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GENERAL HEADQUARTERS
UNITED STATES ARMY FORCES, PACIFIC
Scientific and Technical Advisory Section

REPORT

ON

SCIENTIFIC INTELLIGENCE SURVEY IN JAPAN

September and October 1945

VOLUME II

Supporting Appendices, 1-A to 2-C

Covering Interviews and Other Material
Relating to
Japanese Army and Navy Research and Development
on Instruments and Equipment

1 November 1945

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Appendix 1-A-a

SUBJECT: Tama Radar Research Institute.

PLACE: Roof of New Grand Hotel, Yokahama.

DATE: 12 September 1945.

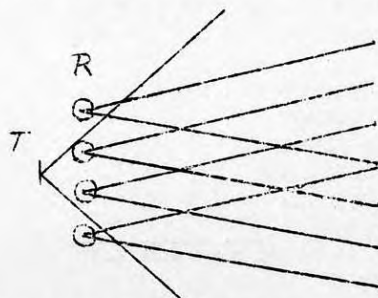
INTERVIEWED: Col HATAO, Chief of Planning & Control Section
Lt Col TAKADA, Charge of Research of Ground Radar of Tama
Radar Research Institute.

INTERVIEWERS: Dr. Compton, Colonel Farrell, Colonel Wolfe, Drs. Moreland,
Griggs; two interpreters.

(Following information secured by Colonel Farrell from Colonel Setaki,
head of a Tama Radar Research section. Lt Gen Suda commanded the Tama
Radar Research Institute. This laboratory was located near the Radar
School in the Commercial College, Kunitachu, approximately 4 km west of
Tachikawa Airport, now 5th AF Hq)

1. Radar Detectors: fixed type; old type.

One transmitter, 4 receivers, frequencies: 68, 72, 76, 80 mc.
Transmitter output 50 kw peak power.



Transmitter beam 90 degrees.

Receiver beams narrower.

Range less than 100 km. Were work-
ing on plan to give height to $\pm$ 500m
by mounting two receivers at differ-
ent heights above ground and utili-
zing the different paths of direct
and ground reflected ray from each.

We stopped this discussion because it was old stuff.

2. High Frequency Radar.

- a. Highest frequency used was 15 cm for ship or airplane detec-
tion.
- b. Characteristics: 500 W - 1 kw peak power.
4-5 V. average power.
3760 recurrence rate.
5 micro second pulse width (was designed
for 1 micro second, but this not achieved)
receiver band width several megacyclos.
- c. Use: Was carried on Army transports.
Range on a periscope was about 2 km if antenna mounted
20 m above water.
- d. Designation: Type 4 antisubmarine Radio Detector.

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e. Production: Army planned to produce 80, some of which were made and installed on 5 ships. All were sunk. Navy independently developed a similar set which was better. After 1 Jan 45 the Army adopted the Navy set, and the Army discontinued production. Hatao and Takada say they had nothing to do with manufacture and know nothing about existence of any sets. They think all produced may have been put on ships and all sunk. The Army laboratory has none. The manufacturers or storage depots or training center may have some. The Dept of Armament of the War Ministry exercised full control.

f. Manufacturers: Nippon Tosen and Tokyo Shibaura Denki.
Nippon Tosen (Wireless) made Navy radar and components.

3. Airborne Radar.

a. ASV type: wavelength 1.5 m
peak power 10 kw
range on ships 50 km
mounted in bombers

We did not question about production and use.

b. AI type: were working on a set which was never put into use, with the following characteristics:

wavelength - 80 cm
peak power - 5 kw
range on plane - 300 m to 4 km

4. Ground-Controlled Interception - GCI.

a. A 184 mc transmitter was used, the set giving distance and azimuth, but not height. The scope was used for "blip matching" to give direction, and range was given by horizontal coordinate of blip.

b. Their own night fighters carried an LFF beacon, responding at 175 mc.

c. This equipment was designed, with aid of voice radio direction, to bring the fighter within 4 km of the target bomber. After this the fighter pilot had to depend on visual observation to make contact.

5. Jap Reconstruction of US B-29 Radar Equipment. The Japs never assembled a working set of the B-29 radar equipment from recovered parts.

6. Tubes and Magnetrons.

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a. Principal producers:

- (1) Sumitomo Tsushin (Tsushin Kogyo plant) at Tomoriko, near the Tama River, about midway between Tokyo and Yokohama. Most of the plant is intact but the part-making magnetrons in Tokyo was destroyed. Part of the plant was dispersed to town of Suwa in Nagano; Kobe (?)
Plant mgr: Dr Yasusiro Miwa (#2 priority; Leet list)
Dept mgr: Dr Masaji Kobayashi (formerly with Western Electric, known by Col Wolfe)
- (2) Nippon Musen (part destroyed; part moved to Nagano)
Tokyo plant mgr: Nakajima
- (3) Kawanishi, in Kobe (destroyed)
- (4) Higachi Mfg Co at Mochi, in Chiba prefecture. (This is a small plant, intact, which makes only ordinary types of tubes.)

b. Dr Griggs showed Hatao and Takada a Jap Navy type magnetron of considerable power, and asked them if they had ever seen it, or knew its characteristics, or what it was used for. They examined it interestedly and replied that it was entirely new to them.

7. Tama Radar Research Institute.

Head: Lt Gen Suda.

Chief Planning and Control Section: Col Hatao

Charge Research on Ground Radar: Lt Col Takada; Also Col Setaki (?)

This was apparently an Army organization. Its laboratory was burned out and its personnel mostly demobilized.

The actual research on radar was done by the manufacturers; Tama Radar Research Inst gave instructions and orders and made tests of equipment.

8. Radar Training Schools (Army).

a. For the new 15 cm radar, an Army training center was established with headquarters in Tokyo, at Abatsuki (?), which was a shipping unit. Training schools at:

- (1) Nishinomiya, at Koyo (or Konje) Middle School, between Osaka and Kobe.
- (2) Yanai, in Yamaguchi Ken prefecture.

b. For other types of radar, the training was done in the Tokyo Commercial School, Koda, now occupied by the Eighth Army. Hatao and

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Tokada think equipment (long-wave ground radar) may still be at this school, probably boxed up.

9. Highest Frequency Communications Set.

This was 40 cm wavelength, amplitude modulation, magnetron oscillator. Hatao and Takada said they had not been in touch with this work. The research was done at the Fifth Army Research Laboratory in Kodaira, Tokyo, of which Lt Gen Takeo Kono was in charge, but whose subordinates would know more about it than he. The Laboratory is intact.

10. C. W. DOPPLER Radar.

The Japs used to have this, but abandoned it in favor of pulse radar.

11. Dr Yagi.

It was stated that Yagi, as head of the Research Board, was given no radar problems by the Army. We could get no indication that Yagi or the Research Board meant anything to these officers. When Yagi was Dean of the Engineering School, the Army gave him some problems to pass on to his staff. It gave none to Yagi for his own handling.

12. Attitude of Cols Hatao and Takada.

These officers appeared to be cooperative and frank. We are inclined to think that they gave us all the information they could, within the limits of time and language.

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Appendix 1-A-b-1

SUBJECT: The Tama Army (Air) Technical Laboratory
INTERVIEWED: Lt Gen Y. TADA, Director of Tama Laboratory
 Col K. SATAKE, Director of Research (?)
INTERVIEWERS: Drs GRIGGS, MOWLAND, LONGACRE, and Major
 HUTCHETT
DATE: 10 October 1945

General

The Tama Laboratory was organized in June 1943 and charged with all research and development of radar for the Army Air Force. Since the Air Force was responsible for air defense and antiaircraft for the Army, the Tama Laboratory was the sole Army research laboratory for radar. The Tama Laboratory was 4 km east of Iachikawa, but was almost completely burned out by the B-29 raids. It was in the process of being dispersed to Nagano Prefecture when the war ended.

Total personnel in the Tama Laboratory was 1070, composed as follows:

Technical Officers - 70
Noncommissioned Officers - 20
Civilian employees of War Ministry - 100
Civilians employed by Tama Laboratory - 880

The budget of the laboratory was as follows:

June 1943 through March 1944 - ¥10,000,000.
April 1944 " March 1945 - ¥15,000,000.
April 1945 " September 1945 - ¥8,000,000.

The Tama Laboratory did not have the specialized personnel required to do research on the radar sets. Their general modus operandi was to contract for basic research with individual college professors and with industrial research laboratories. Tama would then draw up military characteristics for a specific radar set and let a contract for a test quantity with the appropriate manufacturer. The remaining research, development, and engineering was then done by the manufacturer with little help from Tama (cf. Mr. NAKAJIMA's comments in Nippon Hosen interview). Acceptance tests and simulated operational tests were conducted by Tama. Quantities of from 1 to 10 sets of the larger and 50 to 100 of the smaller equipments would be ordered on a model shop basis for trial purposes. When applicable, this equipment would be used in combat trials on Honshu as in the case of radar vs. the B-29.

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The principal research and model shops serving the Tama Laboratory were as follows:

<u>Name</u>	<u>Director</u>	<u>Place</u>
Tokyo Shibaura Denki Co.	Mr. Hamada	Kawasaki
Sumitomo Tsushin Co.	Dr. Niwa	Ikuta
Nippon Musen Co.	Mr. Nakajima	Mitaka (Tokyo)
Kawanishi Co.	Dr. Kusunose	
	(now dead)	Kobe
Mitsubishi Denki Co.	Mr. Hori	Kobe

Relations with the Navy might be classed as a state of "armed neutrality" during the first years of the war. There was never any determined effort to standardize equipment or procurement. Joint procurement and development of the copy of the German Wurtzburg antiaircraft radar by the Army and Navy, initiated about January 1944, seems to have been the first step in cooperation. Since this was a German design, neither service was afraid of disclosing military secrets to the other. Later, in January 1945, when the Army 20-cm set for detection of submarines from Army transports proved definitely inferior to the Navy 10-cm set for the same purpose, the Army initiated procurement through the Navy.

Cooperation with the Germans in radar was non-existent during the early years of the war. Then Col Satake visited Germany, returning by submarine in September 1943. He had been shown all the German radar in large-scale operation, but none of the newer research and development. It was at this time that the decision was made to duplicate the German Wurtzburg, and Mr. Heinrich Foders, a systems engineer from Telefunken came back on the same submarine with Col Satake to aid Nippon Musen in the construction of this equipment. Foders was officially assigned to and paid by the Jap Navy, but he worked freely with the Army and with Nippon Musen on the Wurtzburg. He was not shown Jap research or equipment aside from this.

New Developments at Tama

Research at the Tama Laboratory is divided into seven sections:

1. Detectors - early warning equipment.
2. Locators - GCI, fire control and airborne radar.
3. Short wave navigational aids.
4. IFF
5. Long wave length aids to navigation.
6. Warning and search receivers.
7. Radio countermeasures.

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A complete list of the current projects of the Tama Laboratory is given in Table A.

The more interesting new developments will be described in somewhat greater detail here:

Radar

1. Early Warning and GCI: The Tachi 13, 35, and 36 were combined into a GCI system. The Tachi 35 is an 82-mc radar set with a single transmitter and receiver which has a reported search range of 300 km on B-29's, an angular accuracy of $\pm 1^\circ$, measures altitude to ± 500 M, and range to ± 1 km. The Tachi 13 is a ground interrogator responder for location of an IFF (Taki 15) equipped fighter. The Tachi 13 transmits on 184 mc and receives on 175 mc. Data from both the Tachi 35 and the Tachi 13 are fed into the Tachi 36 which is a computer. The controller gets predicted collision courses from this. The combination is reported to have the capability of positioning a fighter to within 3 km of his quarry.

2. Submarine Search Set - Tase 6: This is a 10-cm search set for installation on Army transports. It was built by Nippon Musen from Navy components with minor modifications to achieve greater range on a periscope. It has a separate transmitting and receiving antenna (each in a 1.5 M parabolic reflector), uses an M-314 magnetron oscillator which is said to have an output of 20-30 kw at 200 cps and 1.5 microsecond pulse length. Performance quoted is a range of 4.5 km on a 1.5 M periscope with an antenna height of 14 M.

3. Wurtzburg "D": This set is a faithful copy of the German, incorporating some of the anti-jamming techniques used by the Hun. This was to be the Japs main reliance for anti-aircraft against the B-29. Due to engineering difficulties, however, only three equipments were made before the end of the war and none of these was fully operational.

4. Nightfighter Radar - Taki 2: An 80-cm, 3-kw peak power radar set with multiple Yagi antennae something like the German AI. Maximum range, 3 km; minimum range 200 M. No provision for blind firing. Six or seven sets installed in aircraft for training. Regarded as not good enough for successful operations against B-29's. Made by Sumitomo.

5. Airborne Navigation Radar - Taki 14: A 27-cm, 2-kw radar set patterned after H₂X. This was a crude ASV set with a rotating parabolic reflector and PPI presentation. It is like the Navy search set, but not so advanced. A small crash program was under way to fit the large four-engined bomber that was designed to bomb the U.S. from Japanese bases. Made by Nippon Musen.

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6. Loran - Tachi 39: This was a 1.5 mc copy of our Loran. Only two ground installations were planned, to provide line of position. Did not get into operational use before the close of the war.

Radio Countermeasures.

1. The following items of army search receiver equipment were either in production or under development:

- a. Taki 4 - frequency range 7 to 1.5 m.
- b. Taki 5 - frequency range 4 to 1.5 m.
- c. Taki 6 - frequency range 7 to 1.5 m.
- d. Tachi 30 - frequency range 40 to 3 cm.

2. The jamming by the B-29's was effective against the Japanese radio locators but not particularly against the radio detectors (early warning). As a counter to our jamming, some consideration had been given to frequency changing, but primary reliance had been placed on the early use of the German Wurtzburg. When asked if they did not think that the Wurtzburg was susceptible to jamming, Col SATAKE stated that by adjusting the plan of the set's antenna, the effect of jamming could be greatly reduced. He had never heard of circular polarization and did not believe such a polarization existed.

3. Radar jamming work was carried on at the 9th Military Technical Laboratory, but as Col SATAKE was also associated with the 9th Laboratory in connection with this work, he was able to furnish a certain amount of information. There were two standard army radar jamming sets; the Taki 8, covering the frequency range 1.5 to .75 m. The 9th Military Technical Laboratory was also working on a jammer for use against our 3 cm radar. They had expected to have a model ready by August with a power output of about 100 wt, and another ready by September with an output of about 1 kw. This lighter set was to have several magnetrons in parallel, operating on slightly different frequencies to provide band spread. Two methods were under consideration for producing small frequency changes; changes to the tuning circuit and changes to the electric and magnetic fields.

Guided Missiles.

The laboratory had given some consideration to the development of guided rockets, but the ideas described appeared to be poorly thought out and extremely difficult to achieve from a practical standpoint. There were two groups of rockets under consideration, one with ranges from 15 to 20 thousand

meters for use against ships. It was planned that all energy necessary for control purposes would be obtained from the radio frequency voltage picked up by the antenna on the back of the rocket.

Proximity Fuses

Some thought had also been given to proximity fuses but apparently no work was done. The two types under consideration were an acoustical type and a type that was tracked with radar and remotely detonated when near the target.

Knowledge of American Equipment.

The Tama Laboratory was the official Army agency for the collection and evaluation of captured electronics equipment. Every aircraft that crashed on the Japanese home islands was supposed to be guarded until a technical intelligence team had inspected it and removed items for study. There was no coordination with the Navy, who had a similar service. It was reported that first come, first served.

Neither the Army nor the Navy had been able to reconstruct a salvaged H2X set to the point where it would operate. They knew the operating conditions well from the meters, circuits, and documents they found, but were in the dark about performance figures, such as power output, etc. They knew the overall performance from the radar scope photos supplied for briefing purposes.

The Japs knew the characteristics of our IFF, but had never been able to assemble a complete equipment. They knew little about the RCM equipment except the wave length. They had pretty complete knowledge about Loran and altimeters.

Tama had received no captured equipment or technical intelligence on American Radar from the Island campaigns after the first haul from Singapore and the Philippines. They knew nothing about our microwave nightfighter, gun laying, or control equipment. They did not know of the existence of proximity fuses.

Effectiveness of American Jamming.

Jamming by the B-29's was reported as being very effective against the radio locators and gun-laying equipments, but no hindrance to early warning. They planned to combat

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this by rapid frequency change in their locators and by the large-scale use of the Wurtzburg. They were under the impression that the Germans were successful with the Wurtzburgs in reading through our jamming. Their information seemed old.

Plans for the Invasion.

Although the Tama people were confident of their intelligence which led them to expect an invasion in southern Kyushu about November 1, they were not undertaking any crash programs to provide equipment for defense against this operation. They were conducting their research and development programs in general as if the war were going to last another ten years.

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Table A

PRESENT CONDITION OF RADARS AND OTHER RADIO EQUIPMENT
(As of August 15, 1945)

Tama Army Technical Research Laboratory

NAME: Search Radars

PURPOSE: Aircraft Detection

TYPE: U.s.w. Search Radars (for ground use)

Classification	Nomen- clature	Characteristics and Per- formance	Weight	Present State of Research
Ko, transmitters & receivers. 3,10,100, & 400 watts	-	Line (sen) guarding by means of the doppler-effect system	100 kg to 2 tons	Research completed
Otsu (Station or base use)	Tachi No. 6	68, 72, 76, & 80 mc/sec; 50 kw; Max. range (planes) 300 km. Distance measurements: ± 7 km Angle measurements: $\pm 5^\circ$	10 tons	Research completed
Otsu (Field use)	Tachi No. 7	100 mc/sec; 50 kw Search distance (planes) 300 km; Distance measurements: $\pm (?)$ km Angle measurements: $\pm 5^\circ$	18 tons (incl. 4 trucks)	Research completed (stopped after rush manufacture of several sets)
Otsu (Mobile use)	Tachi No. 18	94, 98, 102, & 106 mc/sec; 50 kw. Search distance (planes): 300 km. Distance measurements: ± 5 km Angle measurements: $\pm 5^\circ$	4 tons	Research completed
Altitude Measurements	Tachi No. 35	82 mc/sec; 50 kw; Max. range (planes): 100 km; Distance measurements: ± 1 km; Angle measurements: $\pm 1^\circ$; Altitude measurements: ± 500 m.	4 tons	Research completed (Several sets installed)
Auxiliary Receiver for altitude measurements	Tachi No. 20	68, 72, 76, 80 mc/sec; Maximum range (planes): 100 km; Distance measurements: ± 1 km; Angle measurements: $\pm 1^\circ$; Altitude measurements: ± 500 m.	2 tons	Research completed (Stopped after rush manufacture of several sets)

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TYPE: U.s.w. Search Radars (for use on ships)

Classification	Nomenclature	Characteristics and Performance	Weight	Present State of Research
Otsu (for use on ships) (seacraft)	Tase No. 1	100 mc/sec; 50 kw; Search distance (planes): 300 km; Distance Meas.: ± 1 km Angle Meas.: $\pm 7^\circ$	4 tons	Research ended (Equipment of ships with this abandoned; partial transfer to land use)
Yu (?) use	Tase No. 10	150 mc/sec; 10 kw; Search distance (planes) 50 km; Distance meas.: ± 3 km Non-directive	100 (with-out antenna)	Research ended (Stopped after rush manufacture of several sets)

PURPOSE: Search Detection

Submarine Detection	Tase No. 2	15 cm; 1 kw Large craft: 100 km; Submarines: 20 km; Distance meas.: ± 2 km Angle meas.: $\pm 5^\circ$	2 tons	Research ended (Part now being studied for transfer to use on land)
Seacraft Detection (Submarine Detection)	Taki No. 1	200 mc/sec; 10 kw Large craft: 100 km; Submarines: 20 km Distance meas.: ± 2 km Angle Meas.: $\pm 5^\circ$	150 Kg	Research ended

NAME: Radar Locators (for fire control)

PURPOSE: Determination of Factors for Firing on Aircraft

TYPE: Stationary, ground use

Type 1	Tachi No. 1	200 mc/sec; 10 kw; Max. range (planes): 20 km; Distance meas.: 100 Angle meas.: 11° Elevation meas.: ± 2 to 3°	25 tons	Research ended. Stopped after rush production of about 30 sets. Mostly disposed of as discarded equipment.
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Classification	Nomenclature	Characteristics and Performance	Weight	Present State of Research
Type 2	Tachi No. 2	200 mc/sec; 10 kw; Max. range (planes): 20 km; Distance meas.: 100 m Angle Meas.: $\pm 1^\circ$ Elevation meas.: $\pm 1^\circ$	25 tons	Research ended. Stopped after rush production of about 30 sets. Over half discarded. Some in use.
Type 3	Tachi No. 3	78 mc/sec; 50 kw; Max. range (planes): 40 km; Distance Meas.: 100 m Angle Meas.: $\pm 1^\circ$ Elevation Meas.: $\pm 1^\circ$	4 tons	Research ended. Stopped after rush production. Measures now under way against interference.
Type 4	Tachi No. 4	200 mc/sec; 10 kw; Max range (planes): 40 km; Distance meas.: ± 100 m Angle meas.: $\pm 1^\circ$ Elevation meas.: $\pm 1^\circ$	25 tons	Research ended. Stopped after rush production. Changed to Tachi No. 3 because of inconvenience of handling.
Revised Type 4	Tachi No. 31	200 mc/sec; 10 kw; Max. range (planes): 40 km Distance meas.: ± 7 m Angle meas.: $\pm 1^\circ$ Elevation meas.: $\pm 1^\circ$	25 tons	Research ended. Now in rush production.
"Wurtzburg" Type	Tachi No. 24	50 cm; 10 kw; Max. range (planes): 40 km Distance meas.: ± 27 m Angle meas.: $\pm 1/8^\circ$ Elevation meas.: $\pm 1/8^\circ$	15 tons	Test set completed. Stability of parts being improved

TYPE: For Aircraft

Aircraft Locator (also for use against sea-craft)	Taki No. 2	80 cm; 3 kw; Max. range (planes) 3 (?) km to 200 m; Max. range for sea-craft: 8 km Distance meas.: ± 200 m Angle meas.: ± 7 deg.	120 Kg	Test set completed. Studies under way to improve performance of indicating system.
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NAME: Guide Radars

PURPOSE: Determination of Factors of Aircraft in Flight

TYPE: For Direction of Fighter Planes

Classification	Nomen- clature	Characteristics and Per- formance	Weight	Present State of Research
For single aircraft - Ground	Tachi No. 13	Transmitter 184 mc/sec; 10 kw; Receiver 175 mc/ sec; Max. range (planes) 150 km; Distance meas.: ±500 m Angle meas.: ±1°	15 tons	Research com- pleted
For single aircraft - Aircraft	Taki No. 15	Receiver 184 mc/sec; Transmitter 175 mc/sec; 100 w. Non-directive	25 tons	Research com- pleted
For several aircraft - Ground	Tachi No. 28	790 mc/sec; Max. range for planes; 300 km Distance meas.: ±1 km Angle meas.: ±0.3°	500 tons	Experimental set being in- stalled for immediate ser- vice.
For several aircraft - Aircraft	Taki No. 30	190 mc/sec; 20 w. Non-directive	25 kg	(Same as above)
Director for Interceptor Planes	Tachi No. 36	Computer: direction, ±1°; time, 30 sec. Transmitter of deter- mined factors: direc- tion ±10° Indicator	40 kg 20 kg 500 kg	Experimental set now under construction.

NAME: IFF

PURPOSE: For Indicating Friend or Foe

Ground	Tachi No. 17	Transmitter: 184 mc/sec; 10 kw, Receiver: 175 mc/ sec; Max. range for planes; 300 km Distance Meas.: ±3 km Angle meas.: ±2°	1.5 tons	Research ended. Partially in- stalled but not used.
Aircraft	Taki No. 15	Transmitter 175 mc/sec; 100 w. Receiver 184 mc/sec; Non-directive	25 kg	(Same as above)

NAME: Aids to Navigation

PURPOSE: Navigation

Hyperbolic Device for Navigation - Ground	Tachi No. 39	1.5 mc/sec; 150 kw; Max. range: daytime 900 km night 3000 km Precision: 1% of distance	600 tons	Experimental set was previ- ously being in- stalled for di-
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1-A-b-11

Classification	Nomen- clature	Characteristics and Per- formance	Weight	Present State of Research (contd)
				rect service, but was des- troyed by air raid. Prepar- ations have been started again.
Hyperbolic Device for Navigation - Aircraft	Taki No. 39	1.5 mc/sec; Non-directive	50 Kg	(Same as above)

PURPOSE: Determining Topography

Radar for night vision	Taki No. 14	27 cm; 2 kw; Radius of vision 20 km (H = 5000 m) Resolving power: (angle) +3°; Distance: +2 km	120 Kg	Research under way (Push pro- duction was also being pre- pared, but bombing has necessitated study of pro- duction trans- fer.
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PURPOSE: For Measuring Altitude Above Ground

Radio Altimet- er - For high altitudes	Taki No. 11	80 cm; 100 w. 12,000 to 200 m. Error: 110%	25 Kg	Research com- pleted (Pro- duction stop- ped owing to bombing of va- cuum-tube man- ufacturer)
Radio Altimet- er - For low altitudes	Taki No. 13	80 cm; 15 w.; Frequency modulation system 150 to 20 m. Error: +5%	25 Kg	Research com- pleted. Per- formance being improved.

NAME: Intercept Sets

PURPOSE: For Determining Data on Radio Waves.

For aircraft - K6	Taki No. 4	7 to 1.5 m Gain: 120 db; Automatic Recorder system	250 Kg	Research ended (a few sets ex- perimentally made but sta- bility poor). Performance be- ing improved. (Bombing has stopped produc- tion.)
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Classification	Nomen- clature	Characteristics and Per- formance	Weight	Present State of Research
For aircraft - Otsu	Taki No. 5	4 to 15 m; Gain: 100 db; Equal sensitivity (lobe switching) system	45 Kg	(Same as above)
For aircraft - Hei	Taki No. 6	7 to 1.5 m; Gain: 100 db; Automatic frequency changing system	35 Kg	(Same as above)
For ground	Tachi No. 30	40 to 3 cm; Crystal de- tection; Antenna change- over system. Gain 40 db.	120 Kg	(Same as above)

NAME: Jamming Devices

PURPOSE: For Jamming Radio Waves

For aircraft	Taki No. 8	7 to 1.5 m; Continuous 100 w; Impulse: 5 kw. Automatic & manual syn- chronization system.	120 Kg	(Same as above)
For aircraft	Taki No. 23	15 to 0.75 m; Continu- ous 5 w; Impulse: none. Forceful jamming.	50 Kg	(Same as above)

NAME: Special Equipment

PURPOSE: For Guiding Special Flying Objects

Against air- craft - Ground	Tachi No. 200	Partial improvement on revised type 4 radar locator. Equal intens- ity detection (lobe switching), semi-auto- matic control intended. Directional precision: ±5°	Un- known	Research under way. (Pro- gressed only as far as ob- taining an i- dea of the system)
Against air- craft - Aircraft	Tachi No. 200	Quadrant reception Semi-automatic control or steering meter (?) intended.	Un- known	Research under way. (Gotten only as far as obtaining an idea of the system)

PURPOSE: For Adherence

Against sea- craft - For seacraft	Tase No. 100	Equal sensitivity detec- tion (lobe switching) & automatic control applied to Taki No. 5. Expected performance 3 km.	Un- known	(Same as above)
Against sea- craft - For aircraft	Taki No. 37	Doppeler detection sys- tem; 300 mc/sec; Expec- ted performance 5 km.	Un- known	(Same as above)

SUBJECT: Japanese Paper Balloons.

DATE: 19 September 1945

INTERVIEWED: Lt Col TERATO KUNITAKE, CWS (Balloons responsibility and member Japanese General Staff); and Major INOUE (Balloons responsibility).

INTERVIEWERS: Lt Col M Sanders, CWS; Maj H Skipper, CWS; Tec 4 Yagi (interpreter)

I. SUMMARY

1. The Japanese balloon was primarily a weapon of retaliation.
2. No effective military results were anticipated by the use of this method, but an attempt was made to bolster domestic morale which received a serious blow as a result of the Doolittle raid, 18 April 1942.
3. The original intention was to release the balloons from submarines and battleships. The destruction of Japanese shipping voided this plan and stimulated development of a vehicle which could travel directly from Japan to the U.S.
4. All the balloons which were produced, approximately 9,000 were released from Japan.
5. The average cost per balloon was approximately 10,000 yen.
6. The balloon loads varying from 12 kilograms to 30 kilograms, consisted of 2/3 incendiary and 1/3 high explosives.
7. The Japanese had no intention of varying the contents of the payload.
8. In the event of continued war between the U.S. and Japan it was the enemy's intention to discontinue the balloon weapon.
9. The last balloons were released from Japan in April, 1945; and in March of that year the largest number, 3,000, was sent toward the U.S.

II GENERAL

1. The organization responsible for the production of paper balloons and their utilization as a weapon was not a separate one, but was used in conjunction with existing Army organizations. There was particularly close liaison with the Ninth Chemical Laboratory. When the question was raised why this laboratory was selected it was stated that the Ninth Chemical Laboratory was concerned with general, difficult, scientific problems. Positive statements were also made that the intended load of the balloons had been incendiaries and high explosives; that it had never been the Japanese intention to alter these loads with CW or other weapons.

III. HISTORICAL

1. The balloons were originally used by the Japanese for weather forecasting. With this purpose in mind, research was carried on as early as 1935 with paper balloons having a diameter of 4 meters and capable of reaching an altitude of 6 kilometers. This objective having been attained, no further studies were carried on after 1935.

2. Then, on 18 April 1942, Japan was first bombed (Doolittle's raid) the effect on Japanese morale was such that all-out attempts were made to invoke retaliatory measures. The Japanese General Staff considered retaliation by three methods:

- a. Balloons
- b. Planes
- c. Submarines

The present report is concerned only with balloons. With the incentive of the desire to damage the American homeland, intensive investigation of paper balloons as a weapon proceeded at an accelerated pace. At this time (1942), the Japanese intended to develop balloons capable of traveling a distance of 3,000 kilometers and which would be released from battleships or from submarines off the coast of the U.S. To attain this objective, the balloon diameters were increased from 4 meters to 6 meters, and then to 8 meters. In 1943 the diameter was further increased to 10 meters. By the summer of 1943 it was thought that the balloon was available which could travel 3,000 kilometers. However, having reached this goal it was found that the Navy had been depleted to the point where ships would not be available for carrying out the original plan of attack.

3. In view of the general situation, investigation was begun to construct a balloon capable of traversing the distance between Japan and the U.S. By 11 February 1944, 200 balloons, 10 meters in diameter, were available for testing. On this date the 200 balloons were released, only a few of them carrying a load of incendiaries. The majority was simply considered test balloons and carried sand only. Since there were no facilities for observing results, American broadcasts were closely followed.

NOTE: It is of interest to learn that the Japanese did not have meteorological data for the vast distances between Japan and the U.S. Accurate information was limited to the vicinity of the Japanese homeland and the western coast of the U.S. On the basis of information received from their communications authorities, it was felt that some damage had been done. When the question was raised in regard to this point, the statement was blandly made that reports were received of fires and explosions occurring in unexpected areas.

4. On the basis of these results(?) the Japanese began large-scale production of paper balloons in April, 1944. At first the cost of each balloon is estimated as having been approximately 10,000 yen. This price was somewhat reduced as the number increased. The desired objective in production was 20,000 balloons but only a few more than 9,000 were ever finished. All the balloons constructed were released.

5. Although the first specimens of the mass production were available in July and August, none was released until 20 November 1944. From that date, as many balloons as possible were sent in the direction of the U.S.--the number depending on production and existing meteorological conditions. The last group of balloons was released 20 April 1945. Although climactic conditions were not most favorable during the month of March, 3,000 balloons, the largest number ever sent in one month, were released in March, 1945. On 13 March, two balloons were returned after a twenty-four hour trip to Japanese shores by freak winds. These balloons were the only ones to turn back and the loads did no damage since they fell in snowbanks.

6. Due to meteorological conditions, the most favorable conditions for the balloons were found to occur during the period between the latter part of December to the middle of February. Rain and fog were also disturbing elements since the upper surface of the balloons when wet, froze on reaching higher altitudes.

7. There are a few additional facts of general interest in relation to the balloons.

a. They were handmade and were farmed out to small factories to be constructed in toto.

b. The load which was invariably placed in the balloon was 2/3 incendiary and 1/3 high explosive.

c. Nor, as was previously stated, did the Japanese ever intend varying the load. The maximum payload capacity estimated for each balloon by the Japanese was 30 kilograms; the average load was 24 kilograms; and the lightest was 12 kilograms. So far as could be determined it did not occur to the Japanese to use even part of the sand ballast as payload.

d. Since the objective for this weapon was retaliation, the Japanese did not expect it to be very effective and they stated that they would have been entirely satisfied if one-third of these balloons leaving the home island reached the U.S.

e. The balloons were released from the Kanto district (Aomori, Iwanunsa, Nakoso, Otsu, Mohara, Ichinomiya).

f. It is apparent that the ascent of the balloons was accompanied by much propaganda effort to uplift homefront morale and to stimulate general production efforts. However, the Japanese officers interviewed stated that if the war had continued, the materials used for the balloon production were to be given to other industries.

g. All records and plans in connection with this weapon were burned by order of the Japanese General Staff.

RESTRICTED

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h. When questioned as to why they were burned it was stated that the reasons had been explained to General MacArthur.

NOTE: Notification was received today that the Chief of the Balloon (Bomb) Section has returned to Tokyo. The statement was also made that if any documents were required it would be necessary to give the responsible officers a three-day period of grace in order that a complete translation might be made. Translation of all documents are to be translated and produced within a given period. Lt General Kusaba will be available for a conference, 3 October 1945.

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Appendix 1-c

ARMY 90-MM ROCKET

SUBJECT: Information furnished by Masao Sugimoto of 2d Naval Technical Institute.

DATE: 24 September 1945.

INTERVIEWED: Masao SUGIMOTO

INTERVIEWER: Dr. H. K. Stephenson, Dr. D. T. Griggs, Lt. Yamada.

1. In describing wind tunnel studies at the Naval Technical Institute, Mr. Sugimoto gave the following information on a 90-mm Army rocket, models of which had been tested in the high speed wind tunnel:

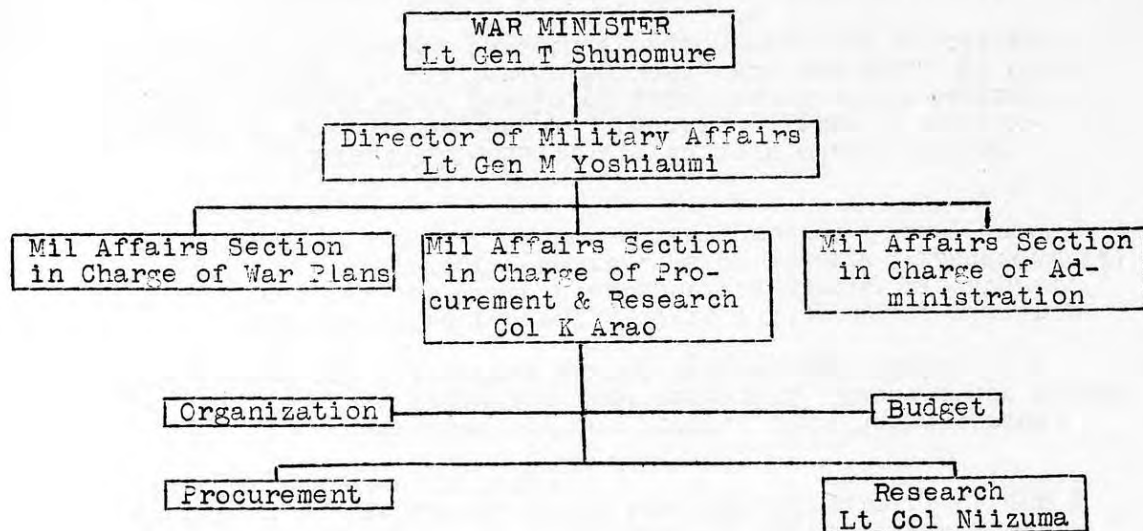
A model of this rocket was made by the "Army Experimental Technical Laboratory" in Tokyo. Experimental models for the Navy tests were copied from the Army type. It was a spinner-type rocket, with 20° jet angle, about 3 sec. burning time and speed of about 100 m/sec. Range was about 2000 meters. The propellant used in this rocket was made at the Naval Arsenal, Hyratsuka, Kanagawa-Ken.

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APP - 1 C.

SUBJECT: Research Program of Japanese Army
 INTERVIEWED: Lt Col NIIZUMA, Director of Research Bureau,
 Japanese War Ministry
 INTERVIEWERS: Dr H K STEPHENSON, Dr E L MORELAND, Dr D T
 GRIGGS, Maj W R HEWLETT
 DATE: 1 October 1945

Lt Colonel Niizuma explained his attachment to the War Ministry by means of the diagram below. His Research Bureau is responsible for the principal Army research laboratories.



The laboratories under the direction of the Research Bureau are as follows:

a. Under Military Service Board for Ground		
<u>Director</u>	<u>Location</u>	<u>Field of Activity</u>
1. Maj Gen K Kuwata	Kokubunji	Guns, Ord Material
2. Lt Gen M Amaaki	Kaganei	Meas. Apparatus
3. Lt Gen S Tachibana	Kokubunji	Matls for Engr Troops
4. Maj Gen H. Kashima	Sogami	Tanks & Motor Cars
5. Lt Gen T Kawano	Kokubunji	Communications
6. Maj Gen Fakiyama	Ookubo	Chem Warfare
7. Maj Gen M Nomura	Ookubo	(Basic Research) (Phys & Chem)
8. Maj Gen T Nagao	Kokubunji	Material
9. Lt Gen R Shimoda	Noborito	(Matl for Mil Police) (Partisan Weapons)
10. Maj Gen O Tanaka	Himegi	Small Ships

In addition there is the Military Ordnance Administrative Board: Director, Maj Gen Y NOMURA, at Fujimimura, Nagano-Ken, for research on heat rays.

b. Under Military Service Board for Air

1. Maj Gen T Ogata	Tachikawa	Body of Plane
2. Maj Gen N Shinano	"	Engines
3. Maj Gen H Masaki	"	Bombs
4. Maj Gen T Yamazaki	"	Communications
5. Maj Gen N Sakato	"	Bombsights
6. Maj Gen T Nii	"	Materials (Metals, etc)
7. Maj Gen S Kawashima	"	Food for Navigator
8. Maj Gen S Kawano	"	Hygiene & Medicine

In addition to the above laboratories, there is the Tama Laboratory at Tachikawa, under the directorship of Lt Gen V Tada, for research on radar.

c. Under Fuel Service Board. This Board directs the laboratory at Chofu for fuel research. Among other things this laboratory has worked on the H_2O_2 rocket fuel.

d. Attached (Addendum I) is a listing of all Army Ground Force and Air Force Laboratories, giving directors, locations and fields of research. Also attached (Addendum II) is a listing of projects for the ten numbered Ground Force laboratories.

A 90 mm antitank rocket was developed. It was launched from a bazooka-type gun, and contained a hollow-charge. The Japanese developed this weapon after seeing both the American and German bazooka-type weapons. Lt Colonel Niizuma believes that this weapon was used on Okinawa.

A 20 cm spinner rocket with a maximum range of 2,000 meters was developed by the Army. This was similar to the Navy 20 cm rocket and used the same type launcher tube. The propellant of the Army rocket is in sticks about $3/4$ " diameter. This rocket was made at the Osaka Arsenal (Army) and the propellant was produced at the 2nd Army Arsenal, Tokyo. The Army 20 cm rocket went to the field before Okinawa, but was probably not used in the Philippines. An experimental 20 cm rocket with 3 times the normal quantity of propellant had been developed. Its maximum range was 7,000 meters.

A 40 cm spinner rocket launched from a rail-type launcher and with a maximum range of 2,000 meters was developed but had not been used in the field.

There had been some research on airborne rockets. One type was 5 cm in diameter, designed for a rapid fire weapon. Its initial velocity was 250 m/sec.

b. "Death Ray". Lt Col Niizuma said that he had been in charge of work on the "death ray" apparatus in 1939, when the work was started. Since the war, Maj General Hideki Kusaba has been in charge of it. Much research was done on this apparatus, but most of the men working on it had been transferred to radar by the end of the war. The work was done at the Army laboratory at Noborito. A number of different wave lengths were tried. One type had a 4-meter wave length, with 50 kw continuous power using a Sumitomo 530-B tube. This could stop a gasoline engine at "close range". It could kill a rabbit in $\frac{1}{2}$ to 1 minute at 3 meters distance. A monkey the size of a medium dog was killed in about 3 min.

c. Infrared. Infrared research was carried on at Ground Lab. No. 7 (Phys & Chem) and was mostly on "noctovision" (image tube) devices. Some studies of heat homing devices were made at Ground Lab No. 2 (Meas. Apparatus) but nothing successful was developed.

d. Baka Bombs. Work on the motors for "baka" bombs was done at Air Lab No. 2 (Engines). The bakas used regular rocket propellant. Some work was also done at Ground Lab No. 7 (Phys and Chem).

e. Proximity Fuses. Lt Col Niizuma did not know of any extensive work by the Army on proximity fuses. An acoustic type had been proposed for antiaircraft missiles, and some work had been done on this at the Air Radar Lab (see par. 2(b)). This work had not been finished. Niizuma believed that the Japanese Navy had done some work on a ground proximity fuse for aerial bombs.

f. Radar. The following is a partial list of the principal Army radar sets mentioned by Lt Col Niizuma:

<u>TYPE OF SET</u>	<u>FREQUENCY</u>	<u>MANUFACTURER</u>	<u>NOTES</u>
Detector	4 m	Sumitomo Elect	
Detector	3 m	Iwasaki	
Locator Mk I	-	Sumitomo Elect	Range B29 18KM
" Mk II		Tokio Shibauro	" " 30KM
" Mk III		Sumitomo Elect	" " 60KM
" Mk IV		Tokio Shibauro	" " 25KM
" Mk IV Mod		" "	" " 50KM
Wurtzburg	50 cm	Nippon Musen	-
Ship Detector	15 cm	" "	-
" "	20 cm	Tokio Shibauro	-

Dector I	2 m	Nippon Musen	(Navy Type)
Locator II	80 cm	Sumitomo Elect	" "
Search Receiver (Modl-8)	1.5 to 4 m	Nippon Musen	-

IFF Equipment. Originally the Army was assigned the responsibility for the development and procurement of all IFF equipment for the Army and Navy. The Army developed an IFF that transmitted on a frequency of 184 mc and received on a frequency of 175 mc. However, the production of this item was so slow that the Navy developed a simplified stop-gap set operating on 150 mc $\pm$ 10 mc. This Navy IFF operated directly with the 2 m radar warning sets and as transmitted on the received radar frequency, a friendly plane appeared as an extra large echo which was periodically coded. To insure mutual identification between the Army and Navy, each shore installation maintained both Army and Navy type IFF.

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PRINCIPAL ARMY GROUND FORCE LABORATORIES

NAMES OF LABORATORIES	CHIEF'S NAME	LOCATION	CONDUCTED WORKS
The First Military Technical Laboratory	Maj. General Kashihiro Kuwata	Koganei-Machi, Kitatama-Gun, Tokyo-To	Investigation, study, planning, design and test of swords and bayonets, rifles, guns, ammunitions and harness for drawing horses and pack horses, and composing the list showing trajectory. 40 millimetre anti-aircraft machine gun. 10 centimetre gun for tank. 15 centimetre self-propelling gun. 10 centimetre non-reactionary gun. 7.5 centimetre anti-tank gun. 10 centimetre anti-tank gun. 7.5 centimetre heavy anti-aircraft gun. 20 centimetre short self-propelling gun.
The Second Military Technical Laboratory	Lt. General Megumi, Amaaki	Kodaira-Machi, Kitatama-Gun, Tokyo-To	Investigation researches, planning, design and test of arms for observation, intelligence, survey, connection and command, and of balloons, observation apparatus, aiming glasses for guns, meters, calculators and water surveying apparatuses.
Yocho-Machi Branch of the Military Ordnance Administrative Board	Maj. General Yasuo Nomura	Fujimimura, Suwa-Gun, Nagano-Ken.	Investigation, researches, planning, design and test of the following arms, that take advantage of heat ray and radiant ray, ship-detecotr, night-radar, auto charge boat, auto-glider.
The Third Military Technical Laboratory.	Lt. General Shorichi-Tachibana	Koganei-Machi, Kitatama-Gun, Tokyo-To	Investigation, researches, planning, design and test of various equipments, explosive powder and firing

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accessories, large type search light, gearing for searchlight, equipments for the near fighting on the seashore, equipments for near-attack, super-heavy raft of pontoon for bridging, railway-tractor, river-crossing equipments for railway.

The Fourth Military
Technical Laboratory.

Maj. General

Hideo-Kashima

Sagamihara-Machi,
Kozagun, Kanagawa
Ken

Investigation, researches, planning, design and test of tank, motor-car, tractor, armed car and other cars, and auto-cars, and fuel, oils.
New-type medium tank(A,B), carriage of 10 centimetre self-propelling gun, medium tractor, carriage of 7.5 centimetre anti-tank gun and 10 centimetre anti-tank gun, steam tractor, amphibious-track, civil motor-car, substitute fuel motor-car, small type four manoeuvrable wheeled motor-car.

The Fifth Military
Technical Laboratory

Lt. General
Takeo Kawano

Kodaira-Machi,
Kitatama-Gun,
Tokyo-To

Investigation, researches, planning, design and test of Signal Ordnance, movable signal and telephone, composing of waves of movable wireless apparatuses, air transport of fixed wireless apparatuses, wireless equipments, air-defence signal equipments, informer of aviation intelligence, heavy signal apparatus of super short wave, simple signal equipment.

The Sixth Military
Technical Laboratory.

Maj. General

Kanemasa Akiyama

Hyakunin-
Machi, Ita-
bashi-Ku,
Tokyo-To

Investigation and researches of chemical arms, Medical and Veterinary investigation and researches concerning chemical war,

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poison, gas detection and defence of it, sanitary researches of precaution and cure against gas.

The Seventh Military
Technical Laboratory

Maj. General Hyakunin-Machi,
Masahiko Nomura Itabashi-Ku,
Tokyo-To.

Investigation and researches on physical fundamental technics of ordnance. Fundamental investigation for the planning of new ordnance. Investigation and researches on scientific actions concerning ordnance from the physiological viewpoint, foundation of various rocket ordnances, utilization of liquid fuel, foundation of non-reactionary, gun, reason of piercing shell, study of militarization of noctovision and electric detector, foundation of under water detector by sound, investigation of sea meteorology, foundation of magnet ordnance and submarine boat, foundation of wireless operation.

The Eighth Military
Technical Laboratory

Maj. General Koganei-Machi,
Takeo Nagao Kitatama-Gun,
Tokyo-To

Investigation, researches, planning and test on materials of ordnance, investigation on the materials of chemical industry, investigation on the foundation of quality and preservation of materials for ordnance, spring, qualities of various steels, bullet-proof steel, rubber, compound resin and batteries.

The Ninth Military
Technical Laboratory

Lt. General Miyata-Mura,
Ryo Shinoda Kamiina-Gun,
Nagano-Ken

Investigation on foundation of super-short wave, investigation and manufacture of materials and equipments for the troops that go attacking ahead of others, and equipments

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The Tenth Military
Technical Laboratory

Maj. General
Osamu Tanaka

Kurumazaki,
Imayado-Machi,
Himeji-Shi

for propaganda and Military Police. Strong ultra super short wave, simple signal equipments, incendiary agent, photograph agent and equipment, equipment for M.P.; equipment for the troops that go ahead of others.

Investigation, researches, planning, design and test on equipments for transportation. Connecting boat, motor-boat, personal landing boat, escort boat, transporting boat, submarine attack boat, driving boat, pillbox that can sink down, simple torpedo, engines for boat.

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PRINCIPAL ARMY AIR FORCE LABORATORIES

NAMES OF LABORATORIES	LOCATION	CHIEF	CONDUCTED WORKS
Military Air Research Department	Fussa	Tatsuyoochi Ogata	1. Synthetic testing of planes, testing of aircraft ordnance, airdrome apparatus, parachutes, and related apparatus. 2. Testing, by actual flight of aircraft ordnance, apparatus and fuel and oil. 3. Experimentation of reactive propelling machinery and related apparatus. 4. Experimentation of the fuel used for reactive propelling machinery. 5. Experimentation of weapons, ammunition, cannon and rifle mounting, tools for guns, their parts and accessories. 6. Instruction in the use of planes of a new type. 7. Tests, by actual flight, for the researches to be made in respective laboratories.
Military Meteorological Department	Koenji	Zenji Takeuchi	1. Studies and experimentation of meteorological instruments.
1st Military Air Technical Laboratory	Tachikawa	Tatsuyoochi Ogata	1. Studies of planes body, propeller, parts of plane and wind-tunnel. 2. Studies on the non-metal materials for aviation. 3. Experimentation of planes body, its parts, propeller and related apparatus.
2nd Military Air Technical Laboratory	Tachikawa	Norishige Shinano	1. Investigation on engines, their parts and accessories, and the parts of planes body for the equipment of engine. 2. Experimentation on fuel and lubricating oil for plane. 3. Testing of engines, their parts and related apparatus.

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IIIrd Military Air
Technical Laboratory

Tachikawa Hiroshi Masaki

1. Studies on bombs, air gas-defence equipments, and bombing apparatus (except optic apparatus).
2. Experimentation of bombing arms, bombs, arms for air chemical war, and their related apparatus.

IVth Military Air Tech-
nical Laboratory

Tachikawa Takeo Yamazaki
Hachioji

1. Researches of signal ordnance and wireless apparatus relating to air service.
2. Experimentation of aerial signal instruments, wireless equipments, search-light and electric apparatus, and their related apparatus.

Vth Military Air Tech-
nical Laboratory

Tachidawa Naotaka Sakato

1. Researches of aerial sights mainly concerning to the spectacles, air photographing camera, sensitive materials, gauge, and navigational apparatus. (excluding wireless navigational apparatus)
2. Experimentation of aerial gauge, automatic management apparatus, air photographic camera, air scouting equipment, and their related apparatus.

VIth Military Air
Technical Laboratory

Tachikawa Tatsuzo Nii

1. Studies on metal materials relative to air service.
2. Fundamental experimentation of metal materials.

VIIth Military Air
Technical Laboratory

Tachikawa Shiro Kawashima
Aome

1. Investigations relating to air clothing, foods, and their related materials, special clothing for air service, air architecture-and civil-engineering tools.
2. Experimentation of air clothing, foods, and their equipments, and special institutions.

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VIIIth Military Air
Technical Laboratory

Tachikawa Seigo Kawano

1. Studies on air military hygienic psychology and its related materials. (Studies on oxygen-inhaler etc. and also relating to aerial hygienic).
2. Undergoing of tests concerning aerial hygienic materials and oxygen-inhaler.

Tama Military Air
Technical Laboratory

Tachikawa Yoichi Tada
Kunitachi

Studies and fundamental testing of electric wave ordnances, and their materials.

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THE FIRST LABORATORY

RIFLE AND MACHINE GUN

Self-Loading Rifle	Researches to get longer firing-velocity than that of ordinary rifle.	1940 - 1943
Weapons for Parachuters	Researches on various kind of ordnances and ammunitions, their receivers, methods of falling, and their fighting-capacity on the ground.	1940 - 1942
Sharp-shooting Rifle	Researches on the accurate shooting rifle.	1940 - 1942
Light machine Gun	Researches to increase its fighting force at the near distance.	1940 - 1941
M. G. for Company	Researches on M. G. similar to and lighter than the model 92 M. G.	
M. G.	New types of M. G. which save the length of its part in the turret as far as possible and use cartridge-holders or cartridge-bands to increase the range.	1940 - 1944
for Double barrel mounting.	Double-barrel mountings of machine guns, to get many effective shots.	1940 - 1943
tank	2-barrel 2-barrel mounting of model 97 tank M. G. and model 1 mount of 37 mm tank gun. MG & 37 mm gun.	1942
2-barrel mount of MG & 47 mm gun.	2-barrel mounting of model 97 tank model 1 47mm tank gun.	1942 - 1943
Grenade Thrower	A grenade thrower attached to the rifle, the range of which is about 1,000m. Researches on its unification to "Tateki" ("Tateki" is a kind of grenade thrower).	1942 - 1943
20m/m A.A.M.G.	1. "Kekiho-I" - tractor drawn 2. "Kekiho-III" - mounted on tractor 3. "Hekiho-I, II" - turret mounting 4. "Kekiho - II" - remote controlled 5. "Sekiho - I, II"- 2-barrel mounting	1940 - 1942 1940 - 1943 1942 1942 - 1943 1940 - 1944
	1. A.A.M.G. similar to that of "Rhein-metal", being the assistance weapon in important distants. 2. Tractor-drawn type	1944 1942 - 1944

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	3. Self-propelling type	1942 - 1944
	4. Electric-controlled	1943 - 1944
	5. For ships	1944
		1942
A.A. mounting	2-barrelled M.G. that has large firing-velocity, attached to the mounting which allows high-angle firing.	
M.G. mounting	4 & 6 barrelled M.G. that has large firing-velocity, attached to the mounting which allows high-angle firings.	1943
Short machine gun for tanks	Researches on the short M.G., easily controlled in a tank, the fundamental design of which is taken from model 100 short M.G.	1942 - 1943
Charged ball-cartridge	Research on the powerful ball-cartridge for A.A.M.G., having the bursting charge.	1941 - 1944
40m/m A.A.M.G.	"Bofors"-type M.G. that has single fixed barrel.	1945
Model 1 37 m/m gun	Researches on 37 m/m gun wt. of projectile - about 9.72 Kg muzzle velocity - about 800 m/s	1942
Model 1 47 m/m (tractor-drawn)	Researches on the powerful anti-tank gun.	1940 - 1942
Model 1 47 m/m tank gun	1. Researches on the powerful tank gun. 2. Researches on double-barrel mounting of 47 m/m gun and M.G.	1940 - 1943
57 m/m tank gun	Two types (A & B) of powerful tank gun mounted on a tank-destroyer.	1940 - 1943
57 m/m & 75 m/m A.T. gun	Researches to increase (defensive) power against enemy tanks.	1940 - 1945
New 75 m/m A.A. gun	Researches on the new 75 cm gun, being capable of flat firing.	1940 - 1943
Model 3 12cm A.A. gun	Researches on 12 cm gun as the main anti-aircraft ordnance of important districts.	1940 - 1943
Model 99 8 cm A.A. gun	Imitation of "Krupp" 88m/m A.A. gun captured in China.	1940 - 1941
Self-propelling gun	Researches to mount model 90 field gun & model 91 10cm howitzer on tractors.	1940 - 1943
Model 97 light trench mortar	Researches to remove the recoiling device of model 94 light trench mortar.	1940 - 1941

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12 cm trench mortar	Researches on the trench mortar that has larger firing-velocity than 15 cm trench mortar.	1940 - 1942
Decomposable 15cm howitzer	Researches to improve model 38 15cm howitzer, and make it decomposable and suitable to the narrow-gauge railway transportation.	1940 - 1941
Guns for parachuters	Researches on the ordnance for parachuters:- infantry gun, trench mortar, 37 m/m & 47 m/m gun.	1943 - 1944
Anti-submarine ordnances	Researches on anti-submarine guns for coasts & ships especially large-range & small range ship mountings. The last investigation is on the 12cm trench mortar, effective range of which is over 2,000 m.	1942 - 1944
Self-propelling large-caliber trench mortar.	Researches on the trench mortar mounted on the tractor, having good mobility (we call it "Sampaku")	1943 - 1944
Guns for ships	Researches on 37m/m, 47m/m, 57m/m & 75m/m guns mounted on ships.	1944
75m/m tank gun (long barrel)	75m/m gun for the new middle tank B.	1944 - 1945
10cm tank gun (long barrel)	10cm tank gun - caliber - 10.5cm, wt of projectile - about 16kg., muzzle velocity - about 900m/s.	1944 - 1945
10cm A.T. gun	Researches on the anti-tank gun similar to the 10cm tank gun (long barrel)	1944 - 1945
Rocket guns	Researches on rocket guns: 1. for the field artillery 2. for ships 3. for the defensive weapon in important districts	1944 - 1945
Non-reaction guns	1. Fundamental researches on 7.5cm non-reaction gun. 2. Researches on the powerful non-reaction gun the caliber of which is 10cm.	1944 - 1945
15cm Self-propelling gun	Researches to mount model 96 15cm howitzer on model 98 middle tank.	1945
Researches to increase the range of A.A. gun	Researches to fit an inner tube (7.5cm) into the barrel of 8cm AA gun to increase the range.	1945

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15cm AA gun	Researches on the new AA gun for important districts the maximum range of which is about 20,000 m.	1944 - 1945
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AMMUNITION

High explosive shells	Researches on the high explosive shell and practice shell for 10cm cannon, 10cm howitzer, 15cm cannon and large caliber howitzer.	1940 - 1942
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Gas shells	Researches on the middle and minor caliber gas shell, the body of which is common to the ordinary shell.	1940 - 1942
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Armor-piercing shells and their fuses	To improve the shape and the metal of middle and minor caliber armor piercers. Researches on their fuses.	1940 - 1943
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Barrage shells	Barrage shells to defend against enemy planes, not dangerous to friend forces on the ground.	1940 - 1943
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Large caliber projectiles, fuses and bursting charge	Researches on ammunitions for 24cm cannon, 24cm, and 30cm and 40cm howitzer.	1940 - 1943
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Mechanical fuses	Researches on the mechanical fuses of 50 - 60 sec.	1940 - 1942
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Combination fuses	Researches on time-train fuses and mechanical fuses for AA gun, with instantaneous priming device.	1940 - 1944
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Anti-submarine shells and its fuses and depth charges	(1) Anti-submarine shell for 28cm howitzer (2) " " " " 15cm cannons (3) " " " " trench mortar (4) Depth charges	1940 - 1944
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Ammunition for Model 99 8cm AA gun	Researches on fixed ammunitions for 8cm AA gun i.e. sharp tipped shell, illuminating shell, and blank cartridge.	1942 - 1943
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Detonators	1. Researches on cartridge detonators and electric detonators, with superior igniting composition. 2. Researches on primers with base-plugs for guns of high bore pressure.	1942
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Anti-aircraft time fuse for minor caliber guns	Researches on accurate time - train fuses and mechanical fuses of simple construction for minor caliber guns.	1942
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Hollow-charged shells	Hollow-charged shells for model 100 grenade-thrower, model 89 heavy grenade-thrower, model 92 infantry gun, 12cm howitzer etc. Research on the shells that can penetrate armor by large final velocity.	1943 - 1944
Ammunition for 20m/m AAMG	Researches on the superior tracing shell with self-explosion device.	1944
Time train fuses for trench mortars and rockets	1. Time-train fuse for trench mortar to defend against enemy planes. 2. Time-train fuse for field and mountain guns. 3. Time-train fuse for rockets.	1944
Ammunitions for 15cm AA gun	Fixed ammunitions of stream-lined shell and practice shell.	1944 1945
Ammunition for large-caliber self-propelling trench mortar	Researches on the high explosive shell.	1944
Ammunitions for 57m/m tank gun	1. Armor-piercing shell 2. High explosive shell 3. Practice shell	1944
Ammunitions for 10cm tank gun (long type)	1. Armor-piercing shell 2. Stream-lined shell 3. Practice shell	1944 - 1945
Ammunitions for 20cm mortar	1. High explosive shell 2. Practice shell	1944

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SECOND MILITARY LABORATORY

<u>Item</u>	<u>1941 - 1942</u>	<u>1942-43</u>	<u>1943-45</u>
Anti-clouding methods for optical weapons	Temporary and basic researches for the prevention of clouding and growth of fungi.	Continued	
New type of range-finder with self-contained baseline	Types of rangefinders other than the regular type, with high accuracy.	Continued	
Hight-finders	Method for obtaining higher accuracy.	Continued	
Locators	Heavy type locator for long range artillery.	Continued	
Simple long-focus camera	Easily constructed long-focus camera for long range photography.	Continued	
Wide angle camera for aerial survey	Aircraft camera with wide angle lense, capable of aerial survey by its photograph.	Continued	
Position indicator for tank use	Instrument indicating co-ordinator of position of tank.	Continued	
Calculator for AA guns	Calculator for 7cm and 8cm AA guns.	Continued, especially for 8cm AA gun.	1. Semi-automatic calculator intending to meet B-29. 2. Full-automatic calculator intending to meet future aircraft (started 1945)
Sighting appartus for AA guns.			Simple sighting apparatus adaptable to various type of guns, and suiting for mass production (started 1945).

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<u>Item</u>	<u>1941 - 1942</u>	<u>1942-43</u>	<u>1943-45</u>
Commanding Appartus for AA artillery bataillon.	Commanding apparatus capable of systematic command of several companies.	Continued	
Autogyro	Production of autogyro	Continued	Continued
Observation air-plane	Low speed airplane for observation.	Continued	
Sighting apparatus for 15cm cannon.		That for use in fortress (started '43)	
Magnetic locator			Magnetic locator for warning of fortified area, (started 1945) 1. Weapons for watching and detecting of submarine. (started 1944) 2. Underwater sound locator and sound detector for watchin and detecting submarine at fortified coast (started 1945)
Simple type of fire control device for fortress.			That for temporary fortress guns. (started 1944)
Heat-ray			Application of heat rays to military use. (started 1944)
Submarine watching apparatus using ultra-low frequency wave.			Apparatus using low frequency of several cycles per second, and this research is requested to be executed by civilians on the outside of the Army. (started 1945)

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THE THIRD MILITARY LABORATORY

AT 1940

ITEM	REMARKS
Close range fighting equipments	Close attack weapons against tanks. Researches for weapons applied in close attack against tanks by means of explosive, flame and smoke, etc. Horizontal boring machine. Apparatus to destroy a strong position such as pill box etc. from underground by means of putting explosives into the horizontal hole bored by boring machine. Destruction pipe for shore use. Destruction pipe to destroy obstacles on shore by means of explosive propelled by rocket.
River crossing equip-ment	Armoured boat. Armoured boat mounting a 37mm gun to cross wide river and easy for land transportation, un-loading and floating. New type cross river equipment (20 ton bridge). New type pontoon-bridge capable of passing 16 ton class tank, and being constructed and carried rapidly and easily. Air cooling light type outboard motor. Improved motor of M95 light type outboard motor adapted for air cooling system, capable to be managed in the muddy stream. Out-put 15 HP
Special traffic equipment	Cable trolley medium type. Equipment of transportation for various articles or materials on precipitous grounds, and easily transported and constructed. Marsh passing. Vehicle able to pass marshy area and easily to load personnel and cannon.
Railroad equipment	Railroad pier-pile. Pier-pile used for the pier of a railroad bridge girder. Railroad bridge, pier building equipment. Raft of pontoon capable to build pier-pile in the water as well as the pier Ferry boat for train. Ferry boat capable to cross a wide river where is no equipment, loading locomotive and trucks on a boat. Track bomb. Vehicle capable of running automatically on the track to reach desired spot and destroy various instruments. explosive- 500kg, running range 10km Dropping signal. Equipment to give signal for the following train by dropping it on the track.
Well boring and water supply equipment.	Well boring car. Vehicle capable of boring a well rapidly and easily, and easily movement and setting. Lifting pump. Lifting pump to lift water by motor-driven pump. (a) pump for shallow well (b) pump for deep well. Water purification car. Water purificator to purify muddy water from well bored by well-boring car, easily and rapidly.

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ITEM	REMARKS
Camouflage Equipment	Method of camouflage Solid camouflage paint Solid Researches for paint of camouflage use and its painting method to cannon and vehicles, taking into construction the experiences of actual fighting. Portable solid camouflage paint capable of being painted easily at the front.
Illumination equipment	Large type searchlight Illumination lamp and sign for landing area Research of 2m reflector. Lamps to illuminate and signal the landing point at night.
Power equipment.	Wood cutting saw, motor Research of equipment to cut tree or timber rapidly and easily by a motor driven cutting saw.
AT 1945	
Close range fighting equipment	Close attack weapons against tanks. Horizontal firing apparatus. Mine-field cleaning equipment. Continued Continued Equipment to reconnoitre mine fields by simple and rapid way, in order to break through mine fields. (a) equipment for foot troops (b) equipment for wagon companies.
River	20 ton Bridge Bridge for pack horse Continued Simple equipment capable of passing foot troops and pack horse troops.
Crossing Equipment	River crossing equipment for tanks Air-cooling light type out board motor. Motorboat transport equipment. Simple equipment capable of passing medium size tank rapidly across river. Continued Truck capable to transport motor boat, large size and small size.
Special traffic equipment	Cable trolley, medium type. Marsh passing vehicle. Marsh crossing instrument. Continued Continued Hand erecting board for marsh crossing of middle class tanks and lighter vehicles.
Railroad equipment.	Ferry boat for train. Light type armoured railroad car. Continued Light type armoured car running on light railroad trucks.

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Well boring and water supply equipment.	Well-boring car Lifting pump Water purificator car	Continued Continued Continued
Power	Standardization of electrical equipment. Standardization of electrical equipment. Electrical working machine. Generator for field operation.	Construction of standard type of various electrical instruments for the purpose of standardizing electrical instrument. Construction of standard type of various electrical instruments for the purpose of standardization electrical instrument. Construction of various electrical working machine, such as: winch, wood-cutting saw, electric drill, sawing machine, crane, etc. Researches on such generators as shown below for electric source of illumination and electrical work in the field operation. (a) automotive 15 KW generator. (b) portable 5KW generator (c) field operation type 1 KW generator Caterpillared car furnished with various devices for light works as wood-works, machine, electric works, etc. Instrument for quick construction of trench and anti-tank trench by application of explosives. Wood-cutting machine for quick and easy cutting of trees.
Equipment	Light workshop car Trench digging instrument (by explosives) Wood-cutting machine	
Illumination equipment	Large type searchlight	Continued
AT 1942.		
Close range fighting equipment.	Close attack weapons against tanks. Horizontal boring apparatus. Mine-field cleaning equipment. Bridging tank. Explosive tank. Flame throwing tank. Mine.	Continued Continued Continued Tank which throws out bridge board by power of explosives over anti-tank trench of 7" width Medium type tank equipped with explosives thrown out to destroy obstacles. Medium type tank throwing flame by means of its own motive power. Mines superior in quality and suitable for mass production.

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	20 ton bridge. 10 ton bridge.	Continued Pontoon bridge moored by a holding rope and suitable for river crossing of light tanks and vehicles.
River crossing equipment	Bridge for pack horse. River crossing equipment for tanks. Armoured boat. Tank carrying boat.	Bridge suitable for river crossing of guns and pack horses. Bridging method as same as 10 ton bridge mentioned above. Continued. Armoured boat 10m in length, suitable for covering small boats in river crossing operation. Motor boat for river crossing of medium type tanks, capable of being operated in three portions for easy transportation.
River crossing equipment	Air cooling light type outboard motor. Landing boat and horizontal type outboard motor. Transportation vehicle of a motor boat.	Continued. Horizontal type out-board motor attached with vertical shaft propellor to the gasoline engine of landing boat. Truck for transportation of a large and small motor boat.
Special traffic equipment	Marsh-crossing board-laying device. Marsh crossing instrument. Marsh reconnoitring car. Hurdle manufacturing machine. Cable trolley light type. Cable trolley medium type. Wood land clearing car.	Caterpillar and car capable of laying the board from the front part by means of its own motor-power for marsh crossing. Continued. Car with caterpillar furnished with rubber floats for reconnoitring marsh. Application of floor-matting weaving machine on weaving weed mattings for marsh-crossing. cable trolley for light load transportation for a distance above 300 m. Trolley of transportation distance about 2000m and capacity 10 ton/h. Car furnished with devices for clearing felled trees and capable of removing roots.
Rail-road equipment.	Light type armored rail-road car. Light rail-road locomotive. Working instrument for super-structure. Light type river-crossing device for railroad cars.	Continued. Light locomotive capable of being produced in the country. Various instruments for efficient construction of super structure of rail-road. River-crossing device for railroad cars of weight less than 45 tons.

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Well boring and water supply equipment.	Well boring car.	Continued.
Power equipment.	Standardization of generators for working machines.	Standardization of small type gasoline engine for working machines.
	Standardization of electrical equipment.	Continued.
	Generator for field operation.	Continued.
	Electrical working machine.	Continued.
	Light workshop car.	Continued.
	Trench digging instruments (by explosive)	
	Wood cutting machine.	Band-saw with flexible shaft driven by 5 HP gasoline engine capable of cutting down trees of diameter less than 1m.
Entrenching equipment.	Trench digging machine.	Excavator type digging machine applied to the body of medium type tank.
	Road constructing machine.	Various road constructing machines such as: Bull-dozer, rippers, grader, roller etc.
Camouflage equipment.	Method of camouflage.	
Miscellaneous equipment.	Special life-saving apparatus.	Simple life-saving apparatus for moving vessel use.
Illumination equipment.	Large type searchlight.	Continued.
AT 1943.		
Close Range fighting equipment.	Close attack weapons against tanks.	Continued.
	Horizontal boring apparatus.	Continued.
	Mine-field cleaning equipment.	Continued.
	Explosive tank.	Continued.
	Close range coast fighting weapons.	Weapons for close-quarter fighting on the sea-shore against over-sea operations.

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Explosive Mines
and firing Hollow charge (exp-
accessories losive.

Continued.
Application of coveal and semi-splievel
hollow charge.

River cross- 10 ton bridge.
ing equipment

Continued.

Special Equipment for trans-
traffic portation through pre-
equipment cipitors road.

Instrument whichpass various equipment through
precipitions and difficult road especially
vehicles.

Railroad M1 Railroad tractor
equipment

Substitution of gasoline engine used in
regular model tractor by Diesel engine.

Entrenching Road-constructing
equip- machines.
ment.

Application of mechanical power to send inst-
ruments as shown below for efficient road-
construction 1 - 10 ton tractor.

Bull-dozer, trencher, carry-all, dump car,
grader (trailer type) grader (auto motive type)
light tank with pushing plate.

Illumination Large type searchlight. Continued.
equipment.

Close Close
range range
fighting coast
equip- fighting
ment. weapons.

Defensive weapons chiefly for landing ships
and boats.
The researches are divided into the following
items.

1. Mine of coast use (MA Mine) The mine is
laid against landing ships or boats and its
charge of explosion about 4Kg.
2. Rocket mine. The mine runs the water
sinface by means of rocket.
3. Simple diving apparatus. Diving apparatus
suitable to dive in the shallow sea by using
an oxygen apparatus.
4. Simple torpedo. Simple torpedo made of
wood which rushes on the sea surface by means
of rocket.

Close
attack
weapons
against
tanks.

Close attack bombs against tanks. The re-
searches are divided into the following items
1. Projective bomb. Conical bombs with
explosives of 2Kg, 5Kg, 10Kg each which were
projected by heavy grenade thrower or M98
explosive projector.
2. Semispherical bomb. Several semi-spheric
bomb with the explosives of 3Kg, 5Kg each to
crush the steel plate of tank.
3. Simple bomb. Several kinds of anti-tank
bombs which can made at the front such as:
cushion type bomb, spear type, emergency bomb

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Explosive and firing accessories.	Grenade-mine. Jumping mine. Large type semi-spheried explosive.	Mines made from shells and bombs out of use. Device which makes 3M mines jump and explode in the air to kill men, horses, etc. Explosive for ship-attacking and its firing accessories.
River crossing equipment.	Simple river crossing equipment.	Equipment making mortar truck etc. cross river simply and quickly by means of simple equipment.
Rail-road equipment.	Railroad equipment for simple loading and unloading. Railroad girder constructing apparatus. Sleeper manufacturing equipment.	Equipment loading and unloading gun and wagon simple on road truck without loading and unloading. Apparatus constructing M99 railroad girder simple and quickly. Equipment suitable for mass production of sleepers at the front.
Power equipment.	M4 working car. Horse loading type working equipment.	Car deprived of armour plate of M3. Light work ship car. Working equipment suitable to horse loading for the service in mountainous country.
Entrenching equipment.	Road constructing machine.	Continued and research for following items. Loading car, 6 ton bull-dozzer, grader (automotive type), dump car, power shovel, 20 ton crusher, shovel type trencher (automotive type), small type bull-dozzer.
	Equipment which runs up trenches.	Equipment constructing quickly cave etc, by means of explosive and electric power.
AT 1945.		
Close range fighting equipment.	Close range coast fighting weapons. Close attack weapons. Simple close fighting weapons.	Bombs to attack landing ships and boats approaching the coast which are follow. 1. Simple rocket bomb. 2. Magnetic mine. Various close attack weapons against tank, pill boxes, etc. Simple mines and firing accessories of explosives, for easy manufacture at the front guerrilla war-fare and guerrilla mobilization forces.
River crossing equipment.	Superheavy types raft of pontoon. Ferry boat for train.	Raft of pontoon which can sail carrying 40 ton class tank. Research for an easy method of mass-production of the ferry boat for train, which is follow. 1. Boat making use of a super heavy type raft of pontoon or applied wooden boat. 2. To economize iron, the vehicle ferried is a full loaded 30 ton tank (home made).

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Entrenching equip-ment.	Rapid entrenching equipment.	1. Equipment making quickly entrenching work and defence works to cannonade and air-raid to protect road, rail-road etc. by means of explosive and mechanical power. 2. Application to weapons of simple entrenching tools.
Illumination equipment.	Large-type searchlight. Controlling gear for locator and searchlight.	Searchlight of 3m. diameter for fortified zone Controlling gear to controll equipment between the locator and searchlight.

FOURTH MILITARY LABORATORY

MOTOR VEHICLES AND FUELS

I. Engines.

<u>TERM</u>	<u>Item of Research.</u>	<u>Researches</u>
1940-1941	Stander Diesel-engine M-100.	Four cycle pre-combustion chamber type, air and water-cooled 1 to 12 unit-cylinder (120x160). Maximum power: Number of cylinder: Out-put: Inter-cooled Air-cooled 4 80 85 6 120 130 8 (V- 160 160 12 type) 230 240 (at 1800 rpm) (at 200 rpm)
1944-45	Increment of out-puts by super-charger in M-100 and M-4 engines.	
1942-44	Diesel-engine M-4.	Four-cycle pre-combustion chamber type, 12 cylinder air-cooled, 400 HP (145x190)
1943-44	Modification of M-100 Diesel engine for Marine use.	
II. <u>Tanks.</u>		
1941-42	Medium-tank M-1.	Weight 14 ton, armament 1x44mm gun and 2xMG, Armour, front 50mm, side 25mm, max-speed 44km/hr, climbing 2/3 engine 230HP.

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<u>Term</u>	<u>Items of research</u>	<u>Research</u>
1941-42	Light Tank M2	Weight 7.2 ton, armament 1x37mm gun and 1xMG, armour: front 16mm side 72 mm, max. speed 50 Km lh climbing 2/3, engine 130 HP.
1943-44	Medium-tank M3	Medium tank M1 changed in armament so as 1x45 mm gun and 1xMG.
1943-44	Medium-tank M4	Weight 30 ton, armament 1x75mm gun and 2xMG, armour: front 75mm side 35 - 20mm, max. speed 45km/h, climbing 2/3, engine 400HP.
1943-45	Medium-tank M5	Weight 37 ton, armament 1x75mm gun, 1x37mm gun and 2xMG, armour: front 75mm side 35-25mm, max. speed 45 km/h, engine 550HP
	Chassis for self-propelling gun.	A. Utilization of M97 tank chassis for mounting of guns stated below, (1942-45) 15H M38, 10H M91, mountain gun, Field gun M90, 20H. B. Utilization of M95 light-tank chassis for mounting of guns stated below, (1944-45) 47mm gun M1, 57mm gun M97. C. Chassis for 75mm AT gun (1943-45) weight 12 ton, armour 12mm, max. speed 40Km lh. D. Chassis for self-propelling 10cm gun (1943-). Weight 37 ton, armament 1x10cm cannon, engine 550Hp, armour 75mm, max. speed 35Km lh. E. Chassis for 10cm AT gun (1944-), weight 25 ton, armour 25mm, max. speed 40 km lh.

III. Electrical equipments.

1941.	6HP Starting motor.	Standard type starting motor.
1940-45.	Non-control charging dynamo.	Dynamo maintaining constant voltage at any revolutions per minutes, by use of special circuits.
1941-43.	15HP Starting motor.	Standard type starting motor with preventing mechanism of untimely disengagement.
1941-45.	Starting and charging motor.	
1943.	30HP Starting motor.	Starting motor for large type Diesel engines, with special reduction gear.

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V. Tractors, special vehicles.

1940-44	Small-tractor	Weight 4.7 ton, crew 8, full-truck type, 80Hp air-cooled Diesel engine, armour 72 - 10mm, max. speed 40Km/h.
1941	Light-tractor	Weight 6.9 ton, crew 7, full truck type, 120Hp water-cooled Diesel engine, max. speed 24Km/h.
1943	Medium-tractor	Weight 10 ton, crew 9, full-truck type, 160Hp water-cooled Diesel engine, max. speed 40Km/h.
1940-41	Armoured Infantry-carrier M1	Weight 6.5 ton, crew 15, armour 6mm, full-truck type, 120Hp air cooled Diesel engine, max. speed 40 km/h
1941-42	Armoured Infantry carrier half-track type	Weight 7 ton, armour 8-6mm, crew 15, half track type, 120Hp, air-cooled Diesel engine, max. speed 50 dm/h.
1945	Steamengine-tractor	Weight 14 ton, vapour-pressure 30Kg/cm, 120Hp
1942	Snow-tractor	Weight 3.5 ton, full-truck type, 80 HP water-cooled engine, gasoline, crew 2.
1942-43	Snow plough car	Weight 11 and 13 ton utilizing 10 ton tractor, rotary type, swept width 2.5m, swept depth 1m.
1943-44	Medium-truck, full truck type.	Weight 6 ton, carrying capacity 2 ton, full-truck type, 150Hp air cooled Diesel engine, speed 40Km/h.
1940-41	Six wheel truck M1 A	Weight 3.8 ton, carrying capacity 3 ton, 65Hp water-cooled gasoline engine.
1940-41	Six wheel truck M1 B	Weight 4.1 ton, carrying capacity 3 ton, 80Hp water cooled Diesel engine.
1940-41	Four-wheel truck M1 A	Weight 3.5 ton, carrying capacity 2 ton, 65Hp water-cooled gasoline engine.
1940-41	Four wheel truck M1 B	Weight 3.8 ton, carrying capacity 2 ton, 80Hp water-cooled Diesel engine.
1942-43	Four-wheel driven truck M2	Four-wheel truck M1 modified to be four-wheel driven.
1942-43	Six wheel driven truck M3	Six wheel truck M1B modified to be six wheel driven.

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1941-42	Heavy truck M2	Weight 5.5 ton, carrying capacity 7 ton, 100Hp water-cooled Diesel engine.
1944-45	Four wheel driven, small truck M4	Weight 1.1 ton, carrying capacity 500Kg, 40 Hp water-cooled, four cylinder gasoline engine.
1944	Small truck M95	Weight 1.1 ton, carrying capacity 500Kg, 25Hp air cooled, two cylinder gasoline engine, also used as air-transported car.
1943-44	Amphibian truck	Weight 3.2 ton, carrying capacity 1 ton, 40Hp water-cooled gasoline engine, modified "Toyoda" truck as amphibian.
1944	Decomposable truck	"Toyoda" truck simplified for composable and transportable ones.
1940-45.	Substitute fuel truck	Researches of substitute fuel trucks using coal, lignite or charcoal.

VII. Fuels and Oils.

1940-44	Fuels and oils to be used in frigid zone.	For the purpose of easy cold-starting in frigid area of Manchow especially lubricating oils of lower freezing points and higher values of coefficient of viscosity was studied.
1941-43	Fuels and oils to be used in tropical zone.	Researches for application of ordinary fuels and oils to be used in tropical zone.
1940-43	Enactment of specifications for fuels and oils.	Researches for deterioration of specification.
1942-44	Rubber-melted lubricating oil.	Researches for obtaining more viscous lubricating oil by melting depolymerization products of rubber into lower viscous one.
1943-45	Transforming vegetable oils into lubricating oils.	Researches for obtaining lubricating oils from vegetable oils by means of single process. Vulcanized rope seed oil almost successfully transformed.

FIFTH MILITARY LABORATORY

AT 1941

Part 1. Wire Communication Apparatus.

<u>Item</u>	<u>Contents</u>
Multiples telephone.	1. Under-voice frequency. 2. 3 channels. 3. Every channel can be used separately.

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<u>Item</u>	<u>Contents</u>
Middle type Multiplex telephone	1. Over 3 channels. 2. Every channel can be used separately.
Repeating set	1. Information and commanding communication for air defence. 2. Civilian telephone can be used. 3. Long distance transmission is possible.
Wire laying car	1. Wire can be set under ground. 2. Can be used for wire communication. 3. Tractor can be used for car.
Lighttype multiplex telephone.	1. 3 channels. 2. Every channel can be used separately.
<u>Part 2. Radio Communication apparatus.</u>	
Fixed radio apparatus.	1. Can be used to communication between important positions. 2. Transmission out put: 1KW, 2KW, 5KW. 3. Receiver: gave more than 140 lb. 4. Telephone only.
Super heavy type radio A	1. Communication distance: 1000 Km. 2. Telegraph only. 3. Output nearly 1KW. 4. Can be used at high speed and for radio facsimile communication. 5. Also direction antenna and civilian electric source can be used.
Super heavy type radio B	1. Communication distance nearly 500 Km. 2. Telephone only. 3. Output nearly 500W. 4. Can be used at high speed.
Boat radio A	1. Communication distance: telephone 20Km, telegraph 100Km, under moving condition on sea. 2. Frequency band: transmission 1500-5700Kc, receiving 400-7500Kc, 3. Total weight nearly 100Kg.
Boat radio B.	1. Communication distance nearly 8Km under moving condition on sea. 2. Telephone only.
Heavy type radio A	1. Used between middle-distance-airplane and ground. 2. Communication distance nearly 500Km. 3. Total weight nearly 1000Kg. 4. Can be used between itself and heavy type radio B, or medium type radio, or tank radio.
Heavy type radio B	1. Used as telegraph for army communication corps. 2. Communication distance: nearly 100Km. 3. Output nearly 30W. 4. Frequency band: 2.2-15Mc. 5. Source: transon storage batter and converter, radio dry cell. 6. Total weight: nearly 180Kg.

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Medium type radio. 1. Type: (1) carried on horse back (2) portable (3) also can be used between air and ground. 2. Communication distance: telephone between air and ground nearly 15Km, telegraph nearly 40Km. 3. Output: telegraph nearly 10W, telephone nearly 5W. 4. Frequency band- Transmission: 500-1570Kc, Receiving: 500-6000Kc. 5. Source: Transmission: hand cranking generator, Receiving: dry cell and hand crank. gen.

Light type radio A. 1. Portable radio used at the front. 2. Communication distance: telegraph 10Km, telephone 5Km. 3. Output telephone more than 2Kw. 4. Frequency band: 1000-5000Kc. 5. Source: Transmission: hand cranking generator, Receiving: dry cell and hand crank gen.

Light type radio B. 1. Used for front communication. 2. Communication distance: telephone 2Kw, 3. Frequency band: 25-30Mc. 4. Source: hand cranking generator. 5. Total weight: under 20Kg.

Tank radio A. 1. Used under moving condition on car. 2. Communication distance: telephone 15Km, telegraph 50Km. 3. Frequency band: 45-57Kc. 4. Output: Telephone 25W, telegraph 500W. 5. Total weight: under 500 Kg.

Tank radio B. 1. Used under moving condition on car, also between air and ground. 2. Communication distance: telephone 4 Km, telegraph 10Km. 3. Frequency band: 3.5-5.5Kc. 4. Output: telephone nearly 10W, telegraph nearly 15W. 5. Total weight: under 250 Kg.

Tank radio C. 1. Used under moving condition on car. 2. Communication distance: telephone 500m. 3. Frequency band: 20-30Kc. 4. Total weight: under 150Kg.

Training transmitter. 1. Used as transmitter for receiving training. 2. Source: dry cell

Training radio instrument with extended connections. 1. Must have similar character to M94 No. 3A, M94 No.5 and M94 No. 6 radios. 2. Every parts similar to normal instruments.

High speed communication apparatus (stationary) 1. Can be attached to fixed radio, for increasing communication speed. 2. Speed: 200-3000 letters/min.

High speed radio communication apparatus A. Speed: 500 letters/min.

Radio stabilizer. Oscillator having next character: 1. Crystal not used. 2. Oscillations output must be large. 3. Stable oscillation. 4. Wide band.

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Rectifier for receiver. 1. Input: 90-120V or 180-240V at 50 or 60 cycle single phase. 2. D.C. output: 1.5V, 0.5A for filament 135V, 25mA and 90V, 25mA for high tension.

Part 3. Special communication apparatus.

Electric warning apparatus. Used for warning of approaching of enemy troops or cars.

Commanding apparatus for air defence communication. Used to command speedily and surely.

Information indicator. Used for speedy and sure transmission of information of air defence.

Radio direction indicator. 1. Controller: can be attached M94 No. 5 radio transmitter. 2. Frequency band medium high frequency. 3. Weight: less than 40Kg.

Special transmitter. 1. Used to disturb radio communication and broadcast receiving. 2. output: 500-1000W. 3. Modulation and frequency wobbling are used. 4. Can be given direction character by using wave antenna.

Movable intelligence radio apparatus. Special receiver A: used to receive enemy radio communication. Special receiver B No. 2: semi-stationary short wave direction finder for long distance. Special receiver B No. 3: short wave direction finder carried on horse back, at short distance.

Stationary intelligence radio apparatus. Short wave direction finder: Rotating Adcock antenna type short wave direction finder using to Brown tube.

Stationary secret telephone. Used to make secret the substance of communication.

Stationary secret telephone. Used to make secret the substance of communication of fixed radio.

Movable secret telegraph. Used to make secret communication substance of movable telegraph (wire & radio)

Movable secret telephone. Used to make secret communication substance of movable telephone (Wire & Radio)

Detector A Radio. Warning system of fixed beams by means of Doppler effect.

Detector B Radio. Used to find direction and distance of enemy aero-planes by receiving reflected waves of transmitted impulse short waves.

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1. Used in a very cold zone for a long time.
2. Hand cranking generator, electric charger, transformer and rectifier etc.

PART I. Wire Communication Apparatus.

<u>Item</u>	<u>Contents</u>
Telegraph Switchboard	Hand worked Telegraph Switchboard for Modified 95 type telegraph. (or 95 type telegraph).
Two Line Repeater	Continued from 1941.
Light type multiplier Telephone.	Having 3 channels and equipment of each channel can be used separately.
Wire drawing car.	Continued from 1941.
Multiplex Telegraph.	1. 3 channels under voice-frequency. 2. Equipment of each channel can be used separately.
Medium type Multiplex Telephone.	Having 3 or more channels and equipment of each channel can be used separately.

PART II. Radio Communication Apparatus.

Fixed Radio equipment.	Continued from 1941.
Super heavy radio	This is used for communication among ground forces, and can be packed and mounted on motor-car to accompany the movement of forces. 1. Out-put power 2Kw 2. Receiver gain about 140 db or more and capable of high speed receiving. 3. Carrying method by motor-car. 4. Radios which can communicate with this: heavy radio, fixed radio. 5. Power source: Transmitting - Motor generator (or local power). Receiving: Battery (or local power).
Super heavy radio Type A.	Continued from 1941.
Super heavy radio Type B.	Continued from 1941.
Boat radio type A.	Continued from 1941.
Boat radio type B.	Continued.
Tele-typewriting Transformer and receiver.	The equipment is composed of tele-typewriter used in wire communication, adding some apparatus necessary for radio.

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Radio Cars

These cars can go with headquarters and are able to communicate even when running or stopping. 1. Radio car type A, Tank equipped with heavy type radio A. 2. Radio car type B, truck having 4 wheel and equipped with heavy type radio A. 3. Radio car type C, truck having 4 wheel and equipped with heavy type radio A.

Heavy Radio type A	Continued
Heavy Radio type B	Continued
Medium type radio	Continued
Light type radio A	Continued
Light type radio B	Continued
Tank radio type A	Continued
Tank radio type B	Continued
Tank radio type C	Continued
Training transmitter	Continued
Apparatus for lecture-hall.	Continued
Radio having extended parts.	Continued
High speed communicating radio (fixed).	Continued
High speed communicating radio type A.	Continued

Armed radio car.	Medium type tank equipped with heavy type radio A and be used for communication only.
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Methods of mounting radio.	Researching how to mount radios on vehicles, vessels, et
Radio for observation in air.	Continued
Study of frequency stabilization.	Continued

Part III. Special communication apparatus.

Electric warning apparatus. Continued.

Air defence communication instruments. Information indicator B.	Can be used for information indicator when radio detectors are used.
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Air defence communicating apparatus.	Used for speeding command of air defence troops.
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Information indicator.	Used for speedy air defence information indicator.
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Radio Facsimile.	Fixed communicating equipment used for sending and receiving of maps, letters, weather-charts etc., and chiefly used in the way of adding this equipments to super heavy radio and fixed radio.
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Special Transmitter.

Continued.

Radio direction indicator.

Continued.

Teletype

Receiver.

1. Semi fixed type. a. Distance of terminal to repeater and repeater to repeater; 100Km. b. Number of channels: Telephone, 6 channel or telegraph 36 channel. c. Frequency: 90Mc d. Antenna: beam antenna. e. Power source: motor generator or local power. 2. Moving type (for field) a. No. of channel: Telephone 3 channel b. Frequency: 700Mc. c. Carrying method: by motor car. This equipment can receive high speed multiplex teletype, dividing in each channel and typewriting them.

Fixed type direction finder.

1. Short wave direction finder. This equipment use Brown tube and crossed V Adcock antenna. 2. Medium wave direction finder. This equipment is sound type using V Adcock antenna.

Movable direction

finder.

1. Special receiver type A Continued. 2. Special receiver type B No. 2 continued. 3. Special receiver type B No. 3 continued. 4. Special receiver type B No. 4 to be able to find the direction of wave source in short distance. 5. Light type commanding equipment for special receiver. Coupled with special receiver type B No. 4 and be able to give command to 3 direction finders in same time.

Fixed type secret telegraph. Continued.

Moving type secret telegraph. Continued.

Fixed type secret telephone. Continued.

Moving type secret telephone. Continued.

Radio Detector type B. Continued from 1941 and developing.

Radio Detector type B for boat. We studied the fitting device of radio detector type B to boat, chiefly we studied antenna and construction of equipment.

Radio Detecotr type B for field.

We studied constructions of antenna equipment and power source to be able to fit radio detector type B to truck.

Part IV. Power Source.

Equipments of power source.

We studied of manual generator, charger, transformer and rectifier which can be used in cold and hot zone.

Dry cell.

We studied of light portable cell effective for long time in cold and hot zone.

Part V. Parts and etc.

All kinds of parts for communication equipment.

We studied parts effective for long time in hot and cold zone.

CONFIDENTIAL

AT 1943.

Part 1. Wire communicating equipments.

<u>Item</u>	<u>Contents</u>
Field cable for voice frequency.	1. Cables saving copper or non used. 2. Can be used for short or middle distance.
Numbering tele-typewriter.	1. Type: start stop. 2. Communication distance: cable loss 15Db or less. 3. Communication speed: over 80 letters /min. 4. Electric source: battery. 5. Transportation: by car.
Medium type multiplex telephone.	1. Over 6 channels. 2. Communication distance: about 60Db by cable loss. 3. 6 channels can be separated 2 groups and used independently.
Repeating set for medium type multiplex telephone.	For long distance communication.

Part 2. Radio communicating equipments.

Fixed radio.	Continued.
Super heavy radio.	Continued
Super heavy radio type A.	Continued
Super heavy radio type B.	Continued (but stoped the study).
Stationary radio for boat use.	Fixed land radio, we studied of radio fixed on boat and can communicate during a voyage. 1. out-put: 2Kw. 2. Receivers gane: 140Db or more. 3. Equipments able to communicate: fixed radio, super heavy radio, long (middle) distance aeroplane-radio, long (middle) distance ground radio to communicate with aeroplane and radio of small ship. 4. Power source: source of ships and motor generator.
Boat radio type A	Continued.
Boat radio type B	"
Methods of mounting radio.	"
Radio tele-typewriter.	"
Radio car.	"
Radio for observation, in air.	"
Tank radio type A	"
Tank radio type B	"
Tank radio type C	"
Heavy radio type A	"
Heavy radio type B	"
Medium radio	"
Light radio type A	"
Light radio type B	"
High speed communicating radio (fixed)	"

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High speed communicating radio
type A. Continued.
Rectifier for receiver. "
Study of frequency
stabilization. "
Armoured radio car. "

Re-newed M 2F radio. 1. Use for signal corps of headquarter and fixed signal corps. 2. Improving standard radio M29 chiefly its fitness of mass-production, gain and protection from dampness.

Part 3. Special communicating equipments.

Electric warning app. Continued.
Special loud-speaker. Used for command of AA battery.
Non-visible ray direction indicator. Used for direction indicating of sailing ships.
Voice power loudspeaker. Used for command of air-defence troops.
Special wire-broadcasting instrument. For information and command of air-defence troops.
Radio tele-photograph. Continued.
J.H.F. multiplex radio. "
Special transmitter. "
Tele-type receiver. "
Fixed type direction finder. "
Movable direction finder. "
Fixed type secret telegraph. "
Movable type secret telegraph. "
Fixed type secret telephone. "
Movable type secret telephone. "

Secret equipment. We studied methods of changing tele-autogram to secret equipment.

Part 4. Radio-detector and locator.

Radio-detector type B Continued.
Radio-detector for field. "
Radio-detector type B for boat. "
Radio-interferer. It detects the waves from enemy's detectors and interfere them.
Identifier of friend force. Coupling with radio-detector type B, it can select friend force from enemies.

Part 5. Power Source.

Equipments of power source. Continued.
Dry cell. "
Battery. "

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Part 6. Parts. etc.

Various kinds of parts for communication apparatus. Continued.

AT 1944.

Part I. Wire communicating equipments.

<u>Term</u>	<u>Contents</u>
field cable.	1. For transmitting voice frequency: a. for short range. b. for middle range. 2. For transmitting of carrier frequency, all continued from 1943.
Numbering tele-typewriter.	Continued from 1943.
Commanding telephone for air-base	Commanding telephone which is used between the headquarters and each air depots at the air-bases.
Carrier telephone.	Having 3 or more channels and each channel can be used separately.
Carrier telegraph.	a. Having 3 or more channels under voice-freq. b. Each channel can be used separately.
Underground cable drawing car.	Continued from 1941.
Heavy type cable-setting car.	It sets the field-cable rapidly.
Bridge for Duplex Telegraph.	Additional set for Duplex Telegraph modified 95 type Telegraph, which uses.
Movable line Tester.	Having Level-meter, Alternator Bridge oscillator (of carrier & freq) & etc. for the maintenance of line.
Variable ratio transformation repeating coil.	1. It can vary the ration of transformer. 2. It is easily adjusted for the line of every kind.
Telegraph switchboard.	Continued.
Two line telephone repeater.	Continued.

Part II. Radio Communication equipment contents.

Fixed radio.	Continued.
Fixed radio for bases of boats.	1. Use - To communicate between base and boats on voyage. 2. Out put - 500W, 1Kw, 2Kw. 3. Gain of receiver 140db or more. 4. 500W - Semi fixed 1Kw 2Kw - fixed.

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Super heavy radio.	Continued.
Boat radio type B	"
Boat radio fixed type.	"
Radio tele-typewriter	"
Radio Car	"
Radio for transport ship.	1. Use for transport ship. 2. Developed the unity of parts and valves of war type ship radio.
Boat radio type C.	For signaling SOS 1. Frequency - fixed 2. Output - 37
Study of frequency stabilization.	Continued.
Part III. <u>Special communicating equipments.</u>	
Tele-typewriter receiver.	Continued.
Information indicator type B for air-defense force.	Continued.
Special visory commanding apparatus.	It is used for the commander at the platoon of radio detector type B.
Special commanding telephone.	1. Special type common carrier telephone. 2. It is used for the command of air-defense forces.
Special commanding telephone svbd.	It has automatic connecting set and simultaneous commanding set.
Special wire-board casting instrument.	Continued.
Special power-transmission line carrier communication apparatus.	1. Carrier telephone utilizing power-transmission line. 2. It is used for the command of air-defense forces.
Special loud-speaker type A and B.	Continued.
Special information indicator.	It is used for the rapid transmission of air-defence informations.
Voice power loud speak.	Continued.
Fixed Intelligence radio apparatus.	1. Direction finder. A. Fixed type for short wave. B. Fixed type for medium wave. C. Some fixed type for short wave. 2. Command giving device this equipment has secret device to send enemys signals to remote direction finder. 3. Equipment to find out objecting point. 4. Receives: A. Fixed type. B. Semi-fixed type. They involve recorder and can receive weather broadcasting.

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VHF multiplex radio.	Continued.
Wire communicating instruments for marine use.	Various kinds of communication instrument for marine use (telephone, loudspeaker, information indicator etc.)
Boat directing indicator.	1. Light beam direction indicator 2. Radio direction indicator.
General information indicating map for air-defence forces.	Maps which indicate rapidly radio-locator informations.
Electric warning apparatus.	Continued.
Apparatus for electric source.	Continued.
Dry cell.	Continued.
Battery.	Continued.
Hand generators for receiver.	This is used for radio which use 1 volt class receiving tubes.

Part V. Miscellaneous.

Various kinds of parts.	Continued.
Development of standard equipments.	Continued.

AT 1944. Part II Radio Communication Apparatus. (From July onward)

Super heavy radio.	Continued.
Boat radio fixed type.	Continued.
Method of mounting radio	Continued.
Boat radio C	Continued.
Study of frequency stabilization.	Continued.

Part I. Wire Communication Apparatus.

Wire numbering tele-typewriter.	Continued.
Commanding telephone for air base.	Continued.
Carrier telephone and telegraph.	1. Heavy type multiples telephone and repeater. 2. Medium type " 3. Light type " 4. Carrier telegraph. All continued.
Telegraph switchboard.	Continued.

Part III. Special Communication apparatus.

Special visory commanding apparatus.	Continued.
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Special commanding telephone.	Continued.
Special commanding telephone switchboard.	Continued.
Special wire broadcasting instrument.	Continued.
Special Power-transmitting line carrier communication apparatus.	Continued.
Special loudspeaker.	Continued.
Special information indicator.	Continued.
Voice-power loudspeaker.	Continued.
Fixed intelligence radio.	Continued.
VHF Multiplex radio.	Continued.
Wire communicating instruments for marine use.	Continued.
Boat direction indicator.	Continued.
General information indicating map for air-defence forces.	Continued.
Single side band receiver.	It can receive SSB wave of each channel separately.

Part IV. Power Source.

Dry cell. Continued.

AT 1945. Part I. Wire Communicating Equipments.

Light type multiplex telephone.	1. Channel- 3 2. Line-loss - 30db or more 3. transport-mounted on horse.
Medium type multiplex telephone.	1. Channel - 6 2. Line-loss - 60db or more. 3. transport - mounted on a car.
Repeating set of the upper.	Two line type.
Simplified line tester.	It is used to check the state of line and detect the troubles simply; and is for air-defence forces.
Two line telephone repeater.	Continued.
Multiplex numbering tele-typewriter.	As planning to multipleximate the numbering tele-typewriter.
Time division multiple telephone.	Are researching a small and light multiplex telephone using time division method.
High frequency wire communication equipment.	It can construct many jacks in the band from 100 to 150Kc
Power-transmitting line carrier communication equipment.	To construct communication system for proper-defence, we are researching the carrier communicating equipments to utilize power-transmitting lines.

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Part II. Radio Communicating Equipments.

<u>Item</u>	<u>Content</u>
Study of frequency stabilization.	Continued.
Air transportation of fixed radio.	Researching the methods of disassembling 2Kw radio and super heavy radio for air-transport, and easy assembling at the front.
Method of mounting radio.	Researching how to mount radios on vehicles, vessels etc
Method of connecting wire equipment to radio.	Researching the methods to multipleximate the regular type radio connecting with wire multiplex communicating instruments.

Part III. Special communicating equipment.

Special power-transmitting line carrier communicating equipment.	Continued.
AC method special information indicator.	for air-defence forces.
General information indicating map for air-defence forces.	Continued.
	- For vehicle use: Frequency -- Super VHF Channels - 6 Vehicles for mounting - radio car antenna c: truck - Movable type (mounted on horse) Frequency -- Super VHF Channel -- B - Fixed type: Application of Communication Bureau "A" type instrument to military use. - Semi-fixed type: Communication Bureau "B" type.
Fixed single side band radio apparatus.	Research conversion at the front of fixed radio instruments to SSB operation by means of adapting apparatus.
Fixed intelligence radio. Tele-type receiver.	Continued. Continued.
Simplified communication instruments and methods.	Easily handled and manufactured communication instrument for guerrilla corps or general mobilization forces; and methods of communication for the leading of guerrilla corps.

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VHF intelligence radio.

1. Direction finder especially for FM wave.
2. Receiver for both AM and FM wave in zone of 20 to 300 MC.

Research on the disturbance of every radio.

1. One stick disturbs the communications among aeroplanes and among tanks.
2. We are researching the efficient use of special transmitter which now arranging accounting proper landing.
3. Are researching on counter-plot for "dema" broadcasting.

Synchronizing apparatus. Are researching on simplified and more stable one.

Part IV. Miscellaneous.

Research on vacuum tube. Regulating and scale.

Part V. Power Source.

Research on substitute fuels. Planning to use Alcohol and Charcoal for power source motor.

AT 1945. From July Onwards.

Part I. Wire Communicating Equipments.

Medium type multiplex telephone and repeater.	Continued.
Heavy type multiplex telegraph and repeater.	Continued.
Power-transmitting line carrier communication equipment.	Continued.
Simplified line tester.	Continued.
Two line telephone repeater.	Continued.

Part II. Radio Communicating Equipments.

Method of mounting radio.	Continued.
Study of frequency stabilization.	Continued.
Method of connecting wire-equipment to radio.	Continued.
Narrow band radio.	Utilizing good characteristics of narrow band receiver, we are researching on a super-small and long-distance radio.

Part III. Special Communicating Equipments.

General information indicating map for air-defence forces.	Continued.
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Fixed single side band radio apparatus.	Continued.
VHF multiplex radio.	Continued.
Fixed intelligence radio.	Continued.
Tele-type receiver.	Continued.
Simplified communication instruments.	Continued.
VHF Intelligence radio.	Continued.
Disturbance of enemy radio.	Continued.
Synchronizing apparatus.	Continued.

Part IV. Miscellaneous.

Regulating and scale of parts and materials.	Continued.
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THE SIXTH MILITARY LABORATORY

THE OTTUMSURE

<u>Term</u>	<u>Items of research</u>	<u>Researches</u>
1940-1941	Flame shell.	1. Flame shell for field gun and mountain gun. 2. Flame shell for light mortar.
	Gas shell.	Gas shell for light mortar.
	Flame throwing tank.	Flame throwing tank by modifying medium tank.
	Discharge device of gas from cylinder	1. Fixed method of blowing off gas. 2. Discharge nozzle.
	Materials for closed quarter fighting.	1. Projecting toxic candle. 2. Hand throwing (HCH bottle).
1941-1942	Flame throwing tank	Prevention from leakage of flame agent.
	Discharge device of gas from cylinder.	1. Travelling device of blowing off. 2. Discharge nozzle.
	Rocket gas shell.	Finned gas shell.
	Gas effect.	Theoretical research of gas effect.
	Approval of gas in field.	1. Sampling method of gas. 2. Analyzing method in field.
1942-1945	Flame throwing tank.	Increase of carrying capacity of flame agent.
	Discharge device of gas from cylinders.	Travelling device of blowing off.
	Rocket gas shell.	Progress in accuracy of finned rocket gas shell.
	Approval of gas in field.	1. Self-recorder of gas concentration. 2. Method of analysis in field.

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1942 -1945 Materials for closed
quarter fighting.

1. Flame projector.

Hygiene and Medical treatment

1940-1941 Fundamental research
of toxicology.

1. Suffering action by HCN. 2. Lethal products
of anti-freezing mustard gas.

1940-1942 Toxicology and first aid
treatment of poison gas.

1. First aid treatment and prevention from
suffering by HCN. 2. Auxiliary research of
toxicology of mustard gas.

1942-1945. Fundamental research of
toxic mechanism, and toxicology
of gases. First aid treatment of gas
suffering.

1. Pathological and biochemical research about
toxic mechanism of mustard gas, poison gas
and HCN. 2. First aid treatment of mustard
gas suffering. 3. Toxicology and first aid
treatment of new poison gases.

Synthesis of poison gas

1940-1941 Rationalization of
synthetic method of
poison gases

1. Mustard gas by means of acid earth and act-
ivated earth as synthetic catalyzer. 2. Diphenyl
cyanoarsine by modifying of the secondary
condensation process. 3. Diphosgen by prevention
from explosion of methylester of formic acid
for this course of chlorination.

Synthesis of new
poison gas.

1. Hydrogenerate ketones.
2. Arsenic compounds of phridine. 3. Increase
of suffering effect of anti-freezing method.
4. Metallic carbonyl.

Properties of poison
gas.

1. Deterioration mechanism of HCN, by examination
of cause and mechanism. 2. Stabilizing agent of
HCN. 4. Spectroscopic research in the measures
to apply to identification of gases.

1941-1945 Rationalization of
synthetic method of
poison gases.

1. Mustard gas from thiodyglycol throw simple
and continuous operation. 2. Mustard gas from
ethylene through ethylene oxide.

1. HCN from Hydrocarbons and ammonium, with
alumina as catalyser. 2. HCN from CO and ammonium
with alumina or ammonium alum as catalyser.
3. HCN from charcoal and ammonium.

1. Condensation and isolation of HCN from coal
gas. 2. Applying of waste chlorine from
magnesium refinery.

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1941-1945 New poison gas.
Properties of poison gas.
1. Poison gases to pass through canister without absorption. 2. Plant product poison.
1. Searching for stabilizing agent of HCN.
2. Spectroscopic research of poison gas.

The defensive

1940-1941 Gas mask.
Restoring device of absorbing capacity of canister.
Protective gas outfit for horse.
Decontaminating materials.
Gas detector.
1. Direct type gas mask (without flexible tube)
2. Modification of adsorbent.
Fundamental research of restoring device mounted on carrier.
1. Horse mask. 2. Horse boots 3. Horse cape.
1. Decontaminating vehicle. 2. Decontaminating device, horse mounted. 3. Modification of decontaminating box (Bleaching powder container)
1. Modification of CO detector. 2. Automatic CO detector.

1941-1942 Gas Mask.
Restoring device of adsorbing capacity of canister.
Protective gas outfit for horse.
Decontaminating material.
Gas detector.
Protective suit for tropical zone.
1. Direct type gas mask (without flexible tube)
2. Gas mask for civilian use. 3. Modification of auxiliary adsorbent.
Restoring device mounted on carrier.
1. Modification of horse mask. 2. Modification of horse boots.
1. Decontaminating vehicle. 2. Decontaminating device, horse mounted.
1. Detector to decide the chance to take mask off. 2. Detector to identify the variety of gases
Protective suit not to be air tight.

1942-1945 Gas Mask.
Restoring device of adsorbing capacity of canister.
Gas detector.
Protective gas suit for tropical zone.
Modification of auxiliary adsorbent.
Fixed type restoring device.
1. Detector to decide the chance to take mask off. 2. Detector to identify the variety of gases.
Protective suit, not be air tight.

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SEVENTH MILITARY LABORATORY. (Formerly the 1st Div of the Mil Lab)

<u>Item</u>	<u>1940-1941</u>	<u>1941-1942</u>	<u>1942-1945</u>
Fundamentals of rocket arms.	Theory and start-mechanism of gun powder rocket.	Continued	Fundamentals of arms utilizing theory of gun powder rocket.
Non-recoiling gun.			Fundamentals of several kinds of non-recoil gun (begun in 1943).
Fundamentals of liquid fuel rocket.			Application of liquid fuel to rocket arms for saving of gun-powder (begun in 1944).
Electric projector.	Fundamentals mechanism utilizing electric power for projector.	Researches of flying state of projectiles near the muzzle conducted by electric projecting device.	Continued.
Fundamental of bofed explosive.			Fundaments of reaction of packed explosives with holes (1942-1943)
High velocity nonrifled gun and finned projectiles.			Use of finned projectile to obtain flat trajectory or long range (1942-1943).
Wind tunnel for research of projectiles.	Wind tunnel for researches of rifle bullets.	Wind tunnel for field gun projectiles.	Continued.
Photo-telephone.	Long distance photo-phone.		
Fundament of optical weapons.	Long range field glasses and photographic observation.		
Fundament of television.		Simplification and weight reduction of television apparatus.	Continued.
Fundament of nocto-vision.	Apparatus for observation.	Light filters photo-sensitive surfaces and electric lenses.	Continued, and also use of ultra-violet rays.

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Application of
gyroscope.

Fundament of
heat rays.

Remote control by
light rays.

Fundament of
under water
detection and
location.

Underwater
sound trans-
mission con-
ditions.

Wireless remote
control.

Ultra-short
wave.

Magnetic mine
sweeping
devices.

Application of
magnetism
to arms.

Engines using
substitute
fuels.

Method for locating
sound source by use
of audible and super
sonic waves.

Method of control
by short wave radio.

Location of moving
bodies by use of
radio-waves shorter
than ultra-short wave.

Laboratory researches
for various kinds of
substitute fuels and
engines.

Continued.

Continued.

Electric auto-
motive wheels.

Horizontal stabilizatio
by gyroscope (started
1943).

Application of thermo-
piles and bolometer for
the observation of
heat source (started 1943).

Optical method for de-
tecting change of dir-
ection using a compass
(started 1944).

Improvement of under-
water microphones, (
started 1943).

Influence of various
water conditions upon
the propagation of aud-
ible and super-sonic
sound waves. (started
1943).

Long distance remote
control (starte 1944).

Sweeping devices for
the army (started 1944).

1. As a method to meet
magnetic mines.
2. Distribution of mag-
netism of underwater
field of steel vessels
(started 1944).

1. Steam driven vehicles
2. Electric auto-motive
wheels.

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Submarine
transport.

Submarine transport for
transporting munitions
and materials (1943-44).

Towed under-
water vessels.

Towed submarine vessels
for the transportation
of military materials
(started 1944).

Treatment of
metals in
vacuum.

Structure of steel,
heat treated in a
vacuum.

"Koha"
(Neociamine)

Physiological effects of
"Koha" (started 1943)

Strengthening
of night eye
sight.

Strengthening of sen-
sitivity for light
and methods of night
seeing by peripheral
sight (started 1943).

CONFIDENTIAL

THE EIGHT MILITARY LABORATORY

Outline of researches since 1941 year.

1941-1942 (At the laboratory in the old Army Technical Center).

I. Metallic Materials.

<u>Item</u>	<u>Outline</u>	<u>Note</u>
Researches on metals for armor plates and armor piercing shells.	Experiments on the metal alloys of economized amounts of Ni, Mo, and other special elements for substitute armor plates. Thickness 4-50mm.	Those which have over 50mm thickness are studied at the Laboratory in the Asaka Arsenal.
Researches on springs.	Experiments on fatigue and recovery of various springs for the purpose of obtaining metal alloys of superior quality. Experiments were done also on torsion bar.	Continued from the previous year.
Researches on brittleness of steel at low temperature.	Experiments to establish the composition, by which the steel has low brittleness even at -40°C, in order to obtain steels of superior quality at low temperature.	Given up in 1941.
Researches on preservation of metals.	Experiments on various metal platings in order to increase preserving quality of metals. Special effort was directed to rustproof method.	Continued from the previous year.
Researches on jacket of ball cartridge.	Experiments on phosphoric acid salt coating on rifle bullets to economize Ni, Ca etc., and its utilization.	Given up in 1943.
Researches on metals for iron cartridge.	Experiments on D-metal as substitute of copper bronze in cartridge for cannon.	Transferred to the Osaka in 1943.
Investigation of specification of metallic materials.	Investigation of fundamental facts for establishment of specification of metallic materials.	Continued from the previous year and established the new specification in 1944.

2. Non-metallic materials.

Researches on rubber.	1. Improvement of quality of rubber (properties towards heat, oil, etc.) 2. Cementing substances with abundant supply (Zinc, white, carbon-black etc.)	
Researches on artificial resins.	1. Researches on substitute for phenol resin. 2. Synthesis of heat-proof organic insulating materials for high frequency electrical wave. (Synthesis of Vinyl Carbazol)	
Researches on oils and fats.	1. Preparation of solid form palm oil and volatile oil. 2. Recoil oil for cannon.	
Researches on fibre and lumber.	1. Type cord of artificial silk. 2. Moisture proof materials of paper. 3. Strengthening of lumber, by injection of resin. 4. Durable fibre for primer.	
Researches on paints.	1. Solid camouflage paints. 2. Investigation of fundamental facts on establishment of specification of paints for military use.	
Researches on flame agents and smoke.	1. Agents for flame ejector. 2. Researches on fundamentals of screening property of smoke.	
Researches on active carbon.	Fundamental researches on simplified method of production of active carbon from easily obtainable raw materials.	
Opanol	Researches on polyiso butylene as insulating material of high frequency electrical wave. Catalyst: Boron trifluoride.	Continued from the previous year. Succeeded in lab. in 1944.
Researches on Polystyrene resins.	Creation of polystyrene type resins of high softening temperature and good insulating quality.	Continued from the previous year.
Researches on recoil oil.	Creation of recoil oil which can be used even at -40C. Use triethylene glycol as the chief ingredient.	Completed in 1944.
<u>Year 1943-45. I Metallic Materials.</u>		
	Production of steel by making use only of home resources and industrial accommodations and yet to meet the specification.	
Researches on sintered iron.	1. Driving band. Experiments on 20-47mm and 75mm sintered iron driving band for the purpose of economization of copper. 2. Shaft bearing. Only preparation of experiments was done.	Mitsubishi Kogyawas given in charge of research.

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Decarbonization of ball cartridge and jacket.	Surface decarbonization of ball cartridge and jacket for the purpose of economization of Ni and Cu.	Cooperation with the first military Laboratory and Tokyo first Basenel.
Researches on pure iron.	Researches on: 1. Iron carbonyl. 2. Ferrital.	1. Edoyama Koyosho and 2. Yawata Seitetsujoair in charge.
Researches on metallic parts of vacuum tube.	Utilization of pure iron for the material of plates etc in the vacuum tube for economization of Ni.	
Researches on light alloy.	Utilization of recovered material and low grade light alloy.	Toho Sangy Lab. in charge.
2. <u>Non-metallic materials.</u>		
Researches on rubber.	Improvement of qualities of rubber application of rubber as buffer and researches on the plants grown in the country and have rubber like exudation.	Continued from the previous year. Researches on the plant started in 1945.
Researches on artificial resins.	1. Creation of heat-proof arganie insulating materials for high frequency. 2. Synthesis of lignin resin. 3. Synthesis of furfural resin.	
Researches on fats and oils.	1. Creation of substitute of "grease" and petrolum. 2. Substitute of cutting oil. 3. Synthesis of superior quality lubricating oil for watches.	
Researches on fibre and lumber.	1. Application of craft paper as materials of arms. 2. Substitute felt. 3. Substitute for Lignum Vitae. 4. Vermifugal method of lumber for ship building.	
Researches on paints.	1. Researches on non-cuprie and non-mercurie paints for ships bottom. 2. Establishment of specification for paints of military use. 3. Fire-proof paints.	
Researches on smoke.	Investigation of practicability of some smoke agents.	
Researches on active carbon.	Industrialization of simple manufacturing method of active carbon.	Continued from the previous year.

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Researches on cell.	Creation of heat-proof moisture-proof good keeping dry cell.	
Researches on cement.	Establishment of simple manufacturing method.	
Researches on materials for optical weapons.	1. Preserving property of photographic plates. 2. Membranes transparent to ultra-violet and infra-red light.	
Researches on night-luminous agent.	1. Researches on luminous bacteria. 2. Sea firefly. 3. Synthesis of Chemiluminescent substances such as luminol.	Completed.
Researches on Rocket propellant.	Application of nitric acid and liquid ammonia to rocket propellant.	

NINTH MILITARY LABORATORY

<u>Item</u>	<u>Details</u>	<u>Contents</u>
Fundamental Research of the ultra short waves.	1. Emission of waves.	At 1940. Successfully emit 20Kw at 3m wave-length, and 30W at 20cm wave-length. At 1941. Successfully emit 10Kw at 2m wave-length, and 50W at 20cm wave-length. In October the system of laboratories was changed and these researches were transferred to 7th Mil. Lab. At 1943. With advance of research the need of the powerful emission was keenly recognized so the same study was continued again. At 1944. Method of emission of 30Kw at 80cm wave-length and of 1Kw at 20cm wave-length were completed. At 1945. On the purpose of powerful emission, 6 watt apparatus parallel feeded several valves of 200 watts was designed. On the course of its construction at Hokuan Branch-office the war finished.
	2. Focusing of waves.	At 1944. The conditions of the electric field distribution of the reflecting mirrors were investigated in details. At 1945. A 10M dia. ellipccoidal mirror was designed.
	3. Valves.	At 1940. Fundamental study on producing "Magnetron" and "Triode" valves. At 1941. The study was transferred to 7th Mil. Lab. At 1943. The design of powerful emission valves was begun again. At 1944. The Magnetron of 30Kw at 80cmwave-length was completed. At 1945. The Magnetron of 300Kw at 80cmwave-length was designed.

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| 4. Materials for the valve and the insulator. | At 1940. Porcelain insulator of low loss angle was researched.
At 1941. The study was transferred to 8th Mil. Lab. |
| 5. Radio-locator applying the principle of "Doppler Effect" | At 1940. Fundamental principle was studied.
At 1941. The study was transferred to 7th Mil. Lab. |
| 6. Effects against living things. | At 1940. Injuring effects against mouse and mormot in the field between condenser plates were studied.
At 1941. The further study on the ellipsoidal focus was carried out.
At 1942. The causes of effects were studied physiologically and pathologically.
At 1943. 2m - 60cm waves cause haemorrhage of lungs. Shorter waves than those mentioned above destroy the cells of brain.
At 1944. The same effect were studied in the radiating electric field in the distance of 10 - 30m from mirror.
At 1945. The same investigation in the strong field were stopped due to the termination of war. |
| 7. Effects against motor engines. | At 1942. Stopping of motor car engines was studied.
At 1943. Uncomplete shield engines were easily stopped by tuned waves.
At 1944. Study against aeroplane engines was not successful owing to its good shielding.
At 1945. Effects of the wave passing through the gap of the engine-cover were investigated. |
| 8. Chemical effect. | At 1940. Synthesis of nitric-acid by spark discharge of ultra short wave was studied.
At 1941. Improvement of viscosity of lubricants by the same method was studied.
At 1942. Study of derivatives of Acetylene by the same method was carried out.
At 1943. Continued.
At 1945. Study of chemical effects in the strong field was intended. |

<u>Item</u>	<u>Details</u>	<u>Contents</u>
Research on the Artificial thunder utilizing electrically charged powder.	At 1940. The artificial thunder was studied by using the electrostatically charged powder which was blow out by high speed air stream. At 1941. The research was continued by using various kinds of powders (about 50) and it was found that starch powder gave the most charge i.e. several coulomb per 1 gm of the powder.	

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At 1942. Powerful discharges took place when these charged particles were blown into a case of conductive material, but it was found that the strong discharge such as found in nature was impossible to get by this kind of methods. The research item was therefore given up owing to hopelessness of military use.

Research of Detection of Electro-magnetic wave due to the Ignition-spark.

At 1940. The frequency distribution of the ignition spark of aeroplane engine was investigated but the district maximum point was not observed.
At 1941. After investigations of various kinds of receiving methods, the super-regenerative method of several meter wave-length was adopted.
At 1942. By a receiver for 6m wave with "Yagi" antenna, it was able to detect in 10Km in distance apart. But according to the splendid progress of the radio-locators, this investigation was given up.

Research of solid fuel engine.

At 1940. The method of driving an engine with solid fuels was studied in order to recover the shortage of liquid fuels.
At 1941. After testing various kinds of powders, it was found that the lycopodium is the best, but this material is not obtained sufficiently; therefore the study using coal powder was carried out.
At 1942. Though engines were driven in some way with coal powder, the investigation along this line was given up by errasion as well as the importation of gasoline from the south.

Research of Bombing Balloon.

1. The balloons used for distributing of propaganda-bills.

At 1940. The balloons 1.5 - 1.8 dia were studied and almost accomplished.
At 1941. The accessories balloon burning methods hydrogen fitting tools at night and locating tools were nearly accomplished. The manufacturing of the paper balloons were investigated.
At 1942. Manufacturing was continued.
At 1943. Ditto.

2. The balloons 4-6m dia, for air defence.

At 1941. The balloons 4-6m dia. for air defence were studied.
At 1942. The same study was continued and those manufacturing methods were carried out.

3. The balloons aiming at the flight 3000Km distance.

At 1942. After air raids upon Tokyo this research was ordered and carried out with 6m dia. balloons.
At 1943. In February this flight was tested shooting from the western part of Japan and the possibility attending 1000Km away was confirmed. In August the flying records of 30 hours were attained but the practical use was not carried out but because the lack of navy submarines.

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<u>Item</u>	<u>Details</u>	<u>Contents</u>
4. The A type Balloons aiming at the flight of 1,000 Km distance.		At 1943. In September the researches with 10m dia. balloon at the height of 10Km were ordered and carried out. At 1944. In February and March the flight was examined by employing 200 balloons since April its improvement and manufacturing were carried out. At 1945. Till April practically use was continued and almost in this interval, some improving researches were accomplished but the further researches were stopped according to instruction of the headquarter.
5. The B type balloons of the same purpose.		At 1943. The fundamental researches were commenced on the different principle from A type. At 1944. At the beginning of the year the testing man- ufacturing was commenced. In August after the test of flight its good character was confirmed. At 1945. Since March its manufacturing with the purpose of practical use was commenced, but was stopped by the burnt down by the air raids in this month.
6. The mechan- izing of the man- ufacturing and pasting of papers aiming at the mass production of paper balloons.		At 1941. The producing apparatus of papers were equipper and its fundamental researches were commenced. At 1942. The pasting apparatus were equipped and the producing and pasting were carried out. At 1943. The same studied were continued, but sufficien strength of paper was not obtained. At 1944. As the result of continuing research raw material almost good character stronger one than that mentioned above however, was not obtained. At 1945. With the stoppage of the practical use of bombing balloons these researches were perfectly stopped.
7. The product- ion of Hydrogen gas.		At 1940. With the purpose of using for propaganda balloons the simple producer wagon that utilizes ferrosilicon and sodium hydro-oxide was studied and accomplished. At 1941. The fundamental study of the producer that produces the hydrogen gas by discomposision of ammonia liquid was carried out. At 1942. It was nearly accomplished but the perfect producer wagon was not realized. At 1943. The manufacturing of hydrogen calsium was studied. At 1944. Utilization of hydrogen calcium for balloon did not and was not brought about owing to not using of submarines. The liquid hydrogen and its holders were then studied with the purpose of automatic supply of hydrogen during the flight of balloons.

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At 1945. The researches were stopped.

8. The shooting and inspecting methods of balloons.

At 1943. The studies on the shooting and inspecting method of balloons were commenced.

At 1944. The same studies were continued and the motion of balloons in upper sky were practically inspected in many ways.

At 1945. The researches were stopped.

9. Weather in high altitude on the Pacific ocean.

At 1943. The investigation to observe general conditions of the weather in high altitude over the Pacific ocean was commenced.

At 1944. By the calculation on the bases of various data on the sea surfaces, complete data of the weather in high altitude over the Pacific Ocean in winter were obtained.

Research on the Ultra-high tension X-ray.

At 1941. The apparatus that produces 1 million volt X-ray and neutron was designed.

At 1942. Its apparatus was experimentally produced.

At 1943. That x-ray apparatus was accomplished and settled. Then during studying its operation its military uses were to be found.

At 1944. The investigations were stopped, because of not finding proper military use.

Research 1. Small sized of wireless communication.

At 1940. For use in the troops which can be readily movable, against the enemys action, the researches on the radio-apparatus which are small-sized and able to communicate for a long distance were commenced.

At 1941. The very small sized short wave transmitter and receiver which can communicate as far as about 500Km was accomplished. The research on the DC generator as a portable electric source was commenced.

At 1942. The small sized radio-apparatus which can communicate as far as about 1,000Vm was accomplished.

At 1943. The small sized radio-apparatus, last mentioned was improved and simplified.

At 1944. The production of the radio-apparatus and generator, last mentioned, was begun. To solve difficult problems about the production of the regular apparatus, the research on the simple transmitter and receiver was commenced.

At 1945. The production of the apparatus last mentioned was continued. The simple transmitter and receiver were accomplished. When the production of this apparatus was begun the war finished.

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2. Direction finding.

At 1941. As a part of the equipment for use in the military police, the researches on the direction-finding were commenced to detect the secret radio-transmission. The small direction-finder for a short distance as far as about 1,000m was almost accomplished.

At 1942. The small direction-finder, last mentioned, was improved. The portable direction-finder, which can locate as far as about 10Km was almost accomplished.

At 1943. The portable direction-finder, last mentioned, was improved, and could find the range about as far as 40Km within the error of plus or minus 5°.

At 1944. The production of last mentioned two types was commenced. The radio wave-form discriminator, which used the Brown-tube, was accomplished. Discrimination of the wave-form of A₂ type radio-waves and finding the range of the scattering-wave zone containing the ground wave were realized.

At 1945. The production, last mentioned, was continued.

3. Noise suppression.

At 1942. The researches of suppression of the noise on the purpose of increasing the receiver-sensitivity i.e. signal to noise-ratio were commenced.

At 1943. Suppression of some kinds of noises by utilizing the time-constant of the electric-wave filter succeeded.

At 1944. The researches were stopped.

4. Radio-Sonde for the bombing balloon.

At 1943. Researches on various sorts of radio-sonde were carried out enthusiastically. According to utilization of the suppression-grid modulation by multi-vibrator, the distinguishing tone could be heard, and prolonged the measuring distance.

At 1944. To find the range of far long distance especially, radio-sonde, output of which was about 40 watts, was accomplished.

At 1945. Researches were stopped.

5. Researches 1. Camera for of of Photo-graphic materials. special uses.

At 1941. Composition of miniature camera for Leicatype was investigated and its preparation was carried out. At 1942. More simple miniature camera was studied. Researches for submarine camera and night-camera were begun.

At 1943. The same study mentioned before was continued. Researches for simple telescope photography were carried out.

At 1944. Portable telescopic camera was improved. Some kinds of those mentioned before were prepared.

At 1945. The production of these camera was carried out on a small scale in view of the war situation.

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2. Photocopying apparatus.

At 1941. Simple photographic copying apparatus was studied.

At 1942. Portable photographic copying apparatus was studied and was used in practice.

At 1943. Speedy photographic copying camera was designed and constructed.

At 1944. Some kinds of those mentioned before were prepared.

At 1945. The production of those camera was carried out on a small scale.

3. Photographic materials.

At 1941. Researches of fine photographic emulsion for good preservation were carried out.

At 1942. Continued, ditto.

At 1943. Photographic materials use in the tropical zone was studied by war requirements.

At 1944. Portable suits of copying and developing apparatus for the field use was designed and instructed

At 1945. The production of those apparatus was partly begun.

Researches of Propaganda apparatus. 1. Scattering method of propaganda bills.

At 1940. Scattering by the small paper-balloon was investigated and tried in the field frequently.

At 1941. Simple scattering method of bills from aeroplanes was completed by war field requirement.

At 1942. Paper-made shells to use for the scattering of bills and its projection was studied. Paper-made bombs for the same use were designed.

At 1943. Rocket for use of scattering propaganda bills was designed and tried practically.

At 1944. The production of some kinds of weapons mentioned above was carried out to some extent.

At 1945. Researches for production mentioned above were stopped in view of the war situation.

2. Loud speaker and recording apparatus.

At 1941. Portable loud speaking apparatus was investigated. Sound recording apparatus, reproduction apparatus and sound recording plate were studied.

At 1942. Improvement of the apparatus before mentioned were carried out and some apparatus were used in war fields.

At 1943. Propaganda motor car equipped with large loud speaker and radio receiving apparatus was designed and constructed.

At 1944. Continued ditto. Armoured car equipped with large loud speaker was planned owing to war field requirement.

At 1945. The researches mentioned before were stopped but some preparation were continued.

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Researches of equipments for the use of Military Police.

1. Identification equipment.

At 1941. Identifying method by means of ultra-violet light, infra-red light, x-ray identification was studied.
At 1942. Systems of physical and chemical identification were investigated.
At 1943. System and apparatus of legal medical identification were investigated.

2. Detective equipment.

At 1941. Researches for finger-print equipment were begun.
At 1942. Identification equipments to the scene were studied.

3. Search equipment.

At 1943. Continued ditto.
At 1942. Various search equipments were studied.
At 1943. Continued ditto.

4. Post censorship equipment.

At 1942. Letters opening equipments were studied.
At 1943. X-ray censorship equipments and detection of secret ink were investigated.

1. Identification equipment.

At 1944. Summary procedure for use of military police in field was studied. Production of those equipments as carried out in part.

2. Detective equipment.

At 1945. Production of those equipment was carried out.

3. Search equipment.

Researches of explosive and incendiary materials.

1. Explosives.

At 1941. Researches for simple mixed explosives by use of potassium chlorate were begun.
At 1942. Handy small light timed or packed explosives for use of volunteer attack corps was studied.
At 1943. Improvement of explosives mentioned before were carried out for the purpose of making them water-proof.
At 1944. Formative, compressed explosives and band shape explosives was studied for use of aeroplane and tank attack.
At 1945. The mass production of small packed explosive planned and carried out in part.

2. Incendiary materials.

At 1941. Researches of incendiary materials were fundamentally begun.
At 1942. Handy, small, light incendiary cans and compressed incendiary materials were studied.
At 1943. Improvements of making them water proof were studied and examined in the tropical war field.
At 1944. Shooting incendiary shells and scattering incendiary shells were studied. Researches of incendiary bombs for to use of balloon attack were carried out.
At 1945. The mass production of small compressed incendiary materials was carried out.

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3. Various types of fuse.	At 1942. Handy and simple fuses for use of volunteer attack corps were studied. At 1943. Simple, chemical and mechanical timer was studied and tried on fields. At 1944. Researches of pressure fuses for use of ball-coon explosion were carried out. At 1945. The mass production of small simple chemical timer was planned.
Researches of special portable equipment and tools for volunteer attack corps.	1. Equipment. At 1942. Improvement of climbing and fording tools was investigated and some types of them were used on war fields. At 1943. Portable bicycles was designed and utilized. At 1944. Handing diving-apparatus was designed. At 1945. Production was carried out in part. 2. Portable materials. At 1942. Water-proof, Ruck-sacks were designed and examined in the tropical zone. At 1943. Investigations of luminous plate, luminous and water-proof watch were carried out. At 1944. Water-proof and hoble matches. At 1945. The mass production of water-proof and unax-tingues hoble match was planned. 3. Provisions and vital agent. At 1943. Researches os portable provisions and vital agent for mountaineering and increasing vitality were carried out. At 1944. Methods of self-supply of provisions were investigated. At 1945. Production of those materials as planned in part.
Researches of chemical materials.	1. Synthesis of iron carbonyl compound. At 1940. Preparation of pure iron by means of iron carbonyl compound was carried out. 2. Preparation of lubricating oil. At 1940. Lubricating oil by means of ultra-short wave from vegetable oil was studied.
	1. Synthesis of iron carbonyl compound. 2. Preparation of lubrication oil. At 1941. The study was transfered to 8th Mil. Lab. owing to the change of the system of military laboratory in October.

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TENTH MILITARY LABORATORY

Established in 1944, and researches newly started.

Item	1944	1945
Renraku-tei (special attack boat)	Researches for speed-boats capable of close quarter attack; almost finished.	Further improvement being continued.
Landing motor boat.	Boats for landing of men, horses and vehicles; made of wood or veneer.	Several types and sizes completed and being continued.
Midget landing boat.	Boats for the surprise landing of a small number of men.	Temporary researches finished.
Escort boat.	Boats for the escort of landing craft.	Almost finished.
Transport craft.	Various types of craft for the transportation of men and materials.	Those made of wood or veneer finished. The increasing of capacity for steel craft (submarine transports) still continued.
Underwater attack boat.	Small boats for underwater attack, semi-submergible and fully submergible types.	Almost finished.
Patrol boat.	Boats for the patrolling of landing craft or the scouting of sea-base.	High speed veneer craft equipped with aircraft engine, finished and named "Igo-Kosoku-tei".
Submergible pill-box.	Pill boxes which can emerge at any time and attack landing craft.	Temporary researches finished.
Simple torpedo.	Those suitable for military craft, rocket type and electric type.	Continued.
Engines for military boats.	1. Marine engines: 120-130HP 600-1000HP 2. Application of aircraft and vehicle engines to marine use. 3. Application of substitute fuels to boats. 4. Steam engines for small boats; reciprocating type and turbine type.	Finished. This continued, destructed by air-raids. Some plans accomplished. Continued. Discontinued by reason of air-raids.

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(Translated from Japanese)

ARMY TECHNICAL HONORS

(Army concerns only. Board of Technic
has no relation) medals, honorable
certificate, rewards.

Showa 19 Sept

SUBJECTS

RESEARCHERS

REWARDS

1. Studies on manufacturing method
and on manufacturing installa-
tion for aviation gasoline from
kerosine by catalytic separation.

Hon Prof Imp U, Tokyo,
Tanaka Yoshio;
Asst Prof Tech Tokyo,
Kobayashi Rujioichi;
Avn Maj Gen Endo Yeihiro;
Fuel Centr Sec,
Lt Col Akashi Masamitsu;
Avn Tech Col Watanabe Hisa;
and other cooperators.

¥ 30,000

2. Studies concerning explosion pri-
nciples and application of explo-
sion powder.

Arm manf. Tokyo. Tech. L.
Col. Koboyashi Akio and
other cooperators.

A reward in
money.

3. Study on Forgeing patterns to
assist mass production of arms.

Mitsubishi Kawasaki Kiki
Engineer. Horicka Yonekichi

¥ 10,000

4. Study on the new manufacturing
method of synthetic rubber for air
plane uses and its industrial com-
pletion.

Ass. Prof. Kiyoto Imp Univ.
Furukawa Ryoze and other
cooperative workers.

¥ 10,000

5. Manufacture of Butanol from
sacharicus substances.

Prof. Taikoku Imp. Univ. Baba
Tamezo; Ass Prof. Takino Yos-
hinori and other cooperative
workers.

¥ 15,000

6. Study on making of nitrogen
in air as a food.

The Provision Dept. Booking
1st. L. Kuto Shiro; Engineer
Oyama Yeizo and other coop-
erative workers.

A reward in
money.

7. Studies on special sanitation.

Kantogun Anti-epidemic
Kiyusui Bu.

A reward in
money.

8. Study on filling devices.

Nagoya attached 1st L. Meiho
Shinichi and other co-workers.

A reward in
money.

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9. Studies on basic properties of special powder and its application as an arm. Tokyo Army Mfg. Tech. Maj. Yamada Masaaki; Prof. Imp. Univ. Tokyo, Nishimatsu Tadachi and other co-workers. A reward in money.
10. Examination method of optical glass and optical arm ports. Ass. Prof. Imp. Univ. Tokyo Kybala Hiroshi and other co-workers. ¥ 3,000
11. Studies on the continuous casting method of light metals. Sumitomo Kinzoku Kakaricho, Shikagoki Goro and other co-workers. ¥ 3,000
12. Studies on mass production of cylinder heads castings. Mitsubishi Jyukogyo Eng. Kawa- guchi Toras. ¥ 3,000.
13. Improvements on height efficiency of engine by general supercharging. Avia, R. L. Avia Tech. 1st L. Okazaki Takuro and Yeitanikane, and other co-workers. A reward in money.
14. Studies on wooden reinforced variable pitch propellers. Eny. Nihon Gatki Chiya Torao; Hirano Jiro and other co-workers. ¥ 3,000
15. "Chi No. 1" Direction finder design and manufacture. Pres. Auritsu Elect. Plant. I So Yeiji and other co-workers. ¥ 3,000
16. Locator. Tama Res. Lab. Tech. Cap. Nos- umi Sutekiyo; Attached Maida Toyaji; (same) Nakagawa Motogo and other co-workers. A reward in money
17. Electric wave height meter. Ass. Prof. Imp. Univ. Tokyo, Inou- ye Kin and other co-workers. ¥ 3,000
18. Studies on manufacturing method Iso-Octane from Butanol and manufacturing equipments. Dept. of Fuel, Avia. Tech. Maj. Kawano Mitsutoshi; Arm, Tech Col. Fukui Kenichi, Arm Tech. 1st L. Kuno Zenji and other co-workers. A reward in money.
19. Study on high complex synthytic fibers. Clothing Depot, Bkg. Maj. Nagano Mosamitsu, Bkg 2nd L. Matsuda Shin and others. Clothing material Dept Eng. Yomauhi Seichi and other co-workers. A reward in money.
20. Studies on manufacture of dye materials for normal temperature dyeing purpose and its application.
21. Manufacture of a new saving food for emergency. Food Depot Eng. Doye Masazo; (same) Fugiyama Yukichi; (same) Koyama Yeizo and other co-workers. A reward in money.

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| 22. Synthytic method of manufacture of vitamin B. 6 Adermin and its application on the fighting power. | Food Depot attch. Ichiba Okiyoshi, (same) Tado Koro Yoshitada and other co-workers. | A reward in money. |
| 23. The principles of Low Temperature Drying and its application on the war food and others. | Food Depot Attch. Monuki Toohiji; Eng. Koyama Yeizo and other co-workers. | A reward in money. |
| 24. Making of fibrous materials to Food and its mass production. | Food Depot, Baking 2nd L. Tomigane Mototaka; (same) Tsumeya Yuzo and other co-workers. | A reward in money. |
| 25. Studies on non re-inforced concrete Conic Drill type covering construction with the cover. | Aviat.. RL. Arch Tech. Cap. Nagasawa Makoto; Bkg 1st L. Shigi Takeshi and other co-workers. | A reward in money. |
| 26. Studies concerning frost bites. | Kantogun Med. LC. Ogata Tsunaji; Med. Maj. Matsumoto Chihiko; (same) Kojima Takeo. | A reward in money. |
| 27. Studies concerning dried pelesma. | Mil Med. Sch. Med. LC. Naito Riyyoichi. | A reward in money. |
| 28. Studies on sanitary water filtering devices for tropical region uses. | Mil. Med. Sch. Med. LC. Naito Riyyoichi, Med. Maj. Yeida Yeichi and other co-workers. | A reward in money. |
| 29. Automatic "Kona" type horse shoe nail manufacturing machine and its horse shoe nail arranging device. | "Han Ma" Ind. Plant. Hanma Shinsaburo and other co-workers. | ¥ 3,000 |
| 30. Studies on the mass production of hydrophobia preventive liquid and on the treating serum. | Kantogun Mil. Horse Anti-epid Depot. Ven. Cap. Yamashita Shiro and other co-workers. | A reward in money. |
| 31. Direction finder and error elimination method. | Communication Bureau. Eng. Hogihara Sei; Dept. Trans. Com. Sub-Eng. Tsumashika Yeizo. | ¥ 3,000. Hon. Cert. reward. |
| 32. Invention on the Residue heat valve and serial resistors. | Tech. Lab. Tech. 1st L. Saga Tomizaburo | A reward in money. |
| 33. Device on the simple manufacturing method of Colloidal Dynamite. | Tokyo Arm Depot. Tech 1st L. Suzuki Toyoji and other co-workers. | A reward in money. |

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| 34. The device on internal combustion engine valve grinding machine. | Kokura Arm Depot Head of workers. Mijahara Yeirchiro. | A reward in money. |
| 35. On moso production by improved treating method in steel bending chamber. | Pres. Of Sumitomo Kinzoku Steel mfg. plant. Yeshu Yenken. | ¥ 1,000 |
| 36. A device on Tungsten thermostat high temp. erotine meter for molten steel temperature measurements. | Sumitomo Kinzoku Steel mfg. plant Eng. Sugano Takeshi and other co-workers. | ¥ 1,000 |
| 37. Studies concerning the practical application of powder type charger. | Avia. Judging Depot. Tech. Cap. Umagoshi Tetsuo and other co-workers. | A reward in money. |
| 38. Studies concerning the practical application of special dispersion shell. | Avia Judging Dept. Cap. Kiryyu Seitaro and other co-workers. | A reward in money. |
| 39. Practical method on rapid spectrum and polarograph analysis of light alloy Retured Scraps. | Omori Norihisa, Sumitomo Kinzoku Shindo Plant. | ¥ 1,000 |
| 40. Application of copper alloys made from powdered materials. | Koga Deuki. Ishikawa Tadashi and other co-workers. | |
| 41. Method of reproduction of working blue prints by a Fine Setting method. | Avia. Eng. Depot. 1st L. Morishima Tadash and other co-workers. | A reward in money. |
| 42. Studies on metal pattern costing method. | Avia. Eng. Depot. Avia. Eng. 1st L. Watanabe Kasei; Eng. Nagakomi Kogio and other co-workers. | A reward in money. |
| 43. Manufacturing method of catalytically decomposed aviation gasoline for emergency. | Nippon Petroleum manager, Kimura Kan; Nakamura Shichuro, and other co-workers. | ¥ 1,000 |
| 44. Studies on prompt and simple tanning method, including insects preventing and dying by profitable use of the liquid from smoke. | Avia. R. L. Ekg Maj. Hori Michio, Att Sawayama Satoshi and other co-workers. | A reward in money. |
| 45. Studies concerning manufacture and utilization of cetyline fixation substances. | Nishin Chemistry. Eng. Yoyanagi Chogoro and other other co-workers. | ¥ 1,000 |
| 46. Study concerning fermentation refining of Moleberry skins. | Prof. Imp. Univ. Kyoto. Koto-giri Yei-ro and other co-workers. | ¥ 1,000 |

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47. Synthetic study on the strong structure dye stuffs. Prof. Imp. Univ. Tokyo Koki Yeio; Clothing Depot. Bkg Cap. Kumagawa Hachisaburo and other co-workers. ¥ 1,000
48. Development of substitution for dye stuff. Hoematoxyline used for organization examination. Vetinary School. Vet. Maj. Ichikawa Mai and other co-workers. A reward in money.
49. Studies concerning colloidal plaster and provisionalization of blood. Prov. Depot. Eng. Koyama Yeizo, Att. Monulsi Toshiji and other co-workers. A reward in money.
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53. Establishment of examination of horse Pyro-plasma. Kantogun mil. horse anti-epidemic depot. Eng. Ono Utaka and other co-workers. A reward in money.
54. Studies on the surface treating liquid for plane plate not using alabia, rubbers and past liquid for rubber punchings. Nanpo Gun Sokuju Div. Eng. Ono Rikiya and other co-workers. A reward in money.
55. Method of reviving vacuum tubes and method of uses. Com Bur. Suzuki Seiji and other co-workers. ¥ 1,000
56. Studies on the substances for prompt tuning. Yamaguchi Toshio and other co-workers. A reward in money.

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SYNTHETIC FUEL RESEARCHES

- | | |
|--|--|
| 1. Coal Liquification | Hokkaido Syn. Oil Co. |
| 2. Manufacture of alcohol and Butanol from Agriculture Products. | Dept of Mil Sup. Fermentation R. Lab. Army & Navy
Fuel Depot. Komatsu Shigern,
Kurono Kanroku. |

ALUMINUM POOR ORE TREATING RESEARCHINGS

- | | | |
|--------------------|----------------------|---------------------|
| 1. Alumite | Asada Chem. Ind. Co. | Himeji Shi |
| 2. Alumina | Nichiman Al. Co. | Toyama Shi |
| 3. Clay | Nitto Chem. R. Lab. | Omiya Shi |
| 4. Shika Numa Clay | San Kei Kougyyo Co. | Tojigiken Shikanuma |

TECH BU MEDALS (1944)

- | | | |
|---|---|------------------------------------|
| 1. Improvements on Periscope | Nippon Opt. Ind. Co. | Oshida Shizuma Kuroki
Naojiro. |
| 2. Two stage charging type "Stocker" combustion. | Kisha Mfg. Co. | Sotogawa Miyoshi |
| 3. Design and manufacture of working machines for aviation engines. | Nalsajima Airplane Mfg. Co. | Numatsu Takeshi |
| 4. Study on the electric wave height meter. | (a) Nippon Gakujitsu Shimko
Koi. (b) Dai Nippon Avia.
Tech Ass. | Hoshiai Masagi and 18
members. |
| 5. Studies on the Porcelain ignition valves for the aviation engines and their industrializing. | Hitachi Mfg. Co. | Yoshioka Fugisaku
and 2 others. |
| 6. Great improvements on ship building ability. | Hanna Ship Build. Co. | Rokuoka Shizo |
| 7. Study concerning electrical ore searching. | Denki Tanko Ass.
(Zaidan Hojin) | Iwasa Mosoku |
| 8. Studies on fundamentals of vacuum tube and on manufacturing technics. | Denshi Kogyo Sho
(Shibaura Elect. Tokyo) | Nishihori Yeisaburo |
| 9. Study on manufacturing of special color elements and applications. | Rikagaku R. Lab. | Ogata Kotaro |
| 10. Synthesis of Achylene Oxide by direct Oxidation of Achylene and Applications. | | Okamoto Go
Mitani Mitsuo |

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11. Studies on infra-red sensitive materials which are highly sensitive and storable.	Konishi (6) photo. Ind. Co; Fuji Photo Film Co.	Nishimura Ryyusuke, Kotani Masajiro Fujisawa Shin and 2 others.
12. New steel ingot manufacturing method.	Nippon Iron Wk.	Kondo Mitsuji Yeino Mankicbi
13. Manufacturing of large light alloy ingot.	Sumitono Kinzokn Ind.	Shikakogi Tachiro
14. Establishing of technic for light alloy forging.	Nihon Iron Work Co.	Ito Masao
15. Study on the adaptation of fields and their improvement for rice planting.	Dept. of Agri: Agri. Affair Exp. Depot.	Shioiri Matsusaburo
16. Studies on tuberculosis prevention vaccine by B.C.G.	Nippon Tech. Promoting Comm.	Kumaya Daizo and 16 others.

SUBJECT: DEATH RAY.

DATE: 3 October 1945.

INTERVIEWED: Lt Gen SHIMODA) Formerly in charge of the 9th Military
Maj Gen KUSAKA) Technical Laboratory, formerly at
Lt Col NIIZUMA) Noborito.

INTERVIEWERS: Drs Griggs, Moreland, and Stephenson.

1. Introduction.

a. For five and a half years the Japs have been working on a "death ray". This is based on the principle that very short radio waves focused in a beam of high power will cause physiological effects in mammals, resulting in death. The purpose of these researches was to develop a military weapon which would cause paralysis or death to any human being upon whom the beam was focused. It was thought that the most suitable military application might be as an antiaircraft device since the equipment is not easily portable and therefore not suitable to moving ground warfare. It might apply, however, as a coast defense or other fixed defense weapon for ground or sea attack.

b. The Japs thought this research sufficiently promising to spend about two million yen (roughly equivalent to two million dollars in purchasing power) on it, though it had not yet reached the stage of practical application.

2. General Organization. Research on the death ray was begun at the Ninth Military Technical Laboratory at Noborito (now under the command of Lt Gen Shimoda). The initial group working on this research was small and was diverted in October of 1941 to radar. The personnel were then transferred to other military laboratories. In 1943, research on the death ray was actively renewed at Noborito. Experiments in 1944 showed sufficient promise so that the program for 1945 was expanded. One million yen was appropriated for this research in 1945, and there were 116 men working on it. Gen Kusaba was in direct charge of this work and this was his only command. (His section had earlier done the work on the balloons which were released from Japan for "strategic bombing of the United States".) His personnel was divided as follows:

Technical Officers	20
Civilian Engineers	4
Civilian Consultants (part time)	12
Technicians	80 (10 EM; 70 civilians)

The principal civilian consultants were as follows:

Y Kusunose (dead)	Engr
Prof K Morita (Tokyo Tech College)	Engr
Asst Prof Nishimaki (Tokyo Tech College)	Engr
Prof Y Asami (Hokkaido University)	Engr
Prof T Minoshima (Hokkaido University)	Med
Prof Matsuoka (Tohoku University)	Med
K Hayashi (Kawanishi Factory at Kobe)	Engr
Dr T Ikebe (Nihon Koshuha at Hokuan)	Engr
Morimoto (International Communication Co)	Engr

RESTRICTED

1-E-3

The entries in the second and third columns represent the average number of spots of local hemorrhage discovered in the post-mortem. Very few of these animals survived the experiment.

b. In 1944, with the 80-cm - 30-kw magnetron feeding a dipole in a one-meter reflector, rabbits were killed in ten minutes at a distance of 30 meters. Marmots took 20 minutes. The experiments planned in 1945 were to use four 300-kw (input) magnetrons in parallel which were expected to give a total output of 250 to 300 kw. These were to feed a dipole in a 10-meter diameter ellipsoidal reflector. It was calculated that this apparatus would kill a rabbit in ten minutes at a distance of one kilometer. As will be seen from the table above, wave lengths shorter than 80 cm appear to be more effective. The research at Woborito was concentrated on a 80 cm because this was the shortest wave length at which they knew how to build output oscillators.

c. Throughout this program experiments were tried on the effectiveness of short-wave radiation in stopping engines by causing pre-ignition. It was found that the radiation was effective in this respect only when the engine was unshielded and it was sometimes necessary to tune the ignition system to the frequency by varying the length of the ignition cable. All experiments against shielded airplane engines were unsuccessful.

5. Future. With the development of higher-power and shorter-wave length oscillators, which has become possible through the Allied' research on radar, it is possible that a death ray might be developed that could kill unshielded human beings at a distance of five to ten miles if these Japanese experiments are reliable indications of the potentialities of the death ray.

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CONFERENCE WITH PERSONNEL OF 7TH MILITARY
TECHNICAL LABORATORY

SUBJECT: Research Program of 7th Military Technical Laboratory

DATE: 13 October 1945

INTERVIEWED: Maj Gen M NOMURA (Dir, 7th Mil Tech Lab), Col
T MINAMITANE, Lt Col (Engr) T TAKISHITA

INTERVIEWERS: Dr H K Stephenson, Maj H E Skipper, Lt Yamada

GENERAL. Maj Gen Nomura explained that he had been director of the 7th Military Technical Laboratory since September, 1944. The laboratory was dispersed because of bombing raids, and at the end of the war, research was being carried on in Tokyo, Kannonzaki, Kanizawa (Ishikawa Pref), Matsumoto (Nagano Pref), and Ito (Suduoka Pref). The information below on the work of the 7th Laboratory is derived from written material submitted by Gen Nomura and his aides, and from interrogation. The laboratory is divided into five sections:

SECTION I. (Rockets, shapped charges, etc) Dir: Lt Col
(Engr) M Minaguchi

I. ROCKET PROJECTILES

1. Basic research. Theoretical investigation of rockets was begin in 1931. Gen Nomura claimed that the Japanese were not aided by information on any foreign rocket developments. The Seventh Military Laboratory did fundamental work, then successful types were turned over to the 1st Military Laboratory for further tests and engineering. The propellant powder was manufactured at the Second Army Arsenal, Tokyo, and the rockets at the Osaka Army Arsenal. All that Gen Nomura knew of the solid-type propellant was that it contains 27% nitro-glycerine.

2. Solid fuel rockets. a. 8 cm class. Work on this type of rocket was started in 1942. They were of the spinner type and had the following characteristics:

Diameter - 87 mm
Weight - 8 kg
Wt of propellant - 0.9 kg
Wt of explosive - 0.8 kg
Max. range - 1100 m
Accuracy:
Range - + 30 m
Azimuth - + 25 m

b. 20 cm class. Successful 20 cm spinner rockets were developed in 1943. One variation of the rocket motor was the provision of ports, at right angle to the rocket axis, which could be opened to allow the escape of gas and shorten the range. In this way a range of from 900 m to 2500 m could be obtained with the same projector setting. Characteristics of this rocket are:

Diameter - 200 mm
Weight - 85 kg
Wt of propellant - 10.2 kg
Wt of explosive - 10 kg
Max range - 2500 m
Accuracy:
Range - + 17 m
Azimuth - + 25 m

c. 30 cm class. Research on 30 cm spinner rockets was started in June, 1942, and successfully completed in January, 1943. Characteristics are:

Diameter - 300 mm
Weight - 120 kg
Wt of propellant - 22 kg
Wt of explosive - 24 kg
Max. range - 2200 m
Accuracy:
Range - + 18 m
Azimuth + 15 m

d. 40 cm class. Research on 40 cm spinner rockets was carried on between May, 1943 and August, 1944. Characteristics are:

Diameter - 400 mm
Weight - 500 kg
Wt of propellant - 83 kg
Wt of explosive - 100 kg
Max range - 4,000 m

e. 60 cm class. Spinner rockets of this class were studied from August, 1944, to the end of the war, but experiments had not been completed. This was the largest Japanese rocket. Characteristics are:

Diameter - 600 mm
Weight - 2,130 kg
Wt of propellant - 40 kg
Wt of explosive - 300 kg

f. 10 cm AA rocket. This was a spinner rocket on which research was conducted between October, 1943, and July, 1945. Characteristics are:

Diameter - 10 mm
Weight - 12 kg

Wt of propellant - 1.2 kg
Wt of explosive - 1.3 kg
Max height - 3 000 m

g. Gliding rockets. In an attempt to develop long-range rockets, research was conducted on rockets equipped with wings consisting of flat plates to make them glide. The first experimental models of a 90 mm gliding rocket were test-fired in September, 1944. This type was unsuccessful because of the rolling of the projectile. A gyro-stabilized model with the following characteristics was tested in March, 1945:

Diameter - 250 mm
Length - 2 m
Wing area - 0.522 sq m
Wing loading - 230 kg

This projectile had insufficient gyro-stabilization, so rolling was severe. Further work on stabilizing was conducted but no successful projectiles were developed by the end of the war.

h. Water-borne rocket. A preliminary model was made of a torpedo-like water-borne rocket. Its diameter was 20 cm and length 1.5 m. It was not tested.

3. Liquid Fuel Rockets. Liquid fuel rockets were planned both to supplement solid fuel types and to get missiles of longer range. The fuels used were the hydrogen peroxide system and the nitric acid system as used by the Japanese Navy. The army research was done independently, however, and about the only information furnished by the Navy was the technique of handling the fuels. This work was started in April, 1944, but results were limited to the measurement of chamber pressures and thrust pressures.

II. RECOILLESS GUN. Research on this gun was conducted between October, 1943, and July, 1944. The following data were supplied.

Diameter of projectile - 75 mm
Weight of projectile - 4 kg
Length of barrel - 1.2 m
Wt of barrel - 100 kg
Exhaust tube:

Length - 70 cm
Angle - 10°

III. SHAPED CHARGES. (Japanese name "TADAM") Research was conducted on shaped charges in sizes between 40 mm and 150 mm diameter. Explosives used were a mixture of TNT and "Shouyaku". Welded steel cones 2 mm or 3 mm thick formed the cavity. Optimum angle was found to be 30°. Tempered Ni-steel twice as thick as the diameter of the explosive could be penetrated. Research was conducted on the technique of welding the steel cones to maintain the required dimensional

tolerance. This was accomplished by atomic hydrogen welding. While most of this work was conducted with static charges, it was planned to undertake research on the use of shaped charges in projectiles.

IV. WIND TUNNEL SERIES. Wind tunnel studies of model projectiles were conducted from 1938 to the end of the war. A small scale high-speed tunnel was built in 1938 which would give an air speed from 330 to 1,000 meters/sec. In 1940 a large low-speed tunnel giving an air speed of 100 meters/sec was constructed. A large high-speed tunnel was designed, but it had not been constructed by the end of the war.

V. ELECTRIC PROJECTOR. Work on this projector was started in 1942 with the aim of using it as a form of artillery piece. The principle was that of the induction motor, the projector being the stator and the projectile the rotor. Power was supplied by a 2,000 KVA, 1,500 cycle, 3-phase generator. Theoretically, a velocity of 500 meters/sec for a 10 kg projectile is possible, but the best results obtained were 350 meters/sec for a 2 kg projectile. This was not considered a practical field weapon, but was used as a projector for models of the winged rockets.

SECTION II. (Optics, television, etc.) Dir: Lt Col
(Engr) T Takeshita

I. TELEVISION. Part of this work was done in collaboration with Tokyo Shibaura Electric Co. It was hoped to develop a television set to be used as the eye of a remote-controlled tank or boat (presumably carrying explosives). Another possible military use would have been to transmit information, such as maps, etc., from one unit to another. Nothing successful was developed, but the latest apparatus had a scanning rate of 200, transmitter on 60 MC, range of about 10 km (with two 10-meter antennas) and resolving power of 200 lines.

II. INFRARED RESEARCH.

1. Near infrared. Infrared research has been conducted in Japan for the past ten years, and an image tube of the RCA type was developed and produced, but none of the equipment was used by the Japanese Army in the active theaters. Several models of image tube, both monocular and binocular, were made with 15 cm and 10 cm apertures. In addition to those using conventional optical system, Schmidt lens type and Mangin mirror type were constructed. Light sources included carbon arc and incandescent lamp, equipped with glass filters. The latter were developed at the Tokyo Shibaura Co and Gen Nomura believes they were copied from an American filter (probably Corning 240). It was claimed that with a 150 cm carbon arc searchlight (filter-equipped) and the binocular image tube with 15 cm aperture, a single man could be detected at a distance of 800 meters. Infrared light signaling with the 5 cm monocular and 15 cm searchlight (incandescent lamp, 6V, 3.5A) could be accomplished up to 10 kilometers.

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2. Far Infrared. Fundamental work on heat ray detectors was done in the 7th Military Laboratory, but the application was handled by the 2nd Military Laboratory. The latter planned to apply heat detectors to the location of planes and to heat homing missiles. The principle detector elements on which research was conducted were iron-constantin thermopiles and a nickel strip bolometer, in which the nickel strip formed one arm of a balanced bridge. Some measurements were made on background conditions in heat detection.

III. PHOTOPHONE. A photophone for voice transmission over a light beam was developed, and it was understood that some of this equipment was in use by the Japanese Army on the Manchurian front. Transmission was by visible or infrared light. Modulation was accomplished by (1) direct modulation of an incandescent lamp with hydrogen filling or a high vacuum mercury vapor lamp, and (2) incandescent lamp with vibrating mirror and a pair of gratings. The receiver was a conventional type, with lens or mirror, photocell, amplifier, and headphones or loud speaker. One set using a 10 cm searchlight gave a useful range of about 4 to 5 kilometers.

IV. AUTOMATIC CONTROL FOR BOATS. Since 1941, research has been conducted on control devices for small boats which were to be loaded with explosive and directed against enemy fleet units. Gyroscopic stabilization was studied, and two types were developed; the "Porro-Brown" type and a ball gyroscope with air bearing. Both of these gave good stabilizing effect for oscillations with a period greater than 5 seconds. An optical stabilizer was also developed. This employed a suspended horseshoe-shaped bar with a vertical slit at each end. Light passing through these slits to photocells was interrupted when the bar was rotated by the boat's changing course, and an electrical system was thereby operated to bring the boat back on course.

SECTION III. (Acoustics) Dir: Lt J Ishikawa

I. UNDERWATER DETECTION. This section handled Army work on underwater detection devices utilizing Rochelle salt microphones. While most of this work in Japan was done by the Navy, it was claimed that some improvements had been made by the Army, and an improved hydrophone had been constructed.

II. UNDERWATER SOUND STUDIES. An observation station was set up at Ito in 1943 to study the propagation of underwater sound. Studies were made in the frequency range 9 KC to 20 KC of: (1) Attenuation of sound waves with distance; (2) Variation of transmission conditions with time, and (3) Fading Phenomena.

SECTION IV. (Miscellaneous Research) Dir: Maj Gen H Noto

I. UNDERWATER CARGO BOAT. An underwater cargo boat was under development, to be towed by a submarine. One of the principal

problems in this work was to control the zig-zag motion of the boat. The horizontal motion was controlled by connecting the draw-bar at the bow to a rudder by means of pulleys, so that a change in tow direction turned the rudder in the same direction. Vertical motion was controlled by compressed air chambers which were set for a given depth of water. A model of this boat had been constructed with a displacement of 103 tons and a cargo capacity of 45 tons.

II. SWEEPING APPARATUS FOR MAGNETIC MINES. The Japanese Army started work on this problem in March, 1944, and at that time were provided with information which their laboratories had accumulated through their research program. A sweeping device was developed for creating a magnetic field to get into the mines. This consisted of a cable 500 meters long, which was buoyed by floats and towed in a W-shaped loop by two boats. The cable carried about 350 amperes current, provided by generators aboard the boats. A sweeping velocity of about 3 km/hour was used. Reversal of the field gave a change of 20 milligauss in the magnetic field 60 meters wide, 140 meters long, and 20 meters deep.

III. MEASUREMENT OF MAGNETIC FIELD OF SHIPS. Some measurements of the magnetic fields of an 8,000 ton and a 2,000 ton cargo ship were made by means of a Helmholtz coil arrangement. This was aimed at devising countermeasures to magnetic mines. However, the work was started in November, 1944, and was stopped because of air raids before significant results were obtained.

IV. REMOTE CONTROL APPARATUS. A radio remote control device for small ships and tanks to be loaded with explosives for offensive use was completed. This apparatus was not practical because no method was available to accurately determine the location of the vehicle except by direct sighting, which good only to about 14,000 meters. Control was by means of a 50-watt transmitter operating at a frequency of 4 to 6 megacycles.

SECTION V. (Medical) Dir: Maj Gen Y Matsuzaki

I. RESEARCH ON "KO-HA". "Ko-Ha" (neociamine) was developed for the treatment of frostbite and thermal burns. It was also claimed that some success had been attained with this material in the treatment of leprosy.

SUBJECT: Research Program of 2nd Military Laboratory
DATE: 15 October 1945
INTERVIEWED: Lt Gen Megumi AMAAKI, Dir, 2nd Mil Tech Lab
INTERVIEWERS: Drs H K Stephenson, E L Moreland, Maj W R Hewlett, Tec 4 Yagi

1. GENERAL. The 2nd Military Technical Laboratory conducted research in Optics, Acoustics, miscellaneous electrical equipment, and the use of the autogyro for observation of submarines.

2. OPTICS

a. Antiaircraft sight. This was a sighting apparatus for the Type 98, 20 mm antiaircraft machine gun. It was copied directly from the "methode Perrieur" of the French. (NOTE: Lt Gen Amaaki spent a number of years in France, last returning from there in 1937)

b. Optical range finders. Several types were worked out, mostly for ground-to-ground ranging. A height finder for planes was based on the same principle.

c. Flash ranging. A method of flash ranging was devised, consisting of triangulation from known positions by photography. Individual soldiers were provided with cameras, and would snap pictures at a signal over a phone system. The method was useless for individual flashes, being applicable only on repeated firings, and was never particularly successful.

d. Night vision glasses. These were developed after the Japanese saw a German model of a night binocular which was used aboard a submarine.

e. Front surface mirrors. Aluminum on a glass base was used, and the method was quite successful.

f. Non-reflecting coatings. The usual magnesium fluoride film on glass was used.

g. Anti-fungus treatment of optical glass. The Japanese have been working on this problem for ten years, but so far no successful fungicides have been developed. Frequent cleaning of optical instruments is necessary.

3. ACOUSTICS

a. Submarine locators. A pulsed supersonic echo-ranging device was developed experimentally. Research had been started on a continuous wave supersonic device based on the Doppler principle. Listening gear using circular arrays of 13 and 80 Rochelle salt pick-ups was obtained from the Jap Navy, and the 2nd Mil Tech Lab worked on improvements.

b. "Ultra-low frequency" submarine detector. (Note: this description is based on an interview with Maj Y Nakajima and Maj H Nakamura, staff of 2nd Mil Tech Lab, on 19 Oct 45) This experiment was based on the rather startling assumption that low frequency sound from a submarine, if propagated along the path of ocean currents, would be reflected back and forth between the "walls" of the current and could be picked up at a distance of several hundred kilometers!!! The informants were vague about the basis of this assumption and did not know where it originated. Studies were begun in August 1944 at the Geophysical Laboratory of Kyoto Imperial University. At a test site in the Inland Sea, a moving coil microphone was suspended at 30 meters depth and was connected directly to an oscillograph of the string galvanometer type. Characteristic frequency of the microphone was 100 cps. On a surface boat of 100 tons, the limit of detectability was 1,000 meters. It was planned to continue the research.

c. Sound ranging for artillery. A method of sound ranging was worked out using a staggered array of six microphones spaced 500 meters apart. Direction of the sound source was measured by the differences in time of arrival of the sound wave at the various microphones. Recording was by means of sensitized paper. In Japanese Army maneuvers before the war, an accuracy of ± 200 m. at a range of 4,000 m. was attained. This equipment was used at Guadalcanal. It would not locate mortars, and it is of interest that the Japanese combat Armies repeatedly asked for the development of a mortar locator. However, nothing for this purpose was ever developed in Japan.

4. ELECTRICAL EQUIPMENT

a. Odograph (called "Position Indicator for Tanks") This is a gyrocompass device for land vehicle navigation for which an error of closure of 1% to 2% is claimed. Only three or four models were built (by the Hokushin Electric Co., Shimaru-Ko, Kamada-Ku, Tokyo), and these are said to have been used in Manchuria.

b. Command Apparatus for AA Company. This is an intercommunication system to coordinate the fire of several antiaircraft companies from a central location. The position of planes to be attacked is indicated by the position of lights on three dials representing the coordinates of the planes. This spots the target, but fire control is determined by each company with its own apparatus.

c. Magnetic locator. This is similar to the device developed by the Japanese Navy for harbor defense. A coil of wire 100 m. by 1,000 m. is laid on the ground and connected to an oscillograph. A magnetic object such as a vehicle or a rifle carried by a soldier moving over the coil induces a current which is indicated on the oscillograph.

d. Heat ray detector. This is the same heat detector used by the Military Ordnance Administrative Board for the heat-homing bomb. (Nickel strip bolometer in balanced Wheatstone bridge) The 2nd Mil Tech Lab intended to use it for personnel detection. It could detect a single man at about 100 meters, the indicator being an audible signal.

5. MILITARY USE OF AUTOGYRO

a. It was proposed to use an autogyro as an observation plane for submarines. An autogyro had been brought to Japan from the United States before the war. This plane was later destroyed in an accident but was copied by the Japanese. Only one or two models were built.

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Appendix 1-H-1

CONFERENCE WITH PERSONNEL OF THE
MILITARY ORDNANCE ADMINISTRATIVE BOARD

SUBJECT: Japanese Heat-Homing Bomb

DATE: 15 October 1945

INTERVIEWED: Maj Gen Y Nomura, Lt Col K Kowakami, Maj S Sonobe

INTERVIEWERS: Dr E L Moreland, Dr H K Stephenson, Tec 4 Yagi

I. INTRODUCTION. Maj Gen Y Nomura is director of the Military Ordnance Administrative Board of the Japanese Army. This Board has responsibility for research on heat detectors and their application. Three military applications of heat detectors were considered, as follows:

1. Heat-homing bombs
2. Heat-homing boats
3. In planes to locate enemy planes. By far, the greatest portion of their work was on the heat-homing bombs.

II. HEAT-HOMING BOMBS.

1. General. This type of bomb was planned for use against ships. Land targets were not considered, and no survey of possible types of such targets was made. The bombs were to be used at night because background conditions for the heat detector are more uniform at night. Nine different models of the bomb were developed. The first eight were abandoned because of insufficient control, so Mark IX, the latest model, was designed with larger control surfaces. It was expected that this model would have been completed for final test by the end of September, 1945. Mathematical work on bomb dynamics was done by Prof Konishi of Shikan Gakko (school) at Asaka, Saitama prefecture. Electrical design was done by Prof Sano of the Communications Engineering Dept of Osaka Imperial University. Aerodynamic studies were made by Dr Itakawa at the Aeronautical Research Laboratory. Of the personnel of the Military Ordnance Administrative Board, Maj Hizuta, Maj Fujita, and Capt Abe are most familiar with the technical details of the research. It was stated that the Japanese obtained no aid from outside sources in this development. An attempt was made to obtain information from Germany but this was unsuccessful.

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2. Results of Field Tests. The MkVII model was the only one of the heat-homing bombs that was extensively tested by actual drops from a plane. Fifty or sixty of this model were dropped from an altitude of 3,000 meters at a raft target anchored near the center of Lake Hamanako (Shizuoka Pref). This lake is about 2,000 meters in radius. The raft was 10x20 meters in dimensions. The heat target was provided by burning wood and coal fires on the surface of the raft, in four areas each 4x4 meters. Of the fifty or sixty bombs dropped, four or five reacted to the controls. The remainder were failures.

3. The Mark IX Bomb.

a. A general sketch of the MkIX bomb is shown in Appendix A. This model has an overall length of 5.45 meters, diameter of 50 cm. Its total weight is 800 kg, and the explosive charge is 200 to 300 kg. The bomb is provided with two sets of "wings" with aileron flaps controlled by an electro-hydraulic system actuated by an amplifier controlled by a bolometer in the nose of the bomb. The ailerons are linked in pairs, fore and aft. Stabilization is provided by a gyroscope controlling four small flaps on the main wings. A brake on the tail holds the speed of fall to 150 meters/sec. to allow the controls time to operate. The bomb is designed to be dropped from an altitude of 3,000 m or more. The controls are switched on at 2,000 m altitude. From 2,000 m. full control will change the point of impact by 600 m. from the point of impact for free fall. A fuse was being designed to give an instantaneous burst with a direct hit on a ship, but provides a delay on a water hit to give maximum damaging effect. (Work on this fuse was done by Capt Akiba, 1st Mil Tech Lab)

b. Appendix B gives a diagrammatic sketch of the control system for the Mk IX, and Appendix C and D give the bolometer arrangement. The bolometer consists of nickel strips forming two arms of a Wheatstone bridge. Scanning is provided by a circular mirror driven eccentrically by a 6-watt motor at a speed of 1 rps. This gives a 40° conical field of view. A single amplifier is used for both sets of controls, with a rotating switch to activate each of two relays, which operate a magnetic control to a pilot valve in the oil control system. The oil is provided by a tank with a compressed air pressure of 80 atmospheres.

c. Regarding sensitivity of the bolometer, the group did not have actual sensitivity figures on measurable temperature contrast. However, it was stated that a resis-

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tance change of 10^{-6} could be detected, giving $\frac{\Delta R}{R} = \frac{10^{-6}}{2}$.

A 1,000-ton ship could be detected from an altitude of about 7,000 m. under good conditions. A man's face could be detected at about 100 m.

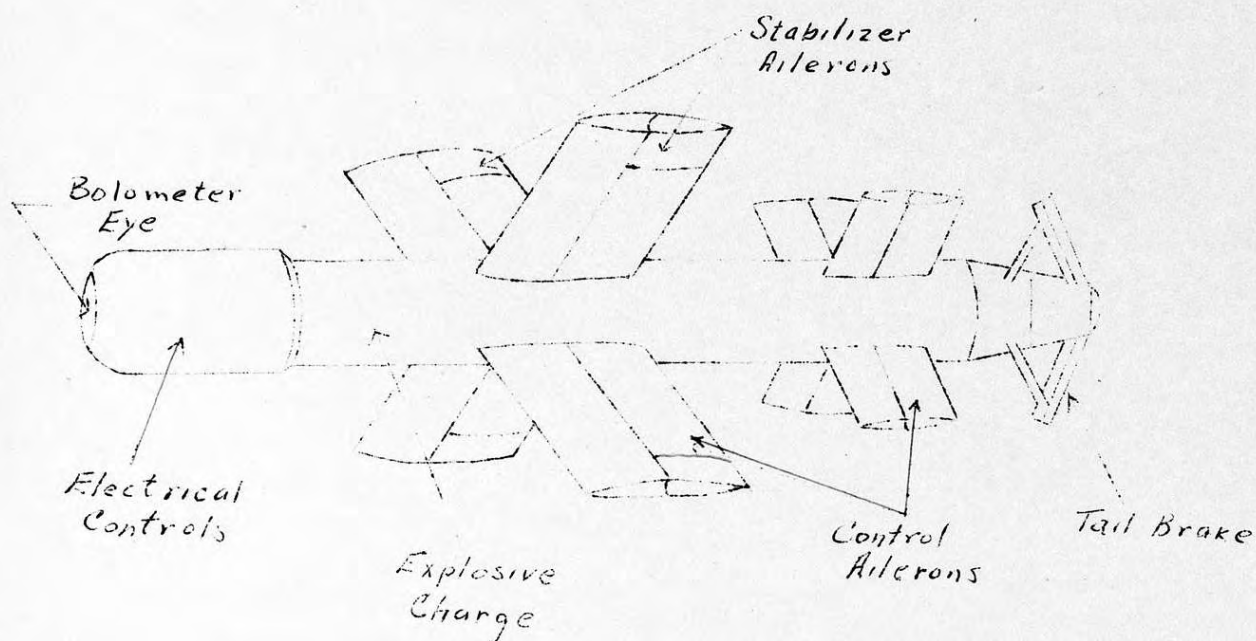
d. A model of the control system for the Mk IX bomb is available at Matsumoto, Nagano Prefecture.

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Japanese Heat-Homing Bomb

APPENDIX A



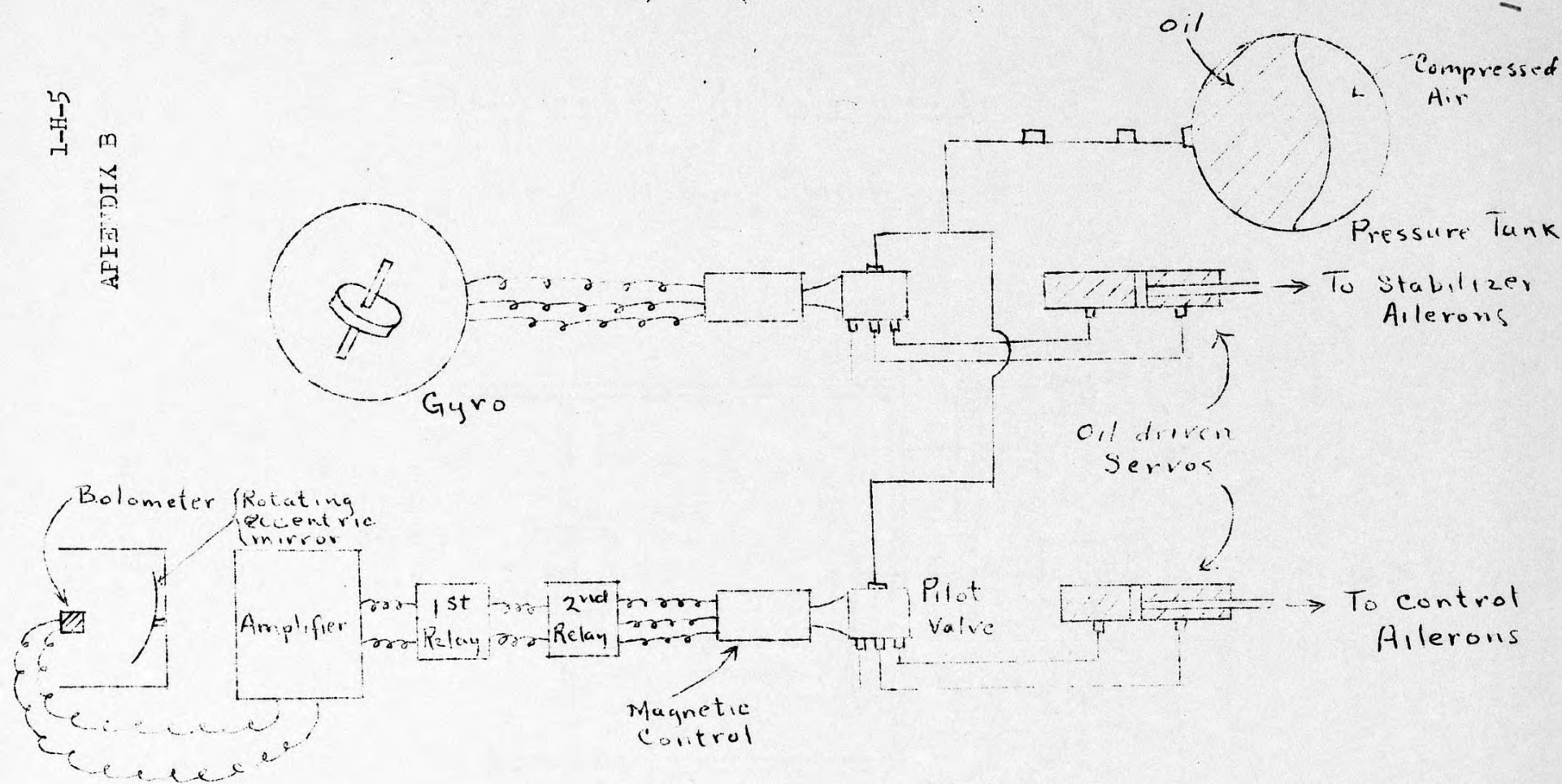
Characteristics of Mk IX Model

Length - 5.45 meters
 Diam. - 50 cm
 Total Weight - 800 kg
 Wt. of Explosive - 300 kg

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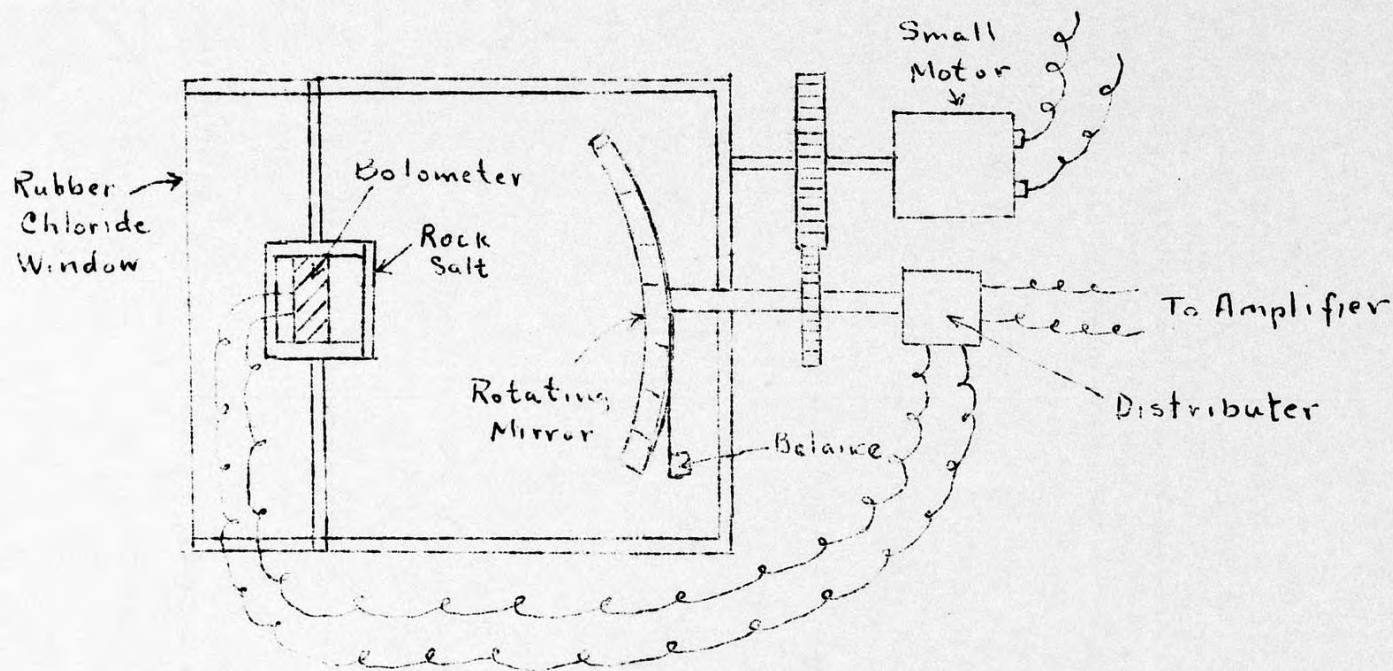
APPENDIX B

1-H

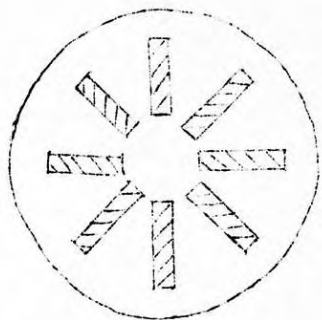


Schematic Diagram of Control System
for Heat-Homing Bomb

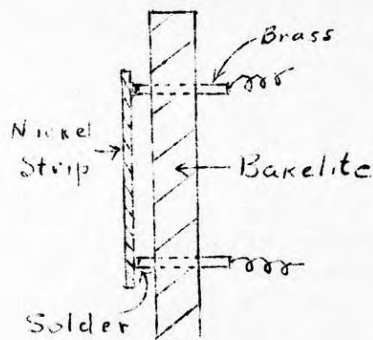
Bolometer Arrangement for Heat-Homing Bomb



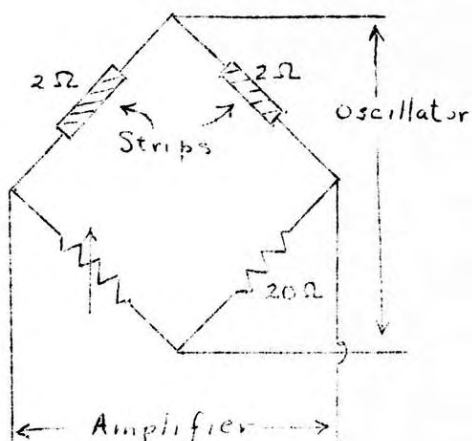
Arrangement of Ni-Strip Bolometer 1-H-7



Bolometer Array



Mounting of Strip



Bridge Arrangement

Dimensions of Ni Strip
(Approx.)

Length - $\frac{3}{8}$ inch
Width - $\frac{1}{16}$ "
Thickness - 1 micron

APPENDIX D

NOTE: The group interrogated did not have at hand the details of the electrical hook-up of the nickel strips. However, it appears that the eight strips were connected in arrays of four, adjacent pairs being hooked together and opposite pairs forming the two arms of the bridge circuit, thus giving two bridges for the operations of the two sets of controls.

SUBJECT: Interview with Representatives of the 5th Military
Technical Laboratory at Kokobunji, near Tokyo.
DATE: 20 October 1945
INTERVIEWED: Col T MORIMURA
Lt Col S UEDA
INTERVIEWERS: Major HEWLETT
Tec 4 Yagi

1. The 5th Military Technical Laboratory was charged with the development of all communication and communication-type equipment for the Japanese Army. It had been previously visited by Capt DEMPSEY and Capt PIKE of the Signal Section, GHQ. In these interviews, the subject of wire communication and VHF radio relay work had been fairly completely covered. The findings in these fields will be only briefly mentioned, as a complete report on them has already been forwarded to the War Department. Briefly, these items were:

a. Teletypewriters. A simplified set had been developed with 16 characters (numbers zero to nine and six punctuation marks). Several models of this machine were found. Work on more complicated-type teletypewriters had been discontinued owing to the shortage of critical materials.

b. Voice and Telegraph Carrier Systems.

- (1) Wire Systems. A field type, 3-channel carrier telephone system had been developed in 1939. It had a range of 300 km over open wire circuits, or 60 km over "cabtype", Japanese rubber-covered, 2 or 4 wire field cable. An improved model was under development that would provide three voice channels and three telegraph channels. Its range would be comparable to the earlier model. The repeater for this new set, however, had not yet been developed. Some work had been done on a portable, voice frequency telegraph system for field use.
- (2) Radio Systems. An experimental VHF radio relay system had been developed and placed in experimental operation in the Tokyo area. It had the following general characteristics.
 - (a) Frequency - 570 to 670 mc.
 - (b) Number of channels - 3 carrier and 1 voice.

- (c) Type of modulation - single side band carrier and frequency modulated sub-carriers on frequencies of 19, 23, and 27 kc. Voice band - 2500 cps.
- (d) Antenna - 36 element array with reflector plate.
- (e) Range - 200 to 500 km with a maximum of two repeater stations. The idea for this set was obtained from Germany but no detailed information was furnished. Work was started on this project in 1941 and about 30 sets were on order.

c. High-Speed Telegraph. A system was under development to send telegraph transmissions at speeds as high as 3000 characters per minute. It depended for operation on punched tape and photocell controlled transmitter and a receiver utilizing photosensitized paper. It was intended to operate under conditions of high atmospheric noise and it was not necessarily intended to provide multi-channel facilities.

d. Personnel Detection Device. This was a device that would detect by acoustic and/or magnetic means the presence of personnel or vehicles moving over or through an area protected by the set. It used a cathode ray-type presentation and only provided coverage over a limited area.

2. The following additional information was obtained in the discussions with Colonels MORIMURA and UEDA.

a. Light Ray Direction Finding System. This device was intended to direct a boat through a narrow channel or to a specified spot on an adjacent shore. In principle, it used a small red light and an IR photocell receiver mounted on the back of the boat and a pair of night glasses mounted co-axially with an IR source with a 20-cm reflector. In operation, the red tail light on the boat was tracked with the glasses. If the boat deviated from the prescribed course, the infrared beacon transmitted a signal indicating either a right or left deviation from the prescribed course.

b. Quartz Crystals and Stable Circuit Elements. The supply of raw quartz in Japan was severely limited and as the Japanese Air Force had first priority on this commodity, the ground forces were engaged in an extensive research program to find suitable substitutes for quartz crystals. By careful design of the oscillating circuit and associated am-

plifier and by control of the temperature coefficients of both the inductance and capacity and with suitable compensating circuit elements, an overall stability of about .05% had been obtained. This deviation included changes in load, tubes, temperature, and mechanical condition. No work had been carried out on magnetostriction oscillators. No serious deterioration of crystals stored in tropical areas had been reported.

c. Moisture and Fungus Proofing. In an attempt to reduce the deleterious effect of moisture and fungus on communication equipment in the tropics, two main schemes had been under consideration.

- (1) The painting of critical components with a Bakelite varnish or with paraffin. (The varnish was not baked.) This technique was intended to be used in the field, but no reports of its actual use by the troops had been obtained.
- (2) The complete inclosure of the set in a rubber case. Windows would be provided to permit observation of dials and meters and rubber glove-type inserts would permit the necessary external adjustments to the set to be made. This system was never placed in extensive use.

d. Radio Countermeasures. Only one item of RCM equipment was reported by Col MORIMURA. This was a communication jammer with a power output of 500 to a thousand watts and covering the frequency range 2 to 10 mc. It was frequency-modulated over a narrow band and amplitude modulated alternately with a 600 and 900-cycle signal. It was intended for use against tactical-type circuits. About 30 of these were being constructed by the Sumitomo Electric Company. No AJ work was under way.

e. Radio Direction Finders. Radio direction finder work was carried on at the Hirakata Shikinjo Laboratory at Hirakata-Machi, Saitama-Ken about 40 km from Tokyo. The work of this laboratory was under the direction of Lt Col S TAKEDA. The best direction finder reported to have been developed by the laboratory was a crossed, buried-U type with a manually-rotated goniometer. Null detection was used. The best accuracy was in the order of $\pm 1^\circ$. The only field type of direction finder in extensive use was reported to be an elevated-H type. Some efforts had been made to improve the accuracy of this set but with no particularly favorable results. Some work had also been done to develop a precision-type front line direction finder suitable for pin-pointing radio stations of

the type that might be around front line command posts, thus permitting artillery fire to be placed on the CP. The best accuracy obtained, however, was only about 11 to 20° at a distance of 10 km. It was stated that no work had been carried on to develop a direction finder suitable for the detection of engine-driven power units.

f. Tactical Radio Communications. Tactical radio communications for the Japanese Army was concentrated in the range from the lower end of the medium frequency band to 40 or 50 mc. The range from about 2 to 12 mc was used for command-type circuits down to about complete level. Within the infantry company, a small portable set operating in the range of about 30 to 40 mc, amplitude modulated, was used. The communication within the tank company was provided in the frequency range 20 to 30 mc, amplitude modulated. No work had been done on frequency modulation for tactical sets. The larger field sets and the vehicular sets used plug-in coils and plug-in crystals, but current development was towards the elimination of the crystal entirely. Other than the constructional details, there appeared to be little of fundamental importance in these sets.

3. Discussion. With the exception of work in VHF radio relay systems and some work on carrier telephony, the Japanese military communications are of little scientific interest. In general, the modernization of the military communication system was hindered by the difficulties of the Japanese written language, the shortage of critical materials, the apparent lack of high-level backing for more progressive communication means, and requirements for the greatest possible simplicity of operation resulting from the low-level of technical training of the troops.

P.S. Subsequent to this meeting, it was learned from the Director of the 9th Military Technical Laboratory that the 5th Laboratory (probably Col MORIMURA) had been engaged in the development of "radio fingerprinting." No details could be obtained.

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ARMY ARSENALS

<u>Names of Laboratories</u>	<u>Chief's Name</u>	<u>Location</u>	<u>Conducted Works</u>
The First Tokyo Military Arsenal Depot	Maj General Gunji Kobayashi	Tokyo City	Studies on, common system of general works of 20 mm bullet for ground and aerial, simplification of manufacturing fuse, epoch-making increase production of aerial ammunition, and improving of the function of the renovated type 4 super short wave radar and etc.
The Second Tokyo Military Arsenal Depot	Lt General Ryokichi Nobuaki	Tokyo City	Study of jet advance powder, regular jet advance powder (the constituent is as same as smokeless powder), jet advance powder apart from regular constituent (Study concerning jet advance powder based on organic unite principles) Study relating on various powders (Study relating on counter-measure of gun flames and smokes) Studies concerning: the foundation relating on explosive manufacturing, explosives' production in large quantity, explosive theory of ignition powder and fire equipments.
Sagami Military Arsenal Depot	Lt General Kanaji Doki	Sagamihara-Machi, Kozogun, Kanagawa Prefecture.	Studies concerning: the tentative making of cog-wheel grinder, method of manufacturing screw, auto-measuring equipment of engineering works, and heat analysis of pinetree root oil.
Nagoya Military Arsenal Depot	Lt General Nobutake Tamura	Nagoya City	Studies concerning: lubrications for steel ball-cartridge of thin covered shell of 30mm for aerial use (studies on paints included), methods in re-using of shot ball cartridges for rifle and machine gun, bolting works on sideplate of tail cylinder and reinforcing plate of type 2, 20 mm light finned machine gun.
Osaka Military Arsenal Depot	Lt General Kihachiro Soma	Osaka City	Studies concerning: improvement of manufacturing methods of various fire guns, methods of producing a large

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<u>Names of Laboratories</u>	<u>Chief's Name</u>	<u>Location</u>	<u>Conducted Works</u>
			amount of wooden gun-stocks and fuses of anti-aircraft gun, methods of manufacturing pure steel, methods of producing a large numbers of stick springs, substitutions of high speed steel and small transporting crafts, methods of manufacturing gun barrel steel and gun barrel materials, methods of manufacturing the substitution of ammunition-belt, methods of manufacturing steel cartridge, improvement of forge, technic prevention of cracking in gas cutting, prevention of vibration of motor driven barges, methods of manufacturing steel cartridge and underneath metal, non-iron metals materials and working-up-methods of them, methods of shaping piano wire string and spring.
Kokura Military Arsenal Depot	Lt General Kisaburō Osachi	Kokura City	Researches concerning: the medium calibre anti-aircraft machine gun that is powerful in medium altitude and easy in manufacturing and management (5 type 40 mm anti-aircraft machine gun). Improvement and simplification of manufacturing methods of 30 mm plane mounted gun, simplifying of manufacturing methods and deterioration of materials of 99 type rifles, Improvement of exactness and simplifying of manufacturing methods of 37mm plane mounted gun, and simplifying of manufacturing methods and deterioration of materials of 20mm double gun IV type.
Military Clothing Main Depot	Lt General Zenzo Ichimura	Akubano, Ogi-ku, Tokyo-to.	(a) Researches in fabricated goods Researches in common clothing, extreme cold weather clothing, extreme hot weather clothing, clothing for special duties, equipments, tent, mosquito netting etc. (b) Researches in materials Researches in fibre, cotton, linen, dyeing, water-proof, substitution in case of leather, tanning materials, saws and oil gum etc.

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<u>Names of Laboratories</u>	<u>Chief's Name</u>	<u>Location</u>	<u>Conducted Work</u>
Military Clothing Depot	Maj General Kin'iro Inukai	Senju-ku, Tokyo-to	Researches in alkali resolvable, manufacturing of dye stuff for staple fibre, improvement of method in opening cocoon, dyeing by using acetic acid, and refining of miscellaneous fibre etc.
Military Provision Depot	Lt General Shinsho Sugano	Etchushima, Fukuoka-ku, Tokyo-to. and Shimo Takaido, Saitama-ku	Researches in military foods and cooking gears. (1) Researches in emergency provisions, special foods, working up foods, sources of supplying vitamin foods for soldiers and vitamin content, foodlizing of un-used resources, horses, dogs and foods. (2) Researches in cooking utensils, water cans and simplification of manufacturing farm tools.
Investigation Dep. of Supply Main Depot	Accountant: Lt General Rokuro Takagi	Izumi-cho, Saitama-ku, Tokyo-to, Koishikawa-ku.	(1) Researches in underground constructions. (2) Researches in clay substitutes in case of cement, machinize of wood works, and machinize of constructions. Plan for scarcity of anti-aircraft resources. Researches in dug-out hangar, shot-proof shelter, wireless switch equipment, stabilization works from preventing ground collapse and method of cement stiff rapidly. Construction of large stretched medium wood. Researches in agglutination receipt, mineral receipt and curved board.
Military Fuel Board Fuel Laboratory	Lt General Takasaburo Miyata	Chofu-shi, Mitaka-gun, Tokyo-to.	(1) Researches in various experiments required for catalysis; the treatment of crude oil produced in the South, manufacturing of aircraft gasoline from rubber; manufacturing of aircraft gasoline by means of dry distillation of coal, lignite, etc, at the place of origin; dry distillation at a low temperature by a flowing system; the treatment of tar; the method of treating pine-roast oil; the treatment of turpentine; the treatment of

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Names of
LaboratoriesChief's NameLocationConducted Works

carphor; manufacturing of aircraft fuel by analysis of oil gun; and manufacturing of aircraft fuel by the treatment of miscellaneous resources.

(2) The method of using perfumes for making fuel; manufacturing of combination fuels by means of acetone catalysis; and manufacturing of "isobutan" from "butanoru".

(3) Researches in lubricating oils. Researches in the manufacturing of high-class lubricating oils by means of natural oil, shale oil, and oil.

(4) Relating to chemical mediums. Researches in the manufacturing of chemical mediums; chemical mediums used for compound petroleum; and the compounding of "orchyn".

(5) Relating to chemical industry. Researches in simple heat-proof wrappers; the welding of special steel; packing materials; the structure of equipment of catalysis; the method of refrigeration in a petroleum compounding furnace; blast furnaces; sheet steel machines used for exchanging heat; and the tools used for measuring manufactured oils.

(6) Relating to fermentation. Researches in the use of products by fermentation; fermentation by means of lactic acid; selection of acetone-"butanoru" corpus; slow fermentation of acetone-"butanoru"; sources of nitrogen substitutes in case of the fermentation by means of alcohol fermentation by using cane sugar as a major material and bean-cakes as a minor material; sources of nitrogen substitutes in case of alcohol fermentation; fermentation by means of wood refuse and other materials.

Laboratory
of Military
Medical
School

Lt General
Ifuka Kungu

Toyama-cho,
Ushijima-hu,
Tokyo-to.

(1) Researches in the treatment of war sick and wounded.
(2) Researches in epidemic prevention concerning vaccine serum, filter etc.

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<u>Names of Laboratories</u>	<u>Chief's Name</u>	<u>Location</u>	<u>Conducted Works</u>
8th Air Technical Laboratory	Medical Colonel Saigo Knon	Tachikawa-shi, Tokyo-to.	(3) Researches in military hygiene, nutrition and medical stores. Researches in oxygen inhaler, semi-stratosphere flight, acceleration and fatigue in flight.
Laboratory of Main Military Medical Stores	Lt General Toraji Shinizu	Yotsu-cho, Seta-rya-ku, Tokyo-to.	Researches in breaking barriers of producing medical stores, deterioration of population, self-supporting at the present location and available resources which have never been utilized.

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JAPANESE NAVAL RESEARCH INSTITUTIONS

1. HIRATSUKA Laboratory of the Second Naval Magazine Yard Experimental
Dept. of Chemistry of the Sagami Navy Yard.
2. KURE Eleventh Aeronautical Navy Yard.

Experimental Dept. of Marine Engines (main steam engines
and auxiliary engines)
Experimental Dept. of Casting
Experimental Dept. of Machine Tools
3. KURE Kure Navy Yard

Experimental Dept. of Ordnance
Experimental Dept. of Torpedoes
Experimental Dept. of Metal Melting
Experimental Dept. of Electricity
Experimental Dept. of Naval Architecture
4. MAIZURU Maizuru Navy Yard

Experimental Dept. of Marine Engines (boilers)
5. YOKOSUKA Yokosuka Navy Yard

Experimental Dept. of Mines
Experimental Dept. of Submarines Elec. Batteries
Experimental Dept. of Marine Engines (combustion engines)
Experimental Dept. of Nautical Instruments
Experimental Dept. of Optical Instruments
6. GOTEMBA Navy Chemistry Warfare Laboratory
7. TOKYO Technical Research Institute

a. Technical Research Institute of Japanese Navy.

Director: Vice-Admiral Sakae Tokunaga

Departments:

General Affairs: Rear-Admiral Kenroku Fujita
Applied Physics: Rear-Admiral Eizo Jimazumi
Chemical Research: Rear-Admiral Akira Kuroda
Naval Architecture: Tech Rear-Admiral Tatumu Izubuti
Material Researching: Tech Rear-Admiral Kiyosi Sasagawa
Experimental Psychology: Rear-Admiral Kazuo Nakamura
Accounts: Paymaster-Inspector Viscount Nobutoi Naito
Medicine: Surgeon Captain Momoru Nomura

Personnel: Officers and Engineers - about 210
Assistants and Workmen - about 2960

Floor Area of Laboratories: 49,692 sq mls

b. Dispersion Laboratories of Japanese Navy Technical Research Institute.

JOKO	Yamagata Primary School, Inamashiro Lake, Fukushima Prefecture Tech Rear-Admiral T. Izubuchi Staff-7, Assistants-25 405 sq M. Resistance, propulsions and timing of ships.
KINUGAWA	Fudiwara-machi, Toduji Prefecture Tech Rear-Admiral K. Sasagawa Staff-4, Assistants-64 3370 sq M.
KUTSUKAKE	Kamizawa, Nagano Prefecture Tech Rear-Admiral S. Oyagi Staff-12, Assistants-152 3990 sq M.
NAGANO	Nagano Workshop of Fuzidenki Co., Nagano Tech Rear-Admiral K. Sasagawa Staff-2, Assistants-21 99 sq M.
KOZA	Koza Navy Yard, Kanagawa Prefecture Rear-Admiral K. Nakamura Staff-5, Assistants 20 100 sq M. Labor conditions and human efficiency.
TOTSUKA	Totsuka Workshop of Towa-Tokushu Co., Yokohama City Tech Rear-Admiral K. Sasagawa Staff-4, Assistants-64 1800 sq M. Steel melting.
YOKOSUKA IKEGAMI	Yokosuka Navy Yard Workmen Training School Rear-Admiral K. Nakamura Staff-10, Assistants-25 200 sq M. Experimental Psychology
WASHIDU	Skiduka Prefecture Rear-Admiral H. Imaizumi Staff-2, Assistants-9 800 sq M. Marine engine vibrations

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TABI

Nimadu
Rear-Admiral H. Imaizumi
Staff-2, Assistants-9 678 sq M.
Torpedo Armament

KYOTO

Kyoto Imperial University
Rear-Admiral H. Imaizumi
Staff-5, Assistants-2 300 sq M.
Combustion of marine engines.

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Appendix 2-B-a-1

SUBJECT: Visit to Naval Technical Research Institute, Meguro, Tokyo.

DATE: 17 September 1945.

INTERVIEWED: Morning

Vice-Admiral Sakae Tokunaga, Chief Officer.

Rear-Admiral Kenroku Fujita, Executive Officer.

Rear-Admiral Marano, Adm Head of Meguro Branch of the Second Naval Tech Institute.

Capt Yagima, Head of Radar.

Afternoon

Vice-Admiral S Tokunaga, Chief Officer.

Rear-Admiral K Fujita, Dept of General Affairs.

Rear-Admiral E Inaizumi, Dept of Applied Physics.

Rear-Admiral A Kuroda, Dept of Chemical Research.

Rear-Admiral T Izubuchi, Dept of Naval Architecture

Rear-Admiral K Sasagawa, Dept of Material Research.

Rear-Admiral K Nakamura, Dept of Experimental Psychological Research.

Paymaster Inspector N Naito, Dept of Accounts.

Capt M Nomura, Surgeon, Dept of Medicine.

INTERVIEWERS: Drs Compton, Longacre, Griggs, Maj Hewlett, 1st Lt Yanada (in the morning), Tec 4 Yagi (in the afternoon).

I. ORGANIZATION OF NAVAL TECHNICAL RESEARCH INSTITUTE.

1. The Naval Technical Research Institute has its administrative headquarters in Tokyo and some of its laboratories and shops. Associated with it is a First Naval Technical Institute at Yokosuka under Vice-Admiral Rikizo Tada, (devoted to aeronautics), and also a Second Naval Technical Institute at Kanazawa, about 10 km south of Yokohama, under Vice-Admiral Sadaichi Matsunaga. The Tokyo establishment is under the command of Vice-Admiral S Tokunaga and is called the Naval Experimental Technical Research Institute. This laboratory has the following sections: Administration, Paymaster, Surgeon, Shipbuilding, Materials, Psychology, Chemistry, and Physics.

2. The Second Naval Technical Institute has the following departments: Administration, Paymaster, Surgeon, Light and Heat, Magnetic, and also the departments of Radar and Communications which also have branches in the Naval Experimental Technical Research Institute in Tokyo, and finally, Acoustics which is located in Numazu in Shizuoka Prefecture. The control of the acoustic work is centered in the Naval Research Laboratory in Tokyo and the manufacturing is, most of it, scattered among civilian firms. The Radar and Communications Laboratories are under the charge of Vice-Admiral Takeshi Nawa.

3. Principal airborne radar development is carried out in the Second Naval Technical Institute in Kanazawa although we saw a 10 cm airborne radar of equipment in the Physics Section of the Tokyo institution. Ship and ground radar are developed in the Tokyo Naval Experimental Research Laboratory.

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II. PROGRAM.

1. Morning:

a. After a general discussion of the organization of the Naval Research Laboratory, we went with Admiral Hamano and Captain Yagima to visit part of the Department of Applied Physics. Here we saw some communications equipment, including a ground beacon of the capital A/W type for ship navigation, reported to have a range of about a hundred miles.

b. Of more interest were two radar sets, one a 10 cm airborne set, weighing about 500 pounds, of which this laboratory model was said to be the only one in existence but which was scheduled to go into production by Nippon Musen. Griggs, Longacre, and Hewlitt are preparing a report on this set and also on the second set which was shipborne, 10 cm.

2. Afternoon:

a. Admiral Tokunaga showed us a map of the entire establishment and pointed out that the Naval Architecture Division had been destroyed in raids of 15 April and 24 May and that part of the materials laboratory had been damaged. The rest of the establishment is intact except that considerable equipment had been dispersed to other districts owing to air raid danger.

b. All research at this institute has been stopped and a large portion of the officers have been demobilized. There were no casualties at these laboratories during the air raids.

3. Our tour covered perhaps one-third of the entire establishment, as follows:

a. Naval Architecture Department. These laboratories were burned out, but the towing tanks were intact except that the dynamometer and other physical equipment were wrecked. There was a large tank 800 ft long, 40 ft wide, and 25 ft deep, with a towing dynamometer which used models of a standard length of $6\frac{1}{2}$ m. At one end of this tank was a rocking basin. There was a much smaller towing tank and also a propeller tank in which 300 propeller models had been tested. The models are mounted on a dynamometer moving at a regulated speed on a track running the length of the tank. There was also a hydraulic circuit for experimental work on cavitation produced by propellers. The maximum speed of water flow was said to be 6 meters per second which I judge was the speed of the water flow produced by the test propeller as it was motor-driven. There were wide windows for observing cavitation.

b. Chemical Department. Here there was research on all naval chemical materials except explosives and poison gas. The most interesting developments which we saw were hydrogen peroxide together with the development of stabilizers, catalysts, and stabilizing containers. The hydrogen peroxide cycle seems to be of conventional type and was described as follows:

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(1) Table of the Rocket Propellant.

(a) The hydrogen peroxide system.

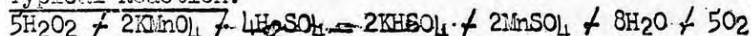
"KO" liquid	H ₂ O ₂	80%
"Otsu" liquid	N ₂ H ₄ ·H ₂ O	80% (Hydrazine hydrate)-US
C liquid	N ₂ H ₄ ·H ₂ O	30%, CH ₃ OH 62%
"Tei" liquid	NaMnO ₄	40% (Sodium Permanganate)
E liquid	FeCl ₂	30%

(b) The nitric acid system.

A liquid	HNO ₃	96%
B liquid	C ₂ H ₅ OH	92%

Stabilizer: 8 - Oxycincholine 0.3 g/l
 Na-Pyrophosphate 0.2 g/l (Na₄P₂O₇)
 Phosphoric acid 0.15 g/l

Catalyzer: K₃Cu(CN)₄ - 2.7 g/l (Potassium Cuprocyanide)

Typical Reaction:

- (2) The catalyzer was fused with cement and used in the form of small blocks half the size of Domino sugar.
- (3) Admiral Kuroda had no information about the military use since he simply turned over the information on the hydrogen peroxide reaction to the naval aeronautics group. He thought they were using it to produce steam for an airplane steam turbine. He did not think they were using it for rocket propulsion or jet engines or launching of rockets or for the propulsion of kamikaze glide bombs.
- (4) In the Chemical Section there was a research program on Rochelle salt for the growing of crystals for use as supersonic oscillators.

c. Department of Applied Physics. Here we saw navigation instruments, radar, and optics.

- (1) The navigation instruments were, so far as we could tell, of conventional type motor, bearing the "Sperry" label. There were, apparently, two lines of development, one having to do with a very light gyroscopic compass for small boat or aircraft use, and the other having to do with a gyroscopic rotating member of spherical form driven by electromagnetic induction but mounted without bearings on an air cushion, produced by a blast

from the bottom of a hemispherical cup within which the sphere fitted and rotated.

- (2) We also saw a gyroscopic device whose function was not fully explained but which appeared to be of interesting construction. One gyroscope was driven by induction from a rotating magnetic field, one end of its axis projected vertically through the upper bearing and terminated in a sharp point. Resting on this point as a bearing was a second rotating member, also driven by a rotating magnetic field from a coil in series with that driving the lower gyroscope. One obvious result of this construction would be to reduce bearing friction for the upper gyroscope to zero, since the bearing was rotating with the same speed as the free rotor which it supported.
- (3) The Optical Section seems to be principally concerned with developing a method for grinding the correcting plate for a small Schmidt optical system which was used for a binocular or field glass of very great light-gathering power. This could be used, for example, as a night vision glass.
- (4) The principal object of interest were the two 10 cm radar sets mentioned above on which Griggs, Longacre and Hewlitt will independently report.

d. Department of Material Research. In this department we saw some experimental field equipment and a sizeable institution of furnaces for production of alloys. There was an installation with "Bureau of Standards" types of equipment for measuring elongations, tensile strength, and other quantities customary in a materials laboratory.

III. NEXT PROGRAM. We agreed to meet again on Monday, 19 September, for an afternoon conference at which the research work of the Naval Experimental Research Laboratory and the Second Naval Technical Institute will be fully described. Then, on the morning of Thursday, 20 September, this description will be concluded and the rest of the establishment in Tokyo visited.

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SUBJECT: Technical Research Institute of the Japanese Navy (2d meeting).
DATE: 19 September 1945.
INTERVIEWED: Vice-Admiral TOKUNAGA and Staff.
INTERVIEWERS: Dr H K Stephenson, Dr E L Moreland.

1. DEPARTMENT OF APPLIED PHYSICS. Following is an outline of the work of this department as furnished by Admiral Tokunaga:

a. Members

Chief director: Rear-Admiral H Imaizumi
Staffs: 39 officers; 20 civil engineers
Assistants: 41
Experimentalists: 620
Workmen: 160

b. System

1st Division: General Physics
2d Division: Ordnance
5th Division: Torpedo
6th Division: Navigation instrument
7th Division: Optical instrument
8th Division: Marine engine
10th Division: Work shop

c. Subjects of Research and their Researchers.

(1) 1st Division.

(a) Physical properties of metal at high and low temperature. Engineer: M Sugihara.

(2) 3d Division.

(a) Research on rocket guns.

1. Effect of the opening angle, and the area of the minimum section of the nozzle.

2. Effect of the position of the center of gravity and the moment of inertial. Engr: M Sugimoto.

(b) Experiment and trial manufacture of a 25 mm rocket gun. Engr: M Sugimoto.

(c) Research on the strength of a trench-motor. Lt Corn (Eng) J Nishiwaki.

(d) Fundamental research on the exterior ballistics. Engr: M Sugimoto.

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- (c) Fundamental research on the penetration of a projectile. Engr: M Sugimoto.
- (3) 5th Division.
 - (a) Research on increasing of the explosive effect of torpedo. Rear Admiral (Eng) S Oyagi. Engr: T Osaki.
 - (b) Study of torpedo firing vehicle. Engr: Y Yagitani.
 - (c) Torpedo Type 92 (Special). Lt (Eng) M Ninomiya.
 - (d) Research on energy sources for torpedo engine. Engr: I Sabanai.
 - (e) Investigation of pumps. Engr: I Sabanai.
- (4) 6th Division.
 - (1) Fundamental research on Gyro-Compass and Gyro-Horizon. Lt (Eng) M Takemura.
 - (2) Research on Magnet-Compass and the correction of its deviation. Lt (Eng) T Ishimoto.
- (5) 7th Division.
 - (a) Studies on the lens of special types.
 - 1. On manufacturing method of "Schmidt Lens" suitable for mass-production.
 - 2. On reflecting telescope for night observation. Lt (Eng) Barron M Shinazu.
- (6) 8th Division.
 - (a) Research on Gas Turbine.
 - 1. Research on gas turbine combustion chamber. Lt (Eng) Y Nogami.
 - 2. Study of combustion of kerosene from pine trees. Lt (Eng) Y Nogami.
 - 3. Cooling method of gas turbine blades. Lt (Eng) J Nishiwaki.
 - 4. Research on axial blower. Lt Corn (Eng) T Nagakura.

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5. Study of refractory materials. Engr: Y Ito.

(b) Research on the vibration of turbine blades.
Engr: S Mori.

(c) Research on the corrosion and erosion of metals
by sea water. Lt Comm (Eng) T Nagakura.

d. Rear-Admiral H Inaizumi presented the following information
from prepared notes and in answer to questions:

- (1) Rocket Studies. These consisted of studies of the effect of placement of center of gravity, nozzle studies, aero-dynamic studies (wind tunnel), investigation of proper area and shape of tail fins. Tests were still going on at the end of the war on a fin-stabilized 20 cm rocket. Admiral Inaizumi disclaimed all knowledge of spin-stabilized Navy-type rockets, and claimed that none were ever used beyond the test stage. It is known, however, that Japanese spin-stabilized rockets bearing the Navy anchor mark were in use by the Japanese Army in the Philippines. On this subject Admiral Inaizumi was either uninformed or evasive.
- (2) Torpedo Research. Investigation was made of a torpedo equipped with a warhead containing a shaped-charge for penetration. Tests had been completed and the head adopted. There was no information on its use in active operations.
- (3) Gas turbine combustion chamber. This research was aimed at the design of improved torpedo motors. Experiments were carried on with a combustion chamber burning bunker oil at the rate of 9,000 kg per cubic meter per hour. Higher pressure chamber tests were planned but not carried out. Various oil and gasoline mixtures were also tried, but it was explained "these methods must be improved".

2. DEPARTMENT OF CHEMICAL RESEARCH. The following outline of the work of this department was furnished by Admiral Tokunaga:

a. Members

Chief director: Rear-Admiral A Kuroda
Staffs: 16 officers; 8 civil engineers
Assistants: 14
Experimentalists: 250

b. Subjects of Research and their Researchers.

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- (1) Study of rocket propellants. Comdr (Eng) T Kitagawa.
Engr: H Shigeno.
- (2) Illumination tube under waters. Engr: K Masaki.
- (3) Fuse material for limiting time. Engr: K Masaki.
- (4) Electric cell acted by sea water. Engr: K Masaki.
- (5) Chemical study of metal corrosion. Engr: H Shigeno.
- (6) Iron cartridge point. Engr: M Uchiyama.
- (7) Gettering material for vacuum tubes. Lt Comdr (Eng) T Hyodo.
- (8) Study on the chemical condensor. Lt Comdr (Eng) T Hyodo.
- (9) Study of Rochelle salt. Lt Comdr (Eng) T Hyodo.
- (10) Application of the nuclear reaction. Comdr (Eng) T Kitagawa.
- (11) Fuels for torpedo. Comdr (Eng) T Kitagawa.
- (12) Fuel cell. Engr: H Shigeno.
- (13) Test of ship's bottom point. Engr: M Uchiyama.

c. Rear-Admiral A Kurada furnished the following information from prepared notes and in answer to questions:

- (1) Submarine illuminator. This device, for locating submarines visually, was described as follows: For detecting submarine boat, the special illuminator was under consideration. The construction consists of two parts: electric cell for the purpose of firing inflammable objects at a distance under sea surface and fire mixture for illumination which give a green color.

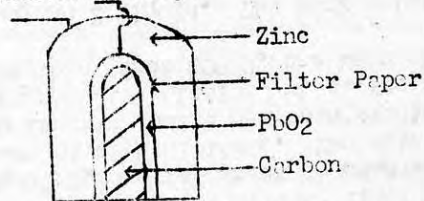
The following formula has been found upon actual trial to yield satisfactory green:

Magnesium	47%
Barium Nitrate	45%
Chloro gun	3%
Paraffin	5%

This will burn not less than one minute, illuminating a circular area of 80 meters in diameter, at 40 meters in depth.

An iron plate of about 2 meters square suspended in sea can be seen down to 40 meters in depth by an illuminator intensity which is 100,000 water candle in air.

The electric cell activated by sea water is illustrated in the following diagram. This cell will furnish 1.7 volts at 1.0 ampere for several seconds. This was experimental only.



- (2) Rocket propellants. The "Ko" liquid propellant, for use in torpedoes or rockets, contains an 80% H_2O_2 together with a stabilizer. The mixture is vaporized by the addition of a catalyzer. This development was aided by "hints" from Germany. The following description of the "Ko" liquid system was furnished:

- (a) Test of stabilization and research on the stabilizer of "Ko" liquid. The stabilization degree of "Ko" liquid is measured as follows:

Sample of "Ko" liquid	200 cc
Temp of thermostat	96° C
Time of heating	24 h
Vessel of "Ko" liquid--hard glass	

Stabilization degree (%) = $\frac{\text{decrease of concentration after heating}}{\text{concentration before heating}}$

It must be less than 10%.

"Ko" liquid contains the following stabilizers:

8-Oxychinoline	0.3 g/l
Na-Pyrophosphate	0.2 "
Phosphoric acid	0.15 "

We have studied the other stabilizers and obtained as superior ones: Oxyno phosphate, tin colloid, etc.

- (b) The catalyzer producing the vapor of "Ko" liquid. "Ko" liquid is decomposed by the catalyzer and produces large amount of water vapor and oxygen at high temperature (about 450 C). A steam turbine can be set in motion by means of the vapor.

Form of the catalyzer is solid cubes. We spray 4.7 l/sec of "Ko" liquid on 2 kg of the catalyzer.

The constituent of the catalyzer is as follows:

Potassium permanganate	4 kg
Potassium perchromate	2 kg
Potassium chromate	2 kg
30 % Potassium hydroxide sol	2 kg
Potassium hydroxide (particle)	1 kg
Portland cement	7 kg

- (c) The catalyzer promoting the combustion reaction of "Ko" and "Otsu" (or C) liquids. In order to prevent the explosion event and to promote the combustion reaction between two liquids, Potassium Cupro-cyanide is added previously into "Otsu" liquid as a catalyzer. Potassium Cuprocyanide is chemically stable, white powder, and has large solubility in water. It is prepared by cupric sulphate, sodium sulphite, and potassium cyanide.
- (d) Chemical test of the material for the rocket propellant. Metallic material suitable for "Ko" liquid are Al, Sn, etc; on the contrary Cu, Fe, Pb, etc, are unsuitable, because these metals have very strong decomposing action upon "Ko" liquid. In the nonmetallic material Vinyl-Chloride polymer with tricresylphosphate as a softener is very suitable for packing or lining materials. It is useable for "Otsu" or C liquid Al or Sn, for "Tei" liquid Pb, and for E liquid Sn or rubber.
- (e) Lowering of the freezing point of "Tei" liquid. The freezing point of "Tei" liquid is too high; that is, 5° C, and it cannot be used in colder atmosphere at high altitude. The method of lowering of its freezing point has been studied, and Calcium Permanganate solution, whose freezing point is less than minus 40° C, has been obtained.
- (f) Study on E liquid. The weak points of "Tei" liquid are high temperature of its freezing point, a difficulty of its manufacture, and a large quantity of the combustion rest. We have obtained an "E" liquid, whose freezing point is minus 30° C. Its preparation is very simple and the combustion residue is comparably small quantity.

Another propellant system, nitric acid and ethyl alcohol, was described as follows:

- (g) Rocket propellants of the nitric acid system. The rocket propellant which consists of concentrated nitric acid and ethyl alcohol as an equal efficiency as the one of the hydrogen peroxide system. Because nitric acid and alcohol cannot ignite itself, an igniting material should be used. As an igniter, the mixture of dimethylaniline-cresolate and dimethylaniline or methylnitrate is used. The primer can also be used for ignition.

- (3) Time Fuse. The following description of the time fuse mixture was furnished: Various fuse mixtures consisting of oxidizers and reducing agents have been studied for several years. It was at first obtained that the composition is as follows:

Barium peroxide	95 parts
Sulphur	5 parts

But this is not sufficient for preservation during a long time on account of the hygroscopic nature of barium peroxide. Therefore, the following are finally the most successful results:

Red lead	16 parts
Ferrosilicon	38 parts
Lead chromate	46 parts

This produced the desired effect of the maintenance of a definite duration of burning if rotation up to 20,000 rpm and depression of atmosphere under to 10 mm in Hg are required. The velocity of combustion shows 4.5 mm per second. This fuse was preserved in no change during two months under the condition of humidity 75% at 40° C.

- (4) Other Information. A question was asked about the development of a true sea-water battery. There was no information on such a development in Japan. No work on nuclear physics has been undertaken at the Naval laboratories. However, the Navy had asked for a study of such problems to be made at Kyoto University by Prof Arakatsu.

3. DEPARTMENT OF NAVAL ARCHITECTURE. The following outline of the work of this department was furnished by Admiral Tokunaga:

a. Members

Chief director: Rear-admiral (Eng) T Ijubuchi
Staff: 8 officers (Eng); 9 civil engineers
Assistants: 26
Draughtsmen and Experimentallists: 250 (approx)

b. System

1st Division: Ship form, resistance and propulsion
2d Division: Stability, rolling and turning
3d Division: Strength and Vibration
4th Division: Protection
5th Divisions: Fitting and equipments

c. Subject of R search and their Researchers.

- (1) Tank experiments of various submarines. Condr (Eng)
T Kondo.
- (2) On the shipform of high-speed small crafts. Engr:
K Takahashi; Engr Y Otsu.
- (3) Flooding calculations of wartime standard cargo ship.
Engr: M Sato
- (4) On the form of bottom of sea-bus.
- (5) Model experiment on the dynamical forces acting on the
ship's bottom at rough sea. Lt (Engr): K Hashimoto.
- (6) On the adhering force of resin system past used for
plywoods. Sub-Lt (Engr) S Honda.
- (7) Strength of wooden ship. Lt (Engr) T Hatano.
- (8) On the methods of electric welding. Sub-Lt (Engr)
S Honda.
- (9) Cavitation of Marine propellers. Engr: S Ikegami.
- (10) On the sweeping apparatus for the magneto-hydro mines.
Lt Condr (Engr) Y Murenaka.
- (11) On the form of towing depth charge. Lt Condr (Engr)
Y Murenaka.
- (12) On the methods of preventing propeller noise. Engr:
F Kito.

d. A large part of the Naval Architecture plant had been destroyed by bombing raids. Much of the work underway at the war's end had to do with the dynamic forces on ship bottoms in rough seas. This

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applied particularly to high-speed small boats, and 15 different bottom shapes had been tested.

Tests of strengths of resin pastes for plywood construction were under way.

The problem of sweeping American-laid "magneto-hydro" mines was under investigation. One method unsuccessfully tried involved a rolling cylinder to detonate these mines.

4. DEPARTMENT OF MATERIAL RESEARCH. The following outline of the work of this department was furnished by Admiral Tokunaga:

a. Members

Chief Director: Rear-Admiral (Eng) K Sasagawa
Staff: 24 officers (Engr); 4 civil engineers
Assistants: 16
Experimentalists: 200
Workmen: 50

b. System

1st Division: Steel
2d Division: Nonferrous steel
3d Division: Non-metallic material
4th Division: Testing of material
5th Division: Chemical analysis
6th Division: Casting, forging, and machining

c. Subjects of Research and their Researchers.

- (1) Heat-proof steel for turbine rocket. Lt Comdr (Engr) Y Yasuda.
- (2) Manufacturing method of magnetic alloy. Lt Comdr (Engr) T Asaki.
- (3) Free-cutting steel. Lt Comdr (Engr) T Asaki.
- (4) Metallic materials for parts of vacuum tubes. Lt Comdr (Engr) M Nakamura.
- (5) Substitution for nichron wire. Lt Comdr (Engr) Y Yasuda.
- (6) Sintering of iron powder for driving band of shell. Lt Comdr (Engr) M Nakamura.
- (7) Properties of pure iron for shells. Lt Comdr (Eng) M Nakamura.

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- (8) Material of dies for iron cartridge. Engr: T Oyama.
- (9) Material of springs for machine guns. Engr: H Fukuchi.
- (10) Properties of steel at low temperature. Engr: K Okamoto.
- (11) Iron and steel melting method. Lt Cond'r (Engr) T Araki.

d. Rear-Admiral Sasagawa furnished the following information from prepared notes and in answer to questions:

- (1) Heat resisting steel for turbine rocket. The creep limit of current steel (A309) is 20 Hgs/mm² at 600° C. We studied to get the same strength at 650° C, and obtained it by the addition of 0.2% N₂. Heat treatment of this steel is suitable to quench from 1150° C, but quenching from such high temperature is practically difficult. We found that it is better to temper without quenching after forging. As to the process of the addition of N₂ in steel, it is suitable to nitride the electrolytic manganese. We enacted the standard method of making this steel and analysis of N₂ in it.
- (2) Free-cutting steel. Lead free-cutting steel is superior to S free-cutting steel in following:
 - (a) Cutting efficiency increases 50%.
 - (b) Yield at rolling increases 10%.
 - (c) Time is saved 50%.

Adding method of Pb is studied and then practical manufacture of Pb free-cutting steel is established. The component of this steel is:

C	Mn	Pb
.2%	.5%	0.2%

The specification of S free-cutting steel for shells is unified, and standard of production and inspection is established, for the purposes of increasing capacity of production and improving the qualities.

- (3) Metals for Vacuum Tubes.
 - (a) Research of current materials.
 - 1. Heat treatment of no plate is studied and annealing at 950° C for 15 minutes is best for improving of its malleability.
 - 2. Thoriated tungsten wire and wires for glass-

sealing are improved. Their surfacial defects are very decreased by purification of raw materials and better hammering.

(b) Research of substitution.

1. Pure iron. Mo, Ta and Ni for anode plate are substituted for by pure iron which is fully deoxidized with AC and hot-ammecated in H₂ stream. Vacuum tubes whose anode is made of pure iron are as good as Mo anode in characteristics and life.
 2. Pure copper for electrodes. Market cu is re-melted and deoxidized with charcoal and others. Thus treated, Cu contains little gaseous component (oxygen) and fits for electrodes of vacuum tubes.
 3. Copper alloyed with silver. Copper alloyed with 2% silver is used for electrodes which requires very minute cutting, because it has suitable machinability and contains little gaseous component. This alloy is also fit for grid supporters of receiving tubes by its heat conductivity.
 4. Ni for cathode sleeve. Electrolytic Ni smelted carefully. A little Mg contained in Ni improves the electron emission of cathode.
 5. Getter Plate. Pure iron which is treated as (b) 1, is used.
- (4) Substitute for Nichrome Wire. As high-temperature heat source we enacted the special 1st class in J.E.S. and we endeavored to improve the manufacturing technic--melting, forging, rolling, cold working, etc., and now we are in the act of going to mass production.

Components are: CR 25%, Al 5%, Fe rest.

- (5) Sintered iron powder for driving band of shell. For machine gun and cannons, we can practically use the sintering driving band if moulding pressure and sintering temperature is high. But as sintering, such high temperature causes many difficulties in practice, we studied to lower the sintering temperature and finally we found that if we interrupt another sintering on the way and sinter again after cold working the semi-sintered driving band, then we had a fairly good one.

5. DEPARTMENT OF PSYCHOLOGY. The following outline of the work of this department was furnished by Admiral Tokunaga:

a. Members

Chief director: Rear-Admiral K Nakamura
Staff: 20 officers; 14 civil engineers
Assistants: 12
Experimentalists: 150

b. System

1st Division: Fundamental research
2d Division: Industrial Psychology
3d Division: Choosing recruits

c. Subjects of Research and their Researchers

(1) 1st Division*

- (a) Psychological Studies for Auditory Function.
- (b) Studies for Coordinate Motion of Both Hands.
- (c) Studies for Search and Find Function of Eyes.
- (d) Studies for Effect of Perceptual Function (except Parallax) in the Stereoscope Vision.
- (e) Studies for Treatment of the Result of the Aptitude Test.
- (f) Studies for Character Test.

* This entire 1st Division by Engr H Kaneko.

(2) 2d Division**

- (a) Studies for Apprentice Test in Naval Work.
- (b) Studies for Suitable Position for Non-Professional Workmen.
- (c) Studies for Vocation and Life-Guidance for Enlisted Workmen.
- (d) Fundamental Studies for Labor Conditions and Work Efficiency.
- (e) Studies for Labor Faculty of Women and its Efficiency.

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(f) Studies for Apprentice Training.

**This entire 2d Division by Engr Y Nakajima.

(3) 3d Division***

- (a) Studies for the Aptitude Test of Radio Operator, Hydrophone-operator, Technical Seamen, and Members of Naval Band.
- (b) Studies for the Aptitude Test of Artillerymen and Rangefinders' Member Measurer.
- (c) Psychological Studies for Superiority Among the Ordinary and Rug Key
- (d) Psychological Studies for Receiving of Light Signal.
- (e) Studies for the Aptitude Test and the Training of Signal Operator.

***This entire 3d Division by Engr Y Kubo.

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ORGANIZATION OF THE SECOND NAVAL TECHNICAL INSTITUTE

Chief: Vice Admiral Sadaichi MATSUNAGA

ADMINISTRATION: Rear Admiral Yuji KOBE

- (1) Administration of general affairs
 - (2) General control of research
- Head Office: Kanazawa (Yokohama)
Branch Office: Meguro (Tokyo)

RADAR and COMMUNICATION: Vice Admiral, Technical, Takeshi NAWA

- (1) Electronic apparatus research
 - (2) Communication apparatus research
- Head Office: Kanazawa, (Yokohama)
General office, radar and radar detector
Branch Office: Meguro (Tokyo)
General Office, communications apparatus, IFF

Experimental Stations:

Shimada (Shizuoka) Theoretical study of radar, magnetrons.
Tokorozawa (Saitama) Direction finder, radar detector
Daito (Chiba) Radar
Tsukishima, (Tokyo) Radar
Hiratsuka (Kanagawa) Wave propagation
Negishi (Yokohama) Radar
Kawana (Chiba) Beacon

ACOUSTIC: Vice Admiral Yasuo YASUBA

- (1) Acoustical Apparatus Research
- Head Office: Numazu (Shizuoka)
General office work, and all research.
Branch Office: Meguro (Tokyo)
General office work

Experiment Stations:

Enoura (Numazu); Office work concerning experiment boat
Awashima (Shizuoka); Part of sea experiment
Shimotogari (Shizuoka); Not in use.
Ose (Shizuoka); Part of sea experiment.
Tabi (Numazu); Underground laboratory.

LIGHT AND HEAT: Captain Kanji IZUSHI

- (1) Light and heat communication apparatus
- Head Office: Zushi (Yokosuka)
General Office, ultraviolet ray beacon, heat ray detector.
Branch Office: Meguro (Tokyo)
Photophony, IFF
Experiment Station:
Ajiro (Shizuoka) Infrared ray communication

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MAGNETIC DETECTION: Vice Admiral Yasuo YASUBA

- (1) Magnetic Apparatus Research
- Head Office: Numazu (Shizuoka)
- Mine detection, magnetic ignitor
- Branch Office: Hayama (Kanagawa)
- Submarine detector, and hit recorder.

YOKOSUKA DIVISION: Rear Admiral, Technical, Keikichiro TANI.

- (1) Research on shipboard installation and fitting of radar and communication apparatus.
- (2) Checking practicability and performance of apparatus
- Head Office: Nagaura (Yokosuka)
- General Office
- Experiment Stations:
 - Negishi (Yokohama), Radar installation.
 - Hatsuse (Kanagawa), Shipboard installation.
 - Kinugasa (Yokosuka), Test Laboratory.

PAY MASTERS: Pay Master Captain Taikichi AOKI

- (1) Disbursing, purchasing, stocking and assigning of materials.
- Head Office: Kanazawa (Yokohama)
- Branch Offices: Meguro (Tokyo)
- Numazu (Shizuoka)

MEDICAL: Captain, Medical, Akira SUGIYAMA

- (1) Health, medical and medical insurance.
- Head Office: Kanazawa (Yokohama)
- Branch Office: Numazu (Shizuoka)

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SUBJECT: Conference at the 2nd Naval Technical Institute
(Radar group from Naval Research Laboratory and
Second Naval Technical Institute.)

INTERVIEWED: Japanese present were mostly vice-admirals and
rear-admirals with some engineers. (Most of
their full names and ranks are given in the doc-
uments submitted to us and attached to this re-
port.)

KAWAZU
TANI
SHINKAWA
HAYASHI
ARISAKA
MINUCHI
TAKAHARA
TAKIYANAGI
TAKASE

HAMANO
WATANABE
YAJIMA
KAWA
ACHI
IZUISHI
KAWAI
OSHIMA
SAITO

KUYAMA
MIYAZAWA
YASUBA
NAGAI
KONISHI
UEMINAMI
KOBÉ

INTERVIEWERS: Drs. COMPTON, GRIGGS, Lt. YAMADA

DATE: 19 September 1945 (Wednesday afternoon)

We were presented with a List of Research Projects of
the Second Naval Technical Institute and a Summary of the Ac-
tivities of the Radar and Communication Departments of the
Second Naval Technical Institute. Both lists are attached.

The above lists are very complete, and the following
further information was developed by interrogation and follows
the number of the sections of the list.

Sec 1, Gp 1. Research on multiple cavity-type magnetrons
was begun a few years after 1927; the split anode magnetron
was invented in Japan in 1927.

Sec 1, Gp 2. The radio-controlled detonator was not
tried in a shell or rocket - the development was not carried
that far. The only detonator tried in a shell was a crystal
detonator without amplification. The powerful oscillators
here mentioned had an efficiency of about 20 per cent.

Sec 3, Gp 1. No radar for night fighters, the type here
indicated, was actually developed. The equipment was consi-
dered too heavy.

The military specifications would have called for a max-
imum range of at least 5 km and a minimum range of 600 meters,
neither of which was considered very satisfactory.

Sec 3, Gp 2 (2). The Navy IFF was 2 meters; the Army IFF, 1.7 meter, so that the two services could not identify each other. When we asked whether each service treated the other like an enemy, the reply was "yes," so far as this was concerned.

Sec 3, Gp 3 (2). The production of these sets was undertaken by Tokyo Shibaura and Hatzi. It was somewhat like the German Wurtzburg but was developed entirely independently in advance of any knowledge about the Wurtzburg. It was a 60-cm set with a large parabola and conical scan.

Sec 3, Gp 3 (3). When questioned as to the significance of Rotterdam, the officers said that this was the German equivalent of the American Pathfinder radar. They secured information about it by wireless from Germany but never received plans or samples. They were very much surprised when we told them that the "Rotterdam Apparat" was the name given by the Germans to the new (to them) radar set which they found in the first H₂S-equipped Pathfinder plane shot down in German territory, which happened to be over Rotterdam.

Sec 3, Gp 6, (2). This is a 2-meter wave length set. The antennas are installed, one in each wing tip. The last few feet of the wing tip is made of plywood in order that the antenna can operate from an inside mounting.

Sec 4, Gp 1 (3). This is a 2-meter wave length set.

Sec 4, Gp 3 (2). These pyrite crystals were not only developed, but also were used.

COMMUNICATION DEPARTMENT

Sec 3. The airborne sets were fully developed in the Naval Research Laboratory, Second Naval Technical Institute. The ship and ground sets were roughly designed by the Navy, and the final designs were set in conference between the Navy and the manufacturing firms.

Sec 5. The radio control apparatus was used

- (1) to control small target ships as targets for gunnery practice; and
- (2) there was some thought of using a radio-controlled ship filled with explosives to be steered into an important enemy installation, but this was not carried out; and

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2-0-a-3

- (3) as to radio controlled aircraft, there were some inventors' ideas but nothing was deemed practical and serious.

Searchlight and Fire Control. We commented on the fact that this list showed no work on radar sets for searchlight or fire control. This was explained as being due to the fact that all research and development work on these sets was completed and no work was going on on this subject at the end of the war. (Note that all of the work listed refers to work which was actually in progress when the war ended. These lists make no attempt to describe past researches already completed.)

The sets used for searchlight and enemy aircraft fire control operate with 1.5 meter wave length and differ principally in size of antenna. The searchlight director has an antenna 2.5 meters by 2.7 meters. The antiaircraft fire control type has an antenna 8.5 meters by 2.7 meters.

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LIST OF RESEARCH PROJECT OF
THE 2ND NAVAL TECHNICAL INSTITUTE
September, 1945

2-c-a

Radar Department

Research and experiment on:

1. Radar for small patrol planes (FK-3)
2. Radar for small patrol planes (N-6 Type 1)
3. Radar for night fighter use (FD-2)
4. Radar for night fighter use (Gyoku-3)
5. Radar for large patrol plane use (FK-4)
6. Radar (Rotterdam type) for large plane use (Kasumi-51)
7. IFF (M-13)
8. Radar detector for plane use (FT-B, FT-C)
9. Wireless homing device (FP)
10. Radar to guide fighters (Hama-62)
11. (a) Radar to guide fighters (Hama-63)
(land based)
- (b) Radar to guide fighters with altitude indicator (Hama-61 (land based)
12. Long range radar (Hama-14) (land based)
13. Improvement of radar Model 13 and Model 22 for submarine use
14. Radar detector for submarine use (E-27)
15. Simplified short wave direction finder
16. Radar to guide boats (TH)
17. Radio altimeter for plane use (FH-1)

Communication Department

Research and experiment on:

1. Wireless telephone for fighter use
(Mark 19, Model 1)
2. Modulator for wireless telegraph
(Experimental Model Mark 5)
3. Expanding wave range of short wave transmitter into medium wave band (Type 4)
4. Adding telephone modulator to short wave transmitter (Type 3)
5. New short wave transmitter (Mark 5, Type 4)

Acoustic Department

Research and experiment on:

1. Propagation of sound waves under water
2. Rochelle salt microphone
3. Under water phonoscope
4. Under water acoustical locator
5. Elimination of vibrations and sounds.

2-C-a

Light and Heat Department

Research and experiment on:

1. Infrared ray communication apparatus (Mark 2 and 3)
2. Infrared ray communication apparatus (Mark 5)
3. Photophony
4. Infrared ray beacon for boat use
5. Heat ray detector (Mark 5)
6. IFF using infrared rays

Magnetic Detection Department

Research and experiment on:

1. Magnet apparatus for mine detection
2. Submarine detector (Mark 3 Type 1, KMX)
3. Magnetic ignitor for hand grenade
4. Drill hit recorder for the use of machine guns against aircrafts

2-C-a

SUMMARY OF THE ACTIVITIES OF
THE RADAR AND THE COMMUNICATION DEPARTMENTS
THE 2ND NAVAL TECHNICAL INSTITUTE

September, 1945

2-c-a

Section 1 of The Radar Department

Group 1: Researches on magnetron tubes:

In 1944, the extreme importance of the application of centimeter waves to radars led us to establish a laboratory at Shimada-machi in Shizuoka-ken, to study the fundamental problems on magnetron tubes. The study has advanced favorably, and made clear the theoretical mechanism of magnetron oscillation which enabled us to make various types of magnetron oscillators. However, the researches could not be fully completed in time for this war.

Group 2: Researches on Apparatus "A":

As one application of centimeter waves, a radio controlled method of igniting detonator was under study. Setting a suitable antenna and a detonator in an anti-aircraft shell, we could explode a shell by the antenna current induced by a sharp directive centimeter wave radiated from the ground.

In order to cause explosions directly by the antenna current, the transmitter power must be extremely large. The efforts were concentrated on producing a powerful oscillator. An oscillator of 50 kilowatt input of 10 to 20 centimeter wave-length was just completed for test. This had led us to the stage of carrying out actual tests with a parabolic reflector of 10 meter diameter which should give a sharp beam wave.

Section 2 of The Radar Department

Group 1: Research on electron tubes:

This group undertakes the researches on electronic tubes commonly used for radar and communication apparatuses. On April 14th, the laboratories of the Meguro Branch were burned and the work was continued in the laboratories of the manufacturers, and at Negishi Experiment Station.

(1) Checking receiving tubes:

Commonly used receiving tubes such as FM 2A05, "sora" RE-3, etc. were constantly checked as to quality.

(2) Checking transmitter tubes:

Commonly used transmitter tubes such as T-304, T-304A, T-321, etc. were constantly checked as to quality.

(3) Research on tubes of new design:

Researches were carried out to develop the following types of tubes: large output oscillator tubes for decimeter waves, secondary emission amplifier tubes, velocity modulated tubes, and high frequency amplifier tubes for decimeter waves.

Group 2: Research on super U. H. F. equipments:

In the laboratory of the Nippon Musen Company, the following problems were studied: design of a circuit for 10 centimeter radar capable of trans-

mitting as well as receiving, crystal detector for super U. H. F. purpose, discharge tube for modulation use and its circuit, and radiating system for centimeter wave radar.

Group 3: Research on parts and materials:

This group was assigned the problems of: standardizing of parts and materials, development of testing technique for parts and materials, and development and testing of high frequency materials.

Group 4: Research on antenna system (cooperated with the Yokosuka air Corps):

Study was made to develop a high efficient antenna for airborne radar and communication equipments.

Section 3 of The Radar Department

Group 1: Research on radar for night fighter use:

The 60 centimeter radar designed for night fighters was not used in the war because of its inadequate effective range. Therefore, fundamental research to increase the power output of the transmitter and the gain of the receiver was undertaken. Flight test on night torpedo bomber was under way.

Group 2:

(1) Research on radar for small patrol planes, Type N-6 and N-6 Improved:

Several sets of 1.2 meter radars for small patrol planes were made for tests. Flight tests showed them to be inadequate in range. Therefore, researches for improving Type N-6 Radar were started. The problems for improvement were: to adopt the anode modulation system, to increase the high altitude characteristics of the transmitter, to utilize the cavity resonator in the high frequency part of the receiver to increase the sensitivity, and to make the width of the impulse waveform narrower to improve the accuracy of measuring the distance and to increase the discriminating ability of targets. When the air raid destroyed the Nippon Musen factory at Hachioji City all of the sets were lost.

(2) I. F. F. Types M-13 and M-13 Improved:

Research was completed for airborne equipment to transmit a special signal to identify enemy from friend which coordinates with Type 13 and Type 11-K warning radar used in greatest number by the navy. Although its performance was not fully satisfactory, the apparatus was in production and was being put into service.

(3) Radar to guide boats, Type TH:

The set was intended to guide friendly boats by locating them with the aid of a receiver and a transmitter placed on board. The search light control radar Type L-3 was used for the land equipment, while radar Type M-13 was used on board. The experiment was discontinued when tests showed unacceptably short range.

Group 3:

(1) Research on radar to guide fighters (Hama-62) (land based):

Although warning radar Type 13 (wave length 2cmeters) has already been installed as land based or airborne equipments, their effective range and accuracy was wanting. Therefore, they could not be used to guide our interceptor fighter planes. The Type 62-B has an improved antenna system, and uses the indicator of the Type 11 radar which improved the ability to locate enemy planes over the interior of the country. The trial test was a success, the set may be seen at Chigasaki but production design could not be completed before the end of the war.

(2) Research on radar to guide fighters, with altitude indicator (Hama-61) (Land based)

This is a radar for measuring enemy's position over water. Actual sets were in production but could not be completed due to repeated air raids. The test set is at Chigasaki, but it also was damaged by air raid.

(3) Research on Radar (Rotterdam Type) for large plane use (Kasumi-51)

This radar was designed to get panoramic scanning from airplanes, and was developed from the centimeter radar Type 220. The trial set was tested at Misawa, and the result was not satisfactory.

Group 4:

(1) Research on "centimeter wave" radar:

Types 105-S2 and 220 radars are for naval ships, and was designed to detect and locate ships. We attempted to improve the Type 2-2 and the Type 105-S2 radar which has three electromagnetic horns, one for transmitting and two for receiving. The equipment is intended for land base as well as for larger ship installations. The directional indication is obtained by the comparison method. The Type 220 radar has a parabolic reflector (1.7 meters in diameter) and measures the direction by the maximum method. It is intended for medium and large ship use. Tests showed the following results;

Type	Battle ship to battle ship			note
	Range Km.	meters	degrees	
105-S2	35	100	0.5	Continuous tracking
220	40	100	0.6	Point by point measurement

is the error of range in meters.

is the error of the direction in degrees.

However, the radars were not installed because towards the end of the war we had very few large ships. On Type 220 we worked to obtain "direct indicating maximum method" with which we could track continuously, but the experiment was not completed.

Group 5:

(1) Research on radar for patrol planes (H-6):

This is the most frequently used radar for patrol planes (wave length 2 meters), and is installed aboard large and medium size planes. The power source for this radar was being redesigned from 12 volts to 24 volts.

(2) Research on radar for small patrol planes (FK-3):

This radar was designed for 2 or 3 seater planes. The weight and size are much smaller than H-6 Type, and the performance is about 80% of that of the Type H-6. The trial set was completed in April of this year, and was in production and going into service.

(3) Research on radar for large plane use (FK-4):

Researches on improving the Type H-6 radar were made to increase the ranges by 1.5 to 2 times that of the H-6 Type radar. The transmitter power was increased, and the modulator system improved. The test was completed in the end of July, and its performance proved to be adequate. However, they were not put into service before the end of the war.

Group 6: Research on antennae:

(1) Research on radar antenna for patrol planes (Mark 5 antenna):

This antenna consists of three Yagi antenna, one front and two sides, and was used on Type H-6 and Type FK-3 radars. The same antenna is used for both radars and was designed so that no frequency change might occur in switching over.

(2) Research on within fuselage antenna:

This antenna is designed to be installed aboard high speed planes. The antenna is installed within the fuselage on both sides. By switching over we could measure the direction of the target by the comparison method. When this antenna is used with the H-6 Type radar, the performance was about 80% of that of the Mark 5. This antenna was just being placed in service.

(3) Research on Antenna for rear guard:

This type of antenna was to be installed on the tail of the land based attack planes, and test preparations were under way.

Section 4 of The Radar Department

Group 1:

(1) Research on shipborne radar detector (radar intercept):

The shipborne radar detector is used aboard fighting surface crafts and submarines. The frequency band is divided into two groups; the centimeter group (3 centimeters to 75 centimeters), and the meter group (0.75 meters to 4 meters). Reception range extends well beyond the line-of-sight distance.

(2) Research on airborne radar detector:

The airborne radar detector is intended for scouting aircrafts and fighter planes. The wave length extends from 0.5 meters to 3.7 meters. Two sets of doublet antennae are installed on both sides of the craft. By means of automatic mechanical switching, the directional indications is had by the binaural principle or by the A-N system.

(3) Research on airborne night fighter radar (Gyoku-3):

This radar is intended for twin-motored night fighter planes. The antenna, transmitter, and receiver are installed in the front nacellus. The antenna beam is electrically revolved by rotating the magnetic coupling coils. The polar indicator system is used, and is of "maximum" method. At altitude of 5,000 meters, the maximum range is 4.5 kilometers against medium size aircrafts, and the minimum perceptable distances is 600 meters. The peak power output is 3 kilowatts.

(4) Short-wave direction finder:

This direction finder is to be air transported and used at front line bases for signal intercept and homing aid. The adcock antenna is 4 meters in length of 4 meter span. The short wave receiver covers from 2.5 megacycles to 7 megacycles, and 4 megacycles to 10 megacycles.

Group 2:

(1) Research on I. F. F:

The airborne I. F. F. is intended for scouting craft and fighter planes. It is used in conjunction with airborne radars, and covers wave lengths from 1.5 meters to 6 meters. Coded signals are transmitted on all wave lengths within this band. Experimental determination of the accuracy and performance was not completed.

(2) Research on wireless beacon:

The beacon is for aircraft and ship use. The wave lengths used are; 1,000 meters (50 kilowatts and 1 kilowatt), 100 meters (80 watts), and 50 meters (30 watts). A-N course indication is used, giving an accuracy better than 2 degrees. The 50 meter beacon uses full visual indicator, but experiments had not been completed.

(3) Research on Lorentz system of blind landing:

This is a copy of the German system. The wave length is 9 meters with power output of 500 watts.

Group 3:

(1) Theoretical study on impulse waves:

The basic theory and design of impulse generators were studied. The immediate purpose was to develop the circuit for the night fighter radar Gyoku-3 which would improve its minimum perceptable range.

(2) Study of crystal detector:

The purpose was to develop a suitable crystal detector to be used on centimeter wave radar intercepts. Uniform reception was desired from 3 centimeter to 75 centimeter wave band. Pyrite crystals with nickel contact feelers were developed. Experiments were being carried out on crystals of metallic silicon.

(3) Study of antennae:

Thorough theoretical study of various forms of all wave all around antenna led us to develop several practical designs. The "θ" Type antenna covers the 4 meter to 7.5 meter range. The "spherical" Type antenna covers the 3 centimeter to 10 centimeter range.

Study was being made on the installation of the all wave 0.5 meter to 3.7 meter racket type antenna for airborne radar intercept. Also for the same use, the slit type rotating beam antenna was under investigation.

(4) Research on goniometer antenna coupler:

The object was to ascertain the maximum gain of the goniometer antenna coupler used for night fighter radar Gyoku-3.

(5) Research on revolving beam antenna for the airborne radar detector:

The problem was to develop an antenna system using an all around "θ" type antenna, and a doublet antenna with goniometer coupler to give a revolving beam characteristics. Satisfactory antenna giving 2.7 db gain was developed.

(6) Research on full visual direction finder:

The object was to develop a direction finder for short interval signal reception, and for simultaneous multiple signal reception.

Section 5 of The Radar Department

Research on electric motors, generators and motor generators:

Power sources for airborne radars and communication apparatuses and for electrical instruments are highly exacting. Performances of motors greatly effect the overall efficiency of apparatuses. Therefore, detailed researches and tests were begun.

The following apparatuses were under test:

1. 250 volt-ampere motor-generator for FK-3 radar. The rating of this machine is as follows; direct current input voltage of 12.5 volts, single phase alternating voltage of 110 volts 400 cycles per second.
2. Constant speed motor for radio altimeter. Specification required for this special motor is that the speed variation be less than 1% for changes in input voltage of 20% and under load torque variation of 50%. Also remedy for wears on brush contacts, springs and commutator was under investigation.
3. 1.5 kilovolt-ampere motor-generator for radar Type 51. This set is rated at direct current input of 27 volts, and generates 110 volts 3-phase, 400

cycles per second alternating current. The automatic voltage regulator for this set was under study.

4. 25 watt generator for FP radar. This set is rated at direct current input voltage of 27 volts and output of 250 volts 0.1 ampere direct current. Methods for eliminating noises produced in this machine were studied.

Section 1 of The Communication Department

Group 1: Research on frequency standards:

As primary standard of frequency, there were five frequency standard, variation of 5×10^{-8} cycles, apparatuses which were calibrated from the time signals from the astronomical observatory. With these apparatuses we monitored the standard frequency waves which were broadcasted by the Department of Communications. This work was started about twenty years ago and reached high standard in Japan. However, the apparatuses were destroyed in April of this year by air raid.

Making use of these standards, simple and stable audio-frequency generators which consist of a crystal oscillator and a frequency dividing circuit were calibrated. We also investigated various mechanical vibrating systems, and lately developed a tuning bar which has a very high "Q" with very small temperature coefficient.

Group 2: Research on multichannel communication:

For multichannel communication we adopted the time division system which is very efficient due to the impulse communication principle. For inter radar posts we had planned the three channel phase modulated telephone at high frequencies.

Group 3: Research on propagation of electric waves:

Studying the data from the various communication stations on the critical frequency of ionized layers and the field intensities we were able to select the suitable frequencies for naval communications. Observations were carried out at the Hiratsuka Experiment Station, and the calculation and tabulating were done at the Tokyo Branch.

Section 3 of The Communication Department

Group 1: Research on wireless telephones:

(1) Wireless telephone for fighters (Type N-1):

This apparatus has been in use for some time. The frequency band is from 5 megacycles to 10 megacycles with power output of around 25 watts.

(2) Research on the new wireless telephone for fighter, Type P-1:

This apparatus is an improvement over the former in that 2 wave selection by push button operation is had. Also, efforts were made to improve the articulation. The apparatus is not in service as yet.

(3) Research on the ultra short wave wireless telephone, Type UP-3:

Researches were directed towards improving the sensitivity of the receiver. Development had not been completed.

Group 2: Research on airborne wireless telegraph apparatuses:

(1) Research on wireless telegraph apparatus for small and medium size planes Type R-3:

A compact apparatus adapted to mass production was developed. The frequency band is 2.5 megacycles to 10 megacycles with maximum power output of about 150 watts. The sets have been in service for several years.

(2) Research on wireless telegraph apparatus for large planes, Type R-4:

The old design was to be revised in three respects; the circuit was to be standardized with that of Type R-3, the component parts were to be standardized to meet increased production schedule, and the electrical characteristics were to be improved. The apparatus has not been put in service.

(3) Research on wireless telegraph for airbase, Type AGS:

A compact all wave equipment suitable for air transportation was developed. The equipment was in production.

(4) Research on adapter for modulation:

An adapter for changing wireless telegraph apparatus into telephone communication apparatus was developed. These are in mass production.

Group 3: Research on transmitters:

(1) Research on new short-wave transmitter (Mark 5 Type 4):

Prototype of this new standard design was being made. The power output is 500 watts, and transmits on frequencies from 2.5 megacycles to 10 megacycles.

(2) Research on improving wireless telephone transmitters:

By redesigning the preamplifier, the operating characteristics were greatly improved. Also the carbon microphones were replaced by dynamic microphones. These apparatuses were in mass production.

(3) Research on adding telephone modulator to short-wave transmitter (Mark 5):

The problem was to add a telephone modulator to the short-wave transmitter Mark 5. A prototype was completed.

(4) Research on improving the frequency stability of transmitters:

Experiments were under way to improve the frequency stability of transmitters.

Group 4: Research on receiver apparatuses:

(1) Research on measurement instruments for receiver adjustment:

A convenient measurement instrument to facilitate the adjustment of superheterodyne receiver was developed. This instrument is used in adjusting the coils, the variable condensers, and the unicontrol mechanism. Prototype was completed.

(2) Redesign of ultra-long-wave receiver:

The receiver for ultra-long-wave reception was being redesigned to facilitate increased production.

(3) Research on improving the coils:

The object was to design a more efficient and convenient coil to replace the plug-in-coil for the all-wave receiver Mark 92. The new design had not been turned over for production.

(4) Research on under water receiver antenna:

Efforts were made to design a small compact under water antenna suited to mass production. The problem was solved by using dust cores.

A special type "Q" meter and several other instruments were also developed to facilitate manufacture of these antenna.

(5) Research on extending the wave range of the small type wireless telegraph apparatus:

Research was initiated to extend the wave length of the small type short wave telegraph apparatus into medium wave band.

Section 4 of The Communication Department

Research on wired communications:

(1) Model 1 Small Type Carrier Telephone Terminal Apparatus:

This is a small type carrier telephone using bare line which carries five channels in the frequency range between 60 kilocycles and 140 kilocycles. The net loss is about 25 db. The sets are in mass production.

(2) Model 3 Telegraph Terminal Apparatus:

This is a carrier telegraph with carrier frequency set at 1615 cycles, and is used in parallel with voice telephone circuit. The net loss is about 25 db. The instruments are in mass production.

(3) Model 5 Carrier Telephone Terminal Apparatus:

This is an improved type of the Model 1 mentioned above, and has six channels in the frequency range between 36 kilocycles and 148 kilocycles. The net loss is between 25 db and 35 db. Although several prototypes were constructed in our laboratory, they were destroyed by air raid.

Section 5 of The Communication Department

Research on radio controlled apparatuses:

The research on the fundamental problems of radio controlled apparatuses for naval ships were being carried out in the special laboratory, using small scale test models. Unfortunately, the air raid of April 16th burned completely all equipments and test models, and researches and experiments were suspended.

Production Section of The Radar Department

Outline:

The production section is in charge of the production of all radar and communication prototypes. Therefore, this section maintains close contact with numerous manufacturers.

As the office of this section was burned through the action of enemy air forces; all records and papers were destroyed. Likewise several manufacturers suffered similar losses.

The following apparatuses were being produced at the beginning of August, 1945:

Names of apparatus	Manufacturer
Radar Type 22-C	Nitchiku, Anritsu, and Hitachi
Receivers for Radar Type 22-C	Nippon Musen
Radar Detector Type 3-A	Nanao Musen
Radar Detector Type 3-B	Sumitomo Tsushin, Nanao Musen, Anritsu
Indicators for Radar Detector Type 5	Nanao Musen
Radiation pattern measuring instrument	Oki
Direction finder (all wave)	Nippon Musen
Portable direction finder Type 97	Anritsu Musen
Direction finder Type 3	Fuji Tsushin
Direction finder (Medium wave)	Nippon Musen

Planning Section of The Radar Department

Outline:

The planning section is composed of two groups, the planning group and the design group. Heads of other sections are members of the first group, where research and experiments are mapped. The second group designs all apparatuses necessary in the experiment laboratories. However, in many instances detailed designing are not necessary for experimenters may obtain equipments directly from manufacturers.

There are about 6,000 sheets and 30 instruction books in the library of the design department.

Inspection Section of The Radar Department

Outline:

The duty of this section is to inspect all radar and communication apparatuses which are in production under the management of the production section. This section is also authorized to change design to meet production process. Work was mostly carried out at the manufacturing plants.

There are two offices, one at the Tokyo Branch and the other at the Kanazawa Headquarter. The Tokyo office is in charge of shipborne and land based equipments, while the Kanazawa office works with airborne equipments.

After passing inspections, the airborne apparatuses are delivered to the Munitions Bureau, while the shipborne and land based equipments are delivered to the production section of our department.

Since as a rule we do not keep such apparatuses in stock, there are only the following apparatuses on hand: Aircraft Wireless Telegraph Apparatus Model 96-3, Model 96-4, Model 19-3, Model 98-4; Aircraft Radar Model 3-6; Frequency meter Model 99-1; Ultra high frequency meter Model 96, and Model 96-1; and Radar frequency meter Model 1.

First Machine Shop of The Radar Department

Outline:

The principal work of this shop is to make various kinds of apparatuses necessary for experiments in our laboratories. Some simple radar and communication equipments are manufactured in the shop under orders from the Aeronautical Headquarters of the Japanese Navy.

The underground shop:

The underground shop was working on the following jobs:

1. Simplified vacuum tube tester
2. Additional telephone modulator
3. Reconstructing radar Model H-6 for 24 volt source
4. Auxiliary indicators for radar Model H-6
5. Molds for battery electrode

The Second Machine Shop of The Radar Department

Outline:

As in the first machine shop, some instruments and apparatuses for experiments at the Tokyo Branch laboratories are made in this shop. However, it is inadequately equipped to construct equipments in any quantity.

The recent action of the American bombers caused us to look for suitable place to keep equipments out of danger.

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Appendix 2-C-b-1

PRELIMINARY REPORT ON
COMMUNICATIONS AND RADAR OF NAVAL TECHNICAL
INSTITUTE No. 2 (Meguro Branch)

DATE: 17 September 1945

I. ORGANIZATION AND KEY PERSONNEL

Naval Technical Institute No 2, under the direction of Vice-Admiral Sadaiti MATSUNAGA, has main laboratories at Kanizawa, 10 km south of Yokahama. It is composed of the following sections:

1. Administrative - Commanding Officer
2. Paymaster
3. Surgeon
4. Radar
5. Communications) Vice-Admiral Takeshi Nawa
6. Heat and Light
7. Acoustic
8. Magnetic

The acoustic research laboratory is at Numazu, Shizuoka, but production of these devices is carried on at Meguro. The radar and communications sections of NTI No. 2 were split off from the Naval Experimental Research Laboratory at Meguro, Tokyo, early in 1945, but a branch of these sections remains at Meguro. The general nature of the geographic split is such that airborne radar and communications is at Kanazawa, while Ground and Ship radar and communications are handled at Meguro. This Meguro branch of NTI No 2 is under the administrative direction of Rear Admiral Hamano. The resident research director is Captain Yataro Yajima.

There is an associated experimental field station on Tsukishima Island, at the head of Tokyo Bay. This, before being taken over by GHQ for communications site No 1, had many operational ground and ship radar sets, both on long wavelength and 10 cm. There was very considerable laboratory space and much new and experimental equipment in evidence. The most interesting thing we saw in a very cursory examination was a 10 cm fire control system with an oscillating antenna in a 6' paraboloid reflector. Though this used a transmitter and receiver similar to the Mod II Mark 2, it had common T and R with only one antenna for the system.

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Appendix 2-C-b-1

At the Meguro branch we found little in the way of facilities for making experimental equipment. It appears that the basic designing is done at Meguro, and engineering and model shop production is done at Nippon Musen, Mitaka plant.

II. JAP 10cm AIRBORNE SEARCH RADAR

The most interesting new radar set we have yet seen in Japan is the 10cm ASV set designed by the Meguro Branch NTI No. 2, and constructed by Nippon Musen, Mitaka plant. We were told that the only complete set of this equipment was the one we saw at Meguro. This is the only microwave airborne radar set we have yet heard of. It incorporates several new developments in Jap radar technique such as the "coaxial" air-cooled magnetron, glow tube T-R, and PPI presentation.

The general form of the system is similar to our early 10cm ASV sets. The state of the microwave radar art is about late 1941, by our standards. It nevertheless serves as an indication of the native ability of the Japanese to produce in time, airborne radar sets of satisfactory performance for instrument bombing purposes.

The characteristics of the system are shown in the following table:

CHARACTERISTICS OF JAP 10cm ASV

Wave length	9.7-10.3 cm
Peak power	5-7 kw
Pulse Repetition Rate	600 cycles per second
Pulse length	1.2 micro-second
Preamp	2 stages double-tuned
Receiver	7 stages IF double-tuned
Video	2 stages
IF	14 megacycles
Band Width	1.5
Cathode Ray Tube	5" electrostatic PPI, 3" A Scope
Phosphor	
Sweeps	20 & 100 km
Range	15-20 km land painting at 10,000'
Type of Scan	
Reflector	89 x 44 cm truncated paraboloid
Radome	
Wt	550 lbs
Input power	V D.C.
Bombing Computer	None

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III. RF SYSTEM OF JAPANESE AIRBORNE 10cm RADAR MARK 51

The magnetron cavities are directly coupled to the coax line which is perpendicular to the plane of the cavity block. The inner conductor of the coax connects to a lead that in turn is connected by four symmetrical straps from the outer frame of the cavity block.

The coax line was 3.3 cm inner diameter with an 1cm inner conductor. It is stub-supported at various points with friction caps that can tune the stub to a $\frac{1}{4}$ wave length. The T for the receiver line is stub-supported on the magnetron side with a $\frac{1}{4}$ wave length stub $\frac{1}{4}$ wave length back from the T. Beyond this T the coax feeds into a flexible coax line having a solid "polysterol" as an insulator. This solid coax has a loss of 2db per meter.

The rotating joints in the antenna mount had capacity coupling for the inner conductor. At the joints the dielectric widened to about 2 inches diameter and then tapered toward the inner conductor. When assembled, the narrow end of this conical dielectric probably came close to the squared-off end of the rotating piece of flexible coax. There was, unquestionably, a gap in between the dielectric at the outer diameter.

Flexible coax went from the base of the antenna to the back of the dish and was transformed to a coax feed of about 1.25 cm diameter. The dipole was quite neatly constructed. About 2.5 cm back, the tube of the coax was cut away symmetrically from the opposite side leaving two pieces about 2.5 cm long which went out to support the driven dipole. These arms were thickened toward the inner conductor and perhaps served as a transformer. The driven dipole was a folded dipole being slotted to within 5 mm of each end and cut adjacent to the connection with the inner conductor. This was made by slotting a 5mm rod about 5 cm long. The reflecting dipole also out of 5mm rod is supported at the center by a 1 cm piece of 5mm rod welded to it and the folded dipole rod colinear with the conductor.

The dish was cut from a parabola of 39 cm diameter with a focal point in the aperture plane. The aperture was 44 cm x 39 cm. The top side of the dish had a horizontal plate filling the cut-off segment. The men in charge claimed not to have done any work as yet on determining the optimum shape for the dish.

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The T to the receiver fed a TR arrangement consisting of a cavity between two short lengths of 4.5 cm x 7.0 cm guide. The input to the guide and the output were the conventional design with the inner conductor running through the guide in the E plane into stub support on the far side. The input piece of guide tapered sharply to a 1 inch diameter copper tube whose axis is perpendicular to the H plane. The aperture into this tube is about 2 cm x 4.5 cm. This copper tube had end plates and a "glow" tube was placed inside of it. Tuning was accomplished by adjusting the position of this "glow" tube along the axis of the copper cylinder. The "glow" tube consisted of a 2.5 cm diameter glass envelope supporting two 5mm metal rods colinearly. The inner ends of these rods were rounded and coated with barium oxide. One of these rods was maintained at a potential of about 2 kv above the other to reduce the time lag in striking. The "glow" tube was filled with pure hydrogen at .06 mm pressure. The actual tube was broken but it seems that the inner ends of the two rods must have been about 1/32 inches apart when assembled.

Hydrogen had been substituted for Argon to reduce the deionization time and reduce the suppression of close signals. However, hydrogen did not give sufficient protection and after a search for other gases or mixtures a pre TR was installed. In this the first was a hydrogen tube while the second was an argon tube. Recently work has been done using water vapor as a constituent. The T & R section at Tsukishima Island used such a double TR as well as those 10 cm ASV being built at Nippon Yusen.

Beyond the "glow" tube there was a sharp widening to a section of 4.5 diameter 7 cm guide. The beat frequency from the magnetron local oscillator was introduced by a loop from the narrow side. The coax take-off for the receiver was symmetrical and identical with the input. The crystal detector was inserted colinearly with the inner conductor of this coax about 3 inches from the guide. This crystal resembled, in outer form, a small fuse. The metal of the crystal was silicon tungsten and an inside tube containing it was filled with wax holding the cats whiskers against the crystal face.

The reputed performances of this system were such as to give land painting out to between 15 and 20 km when flown at 10,000 ft. The Japanese quote their output power as being that radiated by the antenna. On this basis, one can compute a receiver system which has a sensitivity of about 5×10^{-10} watts. Assuming a loss in the RF system of 5db, the receiver sensitivity would be approximately 7×10^{-11} watts.

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The Communication equipment viewed at the Naval Experimental Research Laboratory on 17 September 1945, may be classed in two groups:

1. Navigation Aids. Only one item of this type was seen. This was a ground-based crossed loop transmitter operating in the frequency range of 3 mc and utilizing the equi-signal A-N principle. The set was reported to have an effective range of 100 km and was primarily intended to guide ships down known, fixed courses.

2. Search Receivers. Two types of these receivers were shown:

a. A search receiver covering the frequency range 50 cm to 3 m. This set used a motor-driven scanner to cover the required frequency range. Details of the method of frequency sweep and receiver type were not obtained.

b. A search receiver operating in the 10 cm band. Only the antenna portion of this receiver was shown and was of interest because of its method of determining the approximate direction of arrival of the incoming signal. The antenna consisted of 12 horn-type wave guides in the form of a duodecagon with a central circular aperture about 10 inches in diameter in the middle. Each horn was about 12 inches long with a throat approximately 3 inches across. The height of wave guide was about $1\frac{1}{2}$ inches. A cylinder about $1\frac{1}{2}$ inches thick and 10 inches in diameter fitted into the circular aperture at the base of the horns. The cylinder had a slot about $\frac{1}{2}$ -inch high and 4 inches long along one section of the periphery. As the cylinder was rotated this slot successively picked up signals from each of the 12 horns. A crystal detector was mounted at the center of this cylinder and the resultant video signals were fed down a coaxial line. The method of presentation was not indicated but it might be assumed that a CRT would be used. The whole setup appeared to be in the bread-board stage. It was stated that a similar antenna was being worked out for 3 cm.

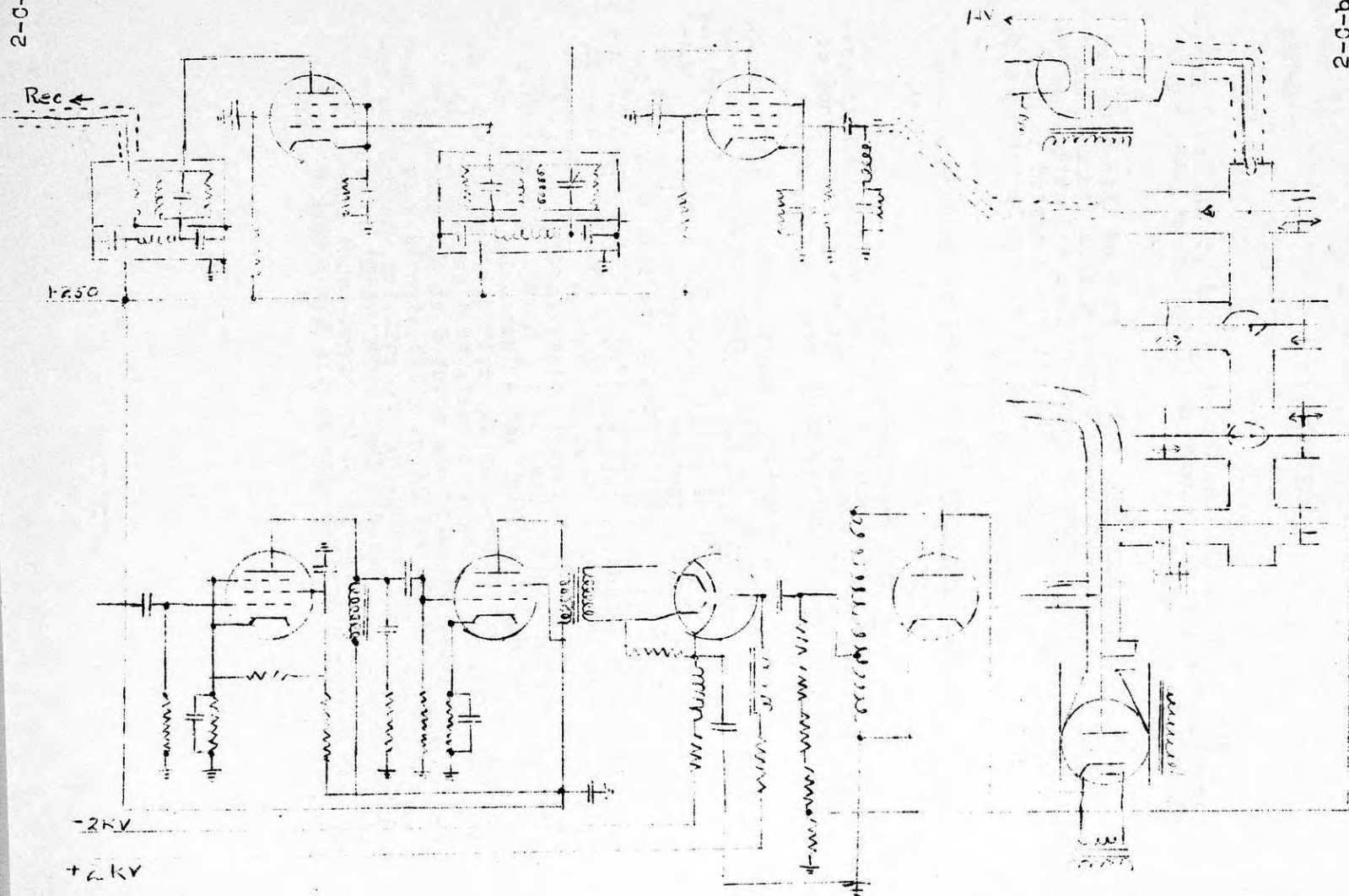
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Modulator, Preamplifier, Local Oscillator, and R F for 10cm Airborne Navigation Radar

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VISIT TO RESEARCH LABORATORIES (ACOUSTIC AND MAGNETIC)
OF THE SECOND NAVAL TECHNICAL INSTITUTE, NUMAZU

SUBJECT: Acoustic and Magnetic Research
INTERVIEWED: Vice-Admiral YASUBA and Staff
INTERVIEWERS: Dr H K STEPHENSON, Maj W R HEWLETT, Lt YAMADA
DATE: 28 September 1945

The party first visited Inoura, near Numazu, where several boats of about 100 tons are kept for experimental work. The rubber mountings for engines aboard ship were inspected. Appendix A is the description furnished of this technique. It was explained that the mounting pads were made by electroplating brass (60% Cu, 40% Zn) to steel, then vulcanizing the rubber onto the brass.

The underwater echo ranging installation (M-3 type 2-4) was inspected on board one of the small vessels. This device is described in Appendix B.

In the magnetic research laboratory two types of underwater mine detectors were examined. (These devices are described in report of conference at 2nd Naval Technical Institute, 20 September 1945). A description of another device, Guard Loop Mark 2-Type 4, was given as follows:

"This is a magnetic detector for land use and is made so compact that the whole apparatus, including its electric source, can easily be transported. A loop of about 200 meter of circumference is buried in the ground at a suitable position and the ends of this loop are lead to an amplifier and a recorder set in the watch station. When a tank, an artillery or a soldier with iron arms pass over the loop, an e.m.f. will be induced in it, and hence we can detect it by watching the recorder. This apparatus was accomplished in October 1943 and about 1000 sets were manufactured but we had no chance to use them in practice."

Several types of underwater sound listening devices, both Japanese and German, were inspected. Appendix C gives some of the information furnished. Detailed drawings and circuit diagrams also furnished have not been duplicated for this preliminary report.

EXPLANATION CONCERNING "VIBRATION PREVENTING" RUBBER
(The 2nd Naval Technical Institute)
(Acoustic Dept)

1. Aim of the Research. The experiments were made on "Vibration Preventing Rubber" to attain the three following effects:

a. To reduce the level of the disturbing noises of the main and auxiliary machines, when in operation, which affect the effectiveness of the sound-listening device and thus to extend its audible distance.

b. To reduce the underwater noises which are radiated from the ship's hull due to the running of the machines and thus to shorten the audible distance of the underwater sound-listening device on other ships.

c. To prevent the destruction of machines in submarines by shocks from the depth charges.

2. Result.

a. Condition of the installation of the vibration preventing rubber on ships.

Example of installation: For the main engines on A-class defense ship.

Displacement tonnage about 1,000 tons.

Horsepower, number of main engines

Weight (each) ---2.200 HP. x 2
--- 37 tons
Revolution (max) --- 610 RPM
Size of Vibration Preventing Rubber Block - 90x180x60 (mm)
Thickness of Rubber Parts - 40 mm
Amount of depression of rubber block under loading - 0.1mm
Amplitude of vibration:
---max.- 0.3 mm
---normal - 0.4 mm

Composition of Rubber:
(inside) natural rubber, vulcanized
(outercover) chroloplane,
artificial rubber

Hardness - 60° shore hardness meter

Besides the above, suitable vibration preventing rubbers were equipped on the propeller shafts, water, oil, and pneumatic pipes to completely separate the vibration and acoustic transmission paths to the ships loading.

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3. Results

a. The level of the disturbing noises which affect the underwater sound-listening devices was reduced by 15 to 20 decibels.

b. Consequently, the audible distance was extended from 1,500 to 8,500 meters (of 100-ton launch)

c. The level of underwater noises which are radiated from the ship's hull was reduced by 10 to 15 decibels. (Consequently, the audible distance of underwater-sound listening device from other ships was reduced by considerable amount).

d. Generally, the decrease of vibrations and noises in all parts of the ship made life comfortable onboard.

e. On equipments other than the acoustic equipments, the decrease in vibration had good effects.

f. Technique of manufacturing vibration-preventing rubber. Regarding the technique of manufacture, that of other countries being unknown, we proceeded with our own method.

- (1) Standard types - manufactured ten types with kinds limited to about 100.
- (2) Adhesive strength to soft steel - 30-50 kg/cm (for tension)
- (c) Load intensity - 1-2 kg/cm
- (d) Hardness - 50-65 (shore hardness meter)

EXPLANATION OF SUPERSONIC DEVICE

CHAP. I. GENERAL DESCRIPTION. We have several types of UERD (Underwater Echo Ranging Device) in use as shown in Table No. 1, but among them M-93 and Simplified UERD have been stopped manufacturing since June, 1944, and the series of M-3 have chiefly been manufactured.

M-3 series are divided into 6 classes--from type 1 to 6 according to the frequencies used and to the type of the ships on which they are installed. However, the design and overall constructions of this kind of UERD are all the same and typically represented by UERD M.3 Type 2-A.

CHAP. II. UERD M-3 Type 2-A

A. Transmitter Parts

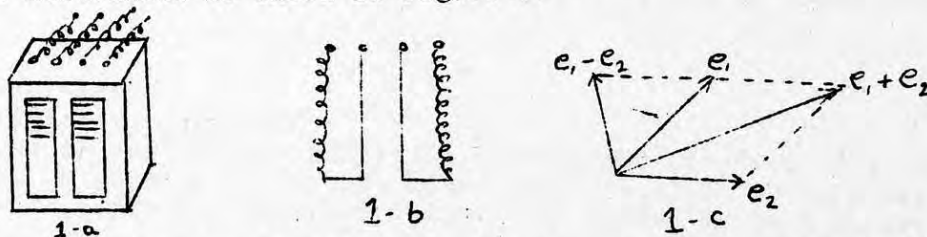
1. The electric oscillator is master-controlled, power-amplification type and produces 13 kc intermittent continuous wave during 50 millisecond or 120 millisecond. Since the condenser discharge method is adopted (because the load factor of this oscillator is nearly 10%), the capacity of the electric power source has been considerably reduced.

2. The transfer from transmission to reception or vice-versa is practiced in the Transfer Relay Box, controlled by Rotary Switch Box, which is also controlled by the following three switches on the panel of Indicator A.

- a. Ranging or Hearing Switch
- b. Duration Switch, 50 ms or 120 ms.
- c. Maximum Range Switch, 1 km, 3 km or 6 km.

B. Receptor and Indicator Parts

1. Echo, the acoustic energy, caught by the twin receiving vibrator units, is individually converted into electrical energy, and these two EMF's are vectorially added and subtracted as shown in Figure 1:



These added and subtracted EMF's $e_1 + e_2$, $e_1 - e_2$, are amplified and shifted into same phase by the phase-shifter circuit, and are applied to the electrode plates of the Braun tube, obtaining the Lissage figure.

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2. The relation between the visual angle ϕ of the image on Braun tube and the angle θ subtended by the direction of the object and the normal to the surface of the receiving vibrator, is as follows:

$$\phi = \frac{rd}{\lambda} \theta$$

where 'd' is distance between the center of the vibrator units
 λ is wave length of supersonics used

3. The mode of sweeping of the spot upon the fluorescent screen of the Braun tube is linear which is obtained by the charge-discharge method of condenser and the constant current charging valve.

4. Echo is also heard by telephone receiver.

CHAP. III. MANIPULATING APPARATUS AND UNDERWATER COVERING

1. For manipulating apparatus, hand-operated type is generally used, but in some cases electro-mechanical type is used.

2. To avoid the direct contact of flowing water with the surface of vibrator, the streamlined Underwater Covering is adopted, made of stainless steel and filled with pure water.

CHAP. IV. METHOD OF INSTALLATION

1. Vibrator is installed under the bridge, avoiding the disturbance of bow-wave.

2. Indicator B and Angle-Receiver are installed on bridge deck and other parts are placed in underwater sound listening room and its neighborhood.

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DESCRIPTIONS OF UNDERWATER ECHO RANGING

Device Model 3 Type 2A

PARTS	DESCRIPTIONS		REMARKS
Oscillator	Frequency (kc)	1 3	
	Mode of Oscillation wave	Intermittent Continuous wave	
	Peak Power (KW)	2	
	Valve	T 307 x 1 P 256 x 1	
	Mode of keying	Grid keying	
	Keying time	50ms or 120ms	Transferrabl
Source for Oscillator	Valve	X 251 x 2 K 250 x 2	
	Output Voltage	DC 3800 V DC 900 V DC 450 V	
Condenser Box	Condenser	20 μ F x 4	
Relay Box	Keying time	50ms or 120ms	Transferrabl
	Keying interval	1.33Sec(1KmScale) 4 Sec(3Km " 8 Sec(6Km "	Transferrabl
Exciter			
Source for Exciter	Mode of rectification	Bridged Selenium rectifier	
	Output	DC, 20V 8	
Amplifier	Mode of amplifier	Couple of 4stage straight amplif.	
	Valve (amplifier)	UZ 6D6 x 6 UZ 42 x 2	
	Gain	90 db	
	Valve (sweeping circuit)	TX 904 x 1 UZ 76 x 1 UZ 6D6 x 1	
	Local oscillator Valve	UZ 606 x 1	
	Audio frequency used echo hearing	1000 cycle	Audio Frequ. Amp valvUZ42
	Mode of detection	Ring Modulation	
Braun Tube Indicator "A"	Mode of sweeping	linear type	
	Scale (Range)	1km 3km & 6km	Transferrabl
	Valve (Brauntube) (rectifier)	SSF 120G x 1 KN 142 x 1	
	Transfer switches	(1)Range or Hearing (2)Scale (3)Keying time	

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Braun Tube Indicator "B"	(Almost same as Indicator "A")		
Rotary Switch	Motor	1 HP constant 50 speed D.C. 100V motor	
	Contacts controlled	(1) Keying time (2) Scale	
Projector	No. Vibrator units	2	Also used as Receiving Vibrator by action of Transfer Switch Box
	Material of unit sheet	0.4 ^{mm} /m Al alloy (Al 13% Fe bal)	
	Type of unit sheet	"NA" type (Patented)	
	Horizontal length of units	8 λ	
	Vertical length of vibrator laminated	3 λ	
	Horizontal directivity	30°	
	Electrical Peak Input	2 KW	
	Electro acoustic efficiency (assumed)	30%	
Manipulating Apparatus	Hand Manipulating of Projector		

THE EXPLANATION OF THE
UNDERWATER SOUND LISTENING DEVICE
Sept. 28, 1945

1. The Maximum Method of Direction Finding. When the plane waves of sound arrive at the group of the hydrophone system, which is arranged in space, there are phase differences of induced current of the hydrophone due to the relative position of each hydrophone to the wave front of incoming sound waves. Therefore, if we control the phase by retardation nets to superpose each current of hydrophones in phase for special direction, the superposed current will be maximum only to that special direction. In this way we can determine the direction of the sound source by the retardation amount which will be practically indicated directly by an angle.

2. The Method of the Suppression of the Disturbing Noise. To suppress the disturbing noise there are many methods. The first method is to increase the number of hydrophones and to suppress the submaximum of the compensatable disturbing noise and also uncompensatable disturbing noises.

3. The Arrangement of Hydrophones. There are many kinds of arrangement of hydrophones. To measure the direction of the sound source accurately and to suppress the submaximum of the disturbing noise, many kinds of arrangements of the hydrophone are considered.

4. The Installation of Hydrophones. There are following four methods of installation of hydrophones on board the ship:

- a. side installation.
- b. bottom installation.
- c. tank installation.
- d. stream-lined over installation below the ship's bottom.

Each installation must be carefully applied to make no disturbance of stream lines of water and in 1-3 method it is always necessary to prepare the water tank as great as possible practically to get good listening range.

5. The Rochelle Salt Crystal. The method of the crystallization of rochelle salt was studied in our laboratory some years ago, but now there are no devices of crystallization here and many crystals are made in factories; Sumitomo-Tsusin-Kogio, Okidenki, Toshiba-Tsusin-Kogio, and also Imai Institute.

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We studied to apply other piezo-electric crystals, for instance, quartz, tourmaline, and the strontium salt of formic acid, but these crystals are all less sensible compared to Rochelle salts and not used in practice.

6. The Hydrophone. Many kinds of hydrophones are studied and produced by way of experiment but not in use. The typical hydrophones in use are following ones:

- a. Type K. R. 10,) Rochelle salts type
- b. Type R. O. 11,)
- c. Type P. 3, moving coil type

7. The Compensator, Amplifier, Filter and other Apparatus. The underwater sound listening device consists of the hydrophones, compensator, audio frequency amplifier, filter and some other apparatus. The compensation is made horizontally, and the vertical compensation is not yet practised. The handle of the compensator is driven by hand and the automatic handling of the compensator by the electric power is only adopted in Mod. 3.

END

MAGNETIC IGNITOR FOR HAND GRENADE

1. General Description. This is an ignitor to be used in a hand grenade attacking the tank. It is designed to be thrown ahead of a coming tank and be ignited magnetically when the tank passes over it. The weight of the ignitor is about 1.5 kg. and the total weight of the grenade is about 10 kg. It is designed to be carried and thrown by one person.

2. Construction and Principle of Action.

a. Permanent Magnet Type. Between the flux collectors, which consist of several sheets of soft iron of 20 mm. wide and 100 mm. long, a cylindrical permanent magnet is supported and balanced by a suitable spring. When the magnetic field intensity is increased more than 200 mOe. by the approach of a tank, the supported magnet turns until the ignition circuit is closed.

b. Induction Type. The main part of this type consists of a coil of 5000 turns of 0.32 mm. enameled copper wire wound on a "Sendust" core of 10 mm. diameter and 300 mm. long, and a relay, whose sensitivity is 30 u.A. and inner resistance 40 ohm. When the magnetic field intensity changes at the rate more than mOe/sec by the approach of a tank, the relay acts by the e.m.f. induced in the coil, so that the ignition circuit is closed.

As the safety device, either type has a set of gear to keep the ignition circuit open from the dry cell for about 3 seconds after the grenade is thrown off.

3. Results of Experiments. By measuring the magnetic field distribution around the tank of middle size, we found that the intensity of magnetic field decreases abruptly at the point a little apart from the tank, and that the maximum increase of intensity is about 200 mOe. and the maximum rate of change for the speed of 5 knots is about 300 mOe/sec. As the American tank is much larger than our middle size one, the above-mentioned sensitivity will be sufficient.

As we obtained sufficient results by the preparatory experiments, we were planning to make such grenades and to experiment for practical use.

END

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2-C.c

SUBJECT: Visit to Zushi, Kanazawa, and Negishi Field Laboratories of the Japanese Technical Institute
INTERVIEWERS: Maj HTWLETT, Dr STEPHENSON, and 1st Lt YAMADA
DATE: 26 September 1945

1. Zushi Field Laboratory of the First Technical Institute. Zushi is a small summer resort at the western base of the Muria peninsula, approximately 40 miles south of Tokyo. Actually two separate laboratories were located here--one responsible for magnetic research and the other for light and heat research.

a. Magnetic Research Laboratory. The principal developed items of a magnetic nature are discussed below:

- (1) Submarine Detector, Mark 3, Type 1. A magnetic airborne detector for use against submarines. It had an effective range of approximately 125 meters vertical maximum, and 80-90 meters horizontal maximum range. It operated on the magnetic gradient produced by the submarine in the earth's magnetic field. Inclosure 1 is a detailed description of this device. Approximately 20 of these sets have been installed in aircraft, and although no detailed information was available, it was stated that the set had a good reputation. The development of this set was commenced October, 1942, and final models were in operation by the end of 1943. A model set was available and its operation was demonstrated by passing a small metal part near the search coil.
- (2) Magnetic Apparatus for Mine Detection. Inclosure 2 contains a detailed description of this device. It is intended to locate mines on the bottom of the sea by sweeping a magnetic search device along the sea bottom. No detailed information was obtained on production of this device.
- (3) Drill-hit recorder for training antiaircraft machine gunners. Inclosure 3 contains a detailed description of this apparatus. For operation it depended upon the residual magnetism of the machine gun bullet inducing a voltage in a search coil in the towed sleeve. This item was not demonstrated.

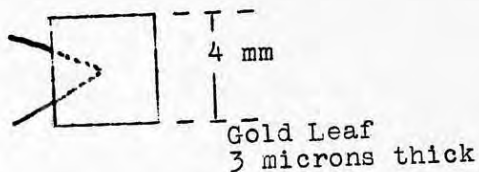
b. Heat and Light Laboratory. The following is a description of the principal projection and equipments discussed at this laboratory.

- (1) Infrared Signaling Devices. Two devices had been developed for the purpose of signaling by infrared means. A larger unit was developed for use by coastal defense ships, for intercommunication between ships, and for ship to shore communication. It consisted of three principal components:
 - (a) A light source suitable filter to eliminate visible radiation. It used a 24-candle-power incandescent lamp, and was operated by a trigger device on the aiming handle.
 - (b) A warning device consisting of a standard type photocell, filtered to exclude all except infrared radiation. Its purpose was to warn the operator that he was being called by another station.
 - (c) A receiving device consisting of an image-forming detector. A special tube was used for this purpose, with a cesium coating on which the infrared radiations were focused, an electrostatic lense produced by a large hollow cylinder, and a phosphorous screen upon which the final, visual image was formed. This tube was placed in operation and a surprisingly satisfactory image was formed. This tube was placed in operation and a surprisingly satisfactory image of objects across the bay was produced. A sample of this tube was obtained. The second signaling device was a small, hand-held, image-forming tube with associated optical and electrical components. It was intended for use aboard small assault boats for signaling purposes and for use in conjunction with an infrared navigation beacon. The proposed operating procedure was that a fairly narrow beam of infrared light was directed against an enemy vessel from a control point.

The attacking craft then traveled so as to maintain itself at all times within the beam. Approximately 100 larger signaling devices had been produced but only about six smaller devices. From stated ranges on various sources, it was estimated that the image-forming tube had a sensitivity of approximately 1.2 mile-candles.

- (2) Airborne near Infrared Detector. This device depended upon the attacking plane illuminating the enemy plane with infrared and observing it through an image-forming tube with associated optical equipment. For this purpose a 7-inch Schmidt optical system had been tried; however, the results of this test were unsatisfactory and work was discontinued. The maximum range obtained was approximately 500 meters.
- (3) Infrared IFF. This device merely consisted of a light hand-held receiver using an image-forming tube and a continuous infrared all-round beacon on the vessel identifying itself. Only about six sets had been produced.
- (4) Voice-modulated, light-beam Communication System. For this communication device a high-pressure mercury arc was directly modulated with the voice frequency. It was stated that this light could be 100% modulated. The lamp itself was rated at 100 volts, 1 Amp. A 2-ft reflector was used to concentrate the light beam. The receiver was of standard photocell construction. A system was reported to have a range of about 15 km under optimum conditions and was intended to supplement other means of communication between coastal stations. Only one trial set had been produced.
- (5) Far Infrared Detector. This device was intended to be carried by night fighters to assist in the intercept of hostile planes. The sensitive element of this device was a thermocouple consisting of constantine and tellurium wire. A sketch of the individual unit follows:

Thermocouple
Wires
.03 mm. diam.



These thermocouples were connected in pairs to obtain compensation for the ambient temperature. When the image of the target was swept across the cells it produced a positive voltage on one side and a negative on the other. Eighteen of these pairs of thermocouples were connected in a series and were then housed at the focal point of an 8-inch mirror. The mirror was housed in a cylindrical case about 10-inches long with the front surface covered by a protective screen consisting of a chloride of rubber. The whole unit was mounted below the plane and searched back and forth through a predetermined angle thus causing the image of the object to be swept back and forth over sensitive cells. This device was reported to have a range of 7-10 km on a night fighter and was intended to be mounted in a "Betty" or a "Toki". In flight tests the unit had been unsatisfactory due to the effects of wind on a mirror assembly. Only three of these devices have been made.

2. Kanazawa Field Laboratory of the Second Naval Technical Institute. This laboratory was located at Kanazawa, approximately 35 miles south of Tokyo, on Tokyo Bay. It was charged with the responsibility for research and development on all radar and communication equipment, exclusive of that assigned to the Megura Laboratory, Tokyo (ship-borne radar). The laboratory employed about 135 technical officers and 115 civilian technicians, and had an annual budget of approximately 100 million yen. Part of this was required for prototype production.

a. The following is a description of the principal radar development projects and associated items:

- (1) Radar Set FK-3. This radar set was mounted in scouting planes and intended for sea-searching use. It operated on a frequency of 150 mc, had a peak power output of 2 kw, a pulse length of 10 microseconds, and a

pulse repetition frequency of 1,000. The antenna used provided about 6.3 DB gain. Only range information and a gross estimate of azimuth were obtained. Indications of azimuth were obtained by the use of side antennas in conjunction with the nose array. It was reported to have a range of about 60 km against large ships. Its detailed weight was approximately 40 kg, including a 12-volt, 50-amp dynamotor. It was built in three separate units: transmitter, receiver and indicator, and remote indicator. About 200 of these sets were produced. It was stated that this set took approximately six months to develop and four months more for production to commence. Much of its design, however, was based on its predecessor, Radar H-6.

- (2) Radar Set Type H-6. This set, in principal, was substantially similar to the FK-3. It had a power output of approximately 3 kw and a range of about 110 km against large ships. Over 2,000 of these sets were produced.
- (3) Radio Altimeter FH-1. This altimeter was of a frequency modulated type, with a maximum range of 200 meters. It operated on a wave length of 90 cm and had a 30 mc sweep frequency. One of its principal uses was for torpedo planes. Its detailed weight was 25 kg. It was a production item.
- (4) IFF M-13. This IFF operated on a mean frequency of 150 mc and was swept over a range of 10 mc on either side. In operation it received a signal from any radar operating in the prescribed frequency range and retransmitted signal appeared on the radar scope as an increase in echo. The set was provided with five codes consisting of dashes with different time spacing. Only 50 of these sets were produced and none was placed in use. The Army also had an IFF system but it did not operate on the same frequency as the Navy IFF. The range of this set was approximately 70 km for a type-13 radar and 110 km for a type-62 radar. The total weight of the set was about 13 kg. It provided audible warning to the pilot

when IFF was being interrogated. It was stated that this device required five months to develop and four months to get into production.

- (5) Radar Set N-6. This radar set operating on 1.2 meters, was intended for use on scouting planes. Tests of this device indicated serious trouble in the high frequency amplifier circuit and development was discontinued.
- (6) Radar Intercept Receiver FTB. This receiver covered the frequency range of 3.7 meters to 45 cm. A motor drive was provided to sweep this receiver through its frequency range at the rate of 4 times per minute. Directional indication to the target was obtained by the use of two antennas slightly overlapping in their coverage. The signal from one antenna was modulated with an "A", the other with "N". By directing the plane towards the target the two signals could be made to merge and give an on-course indication. The weight of this set installed was 17 kg. Approximately eight months were required to develop and produce this receiver. It was in large-scale production.
- (7) Captured Equipment. Several items of American Radar equipment were observed in this laboratory. They were component parts of the AN/APX-1 and 2 and AN/APQ-13. Apparently they had not as yet worked out the functioning of the IFF equipment, nor had they discovered our principle of nomenclature assignment.

b. The following is a description of the principal radio communication and navigation sets:

- (1) Radio Set Model 19, Ground 3 or Air 4. This was a universal transmitter covering a frequency range from 300 kc to 20 mc, with a power output of 160 w CW, 40 w voice or MCW. This set used plug-in, coil assemblies somewhat similar to our own BC-191. It was in the late experimental stage.
- (2) Radio Set Model 19, Air 3. This set consisting of separate transmitter and re-

ceiver covered the frequency range 300-500 kc and 2.5 to 10 mc. It had a power output of 150 w. The transmitter and receiver were of unit type construction, designed for quick replacement. In larger planes where additional weight was possible and an antenna tuning unit for the low frequency range could be plugged in to replace the receiver and the receiver located elsewhere in the plane. The weight of this set was 47 kg.

- (3) Radio Set, Type 3, Air 1, Mod. 3. This set was designed to replace Radio Set Type 19, Air 1, which had covered the frequency band 3.75 to 6 MC. This performance set had had the shortcoming of limited frequency range and only one crystal control channel available at one time. The new set covered the frequency range 5-10 mc and provided for two separate crystal control channels that could be selected by a remote switch. One purpose of the dual channel was to minimize the effects of jamming. It had a power output of 40 w CW, 15 w Voice, and was intended for installation in fighter planes. A minimum of tube types had been used in this set, the principal tube being the SORA or so-called Universal Air Pentode, somewhat similar in characteristics to our 6C6.
- (4) Radio Type 1, Air 3, Mod 1. Covered the frequency range of 30-50 mc. It was intended for short range, plane to plane communication.
- (5) Captured Equipment. A model of radio set AN/ARC-1 was observed in the laboratory. The officer in charge of airborne radio development commented on its fine workmanship and performance and stated that it could not be copied even in Japan.

c. The following general development projects were observed:

- (1) Antenna Research. The principal research on antennas appeared to have been directed towards the development of directional antennas depending upon the Yagi director-reflector principle and upon the development of a few wide-band antennas for search receivers.

- (2) Dynamotor Laboratory. Various types of dynamotors for airborne sets were developed and tested by this group. The latest trend had been towards the use of 400 cycles for airborne sets. They had received no adverse reports on the performance of dynamotors at very high altitudes up to eight thousand meters. Some dynamotors operated at speeds as high as 6,000 RPM.

3. Negishiki Field Laboratory of the Second Naval Technical Institute. This laboratory is located on the outskirts of Yokohama, in the building of the Nippon Race Club. A description of the history of this laboratory, its buildings and principal projects is contained in Inclosure 4. The following general information not contained in this inclosure was obtained.

a. No research work on centimeter radar was carried at this laboratory.

b. Although this laboratory was charged with the improvements to existing sets and production engineering on new sets, they claimed to have done no work on anti-jamming or anti-window devices. They reported that their No. 14 set, an early warning radar, operating in the meter band, had not been adversely affected by window, although the fire control in searchlight radar had been so affected.

c. No particular emphasis appeared to have been placed on moisture or fungus proofing of signal equipment. About the only precaution taken was to pot their transformers. It was not believed that hermetical sealing was used.

Note: It is interesting to note that this laboratory, with an engineering staff of 12 technical officers, 8 assistant engineers (junior rank), and 40 semi-skilled technicians, was commanded by a Vice-Admiral.

4. SUMMARY. The following may be considered the salient features observed on the trip to the Zushi, Kanazawa, and Negishi Field Laboratories of the Naval Technical Institute.

a. A magnetic, airborne detector with reasonably satisfactory operational characteristics had been developed and placed in successful use.

b. Research was being actively pursued in the near infrared field and some of the developments observed should

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have direct and far-reaching implications upon the U.S. Naval program.

c. The utter lack of any work on centimeter radar.

d. The extremely short time when compared by our standards required for the development and production of new equipment.

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Incl 1

GENERAL DESCRIPTION

of

SUBMARINE DETECTOR
Mark 3 - Type 7

28 September 1945

MAGNETIC DEPARTMENT OF SECOND NAVAL INSTITUTE

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 - 8. A.C. Generator
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- V. EQUIPPED AIRCRAFTS
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I. FUNDAMENTAL PRINCIPLE

This is an apparatus to search a submarine by detecting the magnetic field produced around it, by picking up the slight change of e.m.f. induced in a search coil set in an aircraft.

In order to make insensible to the earth field when the body is swinging, the search coil is set on a gyroscope.

Other than this, the noise due to the eddy current field produced in the metallic parts when the body swings, is remarkable.

To eliminate this, two coils are provided, one coil called "compensating outer coil" is fixed to the body and the other called "compensating inner coil" is wound on the search coil.

These two coils and a variable resistance are connected in series.

The outer coil produces an e.m.f. proportional to and in phase with the eddy current, because it cut the earth field flux in the same manner as the body.

The above-mentioned e.m.f. generates the second coil current which, when well adjusted by the variable resistance, can produce a field just opposite in phase and equal in magnitude, and thus neutralize the eddy current noise.

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II. THE CONSTITUTION OF THE DEVICE

<u>CONSTITUTING PARTS</u>	<u>FUNCTION</u>	<u>WEIGHT</u> (kg)	<u>DIMENSION</u> (mm)
1. Search coil with gyroscope	To catch a signal voltage	10.0	
2. Filter	To eliminate the noise voltage of frequency above 1.2 cycle per sec.	5.3	220x150x 120
3. Amplifier	To amplify the signal	23.0	250x400x 410
4. Signal indicating device	Time limiting, signal indication and monition		
5. Eddy current compensator	To compensate the eddy current noise arisen by swinging of body	5.6	410øx65
6. AC Generator	Electric source of gyroscope	6.5	220x120x 154
7. DC Generator	Electric source of amplifier and signal-indicating device	7.0	205x108x 170
8. Discharge controller of position marker	To control the discharge of position marker when a signal arrives		
9. Discharger of position marker	To discharge a position marker		

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III. THE CONSTRUCTION AND THE FUNCTION OF THE CONSTITUTING PARTS

1. Search Coil

a. It consists of a pair of coils, one set on the upside, and the other on the underside of the case of gyroscope. Each coil is wound on a permalloy core and is covered with a metallic case.

b. Electric resistance of coils	15 KSL
No. of turns	16,000 $\emptyset$
Size of wire	0.1mm $\emptyset$ ECW
Permalloy core	Ni 78% alloy
	250x5 $\emptyset$
Bobin	Each coil consist of 3 bot ins (of Dulal min)

c. Compensating inner coil wound on the outer layer of search coil.

d. One end of the permalloy core is set free to escape from mechanical stresses.

e. Sensitivity of the search coil.
ex:--1,000 NT per 1 deg/sec (angular velocity)
when coil axis is set perpendicular to the earth field.

2. Gyroscope

a. Anschutz type (induction motor-driven)

b. Diameter - 130 mm
Weight - 2 kg

c. Electric source.- 3 phase 100 V 400 c/s 0.8A

d. Gimbal - manufactured from the phenol resin insulator to prevent the eddy current noise.

e. Time to rotate up - 10 - 15 m

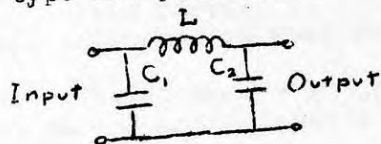
f. The no. of revolutions - 19500 $\pm$ 1500 R/M
Moment of inertia - 50,000 gr. cm

g. Slip frequency is kept about 50 r to prevent the low frequency inductive noise.

h. Damping device is set on the top of coil cylinder to absorb the neutation.

3. Filter

a. II type low pass filter



$L = 4600 \text{ h.}$
 $C_1 = 6 \mu\text{fd.}$
 $C_2 = 5 \mu\text{fd.}$

b. The inductance coil is of ring-core type and shielded very carefully to avoid the influence of earth field.

c. Cut-off frequency - 1.2 c/s
 Attenuation - -40db at 5 c/s

4. Amplifier

a. The input d.c. voltage is transformed to AC voltage by a vibrating interrupter, and then is amplified. The frequency of interrupter is 675 c/s.

b. Three valves (6ZAMI, UZ-6001, UZ-6cb) are used for amplification, and a valve (UZ-6cb) to drive the vibrator gain of the amplifier is 120-130 db.

c. Vibrator. Exciting coil type. The exciting coil is one part of the oscillating circuit. The contact points are of Pt-Rt alloy. The free side of vibrating piece is of ivory to prevent the noise voltage cutting the magnetic field.

5. Signal Indicating Device. Composed of the following parts:

a. Circuit to cut out the constant noise.

b. Device to select the signal period composed of C-R circuit and relays. Upper and lower cut-off time can be adjustable. The following valves are suitable: 0.8-2.5 sec.

(1) Receiver circuit with a valve UZ-6D6.

(2) Electric source stabilizing device for low voltage (Ballast lamp BL-170) and for high voltage (VRA 135/50, VRD 90/50)

6. Eddy Current Compensator

a. Compensating outer coil

Diameter of bobin - 410ϕ
 No. of turns - 400
 Elec. resistance - 12 Ω
 Wire used - 0.9ϕ ECW

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b. Compensating inner coil of 0.6 enameled wire.
No. of turns - 3000. The electric resistance
is 15 Ω .

c. Eddy current noise can be reduced to about 20%
in aircraft in general.

7. DC Generator. The source of amplifier and signal in-
dicating device.

Input - DC 12.5 V 15A
Output - DC 350 V 100mA
12.5V 3A

8. AC Generator. The driving source of gyroscope.

Input - DC 13.5 V 22A
Output - AC 400 - 100V 3-phase 0.78A.

IV. The Arrangement in Aircraft

1. The arrangement in aircraft is as shown in the dia-
gram.

2. Notice for Equipment.

a. No magnetic materials must be found within 1.5-2.0
meter from the search coil. Out of this zone, magnetic ma-
terials of remarkable size must be took off or exchanged with
non-magnetic materials. The rudder controlling wire is of non-
magnetic materials.

b. DC circuit must be arranged as remote as possible
to prevent its magnetic influence.

V. Equipped aircrafts

1. Zero-type seaplane
2. 97-type attacker
3. 96-type bomber
- d. Tokai

VI. The Searching Ability for the Submarines

1. When passed just above the submarine parallel to the
keel line: for A class submarines - 150-120 m; for B class
submarines - 130 - 100 m.

2. Breadth of Detectable Zone: about 150 m at the heigh
of 50 m; about 60 m at the height of 100 m.

1. General Description.

This is an apparatus to determine the location of mines on the sea ground by magnetic method. It consists of many small detecting coils attached to a rope which is towed by two boats as shown in Fig. 1., so as the detecting coils move touching the sea ground. Under this subject the Rope type and the Brush type were manufactured for experiments.

The Rope type consists of many detecting coils arranged in a row which are covered with rubber so as the whole apparatus forms an electric cable-like flexible rope. The Brush type is formed of a main rope and many branch ropes which branch from points distributed on the former and to each end of which is attached a detecting coil so that the whole apparatus has a brush or comb-like form. By either type all the detecting coils are connected in series and the terminals are lead to the towing boat.

2. Principle of Detection and Construction in detail.

(a). Rope type.

The detecting unit used in this type consists of a pair of small coils connected differentially, so that the e.m.f. induced by the earth field compensate themselves and vanish as a whole. Each coil has 6,000 turns of enameled wire wound on an iron tube of 20mm inner diameter and of 230mm long. 30 detecting units are set on the main tow-rope through the hole of iron core with the pitch of about 500mm. The above mentioned arrangement is covered with rubber, so as to form a flexible rope of about 50mm diameter. Two or three ropes constructed as above were intended to be connected in series and be tugged by two boats so as they move sweeping the sea ground, and if a mine touches any part of it, an e.m.f. is induced in the coil, which is amplified and indicated. To eliminate the noise e.m.f. caused by the vibration of wire, a low-pass filter is inserted. The connection diagram is shown in Fig. 2., and it is designed that the American mines can be detected at the speed of 2 or 3 knots.

(b). Brush type.

The detecting unit of this type consists also of a pair of differentially connected coils, 100mm apart, wound on a soft iron rod of 150mm long and 10mm diameter. Each coil is of 30,000 turns of 0.12mm enameled copper wire. 30 units are attached by means of a rope of 5 meters long to the main tow-rope with the pitch of 1 meter. The electrical connection, amplifier, filters etc., and hence the principle of detection are similar to those of Rope type.

3. Results of Experiments.

(a). Rope type.

In laboratory an iron piece could be detected when it touches the surface of the apparatus. At the first experiment for practical use performed at Kurihama-bay, we could detect the mine once, but soon after, the apparatus was caught on an obstacle and cut in two. At the second experiment, sea water leaked into the apparatus and we were forced to cease the experiment.

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(b). Brush type.

In laboratory we found that an iron body of size of ordinary mine moving at a speed of 1-2 m/s could be detected at the distance of 30cm. At the experiments for practical use performed at Murazu we could detect the mine every time when the apparatus was towed at the speed under 2 knots. At higher speed we could not detect the mine because the detecting units did not perhaps touch the sea ground.

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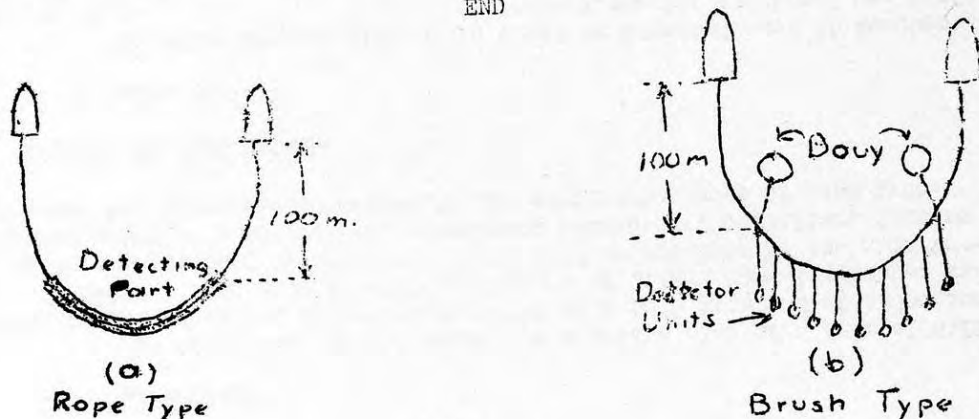
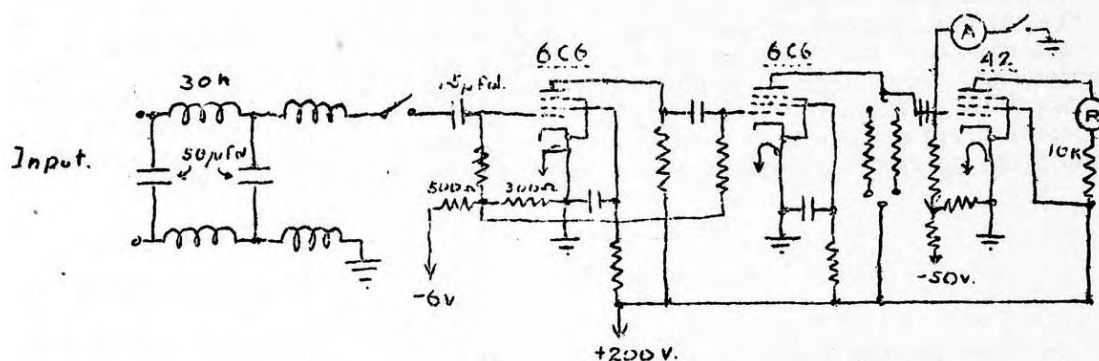


FIG. 1



A; Ammeter (500μA)
R; Recorder (Range 10 ma).

FIG 2.

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Drill Hit-Recorder for the

Use of Machine-gun Against Aircraft

1. General Construction.

This is the apparatus to count the number of shots which pass through or directly near the streamer target tugged by an airplane, by means of a device undermentioned.

On the streamer target a large coil is set up, and the end of which, after passing through an electric filter, is lead to an amplifier and a relay arranged in the airplane tugging the streamer. When a shot passes through or near the coil, an e.m.f. is induced which is amplified so that the relay acts the recording device. The noise e.m.f. caused by the vibration and fluctuation of the streamer etc. may be eliminated by the suitable electric filter.

The construction of main parts are as follows:

- (1) Coil; 2.37 meter long and 0.73 meter wide. 500 turns of silk covered copper wire of dia. 0.2 mm is used.
- (2) Filter; A high-pass filter over 500 c/s and a band-pass filter between 500 c/s and 2000 c/s are used.
- (3) Amplifier; Three vacuum tubes 606 and one discharge tube 16G are used and the recording relay is worked by the anode current of 16G as shown in the circuit diagram. The gain of the amplifier is about 90db.
- (4) Recorder; An ordinary counter for the telephone exchanger slightly modified is used.

2. Main Results of Experiments.

The following table shows the results of experiment carried out at the Naval Artillery School with the 25mm machine-gun at a distance of 300 meters.

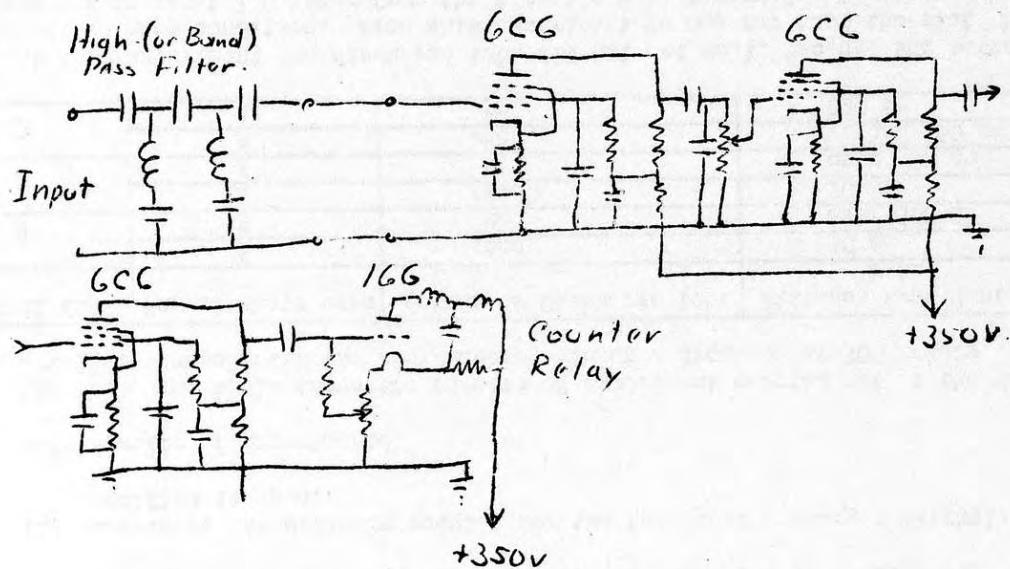
No. of Exp.	No. of shots used	Action of Discharge tube	Distance from Center of coil
1	1	good	50 cm
	5	no	over 300 cm
2	1	good	70 cm
	5	no	over 90 cm
3	6	good	within 160 cm
	1	no	230 cm

At this experiment the discharge tube did not act well, because the batteries were not in good condition. From this experiment we may say that the shot which passes within about 1.0 meter from the target can be recorded. To assume whether this apparatus can be realized or not, we must ascertain the following two problems:

- (a) Whether the noise e.m.f. induced by the vibration and fluctuation of the of the streamer during the flight is negligible compared with the signal e.m.f.
- (b) Whether a streamer with such a coil and leading wire can be tugged by ordinary airplane.

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Circuit of Amplifier of Drill Hit Recorder



- 2 -

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The Negishi Laboratory of the Yokosuka Division

1. History:

In Autumn of 1943 it was determined to use the 1st class stand and few accessory buildings of the Negishi race track which had been purchased by the Navy from the Nippon Race Club for experiments on Radars. The work was placed in charge of The Naval Tech. Inst. and The Naval Tech. Inst. of Aeronautics.

In Feb. of 1945, The 2nd Naval Tech. Inst. was organized, and included a part of The Naval Tech. Inst. and The Naval Tech. Inst. of Aeronautics. Therefore, this laboratory became to be called The Negishi Laboratory of The 2nd Naval Tech. Inst.

After the termination of the war, from the 30th of Aug. to the 14th of Sept. 1945, The 11th Airborne Corps of the U.S. Army occupied the premise, and cooperated with the members of this laboratory, engaged in clearing up unfinished business, in preserving the equipment. However, after the middle of Sept. the 153rd Engineer Construction Battalion took over the property and is now presumably assuming sole responsibility.

2. Buildings and other equipment:

This laboratory consists of the following:

a. The main building: It was formerly the 1st class stand of the race track, and has been used as experiment laboratory, office, machine shop, apparatus room, storage, etc.

b. The branch laboratory: It was formerly the residence of the Rising Sun Petroleum Co., Ltd., and is on the other side of the race course. This was used as a conference room as well as for dormitory.

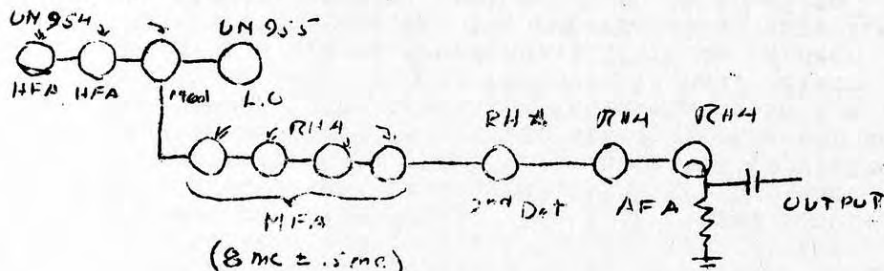
c. The field experiment laboratories: They consist of 4 trailers, 4 cottages and 2 rooms underground scattered over the race course, and were used for various field experiments.

d. Dormitory: There are 2 dormitories on this premises used mainly for assistances.

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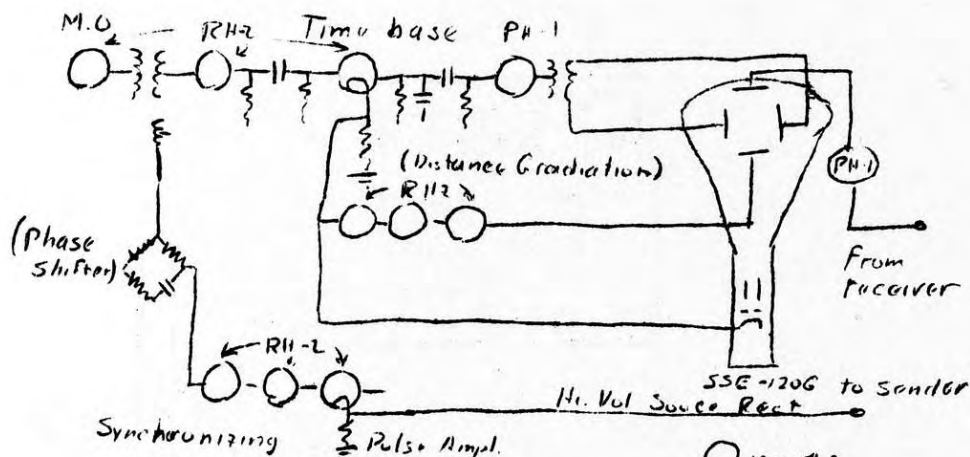
Included the set: 3 phases full wave rectifier (KX.-250 x 6) for oscillator and single phase half wave rectifier (KX.-250 x 2) for modulator and modulator amplifier.
Total input about 6 KVA.

(b) Receiver:



Total gain about 135 db.
Mid-frequency transformers are all double turning transformers.

(c) Indicator and Synchronizer:

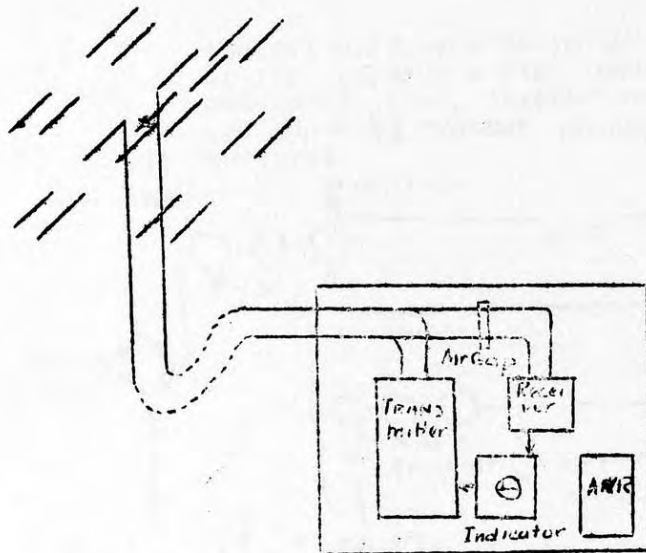


(d) Antenna:

The Squeezed antenna which is a theoretically developed "Yagi" antenna and has a dimension of 1.1λ (width) x 0.6λ (height) x 1.25λ (depth) with gain at 14 db., is used.

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(e) Skeleton diagram of the whole set:



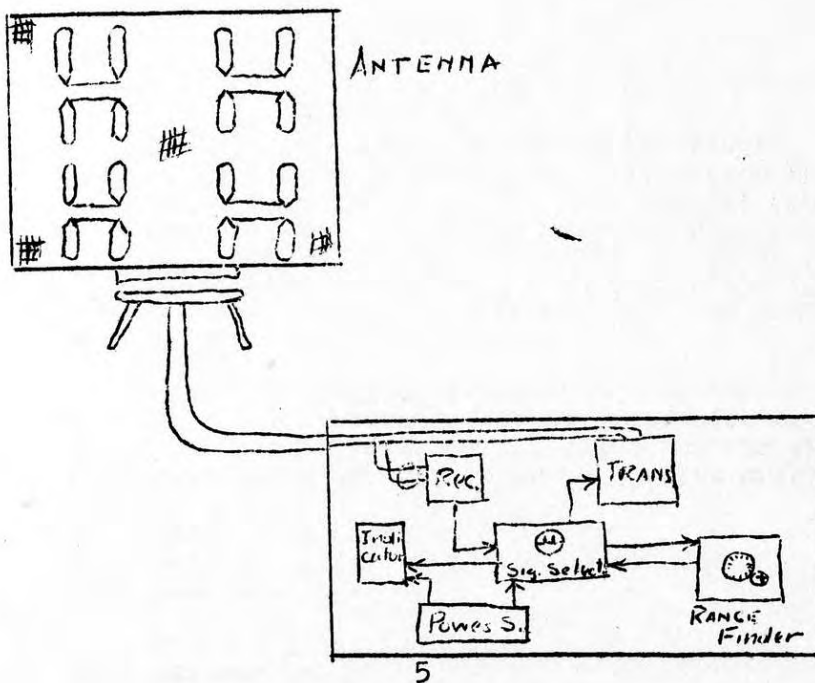
b. The design and trial production of Radar No. 62. We designed this for the purpose of guiding friendly fighters and is used with I.F.F. No. 5 (M-13). Following characteristics were obtained.

(1) General Statement:

The U.H.F. impulsive wave radiated from this set is to be received by M-13 which is carried about our fighters and is amplified and transmitted without any time delay. The transmitted impulsive U.H.F. wave is changed slightly from the former frequency. This re-transmitted impulsive wave is received and synchronized by this set on the ground. The direction and distance to the M-13 i.e. the friendly fighter, is had. Since there is a slight frequency difference between the radiated wave and the retransmitted wave i.e. the sender and the receiver which is tuned to the retransmitted wave, our set indicates only retransmitted wave without disturbance of any echoes from mountains or foe planes.

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- (2) Performance:
 Maximum guidable range; 150 Km.
 Maximum detectible range; above horizon
 Accuracy: Angle; ± 0.4 degree (Cannot determine elevation)
 Distance; ± 0.8 Km.
- (3) Main Features:
 Frequency; 145 to 155 Mc/s.
 Output Power; about 10 Kw. (Peak)
 Pulse repeating frequency; 500 c/s.
 Receiver total gain; 130 db. (about)
 Antenna; Vertical, semi-broad band, 4 x 4 elements with reflecting net; direction is found by equal intensity method.
 For simultaneous sending and receiving a spark gap (B₁) sealed in glass tube with A is used.
- (4) Details:
 (a) Skeleton diagram of the whole set.

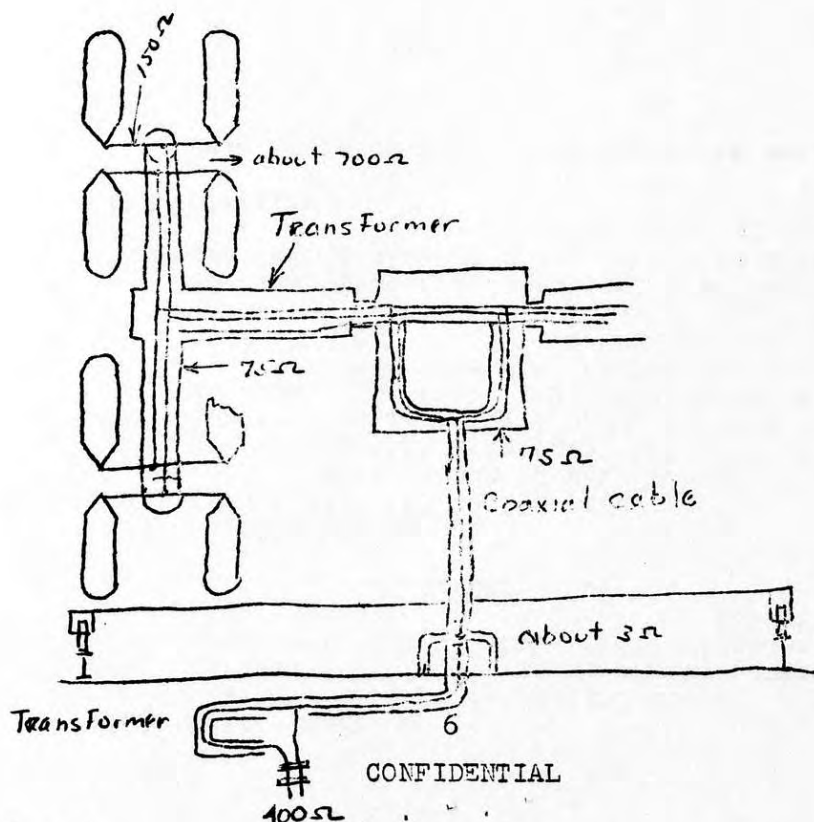


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- (b) Transmitter
Same as Radar No. 13's
- (c) Receiver
Same as Radar No. 13 for submarine.
(I.F. band width; ± 0.5 Mc/s)
- (d) Synchronizer, Indicator and Ranging unit.
Only the pulse repeating frequency and the
max. range scale is changed from that of the
Radar 42 (S-23 on S-24)
- (e) Antenna
Has semi broad-band elements for the purpose
of selecting frequency between 145 and 155
Mc/s and for stability needed for equal intensity
measurement. Impedance matching transformers
is used as illustrated in the figure. The an-
tenna revolves without any restriction through
the use of coaxial cable and slipping.



SUBJECT: Japanese Navy H_2O_2 Rocket Propellant
 INTERVIEWED: Tech Rear Admiral S OHYAGI, Tech Cmdr Dr T KITAGAWA
 INTERVIEWERS: Maj H SKIPPER and Dr H K STEPHENSON
 DATE: 9 October 1945

Preliminary information on the Navy H_2O_2 rocket propellant was obtained in an earlier visit by members of SIS. The purpose of the subject visit was to further investigate the chemistry of the systems reported, as well as the principles of their use.

There were five systems studied at the Navy Laboratory. The chemical components of each is listed as follows:

- *I. H_2O_2 "Kō" liquid (A)
 $N_2H_4 \cdot H_2O$ "Otsu" or "C" liquid
 $CH_3 OH$
- II. H_2O_2
 $Na Mn O_4$ (or $Ca (MnO_4)_2$)
- III. H_2O_2
 $FeCl_2$
- IV. $HNO_3 +$ (dimethylamine cresolate and) ignitor
 C_2H_5OH dimethylamine (or methyl nitrate)
- *V. HNO_3
 C_2H_5OH
 Cordite ignitor

*Systems which proved satisfactory in research and were to be used in production models.

System I above derives energy from both of the following reactions:

- a. $2H_2O_2 \rightarrow 2H_2O + O_2 + (2 \times 23 \text{ k cal./mol})$ ignition
- b. Methyl alcohol + $O_2 \rightarrow CO_2H_2O$ ($\Delta H = 173.7 \text{ kcal/mol}$)

Systems II and III contain no fuel hence depend on release of oxygen for required energy. Systems IV and V depend on burning of fuel in the presence of an oxygen source.

System I was supplied by the Germans in the way of reports. The preparation of H_2O_2 is based on German patent 520064 (1924), Reidel-De-Haen A.G. with Lowenstein. This sys-

tem used in the Me 163 (German) jet plane and the Japanese Shusui plane. A simplified diagram of the mechanics of its use is appended as inclosure 1.

Systems II and III were claimed as Japanese developments.

System IV was found unreliable, but system V used a motor identical with system I except for an added cordite ignitor which was found to be satisfactory.

System I was also to have been used in a 20 cm rocket designed for a range of 10,000 to 20,000 meters. A model of the rocket had not been made, but Admiral Chyagi said research would have been completed by the end of September, 1945. He estimated three months each as the time required to get in-to quantity production with the motors and bodies for this rocket. Inclosure II gives a diagrammatic sketch of the motor principle and some of the rocket's characteristics.

a. Tests of stabilization and research on the stabilizer of "Ko" liquid (80% H_2O_2). This work was apparently portioned out to civilian chemists. It was stated that Prof Ochiai of Tokyo Imperial University and Prof Ishikawa of Tohoku University were working on stabilization of "Ko" liquid. Accelerated stability tests were carried out at 96°C for 24 hours. The decomposition degree (%) was:

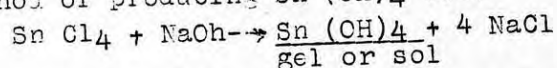
$$\frac{\text{Decrease of concentration after heating}}{\text{Concentration before heating}} \times 100$$

Oxine phosphate  $\cdot H_3PO_4$ and tin hydroxide in a col-

loidal state proved to be the best stabilizers after Prof Ochiai and Ishikawa had tried some 20-30 combinations. Quantities used were:

Oxine phosphate - 0.3-0.5 gms/l
 $Sn(OH)_4$ colloidal - 0.1 gm/l

Method of producing $Sn(OH)_4$ was:



The oxine phosphate-tin hydroxide was to be produced in large scale in preference to 8 oxychinoline, Na pyrophosphate, H_3PO_4 first used in experiments.

b. The catalyzer producing the vapor of "Kō" liquid. (This vapor, steam and O_2) was in turn used for driving the fuel-pumping turbine).

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2-C-e-3

At about 450°C the steam turbine was set in motion. About 4.7 l/sec of "Ko" liquid on 2 kg of catalyzer were required for this purpose.

The Portland block catalyzer for this purpose was made up of:

KMnO ₄	4 kg
K ₂ Cr ₂ O ₇	2 kg
K ₂ CrO ₄	2 kg
KOH	2 kg
Portland cement	4 kg

The purpose of this catalyzer can be seen in Inclosure I.

c. The catalyzer promoting the combustion reaction of "Ko" and "Otsu" (or c) liquids. To prevent accidental explosion and to promote combustion reaction between the two liquids, potassium cuprocyanide ($K_2Cu(CN)_4$) is added to "C" liquid as a catalyzer. It is added at the rate of 2.7 gms/l of "C" in a water solution.

d. Containers for rocket propellant. Materials unsuitable for containing "Ko" liquid are: Cu, Fe, or Pb (Al or Sn all right) Vinyl chloride polymer with 3 cresol phosphate or 3 phenyl phosphate as a softener is suitable as a liner or packing material for "Ko".

For "Otsu" liquid Al or tin is suitable.

For "Tei" lead suitable.

For "F" liquid Sn or natural rubber suitable.

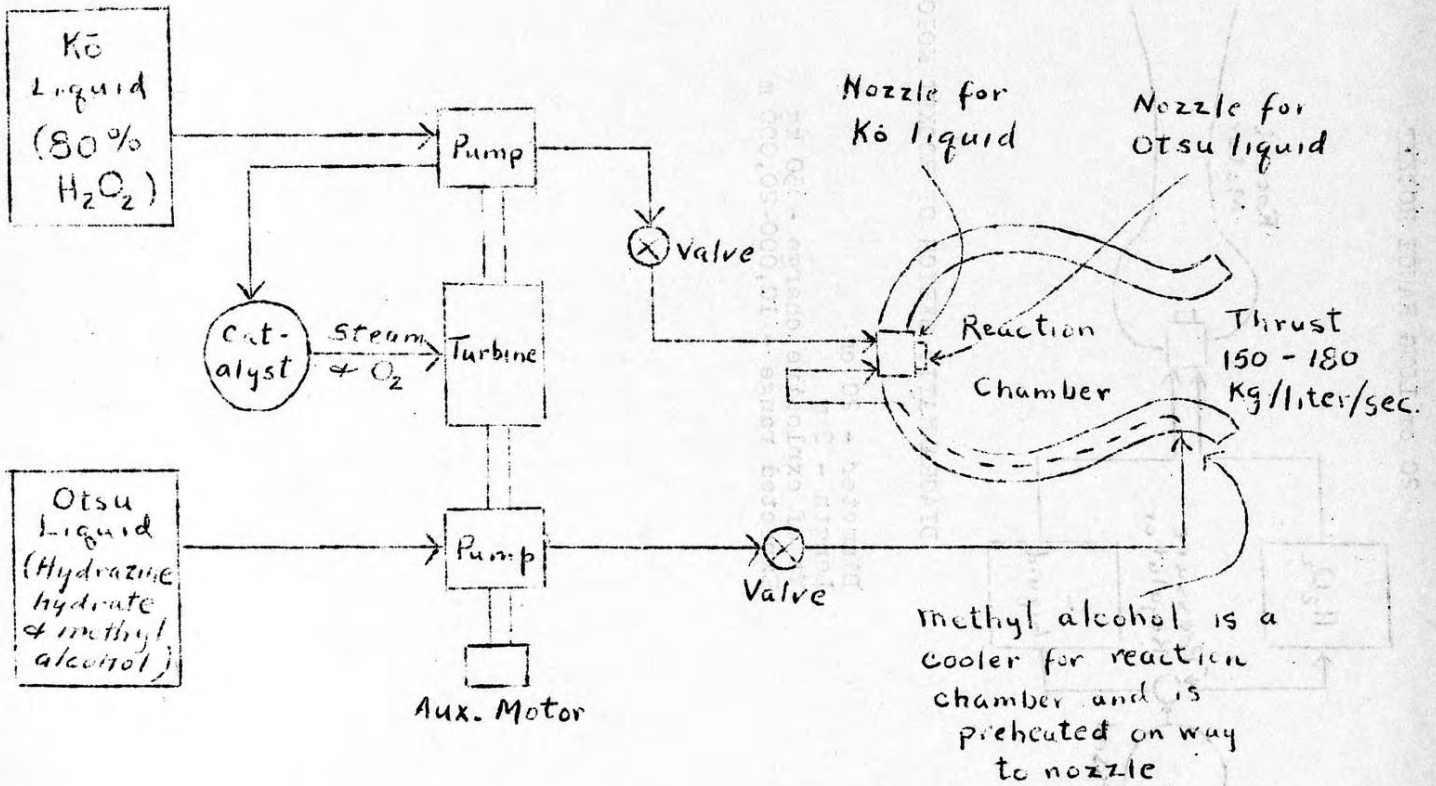
e. Lowering of the freezing point of "Tei" liquid is accomplished by substitution of Na Mn O₄ with Ca (MnO₄).

MISCELLANEOUS INFORMATION. Fuel was added to system III but HNO₃ + alcohol would not self ignite so dimethyl amine or dimethyl amine cresolate was used as ignition mixture.

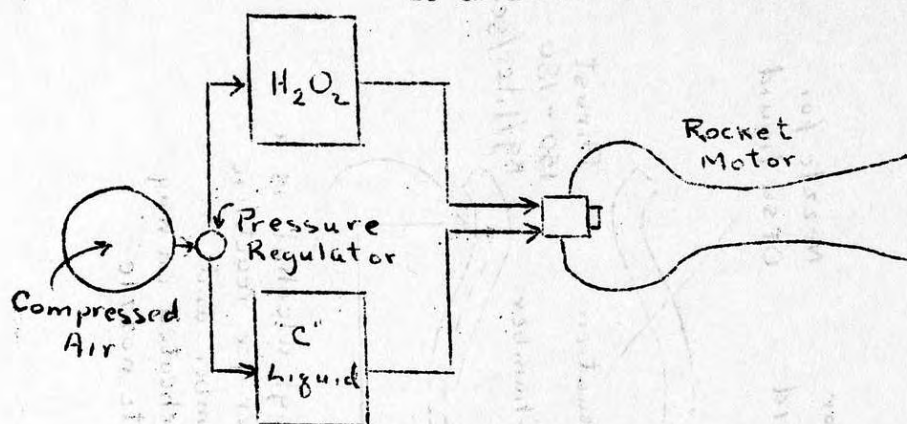
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Jet Motor for Shusui Plane
(ME - 1163)



20 cm LONG RANGE ROCKET



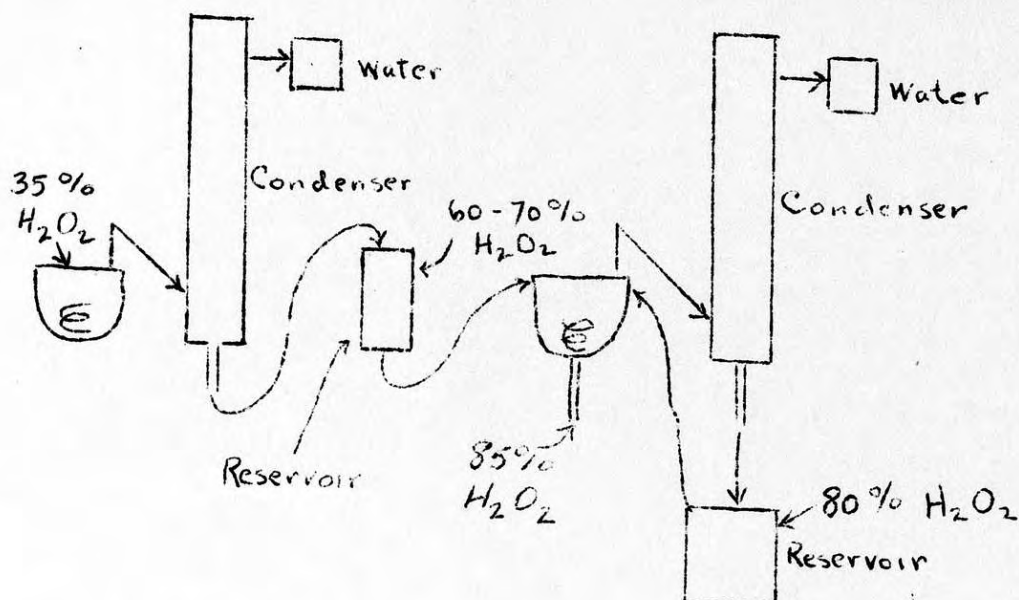
DIAGRAMMATIC SKETCH OF ROCKET MOTOR

Diameter - 20 cm

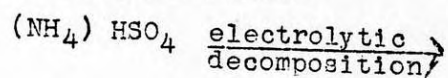
Length - 2 m

Wt of explosive charge - 50 kg

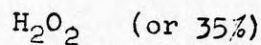
Expected range - 10,000-20,000 m

PREPARATION OF H_2O_2 FOR K $\bar{O}$ LIQUID

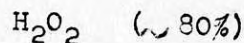
DIAGRAMMATIC SKETCH OF DISTILLATION APPARATUS

Chemical reactions:

↓
Decomposed by
water vapor



↓
Vacuum Distillation
@ 70°C



Z-C-e

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Appendix 2-C-f-1

SUBJECT: Discussion at Second Naval Technical Institute,
Tokyo - Research in Acoustics, Magnetic Detection,
Light and Heat

INTERVIEWED: Japanese Officers Present:

Vice-Admiral YASUBA
Rear-Admiral KOBE
Capt IZUISHI
Capt OSHIMA
Lt Comdr HIRANO
Lt Sato

SAITO
KUYAMA
MIYAZAWA
YAJIMA
ACKI
NAZAI
KONISHI

INTERVIEWERS: Dr H K STEPHENSON, Dr K T COMPTON, Major
W R HEWLETT
DATE: 20 September 1945

ACOUSTIC DEPARTMENT

1. Propagation of Sound Waves Underwater.

Information furnished in writing by 2d N.T.I.

Aim: To obtain fundamental materials and data for designing
underwater acoustic devices.

Outline of the Result: The fact that for supersonic waves
(14 kc), a complicated fading effect occurs during propaga-
tion, was confirmed. This phenomenon was presumed to be due
to tidal currents and other similar causes. Further researches
on this point were being considered when all the observation
apparatus and measuring instruments were destroyed by war
disaster.

Additional information in response to interrogation:

Some studies were made at Lake Achinoko of the effect of
temperature gradients in water. According to information fur-
nished, these studies were not extensive and there were no
significant results. Japanese submarines did not attempt to
take advantage of gradients.

2. Microphone of Rochelle Salt Type.

Information furnished in writing by 2d N.T.I.

Aim: To improve the characteristics of the microphones which
are the elements that constitute the underwater sound listen-
ing device.

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Outline of the Result: Although the sensitivity is less than the one now in use, the better frequency characteristic having a uniform sensitivity over a band of frequencies from 300 cycles, was made.

Additional Information in Response to Interrogation: Improved types of Rochelle salt microphones were developed at the 2d N.T.I. These were then turned over to the following manufacturers to produce:

Sumitomo Tsushin
Oki Electric
Tokyo Shibaura
Imai Research Laboratories

The improved microphones were recently standardized for all types of submarines, but all had not yet been equipped at the end of the war. These microphones were used only for listening in the audio frequency range. Research was under way on supersonic types, but without significant result to date.

3. Underwater Listening Devices.

Information furnished in writing by 2d N.T.I.

Aim: To obtain a new type of underwater sound listening device of good characteristics to replace the one in use.

Outline of the Result: From the standpoint of mass production and to improve the characteristics, the moving coil type hydrophone was discarded and underwater sound listening device M4 consisting of 40 or 80 microphones of Rochelle salt type was made. Although this device is superior both in the accuracy of orientation and audible distance during navigation to M93 now in use, a further study was being made to extend the audible distance by using the maximum binaural system.

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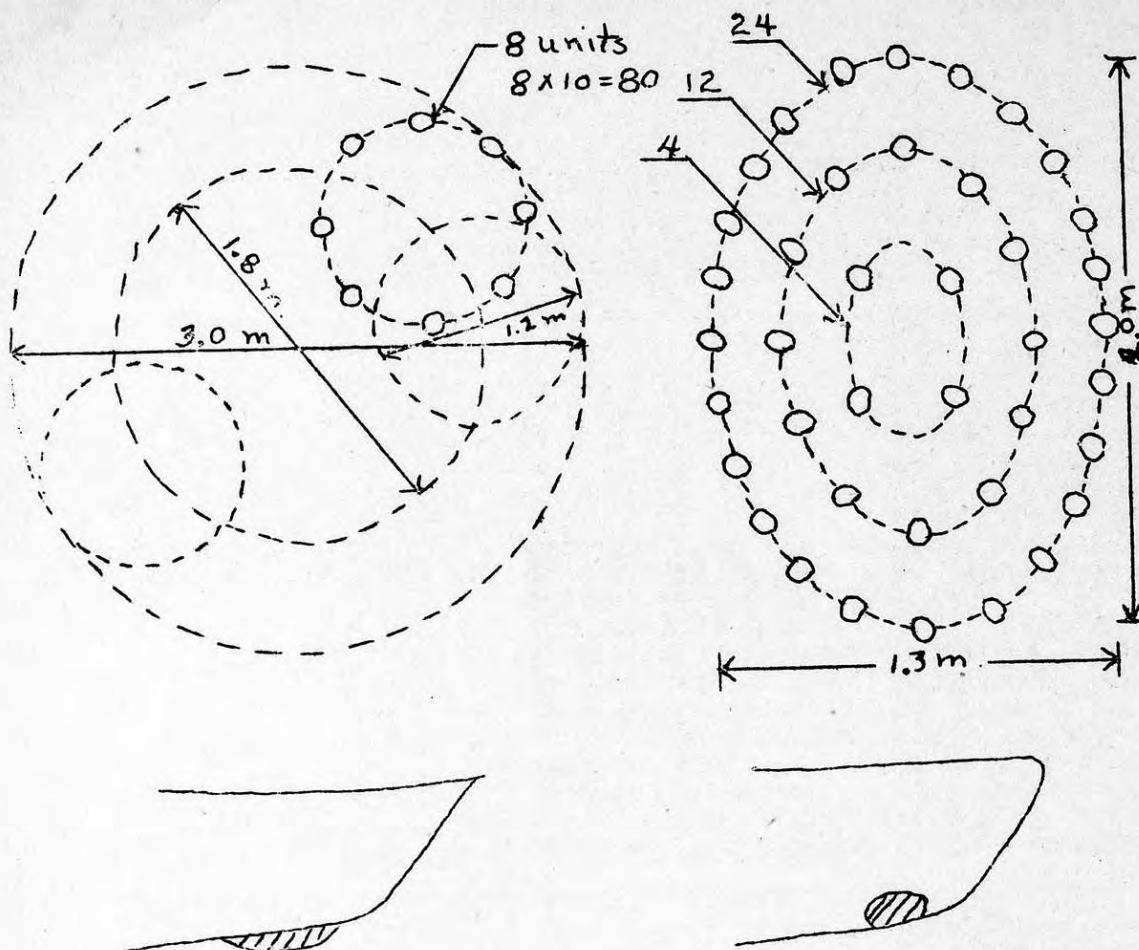
Main Devices.

NAME	USE	ABILITY (CAPABILITY)	REMARKS
<u>III.</u>			
Underwater sound listening device M4	Lookout for submarine and torpedoes	<u>a.</u> Speed at 12 knots 1. Against slowly moving submarine - 1500 meters 2. Against torpedo - 5000 meters <u>b.</u> Accuracy of orientation $\pm 2^\circ$	<u>a.</u> Use 40 or 80 microphones of Rochelle salt type. <u>b.</u> Maximum sensibility method. <u>c.</u> Place of installment of microphones - usually ship's side <u>d.</u> Total number manufactured - 100 sets
<u>IV.</u>			
Underwater sound listening device M93	Lookout for submarine and torpedoes	<u>a.</u> Speed at 12 knots 1. Against slowly moving submarine - 1000 meters. 2. Against torpedo - 4000 meters <u>b.</u> Equipped on slowly moving submarines, against fast-moving ships - 10,000 meters <u>c.</u> Accuracy of orientation $\pm 4^\circ$	<u>a.</u> Uses 16 microphones of moving coil type. <u>b.</u> Maximum sensibility method. <u>c.</u> Place of installment of microphones - ship's side or middle tank. <u>d.</u> Underwater sound listening device M.O - similar to M.93 but has 30 microphones. <u>e.</u> Total number manufactured M.93 - 400 sets M.O - 150 sets

Additional Information in Response to Interrogation: The Rochelle Salt microphones were used in arrays of 40 units and 80 units. The former were mounted on submarines, on the side of the hull. The latter was used on cruisers and destroyers, mounted beneath the hull in a streamlined chest. The following diagrams show the diagrammatic arrangement of the arrays and the mountings.

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The units of each type were connected in parallel with phase compensation. They were directional in the horizontal plane only and were oriented mechanically by hand by means of a compensator. Indication was both aural and by a pointer and scale. Units of both types were installed at the Numazu Experiment Station.

Other types of crystal detectors were tried, but not successfully. Quartz was found to have low sensitivity, as were other organic crystals. Tourmaline was not tried.

4. Underwater Echo Ranging Device (Acoustic Locator).

Information furnished in writing by 2d N.T.I.:

Aim: To obtain a new type of underwater echo ranging device of good characteristics to replace the ones in use.

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Outline of the Result: Acoustic locator M3 using sender and receiver of magnetostriction type and equipped with visual apparatus (Braun tube) was completed. Although this was superior both in the accuracy of orientation and in the searching capability to M93 type now in use, an acoustic locator using sender and receiver separately and having a greater capacity, was being planned to extend the ranging distance. In addition to above, an acoustic locator for the dip angle of the target was completed. However, with this apparatus, a sufficiently good result has not yet been obtained.

Main Devices

NAME	USE	ABILITY (CAPABILITY)	REMARKS
I. Underwater echo ranging device M3	Distance ranging and looking out against submarine	a. Hearable distance at 12 knots - 2000 meters b. Accuracy of orientation $\pm 2^\circ$ c. Accuracy of distance ranging - ± 100 meters.	a. Practically the same as that of Germany's "S" device b. Al & Fe alloy used for magnetostriction material. c. Instantaneous transmitting power 200w, 800w and 2kw d. Braun tube used. e. f. Total number manufactured - 800 sets.
II. Underwater echo ranging device M93	Distance ranging and looking out against submarines	a. Hearable distance at 12 knots - 1500 meters b. Accuracy of orientation $\pm 2^\circ$ c. Accuracy of distance ranging ± 100 meters	a. Stopped manufacturing since June 1944. b. Uses crystal sender and receiver c. Instantaneous transmitting power 70w d. Detect echo by hearing e. Tuning fork used for timing echo f. Total number manufactured - 250 sets.

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NAME	USE	ABILITY (CAPABILITY)	REMARKS
Underwater echo ranging device ("See" device)	Distance ranging and looking out against submarines	a. Hearable distance at 12 knots - 3000 meters b. Accuracy of orientation $\pm 3^\circ$ c. Accuracy of distance ranging - 1150 meters	a. Similar to M-93. Instantaneous transmitting power - 5 kw b. Uses aluminum, steel alloy for vibrator c. Uses Braun tube d. e. Total number manufactured - 170 sets

Additional Information in Response to Interrogation: It was explained that the M-93 device in widespread use used a quartz crystal (Langevin type). The M-3, using the magnetostriction principle operated at 13 kc and was of the pulse type (pulse length 50 to 200 milliseconds). A CW detector based on the Doppler principle was used experimentally, but was not very successful. The maximum input to the M-3 was 2 kw, and the output efficiency to the water was 30%. Area of the transmitter and cavitation limited power output. Three types of M-3 device were developed, two operating at 13 kc and 16 kc for antisubmarine work from surface craft, the third operating at 20 kc for use on submarines for shorter range and greater accuracy. An underwater communications set was developed experimentally. This operated at 9 kc with voice transmission. Under favorable conditions a range of 15000 meters was obtained. This equipment was not used by the fleet.

5. Sound Prevention and Noise Elimination.

Information furnished in writing by 2d N.T.I.:

Aim: To improve the characteristics of underwater acoustic devices by suppressing the disturbing noises produced by the vibration of the main and auxiliary engines of ships.

Outline of the Result: The method of equipping "vibration-preventing rubber" under engines was studied and this was applied to the engines of various types of ships (mainly coast defense ships). We succeeded in reducing the disturbing noises which affect the ships sound listening devices by about 20 db and as the result the audible distance was greatly extended.

Additional Information in Response to Interrogation. All coastal vessels were equipped with rubber mountings for engines and auxiliary equipment to reduce noise. Engines up to 2200 hp were so equipped. German aid was obtained on this technique.

A sound absorbing enamel with a raw rubber base was developed. This was used as a continuous coating on submarines, and

gave a noise reduction of 13-15 db. A protective bubble sheath for submarines was tried but was found to increase the reflectivity of sound.

Experiments were conducted on sound deception and sound jamming but nothing was completed. Noise sources included vibrating metallic sources, Barkhausen noise, and film-recorded noise. Some experiments were conducted on expendable noise-makers.

6. In response to questions, it was disclosed that experiments were conducted on sound ranging for AA fire direction. In this work the German electro-acoustic device was adopted. However, developments in radar caused this work to be dropped.

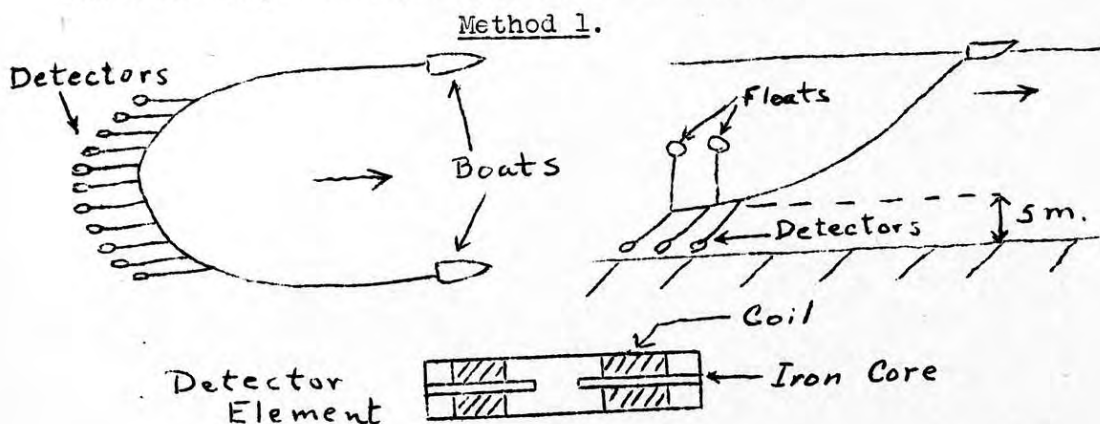
MAGNETIC DETECTION DEPARTMENT

1. General information supplied in writing by 2d N.T.I.:

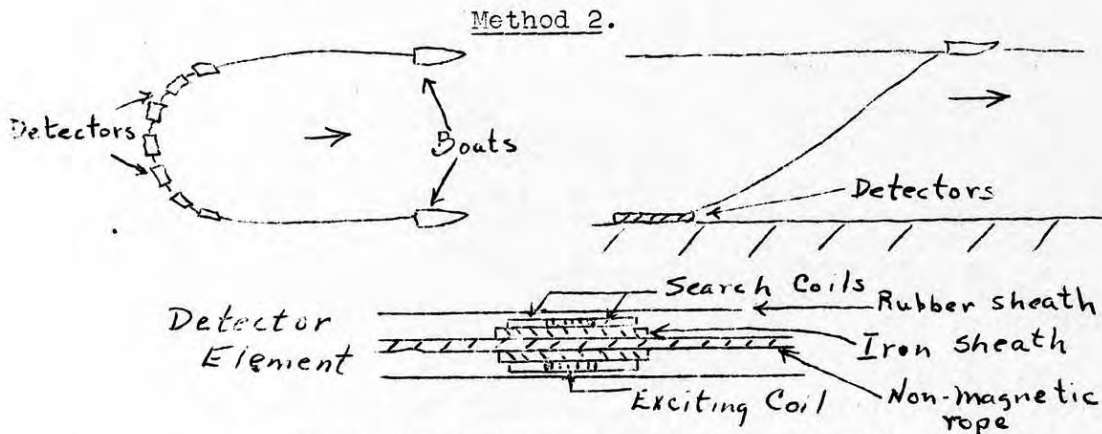
(See appendix A)

2. Information supplied in response to interrogation:

a. Underwater Mine Detection. The first method is illustrated in the diagram below. An array of detectors was towed by two boats. The detector elements consisted of an iron core with two windings connected in opposition. Detector elements were connected in series. When a detector passed within 30 cm of a mine, the resulting electrical impulse was amplified aboard the boats and a meter indicator showed the presence of a mine. The detectors were separated by 50 cm, and were buoyed to pass just over the bottom.



The second method, illustrated by the diagram below, used the same towing cable, but with the detector elements at 50 cm separation attached to the cable. The search coil had to contact a mine to operate. In one type an exciting coil was used, but a later type using permanent magnets gave better results. Method No. 2 failed because sea water got into the coils.



b. Magnetic Airborne Detector. This detector consists of a single detecting coil, with compensating coils for random voltages, all gyroscopically stabilized. An electrical filter reduces the effects of vibration. Detection range on a medium submarine is about 100 meters. This detector had been produced in quantity and about 200 planes had been equipped. Informal reports indicate that this detector is "very effective." It was generally used in the daytime.

c. Hit Recorder for AA Training. This device was not developed beyond the idea stage. It was proposed to use a coil wrapped on a towed sleeve target 73 cm in diameter and 2.37 m long. Iron bullets were to be used in the 25 mm machine gun and the electrical impulse as the bullet passed the sleeve was to be amplified in the plane. It was not proposed to magnetize the bullets artificially. No information was at hand on the possible range of detection, but it was guessed to be on the order of one meter.

LIGHT AND HEAT DEPARTMENT

1. Principal Research Projects. (Information furnished in writing by 2d N.T.I.)

(See appendix B)

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2. Manufacturers of Heat and Light Instruments.

(See appendix C)

3. General Information in Response to Questioning: The "nocto-vision" tube referred to by the Japanese is the standard type of infrared image tube, employing a cesium surface, electrostatic focusing coil and a phosphor surface to produce the image. It was claimed that the Japanese tube was not copied from the Germans. This is the only infrared viewing principle used by the Japanese.

The nocto-vision tube uses a single focusing coil with a fixed voltage of 3000 V.

The best infrared filter consists of an organic dye in glass and is said to transmit about 15 per cent of total light. It was said that a 40 w lamp covered by this filter could be seen by the dark-adapted eye at about 300 meters.

Cesium photocells were used exclusively for near infrared. Some experimental work had been done on PbS and other sulfide cells, but nothing successful was developed.

The chloride of rubber membrane used as a far infrared filter had 50 per cent transmission at 9 microns wave length, and its transmission increased toward the visible. It has a yellowish transparency.

No work on heat-homing missiles was done at the 2d N.T.I. It was suggested that some work of this type was done by the Japanese Army.

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General Description on the Magnetic Detection Department

This Department was set up on the 1st May of this year, its head well as its other officers were appointed on the same day.

Before that day, researches on magnetic detection and on magnetically operating relays were studied at several institutes of the Navy:--the Accoustical Department of the 2nd Naval Technical Institute, the Aircraft Instrument Department of the 1st Naval Technical Institute, the Physics Department of the Naval Technical Research Institute, etc. The most members of these departments who were engaging in the researches on magnetic detection and the like were transferred to this new department. As the head, Vice Admiral Y. Yasuba was appointed who was, at the same time, the head of the Accoustic Department.

The general organization of the department is as follows:

Office Section	(Chief: Captain Oshima)	
Design "	(" : Engineer Kawai)	
Inspection "	(" : Cmdr Kiyohara)	
1st Research "	(" : Capt Oshima)	Fundamental Research
2nd " "	(" : Engineer Kawai)	Magnetic relays, mine detection
3rd " "	(" : Capt Oshima)	Magnetic detection of submarines

The head office was set at Numazu and a branch office was set at Hayama. The Hayama branch used several rented private houses at Hayama and Zushi as its buildings. Naval Engineer Y. Hoshikawa was appointed as the chief of the Hayama Branch.

The principal problems studied at this department is the improvement of the magnetic detector Mark-3 Type-1 which was accomplished at the Aircraft Instrument Department of the 1st Naval Technical Institute and already was in practical use.

Beside this, it was intended to study, at this department, the magnetic relays to ignite the explosives of mines, bombs, depth charges, torpedoes, etc., but those researches were not able to be commenced, because the department was pressed to study on the detection of mines laid by American aircraft, which gave severe damages on our ships at the time when this department was set up.

The principal Researches carried out are as follows:

(1). Mine Detection.

In order to determine the location of mines it was proposed to use many magnetic detectors of small size attached to a wire rope, the both ends of which are tugged by two boats, so that the magnetic detectors sweep the ground of the sea. Under this subject two types of magnetic detector was experimented, but none was succeeded until the end of the war.

(2). Magnetic ignitor of Hand Grenade.

This is a magnetically acting ignitor of hand grenade which is to be thrown before the coming tank, to make explode when the tank passes over it. Two types were under design, but by the bombardment of Numazu they were all lost.

(3). Improvement of the Magnetic Detector Mark-3 Type-1.

This is the apparatus to detect submarines under water from aircraft by detecting the emf induced in the search coil stabilized by a gyroscope.

It can find a middle-sized submarine at the distance of about 100 meters.

(4). Drill hit recorder for the use of machine gun against aircraft.

In order to distinguish whether the machine gun shots hit the target (streamer drawn in the air by aircraft) or not, it was intended to record the shot when it passes near the coil wound around the streamer target by detecting the emf induced in it. By an experiment made on the ground, 25mm bullet that passes near the coil could be detected. But following problems which seem very difficult remained unsolved, since we did not continue such an unimportant research.

(a). Whether the streamer with such a coil and a lead wire can be drawn by an aircraft.

(b). Whether the electrical noise produced when the coil is drawn at high speed, can be eliminated.

END

DETAILED EXPLANATION
OF
RESEARCH PROJECTS

LIGHT AND HEAT DEPARTMENT
THE 2ND NAVAL TECHNICAL INSTITUTE
September 10, 1945

2-C-f.

1. Name
Infrared-ray communication apparatus Mark 2
2. Purpose
Signal communication by infrared-ray for ships in the night.
3. Principle
Infrared-ray beam is transmitted from a tungsten lamp through infrared filter. It is interrupted 20 cycle in one second and lighted or let out with a shutter accordingly of signal.
The beam is received by a cesium photocell and converted to a little electric current, which is amplified to be audible.
4. Characteristics
Transmitters:-
 - (1) 1Kw. tungsten lamp
 - (2) Sector for modulator of 20 cycle
 - (3) Infrared-ray filter
 - (4) Transmitting lens (20cm in diameter, 16cm in focal length)
 - (5) Angle of the beam (about 6 degrees)
 Receivers:-
 - (A) narrow angle receiver (to be used to communicate)
 - (1) Receiving lens (12 cm in dia. 20 cm in focal length)
 - (2) Cesium photocell
 - (3) Amplifier
 - (4) Effective angle (about 10 degrees)
 - (B) wide angle receiver (to be used as a finder)
 - (1) Without a lens, but with conical reflectors
 - (2) 6 photocells (3 pairs)
 - (3) 3 amplifiers
 - (4) Effective angle (190 degrees)
 Effective range 15 KM. in ordinary weather condition
5. Progress
 - (A) We must be careful against shock, and wettness and noise, because we use this apparatus on the ship. Specially we use a vacuum tube 6Z1-V which is specially made against vibration. This vacuum tube has a grid of high resistance, grid current is little, high vacuum. The amplifier is resistance type. Thus we make a stationary amplifier of very small current.
 - (B) Beside of the receiver of narrow effective angle, there is another receiver of all round type, with which we can receive the signal if it comes suddenly.
 - (C) About 100 pairs are already manufactured and used on ships of large type.
6. The transmitter of all round type
If we want to send signal to many ships together, we use the transmitter of all round which is a signal 2 Kw. type with an infrared-ray filter and sector of 20 cycles. About 10 were already made. The wattage is 2kw. and 5kw.

D-2

1. Name
Infrared-ray communication apparatus Mark-3.
2. Purpose
Signal communication by infrared-ray for ships of small type with nocto-vision.
3. Principle
Transmitter:-
A tungsten lamp is covered with infrared-ray filter and transmit infrared-ray beam.
The lamp is lighted or put out with key and transmit a signal.
Receiver:-
The receiver is composed of a nocto-vision tube and an optical system. The transmitted light is converged with a special optics on the surface of the nocto-vision tube and make a non-visible image which is converted to a visible image with a electron lens.
4. Character
The lamp is 30 watt tungsten lamp.
Effective range 5 Km.
This apparatus is very simple but not convenient because we must always peep into the nocto vision.
5. Progress
About 100 sets are already manufactured and used on some ships.

D-3

1. Name
Infrared-ray communication apparatus Mark-5.
2. Purpose
Communication between distant bases on land, using infrared-ray in the night.
3. Principle
The principle is same as the communication Mark-2, enlarged.
4. Character
The diameter of the lens of transmitter is 42.6cm, and that of receiver is 30cm. Effective range is 30Km.
5. Progress
2 sets were completed and sent to Kanoya air-port in Kyusyu, next set is damaged.

1. Name
Photophony Mark-5
2. Purpose
Communication between bases on land. (using visible ray in the daytime and ultra violet ray in the night)
3. Principle
Transmitting Light:-
Intensity of mercury lamp, which is set at the focus of reflector, is modulated by the voice and is transmitted as a narrow beam.
Receiving Light:-
The transmitted beam is converged at the focus of the reflector and accepted on the photocell.
Photoelectric current is amplified by the audiofrequency amplifier, thus loud-speaker is sounded.
Translator:-
Wire telephone is translated by using the prepared translator.
4. Character

Mercury lamp	Natural cooling type 100 W.
Transmitting reflector	Aperture 60 cm. Focal length 25.4 cm Angle of the beam about $\frac{1}{2}$ degree
Receiving reflector	Aperture 60 cm. Focal length 200 cm.
Effective range	15 Km. but variable by weather

If many sets of them are connected with the translator, we can speak between very far positions.
5. Progress
The plan of using this apparatus for ship failed, by the reason of pitching and rolling of the ship.
Recently, background noise was greatly reduced by having made a focal length greater, i.e. the image of a light source became larger, and having put a small slit on a focal plane, we could avoid of suffering from noise caused by stray light near light source.
Accordingly it came to be used in the daytime and the plan of using this apparatus for the communication between bases on land is now progressing.
6. The condition of productions
The first one set was completed except the box reflector.
Four sets were promised to complete in August, but was stopped for the finish of the war. Production of thirty sets was preparing.

1. Name
Heat-ray Detector Mark-5
2. Purpose
Fitting up on an airplane, find out other airplane and ship in the night by detecting heat radiation emitting from their engine and funnel at a distance.
3. Principle.
Focusing at the receiver of the thermopile, which arranged at the focus of the collecting mirror amplify the e.m.f. generated from the thermopile by tuned amplifier after modulated by the vibrator at a constant frequency, and operate a indicator meter.
4. Faculty
Detecting range 7 to 10 Km in the clear sky night.
5. Rotating Machine of Mirror
It is used to rotate the mirror box, in which the mirror and the thermopile are contained, to search the other airplane and ship, and this brings down at an occasion of use.

The data on the first trial production are as follows.

- | | |
|--|------------------------------|
| (1) Rotating Speed | 30 degrees/sec. |
| (2) Rotating Angle | 180 degrees (right and left) |
| (3) An angle of elevation and depression | 40 degrees |

a. Collecting Mirror

- | | |
|--|-------|
| (1) Diameter | 13 cm |
| (2) Focal length | 10 cm |
| (3) Aluminum evaporated surface mirror | |

b. Thermopile

- | | |
|---|-----------------------------------|
| (1) 36 Tellurium-Constantan thermocouple elements are connected in series | |
| (2) Receiver | Gold-leaf (blackened by Bismus). |
| (3) Sensitivity | 0.017 V/ W/cm ² (each) |
| (4) Resistance (total) | 300 ohms |
| (5) Material of Window | Rock-Salt |

c. Window-Screen

- | | |
|---------------|--------------------|
| (1) Material | Chloride of rubber |
| (2) Thickness | 0.03mm |

The first trial production failed by reason of follows.

- (1) The power of motor which used for rotating machine is not enough when worked in flying in the air.
 - (2) Owing to using the clutch as the reversing gear, mirror cannot rotate right and left well.
- Then, we have planned new ones to improve above defects as follows.

- | | |
|--|------------------------------|
| (1) Rotating Speed | 10 degrees/sec. |
| (2) Rotating Angle | 200 degrees (right and left) |
| (With arrangement able to adjust the angle of rotation freely) | |
| (3) An angle of elevation and depression | 40 degrees |
| (4) Motor used for rotation of mirror | 150 W |
| (5) Collecting Mirror | |
| Diameter | 20 cm |
| Focal length | 20 cm |
| Aluminum evaporated surface mirror | |

This is undertaking to produce by way of experiment, and not yet produced.

6. Amplifier

This made by remaking the amplifier of "The Magnetic Detector" more sensitive. The data concerning this is as follows.

- (1) The sensitivity is more than 5×10^{-7} V.
- (2) Controller (including noise compensation rheostat, indicator meter, switch, etc.) is separated from amplifier main about 4 meters by connecting shielded cable.
- (3) The tuned amplifier at 675 cycle/sec.

The first 10 sets are nearly completed.

D-6

1. Name

I.F.F. using infrared-ray

2. Purpose

The apparatus of friend or foe identification using infrared-ray nocto-vision on an airplane.

3. Principle

Transmitter:-

30 c.p. tungsten lamp, infrared-ray organic filter on an airplane. 750 watt tungsten lamp and silvered mirror on the ship.

Receiver

The transmitted ray is collected with a special optical system of wide angle on the surface of a nocto-vision tube. That image is converted to another.

4. Character

Weight of nocto-vision	2.1 Kg.
Effective range	for airplane 5 Km.
	for between airplane and ship more than 10 Km.

5. Progress

For airplane 6 sets are manufactured but not yet supplied by the reason that those weight is too heavy. "Between airplane and ship" is not completed.

1. Name
Infrared-ray beacon for boat use
2. Purpose & Principle
Using infrare-ray beam and a detector of nocto-vision tube, to lead ships safely to harbour in the night.
3. Character
The lamp is 40 watts tungsten lamp with infrared-ray filter. Effective angle is 4 degrees.
The detector is a ce-ium type nocto-vision tube with lens of 6 cm in diameter.
Effective range 7 Km.
4. Progress
2 sets are already made but not used.
Denand was very excessive but we could not make the nocto-vision tube.

Manufacturing Company of Light & Heat Instruments

Name of Company	Position	Instrument to be made
Tokyo Sibaura Co. (Tokyo Sibaura Electric Co.)	Kawasaki, Kanagawa	Infrared-ray Communication Apparatus Mark 2 & 5. Nocto-vision tube, Mirror, Thermopile Amplifier of Heat-ray Detector.
Nippon Densi Kogyo Co. (Japanese Electronic Co.)	Kyobashi, Tokyo	Infrared-ray Communication Apparatus Mark 3 & Infrared-ray Beacon.
Nippon Kowki Co. (Japanese Optical Instrument Co.)	Turumi, Yokohama	Transmitter, all round type of Infrared-ray Communication.
Denji Kogyo Co. (Electric & Magnetic Co.)	Kamata, Tokyo	Part of Infrared-ray Communication Apparatus Mark 3.
Mitsubishi Denki Co. (Mitsubishi Electric Co.)	Amagasaki, Osaka	Electric Parts of the Photophony
Nippon Denchi Co. (Nippon Battery Co.)	Kyoto	Mercury lamp of Photophony
Nippon Koku Hyoshiki (Japan Light Leading Co.)	Meguro, Tokyo	Eliminator of the I.F.F.