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U. S. NAVAL TECHNICAL MISSION TO JAPAN
CARE OF FLEET POST OFFICE
SAN FRANCISCO, CALIFORNIA

8 February 1946

RESTRICTED

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

Subject: Target Report - Japanese Ordnance Fuzes.

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

1. Subject report, covering Target O-18 of Fascicle O-1, of Reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Mr. H. H. Moore, and ordnance engineer of the Naval Ordnance Laboratory, assisted by Comdr. G. R. Dolan, RN. Lt. (jg) K. C. Lamott, USNR, served as interpreter and translator.

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Captain, USN

31053

JAPANESE ORDNANCE FUZES

"INTELLIGENCE TARGETS JAPAN" (DNI) OF 4 SEPT. 1945
FASCICLE O-1, TARGET O-18

FEBRUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ORDNANCE TARGETS

JAPANESE ORDNANCE FUZES

In general, the Japanese were following good fundamental principles in fuze design, but they had not, in any way, produced or used fuzes of outstandingly superior characteristics. The progressively-operating centrifugal detent feature, used in many of their fuzes, and the design principles of the so-called "gaine" are worthy of very close study.

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REFERENCES

Japanese Personnel Interviewed:

Captain T. AKAGAWA, IJN, Ordnance Specialist.

Captain S. YAJIMA, IJN, Projectile and Case Production, Kure Naval Arsenal.

Commander K. TAKAGI, IJN, Ordnance Specialist.

Captain M. MITSUI, IJN, Director, Ordnance Experiment Station, Kure Naval Arsenal.

Dr. A. SUZUKI, Experimentalist, First Naval Air Technical Arsenal.

Technical Lieutenant D. YOSHIDA, Experimentalist, First Naval Air Technical Arsenal.

Technical Lieutenant K. NISHIDA, Experimentalist, Ordnance Experiment Station, Kure Naval Arsenal.

Captain A. DANNO, IJA, Experimentalist, Tachikawa Experimental Air Station.

Key personnel of the Hattori Clock Company, Fuze Manufacturers, TOKYO.

INTRODUCTION

This investigation covered Japanese fuze development and design. Key personnel were interviewed and tours of inspection were made in an effort to bring to light significant technical developments.

Titles of the parts of the report correspond to specific questions listed in Target 0-18 of Fascicle 0-1 of "Intelligence Targets Japan" (DNI) dated 4 September 1945.

The fields of research, development methods, test procedures, etc., as well as the forwarding of seized samples, drawings, etc. are covered in NavTechJap Report "Japanese Naval Projectile Fuzes", Index No. 0-17.

THE REPORT

A. DELAYED ARMING OF PROJECTILE BASE FUZES

The Japanese have made no attempt to provide a delay in the arming of projectile base fuzes beyond the muzzle of the gun, or rather, that point where set-back forces cease to dominate centrifugal forces. They have a system of progressively operating detents which under certain conditions might delay arming (freeing of the plunger) beyond the muzzle, because of the inherent delay in the motion of each detent element. The exact position, with respect to the muzzle, at which the freeing of the plunger occurs is problematical; it might, or might not occur prior to the projectile reaching the muzzle. The Japanese, apparently, have made no effort to determine the exact point where this event takes place. They will admit only a very few prematures, and none recently. Their explanation of prematuring is "supersensitiveness of fulminate mixtures".

A nose fuze, embodying features which would delay arming for an interval of about two seconds after "set-back", had been developed by the Japanese. The idea involves the gauging of the main firing pin by a ring of smokeless powder, which will free the pin when the powder has burned away. The burning of the smokeless powder ring is initiated, two seconds after "set-back", by a gasless powder delay train. The fuze is a time fuze intended for use with an 8cm **mortar** and is adjustable in time, from 2 to 22 seconds. The fuze is illustrated and its main features are tabulated in Figure 34 of NavTechJap Report "Japanese Naval Projectile Fuzes", Index No. O-17. Another small fuze, for use with a rifle grenade, which has a similar delayed arming feature but no adjustable time feature is shown in Figure 33 of the same report.

B. AUTO-RESETTING OF MECHANICAL TIME FUZES

Japanese mechanical time fuzes embody actuation by linear acceleration of the projectile ("set-back") which causes the time-setting finger to be disconnected from the time-setting or index ring and at the same instant clutch the firing disc to the time spindle of the clock mechanism. Thus, assuming that the index ring will not shift under the influence of angular acceleration, it might be said that the fuze will not reset; however this probably is not a valid assumption, because the position of the index ring is not positively fixed, but is maintained only by friction. Therefore, in view of the fact that, chronologically, the torque resulting from angular acceleration (the influence which tends to reset the fuze) and the forces resulting from linear acceleration (the influence which performs the disconnecting and clutching operations and tends to hold the index ring in its original position) are coincident, it is conceivable that the fuze might reset itself.

All service models of the mechanical time fuze were time only (not combination impact and time). However, the Hattori Clock Company, manufacturers of time fuzes for the Japanese Navy, had under development during the latter part of the war, a combination fuze which was described as ready for mass production. No drawings or specifications of this fuze were located. A somewhat mutilated sample of the fuze was found at the Hattori factory and has been shipped to the Ordnance Investigation Laboratory, Stump Neck, Maryland under NavTechJap Equipment No. JE50-3933. The management of the Hattori factory was exceptionally proud of its time fuze production and development and was confident of its reliability.

C. SHORT DELAY TIME TRAINS

The shortest delays used by the Japanese Navy were of the order of 0.03 to 0.10 second made by high compression of black powder and of the same general shape as United States short delay trains. A uniform pressure of 1000 kg/cm^2 (14,200 lbs./in^2) was used for the pressing of these pellets. The delays were found to be unreliable. As a consequence, the Japanese abandoned attempts to make short delays and concentrated on delays of the order of 0.4 second for projectile base fuzes. These delays (0.4 second) were arranged transversely to the axis of the fuze, as shown in Figure 1, and were reported to be more reliable and less subject to deterioration than the longitudinal delays.

It would be interesting to know how well transverse delays would withstand "jolt and jumble" tests and how reliable they would be if made as short as 0.002 to 0.010 second.

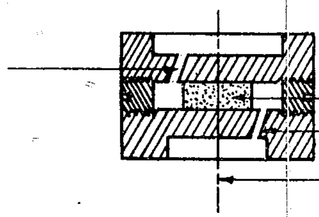

Figure 1

DELAY TRAIN FOR PROJECTILE BASE FUZE

It is interesting to note that delays of the order of 0.4 second would in many instances defeat the purpose of armor piercing projectiles, namely explosions near the mid-breadth of the ship. The Japanese admit that against some classes of ships the projectiles would in many instances emerge from the opposite side unexploded, but they did not consider this a serious fault.

D. LONG DELAY TIME TRAINS

The delay trains of Japanese time fuzes have been made mostly of a mixture of black powder and shellac. Such delay trains have, as is well known, two serious faults: (1) they are subject to deterioriation as the result of high humidity and (2) their rate of burning is a function of back pressure, which undergoes a change with the radical changes of altitude encountered in high-angle fire. The Japanese, in an effort to overcome these faults, were experimenting with various mixtures. One mixture, 95% barium peroxide and 5% sulphur, gave good results with respect to combustion under varying pressure, but was unsatisfactory in regard to deterioration in high humidity. Another mixture which does not produce a gas during combustion and was found to be non-hygroscopic, consists of 46% lead-chromate, 38% ferro-silicon, and 16% red-lead. This mixture has a burning rate of approximately 4.5mm/sec (0.178 in/sec) over a pressure range of 760mm of mercury (sea level) to 10mm (equivalent to an altitude far greater than the vertical range of any modern gun). Thus a delay of 30 seconds could be had in a total length of less than six inches. This non-gaseous mixture requires an igniter, for which the following mixture was found to be satisfactory: 80% red-lead, 20% ferro-silicon. These mixtures were not in service, but preparations were under way for making use of them in the mass production of time fuzes. The above delay and igniter powder was proposed by SUZUKI. Another mixture, proposed by Captain MITSUI, is as follows: 60% $PbCrO_4$, 20% Si (90% thru 325 mesh), 10% Pb_3O_4, and 10% Cu_3P. Captain MITSUI insisted that the above mixture was the best of all those tried.

E. DRAWINGS AND SPECIFICATIONS

Japanese personnel interrogated in connection with this investigation insisted that all detail and production drawings of Japanese fuzes were destroyed. NavTechJap Report, "Japanese Naval Projectile Fuzes", Index No. O-17, shows general assemblies (to scale) and contains tabulations of pertinent information.

F. SHAPED-CHARGE FUZING

The Japanese had shaped charges, producing a result referred to by them as the "Newman effect", in bombs, projectiles and rockets, and used both nose and base fuzing systems. In the nose fuze system the initiation passes to the detonating train, which is in the base of the charge, through a round flash channel located on the center line of the charge. This system would in all probability afford a "stand-off", but of an uncertain amount because of slightly variable inherent delays in the fuze.

The base fuze system uses an inertia type fuze for initiating the detonation and likewise probably would be subject to some slightly variable inherent delay, thus affecting the amount of "stand-off". "Stand-off" is provided by allowing a part of the case forward of the charge to be empty.

G. FORWARDING OF SAMPLE FUZES

Samples, in substantial quantities, of all Japanese fuzes available have been forwarded to the Ordnance Investigation Laboratory, Stump Neck, Maryland.

H. ELECTRIC FUZES

The Japanese Navy had no electric fuzes other than those described in Part A. of this report. Some samples of badly mutilated fuzes, which appeared to be electric, were found, but they were described by Japanese Navy personnel as being of Army origin. No information as to their functions or characteristics was obtained.

I. INFLUENCE OR PROXIMITY FUZES

The Japanese Navy had under advanced development, at least three types of influence or proximity fuzes and one remotely-controlled fuze, all intended for use in bombs. No evidence was found that they were extending their development of influence fuzes to artillery use. Undoubtedly, development was handicapped greatly by a lack of very small electronic tubes which are so necessary for this type of device. The three types of influence or proximity fuzes and the remotely-controlled fuze under development are classified as:

1. The Photo-Electric Fuze: a bomb fuze to operate at a desired distance above the ground for attacks on troop or equipment concentrations. (Japanese Army and Navy)

2. The Acoustic Fuze: a fuze intended for air-to-air attack of bomber formations by planes at higher altitudes, termed by the Japanese "the fuze with ears". (Japanese Army and Navy)

3. Mother-and-Daughter Bomb: An anticipatory fuze, for bombing attacks on personnel or equipment concentrations, which detonated the bomb (mother) a fixed distance above the ground when a plummet (daughter), attached to and preceeding the mother bomb in flight, made impact with

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the ground. (Japanese Navy only)

4. <u>The Radio Fuze</u>: A fuze intended for air-to-air attack of bomber formations by planes at higher altitudes, the bomb to be exploded remotely by the bombardier through the agency of radio. (Japanese Army)

The photo-electric fuze operates on the principle of a chopped light beam of a fixed frequency reflected from the target and a tuned electronic circuit operating from the pick-up of the reflected beam by a photo-electric-cell. It is reported to have been not more than 50% reliable as to functioning and quite unreliable in its control of height of detonation above the ground. Samples of this fuze, with a complete description of its principles, and wiring diagrams have been returned to the Unites States. (See NavTechJap Report, "Description and Operation of Japanese Type 3 Photo-Electric Fuze", Index No. O-24). The fuze had not been advanced to the production stage.

The acoustic fuze development seems to have been carried on by Army and Navy independently, but neither had brought it to a practical state of development. A detailed elementary explanation of its principles and manner of functioning was prepared by D. Y. YOSHIDA. (See Enclosure (A), Part A). The Japanese text was translated into English by YOSHIDA. His translation is sufficiently understandable and descriptive for the purpose of this report. An incomplete and damaged sample of the fuze, described by Navy personnel as the Army's development, has been forwarded to the Ordnance Investigation Laboratory. (NavTechJap Equipment No. JE50-3536). It is the only sample that was found.

The mother-and-daughter bomb and fuze idea is not new to United States fuze designers. A United States patent of the basic idea was issued some twenty years ago, to an engineer now employed by the Naval Ordnance Laboratory. However, this idea never was brought as near to practical conclusion in the United States as had been done in Japan. The Japanese considered it entirely practical, were satisfied with the status of its development and were making plans to place it in mass production. A schematic outline of principal features of the bomb and its fuze is shown by Figures 2 and 3. YOSHIDA also prepared a description of this fuze and bomb which is quite understandable. (See Enclosure (A), Part B) One sample of the fuze and bomb, complete, has been forwarded to the Ordnance Investigation Laboratory.

Figure 4 is a photograph showing actual models of the acoustic bomb and the mother-and-daughter bomb.

The operation of the "Radio Fuze", which is intended for use in the tail of the 50 kg bomb, was described briefly by Captain DANNO as follows:

> "The bomb is dropped from the carrier plane which is emitting a radio signal at a frequency which keeps the fuze in a safe condition. When the bomb is in the vicinity of the target plane, the bombardier fires the bomb by changing the frequency of the signal emitted from his plane. The vertical range is estimated by eye and translated into seconds of fall by a ballistics chart. The bombardier uses a stop watch to determine the exact moment of firing. Four tests of this fuze were made, of which two were considered successful."

Captain DANNO produced the wiring diagrams, Figures 5 and 6, which show the various details of the electric circuit. The fuze system appears to be very complicated and a most illogical method of accomplishing the purpose.

Close questioning of Japanese personnel regarding proximity fuzes for projectiles brought forth only professions of ignorance of any work on such a project and expressions of doubt of the feasibility of such a development, because of the effect of the shock of firing upon such a seemingly delicate mechanism.

MOTHER—DAUGHTER BOMB

220 KG

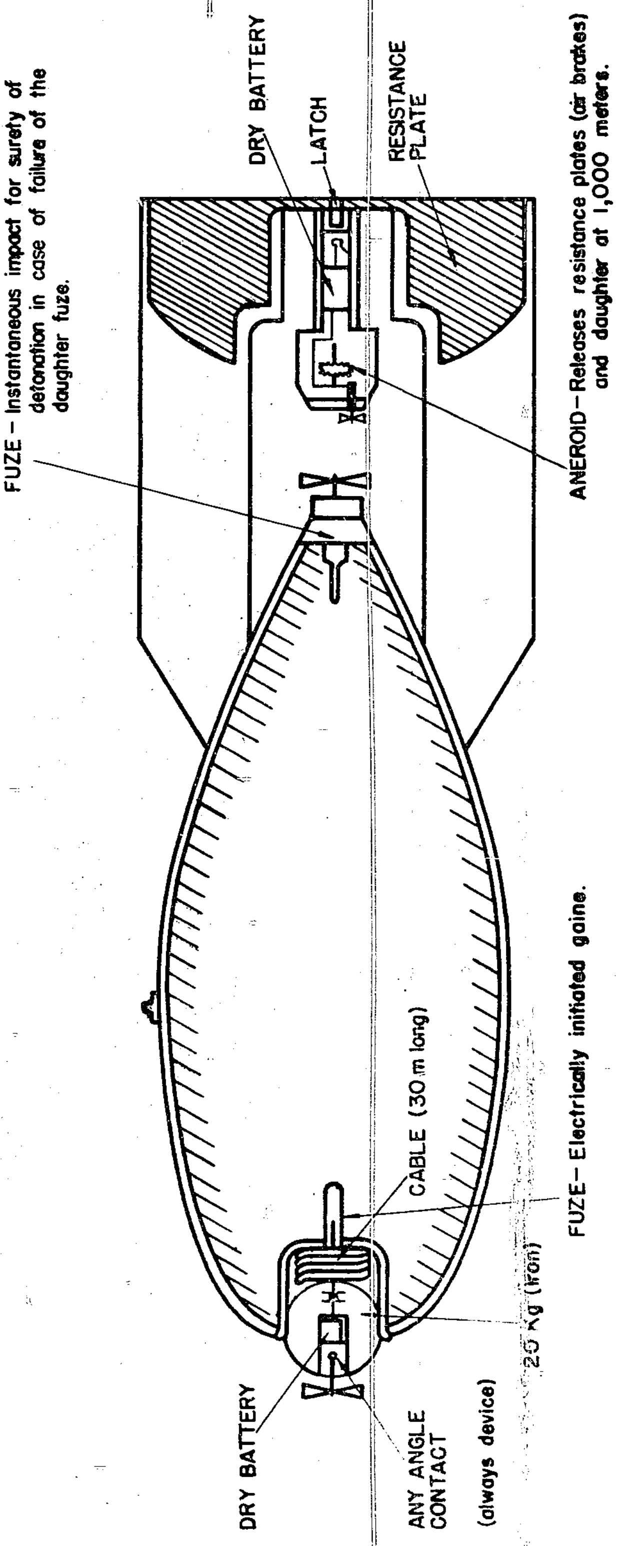


Figure 2
SCHEMATIC SKETCH OF MOTHER-AND-DAUGHTER BOMB

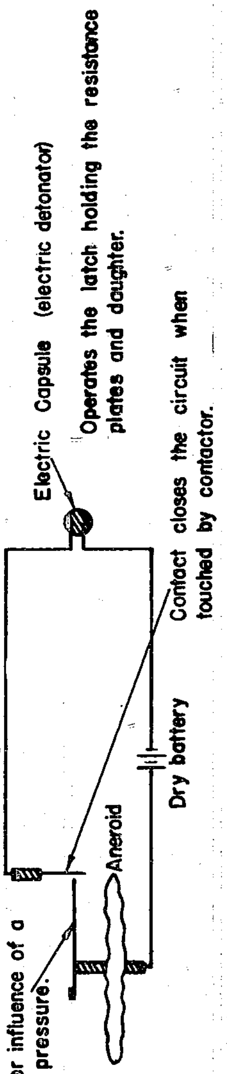


Figure 3

ANEROID FUZE SCHEME FOR MOTHER-AND-DAUGHTER BOMB

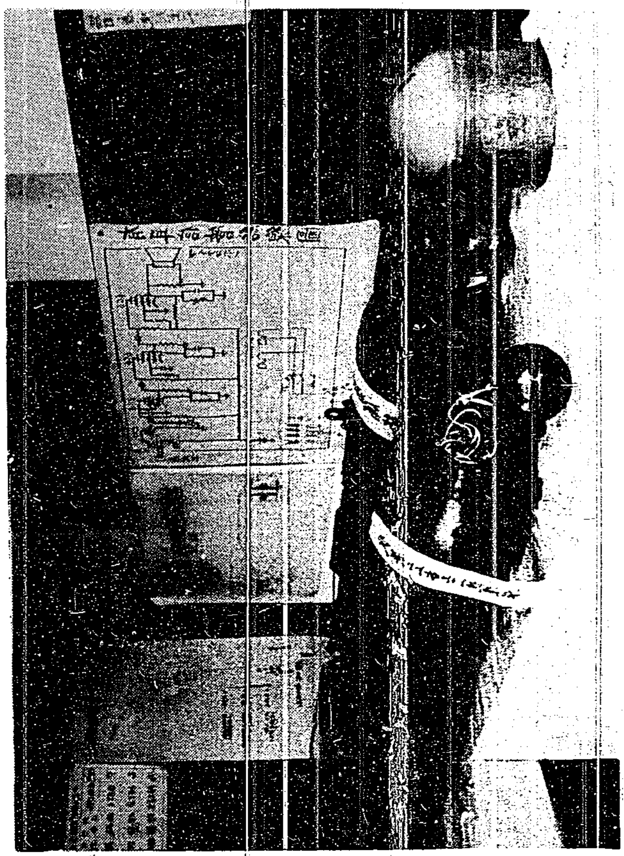


Figure 4

PHOTOGRAPH OF MOTHER-AND-DAUGHTER BOMB AND FUZE AND ACOUSTIC BOMB

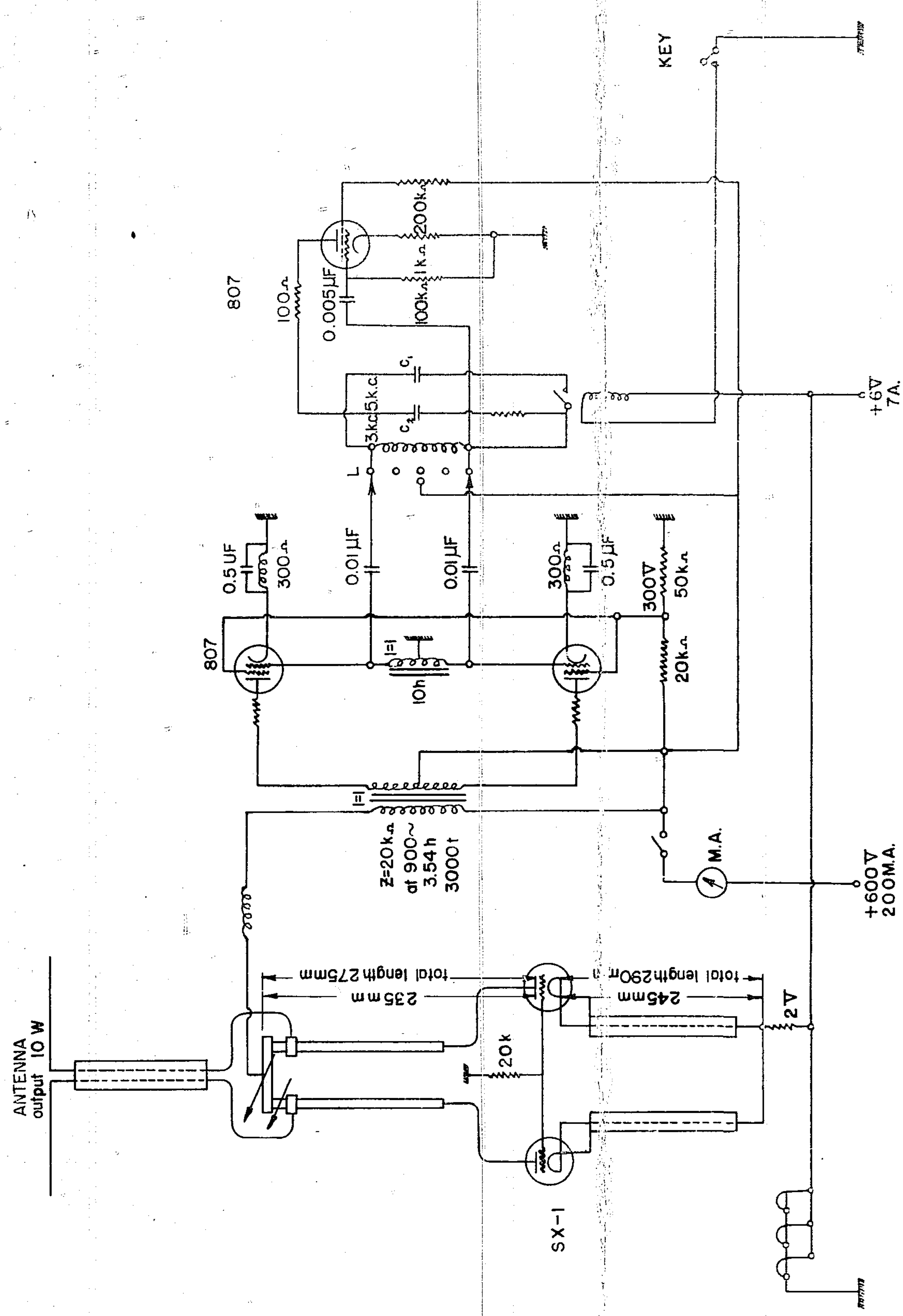

KEY
807
100Ω
0.005μF
200kΩ
1kΩ
100kΩ
C1
C2
3kc
5kc
L
+6V
7A.
0.5UF
300Ω
0.01μF
0.01μF
300Ω
0.5μF
300V
50kΩ
807
I=I
10h
20kΩ
I=I
Z=20kΩ
at 900~
3.54h
3000t
M.A.
+600V
200M.A.
ANTENNA
output 10 W
total length 275mm
235mm
total length 290mm
245mm
2V
20k
SX-1

Figure 5

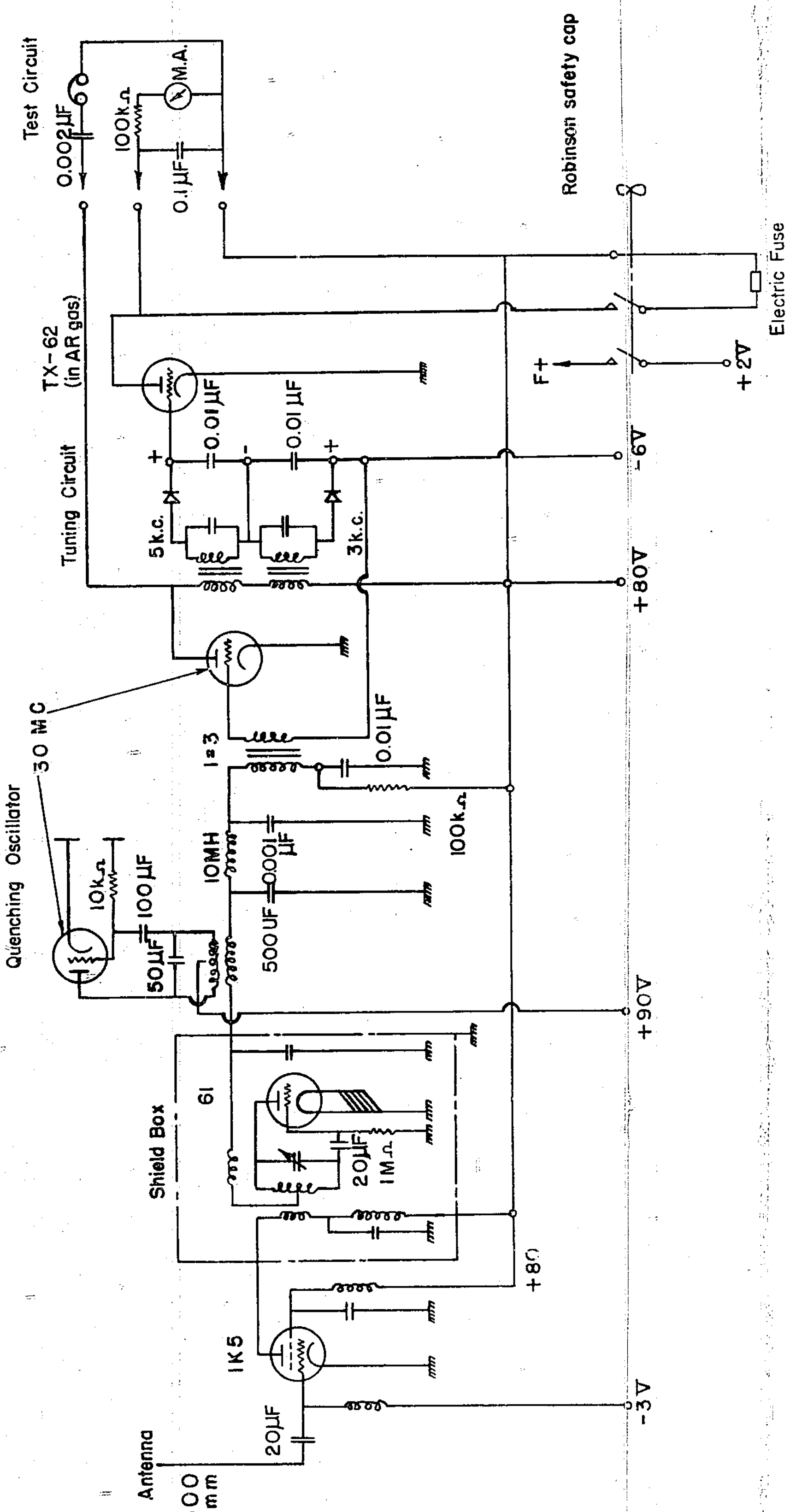
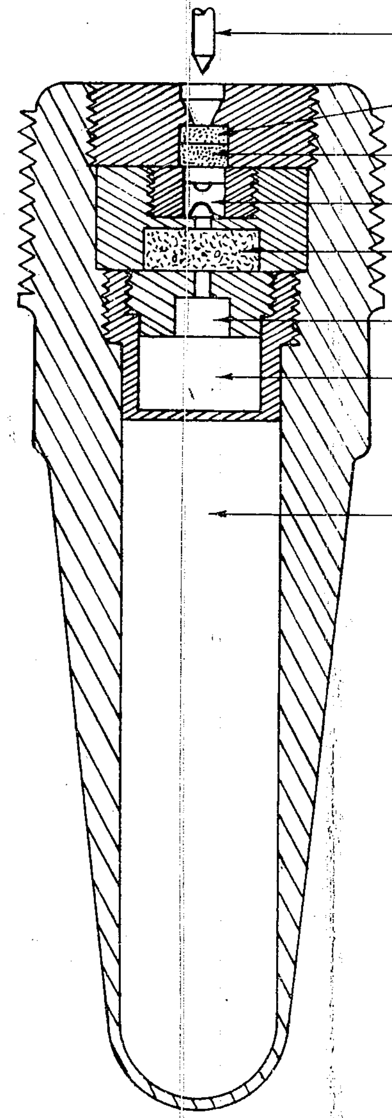


Figure 6

WIRING DIAGRAM, RADIO FUZE (RECEIVER)



NOTE: See Fig.I for a variation of the delay pellet.

Figure 7
SCHEMATIC SKETCH OF GAINE (DETONATING TRAIN)

J. EXPLOSIVE TRAIN DESIGN

The Japanese explosive train design seems to be somewhat original. It is a self-contained unit, starting with the initiator and concluding with the booster. These self-contained units, exclusive of the arming mechanism and mechanical features, are referred to as fuzes by some branches of the naval service and as gaines by other branches. The basic design embraces the following sequence of features:

1. Initiator of fulminate mixture (20% fulminate, 40% potassium chlorate, 40% antimony sulphide) usually about 25 to 30 mg.
2. Small compressed black powder charge.
3. Black powder delay pellet (if delay is used) pressed at 1000 kg/cm^2 (14,200 lbs/in^2).
4. Larger charge of loose black powder.
5. Detonator (lead azide pressed in a capsule).
6. Sub-booster of tetryl.
7. Main booster of high-grade picric acid.

These features are illustrated by Figure 5. Exact dimensions are not available but can be taken from samples returned to the United States.

K. RHEINMETALL FUZING SYSTEM

Japanese naval fuze designers seem to be acquainted with no Rheinmetall fuze other than a mechanical time fuze, the gear train of which they adopted for development subsequent to 1923. Prior to 1923 they had used a time fuze developed by Krupp, the plans and specifications of which were destroyed by the "great earthquake". In years subsequent to 1923 and up to and including the years of the war, they engaged in developing and producing their own time fuze based on the gear train of Rheinmetall. The basic changes, of which they seemed very proud, involved the use of a pallet and an escape wheel for timing, instead of the centrifugal friction governor used by Rheinmetall, and a "set-back" release feature which operates upon the escape wheel instead of the timing disc as used by Rheinmetall. Other features of this new fuze are described in Part B of this report. Many samples have been forwarded to the Ordnance Investigation Laboratory.

Close questioning of DANNO brought forth an admission that he knew of the Rheinmetall electric fuze system for bombs and had experimented with it. He contended that it had been given up, when it was found to be too difficult to regulate the charging of condensers.

ENCLOSURE (A)

GENERAL EXPLANATION ABOUT SPECIAL BOMB FUZES
by D. YOSHIDA
December 13, 1945

Part I. EXPLANATION ABOUT THE ACOUSTIC FUZE NAMED "YUUJI SHINKAN"

I regret that I connot explain the details of the fuze and show the figures for you to be able to fully understand but I have lost them. I suppose that Mr. SUZUKI will give you sufficient information.

A. Explanation About the Meaning of the Name of this Fuze

Yuuji Shinkan has the meaning that the fuze has an ear that receives sound. We can hear sound by our ears. The nearer we get to the sound source, the greater the volume we receive. That is, the change of the volume of sound shows the difference of distance from the sound source. If we can change the sound energy to electric energy by receiving the sound in a receiver, we shall be able to use the electric energy to burn the powder in a fuze, and then the fuze will be used for a bomb.

Hence, when a bomb having this fuze gets near target, it will be caused to detonate by the sound generated by the propeller. We gave the name Yuuji Shinkan to this fuze because it causes detonation by receiving sound.

I had been conducting research on this fuze when the war had terminated. At that time, this fuze had not been adopted to regulation arms and had no name of style and number.

B. Use of the Fuze

The bomb with this fuze will be used for attacking planes in formation by free-dropping without propellant from a plane flying above the formation.

It was designed from the standpoint of hoping that the bomb would cause detonation as near as possible to the target, and in view of eliminating the lack of regularity in the clock-mechanism fuze, that is, failure to cause detonation at the position of the target, when the bomb had been dropped from a plane with incorrect aiming.

C. Types

There are two types of this fuze. The difference between Model I and Model II is in the relative position of the plane and bomb at the time of detonation. They have slightly different mechanisms in the electric circuit to bring about the difference. Model I detonates at a position that is about fifty meters above aeroplanes flying in formation, while Model II detonates at a few meters below the targets.

D. External Form and Weight

The external forms of these types are identical. The dimensions are shown in Figure 1(A). The fuze weight is about 20 kg (40 lbs). The total bomb weight is 250 kg (500 lbs). The shaded part of Figure 1(A) indicates the fuse, including electric power units (dry cells) and all sorts of mechanisms for changing sound energy to electric energy.

ENCLOSURE (A), continued

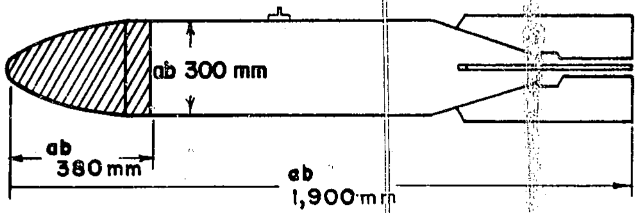


Figure 1(A)

E. <u>Explanation of Model I</u>

In the Model I, sound energy changes into electric energy through the magnetic receiver, and the electric energy burns the powder. This is shown in Figure 2(A). The receiver receives the sound energy and changes it to electric energy. The amplifier enlarges this electric energy to a large enough value to operate a "meter-relay".* The amplified electric energy causes burning of the powder by "meter relay" contact.

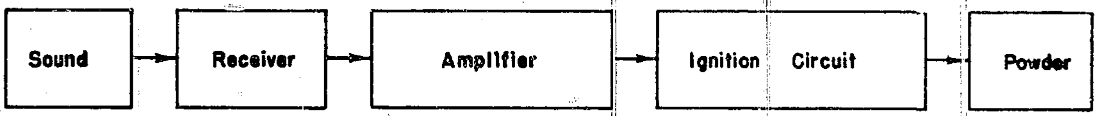


Figure 2(A)

Now suppose a fuze having such a receiver, is dropped on flying targets. If the receiver is set to receive sound as soon as dropped it will receive the sound generated by the plane carrying the bomb. This will cause detonation and our plane will be damaged. This is very dangerous. It must be kept safe and prevented from causing detonation until our plane has gone far enough away from it. As the dropped bomb is getting near the targets, the volume of sound received will increase. If the volume of sound is enough to operate the pointer, it closes the ignition circuit and electric current burns the powder.

The different volume of sound between Position 1 and Position 2 is shown in the left of Figure 3(A). The bomb is not detonated at Position 1, but at Position 2. We can measure the volume of sound of propeller noise at a position far from the source at some decided distance, and we will adjust the "meter-relay" contact to close the circuit when the equal volume has been received. So when we use this fuze in practice, the

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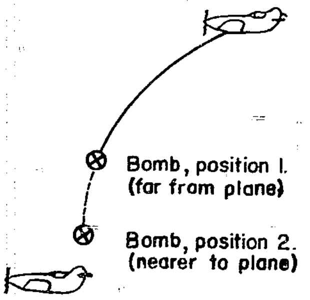
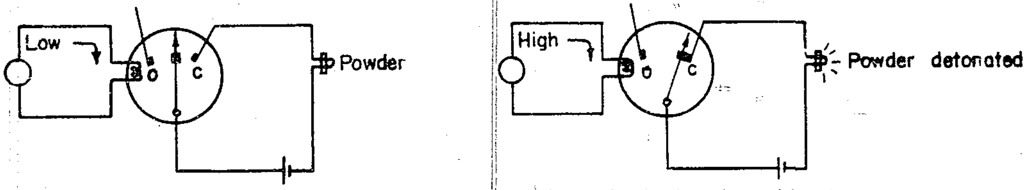
*The "meter-relay" is a kind of switch. It consists of an ammeter that is used for electric current measurement, and the pointer of the meter takes the place of the switch. The pointer closes or opens the ignition circuit. The amplitude of the deflection of pointer is proportional to the quantity of electric current. The quantity of electric current depends on sound energy (volume). The more volume of sound, the more electric current flows. When enough current flows, the pointer, as a switch, closes the ignition circuit until burning of the powder commences. (see Figure 3(A).)

ENCLOSURE (A), continued



Items	Position I.	Position 2.
Volume of sound	Low	High
Pointer (switch)	No contact	Contact
Detonation	No detonation	Occurs



Ignition circuit opened. position I. Ignition circuit closed. position 2.

Figure 3(A)

bomb will cause detonation at the position near the aeroplane at the decided distance. (For example, 50 meters above the target.)

The receiver was a magnetic receiver. The amplifier was two vacuum valves and two step-up amplifiers. The frequency characteristic had been tuned to 1000 cycles. All electric sources used were dry cells, particularly, high tension, laminated dry cells had been used.

F. Explanation of Model II

The volume of sound from a source in air expands in a sphere. Therefore, we receive much volume nearer the source and less volume when we have gone far away from it. When we go toward a sound source and then away from it, we note the volume changing from increasing to decreasing. This change of volume is used as a change of electric energy and the change of electric energy supplies control to a "Thyratron". The voltage or current control of "Thyratron" is enough to cause flow current to control the burning powder. This is the principle of Model II. It is necessary in operation of Model II, that the volume of sound changes enough. We transfer the change of volume to electric change and we make the powder burn by controlling the "Thyratron". In order to burn the powder, the discharge current of "Thyratron" plates is used. The detail of this electric circuit is omitted here, because I have no data and it is so difficult academically.

This amplifier had three vacuum valves and three step-up amplifiers. The "Thyratron" had been the one point of this difficult research. In the other respects, Model II was nearly the same as Model I.

ENCLOSURE (A), continued

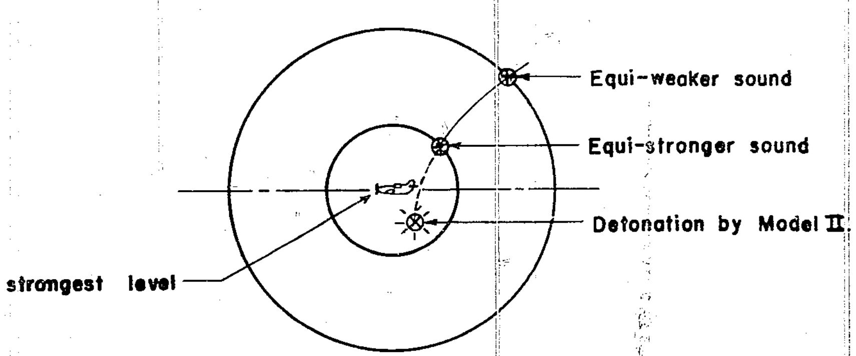


Figure 4(A)

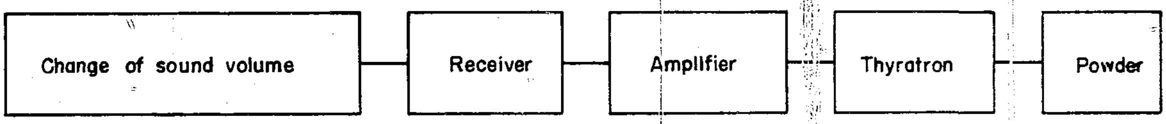


Figure 5(A)

G. <u>Miscellaneous</u>

In both types, the noise that was generated by the bomb shell itself had stood in the way of success.

The position of the receiver had been decided after considering setting it on the shell side, or the top of the head.

Two methods of receiving sound had been considered: through small holes indirectly or directly by the receiver attached to the surface of shell. But, we found the best way was to set the receiver at the top of bomb head and to prevent weakness by special plates (aluminum). The whole external shell of this fuze was made of wood to decrease the vibration transmitted to receiver. The four tails of the bomb also were made of wood instead of steel for the same reasons. We made the surface of the shell as smooth as possible. Hence, we had succeeded in general, but we continued the researches, as we were discontented with the operation of fuze. Therefore, we had not adopted it for use or given it a designation.

The model you should have is the former type of Model I. It is the earliest model and the latest one is quite different from it. I have heard that the research on this fuze had begun at the end of 1943. At first, the research was carried on by the Navy and Army, co-operating with some civilians.

ENCLOSURE (A), continued

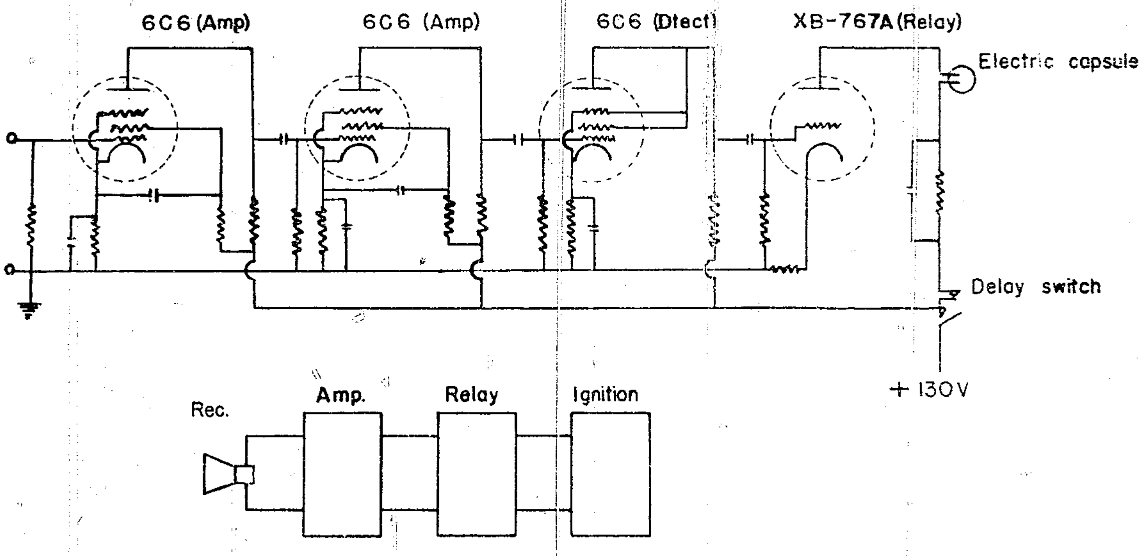


Figure 6(A)

WIRING DIAGRAM OF ACOUSTIC FUZE

ENCLOSURE (A), continued

PART II <u>EXPLANATION OF MOTHER-AND-DAUGHTER BOMB (OYA-KO BOMB)</u>

This kind of bomb would be used for attacking the ground the same as the No. 31 -Style 3 bomb. This bomb had a small steel ball in a large bomb shell. The former was called the daughter bomb (<u>Ko</u> bomb) and the latter the mother bomb (<u>Oya</u> bomb). When this bomb was dropped from a plane, the daughter bomb would reach the ground ahead of the mother bomb. The daughter bomb was connected with the mother bomb by wire, which formed an electric circuit. When the daughter reached the ground, the electric current flowed by closing a circuit and the powder in the mother bomb, still in the air, was ignited electrically. In order to throw out the daughter from the mother body, the velocity of the mother bomb was changed rapidly by resistance plates that were operated by a barometric mechanism which was adjusted by atmospheric pressure. When the velocity of the mother was decreased, the daughter, with former velocity, dropped more rapidly, with the slower mother following her. This happened at a 1000 meter height above ground level.

The method of detonation of powder depended on the discharge current of a dry cell.

This bomb was more simple than the No. 31 bomb. It's weight was 250 kg also. However, we had heard of difficulty with the throw-out mechanism of the daughter bomb and of research concerning methods of making the daughter always reach the ground ahead of the mother.

I had heard also that the barometric mechanism had been completed.