight of the auto pilot and radio control installation was estimated to be about 26.4 pounds, broken down as follows:

Auto pilot system	17.6
Radio control equipment and wiring	4.4
Batteries	4.4
Total	26.4

11. The detailed report to be prepared by the Aircraft Section, A.T.I.G., will include functional and circuit diagrams of the auto-pilot and radio control circuits as well as the tie-in between the two.

Approved:

F. O. CARROLL,
Brigadier General, U.S. Army.

Prepared by:

R. F. DEIBEL, Jr.,
Lt. Comdr., U.S. Navy.

ENCLOSURE (B), continued

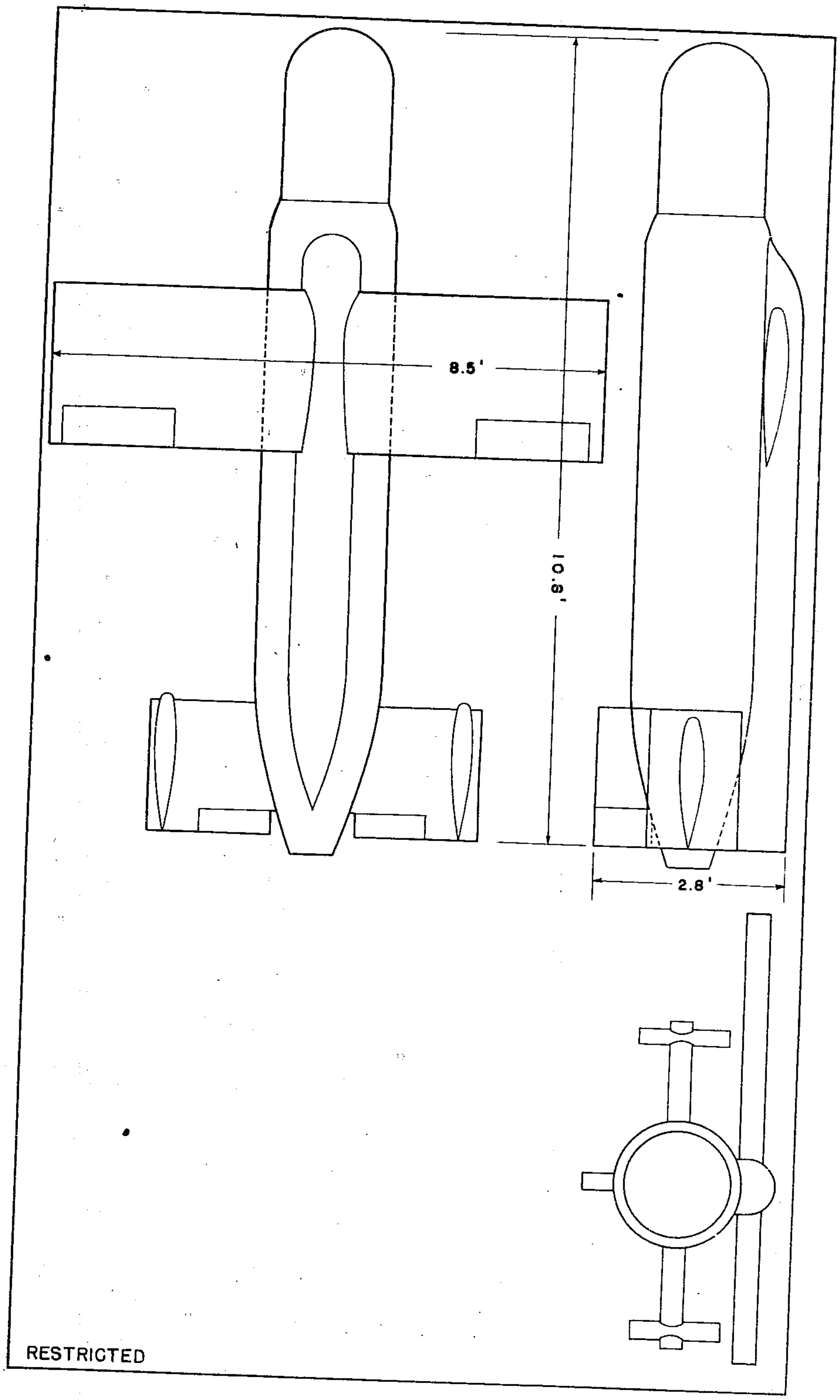

Figure 3(B)
ROUGH SKETCH OF "I-go"

ENCLOSURE (B), continued

RESTRICTED

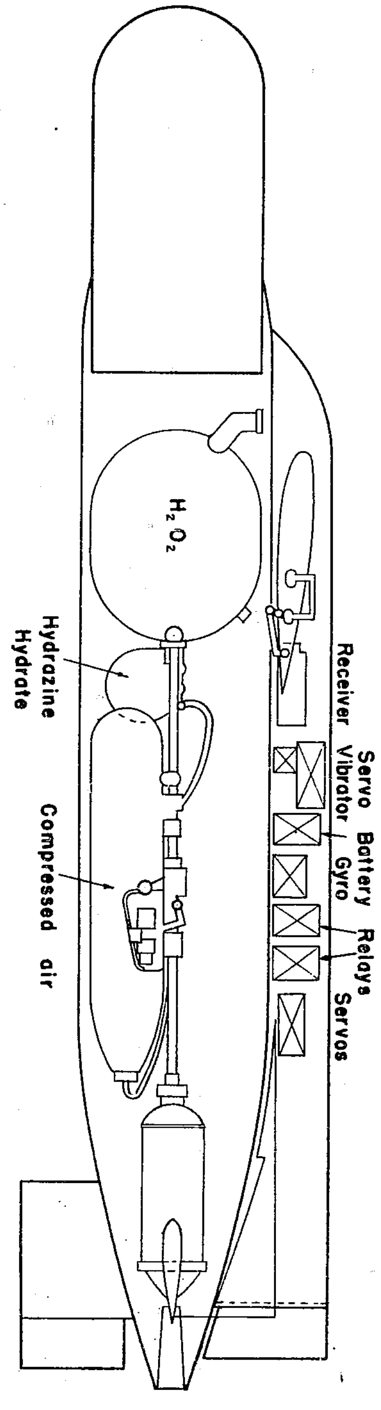

Figure 4(B)

INBOARD PROFILE OF "I-go B"

ENCLOSURE (C)

AIR TECHNICAL INTELLIGENCE GROUP
ADVANCED ECHELON FEAF
APO 925

REPORT NO. 92
16 November 1945

SUBJECT: Japanese Airborne Anti-Submarine Circling Torpedo

REFERENCE: Hdqtrs AAF, "Air Staff Intelligence Requirements in the Far East" dated 25 July 1945. Section III A,1,c and Section III A, 1,g.

PERSON INTERVIEWED: Lt. Comdr. TAREDA NIIRO, IJN

INTERVIEWING OFFICER: Lt. E. G. OXTON.

BRIEF OF MATERIAL DISCUSSED:

Summary:- From April to December 1944, the Japanese Navy was developing and testing a winged, anti-submarine torpedo containing a 220 lb. charge and designed to be dropped from 327 ft. (100m), assume a linear trajectory with a glide ratio of approximately three to one, enter the water, and spiral downward describing circles 260 ft. (80m) in diameter spaced at depths of 260 ft. (80m).

Test drops showed such instability in flight that it was concluded that a gyroscope stabilization system was necessary but no research was done on the weapon after the end of 1944.

Designation: Air Torpedo No. 6.

Weight: 597 lbs. (270 kg)

Description: Except for a metal nose section, to take the force of impact, and two small wing braces, the entire torpedo was made of wood.

Wings and rudder were glued to the wooden torpedo case. Wings remained attached until detonation.

The case was constructed of interlocking spirals of wooden strips 3.3 inches (13mm) thick.

Guiding System: Rudder was fixed at 8 degrees, causing torpedo to circle counterclockwise in 260 ft. circles. It sank because of its specific gravity of 1.4. To prevent the eight degree rudder displacement from affecting flight, the rudder was covered by a hollow fairing between the torpedo body and tailplane. This hollowed section of fairing was attached by means of an aluminum pin which was sheared at impact, unsheathing the rudder.

Propulsion: None. The weapon was unpowered both in flight and in the water.

Warhead: 220 lbs. (100 kg) explosive charge ninety-eight.

Fuzing: It was planned to use a magnetic proximity fuze, but its development was a separate project on which research was incomplete.

Arming: Fuze was to be air armed by a vane which would be allowed to spin when arming wire was pulled.

ENCLOSURE (C), continued

Aiming: Visual. No sighting device used.

Parent Plane: Torpedo bomber TENZAN (JILL 11 or 12) with a capacity of one torpedo.

Launching: Standard torpedo racks were used; no modifications necessary.

Tests and Operational Use: Forty drops were made to test the torpedo's stability in flight. Fifteen of the forty tumbled or spinned in. Wing width was reduced to four feet, and the dihedral was increased from 15 to 20 degrees. These modifications helped somewhat, but stability was still unsatisfactory.

"Many" rudderless torpedoes were dropped over the side of a boat to test the rate of descent in water. The specimens travelled at five to six knots in a dive of 17 degrees. A recorder was attached to indicate rate and angle of descent. The recorder was especially built but operated on the same principles as recorders used on regular torpedo tests. There was no good method of recording the circle travelled by torpedoes dropped with rudders.

Limitations: Maximum pressure the torpedo can withstand is that at a depth of 327 ft. (100m).

Manufacture and production Data: One hundred of the missiles were made. The First Technical Arsenal at YOKOSUKA made all iron parts and the wooden rudder. The wooden torpedo case and wings were made by the Marunimoko Co. in FUTSUKAISHI, Hiroshima Prefecture.

Development Agency and Key Personnel: Research on the project was under the supervision of Commander FUKUBA of the First Technical Arsenal Branch at KANAZAWA.

Lt. Comdr. NIIRO, 28 Gazembo, TOKYO, the officer interviewed, had the liaison mission between the Naval Air Arm and Commander FUKUBA. NIIRO was a torpedo engineer at the Kure Naval Base from February 1941 to January 1944. He is a Navy regular with ten (10) years service.

CONCLUSION OF INTERVIEWING OFFICER:

Knowledge of the attempt at such a weapon by the Japanese is of value at least for USAAF and Navy Intelligence records. Its value to our research on similar missiles requires further investigation.

RECOMMENDATIONS: Samples forwarded to the U. S. require further study for a true evaluation of the weapon.

EQUIPMENT, LOCATION AND DISPOSITION: Technical Air Intelligence Unit acquired, crated, and listed two mockups of the airborne anti-sub circling torpedo. These were contained in boxes M3 and M3A shipped from YOKOSUKA aboard the USS Barnes, marked for the Technical Air Intelligence Center, N.A.S., Anacostia, D.C.

PREPARED BY: ______
E. G. OXTON
Lt., AC

APPROVED: ______
F. O. CARROLL
BRIG. GEN.

ENCLOSURE (C), continued

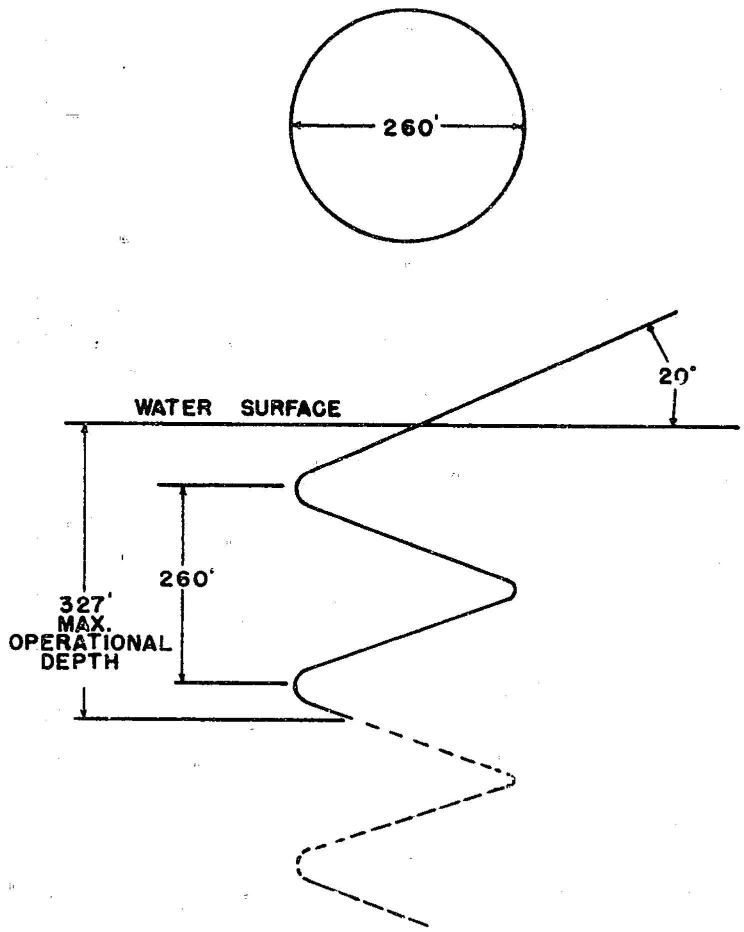

Figure 1(C)

DESIRED TRAJECTORY OF ANTI-SUB CIRCLING TORPEDO

ENCLOSURE (C), continued

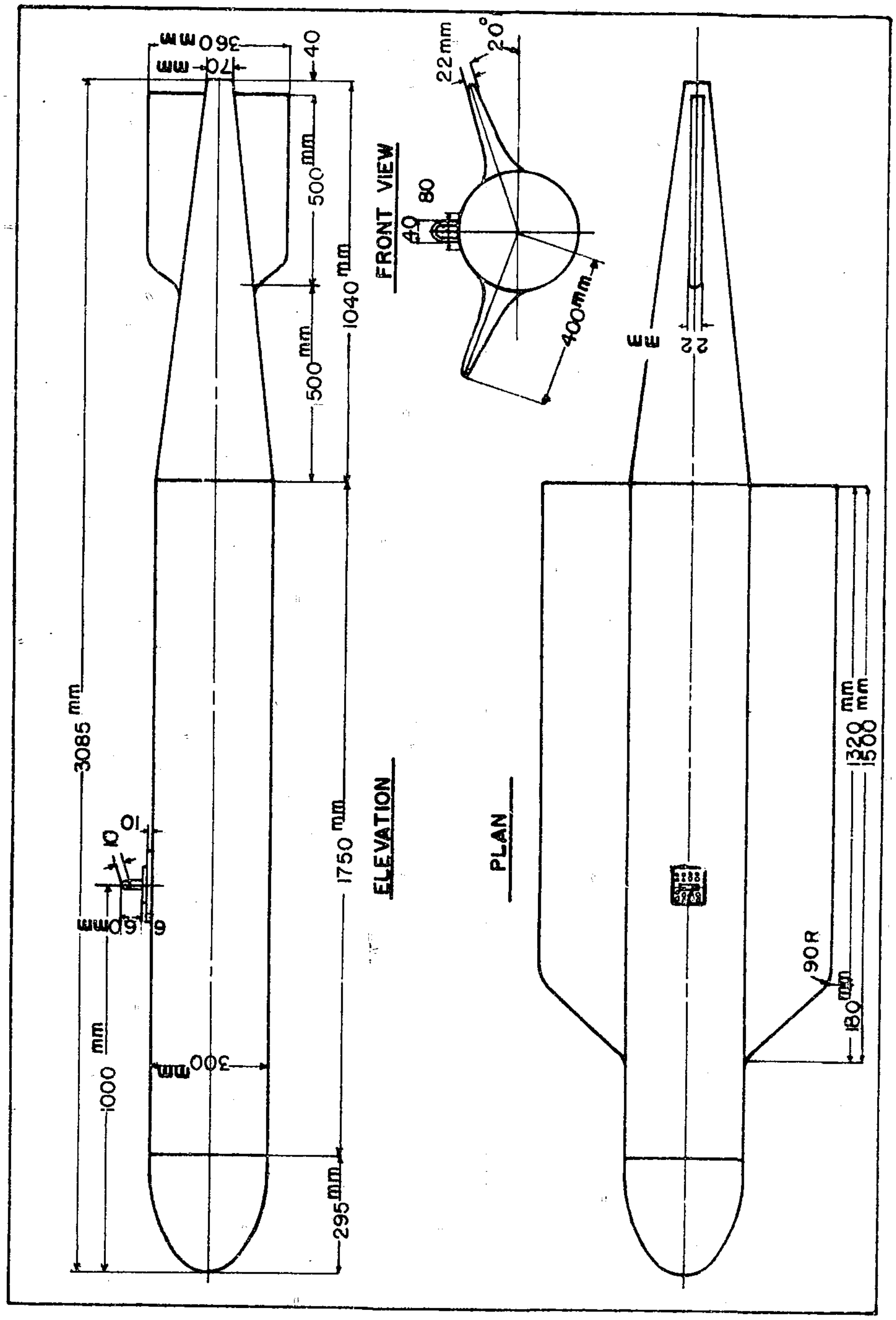

Figure 2(C)
ANTI-SUB CIRCLING TORPEDO

RESTRICTED

ENCLOSURE (D)

AIR TECHNICAL INTELLIGENCE GROUP
ADVANCED ECHELON FEAF
APO 925

REPORT NO. 114
20 November 1945

SUBJECT: Japanese Radio Controlled Flying Bomb "I-go".

REFERENCE: Hdqtrs AAF "Air Staff Intelligence Requirements in the Far East" dated 25 July 1945. Section III Alg.

PERSONS INTERVIEWED: Kyozo NAGAMORI, Teruo HAYASHI, Takeo DOI.

INTERVIEWING OFFICER: Capt. J. A. DILWORTH.

BRIEF OF MATERIAL DISCUSSED:

All phases of the "I-go" bomb.

CONCLUSIONS: None.

RECOMMENDATIONS: None.

EQUIPMENT, LOCATION, DISPOSITION:

All equipment was destroyed before the arrival of ATIG personnel.

APPENDICES: A, B, C.

PREPARED BY: J. A. DILWORTH
CAPT.

APPROVED: F. O. CARROLL
BRIG. GEN.

ENCLOSURE (D), continued

APPENDIX "A"

I. History of "I-go".

A. In July 1944, a radio controlled flying bomb design was started. The missile was not designed with the idea of saving a pilot. American antiaircraft fire had been accurate enough to kill the Kamikaze pilot before they could make a hit, and it was thought that by radio controlling the bomb it would have a better chance to hit the target.

B. By the end of October 1944 the first model of "I-go" B was ready for test. The airframe was built by the Kawasaki Aircraft Co. at GIFU while the gyros and radio equipment were built by Sumitomo Co. in TOKYO. Using a Ki-48 as the mother plane "I-go" was dropped at AJIGAURA near MITO.

C. The first "I-go"A was built by MITSUBISHI and dropped at the end of November 1944. Altogether fifteen (15) "I-go"A and one hundred and fifty (150) "I-go"B missiles were built. After experimental drops at AJIGAURA, ATAMI, and SHIRUISHI, it was decided that the missiles were unsuited for combat use, since by that time American anti-aircraft and fighter aircraft would have shot the mother plane down before drops could be made.

II. Description of "I-go".

A. The "I-go" flying bomb was a high wing monoplane designed in two sizes to accommodate two sizes of warheads. A jet unit was provided in both "I-go" A and B for additional speed which operated for about eighty (80) seconds. The general dimensions of the bombs is given below.

	"I-go" A	"I-go" B
Span	6 m (19.8 ft)	4 m (13.2 ft)
Weight	1500 kg (3300 lb)	750 kg (1650 lb)
Warhead	800 kg (1760 lb)	300 kg (660 lb)
Thrust of Jet	300 kg (660 lb)	150 kg (330 lb)
Speed	550 km/hr (342 MPH)	550 km/hr (342 MPH)
Range	11 km (7 mi)	11 km (7 mi)
Mother Plane	Ki-48	Ki-67

III. Dropping and Guiding Technique:

A. The "I-go" bomb was to be dropped when the mother plane was at 2300 ft. altitude and about 11 km (7 mi) from the target. The mother plane then followed the missile down and was about 4 km (2.5 mi) from the target when the missile struck. The targets which were to be attacked by "I-go" were battleships, cruisers, aircraft carriers, etc.

B. One minute before the drop was to be made current was applied to the radio equipment. At least one minute was required for warm up.

1. After warm up was achieved a button was pressed which actuated a bomb release control which in turn controlled the following sequences of operations:

a. The auto-pilot gyros were excited by a 24 volt current at 20 to 23 amps for 4 seconds which brings them up to a speed of 7000-10,000 RPM.

b. After 4 seconds a 24 volt current is put across a doubled 35mm nichrome wire which melts. This releases the caging mechanism, uncages the gyros, and takes away the power supply to the gyros.

c. The jet unit is turned on and burns for one second.

d. Missile is dropped.

C. After the drop, the bomb was visually guided to the target from the mother plane. The flight path was rather peculiar.

1. The missile was held at a fixed angle with respect to the horizon (not a fixed angle of attack) by means of the horizontally mounted gyro.

2. Control was available in the vertical plane from five degree climb to twenty-five degree dive (angle of aircraft with respect to horizon) As long as control was applied, the missile would alter its attitude to a given angle with respect to the horizon and hold that angle; i.e., if down control was put on and held, the missile would assume an angle of twenty-five degrees to the horizon. Upon release of control the missile would return to its preset normal glide angle. This results in a stair step sort of a glide path in the vertical plane.

3. Control was available to the left and to the right up to a change of original course of twenty-five degrees. The turning sequence was as follows:

a. Suppose left control is given.

b. The rudders throw over ten (10) degrees to the left.

c. The left wing drops five (5) degrees, and the missile turns twenty-five (25) degrees off the original heading.

d. After turning twenty-five (25) degrees, the missile holds this new heading, but the left wing still remains down, i.e., cross control is required to hold the new course.

e. Upon release of control, the missile rights itself laterally and skids back to its original heading.

f. This results in a zig-zag sort of course.

D. The auto-pilot system does not incorporate a rate gyro to limit turning speed, but rather utilizes a wheatstone bridge arrangement which limits the amount of turn and electrically damps out oscillations.

APPENDIX "B"

I. Details of "I-go".

A. Structure of airframe (Kawasaki).

1. The wing was constructed of wood with a single spar 35% aft of the leading edge and housed the antenna. The airfoil section was the NACA-0012 symetrical airfoil. The wing attached to the fuselage with three (3) degrees incidence.

2. The fuselage was made of tin and built in several sections; the center part of the fuselage was built in two halves and bolted on either side with twenty-five (25) bolts. The rear section housing the motor attached to the center in the same manner. An additional cover fitted over the auto pilot, radio, batteries, etc., which were mounted on top of the fuselage.

3. The tail surfaces were made of tin.

4. It was estimated that the missile would be launched at 360 km/hr (225 MPH) from the mother plane with a normal speed of 550 km/hr (342 MPH). The maximum speed for which the structure was designed was 650 km/hr (405 MPH).

B. Automatic Pilot (Sumitomo)

1. Gyros:

a. Exciting current is 24 volts and 20-30 amps which drops to 12 amps after 4 seconds. The exciting current is on for only 4 seconds.

b. Rotational speed at the end of 4 seconds excitation is 7000-10000 RPM which drops to 3500-5000 RPM after one minute. Useful period 1 to 2 minutes.

c. The armature has 30 turns and the field has 40 turns; the commutators are arranged on the plane surface of the rotor.

2. Servo Motors:

a. Motors are 24 volts normally using 10 watts of power (Maximum about 18 watts).

b. The torque (maximum) is about 0.75 kg/cm.

c. Speed of rotation of the motor is 4200 RPM, which is geared down to 70:1.

d. Ratio of the electrical detector is as follows:

	θ(detector)	P (follow-up)	B (rudder)
Elevator	1°	1.33°	$0.4^\circ = \theta/2.5$
Aileron	1°	1.33°	$0.53^\circ = \theta/1.9$
Rudder	1°	1.33°	$0.4^\circ = \theta/2.5$

Limiting range $\pm 30^\circ$ (variable).

e. The sensitivity of the servo-mechanism was $\pm 1^\circ \sim \pm 2^\circ$.

C. Radio Link (Sumitomo)

1. The transmitter was the Japanese Army model TOBY-4 transmitter modified for this work. The resulting transmitter had the following characteristics:

a. Transmitters modified to have a range of 35-48 megacycles and a range of 45-58 megacycles.

b. There were three bands in each range which would permit the use of six "I-go" missiles at one time.

c. Ten transmitters were modified but have been destroyed.

d. Only one control could be applied at one time.

e. A control box with a stick was used.

2. Receiver:

a. The receiver used amplitude modulation and had the following control frequencies:

(1) Up 3000

(2) Down 2600

(3) Right 2200

(4) Left 1800

b. There were 220 receivers built of which 100 were dropped, and the rest destroyed.

c. Control was achieved by electrically shifting the gyro centering point which caused the servos to move the missile until the gyro centered again.

d. The batteries which operated the receiver consisted of 24 cells linked in series, 12 to a bank, and the two banks connected in parallel.

(1) From 30 minutes to 3 hours after filling the battery, the no load voltage was 27 to 29 volts. With a load of 4 to 6 amps, the voltage was 24 to 26 volts. The useful life of the battery was 5 minutes.

D. Motor and Fuel System:

1. The jet motor was designed by the Mitsubishi engine laboratory at KYOTO and delivered 10 ton-second thrust using hydrogen peroxide and a catalyst.

2. The fuel system was as follows:

a. Compressed air at 150 kg/cm^2 (206 lbs/in^2) stored in a 26.8 (.95 cu ft) liter tank for forcing H_2O_2 and catalyst into the motor.

b. Two needle valves, electrically operated, admitted air from the tank to a reducing valve. Two valves were used to insure operation in case of the failure of one.

c. From the reducing valve, a line ran to the H_2O_2 tank and the catalyst tank.

d. The H_2O_2 tank was made of steel and plated on the inside with tin. The tank was cylindrical in shape with hemispherical ends. The capacity was 83.7 liters (22 gal).

e. The catalyst tank was spherical and of the same construction as the H_2O_2 tank. The capacity of this tank was 5.4 liters (1.4 gal).

f. All lines were of dural.

3. Operation:

a. The air was turned on, pressurizing the system and forcing the H_2O_2 and the catalyst to the motor.

b. A flow of H_2O_2 was started before the flow of catalyst to prevent possible flow of the catalyst back up in the H_2O_2 lines.

c. The H_2O_2 sprayed out through holes around the periphery of the back end of the motor and impinged on a baffle plate mounted in the combustion chamber of the motor. Guide vanes had been used previously but were abandoned in favor of the baffle plate arrangement.

d. The catalyst was sprayed from holes in the center of the ring of H_2O_2 holes. Striking the baffle plate, the two combined.

e. A Laval type nozzle completed the motor.

f. The amount of fuel listed was sufficient to give a thrust of 150 kg (330 lbs) for 80 seconds.

III. General Remarks:

A. Although the system of control is inferior, in general, to American designs, the fact that this missile was designed, built, and tested within four months is remarkable and indicates a close organization between the Army and the contractors.

B. The elimination of rate gyros and the use of electrical damping is of interest.

C. The people concerned were emphatic in their assertions that no information on German guided missiles was ever made available to them.

D. Future work in this field was to have included the installation of radar seekers, etc. One project to have been studied was that of launching missiles from the ground to attack enemy installations. It is interesting to note that both the Germans and the Japanese turned to this type of warfare after the destruction of their airforces. Apparently the Japanese learned nothing from the Germans in this respect since at the close of the war, no work had been started on a V-1 type missile.

E. Originally the "I-go" incorporated a radio altimeter to skim at a fixed height above the ground. This did not work, however, and was removed.

F. Complete wind tunnel tests on full, and one half scale models of "I-go" were run. These tunnel tests including tunnel tests of the missile attached to the mother plane (Ki-48) are being translated and will be included in this report as an appendix when available.