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U. S. NAVAL TECHNICAL MISSION TO JAPAN
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RESTRICTED

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

Subject: Target Report - Japanese Research in Airborne Acoustics and Earthwaves.

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

1. Subject report, dealing with Target O-41 of Fascicle O-1 of reference (a), is submitted herewith.

2. The investigation of the target and the target report were accomplished by Mr. E.H. Winger.

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Captain, USN

RESTRICTED

O-41

JAPANESE RESEARCH IN AIRBORNE ACOUSTICS AND EARTHWAVES

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

FASCICLE O-1, TARGET O-41

JANUARY 1946

U.S. NAVAL TECHNICAL MISSION TO JAPAN

SUMMARY

ORDNANCE TARGETS

JAPANESE RESEARCH IN AIRBORNE ACOUSTICS AND EARTHWAVES

Little fundamental research on airborne acoustics and earthwaves has been conducted in Japan in recent years. Research emphasis has been placed on underwater sound. Acoustic aircraft detecting equipment has remained unchanged since 1931. A sound locator used to determine the position of guns was developed in 1938 from German design; no novel applications of acoustics are evidenced in its construction or operation. Minor research on earthwaves had been started but was dropped; hence no ordnance equipment based on it has been developed. Experiments on an acoustic altimeter were conducted in 1935 but failed to lead to the development of usuable equipment. Some progress has been made in the development of an acoustic proximity fuse. Research programs dealing with propagation, attenuation, physical and physiological effects of sound were so minor in scope that there is no evidence of important information having been gained from them.

TABLE OF CONTENTS

REFERENCES

Japanese Personnel who Assisted in Gathering Documents:

Tech. Lt. Col. KADOWAKI, Second Military Technical Laboratory; KOGANEI.

Tech. Maj. Yutoku NAKAJIMA, Second Military Technical Laboratory, KOGANEI.

Japanese Personnel Interviewed:

Major Gen. M. NOMURA, Chief, Seventh Military Technical Laboratory.

Tech. Maj. H. NAKAMURA, Seventh Military Technical Laboratory.

I. OMURA, Military Engineer, Seventh Military Technical Laboratory.

Lt. Col. J. ISHIKAWA, Seventh Military Technical Laboratory.

Tech. Capt. C. KOYAMA, Seventh Military Technical Laboratory.

Lt. Col. KADOWAKI, Second Military Technical Laboratory.

Tech. Major Y. NAKAJIMA, Second Military Technical Laboratory.

Kinzo ARIU, Technician, Yokogawa Electric Co., MITAKA.

Dr. K. SATO, Professor, Tokyo Imperial University.

Lt. YOSHIDA, First Naval Arsenal, YOKOSUKA.

Maj. Kiyoshi KASAMATSU, Field Artillery School, YOTSUKAIDO.

LIST OF ENCLOSURES

(A) List of Pamphlets on Acoustic Ordnance Equipment Forwarded Via ATIS to WASHINGTON Document Center.

LIST OF ILLUSTRATIONS

INTRODUCTION

This report covers information obtained on the application of airborne acoustics and earthwaves to Japanese ordnance. A survey of Army and Navy technical institutions was made and technical personnel from these institutions were interrogated. Several trips were made to interrogate Japanese technicians, civilian and military, in an attempt to obtain information on acoustic research and to inspect research facilities. Whenever possible documents and handbooks pertaining to acoustic ordnance equipment were appropriated.

To prevent duplication of other reports, not all of the information obtained by the author of this report is included herein. Subjects which fall within the general scope of this subject but which are of primary interest in other investigations are not discussed in detail. In such instances, all information gathered by this author was made available to the proper investigator and this report contains a reference to his report. Discussions of standard acoustic devices well known to U. S. technicians, and descriptions of acoustic devices for which there are Japanese handbooks available, are treated briefly. Further information can be gained by using the references.

In recent years fundamental acoustic research in Japan had been devoted almost entirely to underwater sound. As a result very little ordnance equipment relying on airborne sound waves or earthwaves had been developed. A few research programs concerning airborne acoustics and their possible application to ordnance had been started, but they were terminated because of the low priority assigned to them.

THE REPORT

Part I - AIRBORNE ACOUSTICS

The most widely used apparatus relying on airborne acoustics was aircraft detection equipment. Where radar was available acoustic detection was used as an auxiliary, but in many instances radar was not available and the acoustic equipment was relied upon entirely. Two types were in use, designated as Type 90 Large Detector and Type 90 Small Detector. Both of these instruments were of well known design, although outmoded as judged by U. S. standards, and had no error compensating equipment. Operating instructions and descriptions for each type are given in associated Japanese handbooks: NavTechJap Documents No. ND50-3800 and ND50-3801 (see Enclosure A). These handbooks were originally published in 1931 and were reissued in 1940. Investigation failed to disclose the use of acoustic equipment aboard armed auxiliaries not equipped with radar to indicate attack direction viz: tankers, cargo carriers, etc.

To locate gun emplacements the Japanese developed a device designated as the Type 97 Sound Locator. This equipment was patterned after German sound ranging apparatus and involved standard methods of operation. The apparatus consisted essentially of six microphones used to pick up the sound waves produced by the firing of a heavy gun, an oscillograph and a recorder to make traces on recording paper of the sound reaching each microphone, and a standard frequency generator used to provide a time axis on the recording paper. A circuit diagram of the apparatus is shown in Figure 1. Complete details of construction and operational instructions may be found in NavTechJap Document No. ND50-3802 (see Enclosure A). The field arrangement consisted of one advanced post, six microphone stations, and one main post (see Figure 3). A soldier, stationed at the advanced post, could turn on the recorder at the main post by means of a key (Figure 1) before the sound waves had reached any of the microphone stations. Sound waves struck each microphone in order of its distance from the blast and caused a trace on the recording paper by means of the six-element electromagnetic oscillograph and light reflected from the oscillograph mirrors to the photographic paper on the recording drum. Light was simultaneously reflected to the recording paper from a mirror on one prong of an electrically driven 50 CPS tuning fork, thus providing a time base. Figure 4 shows a record of a gun blast as picked up by the six microphones. By means of the time base, the differences in time for the sound wave to reach each station were established and the position of the gun was computed by triangulation.

The equipment had no outstanding design features. The microphones, shown in Figure 2, were not designed to resonate at any particular frequency; the diaphram was not tuned to resonate at the sound of cannon nor had the construction followed the pattern of an acoustic filter. As a result, the microphone did not discriminate different sounds; cannon blasts were masked by the sound of small guns and by rustling of nearby underbrush. Figure 2 shows the method of mounting the microphone.

It was claimed that a 10cm cannon could be located at a distance of 10 kilometers and 15cm cannon at 15 kilometers, the errors being about 200 meters in distance and 5° in direction. Considerable time (two to three hours) was required to set up the equipment, most of this time being used to lay out the wires leading from the microphone stations to the recorder. It was planned to use radio transmission but this procedure never was realized in practice.

In 1935 an attempt was made to develop an acoustic altimeter patterned after German experimental designs. Experimental difficulties proved too great and a production model was never constructed. Research was discontinued in 1936. A trial model used a sound source consisting of a hammer banging on a diaphram tuned to 3000 CPS to send out sound waves which were to be reflected from the ground back to a pick up. The pulsating noise of the airplane exhaust interfered and the research program was discontinued.

Some progress was made in the development of an acoustic bomb fuse. This subject is covered in NavTechJap report "Japanese Ordnance Fuzes", Index No. 0-18.

<u>Key to Figure 1 - TYPE 97 SOUND LOCATOR</u>

(1) When direct type used
(2) When voltage booster type used
(3) Circuit switch
(4) Voltage booster type terminal
(5) Receiver
(6) Circuit switch
(7) Direct type terminal
(8) Booster transformer
(9) Square No. 5 dry cell
(10) Terminal for (TN: illegible)
(11) Terminal for inner wiring
(12) Terminal for direct type outer wiring
(13) Transformer switch
(14) Transformer
(15) Volume regulator
(16) Vertical switch
(17) Upper oscillator terminal
(18) Lower oscillator terminal
(19) 30 milliamperes (?) (TN: hardly legible)
(20) Voltage booster type outer wiring terminal
(21) Motor switch
(22) Motor power terminal
(23) Tuning fork power terminal
(24) Motor
(25) Power line for motor
(26) Power line for lighting system
(27) Electric bulb
(28) Lighting system
(29) Power terminal for lighting system
(30) Diagram showing operation of Sound Wave Recorder
(31) Small wave reflection mirror
(32) Oscillator
(33) (TN: illegible)
(34) Transformer
(35) Booster transformer
(36) Booster voltage type
(37) Reciver
(38) Direct type
(39) 30 milli-amperes ammeter (?) (TN: barely legible)
(40) Tuning fork
(41) Light rays
(42) Tuning fork reflection mirror
(43) Plate with narrow slits
(44) Projection focus lens
(45) Projection focus lens
(46) Electric bulb
(47) Film
(48) Mercury switch magnets
(49) Mercury switch
(50) Terminals for batteries
(51) Voltmeter
(52) Pressure terminals (?)
(53) Key
(54) Ammeter
(55) Advanced post terminals
(56) Key box
(57) Transformer hole
(58) Transformer plug
(59) Cell
(60) Connective wiring
(61) Key
(62) Terminal for outside wiring
(63) Rheostal used for inspection
(64) Inspection push button
(65) Ammeter
(66) Protective rheostat

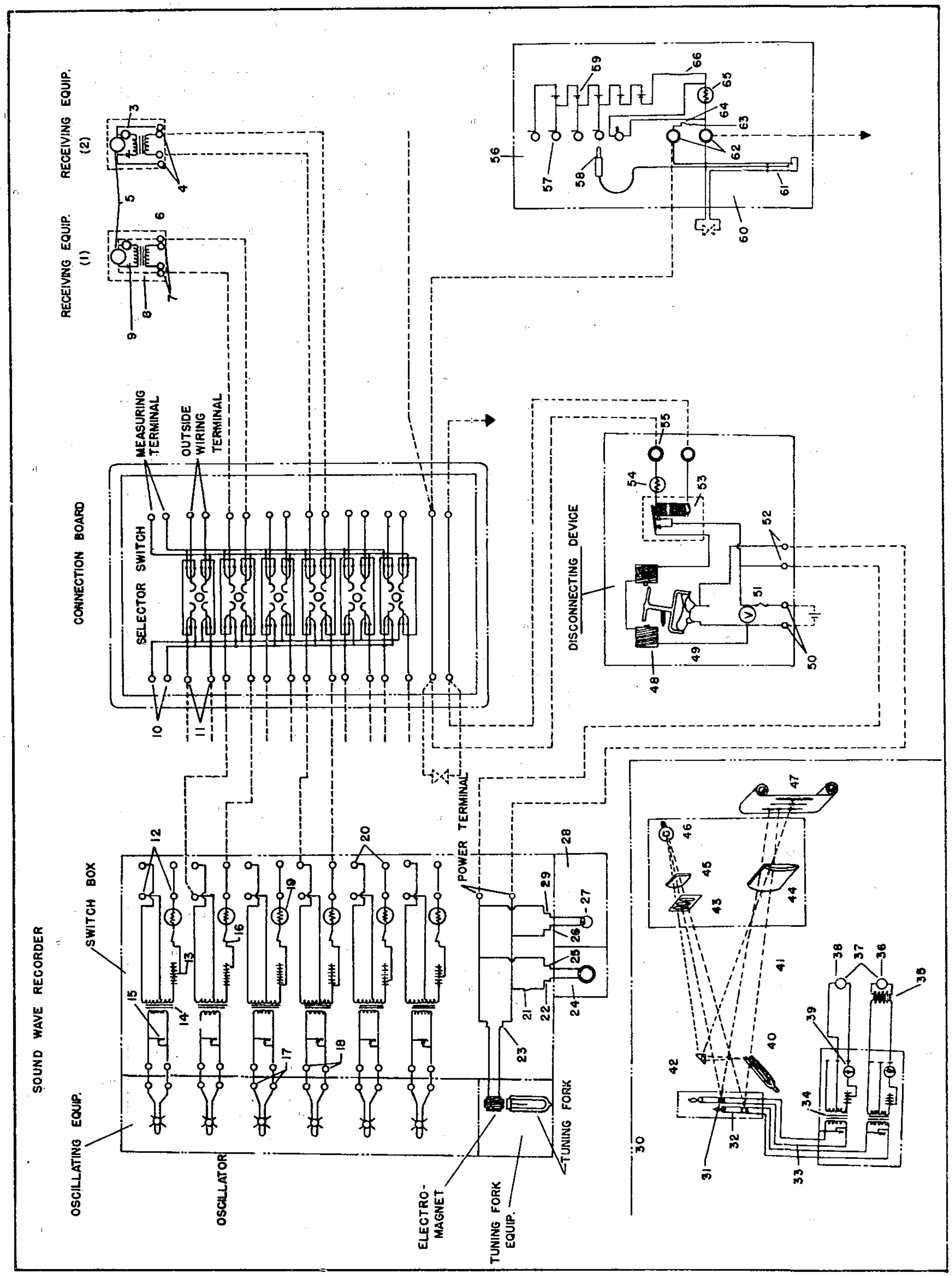

Figure 1
CIRCUIT DIAGRAM OF TYPE 97 SOUND LOCATOR

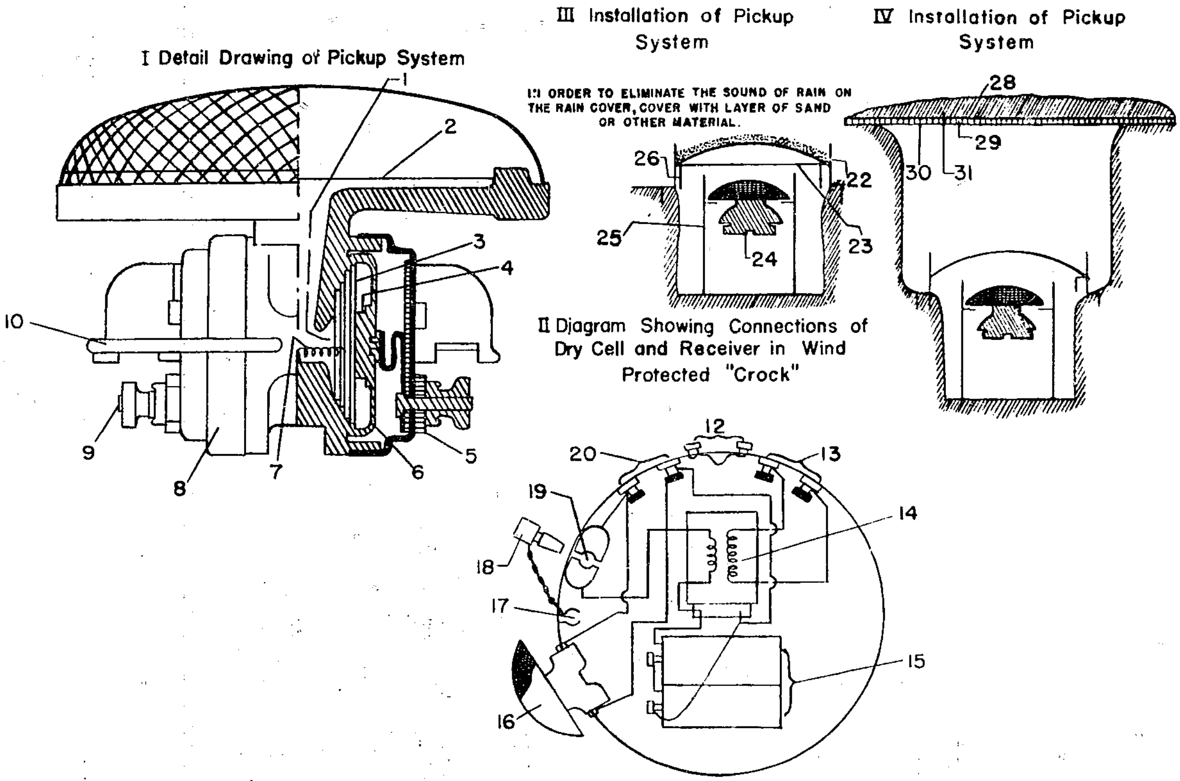

Figure 2

SKETCH OF RECEIVER

Key to Figure 2 - SKETCH OF RECEIVER

(1) Sound waves enter
(2) Protective diaphragm
(3) Carbon plate
(4) Catches grains of carbon
(5) Insulation
(6) Miscroscopic sound equipment
(7) Connects the miscroscopic sound equipment on left and right, creating an electrical circuit in series.
(8) Cover
(9) Terminal for outside wiring
(10) Cover catch
(12) Outer wiring connection
(13) Voltage booster terminal
(14) Booster transformer
(15) Square No. 5 dry cell
(16) Receiver
(17) Stopper hole
(18) Stopper
(19) Hole in connection plate
(20) Direct type terminal
(22) Drainage hole
(23) Rain cover
(24) Receiver
(25) Wind protected "crock"
(26) Hole where sound waves enter
(27) Cover the entire opening with a layer of about 2 cm of dirt.
(28) Spread a mat and leaves over the opening so that the dirt above will not fall through.
(29) Twigs and branches
(30) Dirt

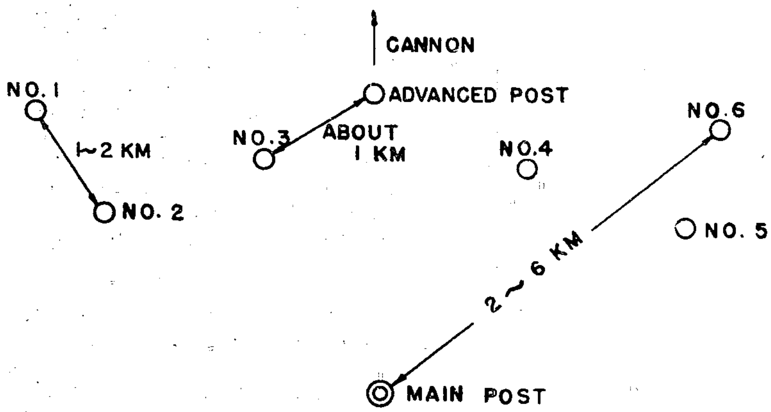

Figure 3

POST ARRANGEMENT OF TYPE 97 SOUND LOCATOR

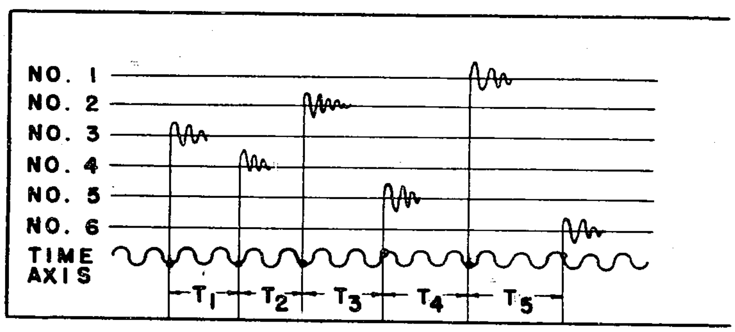

Figure 4

RECORD OF SOUND WAVE OF CANNON

Part II - EARTHWAVES

Early in the war (1941 - 1942) the Japanese made an effort to develop a device to detect personnel and vehicles, and to locate gun emplacements by means of sound waves propagated through the earth. Adequate equipment was never developed, but an experimental model was constructed and field tests were conducted on it. Figure 5 is a schematic diagram of the device, called an earthborne sound detector. The earth waves were detected by a magnetic type seismic pick-up having a frequency range of about 2 to 100 CPS with a resonance peak at about 10 CPS. This pick-up was buried in the ground at a depth of about 50cm. The output of the pick-up fed a one-stage amplifier followed by a special bridge circuit, two stages of amplification with a gain of about 50 db, and a magnetic type speaker. The bridge was balanced by shorting the grids. The output of the pick-up unbalanced the bridge, letting through the signal from the oscillator for amplification. The oscillator was a 1000 CPS tuning fork. In field tests it was found that footfalls on tip toe could be detected at distances of 10 to 12 meters from the pick-up; two men running could be detected at 50 to 60 meters.

Also planned was an earthborne sound locator. It was thought that, by amplifying the outputs of two pick-ups (using a phase changer on one) and leading both outputs into a two-element oscilloscope, phase relationships would indicate the position of the source of the earthborne sound waves. Experiments on this apparatus were not conducted, however, because of low priority and because considerable difficulty was faced in the design of the low frequency amplifiers.

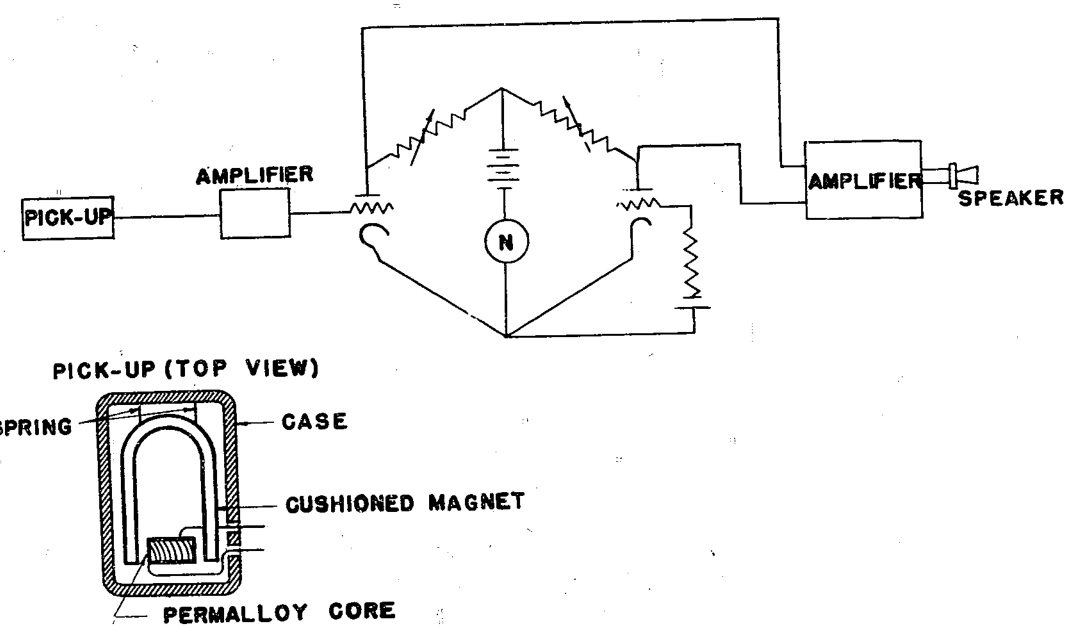

Figure 5

EARTHBORNE SOUND DETECTOR

ENCLOSURE (A)

LIST OF PAMPHLETS ON ACOUSTIC ORDNANCE EQUIPMENT
FORWARDED VIA ATIS TO WASHINGTON DOCUMENT CENTER

NavTechJap No.	Title	ATIS No.
ND50-3800	Type 90 Large Acoustic Detector	3885
ND50-3801	Type 90 Small Acoustic Detector	3886
ND50-3802	Type 97 Sound Locator	3887