37

~~CONFIDENTIAL~~

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

REPORT

ON

SCIENTIFIC INTELLIGENCE SURVEY IN JAPAN

September and October 1945

VOLUME I

1 November 1945

~~CONFIDENTIAL~~

DISTRITUTION

Reports on Scientific Intelligence Survey

Agency	Vol I	Vol II	Vol III	Vol IV
1. Commander in Chief	1	-	-	-
2. Chief of Staff	1	1	1	1
3. Deputy Chief of Staff	1	-	-	-
4. A C of S, G-1	1	-	-	-
5. A C of S, G-2 Att: War Dept Intel Target Section	3	3	3	3
6. A C of S, G-3	1	-	-	-
7. A C of S, G-4	1	-	-	-
8. Chief Chemical Officer	3	3	3	3
9. Civil Engineer	3	3	3	3
10. Chief Surgeon	3	3	3	3
11. Chief Ordnance	3	3	3	3
12. Chief Signal Officer	3	3	3	3
13. Chief Anti-Aircraft Officer	3	3	3	3
14. Chief Counter Intel Officer	1	-	-	-
15. Chief Economic & Scientific Section	2	2	2	2
16. Chief Civil Communication Section	1	1	1	1
17. Commanding General FEAF	1	-	-	-
18. Air Technical Intelligence Grp	2	2	2	2
19. Operations and Analysis Section FEAF	1	1	1	1
20. Chemical Officer FEAF	1	1	1	1
21. U.S. Strategic Bombing Survey	5	5	5	5
22. CG 6th Army	1	1	1	1
23. CG 8th Army	1	1	1	1
24. CG ASCOM-C	1	1	1	1
25. Naval Technical Mission to Japan	1	1	1	1
26. Navy Department, ONI	2	2	2	2
27. Navy Department, Bureau of Aeronautics	1	1	1	1
28. War Department, G-2 Att: Scientific Branch	52	7	7	7
29. Members of Committee	7	2	3	3

Note to all concerned:

Stencils are in possession of G-2 War Department where additional copies may be had upon request.

Note to all Theater agencies:

Extra copies or copies not desired will be returned to the AGO, SCAP, for retention.

CONFIDENTIAL

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

REPORT

ON

SCIENTIFIC INTELLIGENCE SURVEY IN JAPAN

September and October 1945

VOLUME I

1 November 1945

CONFIDENTIAL

CONFIDENTIAL

CONTENTS

CONFIDENTIAL

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

REPORT
ON
SCIENTIFIC INTELLIGENCE SURVEY IN JAPAN
September and October 1945

BRIEF SUMMARY REPORT
(The full report begins on page 9 .)

I - OBJECTIVE

The objective of the Survey was to make a quick, preliminary investigation to determine how the Japanese had organized for scientific war research, and to try to discover and identify for further study any important developments or improvements in techniques which might have been made. Aeronautics, Military Medicine, and Atomic Energy are covered by other investigating groups and were not included in this Survey.

II - ORGANIZATION

The technical staff of the Survey consisted of a small group (averaging about eight) of civilians and military personnel who had been actively connected with development of new military weapons and techniques and were immediately available in the theater.

III - PROCEDURE

The Survey consisted of interviews with scientists, leaders of research in industrial organizations, and Army and Navy technical officers, and visits to some of the laboratories where research and development work had been in progress.

Detailed studies of equipment and facilities were left for the Service Intelligence Teams. Approximately 135 interviews were held with about 300 scientists and technical people, representing some 50 separate organizations or projects.

IV - RESULTS OF SURVEY

A. Cooperation from Japanese.

The Japanese interviewed were invariably courteous and, on the whole, reasonably cooperative. Some were obviously eager to give all of the information wanted; some inclined to limit their answers to very literal and narrow interpretations of the questions asked. In at least one case, it was discovered that a young Navy officer had clearly lied.

On the whole, the Survey group is satisfied that it got the initial information on the important developments in the fields included within the Survey.

B. Japanese Organization for Research and Development.

Prior to the war with the United States, Japan had shown an active interest in supporting research, and two organizations, the Japanese Society for the Promotion of Scientific Research and the National Research Council, had been set up with considerable funds (mostly supplied by the Government) for grants-in-aid of research. During the war a third agency, the Board of Technology, patterned after the Office of Scientific Research and Development, in the United States, was set up, directly under the Prime Minister, for coordinating and supporting research, with an annual budget for research purposes of ¥20,000,000 (in addition to other funds for educational purposes).

The total funds available for support of research through these three civilian organizations amounted to ¥44,000,000 in the last year of the war--roughly equivalent in purchasing power in Japan before the surrender to $44,000,000 in the United States. These funds were used to support research projects conducted by individual research workers or small groups of workers, as judged by American standards. No contracts were given to universities, as such, or other agencies for large-scale operations. There was also a separate organization with an annual budget of ¥6,000,000 for supporting research in aeronautics.

The Army and Navy had extensive organizations for research and development, and the larger manufacturers also had research laboratories, but nothing like so extensive, relatively, or so well organized and staffed as the corresponding laboratories in America.

University laboratories, as such, did not take contracts for undertaking research on a large scale, which proved so successful in the United States. A comparatively few of the professors got into effective war work and consequently, a strong potential asset was wasted.

There was no effective agency for coordinating research of the Army, Navy, and civilian scientists, and for bringing the full capacities of the civilian scientists to bear on military problems. One of the principal objectives of the Board of Technology had been to effect this coordination, but it failed completely to accomplish this purpose, due to the opposition of the Army and Navy which were too powerful to be controlled.

Another respect in which it failed was that it did not mobilize the civilian scientists for mass attack on major problems under contracts with universities or other large organizations, but allowed such efforts as the scientist made to be dissipated on small-scale projects under individual contracts.

In the fall of 1944, an effort was made by the Army and Navy to set up a joint committee, with civilian representation, to coordinate research, but it came too late and accomplished little.

C. Summary of Information on Japanese Technical Developments.

1. RADAR. Japanese research on radar at the close of the war had reached a stage roughly equivalent to that of the United States in early 1942. The operational radar showed strongly the influence of the antiquated British and American radar captured early in the war in Singapore and the Philippines. Research and development on new equipment was largely original and showed little influence from German or Allied developments except in the general trend toward shorter wave lengths and airborne navigation and bombing radar.

Research on microwave systems had progressed slowly due to the diversity of effort and inadequate personnel and facilities. In general, the Japanese had only about ten percent as many scientists and engineers working on its research problems as worked on corresponding problems in the United States.

Only in research on magnetrons did the Japanese compare at all favorably with Allied efforts. They had probably a greater variety of magnetron types and frequencies than the United States. The performance of their best pulsed magnetrons was, however, considerably inferior to American magnetrons built for the same purpose.

Although the German influence on research and development was negligible, late in the war Japan was duplicating the German Wurtzburg as their standard antiaircraft radar. They were given assistance on this unit by the Germans. Due to delays in copying German manufacturing methods, only three Wurtzburgs were nearing completion before the war ended.

Japanese research on radar failed to meet the needs of the war because of lack of proper direction, organization, and coordination. This arose in part from the fundamental failure of the Japanese High Command to realize the operational importance of radar. The original work of many individuals was first-class, and with a better organization, Japan could conceivably rise to the front rank of radar development.

2. COMMUNICATIONS. No really significant work in the field of communication was found during the course of the investigation with the possible exception of the work in ionospheric measurements. The most advanced thinking outside of this one field appeared to have been done on radio-relay systems, but the equipment actually developed was inferior to the standard American equipment of the same type; i.e., the AN/TRC-3. In general, the modernization of the military communications system was hindered by the difficulty of the Japanese written language, the shortage of critical materials, the apparent lack of high-level backing for more progressive communications means, and the requirement for the greatest possible simplicity of operation resulting from the low level of technical training of the troops.

3. RADIO COUNTERMEASURES. This field was only very briefly investigated. It was determined, however, that the Japanese had developed and initiated procurement for 30 units of a 500 to 1,000-watt communications-type jammer covering the frequency range from 2 to 10 mc and were developing 100 and 1,000-watt jammers to be used against American 3-cm radar. They also used "window" effectively.

4. OTHER SIGNAL EQUIPMENT. Under this grouping are considered the work on Meteorology, Flash and Sound Ranging, Radio Direction-Finding and Navigational Aids, and Radio Measurements and Standards. Little really important work was found to have been done in any of these fields with the possible exception of Meteorology. This subject is being carefully investigated and evaluated by a competent group under the direction of FEAF and is therefore not extensively covered in this report.

5. ROCKETS AND JET PROPULSION. The Japanese Army started theoretical work on rockets about 1931, and by the end of the war had in operation or development a line of spin stabilized rockets from 5 cm to 60 cm in diameter. The latter was scheduled for final testing in September, 1945. The Survey was unable to cover Navy rocket developments in detail but 20 cm and 45 cm spin stabilized rockets of good design had been seen in the Philippines by members of the Survey group

Research was under way on the development of long-range, liquid-fuel rockets using H_2O_2 and alcohol.

The Navy was also working on the development of a jet-propelled fighter plane similar to the German Me-262 and had apparently had some help from the Germans. Only a few test models had been built.

6. GUIDED MISSILES. The Japanese were experimenting with a heat-homing bomb for attack on ships. They had not actually made a successful model but thought they had arrived at a successful design (Mark 9) which was expected to be ready for test by September, 1945. The control element, if greatly refined, might be interesting. They had also done some unsuccessful work on heat-controlled and television-controlled boats for attack against ships.

7. INFRARED. Some use was apparently made of near infrared for signaling purposes but no radical improvements had been made over well-known techniques. The Navy was also experimenting with far infrared for detection of ships and airplanes at night by the heat from the boiler or engine exhaust.

8. UNDERWATER SOUND. In this field, more than any other, the Japanese seem to have been helped by the Germans, who had sent them plans, specifications, models, and technicians. Apparently good, but not outstanding, listening and echo-ranging units had been made and standardized. The latter is a direct copy of the German prototype. Anti-vibration

mountings to lessen the noise from the engines had also been copied from the German designs. It is claimed that an underwater communication set, with a range of 15,000 meters had been developed, but it was not used by the fleet.

9. DEATH RAY. A real effort was under way to develop a "Death Ray" which it was hoped could be used to kill the crews of airplanes. Rabbits had been killed by high-frequency electro-magnetic waves at a distance of 30 meters with an exposure of 10 minutes. A new tube, many times more powerful than any tube previously built in Japan, was under construction, which, if successful, was estimated to kill a rabbit at 1,000 meters in 10 meters. The earnestness of the Japanese effort is indicated by an appropriation of ¥1,000,000 for this work in 1945. There is, however, nothing in this development to indicate any serious threat to crews of airplanes, or in other military use. Efforts had also been made to stop gasoline engines by similar techniques but this project had been abandoned as impractical.

10. ATOMIC BOMB. A special Atomic Bomb Survey group has inquired into Japanese activities in this field, and it was therefore not included in the scope of this Survey. Incidental questioning of scientists in the course of this Survey did not bring to light any information about atomic power or nuclear research in Japan not already known to the Atomic Bomb Survey group. It also seemed clear from this incidental inquiry that the Japanese had not made any real progress in the release of atomic energy.

11. MISCELLANEOUS DEVICES. The Japanese report they originally planned to make 20,000 of the paper bombing balloons for "attack" against the United States and that they had actually produced and released 9,000. They also report that the project was almost exclusively for home propaganda purposes, originally initiated to offset the serious effect of the Doolittle raid on Japanese morale.

A simple airborne magnetic detector (MAD) for use in detecting submerged submarines had been developed which, it is claimed, had some usefulness; a proximity-fuse for use on bombs to give an air-burst above ground level was developed (used experimentally in Leyte, and perhaps elsewhere), which employed reflected light from a light beam carried by the bomb for controlling the burst; a number of developments in the general field of metallurgy were completed, mostly directed toward relieving shortages created by the blockade; and work was done in the development of synthetic fuels. In none of these areas, however, do any developments of lasting importance appear to have been made.

12. CHEMICAL WARFARE. Japanese laboratories had synthesized and examined more than 1,000 compounds as possible new poison gases, but they claim to have found none superior to the gases used in the last war.

CW munitions were, on the whole, poorly designed and inefficient.

The Japanese are evidently unaware of the poor protection of their gas mask canister against CK, and of the United States' intention of taking advantage of this fact in case of chemical warfare.

The Japanese freely admit their lack of a protective clothing wearable in hot weather or tropical climates, and the catastrophic effect this fact could have had on their island-defense system if gas had been used.

D. Aid from Germany and other Sources.

With very few exceptions, the Germans do not seem to have given the Japanese a great deal of technical help. The major exception was in the field of underwater sound. In this field they sent plans, specifications, models of underwater supersonic detection equipment, and technicians to Japan. They also gave specifications and sent a technician to aid in construction of early-warning radar sets of the Wurtzburg type, but only one set got as far as experimental use. In addition, they sent a number of technicians to aid in other fields but Japanese and Germans agree that little was accomplished.

The Japanese fire control equipment clearly follows the old British "G-2" units captured at Singapore, but on the whole, they seem to have benefited little from captured equipment. At the close of the war several developments were under way, modeled on American equipment captured or salvaged from wrecked airplanes, but nothing important had gotten into operation.

V - EVALUATION OF JAPANESE RESEARCH AND DEVELOPMENT

The Japanese made little progress in the development of new equipment requiring scientific skill even when measured in terms of their relatively small facilities.

Probably the most important factor in this lack of progress was the failure of the Army and Navy to make effective use of university scientists in helping to solve their technical problems. The scientists were generally not taken into confidence but were viewed with distrust and suspicion. When used at all, it was nearly always on narrow, detail problems.

Failure to organize for mass attack on important problems; weakness and incompetence of the Army and Navy research organizations; almost complete lack of cooperation between the Army and Navy; and dependence in normal times very largely on America and Europe for new ideas and new developments were probably also important contributing factors.

In general, the new technical developments were far behind corresponding American or German developments, and little ahead of American and German pre-war standards.

Exceptions to the general rule of lack of progress were noted in the fields of Chemical Warfare, Meteorology, Ionospheric Measurements and Rocket Developments, in all of which some systematic work had been done, but nothing startling or in advance of Allied techniques had been developed.

VI - CONCLUSIONS

Japanese progress was badly handicapped by lack of proper organization for research and development, and by almost complete lack of cooperation between the Army and Navy.

They have a fairly large number of able scientists who could, unquestionably, have made significant contributions to the war effort, if they had been properly used.

The Japanese are obviously now well aware of this situation, and will certainly be more effective if another emergency arises.

NOTE. A more detailed statement of the methods and results of the Survey is given in the following pages, arranged under the same headings as used above.

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

REPORT
ON
SCIENTIFIC INTELLIGENCE SURVY IN JAPAN
September and October 1945

I - OBJECTIVE

The Scientific Intelligence Survey was undertaken at the request of the Commander in Chief, United States Army Forces, Pacific, to make a quick preliminary investigation of scientific research and development in Japan during the war, with two major objectives:

1. To discover the Japanese organization for carrying on war research and to appraise its effectiveness; and

2. To ferret out, as far as possible in a brief survey, any new discoveries or techniques of significance to war activities, and identify them for more detailed study by other appropriate agencies.

(Note: Aeronautics, the general field of Military Medicine, and Atomic Energy were not included within the scope of this survey as they are covered by other agencies.)

II - ORGANIZATION

The initial technical staff of the Survey group consisted of four civilians and three army officers, all of whom had been closely associated with the development and application of new devices and techniques for American military use, and were immediately available in the theater. In addition, Dr Karl T. Compton, President of the Massachusetts Institute of Technology, and a member of the National Defense Research Committee from its inception, served as Consultant to the Survey in developing the organization and plan of operations, and participated in the activities of the Survey during its first two weeks in Japan.

The technical staff of the Survey group, and their previous connections with war activities were:

Dr KARL T. COMPTON - Consultant (Until 24 September 1945)
Member of National Defense Research Committee, OSRD.

Dr DAVID T. GRIGGS -
Radiation Laboratory; Consultant Office of Secretary of War, Advisory Specialist Group USSTAF and FEAF

Major WILLIAM R. HEWLETT, GSC -
New Developments Division, War Department General Staff

Dr ANDREW LONGACRE -
Radiation Laboratory: Office of Field Service, OSRD.

Dr. EDWARD L. MORELAND - Chief of Survey
Executive Officer, National Defense Research Comittee, OSRD

Lt Colonel MURRAY SANDERS, CWS -
Office of Chief CWS, Special Projects Division

Major HOWARD E. SKIPPER, CWS -
Medical Division, Chemical Warfare Service

Dr H. KIRK STEPHENSON -
National Defense Research Committee, OSRD; Office of Field Service, OSRD (Head of Research Section of Pacific Warfare Board)

Lt HARRY H. YOUNGS, MAC (Since October 1945) -
Office of Chief, CWS, Special Projects Division

In addition to the foregoing, who were officially assigned to the Survey, Lt Colonel W. S. MOORE, MC, was designated by the Chief Surgeon, AFPAC, to maintain liaison with the Survey, and Lt GORDON T. WALLIS, Chemical Warfare Officer with FEAF, ADVON, gave a great deal of help in the investigation of Chemical Warfare targets.

III - PROCEDURE

Before the Survey group came to Japan, a list had been prepared, in part from information received through G-2 in Washington and in part from information available in the CIC Library in Manila, of the Japanese scientists thought likely to have played an important part in war developments or at least to know who had participated in such activities. The

Washington list contained the names of twelve "first priority"targets. Six additional names were added to this first priority list on the basis of the additional information found in Manila.

After arrival in Japan, all of these key men, except two who had died, were interviewed, and on the basis of information secured from them and from other sources, additional individuals were added to the list of those to be questioned. The Survey consisted largely of interviews, by appropriate members of the Survey group, with Japanese scientific and technical personnel of the universities, the Army, Navy, other governmental agencies concerned with research and development, industrial organizations participating in the development of specialized war equipment and other research institutions. Visits were, however, also made to a number of the laboratories where developmental work had been in progress.

The standard procedure, which was followed in all but a few special cases, was to request the Japanese Government, through established U.S. military channels, to arrange for a designated individual, or group, to be present for an interview at a specified place and time. This method of arranging for interviews worked very smoothly and effectively. The first interview with each individual or group was usually held at the offices of the Survey except when there appeared to be a definite advantage in holding the interview at the laboratory or office of the people interviewed. Follow-up interviews, when needed, were held either at the offices of the Survey or elsewhere as conditions indicated.

In the course of the Survey, a total of 135 interviews was held with approximately 300 scientific and technical people, representing some 50 separate institutions or projects. A very definite impression was gained from these interviews that the top men, particularly in university scientific circles and in industry, are really first-class, although the number of these first-class men is probably relatively small as compared with the United States.

IV -- RESULTS OF SURVEY

A. Cooperation from Japanese.

The Japanese interrogated were uniformly courteous and, on the whole cooperated reasonably well. Some groups seemed eager to be helpful and went to great pains to get together information which had been requested, or which they thought would be wanted. Other groups showed some tendency to answer specific questions asked but not to give closely related information which was not specifically asked for. Some, while apparently quite willing to talk about their own work, were obviously reluctant to tell about work done by others. In one case it was discovered that a young Navy officer who had been interviewed, had clearly lied, about a relatively unimportant matter.

In response to requests for statistical data, or other detailed information, it was frequently stated that all records had been destroyed, in accordance with official orders issued 15 August 1945. If this statement was ignored and the request was made that the information be supplied later, it was usually produced.

In a number of cases men who had been interviewed came back later, of their own accord, to amplify, or in some cases, correct information previously given.

On the whole members of the Survey group are of the opinion, based on the consistency of the information gathered, that a reasonably complete and reasonably accurate over-all picture of Japanese scientific and technical developments, in the fields covered by this Survey, has been obtained and that nothing of military significance has escaped attention.

B. Japanese Organization for Research and Development.

1. Government Support of Civilian Research.

Even prior to the war with the United States, Japan appears to have recognized clearly, at least in theory, the importance of scientific research to the progress and development of the country. In addition to Army and Navy research activities, two important civilian organizations had been developed for the specific purpose of encouraging and giving financial support to research. One of these, The Japanese Society for the Promotion of Scientific Research (Nippon Gakujutsu Shinko-Kai) was organized about 1934. It had an annual budget for support of research of approximately ¥5,000,000. About three-fourths of this was supplied by the government, through the Ministry of Education, with most of the balance coming from donations from industry supplemented by a small amount of fixed income.

The second pre-war agency was organized about 1939 and put under the National Research Council (Gakujutsu Kenkyu-Kaigi) of the Ministry of Education. It was supported entirely by government funds. Prior to the war it is said to have had some ¥3,000,000 per year available for support of research, but by the later years of the war, this had increased to approximately ¥19,000,000 per year.

During the war the research activities supported by these agencies naturally tended to become more objective than during normal times, and were directed particularly toward war projects, but even during that period a considerable amount of support was given to projects having no possible bearing on the war.

In addition to these two pre-war agencies for support of general research, a third was established during the war. This was The Board of Technology (Gijutsuin), created early in 1942 directly under the Prime Minister and supported entirely by government funds. In addition to considerable expenditures aimed at giving visual education in modern production methods and at arousing the public to an appreciation of the importance of science and modern technical developments, the Board of Technology had available approximately ¥20,000,000 per year for grants in aid of research projects.

During the later years of the war the total funds available from these three civilian organizations for support of research therefore aggregated approximately ¥44,000,000 per year. Inquiry as to salaries paid to various categories of workers indicates that the purchasing power of a yen in Japan was, at that time, substantially the equivalent of that of a dollar in the United States, so that this ¥44,000,000 may be taken as the equivalent of $44,000,000 in the United States. It should be noted that a considerable number of grants were made from these funds in support of aeronautical and medical research which are not included within the scope of this Survey.

In addition, there was a separate organization, the Japanese Aeronautical Engineering Society (Dai Nippon Koku Gijutsu Kiokai) devoted exclusively to the support of aeronautical research and therefore not included in this survey. This organization had an annual budget of ¥6,000,000.

Basically all three of the organizations for supporting general research described above operated along similar lines. Proposals for research projects originating within the organizations, or within the Army or Navy or other government agencies, or from individuals or groups of individuals, were referred to qualified committees for consideration. If recommended and approved grants-in-aid were given, ranging in amount from a few hundred yen to several hundred thousand yen. In most cases, the grants were the sole support of the projects, in others they supplemented other funds. During the war years, projects proposed by the Army or Navy were substantially in a "must" category.

The three organizations together gave grants-in-aid to more than 1,000 projects during the last year of the war, the majority of which had a more or less direct bearing on war activities. More detailed descriptions of these three organizations and lists of projects to which grants-in-aid were made during the past year are included, respectively, in Appendices 25, 20 and 8-B, attached.

In addition to these three publically-supported organizations giving financial support to research, a number of other advisory committees and councils were created during the war but only one of these appears to have given promise of having any influence on the research program. The number of these organizations and the frequency with which they were changed bears some evidence of hysteria as well as of comprehension that the efforts of the scientists were not being well directed. The one exception was the Army and Navy Technical Control Committee (Rikukaigen Gijutsu Ungo Iinkai) formed in October 1944 by the Ministries of War and Navy. The Committee was made up of four each, of the Army and Navy and University men of high caliber. It handled problems of greater secrecy and more operational in character than the Services had entrusted to outsiders. In one instance, at least, it arranged for the Army to carry through the development of a project suggested by the Navy because the Army had better facilities. However, it was burdened by a lot of "trivial" problems from the Services and came into being too late to produce any important results.

2. Army Research Facilities.

The Army, which has a separate branch of Technical Officers of all grades up to Lieutenant General, had an extensive organization for development, which included a considerable amount of research. It operated a total of 21 laboratories made up of 10 Ground Forces Laboratories, 8 Air Forces Laboratories, a separate laboratory for radar development (TAMA Air Technical Laboratory), a Fuels Laboratory and the Military Ordnance Administrative Board (engaged in research) in addition to numerous arsenals. Each laboratory was headed by a Lt. General or Major General. A list of the Army laboratories indicating the type of work performed at each is attached as Appendix 1-D.

3. Navy Research Facilities.

Similarly the Navy had a total of 8 principal laboratories for research purposes as set forth in Appendix 2-A attached, not counting the dispersal laboratories which were being set up. One of the important establishments is located at Meguro, Tokyo. It houses the Naval Technical Research Institute and the microwave radar systems research of the Second Naval Technical Institute, established in February 1945 with headquarters at Kanazawa. The First Naval Technical Institute with headquarters at Yokosuka was devoted to aeronautics and was therefore outside of the scope of this Survey. At the end of the war the Navy was dispersing its laboratories as rapidly as possible in an effort to minimize damage by air raids but several of its laboratories had already suffered severely.

The Navy also had Technical Officers, up to the grade of vice-admiral. This technical staff was recruited largely from the graduates of the universities and engineering colleges.

4. Research by Industrial Organizations.

The large manufacturers, including such organizations as Tokyo Shibaura Denki (affiliate of the General Electric Co.); Sumitomo Tsushin (affiliate of the Western Electric Co.); and Nippon Musen (affiliate of the Telefunken Co. of Germany) also have research and development laboratories but in no way comparable in scale or capacity with the research organizations of their foreign affiliates. Apparently these companies normally relied largely on America and Europe for their new developments and were not set up to carry on major research and development programs.

5. Institute for Physical and Chemical Research.

The Institute for Physical and Chemical Research (Rikagaku-Kenkyo-jo) in Tokyo is a research institution of a different type, without exact counterpart in the United States, which has apparently played an important part in the industrial development of Japan. The Institute was organized about 29 years ago and, until largely burned out by the fire raids, had an extensive plant where both fundamental and applied research could be carried out on a large scale. It was originally organized largely by professors of Tokyo Imperial University and much of its important work is still headed by professors from the University. The objectives have been primarily industrial, but some basic research has been included. It does not appear to have played an important role in war developments. The Institute was originally financed by donations but is now supported mainly by proceeds from successful inventions, which it has sold or licensed to industry, or which have been used as the bases for establishing new industries in which the Institute retained substantial interests. More than sixty industries are using inventions of the Institute, covered by some 100 major patents and several hundred of lesser importance. Eighteen of these industries were founded on inventions of the Institute, which has enjoyed an income from its inventions of approximately ¥3,000,000 per year. (Appendix 6)

6. Research by Universities.

Universities, per se, did not engage in war research. The reason for this is not clear but in any case it seems to be a fact which neither the military authorities nor the universities made an effort to correct. Some of the university professors got effectively into important war work by joining the staff of a Service laboratory, as full-time employees (more common with Navy) or by becoming consultants to industrial laboratories or the Services. Undoubtedly important contributions were made by these men. For example magnetrons, which were relatively well advanced in Japan were developed largely by Professors Takao and Morita.

Only a small fraction, however, of the key scientists and engineers were so employed. University staffs undoubtedly constituted a pool of untapped scientific ability which far exceeded the talent available within the military and industrial laboratories. The failure of Japan to employ effectively this resource is a measure of her failure in war research.

An example of misuse of scientific personnel is the war history of Professor Sagano, head of the Physics department at Tokyo Imperial University and one of Japan's leading young physicists. He had expressed a desire to be useful in the war effort, but was not encouraged to engage in important Army or Navy projects and spent his time perfecting vacuum technique for the tube manufacturers; a job for a technician rather than a highly experienced experimental and theoretical physicist.

The majority of the university scientists and engineers interviewed by the Survey had continued their normal teaching and research throughout the war without particular emphasis on techniques directly applicable to military needs. In comparison with America and Britain, University researchers in Japan were only about one-tenth mobilized for war. Reports from Germany indicate that a somewhat similar situation prevailed there.

7. Organization for Coordinating Research.

In spite of elaborate organization for encouraging and supporting research, there was no effective agency for coordinating research activities or for bringing the talents of the civilian scientists to bear on military problems in a large way. The Board of Technology, referred to above, was intended to be the over-all coordinating agency for Army, Navy and civilian research for the war. It was patterned after the Office of Scientific Research and Development (OSRD) in the United States which the Japanese knew about through press reports. To enable it to function effectively, in directing and coordinating research for the Army and Navy, it was set up at a high level, its chairman ranking all the Army and Navy research directors and reporting directly to the Prime Minister, who took a personal interest in the establishment and activities of the Board.

Although the Board of Technology had an organization strikingly similar to OSRD and was invested with much the same powers, it failed utterly in its mission, and far from coordinating all research, really had a negligible effect on the Japanese war research program. The primary reason for its failure is inherent in the high level organization of Japan. Although the Prime Minister was head of the civil government, and had nominal authority over the Minister of War and Minister of the Navy, they, in fact, reported directly to the Emperor, and were too powerful to be influenced by the Prime Minister or the Chairman of the Board of Technology. Both the Army and Navy resented the establishment of a board to deal with problems which they regarded as their private affairs. The result was that the Board of Technology was not taken fully into the confidence of the Army and Navy in research on new weapons and was completely ineffective in coordinating their research activities.

An almost equally important failure of the Board was the fact that it did not mobilize under its control the chief civilian scientists of Japan. Viewed in the light of OSRD experience it would seem that one of the important reasons for this was the policy of contracting with individuals for small-scale effort rather than with universities and other large research institutions for broad programs of research and development.

As a result of its inability to coordinate research, it served, in effect, only to supplement the other two civilian agencies giving grants in aid of small-scale research.

One noticeable factor, in contrast with American practice, is that so far as could be discovered, in no case did a university, per se, take a contract for a research project. Any work done by university professors was on a personal basis through direct arrangement with the Army or Navy or under a grant from one of the civilian agencies previously described. University professors are apparently allowed great freedom in undertaking personal research and the universities do not concern themselves with research projects of its staff members, even when the research is conducted in the university laboratories. This is probably an outgrowth of the fact that the professors in Japanese universities are so poorly paid that it is an economic necessity for them to earn outside income.

C. Summary of Information on Japanese Technical Developments.

The information on the status of Japanese technical developments gathered from the various interviews and inspections is summarized below by categories of equipment or techniques:

1. RADAR.

a. General.

Radar in Japan, as of August 1945, had reached approximately the same stage of development that it had in England at the time of the Battle of Britain. The early warning equipment remotely resembled the old British CH of 1940 vintage. IFF was in a rudimentary stage and there was no standardized system or even frequencies common to the Army and the Navy. Naval fire control by radar had been discontinued when their 200 mc radar was jammed, and only recently had they begun the development of 10 cm fire control equipment which exists now only in experimental quantities and is primitive in nature. Their most urgent need in radar was in good antiaircraft fire control equipment, and good nightfighter and GCI equipment. In the face of the threat to their very existence caused by lack of this equipment, apparently very little was being done to remedy the situation. No new equipment in these categories was found in the Survey beyond simple extensions of their old and totally inadequate gear. They had poor liaison with Germany, and not until late in the war did they profit from German advances in radar, and then only on a single type of equipment which did not reach operational use.

b. Japanese Organization for Research in Radar.

The Army and Navy separately had sole responsibility for planning and carrying out their individual radar programs. There was no program of any importance for radar research in universities or government institutions outside the armed services. In general, the Army and Navy research laboratories gave military characteristics and to some extent design characteristics to the manufacturer, who made the set. The manufacturers were however not staffed or equipped for rapid progress in research and developments.

Both the Army and the Navy had recently organized special over-all radar laboratories, in an effort to expedite radar development. The Navy, in February 1945, set up the Second Naval Technical Institute under which was consolidated all their radar research. The Army, in June 1943, established the Tama Technical Research Laboratory which was charged with all radar research with an annual budget of approximately ¥15,000,000. It is the general opinion of all impartial observers that the Navy technical personnel was better qualified than the Army. Both the Army and the Navy did some design work but their facilities were, by American standards, very limited and their output small. Their engineers appeared to have worked very closely with the industrial research laboratories in the development of new equipment.

The procedure for design and production of new radar equipment roughly paralleled that in the U.S. before the war. The Navy had sufficient research personnel and laboratory facilities to accomplish about one half to two-thirds of the research on their new gear. The remainder was done largely in the industrial research laboratories. The Army had inadequate personnel and facilities to do the research on their new gear. They contracted for the major fraction of their radar research. Some fundamental research was done by individual university professors on contract, but the bulk of research for the Army was done by the inadequate industrial laboratories, mostly on development contracts for new equipments which were tested by the Army with some participation by the design engineers. Both the Army and the Navy conducted tests on "breadboard" models in their field stations.

There was no program for radar research in any way comparable to that of OSRD. There was no over-all planning for the equitable distribution of research among the several agencies; for the avoidance of duplication of effort between the Services and between the research laboratories; or for the recruiting and training of research personnel. There was intense inter-service jealousy and a detrimental degree of secrecy prevailed. Manufacturers were ordered to separate their research for Army and Navy and not to let the left hand know what the right was doing. (Appendix 1-A; 2-B-a; 2-C-a and b)

c. The Research Laboratories.

The principal radar research laboratories of Japan are listed in Table 1 below.

Table 1.

Name	Head-quarters	Director	No. of Engr.	Total Personnel	1945 Budget
2d Naval Tech Inst Radar & Communications Section	Kanazawa & Meguro	V-Adm NAWA			
Tama Radar Res Lab	Near Tachikawa	Lt Gen TADA	70	1070	¥16,000,000
Tokyo Shibaura Denki Co.	Kawasaki	Mr. HAMADA			¥ 6,000,000
Nippon Muson Co. (affiliate of Telefunken)	Mitaka	Mr. NAKAJIMA	55	155	
Sumito Tsushin Co.	Ikuta	Dr NIWA	400	800	

The budgets of the Army and Navy laboratories included large amounts for test purposes. The details of work of each of these laboratories may be found in the appended interviews. (Appendix 1-A, 2-B, 2-C, 4, 7, 13)

d. Recent Products of Japanese Radar Research.

All of the interesting new radar sets that were learned about are given in the following list.

(1) Navy Equipments

(a) 10-cm Airborne Search Set. This is the Japanese Experimental Set No. 51, and is referred to by the code name "Rotterdam" which the Japanese got from the Germans without knowing its origin. They deny having received any important technical information from the Germans or from captured Allied equipment which led to this design. They did know, however, of the PPI scope and of the use of 10-cm rad-iation for Pathfinder and blind bombing purposes. The equipment appears to have been conceived locally for the most part although it bears a similarity to early American airborne search sets. It has a TR of Japanese design and a PPI scope. Only three sets were built by Nippon Musen, of which one had been flown. It is just a standard microwave search set with no bombing computer. (Appendix 2-C-6,7)

(b) 10-cm Fire Control for Ships. This equipment was in the very early stages of test. It used a rapidly-oscillating dipole in a 1.7-meter parabolic reflector The radar components were quite similar to the standard Japanese navy 10-cm search equipment with the exception of the TR and the indicator. The set was stabilized by hand cranks and manually centered on the target with the aid of an error signal indicator. Azimuth and range data were fed to the computer for the main batteries by selsyns. Accuracy claimed was ±½° in azimuth and ±100 yards in range. This was built by Nippon Musen.

(c) Centimeter Radar Listening Devices. The Japanese had quite a line of crystal-video receiving equipments which they used to detect the presence of American radar under a variety of conditions. No notable advances in the art were seen, however. (Appendix 2-C-d)

(d) Microwave Shell Exploder. This set was in the design stage. It was planned to use a 50-kw CW, 10-cm transmitter in a 10-meter parabolic reflector to generate a narrow beam of high-intensity radiation which would explode a Japanese antiaircraft shell passing through it by means of high induced current thus producing an air burst at the desired location. Research had been concentrated on the magnetron and their systems thinking had not progressed very far. (Appendix 2-C-a).

(e) The Joint Army-Navy Wurtzburg. This was as exact a duplicate as the Japanese could make of the German Wurtzburg "D." They made an effort to build all the components to the German specifications. This was done by the Nippon Musen Company which was the logical choice, since it is a Telefunken affiliate. Three equipments had been made but only got as far as experimental use. (Appendix 1-A, 7, 26)

(2) Army Equipments.

(a) 5-cm Airborne Radar Bombing Set. This was in the very early experimental stage, and the first breadboard model was just being tested when the war ended. It was designed and constructed by the Ikuta Laboratory of the Sumitomo Co. (Western Electric Co. affiliate) and was for the most part a poor imitation of the Western Electric AN/APQ-13 which had been recovered from crashed B-29's. The primary purpose for making this set was given as an attempt to build a set like the B-29 radar for the purpose of developing jamming apparatus to be used against the American B-29 equipment. Results of this attempt were inconclusive due to the faulty performance of this breadboard equipment. The method of jamming which was being investigated was a primitive brute-force method in which they used constant-frequency magnetrons with a high recurrence rate, and were planning to attempt to saturate the receivers with a multitude of jammers at the same location. They had no realization of the power output of American sets, and consequently must have grossly overestimated the receiver sensitivity, since they knew the range of American sets.

(b) Tase 6, 10-cm Submarine Search Set (in cooperation with the Navy). This was similar to the Navy standard search equipment except for a few modifications to give it a higher range on submarine periscopes. This was built by Nippon Musen. (Appendix 1-A)

(c) Tachi 35, 82-mc Early Warning and Height Finder. Three experimental sets were made. They have a reported range of 300 km on a B-29, measure altitude to ±500 meters, and an angular accuracy of ±1°.

(d) Tachi 13 and 15, Beacon Finder Director and IFF Set. Tachi 13 is a ground equipment which transmits on 184 mc and receives on 175 mc; and is said to give position of friendly fighters to 3 km. Data from the Tachi 13 feeds into the computer Tachi 36 where it is combined with data from the Tachi 35 to enable the controller to make GCI interceptions. The Tachi 15 is the airborne IFF set. This IFF was in the experimental stage and only five or six installations had been made before the war ended. There was no uniformity between the Army and Navy on IFF equipment or frequency. The Navy used an IFF frequency of 150-160 mc.

(e) Taki 2, 60-cm Night Fighter Set. This set had a 3-kw output, a range of 3 km to 200 meters on a medium bomber. Five or six installations had been made for training purposes. This was manufactured by Sumitomo Tsushin Co.

(f) Loran. A 2-station Loran system for a line of position was being designed to operate on 1.3 mc. The Japanese were familiar with the American airborne Loran equipment from B-29's and with the system of navigation through the navigation charts from the B-29's. (Appendix 1-A)

(3) Components.

In the line of new components following, only those which show an advance over standard pre-war procedure are discussed.

(a) Magnetrons. The Japanese development of magnetrons is by far the most noteworthy development in their radar research. This development is almost entirely original with Japanese scientists, although there is a minor influence due to the recent capture of American magnetrons in the B-29 H_2X radar. The Japanese began intensive work on multiple cavity magnetrons in 1936 and have continued it at an accelerating pace ever since. They have developed a great variety of types of both pulsed and CW magnetrons at all frequencies from 80 cm to 0.7 cm. They seem to have skipped the American K band (1.2 cm) region, but it was not learned whether this was accidental or done with the knowledge of the bad water absorption near that frequency. Their tubes give evidence of a pretty complete understanding of all the important factors in magnetron design. For example, they independently developed the "strapping" technique, they have tunable magnetrons, and they use oxide coated cathodes. However, their tubes are far inferior to American tubes in power output, efficiency, and life. Cursory inspection would suggest that this may be due primarily to low-emission and short-life cathodes, and to lack of precision construction.

There are two schools of magnetron design in Japan. One - the Navy (Shimada Laboratory - Nippon Musen) and the other - the Army (Prof. Morita - Sumitomo, etc.) The former makes use of an anode with alternating large and small cavities to provide decoupling between adjacent resonant cavities for stability. This school uses no strapping, or three-phase strapping (coupling every third cavity). The second school has developed magnetrons remarkably like the American designs, but apparently developed quite independently, with a twelve cavity strapped magnetron being about the most common. Each school has developed fairly successful magnetrons, both pulsed and CW. Each thinks its technique superior to the other, and each has tried both types. The only tubes to go into large-scale production have been manufactured by the Nippon Musen Company to their own designs, which have, however, been greatly influenced by the research work at the Shimada laboratory of the Second Naval Technical Institute.

Representative samples of the Nippon Musen Magnetrons have been sent back to the U.S. through the Office of the Secretary of War (Dr. Bowles), for study by the magnetron experts from the several interested agencies in the United States. A complete collection of magnetrons and related high frequency tubes from the Shimada Laboratory is also being sent back to the United States through the Office of the Chief Signal Officer, AFPAC. This includes every major type of tube built by that laboratory from 1936 to the present, together with statements of operating characteristics and principal results of the experimental tests with each tube. The most advanced magnetrons seen, in terms of performance, are: (1) a 2.8 cm pulsed magnetron with 130 kw peak power input and an estimated 20% efficiency, and (2) a 20 cm CW magnetron with 50 kw input and about 20% efficiency. Samples of both of these are included in the Shimada Laboratory collection. (Appendix 7, 19, 22, 24)

(b) Velocity Modulation Tubes. The Sumitomo Company has produced the most promising velocity modulated tubes. They have a 3-cm reflex klystron which appears to be very easy to manufacture and is reported to have good stability. A sample of this will be sent back to the United States, through the Office of the Chief Signal Officer, AFPAC, for study by a group of experts. Other researches in velocity modulated tubes have been made but with unsatisfactory results on the whole. The standard local oscillator for microwave sets in Japan is a low power CW magnetron which is tuned by varying its output impedance, which results in pulling the magnetron frequency. (Appendix 13)

(c) High Frequency Triodes. The Sumitomo Company has manufactured a 10-20 cm triode which is quite similar to the American GE Lighthouse tube of which, however, they were unaware. (Appendix 13)

(d) TR Tubes. The Navy has led in the development of TR tubes and their experience has independently followed more or less the lines of American experience in TR tubes, although they are now at a less advanced stage than the United States. (Appendix 2-C-b)

(e) Other Components. The other components, in general, show no interesting development. The receivers are of antiquated design, the indicators are rudimentary, and the RF systems are primitive in the extreme.

c. Japanese Information about German and American Radar Design.

There has been small interchange of technical information and personnel with Germany. So far as could be determined, only two radar technical men (Mr. Heinrich Foders and Mr. Emil Brinker) came to Japan during the war. Some Japanese military men, notably Col. Satake, visted Germany where they were shown the operational German radar. They were, however, not permitted to see German research and new developments in radar. Late in the war considerable technical information was interchanged by radio, but this was not enough to enable the Japanese to make efficient use of German experience. (Appendix 26)

There seems to have been a pretty complete lack of intelligence on captured American equipment after the initial haul from the Philippines and Singapore. Although they had recovered many radar sets from B-29's, the individuals concerned with the design of new radar had no real appreciation of the operating characteristics of this equipment. The ignorance of the Japanese as to potentialities and scope of American radar is striking. (Appendix 1-A, 2-C)

f. Conclusions.

(1) Japanese research in radar is at a very low level, comparable to that of the United States in early 1942. Achievements by individuals do, however, indicate that Japan has the inherent capability of developing a modern radar program.

(2) There was lack of early realization by the Japanese High Command of the importance of radar in modern warfare. All of the weaknesses in Japanese radar may be traced to this basic cause.

(3) Until recently, there was complete lack of coordination between Army and Navy and no over-all radar program. This had its roots in the jealousy of the Services and was nurtured in the atmosphere of secrecy which prevailed. It resulted in excessive duplication both in research and production and, by splitting the efforts of the country, was a major contributing factor to the failure of Japanese radar.

(4) There were insufficient funds, personnel, and equipment priorities to carry out a radar research program.

(5) By American standards, Japan had only five to ten per cent of the research personnel (scientists and engineers) necessary to carry out a full-fledged radar program.

(6) There was no systematic integration of civilian scientists and electrical engineers into the radar program. Many men of excellent technical qualifications for

radar research were left doing picayune jobs, often not related to the war.

(7) Finally, the radar research institutions were seriously damaged by the bombing of the B-29's, and were then completely dislocated by the program of dispersal which was put into effect in the Spring of 1945.

2. COMMUNICATIONS.

a. General.

Standard commercial type communication equipment, or minor modifications of it, have not been included within the scope of the Survey, nor have the more standard military communication sets except where they have some unusual characteristic. Principal interest has been centered in the newer types of communication means which are of a nature to be readily adopted to military use. In considering work of civilian organizations, it is important to note that, by and large, these groups were only given a small part of the problem to work on, and rarely the responsibility for the entire system.

b. Radio Communication.

(1) Army.

Most of the radio communication work for the Army was carried on at the 5th Military Technical Laboratory, at Kokubunji. (Appendix 1-I)

(a) Radio-Relay Systems. It is believed that the most important work in the field of radio communications was that on radio-relay systems. Although the equipment developed was in many ways inferior to our own sets; i.e., AN/TRC-3, 4, the work indicated a trend of thought that is important. The most fully developed set operated in the frequency range 570-670 mc and provided 4 voice channels. It could not, however, directly inter-operate with field telephone carrier systems.

(b) "Flash" Telegraphy. Some work had been done on a form "flash" telegraphy (3,000 characters per minute), but the equipment was large and cumbersome and required the use of a photographic process for receiving, and a punch tape for sending.

(c) Tactical Radio Communication. Tactical radio communication was of a straightforward nature and fairly well confined to the high-frequency band with the exception of a lightweight infantry pack set, somewhat reminiscent of the SCR 194, 195, operating in the frequency range 30-40 mc. No work on Frequency Modulation (FM) was reported. Due to the shortage of quartz and a relatively low priority of ground communication equipment, efforts were under way to eliminate the use of quartz crystals in ground sets.

(d) Special Radio Equipment for Agents. The 9th Military Laboratory at Noborito was primarily concerned with special equipment for subversive agents, special police, etc. This laboratory developed some small transmitters for use by agents. They were characterized by simplicity in construction and operation, lightness of weight, and small size. They were hand-generator operated.

(2) Navy.

Most of the radio communication work for the Navy was carried on at the Kanazawa Field Laboratory of the 2nd Naval Technical Institute. (Appendices 2-B-a & 2-C-d)

(a) Aircraft Radio Sets. The main development work at this laboratory was on radio sets for aircraft, with the principal effort on constructional and engineering design. Most of the sets were crystal-controlled and amplitude modulated.

(b) Pulsed Radio-Relay System. For inter radar-site communication purposes, consideration had been given to the development of a multi-channel phase-modulated pulse communication system operating on the time division principle. It is not believed that any of these sets were constructed.

(3) Civilian Work.

Little work of scientific interest from the military standpoint was being carried on by civilian agencies. This, in part, was due to the military policy of maintaining systems responsibility within the military organization. A few projects, however, are worthy of mention.

(a) Basic Research on Microwaves. The Japanese Broadcasting Company maintained a group under Dr. G. Hara, which prior to the war, was engaged in television transmission research. During the war apparently little effort was made to adapt television to war purposes and this group was assigned to basic microwave research. It is now planned, however, that it will return to the television transmission work. A frequency in the range of 40 cm is under consideration for television relay purposes. Any relay television transmission systems developed in this range would have direct application to military communication needs should the occasion arise. (Appendix 28)

(b) Pulsed Radio-Relay System. It was reported that Prof. Koike, at the Tohoku Imperial University at Sendai had developed a successful phase-modulated single-channel pulse communication system, operating in the frequency range of 200 mc. This report was not investigated further.

(c) Speech Secrecy Device. It was reported that Prof. H. Nukiyama, of Tohoku Imperial University, had developed a speech secrecy device for use over radio circuits. No other details were available and no investigation was made of the report.

c. Wire Communication.

(1) Army.

All Army wire communication research was carried out at the 5th Military Technical Laboratory at Kokobunji. The most important projects under way were considered to be:

(a) Carrier Telephone and Telegraph. A 3-channel carrier-telephone system for field use had been developed and had a reported range of 300 km over open wire circuits, or 60 km over Japanese field cable. An improved model was under development that would provide three voice and three telegraph channels with no reduction in range. A voice-frequency telegraph set for field use had also been worked on.

(b) Teletypewriters. Some work had been done to adapt the standard 50 character Japanese commercial teletypewriter to field use, but the project had been discontinued due to the shortage of critical materials. A simpler set had been developed with only 16 characters, numbers 0-9 and 6 punctuation marks. This set was intended for use solely with number codes.

(2) Navy.

The Navy had three models of carrier and telephone and telegraph apparatus.

(a) Carrier Telephone. A small five-channel carrier telephone set for use on open wire lines, operating on frequencies in the range 60 kc to 140 kc had been produced and an improved six-channel carrier telephone set for use on open wire circuits operated on frequencies in the range 36 kc to 14? kc was under development.

(b) Carrier Telegraph. A voice-frequency telegraph set operating on a frequency of 1615 cps had been produced.

(3) Civilian Work.

(a) Carrier Telephone and Telegraph. The Sumitomo Electric Co. (an affiliate of the Western Electric Co.), had been engaged in development work on carrier telephone systems. As the Sumitomo Electric Co produced the military carrier telephone set mentioned in paragraph 1,b,(1) (a) above, it is difficult to determine who was the actual developer of the set. It may be assumed, however, that the Company engineers played an important part in its development.

(b) Teletypewriters. The Electro-Technical Laboratory of the Board of Communications had been actively engaged in research on improved teletypewriter sets. The most interesting work in this field was on a radio teletypewriter system in which each character was transmitted twice, with an adjustable time between each transmission. (Appendix 17)

(c) Security System for Teletypewriters. The same organization had also done some development work on a security system for use with teletypewriters. For operation it depended upon standard 25 contact step-relays which were changed for each character. A change in a step-relay resulted in a change in polarity of each mark or space. The length of a key was determined by the number of step-relays that were placed in series, each relay multiplying the key length by 25. (Appendix 17)

d. Visual and Acoustic Communications.

(1) Navy Work.

The Navy had three projects in this class which are of interest. (Appendix 2-C-d)

(a) Sub-aqueous Signaling. A set had been developed for underwater voice communications that was said to have a range of 15 km under favorable conditions. It operated on a frequency of 9 kc.

(b) Voice Modulated Light. A voice modulated light system with range of about 15 km had been developed on an experimental basis. It used a 100 watt high-pressure mercury-vapor lamp with direct modulation and a standard photocell receiver. It was intended for use between land bases to supplement normal communication means.

(c) Infrared Signaling. (See section of this report on Infrared, Page 39)

e. Radio Wave Propagation.

The Japanese have been active in ionospherics and radio propagation work since 1932. The activity reached a peak in 1944, when 14 separate stations were in operation for the measurement of ionospheric heights. These stations spread from Paramushiro, in the Kuriles, to Bandoeng, in Java. Some of these stations were under Army, some under Navy, and some under civilian jurisdiction. The principal civilian agency was the Ministry of Education, although the Board of Communication had also been active. Excellent cooperation appeared to have existed between the military and civilian agencies. The work was mostly confined to ionospheric measurements and the reduction of data to usable form, and to certain theoretical research. No significant work appeared to have been done on tropospheric propagation.

f. Components and Special Problems.

(1) Vacuum Tubes. A considerable effort had been made to reduce to a minimum the number of tube types employed for military sets. The most important of the standardized tubes were a universal pentode of German design, and a universal pentode of the American GT octal type, known as "SORA". An interesting feature of this tube was its iron anode structure which, when heated by induction means after the seal-off, picked up the excess oxygen in the tube by forming Fe_2O_3. Considerable work had also been done to find suitable substitutes for the more critical metals used in vacuum tubes. This work included substitutes for such materials as tantalum, nickel, and strontium. The bulk of the research on receiving and small transmitting tubes was carried on by civilian agencies. Some of the centimeter tube research was carried on by the military laboratories. Centimeter tube research is discussed in more detail in the section of this report on Radar, Pages 23 and 24.

(2) Quartz Crystals and Stable Circuits. Very little research appeared to have been carried out on

quartz crystals. The supply of this material was critical and efforts were under way to redesign some of the ground sets to eliminate the requirements for this item. There was no reported difficulty with crystal aging. The Army had done some work on frequency-stable circuits not requiring the use of quartz crystals and claimed to have obtained over-all stabilities including effects of changes in tubes, temperature, and load of less than .05%. No work appeared to have been done on the use of magnetostriction oscillators for frequency control.

(3) Moisture and Fungus Proofing. Very little practical work appeared to have been done on this problem. The Navy reported no serious difficulties on this problem and was only taking minor precautionary measures. The Army was more active and had actually sent out a report recommending the painting of some of the more critical parts of field sets with a non-baking bakelite varnish and with paraffin. No report of this procedure actually being used by the troops had been received. The Army had also given some consideration to complete inclosure of the set in rubber, with transparent windows to permit meter and dial readings to be taken and glove-like inserts for manual manipulation of controls. It was interesting to note that no pressure appeared to have been placed on the manufacturers, to get them to produce components with better moisture resistant characterisitcs. The Electro-Technical Laboratory of the Board of Communication had done some independent work on this subject which appeared to have been planned on a scientific basis, but this work had not been completed.

3. RADIO COUNTERMEASURE.

a. General.

The subject of radio countermeasures is only briefly dealt with in this report. For a complete report on the specialized field, it will be necessary for a group thoroughly familiar with the subject to make a careful survey of the Japanese effort and evaluate the results in the light of American experience. The information obtained in this field is listed below.

b. Jamming Equipment.

(1) Army Work.

(a) Radar Jamming. Two airborne jammers had been developed covering the frequency range 7 to 1.5 meters and 15 to .75 meters. A jammer operating on a frequency of 3 cm and with a power output of about 100 watts had been developed but not placed in production, and development of a 3-cm, 1000-w jammer was nearing completion.

(b) Communication Jamming. A 500 to 1000-w jammer covering the frequency range 2 to 10 mc had been developed and 30 of these sets were in production. This set was intended for use against tactical field communication circuits.

(2) Navy Work.

No information was obtained on navy-type jammers.

c. Search Receiver.

(1) Army Work.

(a) Radar Search Receivers. A line of radar search receivers had been developed covering the frequency range 7 to 1.5 meters and 40 to 3 cm.

(2) Navy Work.

(a) Shipborne Equipment. For this application a search receiver was used that covered the frequency range 4 to .75 meters and 75 to 3 cm. It was reported to have been installed on both surface and underwater craft.

(b) Airborne Equipment. For this application a search receiver was used that covered the frequency range 3.7 to .5 meters. Lobe-switching was used to obtain an indication of bearing.

d. Window.

No information was obtained with regard to the development of various types of window (chaff) by the Japanese.

4. OTHER SIGNAL EQUIPMENT.

Various items of miscellaneous signal equipment are grouped under this heading for convenience.

a. Meteorological Equipment.

This subject is under careful review by a group of specialists operating under the Weather Section of

FEAF. Three items, however, are considered to be of sufficient interest to warrant mention.

(1) Cloud Sonde. This device is intended to measure the height and thickness of clouds. For operation it depends upon the differential heating of two bi-metal strips exposed upwards - one painted black and the other white. When a cloud is pierced by balloon-borne sonde, the intensity of the light is increased and a differential deflection is directly converted to a change in capacity and this to a change in radio frequency of the sonde. Pressure is indicated by means of a baro-switch. For use at night, a light source and a photocell receiver are utilized.

(2) Spherics. Quite an intensive program under military auspices was under way for the location of the centers of electrical atmospheric disturbances (noise) by radio direction-finding means and the correlation of this information with weather data. The direction-finder sets operated in the middle of the high frequency band and gave continuous indication of the direction to the center of the noise area. Arrangements have been made to have this work investigated by the radio propagation and noise experts of the Signal Section, GHQ. The Japanese Broadcasting Co. was also engaged in a research project to determine the center of atmospheric noise by radio direction-finding means, using frequencies in the vicinity of 20 kc.

(3) Radio Tracking of Meteorological Balloons. The Japanese Army had developed a radio direction-finder for tracking meteorological balloons thus permitting the measurements of winds aloft under conditions of poor visibility. Altitude was indicated by means of a baro-switch. It was stated by AAF investigators who had seen this equipment that the accuracy of this system was in no way comparable to that obtained with the SCR 658.

b. Sound and Flash Ranging.

Work on these two problems was carried on at the 2nd Military Technical Laboratory in Tokyo.

(1) Sound Ranging. The equipment and techniques used for this purpose were of a straight-forward nature and utilized a photographic process for the measurement of the time difference of arrival of sound at the six microphones used in the array. This equipment had been tried against our mortars at Guadalcanal but with no satisfactory results. A project had been initiated to develop a set specifically for mortar location purposes but it had been unsuccessful.

(2) Flash Ranging. Work on this problem had been of an exceedingly crude nature and relied on unsynchronized cameras for operation.

c. Radio Direction-Finding and Navigational Aids.

(1) Army Work.

Army work on these problems was carried on at the Hiragata Shikinjo branch of the 5th Military Technical Laboratory, and at the 4th Military Air Technical Laboratory at Tachikawa.

(a) Fixed Direction-Finders. The best type of fixed direction-finder was considered to be a crossed buried-U with a manually-operated goniometer, and operating on the null principle. It had a reported accuracy of ±1°.

(b) Tactical Direction-Finders. The tactical field direction-finder was reported to be of poor accuracy and quite unsatisfactory. Some effort had been made to develop a precision front-line direction-finder for use by the artillery, but the research had not been successful.

(c) Portable Direction-Finders. At the 9th Military Technical Laboratory, a small, portable direction-finder had been developed for use in determining the final location of illicit transmitters.

(d) Range Estimation Device. The same laboratory had developed a set utilizing a cathode-ray tube with which estimates could be made as to the distance to an unknown station sending CW signals. This was accomplished by observing the leading edge of each signal and observing the relative time of arrival of ground and sky wave components.

(2) Navy.

The only naval equipment reported was at the 2d Naval Technical Institute at Tokyo and at the Kanazawa Field Laboratory. This work was: (Appendix 2-C-a)

(a) Transportable Direction-Finders. An air transportable direction-finder for front-line use for intercept and navigation purposes was in production. It used an Adcock type antenna and covered the frequency range 2.5 to 10 mc.

(b) Radio Beacons. A line of radio beacons ranging from 30 w to 50 kw, and from 300 kc to 6 mc, all operating on an A-N principle, were in use.

(c) Instantaneous Direction-Finder. An instantaneous type direction-finder was reported to be under development but was not investigated.

(d) Airborne Direction-Finders. The airborne direction-finding equipment appeared to be adaptations of standard American and German equipment.

(3) Civilian Work.

The main civilian agency found to be working on this problem was the Electro-Technical Laboratory under the Board of Communications. The principal projects of this group were: (Appendix 27)

(a) Omni-directional Radio Beacon. An omni-directional radio beacon which gave direct indication in the plane as to the bearing to the beacon was under development.

(b) Improved Airborne Direction-Finders. Work had been done on an airborne direction-finder for use in the frequency range 9 to 2 meters (the work was unsuccessful at wave lengths less than 7 meters).

(c) Site Errors. A study of radio direction-finding site errors and the establishment of siting criteria had been undertaken.

d. Electrical Measurements and Standards.

No extensive survey was made of this field but certain of the findings are considered worthy of mention as indicative of the effort on these problems.

(1) Navy. The 2d Naval Technical Institute had maintained a primary frequency standard, accurate to 5 x 10^{-8}, and calibrated against signals from the astronomical observatory. Much of this equipment was destroyed in the air raids. Work on various sub-standards was also carried on by this group.

(2) Civilian Work. It is believed that the most active civilian group concerned with standards and measurements was the Electro-Technical Laboratory under the Board of Communications. Up until recently the laboratory had maintained the primary frequency standard for the Board, but recently this work had been set up under a separate group. The laboratory had done extensive work on the design of measuring and test equipment for use at radio frequencies. In addition to a complete line of standard signal generators, it had also developed a number of special signal generators

for specific purposes. Various means for the measurement of current, voltage, and impedance had also been developed. This organization was not in a position to manufacture equipment but made its findings available to all who were interested in the subject. (Appendix 17)

The Japanese Broadcasting Company's group on microwave research had developed means for the measurement of current, power, impedance and frequency down to wave lengths of 10 cm. (Appendix 28)

5. ROCKETS AND JET PROPULSION.

a. Solid Fuel Rockets.

The Japanese Army began theoretical studies of solid fuel rockets about 1931. This report does not cover the history of their rocket program, but is limited to the more recent developments. Spinner rockets were developed from 1942 onward, after basic research in the late '30's. This program successively developed ground firing spinner rocket classes of 8 cm, 20 cm, 30 cm, 40 cm, and 60 cm, all following the same general design. The 60 cm, which is the largest Japanese rocket, was under development at the end of the war, and final tests were to have been performed by the end of September 1945. A 5-cm rapid firing aircraft rocket is the only one of this type known to be under development. A 10-cm antiaircraft rocket with maximum altitude range of 3000 meters was one of the most recent developments. A 90 mm rocket of the "bazooka" type was undertaken by the Japanese after they had examined American and German bazooka-type weapons. Range variation techniques were worked out. One such was a modification of the 20 cm spinner which provided ports opening at right angles to the rocket axis. Opening of these ports, by turning a threaded collar, allowed a portion of the gases to escape laterally, and a rnge variation from 900 meters to 2500 meters was possible with the same quantity of propellant and the same projector setting. It is not known whether this development had reached production and use stages. One was simply to provide a larger rocket motor for a standard head. The other was to provide a flat plate as a "wing" to make the rocket glide. The latter was unsuccessful because of rolling and attempts to provide gyro stabilization resulted in failure.

It should be noted that the information in the preceding paragraph is based on investigation of Japanese Army rockets. Navy solid fuel rockets were developed and produced at the Kure Naval Arsenal, which it was not possible to visit during this Survey. Members of the Survey had some acquaint with Japanese Navy rockets of 20 cm (three types) and 45 c sizes which were captured in the Philippines. These were well designed spinner types.

Although successful spinner rockets were developed in Japan at the beginning of 1943, the earliest known use of standard type rockets in the field was the 20 cm and 45 cm spinner rockets of Navy design encountered in the Philippines. The lag was probably the result of production and transportation difficulties.

Fundamental research on Japanese army rockets was done by the 7th Military Laboratory. The 1st Military Laboratory did the final testing and production design. Production was by the Osaka Army Arsenal. The solid propellant was developed and produced by the 2nd Army Arsenal, Tokyo. It is maintained by the Japanese that they received no aid from other countries on their rocket program.

b. Liquid Fuel Rockets and Jet Propulsion.

Research on liquid fuels was started in Japan with the multiple purpose of supplementing solid fuels, increasing the range of rockets and developing jet-propelled planes. The Navy did most of the work, which was spurred by the disclosure to the Japanese by the Germans of their hydrogen peroxide-alcohol fuel and the technique of manufacture. Because of the difficulty of manufacturing large quantities of the highly concentrated hydrogen peroxide required, the Japanese investigated a number of substitute systems. Most important of these is the nitric acid-alcohol system, which is claimed as entirely a Japanese development.

Principal aim of the Japanese Navy liquid fuel research was to develop the "Shusui" plane, a jet-propelled fighter copied after the German Me-262. It has not been determined to what extent the Germans aided in this development, but they are rumored to have sent a dismantled German jet-propelled plane to Japan by submarine. The Japanese (Naval Technical Institute) claim that only a few models of the Shusui plane were built and report that one of these crashed during tests.

The Army and Navy had both planned to use liquid fuels for long-range rockets. The Navy had designed a 20 cm rocket using the hydrogen peroxide-alcohol fuel which was expected to have a range between 10,000 and 20,000 meters. The Army (7th Military Laboratory) began liquid fuel studies in August, 1944. The Navy provided information on the technique of handling the fuels but apparently little else. Army results were confined to the measurement of chamber pressures and thrust pressures. (Appendices 1-C, 1-D, 1-F, 2B-a, 2B-b, 2C-c)

6. GUIDED MISSILES.

a. Self-controlled.

(1) Heat-Homing Bomb.

This is the most important guided missile on which the Japanese are known to have worked. It was developed by the Military Ordnance Administration Board. Nine types of bomb were worked on, but of these the only one extensively tested was the Mark 7. Fifty or sixty of the Mark 7's were dropped from 3000 meters at a raft moored in a lake and with burning wood and coal as a heat source. Four or five bombs responded to the controls, and the rest were failures. It was decided that the control surfaces were too small in the first eight models, and in the Mark 9 they were to have been increased two and one-half times. This model was expected to be ready for test by the end of September 1945. It was a bomb 50 cm in diameter and 5-1/2 meters long. Total weight was 800 kg of which 200 kg or 300 kg was high explosive charge. Control was provided by a nickel strip bolometer in the nose, which through an amplifier and relays, operated a hydraulic oil system. This in turn controlled small flaps on two sets of four "wings" fore and aft, which acted to keep the bomb's nose headed toward the heat source. Gyro-stabilization was provided. It was planned for use only against ships and for night attacks because the heat contrast between ship and background would be greater.

(2) Heat-Homing Boat.

It was planned to use the detector developed for the heat-homing bomb to guide a heat-homing boat for attacks on shipping. However, in tests it was found that there was not sufficient heat contrast of a ship against the horizon, so the experiments were dropped.

(3) Pilotless Plane.

It is reported that a rocket-launched pilotless plane loaded with explosives and guided to its target by radar or other homing means was proposed by the Army. It is understood that no work had yet been started.

b. Remote-Controlled.

The 7th Military Laboratory conducted some investigation in collaboration with Tokyo Shibaura Co. on the possible use of a television eye to direct an explosive-laden boat or tank against a distant target by radio control. Nothing successful was developed.

c. Suicide Planes.

Information on this subject was picked up incidentally to other investigations, as it was not looked into specifically. Work on motors for baka-bombs (called "Tokkoki" by Japanese) is reported to have been at the 2nd Military Air Laboratory, and the 3rd Military Air Laboratory is also reported to have worked on the baka. It is reported that a new suicide plane powered by the hydrogen peroxide rocket fuel was in an experimental stage. (This was probably a Navy plane) (Appendices 1-F, 1-H, 3, 8-b.)

7. INFRARED (IR).

a. Near Infrared.

Basic instrumentation for near IR was done by Tokyo Shibaura Electric Co. They developed infrared viewing equipment, photocells, amplifiers, filters and light sources. Research on military uses was conducted for the Navy by the 2nd Naval Technical Institute, and for the Army by the 7th Military Laboratory. A variety of equipment was produced but about all that saw actual use was some signaling equipment on Navy ships.

The only photocell used by the Japanese for near infrared was the conventional caesium cell. There was some experimentation on lead sulfide and other sulfide cells, but nothing successful was developed. There was no work during the war on thallofide cells. The image tube (called noctovision tube by the Japanese) was of the RCA type, using an optical lens system, a semi-transparent photo-emissive receiving surface, an electrostatic focusing coil and a phosphor imaging surface. Several types of optical system were tried. The Schmidt system was favored, but it was difficult to produce the corrector plates. The image tube was the only IR imaging principle used by the Japanese. At least two types of filters were used, a plastic membrane and a glass type. The glass filter was developed by Tokyo Shibaura, who are reported to have copied an American filter (probably pre-war) initially. The light source was usually a tungsten lamp.

Infrared signaling was accomplished by mechanically or electrically operating a shutter over a light source, and reception was either by image tube (visual) or by photocell and amplifier. An effective range of 15 km is claimed for the Navy Mark 2 apparatus (coiled light source and photocell receiver) of which about 100 sets had been manufactured and installed on large ships. A 5 km range was claimed for a manually keyed system with image tube receiver which had been used on some small ships. An infrared IFF system was under development by the Navy but was not yet successful.

A photophone for voice transmission by infrared or visible light was developed by the Army. An effective range of 4 or 5 km is claimed. A similar device, but using visible or ultraviolet light, was developed by the Navy and range was said to be about 15 km under good conditions.

b. Far Infrared.

Research on heat detection was done by Army, Navy and industrial laboratories, principally Tokyo Shibaura Co. The Heat and Light Department of the 2nd Naval Technical Institute handled Navy research. Fundamental work for the Army was done by the 7th Military Laboratory, and applications by the Military Ordnance Administrative Board and the 2nd Military Laboratory.

The Navy planned to use heat detectors in planes to locate enemy planes and ships by engine heat. The detector consisted of a bank of 36 constantin-tellurium thermocouples connected in series, and a plane to plane detecting range of 7 to 10 km is claimed under good conditions. This equipment was experimental only. The army used a nickel strip bolometer for the heat-homing bomb (see Guided Missiles) and the same detector. Range on a man was about 100 meters. An unsuccessful attempt was made to develop a heat-homing boat. (Appendices: 1-F, 20-d, 20-f, 4-a, 4-b.)

8. UNDERWATER SOUND.

a. General.

Most of the development work on underwater sound in Japan was by the Acoustics Department of the 2nd Naval Technical Institute. Some work was done for the Army in the 7th Military Laboratory, but basic information was supplied by the Navy. In this field more than in any other investigated during the Survey the Germans aided the Japanese. Plans and completed equipment were sent to Japan along with German technicians from the Atlas Werke, manufacturers of German underwater sound equipment. A fair amount of the equipment and techniques in this field were patterned directly after the German.

b. Underwater Listening Devices.

The latest development is the M-4, a listening device consisting of arrays of Rochelle salt microphones cialists in mechanical design, plant construction, or production, rather than in research and development. Several of them are still in this country and three, in addition to Foders, have been interviewed by members of the Survey group. They were unanimous in their scorn and dislike of the Japanese and felt that their missions had accomplished very little.

The Germans also gave some help on methods of producing H_2O_2 which the Japanese expected to use as fuel in rockets and jet-propelled aircraft. In addition, a sample of a chemical warfare decontaminating agent was brought to Japan by a Japanese returning from Germany by submarine, and a Naval Attache returning from Germany also brought the information that the Germans were working on Nitrogen Mustards. It is not clear, however, that these actions had been authorized by the Germans.

In 1943, Col. Satake, in charge of ground radar research at the Tama Technical Laboratory, paid a visit to Germany. He reports that the Germans were free in showing him equipment which they had in field use but refused to give him any information about new developments under way, and denied him admission to any of the laboratories where research and development were in progress.

There is some evidence that the Japanese may have gotten somewhat more help from the Germans than they like to admit but it is not a matter of great importance.

They got some help from Allied equipment and documents captured or salvaged from wrecked airplanes. For example, they learned about the Loran system of navigation and were making use of this information to develop a partial and very limited system of their own. Their fire control equipment clearly follows the old British GL units captured at Singapore, and similarity suggests that both their "frequency modulated" and their "pulsed" radio altimeters were probably based on U.S. models. A 5-cm H_2X radar set under development was obviously following the U.S. 3-cm H_2X, and Bazookas were in process of development based on U.S. and German designs.

On the other hand, in spite of the fact that many B-29 bombers were shot down over Japan and a great deal of equipment was undoubtedly salvaged from the wreckage, the Japanese responsible for the design of radar never appreciated the operating characterisitcs of this equipment or the real power and value of the set. This is the set which was used so successfully for navigating over the islands and for bombing through overcast. An American "AN/ARC-1" radio in good condition was seen by members of the Survey group at the Second Naval Technical Laboratory at Kanazawa. The officer in charge commented on its fine workmanship and performance but stated that it could not be reproduced in Japan because of lack of facilities and inability to make some of the components.

V - EVALUATION OF JAPANESE RESEARCH AND DEVELOPMENT.

In spite of a national policy for fostering research, and of extensive organization for encouraging and supporting it financially, most of which was well established before the war, the Japanese made relatively little progress during the war in any field requring scientific skills of a high order.

A. Failure of Army and Navy to Use Civilian Scientists Effectively.

Probably the most important factor contributing to this rather striking lack of progress was the failure of the Army and Navy to make any significant use of the considerable body of scientists available in the universities. It is the universal testimony of the scientist, corroborated by Army and Navy officers, that only in a very few cases were the scientists taken into full confidence on important problems with an opportunity to work effectively. Where problems were assigned to university scientists by the Army or Navy, they were usually narrowly-defined, detail parts of larger problems about which the scientists were given no information. This condition does not permit of effective work by the scientists.

As has been pointed out above, a very considerable amount of money was available for support of reserch and many projects were given support. The grants-in-aid made to the university scientists at the request of the Army and Navy, usually covered the narrowly-defined type of project referred to above. The research was usually closely controlled by the services as to scope and methods, and the researches were generally not suitable by their very nature for university professors.

The almost universal complaint of the scientists is that they were not only not taken into confidence, but were regarded with distrust and suspicion and almost as enemies.

The unwillingness of the Army and Navy to confide in the university scientists is attributed to many possible causes, those most frequently suggested being: (1) Professional jealousy on the part of the career Technical Officers of the Services who were usually not first-class men; (2) The liberal political views of many of the university professors which had antagonized the Army and Navy; and (3) Suspicion as to the loyalty of the scientists, many of the best whom have studied in America or England.

B. Failure to Organize for Mass Research Attack.

Even if the Services had been willing to confide in the university scientists, there was, as has already been pointed out, no effective organization in the existing set-up for bringing the full weight of scientific effort to bear on the most critical problems. Not only was there no available co-ordinating agency, but no plan had been worked out under which a university, as such, would take the responsibility for organizing and carrying through a research project as was done so effectively in the United States, both under direct contracts with the Services and under OSRD contracts. This means that, unless this situation had been corrected, the abilities of the scientists would, in any case, have been used piecemeal as individuals or small groups on small problems, rather than in wholesale mass attack on major problems.

Somewhat the same situation seems to have existed to a lesser degree when the Army or Navy arranged for research or development (as distinguished from production engineering) by an industrial organization. The workers engaged in the Service research were isolated from their fellow workers and not allowed the benefit of exchange of ideas. Even in production design when the same manufacturer was working on two similar designs for the two Services, the two developments were kept entirely secret from each other, and the two sets of workers in the same organization were not allowed to exchange ideas.

The manufacturers also report that they were usually given little or no opportunity to see that equipment designed and built by them was properly installed and adjusted, and were seldom given any information as to its performance.

This may all have grown out of reluctance of the Army and Navy to take outsiders into confidence, but no evidence has been found that the universities or industrial organizations made any real effort to change the situation.

C. Weakness of Army and Navy Research Organizations.

Internally, the Army and Navy do not seem to have been well organized for research. Both Services, as has been previously mentioned, have separate career branches of Technical Officers of all grades. Such an organization, if closely coordinated with the operating branches of the Services, could be very effective. There is some evidence, however, that the cooperation had not been close and, moreover, that the various laboratories under the same Service did not keep each other informed as to progress in new developments and techniques. There is even evidence that the Service laboratories working on the development of components to be used in equipment being developed by other Service laboratories, were not always informed of the tactical requirements of the systems in which the components were to be used.

The universities also report that the technical branches of the Army and Navy had not been able to attract the best graduates from the universities, especially among those who had taken graduate work. This means that the Service laboratories started out with second-rate men. The situation was aggravated by the fact that after a few years' experience the men were diverted to administrative work, leaving the actual direction of the technical work of the laboratories to inexperienced men, mostly without benefit of graduate work.

D. Lack of Cooperation Between Army and Navy.

Another very important factor in explaining the small progress made during the war was the almost complete lack of cooperation between the Army and Navy until the closing months of the war, and then only on a very small scale on special problems. Testimony is unanimous from scientists, manufacturers, and Army and Navy officers that generally there was no cooperation. There is apparently also no question but that bitter enmity between the two Services was widespread. As one eminent Japanese scientist expressed it, "a General and an Admiral would rather lose the war than shake hands". This lack of cordiality undoubtedly was largely responsible for the almost complete lack of cooperation. It is generally agreed by scientists and manufacturers who have had contact with both the Army and Navy technical staffs that the Navy personnel is clearly superior, and that the Navy was generally well ahead of the Army on technical developments; professional jealousy may, therefore, well have played a part.

An example of the lack of cooperation between the Army and Navy is found in the handling of technical material and information salvaged from wrecked enemy airplanes. It is reported that the Service which arrived first on the scene took everything useful it could find, but did not advise the other Service as to what it had found. The prohibition against two groups of workers in the same industrial organization developing similar equipment for the two Services exchanging ideas has already been referred to. The extreme example of lack of cooperation between the Services, however, is in the "IFF" equipment for identifying friendly airplanes, where the two Services used different identification frequencies with the result that an Army plane could not be distinguished from an enemy plane by the Navy, and vice versa. Both Army and Navy technical officers, when queried on this point, agreed with a laugh that it was so.

E. Quality of Technical Developments.

In general, new technical developments were found to be far behind corresponding Allied or German developments, and in many instances had made little advance since the war against the United States started. A contributing factor to this lack of progress may have been the dependence, in normal times, already referred to and freely admitted by the Japanese, on the United States and Europe for new ideas.

There were a few exceptions to this general rule of almost complete lack of progress, notably in the fields of Chemical Warfare, Meteorology, Ionospheric Measurements, and Rocket Development, in all of which some systematic work had been done. In no case, however, were any radically new or important developments found which were in advance of techniques known to the Allies.

VI - CONCLUSIONS

The general conclusion to be drawn from the Survey is that Japanese progress was badly handicapped by lack of proper organization for research and development and by almost complete lack of cooperation between the Army and Navy. There is good evidence that there is a fairly large number of able scientists in Japan who, with proper organization, could have made substantial contributions to the war effort.

The Japanese are more or less familiar with the more effective organization for war research in the United States, and it is clear that they are fully aware of the handicap imposed on them by failure to organize their research programs properly and by lack of cooperation between the Services.

They may, therefore, be counted on to correct these errors if another emergency arises and, consequently, to be much more formidable, in the development of new equipment and techniques.

- - - - - -

Notes of the interviews and more detailed statements about some of the organizations and developments will be found in the Appendices contained in Volume II and Volume III of this report. Lists of these appendices are attached, followed by an index listing the organizations and principal individuals interviewed, in alphabetical order.

Volume IV contains a more detailed report on Chemical Warfare with its associated appendices.

1 November 1945.

GENERAL HEADQUARTERS
UNITED STATES ARMY FORCES, PACIFIC
Office of Deputy Chief of Staff

APO 500
24 August 1945

SUBJECT: Scientific Mission to Japan

MEMORANDUM FOR: Dr. Karl T. Compton) Pacific Branch, OSRD,
Dr. E. L. Moreland) GHQ, AFPAC, APO 500.

1. The proposal made in your memorandum of 16 August to send a small scientific mission into Japan at the earliest practicable date for the purpose of making a quick survey of the Japanese organization for scientific research and development is approved.

2. It is desired that you proceed with necessary measures to assemble this group and that you present the specific requests for travel orders and to cover requirements in connection with execution of the mission.

For the Commander in Chief:

/s/ R. J. Marshall,
R. J. MARSHALL,
Major General, U. S. Army,
Deputy Chief of Staff.

(COPY)

LIST OF TOPIC HEADINGS OF REPORT

VOL II

TABLE OF CONTENTS

2-A	Japanese Naval Research Laboratories. Locations; organization of Technical Research Institute; dispersion laboratories.
2-B-a	Naval Technical Research Institute Organization; naval architecture; rocket propellant; gyroscopes; organization of 2d Naval Institute.
2-B-b	Naval Technical Research Institute Organization and projects of various departments.
2-C-a	2d Naval Institute. Radar; Communications; Searchlight and fire control; list of projects; summary of activities of radar and communications.
2-C-b	Communications and Radar of 2d Naval Institute. Tsukishima Island; 10 cm Airborne Search Laboratory; Communications
2-C-c	2d Naval Institute. Acoustic and Magnetic Research; mine detectors; vibration reduction; underwater sound.
2-C-d	Zushi, Kanazawa, and Negishi Field Laboratories. Magnetic detectors; Infrared; voice-modulated light beams; radar sets; altimeter; IFF; intercept receiver; captured American equipment; radio; antenna research; dynamotors.
2-C-e	Japanese Navy H_2O_2 Rocket Propellant
2-C-f	Acoustics, Magnetic Detector, Light and Heat at 2d Naval Institute. Underwater acoustics; echo ranging; sound prevention; noise elimination; mine detector; airborne detector; hit recorder; infrared communications; photophony; heat ray detector; infrared IFF; infrared beacon; manufacturers

VOL III

TABLE OF CONTENTS

Appendix

8-C-b Lt. Gen. Reikichi Tada
Synthetic fuels; aluminum; magnesium; uranium; "baka" bombs; heat homing bomb; Board of Technology; Comments on list of 8-B.

9 Dr. T. Yamamoto
Grants in aid for research at Waseda University; Wartime Scientific Control Center; Japan-Germany-Italy Friendship Society.

10 Prof. Yoshio Tanaka
Substitute lubricating oils; synthetic rubber.

11 Prof. Isamu Yamamoto
Tokyo Institute of Technology; high frequency physiology.

12 Dr. K. Honda
Metals Research Institute.

13 Sumitomo Tsushin Company
Plants and Ikuta laboratory; high frequency triodes; magnetrons; communications; radars; tube production.

14 Dr. Daitaro Arakawa
Marine radio; television; velocity modulated tube;

15 Dr. Ryoto Mitsuda
Electric power.

16 Dr. Koiku Wada
Aerodynamics; Ministry of Education; Aeronautical Council.

17 Dr. Kamichi Ohashi
Electro-Technical Laboratory of Ministry of Transportation and Communication; teletypewriters; tropicalization; propagation; geophysical prospecting; telemetering; remote control of ships; history, organization and program of Electro-Technical Laboratory; details of teleprinter.

18 Dr. Satoyasu Iimori
Aluminum from clay.

19 Dr. K. Okabe
Magnetrons.

20 Dr. H. Hayashi
National Research Council; function; budget; list of grants.

Appendix

21 Dr. I. Kogu
Quartz crystals.

22 Japanese Magnetrons
Type, list of Navy researches.

23 Japanese Meteorological Work
Central Meteorological Laboratory; Cosmic rays; automatic weather station; bombing balloons.

24 Prof. K. Morita
Start of Japanese radar work; 3 mm diathermy; summary of wartime activities; parabolic antenna design; magnetrons; BK tube detectors; impedance measurement; dielectric loss measurement.

25 Dr. Hontaro Nagaoka
Japanese Society for the Promotion of Scientific Research; organization; list of projects.

26 Heinrich Foders, Kurt Schmidt, Franz Pohl, Kurt Schiffner
German technical assistance to Japan; problems with Japanese production of Wurtzburg radar; anti-jamming modifications for Wurtzburg; two-engine Japanese Navy bomber; underwater sound equipment; problems of Japanese-German technical cooperations; list of other German technicians known to be in Japan.

27 Dr. Minoru Okada
Omni-directional radio beacon; rotating marine beacon; radio direction-finder site errors; VHF airborne direction-finders.

28 Dr. G. Hara
Wartime work of the Research Section of the Japanese Broadcasting Company; vacuum tubes for detectors; pulse modulation; atmospheric noise measurements (Spherics).

ALPHABETICAL LIST OF ORGANIZATIONS AND PRINCIPAL INDIVIDUALS INTERVIEWED

*In Volume IV - Chemical Warfare

*In Volume IV - Chemical Warfare

*In Volume IV - Chemical Warfare