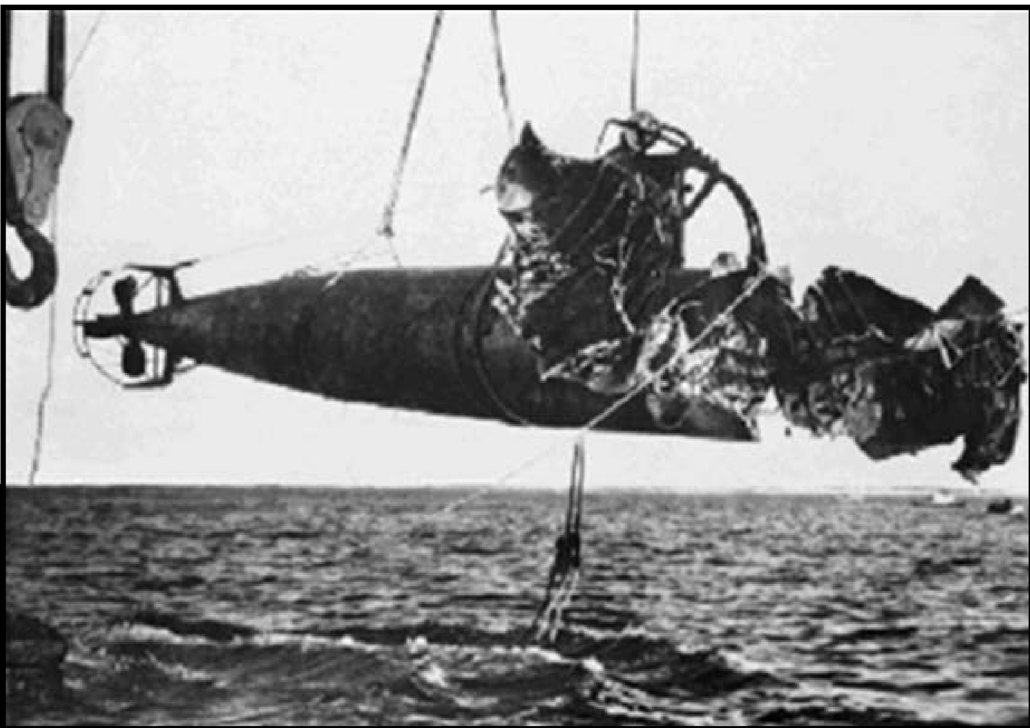
An Assessment of Potential Unexploded Ordnance (UXO) Aboard the *M24* Japanese Midget Submarine (1942)



Prepared by Dr Brad Duncan and Tim Smith

Maritime Heritage Program
Heritage Division
Office of Environment and Heritag
Parramatta February 2017

Report produced with the assistance of the Australian Historic Shipwrecks Program, Commonwealth Department of Environment and Energy, Canberra.

Report Prepared by Dr Brad Duncan and Tim Smith (OAM): March 2017.
With contributions by Steven Carruthers, Damien Allan, Bob Curran, Matt Carroll, Shaun Elliot, Stirling Smith, No Frills Divers, Kevin Slade, Malcolm Venturoni, Dr Ian MacLeod, Matt Skelhorn, Andy Liddell, Shane Casey, James Delgado, Hans Van Tilberg, Shane Moore, Nick Jenzen Jones, Kenton Fulmer, Gary Jackson, Vicki Richards, Shane Casey, Teri Bryant, David Steinberg.

Disclaimer

Any representation, statement, opinion or advice, expressed or implied in this publication is made in good faith but on the basis that the State of New South Wales, its agents and employees are not liable (whether by reason of negligence, lack of care or otherwise) to any person for any damage or loss whatsoever which has occurred or may occur in relation to that person taking or not taking (as the case may be) action in respect of any representation, statement or advice referred to above.

Figure 1 (Cover): Lieutenant Chuman's midget submarine *Ha-14* recovered from the boom net Sydney Harbour 1942 (Image AWM #042074)

Executive Summary

This report examines the historically known potential unexploded ordnance aboard the Japanese midget submarine *M24* which was discovered approximately 3 nautical miles offshore from Mona Vale Headland/ Bungan Beach in 2006.

The wreck may contain the remains of three type of unexploded ordnance:

- Two 67 lb (30.39 kg) demolition charges comprised of highly volatile shimose (explosive) powder and associated detonators and light burning detonation cord fuses;
- A flare gun (Very type) signal pistol and associated shells;
- A Nambu Type 14 pistol and associated cartridges (probably 8mm);
- No explosives associated with torpedoes are likely to remain on board.

Based on the available evidence it has been assessed that the demolition charges were likely to have been installed approximately midway along the forward and aft battery compartments in the walkway area, between forward battery banks 3 -5 and forward battery bank frames 4-6. It is assumed that this situation is replicated in the aft battery compartment, although this has not been proven.

The location of the pistols and associated shells is unknown, but based on the descriptions of the *Ha 21* it is likely that the Nambu pistol lies in the conning tower with the remains of the senior officer.

The current state of the shimose powder in the demolition charges is unknown. Although the canisters in which the explosives were contained are likely to have leaked, this has not been confirmed. Hence these charges should still be treated as live and potentially volatile.

It is likely that the propellants from the Very pistol paper cartridges have leaked and are now inert. The shell cases of the Nambu 14 pistol may possibly still be volatile, but their low explosive potential means that they present a minimal threat to individuals even if they are manually handled.

A risk minimization matrices is also presented which places the risk of accessing the site as moderate if preventative steps are taken to avoid disturbing the site. These management steps reduce the potential risk posed to divers and mariners to an acceptable level if the submarine <u>is not disturbed</u>.

It is recommended that due to the explosive potential of the former demolition charges, that access to the wreck site continue to be limited by the current Permit system.

It is recommended that the site not be totally closed to the public, but that any Permit applicants be required to first undergo a safety briefing on these aspects as a safety precaution prior to accessing the site. Due to the presence of this ordnance and likely human remains, no internal access via cameras or probes is allowed unless specifically permitted.

Any limited opening of the site for public access should be undertaken in close consultation with the Japanese Government.

Further recommendations for the site and its management are presented.

Acknowledgements

The authors express their special thanks to the following people for their generous assistance and lengthy advice contributions to the project:

- **Mr Steven Carruthers**, *M24* historical researcher and Author;
- **CMDR Damien Allan**, former MCDSPO Director, HMAS *Waterhen* (RAN Rtd);
- **Mr Robert Curran** – Former Newington Armoury Logistic Manager and Australian Naval Armament Depots web site Manager;
- **Mr Malcolm Venturoni/ Mr Kent Clifton Bligh/ Mr John Osmond/ Mr James Parkinson/ Mr Cate Venturoni,** Professional Diving Services;
- **LCDR Mathew Carroll** RAN Commander Officer, Australian Clearance Diving Team 1, HMAS Waterhen;
- **Chief Petty Officer Shaun Elliott**, RAN Naval Clearance Diving Team 1, HMAS Waterhen;
- **Leading Seaman / Clearance Diver Tom Hale,** RAN Naval Clearance Diving Team 1, HMAS Waterhen;
- **Mr Stirling Smith,** Maritime Archaeologist, NSW Heritage Division;
- **Mr Kevin Slade**, former Deputy Director, Nautical Information and Publications, Australian Hydrographic Office;
- **Dr Ian MacLeod,** Former Executive Director and former Manager/ Conservation Scientist Department of Materials Conservation, Western Australian Museum.
- **Mr Matt Skelhorn**, Wreck Researcher, CSS, Salvage and Marine Operations, UK Ministry of Defence;
- **Mr Andy Liddell,** Salvage Master, UK Ministry of Defence;
- **Mr Shane Casey**, Senior Curator, Military and Heraldry, Australian War Memorial**;**
- **Mr James Delgado,** Director of Heritage, National Oceanic and Atmospheric Administration (NOAA);
- **Dr Hans Van Tilberg,** Maritime Heritage Coordinator, Unit Diving Supervisor, Office of National Marine Sanctuaries, NOAA.
- **CMDR Shane Moore**, former Director Naval Heritage Collection - RAN, Garden Island and Spectacle Island, NSW (RAN Rtd);
- **Mr Gary Jackson**, Headland Creative Pty Ltd
- **Mr Kenton Fulmer, Explosives Ordnance Advisor,** Armament Research Services (ARES – UK);
- **Mr Nick Jenzen Jones,** Director, Armament Research Services (ARES);
- **No Frills Divers – Alan Simon, Dave Arnold, Paul Baggott, Phil Hendrie, Greg Kearns, Dave Muir, Tony Hay;**
- **Ms Vicki Richards** Research Officer/Conservation Scientist, Department of Materials Conservation, Western Australian Museum;
- **Lt Charlie Kenney, RAN,** Executive Officer, HMAS *Gascoyne*;
- **Lt CMDR Steve Hussey** and crew of HMAS *Yarra*;

The Heritage Division, NSW Office of Environment and Heritage, wishes to also thank the following organisations and individuals for their contributions to the survey, interpretation and analysis of unexploded ordnance aboard the Japanese midget submarine wreck *M24*:

- **Ms Yumi Isabelle Akieda**, Research Fellow, Japan Center for International Cooperation in Conservation, National Research Institute for Cultural Properties, Tokyo;
- **Prof. Teri Bryant**, Nambu World Website, www.nambuworld.com;

- **Mr David Detata,** Team Leader – Physical Evidence Section, Forensic Science Laboratory, ChemCentre, Curtin University;
- **Mr Angela Downey,** Team Leader Scientific Services Division, WA Chem Centre, Curtin University;
- **Mr John Field**, Senior Researcher, Consulate-General of Japan, Sydney;
- **Prof. Martin Gibbs,** University of New England;
- **Mr Peter Grose**; *M24* researcher and Author;
- **Ms Patricia Hale,** Heritage Officer, Listings Team, Heritage Division;
- **Mr Richard "Rick" Huston**, J35 Branch Chief, Joint Prisoners of War/ Missing in Action Accounting Command (JPAC) J3 Operations;
- **LT CMR Iain Hutchins,** HMAS *Diamantina*;
- **Dr Bill Jeffery;** Assistant Professor, Anthropology, Division Of Humanities, College Of Liberal Arts And Social Sciences, University Of Guam;
- **Dr Jun Kimura,** Junior Associate Professor, Dept. of Maritime Civilizations, School of Marine Science and Technology, Tokai University, Japan;
- **Capt. Greg Kouta (Ret)**, Ex Submariner, Japanese Maritime Self Defence Force;
- **Mr Daniel Lenihan,** Underwater Archaeologist, Submerged Cultural Resources Unit, US National Parks Service;
- **Mr Andy Liddell,** Salvage & Marine Operations, UK Ministry of Defence;
- **Dr Siobhan Lavelle OAM,** former Manager – Listings Section, Heritage Division, Office of Environment and Heritage (NSW);
- **Dr Tom Lewis OAM,** Military Historian; Darwin Military Museum, Northern Territory;
- **Mr Grant Luckman,** Senior Program Officer, Historic Heritage Section, Wildlife Heritage and Marine Division, Commonwealth Department of Environment and Energy;
- **Mr David Marshall (deceased)**, Aviation and Marine Artist, Bayview, Sydney, NSW;
- **Ms Rosaleen McVittie,** Founding and former President, Chado Uresenke Society, Sydney;
- **Mr Angus McInnes,** former Defence Science Technology Organisation (DSTO);
- **Mr Victor Mastone**, Director and Chief Archaeologist, Board of Underwater Archaeological Resources, Boston Massachusetts, USA;
- **National Archives of Australia;**
- **Mr Shunsuke Nakayama**;
- **Ms Venessa O'Connell,** Survey, Manager/ Port Authority of New South Wales;
- **Mr Ian Oxley,** Historic Environment Intelligence Analyst (Marine), Historic England (UK);
- **Mr John Perryman CSM**, Director of Strategic and Historical Studies, Sea Power Centre - Australia, Canberra;
- **Ms Ashlea Rowland, Economic & Political Section,** Consulate General of Japan, Sydney;
- **Ms Dianne Rutherford,** Curator | Military Heraldry & Technology, Australian War Memorial;
- **Ms Lindsey Shaw,** former Senior Curator, Maritime Technology, Exploration & Naval History, Australian National Maritime Museum;
- **Mr David Steinberg ,** Senior Heritage Officer, Heritage Branch, Department of Lands, Planning and the Environment, Northern Territory;
- **Mr Alvin Teel**, J2 Research Analyst/Linguist, HQ, Joint Prisoners of War/ Missing in Action Accounting Command (JPAC);
- **Koichi Tsuchida**, Former Political Consul General, Consulate General of Japan;
- **Mr Martin Tunwell**, Hydrographic Surveyor, Port Authority of New South Wales;

- **Mr Andy Viduka**, Assistant Director Maritime, Historic Heritage Section, Wildlife Heritage and Marine Division, Commonwealth Department of Environment and Energy;
- **Mr John White,** Military Heraldry and Technology, Australian War Memorial.

To anyone that we have omitted, we offer our sincere apologies and but also recognize your contributions.

Contents

Figures

Tables

Abbreviations

ADM	Admiralty (UK)
AP	Ammonium Perchlorite
AUSCDT	Australian Clearance Diving Team One (RAN)
AWM	Australian War Memorial
CMDR	Commander
CE	Composition Explosive. This is the nondescript name which contain varying percentages of RDX (Research Department Explosive) aka Cyclonite or cyclotrimethylenetrinitramine
DSTO	Defence Science Technology Organisation
ft	Feet
FFFF g	Grading mechanism for gunpowder for extreme small bore, short pistols and most commonly for priming flintlocks
HDNA	Hexanitrodiphenylamine
HMAS	Her Majesty's Australian Ship
JPAC	Joint POW/MIA Accounting
Cal	Calibre
Lt	Lieutenant
LCDR	Lieutenant Commander
m	Metres
MCDSPO	Mine Warfare & Clearance Diving Systems Program Office
MIA	Missing in Action
NAA	National Archives of Australia
NOAA	National Oceanic and Atmospheric Administration
NSW	New South Wales, Australia
PETN	Pentaerythritol trinitrate (in relation to detonators)
POW	Prisoners of War
RAAF	Royal Australian Air Force
RAN	Royal Australian Navy
RDX	Research Department Explosive
RN	Royal Navy
TMTNA	Hexogentrimethylentrinetramine
TNA	Trinitroanuisol
TNT	Trinitrotoluene
UCSB	University of California Santa Barbara
UK	United Kingdom
USS	United States Ship
UXO	Unexploded Ordnance
VIC	Victoria, Australia
WA	Western Australia, Australia

1. INTRODUCTION

This report considers the potential risks posed to divers and mariners by explosive charges and other ordnance carried aboard the wreck of the Japanese midget submarine *M24*. It should be noted that the Japanese Naval designation for the submarine was unknown, but the Australian designation for the vessel used in historic reporting at the time (*M24*) has been adopted as the identifier for this wreck site. This report should be read in conjunction with previous research by Tim Smith [1], which presents a wider appreciation of the background history of the sinking of the *M24* midget submarine wreck and the Sydney Harbour attack in 1942.

The site of the *M24* is managed by the NSW State Government by the Maritime Heritage Program Team, Heritage Division, Office of Environment and Heritage, on behalf of the NSW State Government and the Commonwealth Department of Environment and Energy. The site is currently protected by a Historic Shipwreck Protected Zone, where entry to the zone is restricted under a Permit system. Currently permits to visit the site have only been issued for authorised works to be undertaken. No public access to the site is currently granted due to the likely presence of two deceased crew aboard the vessel, and the sensitivities of the wreck as a grave site and its significance for the Japanese and Australian communities.

With an anticipated opening of the site to divers on a temporary basis, an investigation is required to determine the extent of unexploded ordnance aboard the vessel along with its explosive potential.

The report uses contemporary historical documentation of Japanese midget submarines recovered from attacks on Pearl Harbour (Hawaii) and Sydney Harbour (NSW, Australia), along with current inspections of the remains of the midget submarine wrecks (*Ha-14*, *Ha-21*) recovered from Sydney Harbour (currently held at the Australian War Memorial and Garden Island, Sydney) to predict the risk posed by the various explosive devices carried aboard. Advice has also been sought from past and current staff, officers, crew and staff of: the Royal Australian Navy (RAN) - Australian Clearance Diving Team One (HMAS *Waterhen*)/Navy Heritage Centre (HMAS *Garden Island*)/Australian Hydrographic Service/Newington Armoury/Defence Science Technology Organisation (DSTO)/Seapower Centre - Australia; Western Australian Museum/Conservation Laboratories; Salvage and Marine Operations ,UK Ministry of Defence; Historic England (UK); Australian War Memorial; US Joint Prisoners of War/Missing in Action Accounting Command (JPAC); Submerged Cultural Resources Section, US National Parks Service; NOAA/ US Office of National Marine Sanctuaries; Armament Research Services Pty Ltd (ARES); Nambu World and other overseas technical military sources, particularly in regards to explosive potential of the scuttling charges contained aboard and pistol round charges.

[1] **Smith 2007**; **Smith 2008**.

2. BACKGROUND

a. Midget Submarine Attack on Sydney, 31 May and 1June 1942

On the night of 31 May 1942, the Imperial Japanese Navy undertook an attack of Sydney Harbour using Ko-Hyoteki (甲標的) Class midget submarines (also known as "A Class" Type A Kai 1 in Allied war documentation [2]). During the evening, three *Ha* Class midget submarines entered the harbour to attack Naval shipping moored close to Garden Island. Two of the submarines were discovered before they could do any damage. One of these submarines, the *Ha-14* commanded by Lieutenant Chuman, detonated explosive scuttling charges when it was apparent that the vessel was about to be captured after becoming entangled in the anti-submarine net inside the entrance to Sydney Harbour. The other submarine, *Ha-21*, was destroyed by small naval auxiliary vessels using depth charges in Taylor's Bay. Sections of the two submarines were reassembled and for many years were displayed outside the Australian War Memorial. From 1985-1987, these hulls were conserved and refurbished by apprentices (under supervision) at the Cockatoo Island Dockyard Pty Ltd, where they were again recorded prior to some sections being replaced[3]. They are currently on display in the ANZAC Hall at the Australian War Memorial and at the Naval Heritage Centre, Garden Island NSW.

Figure 2: Reassembled sections of *Ha-14* and *Ha-21* midget submarines taken at Australian War Memorial in 1967 (Image: NAA # 11445768)

However the *third submarine* (known locally to Allied defence personnel as the *M24,* a designation given due to its association with its mother submarine *I24* [4]) midget submarine launched two torpedoes at Allied shipping (in particular the heavy cruiser USS *Chicago)*, one of which ran ashore at Garden Island and failed to detonate. The other exploded under the requisitioned ferry HMAS *Kuttabul* which was being used as a naval dormitory, sinking the vessel and killing 21 seamen onboard. It was the largest single loss of Naval ratings associated with enemy action to occur in NSW

[2] **Lenihan 2001.**
[3] **The Royal Institution of Naval Architects, 1989.**
[4] **Smith 2008:**80.

during WWII. After the engagement, the *M24* snuck out of the harbour and was lost to history for the next 64 years. The action demonstrated the vulnerability of Australia's defences to seaborne attack, and was a wake-up call for Allied forces in the Pacific region. Further comprehensive details of the history of the attack are available in a report by the NSW Heritage Branch (now the NSW Heritage Division) which is responsible for management of the site [5].

b. Discovery of Lost Midget Submarine M24

On 20 November 2006, the (then) Department of the Environment, Water, Heritage and the Arts was advised by the Department of Defence of the reported discovery of the wreck of the missing Japanese midget submarine *M24* by divers from the No Frills Divers off Sydney's Northern Beaches (offshore from Mona Vale Headland/ Bungan Head, Newport – Figure 3). The submarine was found intact, with some damage to the conning tower and bow sections caused by fishing net entanglement (see Figures 4 and 5).

The discovery of the shipwreck generated intense interest from recreational divers who were keen to dive the site. The intact hull structure suggested that the explosive scuttling charges on the *M24* had not been detonated by her crew, indicating that potential unexploded ordnance was still an issue aboard the craft. The torpedoes were also missing from the torpedo tubes, which aided in the identification of the site. Following the discovery of the site, a Historic Shipwrecks Protected Zone was proclaimed around the site (under the Commonwealth *Historic Shipwrecks Act* 1976), both to protect the site from disturbance, and divers from the potential hazards of unexploded ordnance.

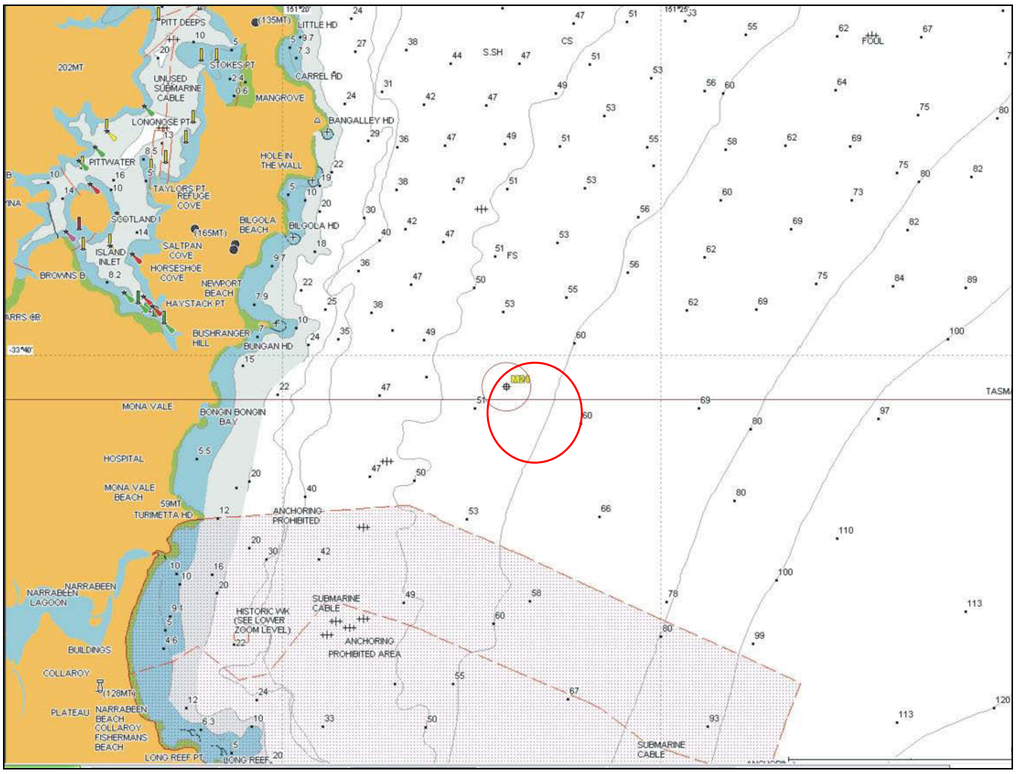


Figure 3: ***M24*** **location map. The site lies east of Bungan Head, Newport - north of Sydney (Image: Australian Hydrographic Office).**

[5] **Smith, 2007.**

Figure 4: Intact *M24* midget submarine on seabed (Image: No-Frills Divers).

Figure 5: CGI model of *M24* on seabed when it first sank (Image: Animax Films).

3. AIMS

One of the principal problems facing management of the *M24* midget submarine is that the type and probable location of the scuttling charges and other explosive devices used within the vessel were (until recently) unknown. This report explores the nature, type and probable storage location of scuttling demolition charges and other unexploded ordnance (UXO) that are likely to be still contained in the *M24* Japanese midget submarine wreck, and assesses the risk they may present to anyone visiting the wreck site.

This report uses contemporary historical documentation of Japanese midget submarines recovered from attacks on Pearl Harbour (Hawaii) and Sydney Harbour (NSW, Australia), along with contemporary inspections of the remains of the midget submarine wrecks recovered from Sydney Harbour (currently held at the Australian War Memorial, National Archives, and Garden Island, Sydney) to predict the risk posed by the various explosive devices carried aboard.

The demolition charges were small portable devices, and were not necessarily located in the same position in each craft. However, based on the following assessment of recovered submarines of the Pearl Harbour and Sydney attacks, combined with contemporary archival documentation, an argument is presented for the most likely location within the *M24* archaeological wreck site to inform ongoing management and risk decisions. The probable locations and nature of other UXO carried aboard, including pistols and torpedo armament, are similarly explored.

4. DISCUSSION

Following the attack on Pearl Harbour (Hawaii) in December 1941, American Allied Forces advised the Australian Government that there was the potential for attack by Japanese midget submarines, as similar vessels had been used by the enemy there. Analysis of a captured midget submarines (*Ha-19*) used in that raid revealed that the vessels were armed with two torpedoes, along with 300 lb (136kg) scuttling charges located in the aft of the vessel[6].

After the attack in Sydney Harbour, the Department of Defence undertook extensive documentation of the recovered remains of two captured and partially destroyed midget submarines recovered from Sydney Harbour. One submarine (*Ha-14*) was caught in a submarine net along the Western end of the Inner Harbour net, and another (*Ha-21*) was destroyed at Taylor's Bay near Bradley's Head by the RAN using depth charges [7].

Analysis of the historically recovered remains revealed that in addition to two torpedoes, the Sydney attack vessels also carried explosive charges (mounted fore and aft) which were planned to be used by the crews to either scuttle the submarines upon recovery by their *I* Class mother submarines, or to destroy their vessel immediately should they be in danger of imminent capture. The vessel commanders also carried a Taisho (Nambu Type 14) service pistol which the crew could use to either defend themselves or commit suicide to avoid capture and interrogation. Evidence of these practices were recorded in the submarines involved in the Sydney Harbour raid, where the midget caught in the submarine net (*Ha-14*) was destroyed by firing a forward scuttling charge, and the midget trapped in Taylor's Bay (*Ha-21*) attempting to wreck the vessel by firing scuttling charges which did not operate due to wet fuses [8] [9] [10] [11] [12] [13] [14] [15] [16] [17]. In the latter instance, the crew had used the pistol to commit suicide.

Early reports also concluded that the mode of entry of the submarine into Sydney Harbour was through an uncompleted section of the submarine net, and that an explosive charge had also been used to try to blow a hole through the submarine net

---

6 (**NAA #413209, p. 126, 127**: Doc. TOO 0900z/1, 1/6/1942): No 1 Destroyed itself after apparently trying to penetrate the net defences… (Midget submarines are) Armed with Two 18" torpedoes and 300lb TNT demolition charge carried under the stern to permit self destruction or suicide attack.

7 (**NAA #413209, p. 69**: Doc. TOO 0900z/13, 13/6/1942): Navy Office: *Fourth* (submarine) *blew itself up and was later found to have propeller fouled in net*

8 (**NAA #399556, p6:** Doc. 1855/3/193, 1/6/1942**)**: *No 1 destroyed herself after apparently attempting to penetrate the net…*

9 **NAA #399556, p21**: Doc. 0729z/24, 24/6/1942: *Number one destroyed herself in the net*

10 (**NAA # 398841, p41**: Doc. 496: 11/6/1942, p. 1): Notes on submarines captured in Sydney Harbour: Two demolition charges are carried in each submarine 1 fore and the other aft, and packed in a round canister 2 fuses to each, 1 electric contact and 1 match. One submarine was blown up from inside by demolition charge…Interesting to note that of the two men found in the submarine one was an officer found dead in the conning tower and the rating was found in the stern shot obviously by the officer who himself committed suicide

11 (**NAA #413209, p. 26**: Doc. BS1749/201/37, 16/7/1942, p.2): Midget submarine H14 blew herself up in submarine net at 22:35 after becoming stuck.

12 (**NAA #413209, p. 27, 28**: Doc. BS1749/201/37, 16/7/1942, p.3-4): Royal Australian Navy: Midget Submarine Attack on Sydney Harbour May 31st – June 1st 1942: *Midget 21: Both members of the crew had been shot through the head; demolition charges had been fired but the fuzes were drowned.*

13 (**NAA #413209, p. 29**: Doc. BS1749/201/37, 16/7/1942, Appendix 1, p.1): *2235: "Yarroma "reported submarine had blown up"*

14 (**NAA #413209, p. 35**: Doc. BS1749/201/37, 16/7/1942, Appendix 3, p.1): *Demolition Charges 1 fired. 2 fuzes. 1 fuze drowned.*

15 (**NAA #413209, p. 43**: Doc. TOO 0729z/24, 24/6/1942): *Number one* (submarine) *destroyed herself in the net...*

16 (**NAA #413209, p. 51**: Doc. BS 1495.201.37, 17/6/1942): *Submarine 1. Self destroyed...*

17 (**NAA #413209, p. 102**: Doc. TOO 0330z/6, 6/6/1942): *No.2 blew itself up endeavouring to pass through the net. This submarine has been examined by a diver and is seriously damaged.*

defences[18]. This was later discounted when it was realised that the submariners had detonated an explosive scuttling demolition charge [19].

Apart from the scuttling demolition charge, historical records indicate that there were also three other potential types of ordnance that were carried onboard:

- Service Pistol - Taisho Nambu Type 14 [20];
- Flare Gun (Very Pistol) and cartridges (triple barreled 28mm Type 90) [21];
- Primer pistol mechanism for torpedoes [22].

These will also be discussed in further detail below.

a. Demolition Charges on Japanese Midget Submarine

i. Pearl Harbour Attack Midget Submarines

Prior to the attack on Sydney Harbour, several intelligence reports were received by the Australian armed forces warning of the possibility of a midget submarine attack on Allied shipping. These reports detailed the nature of the midget submarines which took part in the raid on Pearl Harbour.

The original Pearl Harbour (Dec 1941) midget submarine attack force comprised Type A midgets, which were similar to, but later modified design in the boats used in the Sydney raid (an access hatch was added to allow entry from the mother submarine to the midget, and the bow net cutter configuration was changed)[23].
From analysis of the contemporarily recovered Hawai'i midget (*Ha-19*), it was found that they were fitted with a single: *300 pounds* [135 kg] *TNT demolition charge carried* under the stern *electrically connected to the batteries to permit self-destruction or suicide attack against ship or harbour objectives* [24] [25] [26] [27].

Another record provided a slightly different picture:

---

[18] (**NAA #399556, p6**: Doc. 1855/3/193, 1/6/1942): *No 1 destroyed herself after apparently attempting to penetrate the net...*

[19] (**NAA # 398841, p41**: Doc. 496: 11/6/1942, p. 1): *Notes on submarines captured in Sydney Harbour: One submarine was blown up from inside by demolition charge…*

[20] (**NAA # 398841, p41**: Doc. 496: 11/6/1942, p. 1): Notes on submarines captured in Sydney Harbour: …Interesting to note that of the two men found in the submarine one was an officer found dead in the conning tower and the rating was found in the stern shot obviously by the officer who himself committed suicide.

[21] (**NAA #399556, p17**: Doc. TOO 0725z/11, 11/6/1942): *My 0945/10. Bow portion of submarine No. 14 recovered today Thursday AM. Bow Completely intact with torpedoes in tubes and bow caps on. One Japanese ensign recovered and one verey pistol. Pistol has three barrels, one painted white one painted red and yellow, one painted green and possibly another colour may be blue with selective trip hammer. Cartridges have also been recovered.*

[22] (**NAA #399556, p65**: Doc. TOO 0938z/4, 4/9/1942): Explosives filling for torpedo warhead is 780 pounds of following mixture: Hexamite: forty five per cent. TNT: fifty five per cent.

[23] Delgado, pers comm, 14 March 2017.

[24] (**NAA # 398841, p.17**: Doc Serial / 81-41, 15/12/1941, p.2): *Intelligence Report. Serial 81-41, Monograph Index 912-1000. From: Op-16-F-2 at Washington DC dated December 15 1941,Subject:Japanese Midget Submarines [Pearl Harbour]: Armament: a) 2-18 inch torpedoes (b) 300lb TNT demolition charge carried under stern, electronically connected to batteries to permit self destruction or suicide attack against ship or harbour objectives*.

[25] (**NAA # 398841, p. 68**: Doc. 81/41: 15/12/1941, p. 2): *Issued by Intelligence division of the Office of Chief of Naval Operations, Navy Department: Intelligence Report: Japanese Midget Submarines (re: Pearl Harbour)…5. Armament: ..(b) 300lb TNT demolition charges carried under stern, electrically connected to the batteries to permit self destruction or suicide attack against ship or harbour objectives.*

[26] (**NAA # 398841, p. 75**: Doc. BADs 1845 4/11: 17/12/1941, p. 1): *Department of External Affairs. Encypher from – Australian Legation Washington. Most Secret No 1155 for Chief of Naval Staff from Naval Attached. Tropic. (re: Pearl Harbour)…5. Armament: ..(b) 300lb TNT demolition charges carried under stern, hooked to the batteries to permit self destruction or suicide attack against ship or harbour objectives*.

[27] (**NAA # 398841, p. 72, 73**: Doc. TOO 1720a/16: 16/12/1941): re: Pearl Harbour Midget Submarines: *1-300 pound bomb attached to battery...*

<u>Demolition charges:</u> At Pearl Harbour – 300 lbs. demolition charge in aft compartment, with 50ft. fuse. Sydney Harbour – two charges, one forward and one aft" [28].

ANALYSIS OF DEMOLITION CHARGE IN AFTER BATTERY #19	
DEMOLITION CHARGE FOUND IN JAPANESE SUBMARINE:	
DETONATOR:	
Name of product:	SHIMOSE pvisue (Hexagonal) powder no 7.
Powder type:	SHIMOSE blasting powder.
Detonator:	Made November 1941.
(Rest):	Made May 1938.
Item:	No 679.
LONG CENTRAL CHARGE BELOW DETONATOR:	
Powder type:	SHIMOSE pvisue (Hexagonal) powder #2.
Item:	No. 474.
Made:	October 1934.
Cast:	September 1935.
Remade:	November 1941.
SHORT CENTRAL CHARGE BELOW DETONATOR:	
No:	SHIMOSE pvisue (Hexagonal) powder No. 1 long
Item:	No. 67.
Made:	October 1905.
	Navy SHIMOSE powder arsenal.
TRAPEZOIDAL SHAPED POWDER CHARGES:	
Name:	SHIMOSE pvisue (Hexagonal) powder.
Item:	# 474.
Made:	October 1934.
Cast:	September 1935.
	Navy Powder Arsenal.
HOLLOW WOOD OR PLASTIC TOWELS CONTAINING DETONATOR:	
No:	SHIMOSE pvisue (Hexagonal) powder #5,
	Empty towels.
Item:	No 65.
	Naval SHIMOSE Powder Arsenal.
Repaired:	June 1926.

Table 1: Analysis of demolition charge in after battery compartment of Pearl Harbour Midget Submarine *Ha-19* (Source: Submarine Squadron Four 1941:9).

[28] (**NAA # 398841, p. 61**: Doc. 375/31: 25/8/1942, p. 3): *<u>Secret NZ Naval Intelligence Memoranda. Serial No.11, 3rd September 1943: Japanese Midget Submarines</u>, ...<u>Torpedoes</u>: Inertia type pistol fitted to side of head. ...Demolition Charges: At Pearl Harbour – 300lbs demolition charges in aft compartment, with 50ft fuse. Sydney Harbour – two charges , one forward and one aft.*

A report into Japanese midget submarine *Ha-19* recovered at Pearl Harbour in 1941 gave an analysis of the scuttling demolition charge and provides insights into other materials on-board the submarine [29]. The report stated that the charge was located in the aft battery #19 (see Figure 6), although it is unclear whether it is referring to the battery bay or the submarine identification number. The composition of the charge is shown in Table 1. The scuttling charge consisted of compacted Shimose powder of different grades shaped into hexagonal and trapezoidal configurations. A hexagonal Shimose powder detonator was inserted above a long central hexagonal charge, below which was a shorter hexagonal block. Trapezoidal compacted Shimose powder blocks were placed around the above configuration. The type of storage container used for the charge is not mentioned in this document [30]. The report also details that pistols, pistol ammunition (23.6 Cal), 4 primers and blasting powder were also found in the vessel, which had washed ashore [31].

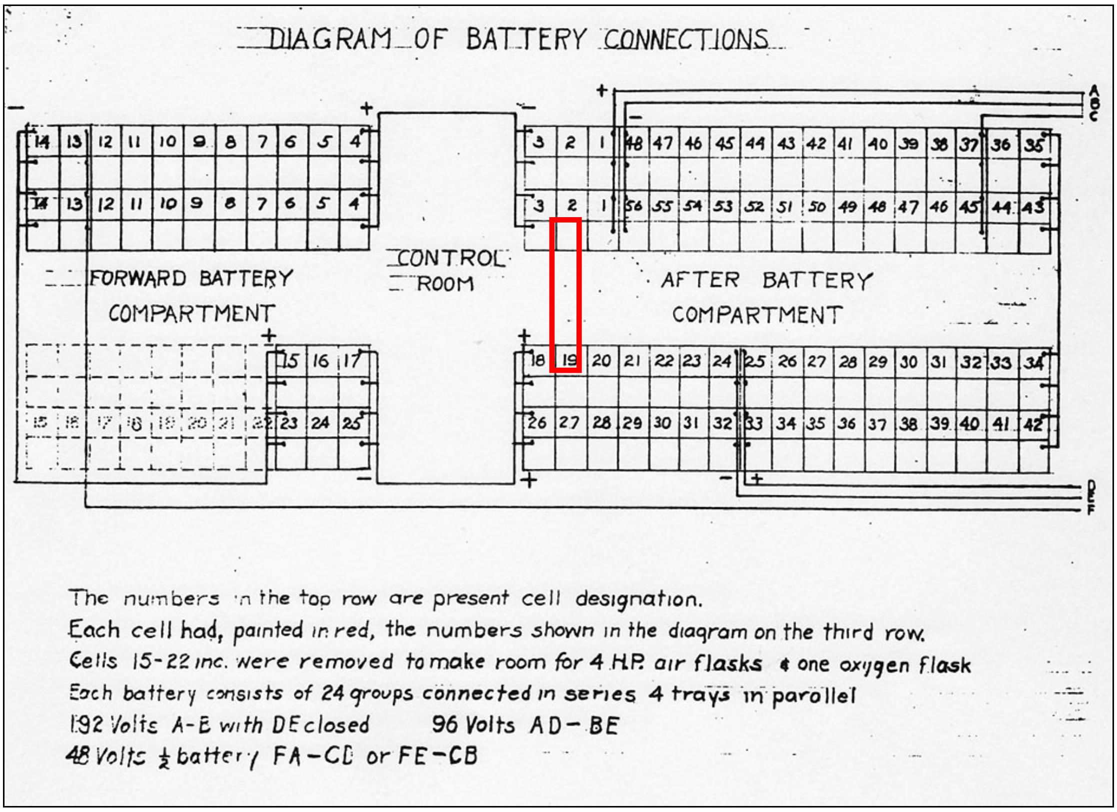


Figure 6: Setup of batteries on Pearl Harbour midget submarine *Ha-19*, showing the possible area where scuttling charge was discovered (Image: after Submarine Squadron Four 1941)

Only one diagrammatic image was found during this study showing where a demolition (explosives) charge was stored in the Pearl Harbour Japanese midget submarines. Although the author [32] identified the historical diagram of the submarine as a Ko-Hyoteki, it is unlikely that this is the correct submarine type and it appears that this is a stylised image possibly from previous press coverage of the issue, and as such is of little value to this analysis report.

[29] **Submarine Squadron Four, 1941**: 5, *Analysis of Demolition Charge in After Battery #19*.
[30] **Submarine Squadron Four 1941**: 1, 5, 9.
[31] **Submarine Squadron Four 1941**: 14, 15.
[32] **Scott 2012**

ii. *Sydney Midget Ko-Hyoteki (甲標的) Type A Kai 1* (improved version 1) *Class Submarines: Historical Evidence*

The collective evidence related to WWII Imperial Japanese midget submarines (archival, photographic, and archaeological) provides clues to the probable location of where scuttling (or demolition) charges were located within the remains of *M24*. However, from the outcome of this study, major discrepancies were identified in contemporary historical reports regarding the nature and location of the demolition charges aboard the recovered hulls of the *Ha-14* and *Ha-21* Sydney attack midget submarines. These inconsistencies meant that the historical records had to be more closely analysed to interpret the extent and nature of unexploded ordnance aboard the Sydney Attack midget submarines.

Type A Kai 1 class midget submarines included slight variations on the Type A submarines used at Pearl Harbour. These included:

- 3 sections bolted together;
- Slightly wider hull;
- Improved gyro compass;
- All weather hatch on the underside to allow crew transfers at sea;
- Slightly longer periscope extension;
- Nose and propeller guards;
- Netcutters at bow and forward side of the conning tower;
- External torpedo caps with hydraulic ram releases. [33]

A key surviving Australian line drawing (profile and sections) of the midget submarines (see Figure 7) was made by draughtsman William Dinnie at Garden Island Naval Base. These plans are held by the Australian War Memorial as part of the original intelligence assessments of the two recovered midgets from the Sydney Harbour raid [34] [35]**.** They were drawn after much vital material was removed from inside the craft for analysis and after the charges were taken out to be rendered safe. The drawings largely reflect midget *Ha-21*, the most intact midget recovered from Taylor's Bay. Many details of internal fittings and fixtures, especially piping, cabling, light fixtures, and ancillary equipment outside of the control room, were not recorded at all on the general arrangement plans that have been found to date. The submarines were divided into five compartments which (from the bow moving aft) comprised of torpedo, forward battery, control, after battery, and engine rooms [36] [37] (see Figures 7 - 9).

---

[33] **Smith 2007**: 19.

[34] (**NAA, # 485279 (1942)):** *Naval (inc. Enemy) - Submarines and Anti-Sub Devices: Plans and diagrams, photographs of midget (Japanese) submarine and components, involved in Sydney Harbour attack, 1942.*

[35] (**NAA # 9556087 (1942)):** *HMA Naval Yard - Garden Island. Japanese submarine. General Arrangement. Scale:- 1/2" - 1 Foot. 30/6/1942).*

[36] (**NAA #399556, p22**: Doc. 1236z/23, 23/6/1942): *...Five compartments accessible to crew with water tight divisional bulkheads and two small compartments around torpedo tubes and one aft at stern the later filled with oil and all three inaccessible to crew.*

[37] (**NAA #399556, p153**: Doc. TOO 1850B/2, 2/6/1942): *Five compartments comprise torpedo, forward battery, control room, after battery, motor room.*

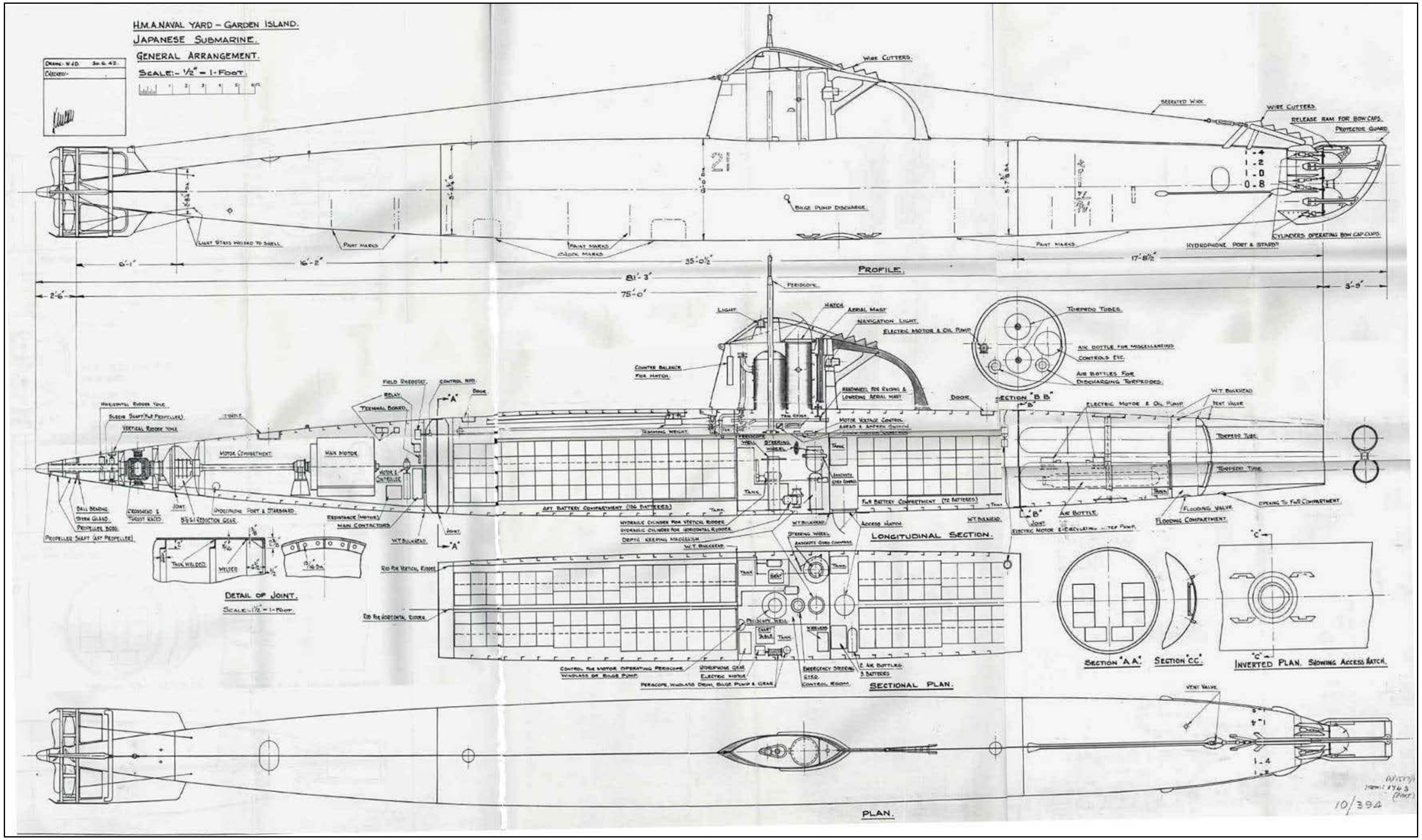


Figure 7: Historical Plan of the *Ha 21* Midget Submarines from the Sydney Harbour Attack (Source: NAA # 485279 (1942)).

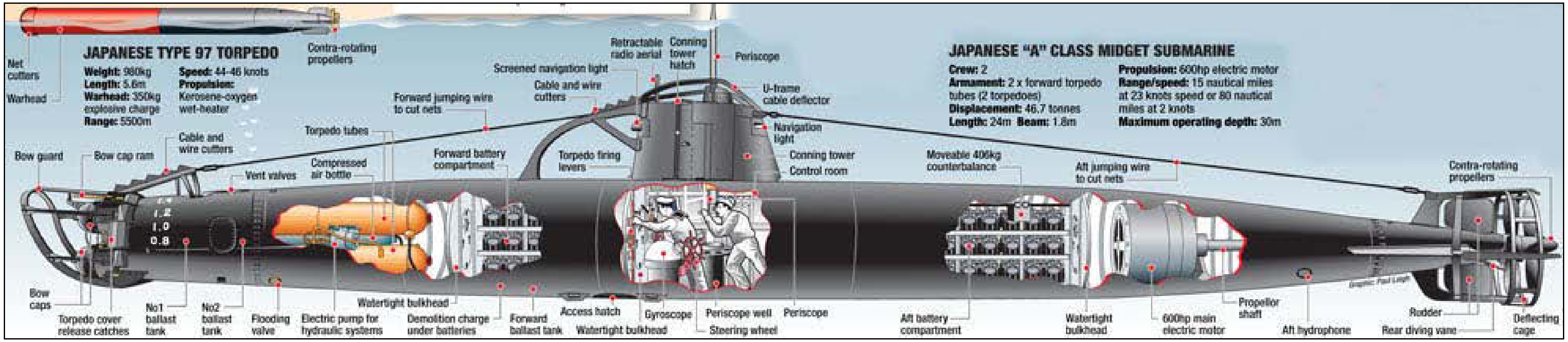


Figure 8: Schematic diagram of interior of a Type A *Japanese* midget submarine (Image: After Heritage Division 2012 and © Newspix/News Limited).

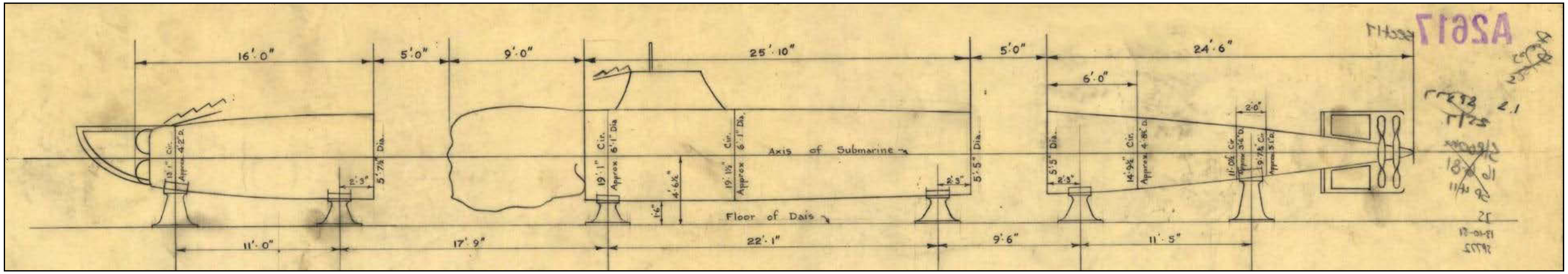


Figure 9: Drawing showing the reconstructed sections of *Ha-14* (midsection and stern) and *Ha-21* (Bow) Submarine (Image: NAA Collection # 224848).

iii. *Historical Reports on the Location of the Scuttling Charges on the Sydney Attack Midget Submarines*

Although the official reports documented that the submarines carried scuttling charges, the evidence of the nature and location of the explosives were scantly recorded. Initial reports indicated that the size of the scuttling explosive charge was a 300 lb TNT charge mounted under the stern [38]. However, this report appears to have been confused with earlier descriptions of the charges used in the midget submarine attacks on Pearl Harbour. [39]

The official assessment of the two recovered midget submarines from the Sydney attack was conducted by the Royal Australian Air Force (RAAF). The report: *Examination of Japanese Submarine Captured in Sydney Harbour. 16 June 1942, 6/2/17. Royal Australian Air Force, HQ Eastern Area*, stated:

> *Two demolition charges are carried in each submarine, 1 fore and the other aft [the following text was removed by official wartime censor], and packed in a round canister, 2 fuses to each, 1 electrical contact and 1 match* [40]*.*

A contemporary document on Eastern Fleet Intelligence on midget submarines confirms that:

> *Whereas the Pearl Harbour design only had a self-demolition charge fitted aft, the Sydney type had two such charges, one forward and one aft* [41].

The remaining charges in the two recovered Sydney midget submarines (two from the Taylor's Bay midget (Matsuo's *Ha-21*), and one remaining in the Harbour net wreck (Chuman's *Ha-14*), were diffused by civilian torpedo fitter Frank Lingard [42] [43]. However, no diagrammatic recording has been found to date of the specific location of where the charges were mounted inside the submarines. Many sources detail that the charges were carried both forward and aft, although the exact location is not specified [44] [45] [46].

The firing mechanism of the charges of the Sydney midget submarines (that were initially recorded as being the same as those found in the Pearl Harbour midget

---

[38] (**NAA #399556, p.6, 9**: Doc. 1855/3/193, 1/6/1942, p 1): *1855/3/193. Submarine Attack on Sydney on 31st May, Secret. DCNS. CNS. 300lb T.N.T. demolition charge mounted under the stern to permit self-destruction or suicide attack...*

[39] (**NAA # 398841, p.17**: Doc Serial / 81-41, 15/12/1941, p.2): *Intelligence Report. Serial 81-41, Monograph Index 912-1000. From: Op-16-F-2 at Washington DC dated December 15 1941,Subject:Japanese Midget Submarines [Pearl Harbour]: Armament: a) 2-18 inch torpedoes (b) 300lb TNT demolition charge carried under stern, electronically connected to batteries to permit self destruction or suicide attack against ship or harbour objectives...*

[40] (**NAA # 398841, p41**: Doc. 496: 11/6/1942, p.1): *Notes on submarines captured in Sydney Harbour: Two demolition charges are carried in each submarine 1 fore and the other aft, and packed in a round canister 2 fuses to each, 1 electric contact and 1 match. One submarine was blown up from inside by demolition charge…All electric wiring made of very heavy brass. …Interesting to note that of the two men found in the submarine one was an officer found dead in the conning tower and the rating was found in the stern shot obviously by the officer who himself committed suicide.*

[41] (**NAA # 398841, p. 48**: Doc. 496: 25/8/1942, p. 5): *Eastern Fleet Intelligence Summary: Midget Submarines. Index No.915, 1st Edition A. September 1942. prepared by COIS E.F. Kilindini, 2 Sept 1942. Japanese employment of midget submarines in an attack on Sydney Harbour, description of the midgets used and suggested methods of countering this form of attack.: Whereas the Pearl Harbour design only had a self-demolition charge fitted aft, the Sydney type had two such charges, one forward and one aft.*

[42] **Curran 2013.**

[43] (**NAA #413209, p. 39**: Doc. BS1749/201/37, 16/7/1942, Appendix 6, p.1). *Rear Admiral Muirhead Gould Commendation report: Recommendations for Recognition of Personnel….(9) Mr FJ Lingard (Torpedo Fitter): For the removal of pistols and primers from torpedoes, and demolition charges from submarines, this being carried out entirely voluntarily...*

[44] (**NAA #399556, p.19)**: Doc. 1436/12, 13/6/1942), *Submarines equipped with two demolition charges one aft and one foreward and manned by two men.*

[45] (**NAA #399556, p138**: Doc. TOO 0800z/13, 13/6/1942), *Self demolition charge found forward as well as aft.*

[46] (**NAA #413209, p. 67**: 2026.1.70): Department of Navy - Secret/ Confidential. *The Navy; The Secretary, Department of External Affairs and The Secretary Department of Navy; 13/6/1942: Secret:, Self demolition charge found forward as well as aft.*

submarines, which was a 300lb charge [47]) recorded that they were attached to a battery [48]. Another report indicated that the charges were also wired into the batteries for electronic firing with twin flex cable [49], which has since been identified as the fifth and lowest class of electrical cabling identified within the submarines [50] [51].

The non-electric fuses of the Pearl Harbour submarines were ignited using a 50ft (15m) length of powder fuse cord [52] [53], and the fuse of one charge in *Ha-21* was extinguished by water [54] [55] which was admitted from the first explosion [56]. It appears that the fuses were long enough to be lit from the control room, and the body of the officer who had committed suicide was found in this area. This suggests that the officer used the fuses rather than the electric detonators to ignite the charge [57].

An official war time technical report by Commander K. Urquardt stated that:

> *The scuttling charges were wired in a temporary fashion through a clockwork timer to 4 dry cells. Each charge was about 60 pounds of explosive with 4 primers in each charge* [58]**.**

Another technical report conducted at Garden Island in Sydney in 1942 specified that:

> *Each Midget Submarine carried two scuttling Charges – in the passage ways of each of the Battery Rooms (see Figure XIII –* [Figure 13 below]*).*
> *Each Charge weighed 103 lbs. total – estimated weight of explosive – 60 lbs. The temporary method of securing and firing indicated that the scuttling charges were only fitted at the last minute. A switch in Control Room fired them through a clockwork operated delay. Four special dry cell batteries, operated the firing of the charges. Each charge had four primers. Only one charge had been fired – the forward one in No. 14. Attempt had been made to fire the others* [59]*.*

The overall size of the scuttling charges carried on-board in these statements are at odds with other earlier contemporary accounts (as outlined above) as the total

---

[47] (**NAA # 398841, p. 99**: Doc. OPR No.1: 27/2/1945): *Statistical Data of Midget Submarines (Extract from ONI 220-J) ...Scuttling Charge: 300lb (Pearl Harbour Type). Same (Sydney Harbour Type) (The appearance of this is unknown).*

[48] (**NAA # 398841, p. 72, 73**: Doc. TOO 1720a/16: 16/12/1941): *Pearl Harbour Midget Submarines: 1-300 pound bomb attached to battery.*

[49] (**AWM # PR89/172, p.6**): *the demolition charges were very temporarily wired in ordinary twin flex (23/0076).*

[50] ***Curran* 2011**.

[51] See (**ADM 1/17012, (1942) p. 20)** for further discussion of electrical circuitry wiring aboard the Sydney Attack midget submarines.

[52] (**NAA # 398841, p. 61**: Doc. 375/31: 25/8/1942, p. 3): *Secret NZ Naval Intelligence Memoranda. Serial No.11, 3rd September 1943:Japanese Midget Submarines, ...Torpedoes: Inertia type pistol fitted to side of head. ...Demolition Charges: At Pearl Harbour – 300lbs demolition charges in aft compartment, with 50ft fuse. Sydney Harbour – two charges , one forward and one aft.*

[53] (**NAA # 398841, p. 71**: Doc.TOO 1923a/8: 18/12/1941): *re: Pearl Harbour Midget Submarines: demolition charges 300lb in aft Sector (?) with 50 foot powder fuse...*

[54] (**NAA #413209, p. 27,28**: Doc. BS1749/201/37, 16/7/1942, p.3-4): *Royal Australian Navy: Midget Submarine Attack on Sydney Harbour May 31st – June 1st 1942: Midget 21: Both members of the crew had been shot through the head; demolition charges had been fired but the fuzes were drowned.*

[55] (**NAA #413209, p. 35**: Doc. BS1749/201/37, 16/7/1942, Appendix 3, p.1): *Demolition Charges 1 fired. 2 fuzes. 1 fuze drowned*

[56] (**NAA #399556, p18**: Doc. 0043z/13, 23/6/1942): *Fuses were non electric and in one case fuse of second charge was extinguished by water admitted XXXX probably by the first explosion.*

[57] (**NAA # 398841, p41**: Doc. 496: 11/6/1942, p. 1): *Notes on submarines captured in Sydney Harbour: Two demolition charges are carried in each submarine 1 fore and the other aft, and packed in a round canister 2 fuses to each, 1 electric contact and 1 match. One submarine was blown up from inside by demolition charge...Interesting to note that of the two men found in the submarine one was an officer found dead in the conning tower and the rating was found in the stern shot obviously by the officer who himself committed suicide.*

[58] **(AWM PR84/047)** *Technical Report on Japanese Midget Submarines: Certificate & Technical Report, July 1942, AWM File 419/11/48: The scuttling charges were wired in a temporary fashion through a clockwork timer to 4 dry cells. Each charge was about 60 pounds of explosive with 4 primers in each charge.*

[59] **AWM # MP1049/2 (1942): Sheet 30.**

amount of explosive per submarine in the Sydney attack equated to approximately 120 pounds (54.43 kg), suggesting that the earlier accounts were incorrect. The use of a clockwork timer would appear appropriate, as it enabled the returning midget crews to pre-set the scuttling charge, exit the boat and head for the waiting *I*-class submarine, before the midget submarine exploded and sank.

Several other clues are evident to refine the placement of the demolition charges aboard the midget submarines. Examination of the recovered remains of the *Ha-14* in 1942 indicated that the internal explosion had severed the foremost compartment (the forward battery room) forward of the conning tower. The separate torpedo room section was still intact with its torpedo tubes [60] [61] [62] [63] [64]. This suggests that the forward charge was mounted in the compartment aft of the torpedo room (the forward battery room).

This was confirmed by a technical report from 1942, which stated that:

> *Each Midget Submarine carried two scuttling Charges – in the passage ways of each of the Battery Rooms. Each Charge weighed 103 lbs. total – estimated weight of explosive – 60 lbs. The temporary method of securing and firing indicated that the scuttling charges were only fitted at the last minute. A switch in Control Room fired them through a clockwork operated delay. Four special dry cell batteries, operated the firing of the charges. Each charge had four primers. Only one charge had been fired – the forward one in No. 14. Attempt had been made to fire the others* [65].

Further support for the charges being located in the battery rooms was provided by Rear Admiral Muirhead Gould (RN - Rear Admiral-In-Charge, Sydney):

> *In his report Muirhead noted that Lingard not only diffused the unexploded torpedo that ran ashore at Garden Island (from M24), but each of the four unfired torpedoes recovered from midgets Ha-14 and Ha-21. He also diffused, 'three demolition charges remaining unexploded in the Battery Rooms. The method of firing these charges was not known until the first charge had been removed',* (i.e. when the midget submarines were brought ashore at Clarke Island, Sydney Harbour) [66].

When the *Ha-21* submarine was discovered in Taylors Bay, it apparently had a 15-20 ft (4.5 – 6m) section of its stern missing [67]. It is likely that this depth charged damaged section separated from the hull during the salvage recovery phase. Therefore this event should not be interpreted as being a result of the internal demolition charges, as they were found intact when the vessel was recovered.

---

[60] (**NAA #399556, p15**: Doc. TOO 0801z/6, 6/6/1942): *Second submarine recovered except for foremost compartment which had been severed by internal explosion but was intact with torpedoes in tubes.*

[61] (**NAA #399556, p17**: Doc. TOO 0725z/11, 11/6/1942): *My 0945/10. Bow portion of submarine No. 14 recovered today Thursday AM. Bow completely intact with torpedoes in tubes and bow caps on.*

[62] (**NAA #399556, p22**: Doc. 1236z/23, 23/6/1942): *Number 21 is missing approximately 20 feet of the stern and number 14 is minus the bows just forward of the conning tower.*

[63] (**NAA #399556, p35**: Doc. TOO 0801z/6, 6/6/1942): *Second submarine recovered except for foremost compartment which had been severed by internal explosion but was intact with torpedoes in tubes. Number of boat was fourteen.*

[64] (**NAA #413209, p. 100**: Doc. TOO 0801z/6, 6/6/1942): *Second submarine recovered except foremost compartment which was severed by internal explosion but was intact with torpedoes in tubes. Number of boat 14… The Submarine contained at least 3 bodies.*

[65] **(AWM MP1049/2, (1942), Sheet No. 30):** *Technical Report on Japanese Midget Submarines (Excluding Reports on Wireless and Electrical Equipment – Dealt with Separately). Garden Island, Sydney, July 1942. Copy No. 4. Scuttling Charges, Sheet 30, Each Midget Submarine carried two scuttling Charges – in the passage ways of each of the Battery Rooms… Only one charge had been fired – the forward one in No. 14. Attempt had been made to fire the others.*

[66] **Smith 2007**: 25 citing **Lind 1992**:84;

[67] **(NAA #413209, p. 103**: Doc. TOO 0750z/5, 5/6/1942): *Submarine raised and placed on Clarke Island this afternoon damage by depth charges. 15-20 ft of stern missing. No 21 painted on side.*

It was also noted in one comparative report between the Pearl Harbour and Sydney Harbour submarines that six flasks (batteries) had been removed from the forward battery compartment, predominantly to make room for an access hatch [68] [69]. It was initially speculated (during this current study) that some of this space was possibly used to secure the explosive canister mounted in the forward section of the vessel.

Another scenario that was considered is that it is also possible (although highly unlikely) that the demolition charges were not loaded onto the *M24* prior to its departure from its mother ship. No evidence has ever been found to suggest this may be the case.

Examination of historical photographs of Lt Chuman's midget (*Ha-14*) indicated that it was destroyed by firing the forward scuttling charge (when trapped in the harbour boom nets), and further suggested that the canister was stored at (interior) deck level. This is reflected by the upward and outward explosion and shearing of the fore plates. Initial photographs of the recovered wreck of *Ha-14* show the forward battery room compartment has been exploded outwards towards the torpedo room/ forward battery room bulkhead, and that the hull plates bent backwards around the conning tower like a banana skin (see Figures 1, 10, 11, 12). This initially suggested that the explosive may have been mounted against, or close to, the forward battery room/control room bulkhead.

The hull sides were later straightened back into position to enable the midget submarine to be paraded around New South Wales and Victoria on the back of an Army lorry (Figure 12). The best intact sections of the remains of both submarines (*Ha-14* and *Ha-21*) were joined together to form a single submarine display which is still presented in the ANZAC Hall at the Australian War Memorial exhibit, Canberra (see Figure 9) . Inspections of the submarine components by Heritage Branch Deputy Director Tim Smith examined evidence of the blast damage in 2007 [70].

From the historical and on site research outlined above, it is likely that the two demolition charges contained within *M24* will be located in the passage way:

1. forward battery room just forward of the battery bay partition;
2. of the aft battery room aft of the control room bulkhead.

These charges would be accessible to the crew from their main position within the conning tower area, to enable manual lighting of fuses or by use of clockwork fuses. They would be placed to cause the maximum damage at the junction of the principle joint areas comprising the 3 principle sections of the submarine and they would most likely be removable to allow installation into other midget submarines; refitting of individual submarines; and/or during maintenance/ refurbishment of the charges themselves [71].

---

[68] (**NAA #399556, p30**: Doc. TOO 1303/21, 21/6/1942): *Notes configuration of batteries and differences between Pearl Harbour subs*: *Only structural channel noted since Pearl Harbour possibly having magnetic influence is removal of six flasks forward battery compartment to make room for access hatch in submarine.*

[69] **ADM 1/1/7012 (1942) p.18:** Report on Japanese Submarine (Electrical).: *It will be noted that Batteries are numbered 1 to 56, but that Nos. 4, 5, 24, 25 are missing. These missing units are from a position immediately forward of the Conning Tower, and have been removed to allow fitting of a small hatch in the bottom of the submarine. (It is understood that the submarine investigated at Pearl Harbour had these batteries fitted and had no hatch. The use of the hatch is dealt with elsewhere).*

[70] **Smith 2007**: 26, 42.

[71] Advice given by Lt CDR **Carroll pers comms 2016**, and CPO **Elliott pers comms**, **2016,** RAN Clearance Diving Team One, 2016.

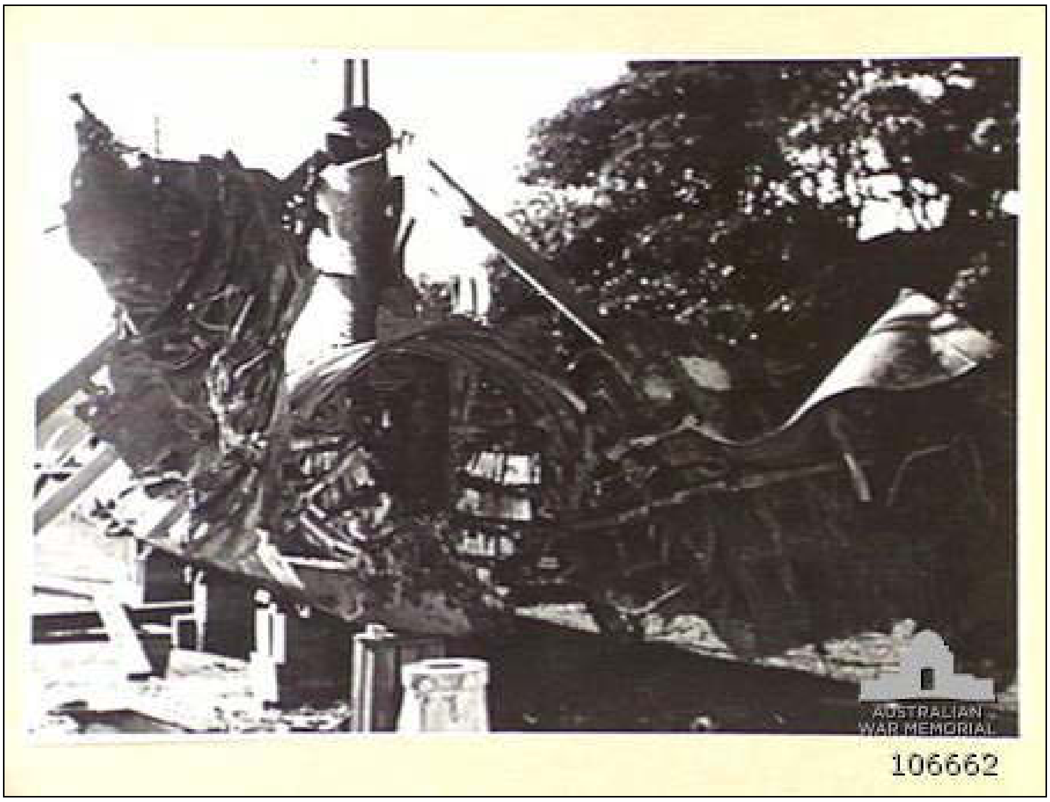


Figure 10: Picture showing exploded hull of the *Ha-14* Midget Submarine (Image: Courtesy AWM 106662).

Figure 11: Picture showing exploded hull of the *Ha-14* Midget Submarine after being cleaned up for exhibition (Image: Herald Newspaper 1942 - AWM P00455.013).

Figure 12: Midget submarine on trailer on touring exhibition showing mangled foreward end of the submarine minus torpedo and engine rooms (Image: Goggs 1942 - AWM P03932.002).

This hypothesis was supported by photographs contained within an initial intelligence investigation report on *Ha-21*, held at the Australian War Memorial, Canberra (Plans and diagrams, photographs of midget (Japanese) submarine and components involved in the Sydney Harbour attack, 1942. Australian War Memorial, (AWM54, 505/6/7). Figures 13 and 14 show the forward scuttling charge still in situ. The charge appears to be a cylindrical canister, similar in shape to a modern-day pressurised beer keg (which is consistent with the description contained in the report [72]). The caption adjoining the photograph notes "*Scuttling charge lashed to improvised chocks*". The charge is clearly situated in the passageway between the forward battery stacks and slightly forward of the battery bay partition that separates the forward battery room from the control room/ underfloor hatchway space. Figure 14 shows what might be either the control room hatchway door or the floor access hatch in the open position on the left hand side of the photo (?). This suggested that the demolition charge was located very close or adjacent to the aft section of the battery banks, just in front of the escape hatch.

Furthermore, the stanchions (labelled "hangers" on the plan) supporting the battery banks frames are clearly visible in Figures 13 and 14, and show that head and base of the demolition charge was located approximately alongside the third and second stanchions aft of the torpedo room bulkhead. When compared to Dinnies plan (Figure 14), this suggests the charge was located under where the conning tower netcutter attached to the hull, between frames hull 3-5.

[72] (**NAA # 398841, p41**: Doc. 496: 11/6/1942, p. 1): *Notes on submarines captured in Sydney Harbour: Two demolition charges are carried in each submarine 1 fore and the other aft, and packed in a round canister 2 fuses to each, 1 electric contact and 1 match.*

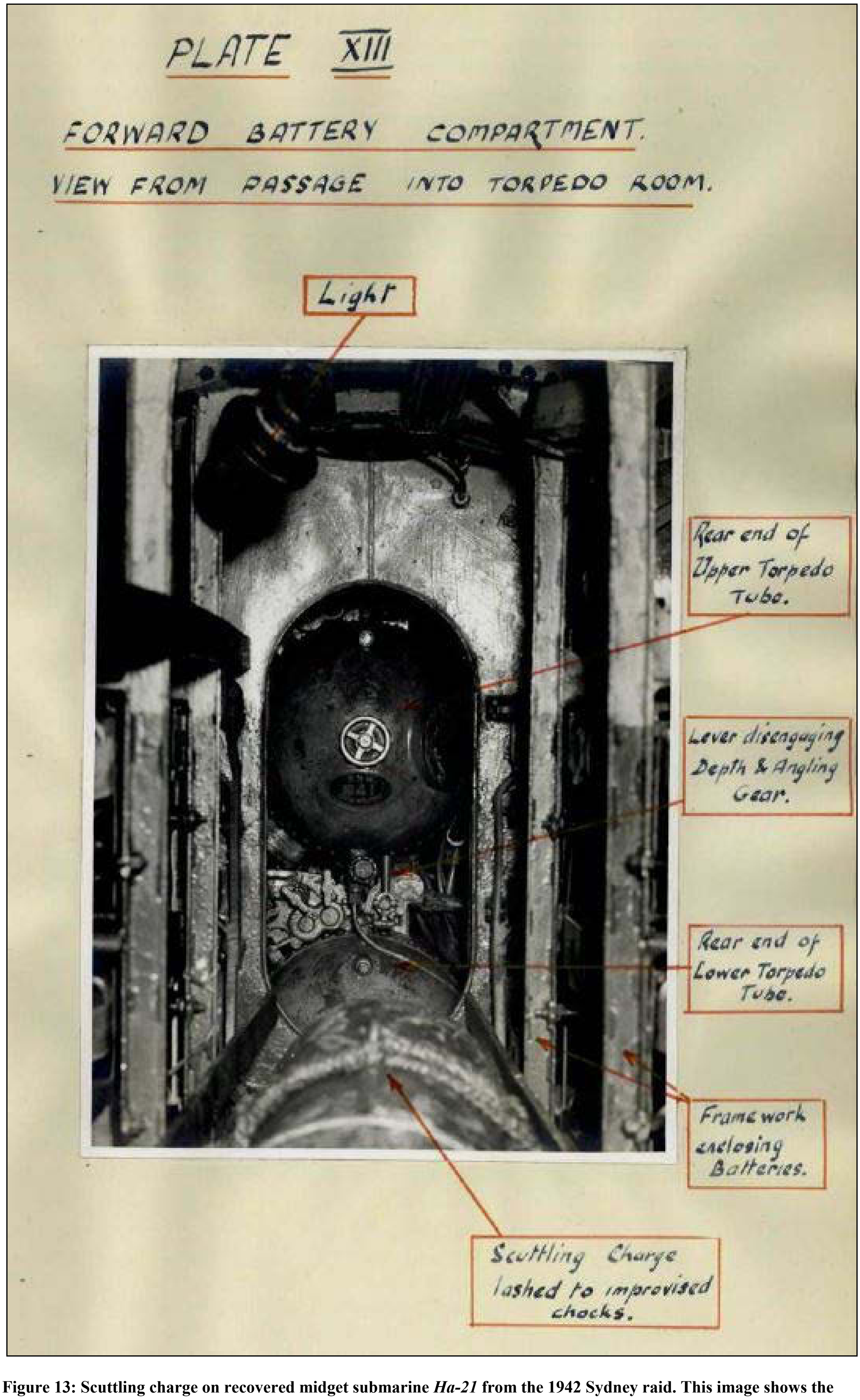


Figure 13: Scuttling charge on recovered midget submarine *Ha-21* from the 1942 Sydney raid. This image shows the forward charge roughly secured in the passageway of the forward torpedo room, close to the bulkhead separating the forward battery room and torpedo room (Image: from AWM # MP1049/2 (1942):. A similar image is also available in NAA # 485279 - Australian War Memorial AWM54, 505/6/7).

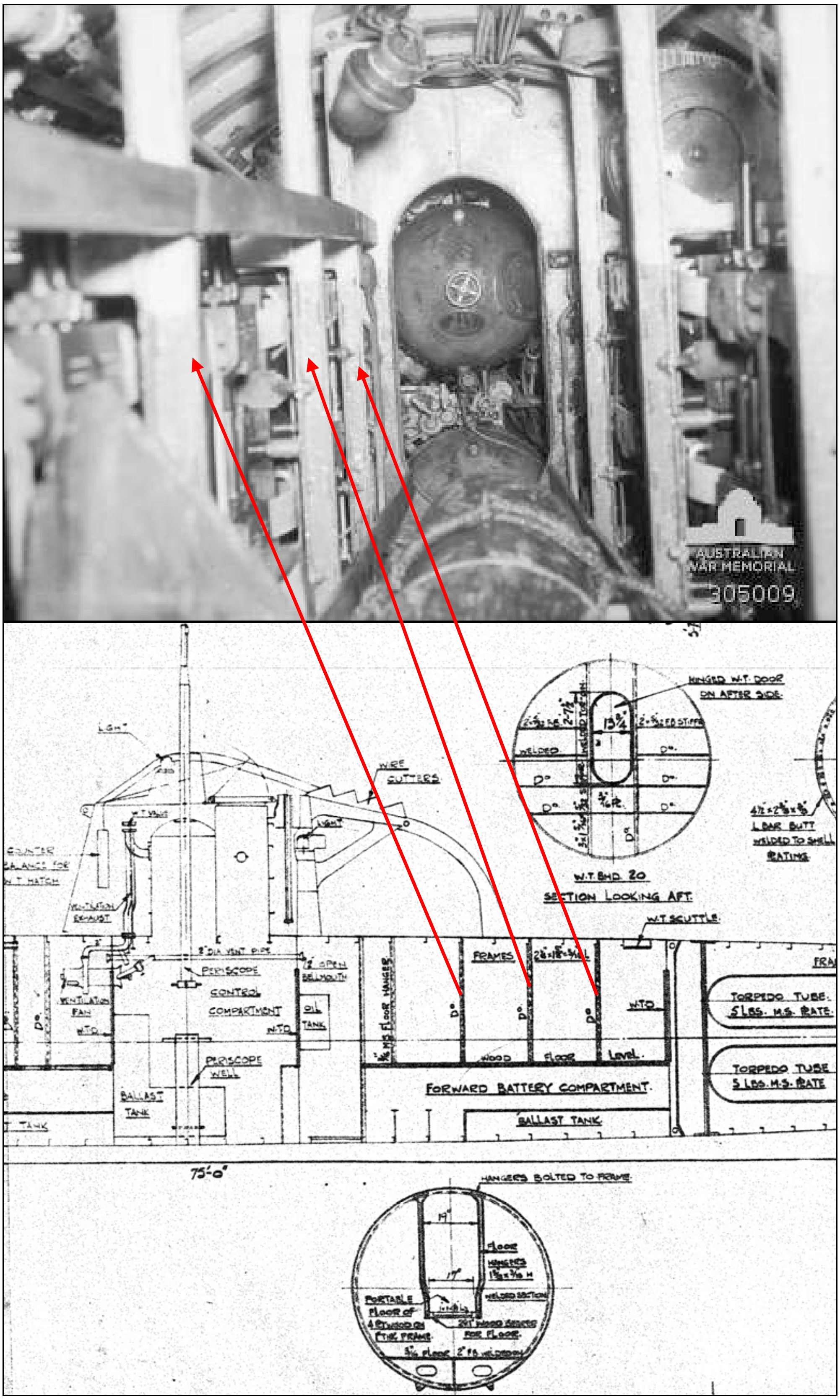


Figure 14: Scuttling charge shown into the forward battery room with the torpedo room (in the background) of *Ha-21*. This appears to be a later better lit image of the hull section shown above. Note the vertical battery bank stanchions or hangers along the edge of the passageway and their corresponding location on the plan below (Images: Australian War Memorial AWM # 305009 and NAA # 9556087).

iv. Archaeological Evidence: Ha-14 Inspection 2007

In 2007, Tim Smith (Heritage Branch) undertook an inspection of the *Ha-14* and *Ha-21* hulls which had been reconstructed to form a composite display at the AWM, with a view to deriving the probable location of the exploded demolition charge based on hull damage on the recovered wrecks. His inspection concentrated on examining the forward battery compartment of the Ha-14 (Figures 15, 17, and 18). It revealed that there was extensive damage to the torpedo room bulkhead area (which was almost totally gone), and that the conning tower bulkhead end demonstrated only slight damage.

However examination of an historical image taken not long after the submarine was recovered (Figure 16) reveals extensive damage in the battery bank partition wall area just forward of the hatchway door. It appeared from this image that the blast explosion has occurred in an area approximately one battery bank forward of the after most section of the battery bank stacks, as all batteries forward of this area have been blasted out and away from aft bulkhead. The presence of the still extant battery bank might explain why the current control room bulkhead is in relatively good condition, as the batteries appear to have shielded it from the main force of the blast. Tears in the hull originate at approximately 3 frames forward of the control room bulkhead, indicating that the demolition charge (at least in the forward battery room) was placed close to the aft end of the battery banks. This observation was supported by Smith's 2007 photographs of the inspection of the *Ha-14* hull at AWM, where it can be seen that the explosive breaks in the side and bottom of the hull are centred approx. 3-4 frames forward of the control room (Figure 17), where the hull has exploded outwards and bent backwards. There is also massive shearing of the hull upwards and downwards at this location, suggesting it was just forward of the epicentre of the blast.

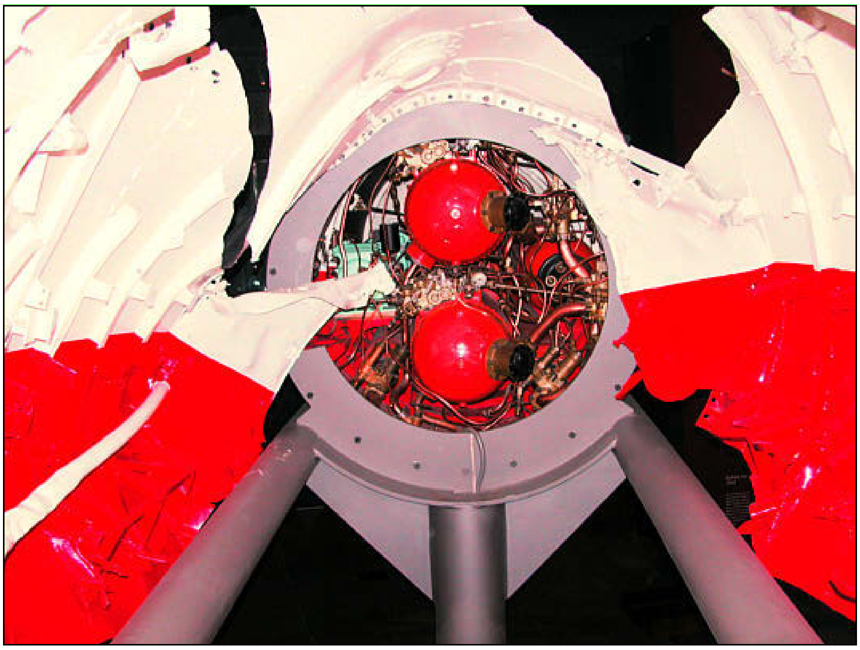


Figure 15: Impact of the detonation of the forward charge on *Ha-14* visible on the displayed hull section, Australian War Memorial, Canberra (Australia). This section is the same view as those shown in Figures 12 and 13 (above), except that the bulkhead between the forward battery and torpedo rooms has been removed. The silver sections are frameworks of the display mountings. Note the original interior paintwork scheme which was discovered during restoration works at Cockatoo Island [73] (Photo: Tim Smith).

[73] **The Royal Institution of Naval Architects, 1989:**9.

Figure 16: View of detonation area in forward battery compartment of *Ha-14* looking aft to control room (Image: AWM 305084, AWM Collection).

Figure 17: Inside *Ha-14* aft battery room facing aft control room compartment bulkhead. Note the dark section of hull bent upward and inwards at the bottom of the image. On display at AWM, Canberra (Image: Tim Smith).

Figure 18: Aft battery room inside remains of *Ha-21* (Australian War Memorial, Canberra. The aft scuttling charge is considered to have be placed within the floor passageway, possibly close to the control room bulkhead. The remains of the battery banks shelves are located either side of the companionway (Photo: Tim Smith).

v. Historical Evidence: Comparison of Australian War Memorial WM Photos and Dinnies Technical Plan of the Ha-21

The Australian War Memorial, Canberra, vessel plan (Figure 9) and a modern AWM photograph of the composite hulls showed that the charge blast area appeared to be concentrated approx. 25 ft (7.62m) forward from the aft battery/engine room bulkhead (and forward of the control room hatchway bulkhead). The HM *Dockyard Garden Island* scaled plan of the submarine (Figure 7 [74]), showed the distance from the aft battery/engine room bulkhead to the torpedo room bulkhead is 35 ft (10.668m). This could place the charge inside the forward battery compartment, approximately 10ft (3.048m) aft from the torpedo room bulkhead, at the beginning of the battery bank stacks approx. 1 $^{3/4}$ ft (0.5334m) from the control room bulkhead.

With the discovery of a recently declassified document [75] by Steven Carruthers in 2011 (see Figures 13-14) the size of the charge was shown to be 18 inches (45 cm) long (see below). From the measurement taken from the scaled plan (Figure 7) it appeared that this front battery room was only about 11.5ft (3.45m) long, with the access hatch space about 21 inches (70 cm) until the start of the forward battery compartment battery bays. If the charge (which was 18 inches long) was located approximately 1 battery bay forward of the aft most battery bank partition wall (each battery bank scales to approx. 1ft [30 cm] long), then the demolition charge might sit approximately 33 inches (82.5cm) inside the compartment. This possibly placed

[74] **NAA, # 485279 (1942).**

[75] **NAA# 400146 (1942-43)**: Davis D.J. 5/10/42: *Munitions Supply Laboratories, Report on Demolition Charge from Japanese Submarine Recovered at Sydney*, *Report E. & A.R. No. 35)*, Report From Naval Staff Office to Secretary Naval Board (Naval Office) 29 April 1943, No. S.A. 79/3/, Series MP 1049/5, Control Symbol 1872/2/161, Barcode 400146.

the charge blast about approx. $3^{1/4}$ ft (97.5 cm) forward of the control room hatch bulkhead, or approximately midway along the second bank of batteries. This appeared to be consistent with the possible location stated in the Pearl Harbour midget submarines in the aft compartment [76].

This varies slightly from previous interpretations by Smith in 2007 (see below), who suggested that the forward demolition charge was located towards the torpedo room and engine room bulkheads (see Figure 18). It was clear that another inspection of the *Ha-14* submarine remains was warranted to check these observations.

vi. Archaeological Evidence: Ha-14 Inspection 2016

Another more detailed examination of the *Ha-14* hull in the forward battery compartment was undertaken by Brad Duncan and Stirling Smith in July 2016. This inspection was facilitated by Shane Casey of the AWM after normal museum hours whereby the authors were allowed access via ladder to the interior of the hull.

In order to more accurately estimate the location of the blast damage, a section of the scaled plan drawing of the more intact *Ha-21* (Figure 7) was used to examine the frame spacing in the forward battery compartment in relation to the areas of evident blast damage in the *Ha-14* hull section. This approach was adopted as it was difficult to accurately measure the length of features inside the *Ha-14* hull due to deformities caused by the explosion. For the purpose of this analysis, it was decided to count hull frames within the vessel to be able to relate the current hull structure to the historical plan). For simplicity of observations, the frame starting at the battery bay partition (just forward of the conning tower bulkhead was named the battery bank partition frame (or frame zero), with frame numbers increasing towards the bow to a total of nine frames (see Figure 19). This convention has been used for the following analysis of all damage during this survey as although the hull frames have been bent and twisted by the explosion, their location was clearly identifiable within the current *Ha-14* remains. An associated extract of the location of ballast tanks within the submarine are also of relevance (Figure 20). A 3D model of the interior of the submarine's forward battery compartment as also produced using Agisoft Photoscan software (Appendix One) photogrammetric software, which further aided with these observations. Difficulties were experienced in producing panoramas for the inspection due to inconsistent low mood lighting associated with a light and sound presentation display.

This inspection showed that the blast radius appeared to have been concentrated between frames 3-6 forward of the battery bank partition in the forward battery room. Massive shearing forces radiating outwards on the top side of the vessel was evident, along with small shrapnel holes (possibly deriving from the metal casing of the demolition charge itself) which were evident between frames 3-7. As the upwards blast force would have been unimpeded by any internal structure (unlike the side of the hull which was protected by banks of batteries, and the underside was partially protected by the internal flooring and a water tank – see Figure 20), it appears that this area took the full direct force of the blast (Figure 21). Hull plate has also been deflected upwards at frame 3 on the starboard side just aft of where the net-cutter support arm attaches to the hull (at frame 4). It is possible that the explosion was cushioned to some extent by the rigid net-cutter arm, channelling the explosive force further forward towards the bow (?). A technical report from 1942 [77] also noted that: *It is interesting to note that the disruptive force which tore the plates of the shell, in*

[76] **Submarine Squadron Four 1941**.
[77] **AWM # MP1049/2 (1942):** Sheet 30

no instance caused fracture along a weld. This suggest that the explosive force may have been cushioned by the welded area where the net-cutter connected to the hull, thus directing the explosion out to each side of the hull instead of giving way.

Examination of the former battery bank areas demonstrated significant tearing of the hull a massive sudden overpressure force starting at frame 3 on the port side and frame 2 on the starboard side, which suggested that this was the area that fronted the blast or that this was the area where the blast's force was directed. This is reinforced by examination of remains of the former battery bank racks on the starboard side, where the base of the rack at frame 3 is intact, but the racks and frames forward of this section are bent and twisted backwards and upwards until frame 7 (Figure 22). Similarly on the port side interior (Figure 23), the battery rack base at frame 3 is intact, and explosive damage is evident on the rack stands bases/ frames between frames 4-7 and on a pipe running at walkway level between frames 4-6.

Most of the submarine's floor between frames 3-9 is missing, and appears to have been squarely cut off all the sides of the hull (possibly following recovery of the submarine) making interpretation from this area impossible. The bottom of the submarine hull in the area of frame 2 has a sizable deformation in the floor (see Figure 21) which was strangely bent upwards and inwards. Although this could be a result of the subsequent transport and propping of the submarine during the travelling display, it is also speculated that the ballast water tank below the floor between frames 3-9 might have deflected downwards (as the water contained within was incompressible) and the contained water may have resulted in it being forced out is such a direction as it punctured the hull forward of this section, forcing the adjacent hull upwards. Allan [78] has remarked on similar strange occurrences in other vessels where the blast was reflected back from another solid surface (e.g. the explosion aboard *USS Maine* in Havana Harbour), and the hull plate was bent inwards from an internal explosion [79] and agrees this observation is plausible. He also commented on other examples where a blast causes the plate to whip back in the opposite direction from that which is expected.

[78] **Allan pers comms 2016.**
[79] see **Rickover 1976**, and **Fisher 2009.**

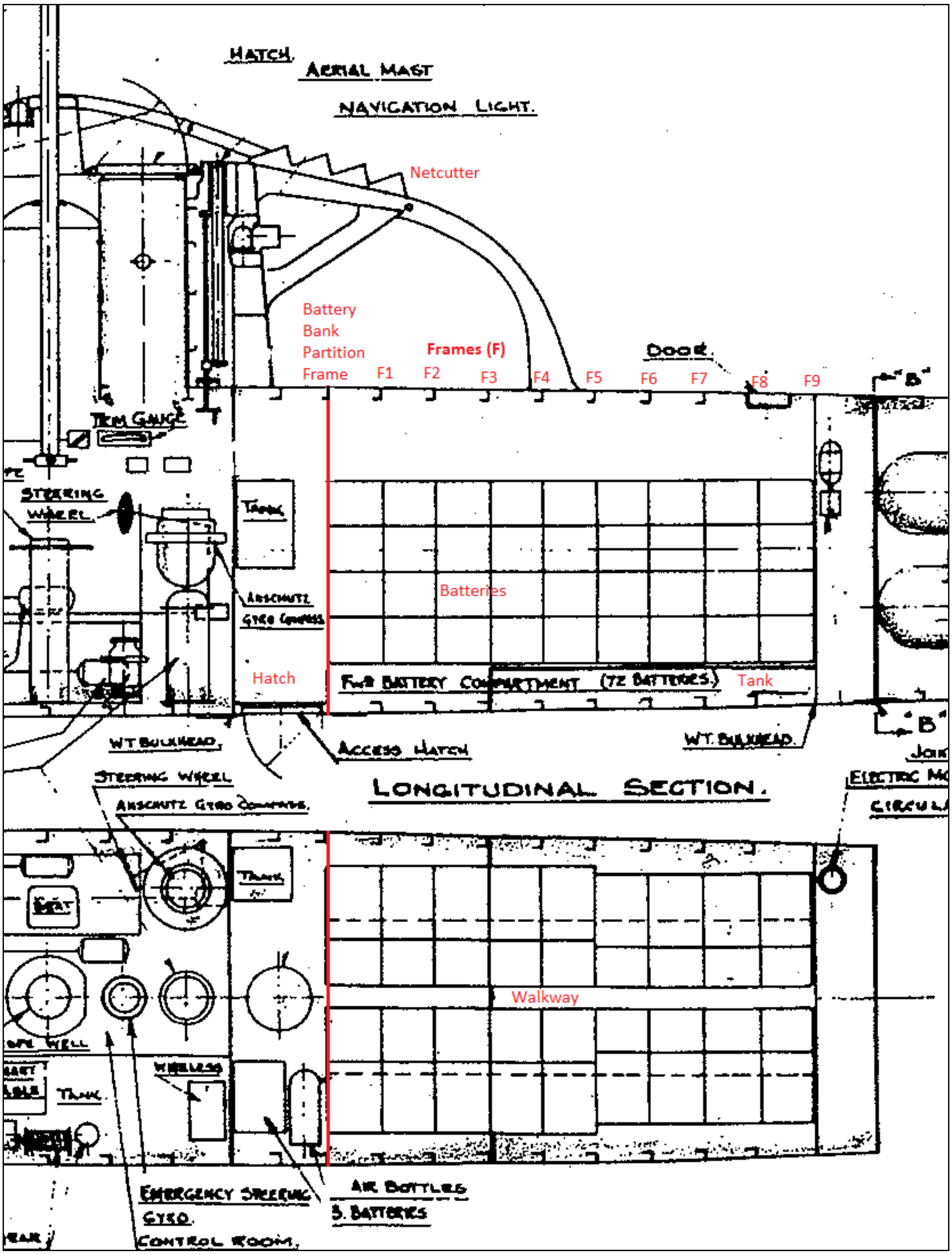


Figure 19: Close-up of plan showing forward battery room compartment and key features (Image by B. Duncan after: NAA # 485279 (1942)).

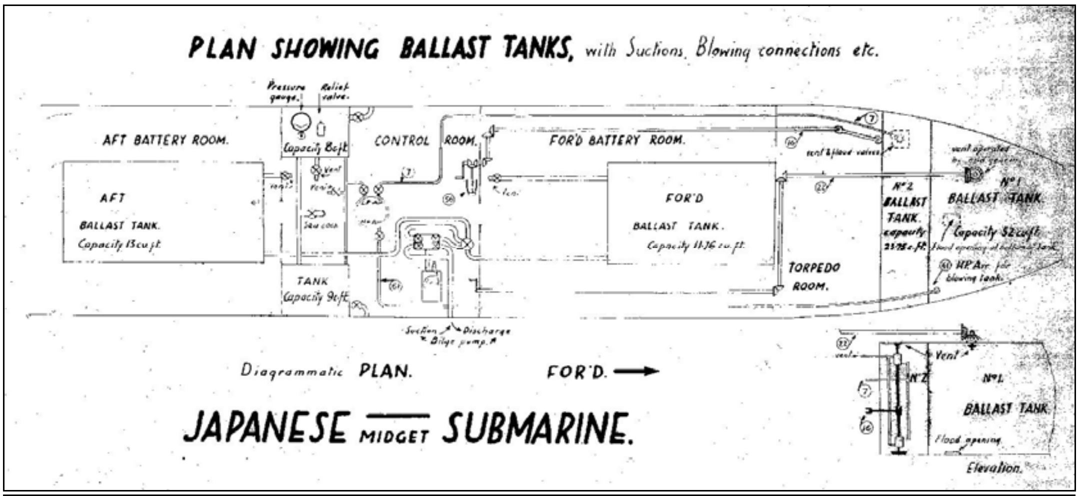


Figure 20: Aerial plan showing location of ballast tanks on midget submarines. Note the ballast tank located between frames 3-9 in the forward battery compartment. (Image: Submarine and Anti-sub devices Plans and diagrams 485279 pt6, AWM 485279).

Examination of the exterior hulls shows a marked bulging or "bubbling" caused from the interior explosion on both sides (Figures 24-26). There is a distinct vertical line of maximum deformation on the outer hull which is in alignment with frame 4 in the interior on both sides of the *Ha-14* hull.

Signs of imploding force were observed on the bulkhead plates between the forward battery room and the control room /conning tower compartments. The force was enough to break the bulk head hatchway surrounds, implode the bulkhead plating at the top of the hatch and cause stress fracture tearing on the ports side (Figure 27). The bulkhead plating fronting the torpedo room is also bent outwards towards the torpedo room compartment (Figure 28), although it is difficult to interpret this section as the hull of the *Ha-21* has been connected to this section.

From the observations presented above, it is therefore probable that the blast was concentrated between frames 3-5 of the forward battery bank compartment, suggesting that this was the probable location for where the demolition charge was placed in the forward battery compartment. Although it is probable that the placement of the aft charge was mirrored in the aft battery compartment (i.e. placed a similar distance from the control room), it has not been possible to conclusively demonstrate that this was the case due to a lack of documentary records. Therefore the location of the demolition charge in the aft battery compartment is at this stage speculative.

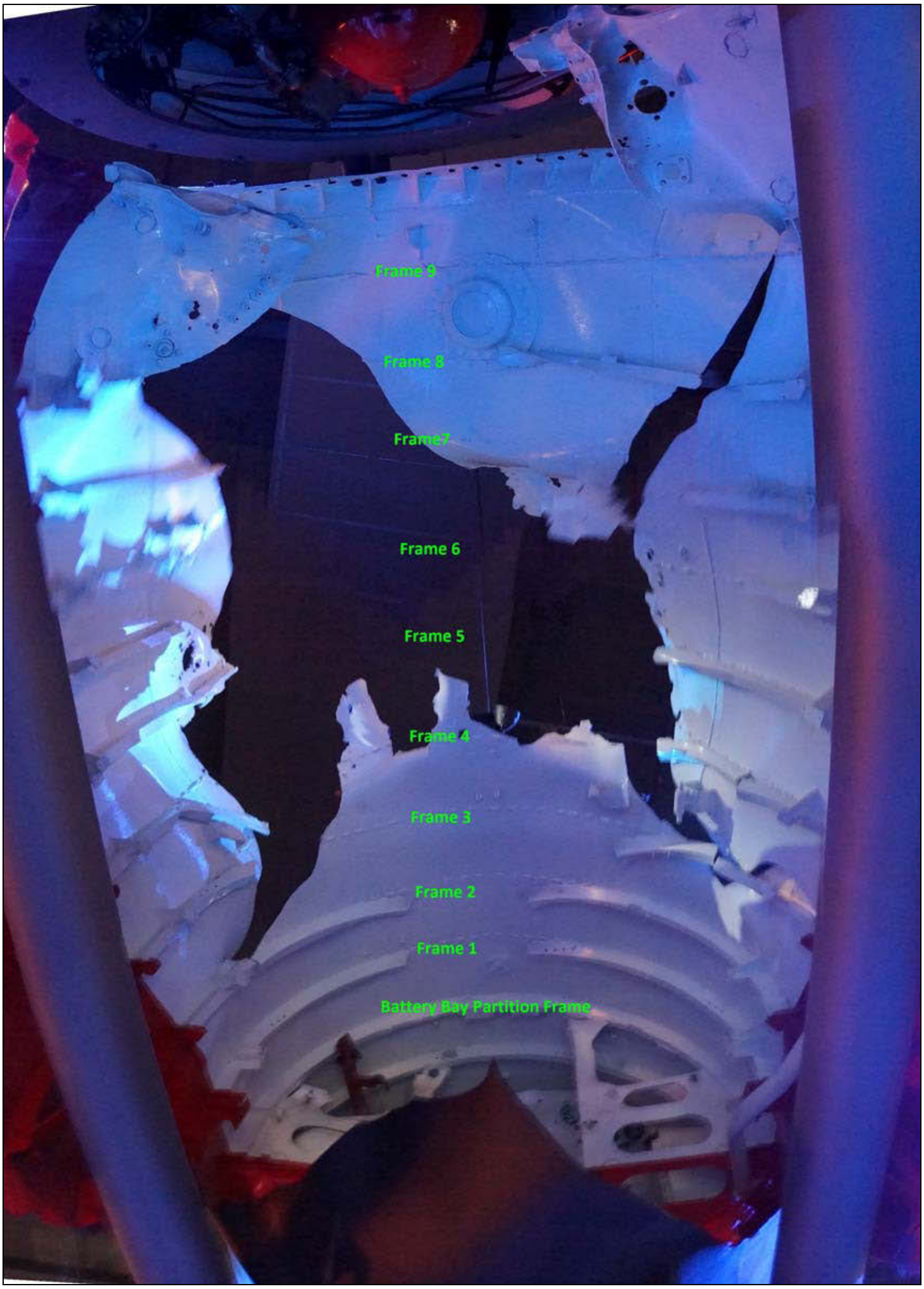


Figure 21: Interior of *Ha14* hull looking aft toward battery bank partition frame. Note tearing of hull starting at frames 2 and 9 on either side; and shrapnel holes / out hull bending upwards between frames 4-6: and the upwards deformation of the exterior bottom hull (dark grey at bottom of picture) which is partially obscuring the battery bay partition in the middle of the image (Image: After Photomosaic by B. Duncan, Heritage Division).

Figure 22: Starboard interior of *Ha 14* hull. Note battery bank stand and frames are deformed between frames 4-7, shrapnel holes between frames 4-6; and hull tearing starting at frame 2 (Image: After Photomosaic by B. Duncan, Heritage Division).

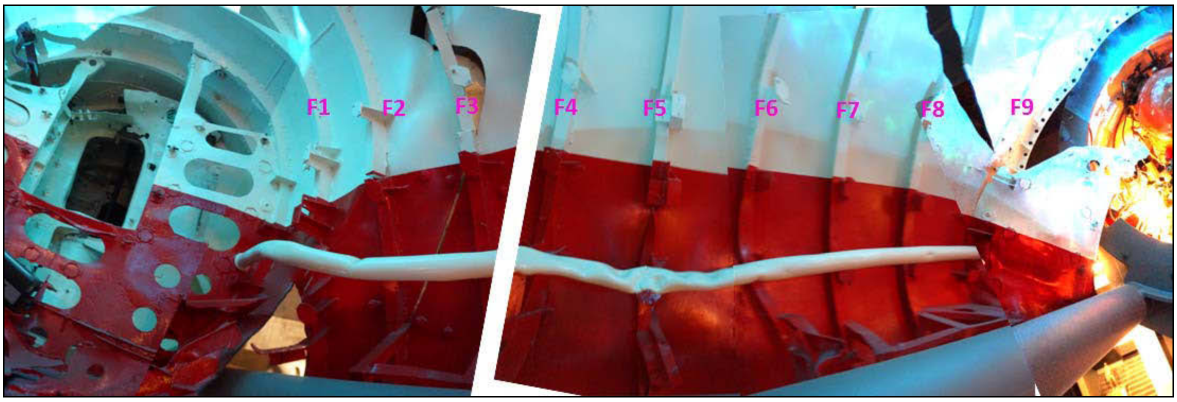


Figure 23: Port Interior of *Ha 14* hull. Note battery bank stand missing and pipe badly damaged between frames 4-6, and hull tearing starting at frames 3 and 9 respectively (Image: After Photomosaic by B. Duncan, Heritage Division).

Figure 24: Composite hulls of *Ha 14* and *Ha 21* pieced together for a display at Australian War Memorial. (Note blast of charge below conning tower net-cutter in approximate. proposed location of forward battery room charge. (Image: B. Duncan, Heritage Division).

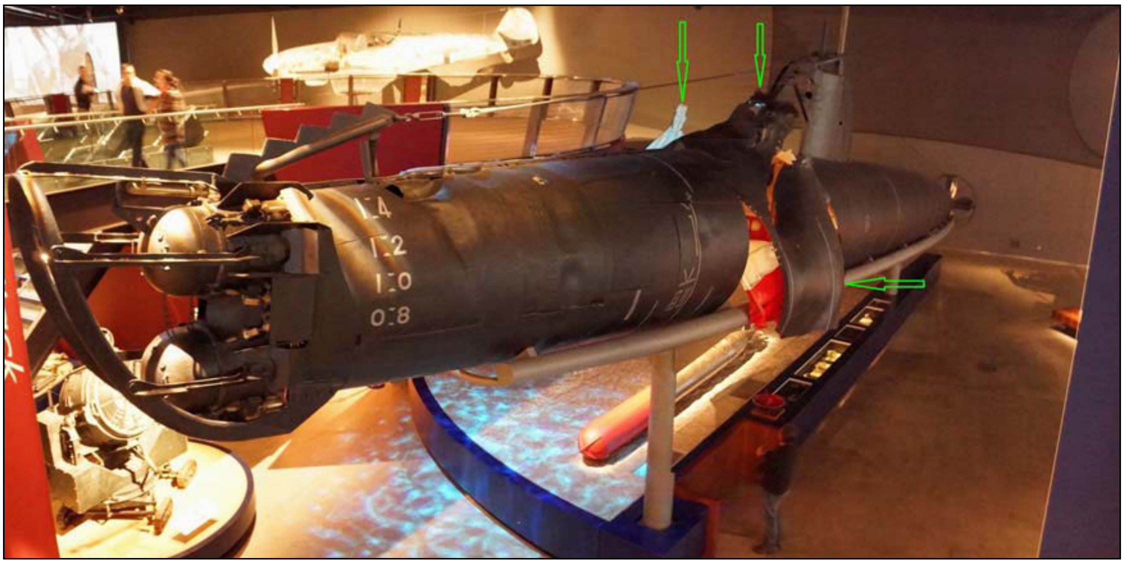


Figure 25: Bow section of *Ha 21* and attached hull of *Ha-14* hull looking aft. Note the evidence of upward explosion near conning tower (green vertical arrows) between frames 4-6 forward of the net-cutter. The athwart explosion is evidenced by a bulging/ bubbling with a distinct vertical line of the outer hull plates, which corresponds to frame 4 on the interior of the hull –see horizontal arrow. (Image: After Photomosaic by B. Duncan, Heritage Division).

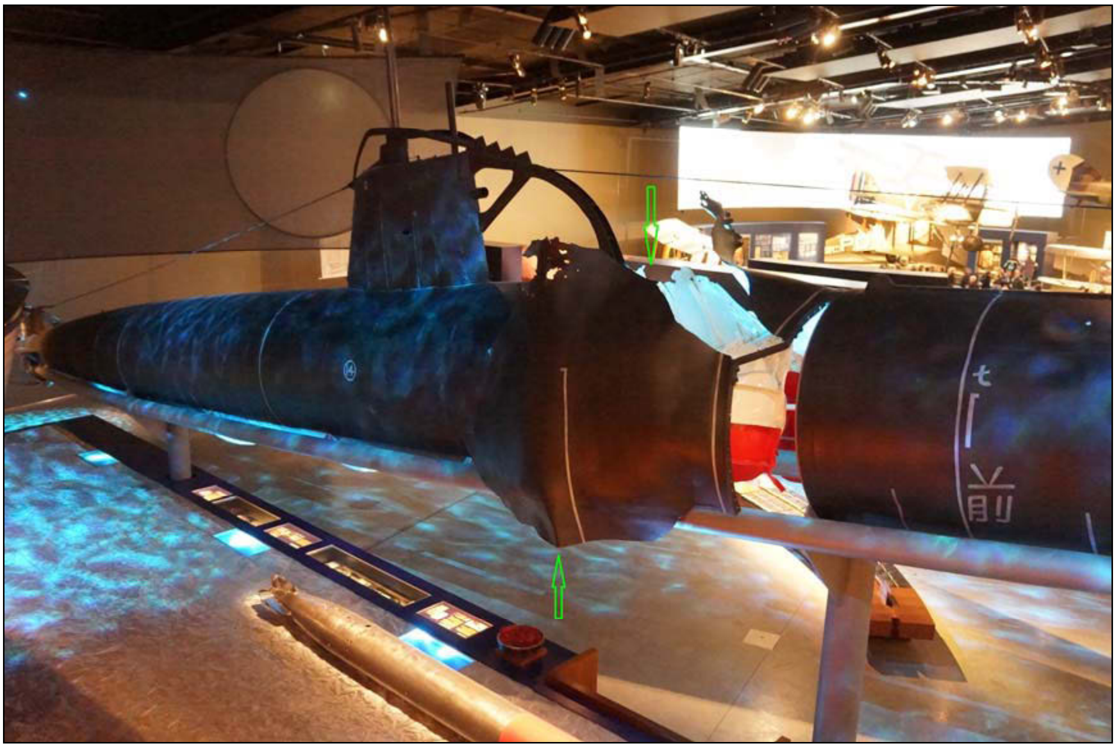


Figure 26: Hull of *Ha-14* hull looking aft on the starboard side. Note the evidence of upward explosion near conning tower (green downward vertical arrow) between frames 4-6. Note that shrapnel and upwards explosion is evident by protruding hull plate aft of the net-cutter frame (located above frame 4). The athwart explosion is evidenced by bulging/ bubbling line of the hull plate (Image: B. Duncan, Heritage Division).

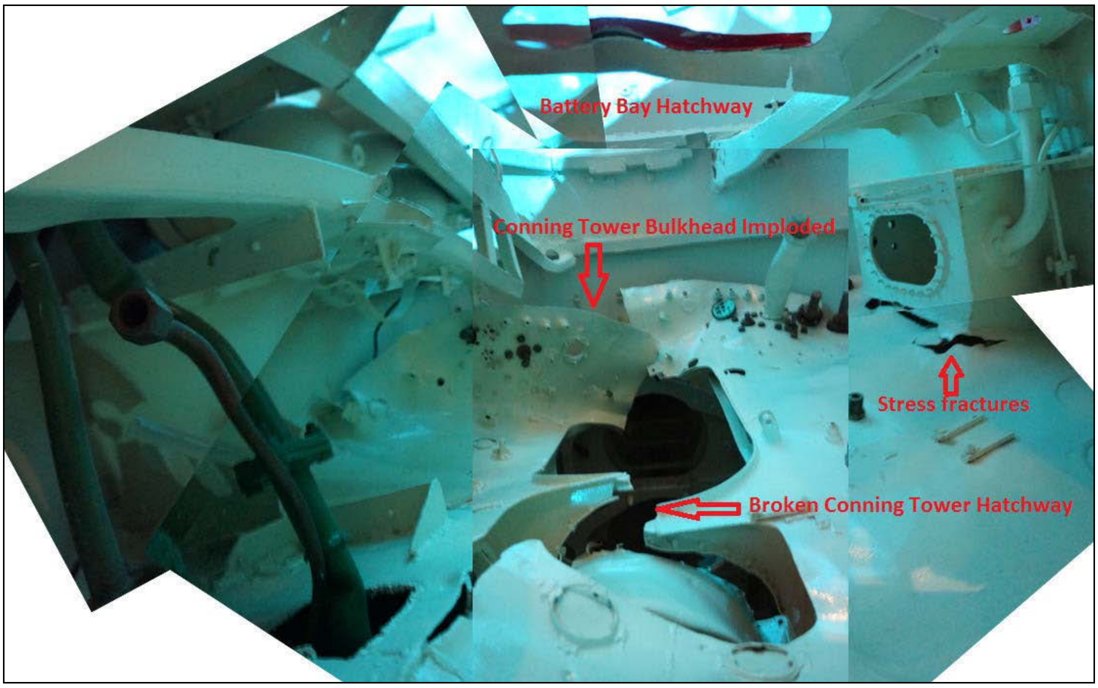


Figure 27: Conning Tower Bulkhead of Ha 14 looking through escape hatch in floor. Note extensive damage to the conning tower hatchway and bulkhead, where plating has become detached (Image: B. Duncan, Heritage Division).

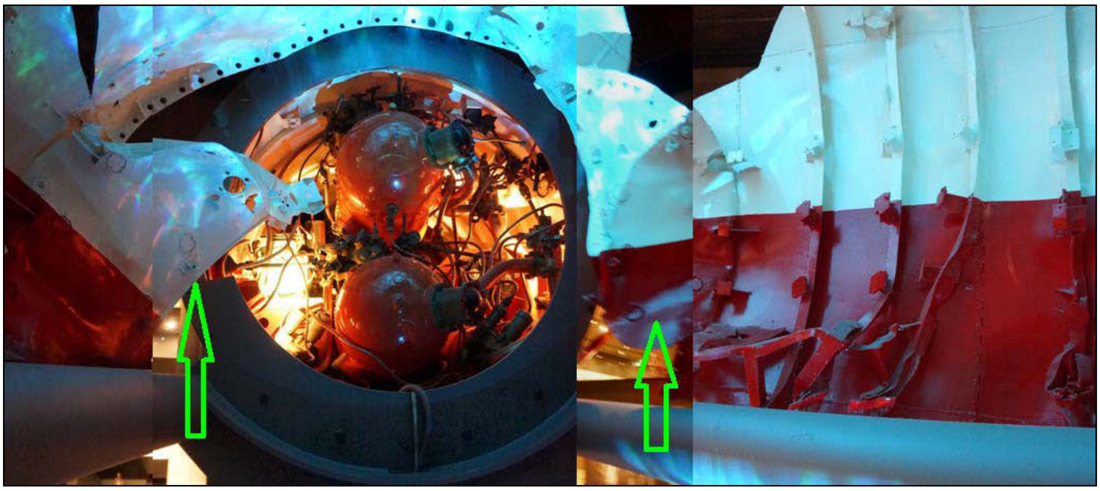


Figure 28: Torpedo Room Bulkhead remains as indicated by arrows (Image: B. Duncan, Heritage Division).

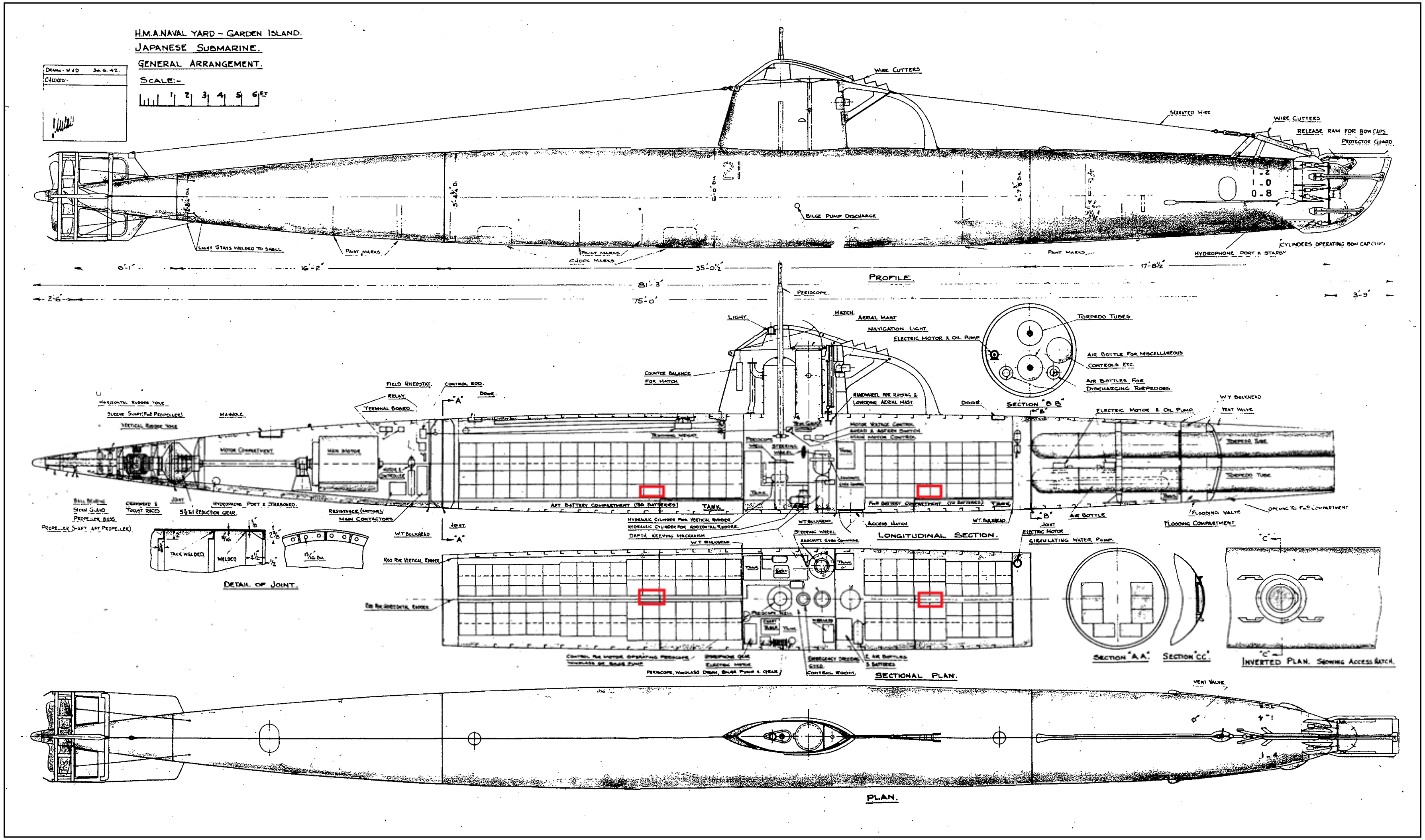


Figure 29: Interpretation of likely locations for demolition charges shown in red (Image: After plans held at Australian War Memorial, AWM54, 505/6/7, NAA # 485279).

vii. *Identifying the Composition of Demolition Charges from the Sydney Attack Submarines*

• Historical Accounts of Japanese Explosives

Limited information was initially available on the nature of the explosive charges in the captured *Ha* (A class) submarines. The known consistency of the Japanese torpedo warhead was 780 pounds of explosive consisting of forty five per cent Hexamite and fifty five per cent TNT [80]. However, a report on Japanese explosives from 1945 specifies that the Japanese used a great deal of trinitroanisol (TNA) and hexanitrodiphenylamine (HDNA) in their explosives, despite the health risk to their workers. Type 94 explosives were found to be the most powerful underwater charges (consisting of 60% TNT and 40% TMTNA). Tables 2 and 3 show the variety of charges available in the Japanese Navy [81].

The report notes that there are four types of manufacture of Japanese explosives: which were:

- Trinitroanuisol (TNA)
- Picric Acid
- Hexanitrodiphenylamine (HDNA)
- Trinitrotrinitramine

Of note are the Type 94 (consisting of 60% TNT and 40% TMTNA) which was used for hollow charges, grenades and torpedoes; Type 97 (60% TNT and 40% HNDA) and/or Type 98 (60% TNA and 40% HNDA) which was used for torpedo, bomb and depth charges; and common projectiles; or any of the charges in Table 2 which were used for mines or depth charges; all of which could have been used for the main scuttling charge. The priming charge was most likely to be Shimose explosives and Pa, Picric Acid which was used for priming charges. It should, however, be noted that the explosives listed in the 1945 report may not be the same as those being used when the Sydney midget submarines were originally fitted with ordnance in 1942.

Based on the tables outlined in the 1945 report (see Table 2), expert advice was sought from (former) Commander Damien Allan (MCDSPO Director of HMAS *Waterhen*), who speculated on the probable composition of the charges by examining known Japanese explosives available at that time. He concluded [82] that it was probable that the TNT in the charge was likely to contain impurities, and is therefore likely to exude. He was unable to speculate on how this would affect the charge if it was the main constituent, nor on the effects of the HNDA mix, particularly as there were inconsistencies regarding the shape, size and integrity of the penetrations into the charge which are currently unknown. In Commander Allan’s opinion, there was a very high probability that the scuttling charges will consist of either Type 88, Type 97 or Type 98 explosives (as outlined in Table One). Commander Allan's interpretation of the type of likely explosive contained in the charge was later proved correct when the official analysis of the demolition charge was later released by the Australian National Archives (see below).

---

[80] **(NAA #399556, p65: Doc. TOO 0938z/4, 4/9/1942)**: *Explosives filling for torpedo warhead is 780 pounds of following mixture: Hexamite: forty five per cent. TNT: fifty five per cent.*
[81] **US Naval Technical Mission to Japan 1945**: 1, 7
[82] **Allan pers comms 2009**

Table I
EXPLOSIVES USED BY JAPANESE NAVY

Name	Composition	Color	Employment	Sensibility Percussion Test (drop hammer) (cm)	Friction Test (kg)	Explosion Point (°C)	Explosion Point (Inst.) (°C)	Mortar Test (Relative)	Power of Expl. Specific Brisance (Relative)	Velocity of Explosion (m/s)	Loading Density	Melting Point (°C)
Type 91, TNA Trinitroanisole	OCH_3; O_2N (ring) NO_2; NO_2	Yellow	Armor-piercing Projectile	19	60	279	490-500	100	92	6600	1.60	64
Type 92, TNT Trinitrotoluene	CH_3; O_2N (ring) NO_2; NO_2	Light Yellowish Brown	General Machine gun Projectile	17	60	321	480-490	96	96	6900	1.59 (melting)	82
Tetryl (Tet) Tetranitromethylamiline	CH_3-N-NO_2; O_2N (ring) NO_2; NO_2	Bluish Yellow	25mm machine gun Priming charge Projectile	11	40-50	190	350	115	101	6900	1.50 (press)	130
Hexogen TMTNA Trimethylentrinitramine	CH_2; O_2N N C N NO_2; H_2 C N C H_2; NO_2	True White	For Type 94 Explosives	13		240			114	8380	1.60 (press)	200
Hexyl HNDA Hexanitrodiphenylamine	O_2N (ring) N H N (ring) NO_2; O_2, NO_2, NO_2, NO_2	Yellow	For Type 97 & 98 Explosives	17		250			90	7100	1.64 (press)	250
Pentrit TNPE Tetranitropentaerythrite	$C(CH_2NO_3)_4$	White	20mm machine gun	13	60	205		108	128	8400	1.60 (press)	140
Type 94 M	TNA 60 TMTNA 40	Yellow	Hollow charge granade Torpedo (abandoned)	13	40-50	216	430-440	112	107	7700	1.64 (melting)	178
Type 97 H	TNT 60 HNDA 40	Light Yellowish Brown	Torpedo & Depth Charge	14	60	302	480	92	96	7100	1.65 (melting)	
Type 98 H_2	TNA 60 HNDA 40	Yellow	Bombs torpedo & Depth Charge	14	60	264	490	96	100	7100	1.65 (melting)	
Type 2, Incendiary explosives B4	TNA 60 Al powder 40	Grayish White	Projectiles	17	60	300	500-505	64	82		1.90 (melting mixture)	
E	TNA 60 NH_4NO_3 40	Light Yellow	Bombs (not yet used)	19	60			108			1.60 (melting mixture)	
Simose explosives PA, Picric acid	OH; O_2N (ring) NO_2; NO_2	Yellow	Priming charge Common projectiles	12	60	303		100	100	7800	1.66 (melting)	122.5
A (ko)	TNT 60 HNDA 24 Al powder 16	Dark Green	Torpedo (not yet accepted)									
Pentryl	TNT 50 TNPE 50	Light Yellow	Aero G.M.T. Hollow charge									

1. Percussion Test: Weight of hammer 5 kg. Does not explode within height indicated. 2. Friction Test: Explosive will withstand the indicated value. 3. Mortar Test: Indicated value compared with picric acid.

8

Table 2: Explosives used by Japanese Navy (Table from: US Naval Technical Mission to Japan 1945).

Table II
AMMONIUM EXPLOSIVES USED BY THE JAPANESE NAVY

Name	Composition	(%)	Color	Sensibility Percussion Test (drop hammer) (cm)	Friction Test (kg)	Explosion Point	Mortar Test (relative)	Power of Expl. Spec. Brisance (relative)	Velocity of Explosion	Apparent Gravimetric Density
Type 88 K_0	Ammonium Perchlorate Ferrosilicate Wood Pulp Heavy Oil	75 16 6 3	Gray	17	30-40	430	100	100	3600m/s	1.05
Type 4, Mk 1 K_1	Ammonium Perchlorate Ferrosilicate Talc Chlornaphthalene	80 8 10 2	Grayish White	18	60	455	84	89	3600	1.24
Type 4, Mk 2 K_2	Ammonium Nitrate Wood Pulp Coal Tar	89 65 6	Grayish Black	34	60	470	82	70	3900	1.00
Type 4, Mk 3 K_3	Ammonium Perchlorate Ammonium Sulfate Ferrosilicate Chlornaphthalene	47 32 20 1	Grayish White	20	60	470	81	83	2900	1.20
Type 4, Mk 4 K_4	Sodium Chlorate(or potash chlorate) Petroleum	88 12	White	14	60	580	59	77		1.6-1.5 1.05
Type 4, Mk 5 K_5	Ammonium Perchlorate Ammonium Nitrate Ferrosilicate Wood Pulp Heavy Oil	55 29 10 5 1	Gray	28	60	450	81	92		1.05
Type 4, Mk 6 K_6	Sodium Chlorate Petroleum Wood Pulp	84 10 6	Yellowish Brown	17	60		67	78		1.3-1.4
Type 4, Mk 7 K_7	Sodium Chlorate Wood Pulp Coal Tar Wood Charcoal	84 5 3 8	Grayish Black	25	30	385	63	82		1.2
Type 1, Mk 1 P_1	Ammonium Picrate Aluminum Powder Wood Pulp Heavy Oil	81 16 2 1	Dark Green (Powder)	17	60	490	81	100	4280	1.16
Type 1, Mk 5 P_5	Ammonium Picrate Ferrosilicate Wood Pulp Heavy Oil	81 16 2 1	Dark Green	15	60	450	72	99	4100	1.16
Type 1, Mk 6 P_6	Ammonium Picrate Ferrosilicate Wood Pulp Heavy Oil	86 11 2 1	Dark Green	13	60	450	74	95	4620	1.13

(Note: All above explosives were used in mines and depth charges.)

9

Table 3: Ammonium based explosives used by Japanese Navy (Table from US Naval Technical Mission to Japan 1945).

• Report of Construction Details and Composition of the Demolition Charges from *Ha-14*

In August 2011, *M24* historian and researcher Steven Carruthers finally discovered the official report of the exact composition of the demolition charge recovered from *Ha-14* Japanese submarine, which had recently been declassified [83]. The full report (see Appendix Two) provided a detailed analysis of the recovered demolition charge from the *Ha-14*. The relevant following details of its construction have been extracted directly from the report below [Note: Historical figure numbers cited in the official text have been replaced with corresponding Figure numbers in this report]:

> *The appearance of the demolition charge as received is seen in Fig.* [30]. *The casing of the charge is of welded steel construction and a lug is attached to facilitate handling. At one end of the casing is a flange on to which a steel cover plate is held by eight bolts. A rubber gasket is present between the cover-plate and the flange. A central hole out in the cover takes a 2 ¼" internal diameter collar welded to the outside of the cover. This internal diameter enlarges to 3" at the outer end, leaving a shoulder against which a rubber disc and steel plate are held firmly by a cap (Fig.* [30]*), screwing on to the collar.*
>
> *Three lengths of safety fuze pass through the plate and rubber, and thence through the hole in the cover plate into the interior of the demolition charge. A 7/16th" dia. Steel rod 2 3/8th" long is welded centrally to the steel plate and has a small plate welded to the far end. Three slots in this plate take the safety fuse.*
>
> *The dimension of the casing are:-*

Length of body to cover plate	*18"*
External diameter of body	*10 ¼"*
Internal diameter of body	*10"*
External diameter of flange	*11 ¾ "*

> *Removal of the cover disclosed a perforated cardboard disk beneath which was the explosive filling (Fig.* [30]*). The filling consisting of preformed blocks covered with waxed paper, was built up into a hexagonal prism, and held rigid in the cylindrical casing by six shaped wooden strips (Fig 2. g). A cardboard disk was present between the base of the filling and the base of the casing.*
>
> *The filling was made up of two layers, the first being 11 13/16" deep and the second, at the base, being 5- 7/8" deep. In Fig. 3 some of the blocks have been reassembled to show the construction.*
>
> *The lower layer consisted of six blocks (Fig.* [32].*e) surrounding a central hexagonal sectioned block (f). The upper layer consisted of six blocks (a) of the same cross section as blocks (e). Filling the central hexagonal space were three blocks, a cylindrical block (b), and a large cylindrical block (c) and a hexagonal suctioned block (Fig. 2.d) with central cylindrical cavity into which (b) and (c) fit. This latter block is not shown in Fig. 3, but the space it occupies is shown.*
>
> *Small cardboard strips were present between some of the blocks at the upper surface of the filling to act as packing pieces.*

---

[83] **NAA# 400146 (1942-43)**: Davis D.J. 5/10/42: *Munitions Supply Laboratories, Report on Demolition Charge from Japanese Submarine Recovered at Sydney*, *Report E. & A.R. No. 35)*, Report From Naval Staff Office to Secretary Naval Board (Naval Office) 29 April 1943, No. S.A. 79/3/, Series MP 1049/5, Control Symbol 1872/2/161, Barcode 400146.

The dimension of the blocks are: -

- *Length of edges of cross section of blocks (a) and (e)* — *(2-7/16", 2-7/16", 2-7/16", (4- 15/16"*
- *Depth of blocks (a) and (d)* — *11-13/16"*
- *Depth of blocks (e) and (f)* — *5-7/8"*
- *Length of edges of cross section of blocks (f) and (d)* — *2-7/16"*
- *Diameter of blocks (b) and (c). and diameter of cylindrical cavity in (d)* — *3- ¾ "*
- *Length of block (b)* — *4"*
- *Length of Block (c)* — *7-13/16"*

(NAA #399556: p. 3).

The total weight of the explosive in the demolition charge is approximately 67 lbs; weight of steel container 35 lbs; wood packing plus 3 ¾ lbs. Total weight of filled container 104 ¾ lbs.
The central cylindrical block (b) serves as a primer, and is made of pressed, powdered Picric acid. Three holes in the upper surface [Figure 31] *take the detonators at the ends of the lengths of safety fuse. Although the detonators were not received with the demolition charge, they were stated to be of the commercial type. Block (d) is made of biscuit-cast Picric Acid, except for the upper portion which surrounds block (b). This portion is made of cast Picric Acid. The remainder of the blocks are made of cast Picric Acid made by the biscuit method.*

Figure 30: Side view of Japanese demolition charge, showing cover plate, safety fuse and collar (Image: After NAA# 400146).

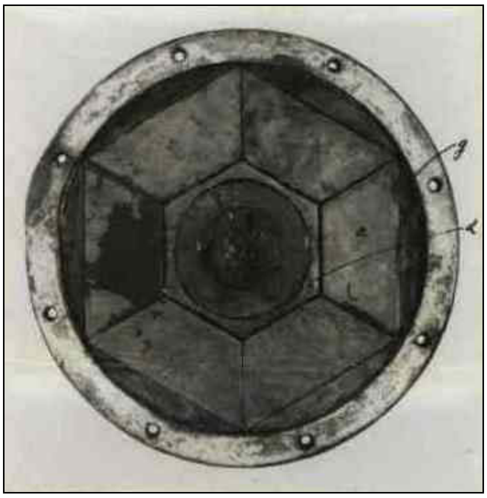


Figure 31: View of end of Japanese demolition charge after removal of cover, showing arrangement of blocks of explosive and wooden strips. Note rubber gasket on flange (Image: After NAA# 400146).

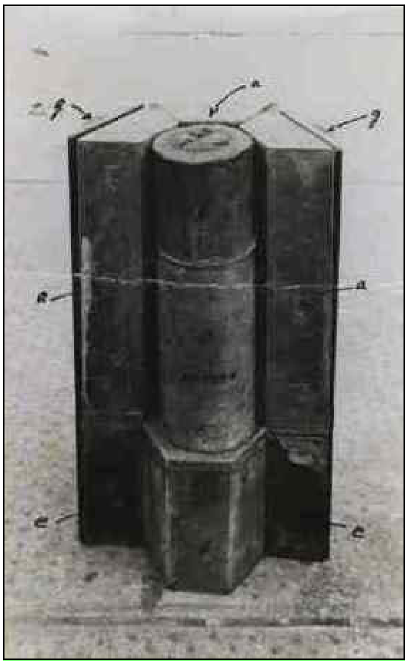


Figure 32: A portion of the blocks of explosives from the Japanese demolition charge, assembled, showing arrangement (Image: After NAA#400146).

Figure 33: Manufacture/ maintenance tag from scuttling charge (Image: After NAA# 400146).

This description of the Sydney midget submarines' explosive charges is very similar, (although smaller in design) to the charge recovered from the Pearl Harbour *Ha-19* submarine. Delgado (et al) [84] have observed similar trapezoidal shaped charges consisting of compressed picric acid powder were also found on the *I-24* submarine.

The charges themselves were therefore quite small, only 18 inches (45 cm) in length and 10 ¼ inches (25 cm) in diameter. Weighing a total of 104 lbs (47kg), they could have been manhandled by the two crew members quite readily. The existence of a single lug on the casing suggests that they may have been either lowered into the submarine interior by a rope and/or pulley through the conning tower, or alternatively could have been passed up through the bottom hatch from the mother submarine (no details are available as yet as to how the charges were loaded). The charges could then have either been manually (or possibly using the counterweight rail) either fore and aft to their designated position.

To better understand the configuration of the demolition charges, graphic artist and 3D specialist Gary Jackson (of Headland Creative) generated three dimensional visualisations of the demolition charges based on the NAA report description (see Figures 34, 35).

---

[84] **Delgado et al 2016.**

Figure 34: 3D representation of the explosives charge (Image: Courtesy Gary Jackson, Headland Creative).

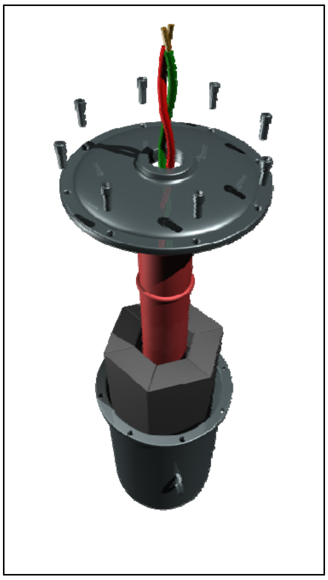


Figure 35: 3D representation of the explosives charge showing components of the charge (Image: Courtesy Gary Jackson, Headland Creative).

- **Expert Evaluation of the *Ha-14* Demolition Charge Construction and Composition**

Opinions were sought from several experts specialising in unexploded ordnance regarding the nature, composition and explosive potential of the demolition charges aboard the midget submarines engaged in the Sydney attack.

Robert Curran, a former logistics manager at Newington Armoury Explosives Depot, NSW provided the following interpretation of the charge based upon the specifications contained in the military report:

> *The scuttling, or demolition charge consisted of a welded steel cylinder, approximately 18" long by 11" diameter, with a removable cover plate and collar at one end, and a lifting lug centrally placed on the side. Three lengths of safety fuse were led from the exterior, through the cover plate and collar, into the interior of the cylinder. The interior end of each length of safety fuse terminated in a commercial-type detonator ("blasting cap") which would have been crimped to the end of the fuse. This is called a "capped fuse".*
>
> *The explosive charge consisted of an hexagonal prism arrangement of cast Picric Acid blocks, in 2 layers, with a central cylindrical "primer" block of pressed, powdered Picric Acid, recessed to accommodate the three detonators. Wooden spacers and cardboard packing pieces were used to fill the voids between the explosive charge and the cylinder. The total weight of explosive was approximately 67 lbs, and the total weight of the charge was approximately 105 lbs. Some of the Picric Acid blocks had been manufactured as long ago as 1917 and even 1903 in one case; this, together with the simple design, suggests that the charge was assembled from pre-existing materials. The primer block was of more recent (1939) manufacture so may have been cast specifically for use in this charge.*
>
> *The "explosive train" (i.e. the sequence of initiating events) would be familiar to any shotfirer, or person who has used explosives for agricultural purposes,*

and is about the simplest possible. The external ends of the safety fuse would be lit, and the flame would travel up the core of the safety fuse until it reached and initiated the detonator. The shock from this would detonate the primer block and the detonation would propagate throughout the entire explosive charge.

The presence of 3 lengths of capped safety fuse is presumably a "fail safe" device, against failure of up to 2 of the lengths to convey the flame to and initiate the detonator. Safety fuse is susceptible to moisture ingress, so the capped fuses may not have been fitted to the charge until the submarine was committed to operations. It is presumed that the 3 lengths were to be lit simultaneously. The method of lighting the safety fuse isn't apparent, however any flame source, such as a match or cigarette lighter, would suffice.

The length of the safety fuse used isn't known. Safety fuse of that era typically had a burning rate of 80 seconds per yard. If the external portion of the fuse was only as long as shown in the photograph of the charge in the Munitions Supply Laboratory report, the delay from lighting the fuse until detonation would have been in the order of 10s of seconds at most. However it's possible that the safety fuse had been cut short after recovery for convenience in handling, or that the method of lighting the three fuses (e.g. a multiple fuse igniter) involved some delay [85].

- **Blast Radius and Destructive Force of the *Ha-14* Demolition Charge**

Based on Curran's description, it is clear that the central core exploded first, thus initiating the sequence of the other charges, although the speed of the initiation sequence would have made any time differences in the sequence negligible, as observed by CMR Allan:

the length to diameter ratio of the charge was insufficient to make the shape of the charge a major factor in the nature of the damage, as there would have been an explosion front radiating normal to the cylindrical shape, as well as out of each end. The axis of the explosion is parallel with the axis of the submarine for what that is worth, but the charge length is still very short in relation to the length of the compartment. Overall, the charge has demonstrated itself as being very effective, with damage radiating along the axis of the submarine. Factors that may have had more effect on the nature of the damage may have been the way the canister split open, whether the ends popped first, the equipment and batteries in way of the explosion, and the internal pressure hull shape. [The] *control room may have been shielded to some extent by a heavy object, but the charge seems to be centrally located between battery banks. Maybe control room door was shut?* [86]

The damage observed in historical documents and the modern reconstructed Canberra display of the two submarine sections (including the forward battery room of the *Ha-14)* is consistent with this blast epicentre.

Therefore, based on the measurements from the two plans, the shape and construction of the charge, and the banana skin shape of the hull exploding outwards towards the torpedo room, it is likely that the charge was located slightly aft of the battery bay partition in the forward battery compartment between frames 3-5, and

[85] **Curran pers comms 2011**: Email from Robert Curran to Brad Duncan, 9/15/2011.
[86] **Allan pers comms 2016**: email to Brad Duncan 1/7/2016.

that the was charge lying down facing forwards with detonation point closest to the control room end (see Figure 29).

• The Historical Development of Shimose Powder

Shimose powder was developed by Masachika Shimose of the Japanese Naval Armaments Plant [87] [88] [89], as a more powerful variant of picric acid explosives, which had been used in different forms by the French (as melinite) and British (as lyddite [90]).

Shimose powder was manufactured from saltpetre and yucca palms sourced from Chile, the latter of which provided the picric acid component [91]. Shimose powder presented two great advantages of the new explosive: the high pressure and extreme heat of the blast. Furthermore, these characteristics were accentuated by replacing the former thick jacketed armour piercing (AP) shells (used in battleships with new thinner skinned ordnance known within the navy as *furoshiki* shells, which allowed more explosives to be placed within a shell thus producing a greater bursting effect. This technology was put to use by the Imperial Japanese Navy in 1893, and was used with great success in the 1905 Russo- Japanese War, where it played a major role in the devastation of the Russian Fleet at Port Arthur and the Korean Straits [92].

Shimose explosive powder was easy and cheap to manufacture, exempt from the long term effects of humidity which caused instability [93], and relatively safe when compared to other unstable explosives available at its time of invention (e.g. guncotton and blasting gelatine). The explosive powder was not subject to explosions caused by striking with iron hammers or bullets, or by ignition, but would burn like turpentine in these cases and could be extinguished by water. When combined with saltpetre, it produced military grade explosive, whose blast was second in power only to American gelignite. Demonstrations by Shimose of the bursting blast produced by his powder within an armour piercing shell penetrated two inch thick armoured deck plating by producing thousands of shrapnel fragments from the shell capable of penetrating steel [94] [95].

• Analysis of the Demolition Charge

Picric Powder is a mixture of 43% ammonium picrate and 57% potassium nitrate. It is a prepared by mixing the finely ground ingredients in a dry state. This bright yellow crystalline substance is more sensitive than picric acid, and will ignite from a flash and burns rapidly to detonation. Its chemical stability is good if it is kept dry. Picric powder will react when in contact with metals. Picric powder is used as an exploder in certain lyddite filled shells when the explosion is brought about by means of a flash from gunpowder and not by a detonation system [96].

Delgado et al's [97] investigations into Shimose powder observed that it:

---

[87] **National Diet Library 2004.**
[88] **Tuapeka Times 31/5/1904**:4.
[89] **Wanganui Herald 14/9/1905**:4.
[90] **Wikipedia 2010** citing **Kowner 2006**: 363.
[91] **The New York Times, 31/12/1907:1**
[92] **Evans and Peattie 1997**:63.
[93] **Wanganui Herald 1/9/1905:**4
[94] **The *Advertiser* 24/1/1905**:8
[95] **The *Age* 31/5/1904**
[96] **Admiralty Naval Ordnance Department 1945**:9
[97] **Delgado, James P., Kerby, Terry, Van Tilberg, Hans K., Price, Stephen, Varmer, Ole, Cremer, Maximillian D., and Matthews , Russell, 2016,** *The Lost Submarines of Pearl Harbour: The Rediscovery and Archaeology of Japan's Top-secret Midget Submarines of World War II.*

[was] *also known as picric acid, it is a trinitrated derivative of phenol or trinitrophenol* [98]*. The Imperial Japanese Navy adopted Shimose powder in 1893 and commenced manufacture of it in naval facilities after 1897. It was a highly effective, powerful explosive with greater effect than TNT. A common artillery shell filled with 1.70 kg of Shimose exploded with an effective radius of 18 m* [99]*. The empirical formula is* $C^6H^3N^3O^7$ *and Shimose generates 826 l/kg in explosive gas volume, with the heat of explosion being (*H^20 *liquid) 822 kcal/kg = 3437 kJ/kg, (*H^20 *gas) 801 kcal/kg = 3350 Kj/kg, a specific energy of 101 mt/kg = 995 kJ/kg, a specific heat of 0.254 kcal/kg = 1/065 kJ/kg, and a deflagration point of 300° C = 507° F* [100]*.*

- **Fuses and Detonators**

Curran [101] suggested that although the charge may have been fitted for the use of more than one fuse type for detonation, it may not have been fitted with all of them prior to the final launching of the submarine. He has suggested that it is extremely unlikely that the fuse type was altered during the operation (as this would have involved unscrewing eight bolts, removing other awkward parts and the detonators and then replacing all - this to be done whilst the crew were preoccupied with navigating and operating the sub. So the decision on method (electrical or safety fuse) would have been made before deployment.

Curran [102] further suggested that an electrical method to initiate the capped safety fuses was also a viable method to ignite the charge. He has suggested that if this was the method used, the following sequence may apply (as opposed to ignition of the safety fuse via a match);

- 4 x 1.5v, 2.5 Ampere dry cells in series
- a hand operated switch or a time switch
- a fuse
- The Japanese were also known to have used electrically operated demolition clocks (also known as time switches) to ignite fuses, and it is possible that these were also used for ignition of the charge.

A document later provided by Matthew Skelhorn (Wreck Researcher, Salvage and Operations, UK Ministry of Defence) confirmed this prediction:

> *The temporary electrical demolition charge ignition system consisted of 4 1.5v., 2.5 Amphere dry cells in series which ignited a fuse via a hand operated switch and a time switch …The Demolition charges were very temporarily wired in ordinary twin flex (23/ 0076")* [103]*.*

The clockwork mechanism was activated by a switch in the Control Room, which was powered by four special dry cell batteries, and these initiated the firing of the explosives charges [104].

The demolition charge report [105] stated that three lengths of safety fuse were identified passing into the charge. Curran [106] has speculated that although the clock

[98] **Lacroix 1997**:763.
[99] **Lacroix 1997**:239.
[100] **Meyer et. al. 2002**:256-257.
[101] **Curran pers comms 2011**: Email conversations and advice to Brad Duncan; 14/9/2011.

[102] **Curran pers comms 2011**: Email conversations and advice to Brad Duncan; 14/9/2011.
[103] (**ADM 1/17012, p.22):** Report on Japanese Submarine (Electrical).
[104] **(AWM MP1049/2, (1942), Sheet No. 30):** *Technical Report on Japanese Midget Submarines (Excluding Reports on Wireless and Electrical Equipment – Dealt with Separately). Garden Island, Sydney, July 1942. Copy No. 4. A switch in Control Room fired them through a clockwork operated delay. Four special dry cell batteries, operated the firing of the charges.*

may have been capable of igniting more than one length of safety fuse (as a failsafe mechanism), it is possible that one fuse was electrically operated, with the others rigged for manual ignition using a safety match in the event that the electrical initiation failed. The lengths of the remaining fuses may have varied dependent on whether the charge was to be exploded from outside the submarine (in the case of the crew exiting during rendezvous with the mother vessel), or to be detonated by the crew inside the vessel (if the submarine was in imminent danger of capture).

Regardless of the method used for the initial ignition (electrical or manual), both would have been affected by the influx of water into the vessel, which may explain why the *Ha-21* never exploded and why the *M24* is currently intact (as the fuses or electrical system may have been water damaged). An alternative explanation for the lack of explosion at *M24* site is that the crew did not want to give away their location in such shallow water (54m).

These observations have potential implications for the assessing the probable length of safety fuse present in the *M24* submarine. If the above scenario is correct, it is reasonable to expect that the *M24* carried a similar amount of safety fuse to that carried on the Pearl Harbour midget submarine, whose exterior detonation safety fuse was 50 ft (15m) long. The overall distance between the likely ignition point within the *M24* submarine (the top of the conning tower) and the battery compartment is approximately 17ft (5.18m) (approx. 12ft [3.6m] top tower, 2ft [0.6m] to the control room compartment and 5ft [1.5m] to demolition charge in battery room), and it is likely that this was the maximum distance for the two lengths of safety fuse (the distance may have been shorter if the interior manual detonation cord ignition point was located inside the battery room). Assuming the above speculated combination of fuses are correct, and allowing at least another 6ft (2m) for leeway in case the charges were actually located further inside the battery compartments or the safety fuse cord extended further outside the conning tower than anticipated, then it is likely that a maximum of approximately 25 ft (7.5m) of safety fuse per charge = 50 ft (15m) total is contained on the *M24* submarine. Commander Allan has estimated that the weight of the safety fuse would be insignificant – possibly less than 1kg.

Curran estimated that although there are two types of Japanese safety fuses from WWII, each of which are different colours and diameters, both have a burning rate of 32 seconds per foot (9.6m/s). This burning rate equates to around 27 minutes for a 50 ft (15m) fuse, which would have been long enough for the crew to depart and for the parent submarine to move to a safe distance. In cases where a shorter burn time was required, the fuse could be cut accordingly [107].

Curran has further speculated that the statement from the report: "the demolition charges were very temporarily wired in ordinary twin flex (23/0076)" [108], identified as the fifth and lowest class of electrical cabling within the submarines" indicates that the flex may have been used to lash the charges in position in lieu of rope" [109]. This observation might explain the presence of electrical cabling associated with the charge, which is also visible in contemporary historical photographs of the charge (See Figures 13 and 14).

---

[105] **NAA # 398841, p41**: Doc. 496: 11/6/1942, p. 1: *Notes on submarines captured in Sydney Harbour: Two demolition charges are carried in each submarine, 1 fore and the other aft* [the following text was removed by official wartime censor]*, and packed in a round canister, 2 fuses to each, 1 electrical contact and 1 match.*

[106] **Curran pers comms 2011.**

[107] **Curran pers comms 2011**, email to Brad Duncan, 15/9/2011.

[108] (**AWM # PR89/172, p.6**): "*the demolition charges were very temporarily wired in ordinary twin flex (23/0076)*".

[109] **Curran pers comms 2011**: Email to Brad Duncan, 9/15/2011

The structure of the canister raises further consideration of whether it has remained intact during its immersion since the submarine was sunk. Curran speculates that as the entry point of the fuse or wiring into the charge case through the rubber cap which leads onto waxed cardboard is an inherent weak point in the sealed vessel, he conjectures that it is unlikely that the container has remained waterproof [110]. This observation may have implications for the explosive potential of the charge (which will be discussed later in this report).

- **Composition of Fuses and Detonators**

Speculative advice as to the nature of the detonators used in the device has been provided by Commander Allan (formerly of HMAS *Waterhen*). Prior to the discovery of the official examination document, CMR Allan speculated that previous references to Japanese demolition and booby trap charges in general usually refer to standard commercial type detonator options. He further suggested that there were four types of fuses probably used to ignite the explosive charges, as the historical references all discuss battery packs, timers and match lit fuses:

- ***Safety or Match Fuse***:
  The standard safety fuse was likely to have used gunpowder (also known as black powder), which would have deteriorated some time ago in water. Japanese mechanisms were known to use pentaerythritol trinitrate (PETN) in match fuses. Safety fuses were often burnt to a Mercury Fulminate /PETN/CE detonator.

- ***Electrical Fuse***:
  In an electrical mechanism, powdered gun cotton was most likely used as an initiator. Gun cotton is likely to decompose to safe condition over time if in presence of moisture. If any detonation cord were used to detonate the charge, then it would have used PETN.

  However, some Naval electrical detonators use picric acid as the exploder. Over time, Picric acid demonstrates a higher likelihood to become neutralised if it has been exposed to water for a long period. Further problems arise if the container has remained watertight and the picric acid has reacted container material. In the case of the Sydney Midget Submarines, the container of the scuttling charge is made of steel. Although it is generally known amongst defence force personnel that heavier elements (e.g. iron) will produce sensitive by-products, and that light elements (e.g. aluminium and tin) will remain stable, the effects of copper or zinc, on degrading explosives are not widely known. Similarly, there is little information available regarding the effects of currently watertight degrading detonators.

- ***Percussion Fuse***
  Percussion fuses are those ignited by a trigger striking action which ignites a small explosive charge, often within a cap [111]. These fuses are probably made of Mercury Fulminate, which are likely to decompose to a safe condition over long period of time in presence of moisture. Although these types of fuses have not been mentioned in the official demolition charge report [112], it may be possible that they were used on board the *M24* if there individual/ preference variation between whoever was setting the charges.

- ***Detonation Cord***

[110]**Curran pers comms 2011**, email to Brad Duncan, 15/9/2011.
[111] **Wikipedia 2011a.**
[112] **(NAA# 400146)**

Any detonation cord used in the submarines was likely to have been PETN, although it is unclear what may have been used in the Sydney midget submarines, in general any historical references to the Japanese demolition and booby traps refer to standard commercial type detonator options. Delay timer clocks tended to be used in conjunction with electrical or mechanical (percussion) fuses.

- **Explosive Potential of the Demolition Charges**

CMR Allan has pointed out that, even assuming that the main charge may be intact and stable, the condition of the detonators may not be. He has suggested that the best case scenario is that both charges have corroded exposing the explosives to seawater some time ago, and that the explosives themselves have decomposed and become inert. The worst case scenario is that the charges have remained watertight within the external casing in good condition, meaning that the internal charge has potentially become chemically unstable, making them sensitive to rough handling. Furthermore if the detonator used in the scuttling charge was Picric acid, this substance in contact with steel presents a potentially volatile combination. Similar observations have been made for picric acid in munitions shell casings aboard the *Royal Oak* shipwreck in the UK:

> *It is feasible that if the shells have corroded allowing ingress of water, which is very possible, the water will de-sensitise the energetic materials and in the case of picric acid fillings dissolve them as these are of relatively high solubility in water* [113].

Examples from other UXO assessments provide notable analogous assessments in regards to detonators. In his comments regarding explosives contained in the torpedo of the British E-Class *AE2* submarine, Turner [114] cited evidence provided by shipwreck conservation scientist Dr Ian MacLeod's report on the effects of time and sea water on the torpedo and its constituent parts. He concluded that:

> *The risk of the detonator being able to detonate is low. The risk of the tube being dry is low. The probability of a TNT warhead having suffered biodegradation (rendering it inert) is high.*

This report stated the risk presented of an explosive shock from igniting the warhead was 10%.

Only further onsite research will be able to gauge whether the remaining charges on *M24* are volatile or rendered mute from the effects of salt water corrosion. Of critical concern is the exact nature of the canister that housed the explosives and whether it has leaked or flooded. This aspect is examined in further detail below.

[113] **Liddell pers comms 2012**, after **Albright 2012** p. 78.
[114] **Turner 2007a**:2.

b. *Pistols on the Sydney Attack Midget Submarines*

i. Flare Gun (Very Pistol) and Cartridges

There are three documents that mention the presence of a 3 barreled Flare Gun (Very pistol) recovered from *Ha-14* [115] [116] [117]. A detailed description of the Very pistol was given:

> *One Japanese ensign recovered and one Verey pistol. Pistol has three barrels, one painted white one painted red and yellow, one painted green and possibly another colour may be blue with selective trip hammer. Cartridges have also been recovered* [118].

No report has been discovered which has analysed the Very pistol, despite it being sent to the Gunnery School (at Sale or Mildura, Victoria - this was not specified in the document) and the cartridges to the Assistant Armament Supply Officer at Maribyrnong, VIC for examination [119].

It is likely that the Very pistol mentioned was a triple barreled 28mm Type 90 signal pistol, which had a large lever at the rear which was turned to select which barrel would be fired Figures 36, 37). Three versions of this gun were produced for the Imperial Japanese Navy by Kayaba Kogyo K.K. This type of pistol had a hammerless spring buffer to lessen recoil when fired. The pistol was produced between 1930 through 1945 in three basic variations [120] [121] [122]. Note: Very pistols were often also incorrectly called "Verey" pistols[123].

Price [124] provides the only available evidence found on the nature of 28mm Japanese signal pistol (flare) cartridges that could be accessed during this study. The Japanese called flares attached to parachutes "Dragons". Dragons came in a wooden box of 30 shells (built with timber nails, felt cushions and two timber cartridge supports. Cartridges could also be carried in the field in a purpose built canvas web waist strap belt which held 18 cartridges (although it is unclear from the Australian records if a box of shells were recovered or only shells contained within the gun itself). All cartridges had brass bases, no grooves and all closure plugs were marked *Dragon*. Only yellow *Dragons* evidenced a Naval mark, which was not present on the white Dragon shells; suggesting that the shells he investigated had been refilled by the Imperial Japanese Navy [125].

---

[115] (**NAA #399556, p.17**: Doc. TOO 0725z/11, 11/6/1942): *My 0945/10. Bow portion of submarine No. 14 recovered today Thursday AM. Bow Completely intact with torpedoes in tubes and bow caps on. One Japanese ensign recovered and one verey pistol. Pistol has three barrels, one painted white one painted red and yellow, one painted green and possibly another colour may be blue with selective trip hammer. Cartridges have also been recovered.*

[116] (**NAA #399556, p50**: Doc. TOO 0445z/22, 22/6/1942): *Verey pistol recovered from H21 being forwarded to NOC FHD for examination by Gunnery School.*

[117] (**NAA #399556, p35**: Doc. TOO 1151z/15, 15/6/1942): *Verey pistol sent to Capt Superintendent of training for examination by Gunnery School. Cartridges to Assistant Armament Supply Officer Maribyrnong for examination of explosives.*

[118] (**NAA #399556, p17**: Doc. TOO 0725z/11, 11/6/1942).

[119] (**NAA #399556, p35**: Doc. TOO 1151z/15, 15/6/1942).

[120] **Schlickman and Carlisle n.d.**

[121] **Bryant 2008.**

[122] **Price 2004.**

[123] **Allan pers comms 2010-2016**: Email to Brad Duncan 6/6/16.

[124] **Price 2004.**

[125] **Price 2004:** 5-7.

Figure 36: Triple Barrelled 28mm Type 90 Japanese Signal pistol Type 3 (Image: Courtesy Teri Byrant, http://members.shaw.ca/ursacki/fgtype90triple3vpix.htm).

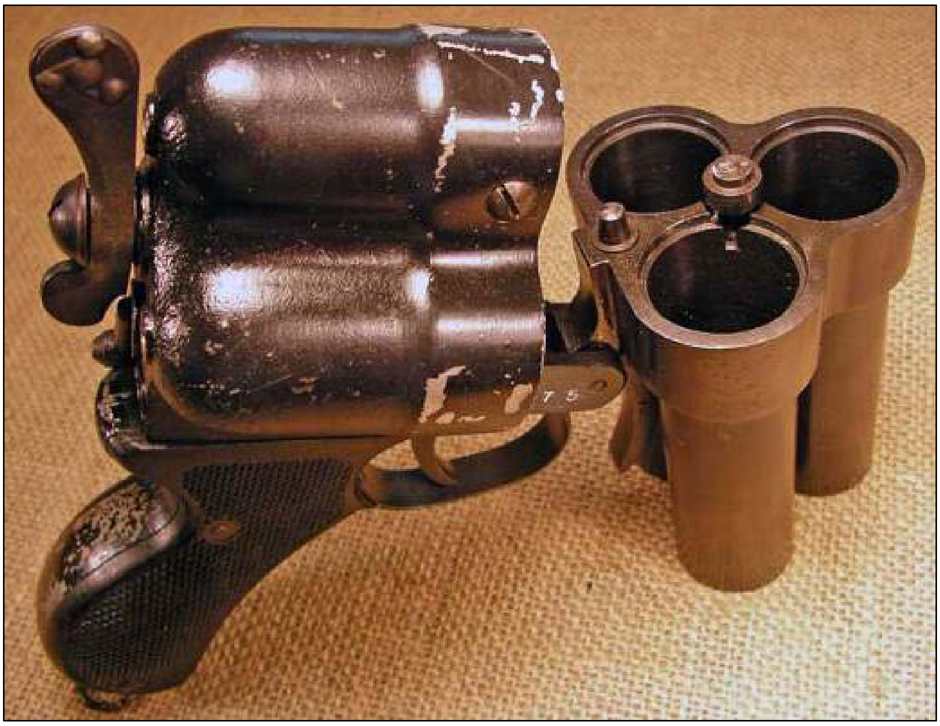


Figure 37: Triple Barrelled 28mm Type 90 Japanese Signal pistol Type 3 (Image: Courtesy Teri Byrant, http://members.shaw.ca/ursacki/fgtype90triple3vpix.htm).

Cartridges were one of two types: A *Star* shell or *Dragon* shell, and both types were produced in various colours. Star shells were manufactured with multiple and single shells which ignited about 100ft from above its firing point and produced a streak of coloured light across the sky when fired. *Dragons* used a parachute to float the suspended burning flare. All cartridges used a battery cup percussion igniter system, similar to primers used in a shotgun shell [126].

Price [127] references the only known historical military report that provides a qualitative assessment of Japanese WWII signal gun cartridges (*Japanese Explosives Ordnance: Signal Cartridges* by USN Mobile Explosives Investigation Unit No. 1) which were based on a Type 97 Very pistol. The size of cartridges for the Type 97 gun were 3 ¾ inches x 1/16' base diameter. Table 4 summarises the colour wrapping codes against observed flame colour when fired at night.

Wrapping Colour	**Type Cartridge**	**Flame Colour**
Green		Blue - White
Green	B	Blue- Green
White	L	Lavender
White	K	Bright White
Red	J	Red
Red/ White	A	Two Pellets: Red flame and green flame

Table 4: Colours of flare wrapping identification compared to flame colour.

It has been suggested by Price [128] that the differences in the colour composition of the observed fired rounds during these tests might indicate that the Japanese were relying more on the number of rounds being fired than the consistency of the flame colours. However, the differences in colour for the same wrapping might also be explained by differences in storage humidity conditions (and subsequent deterioration of the charge) and inconsistencies when mixing compounds between factories. There are many Western examples of different flare colours being used to signify different events (e.g. blue flares meant distress signals [129]). However, Price noted that there were at least 9 known different colour codes for cartridges for the Japanese 28 mm Very Pistol (Figure 38), and that the colour of the flame and smoke were both significant for signaling during night and day operations respectively [130]. He suggested that although the US Navy coded their cartridges by the flame colour they produced at night, the inconsistency in flame colour, along with Japanese prominent reference to smoke colour in pyrotechnic devices, indicating that they were primarily designed for use during the day? [131].

Based on the colours painted on the side of the gun as described in the National Archives record [132], it is likely that the composition of the three flares cartridge types were: Type B, L and K cartridges. It is possible that the yellow red markings either indicated a Type A cartridge (where the white paint has deteriorated) or a variation of it which used yellow and red flames.

[126] **Price 2004**:7.
[127] **Price: 2004**: 8.
[128] **Price 2004**:9.
[129] See **Duncan 2006**: 224, 227, App. F-4.30.
[130] **Price 2004**: 17-19.
[131] **Price 2004**:20
[132] **NAA #399556, p17**: Doc. TOO 0725z/11, 11/6/1942: *...One Japanese ensign recovered and one Verey pistol. Pistol had three barrels one painted red and yellow, one painted green and possibly another colour may be blue with selective switch hammer. Cartridges have also been recovered.*

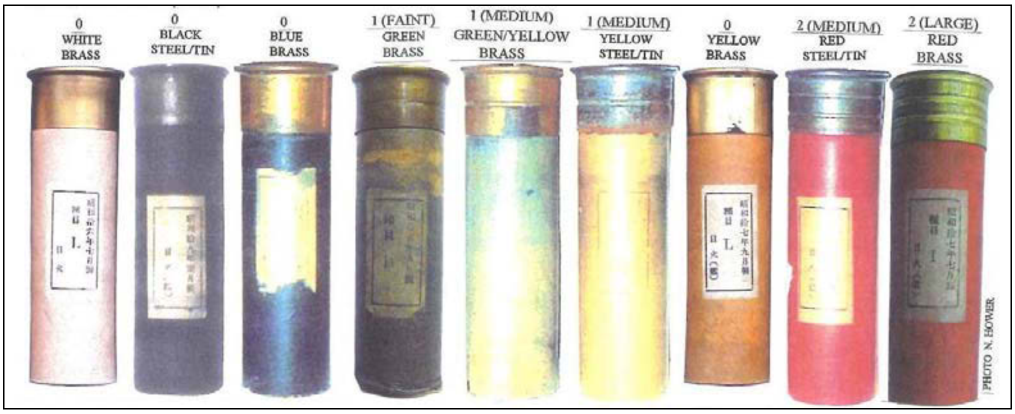


Figure 38: Varieties of 28mm Japanese Very Flare Cartridges (Image: After N. Hower in Price 2004: 13).

All 28 mm signal cartridges consist of a colour coded case, base, primer, closure plug, label, an internal expulsion charge and the signal shell/s. The cases are pressed paper tubes with one open end and a compressed cup shaped of approx. 1/16" thick. A cup filler piece (with a central hole at the base) fits into the interior of the case and aligns with the primer hole. This cup filler contains the *Star* or *Dragon* charge, which is ejected from the pistol on firing, with the base plate and filler cup retained in the gun. The thickness of the closure plug, which is inserted into the open end of the charge, determines the height at which the shell is launched to (as it contains the explosive force of the discharge for longer dependent on its strength. A hard clear seal covering the closure plug seals the unit, and is marked as *Dragon* if it is that type of cartridge (Figure 39). The primer is typical of those used in shotgun shells today [133].

The active explosive ingredient in the flare shells and primer ingredient is 21.3 and 260 grains FFFF g of black powder respectively [134]. Distinctive Flare colours would have been generating by mixing different chemical compounds with the explosive such as:

- Green: Barium + Chlorine producer;
- Red: Strontium or Lithium salts;
- Silver: Burning Aluminum, Titanium or Magnesium powder or flakes
- Yellow: Sodium compounds [135]

Another technical report [136] on a group of Japanese 50mm Very pistol cartridges captured at Hollandia Dutch New Guinea was undertaken by the 98th Chemical Service Company are of relevance here, and recorded Black and Yellow Dragon types. They observed that the cartridges consisted of: paper labels; cork disc; projectile; felt spacer; and propelling charge (see Figure 40). The propellant composition was recorded as being:

<u>Black Dragon Smoke Mixture</u>

- Potassium Chlorate 51%
- Napthalene (by difference) 36.6%
- Antimony Trisulfide 7.2%
- Inert matter, mainly rust 5.2%

---

[133] **Price 2004**: 11-16.
[134] **Price 2004**:26-29.
[135] **Science Notes 2016**
[136] **AWM # 54/179/1/25 (1945),** *T/Sgt Robert Jackson 17 August 1945, Laboratory Section, 98th Chemical Service Company, Captured Material Technical Report No. 4 Japanese Very Type Smoke Signal Cartridges.*

Yellow Dragon Smoke Mixture

- Potassium Nitrate 28.5%
- Sulfur 13.7%
- Arsenic Disulfide 56.7.2%
- Moisture 1%

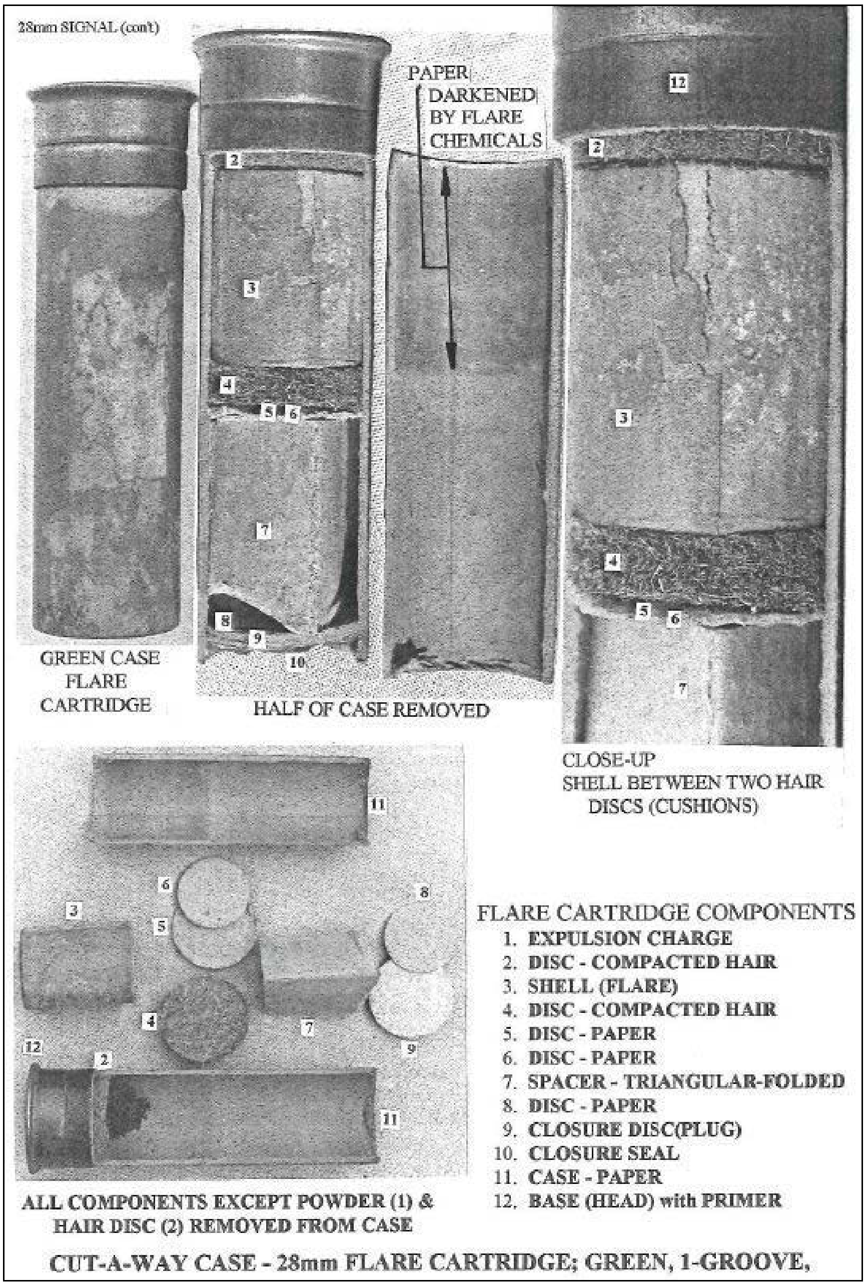


Figure 39: Japanese 38mm Very Flare Pistol Cartridges (Image: After Price 2004: 25).

The study also recorded that Black Dragon's produced thick black smoke which burned for ten seconds, whereas Yellow Dragons produced orange smoke near the combustion point and produced yellow smoke as it spread and lasted for 2 seconds. Figure 41 showed the interior of a Japanese Very Smoke signal cartridges.

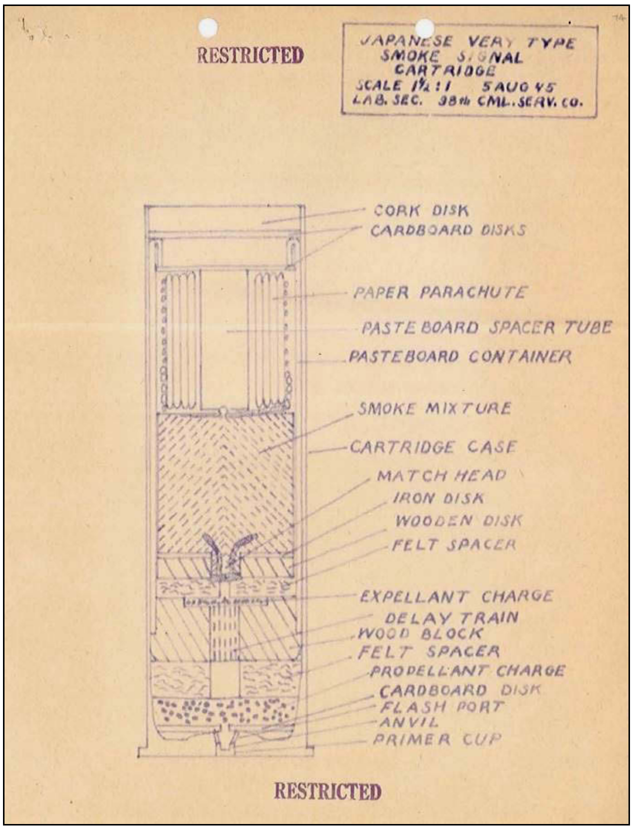


Figure 40: Composition of Very Smoke Signal cartridge (Image: from Very Round Pistol Report - Hollandia AWM #54 179/1/25).

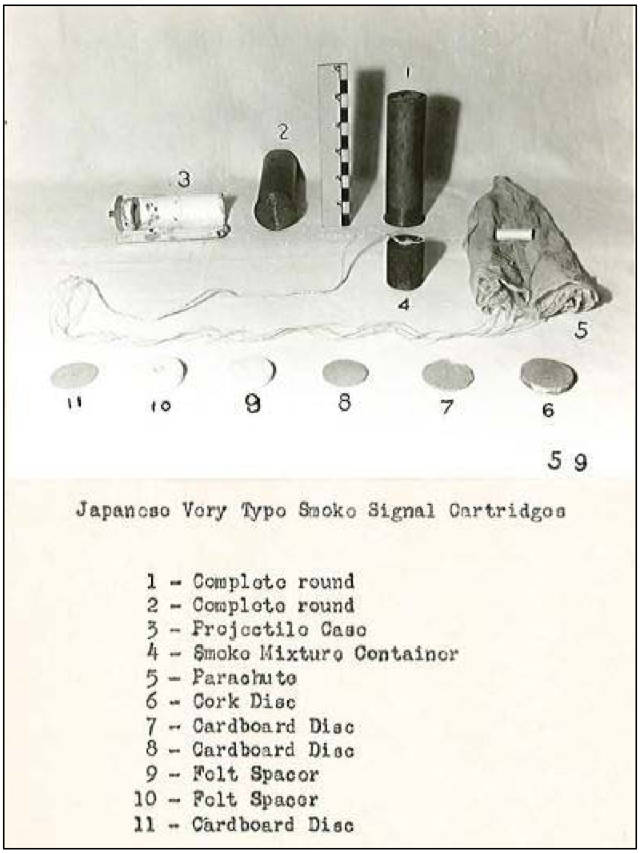


Figure 41: Physical composition of Japanese Very Smoke Signal Cartridge (Image: from Very Round Pistol Report - Hollandia AWM #54 179/1/25).

ii. Nambu Service Pistol and Cartridges

One service pistol appears to have been issued to each officer on each midget submarine. This was used as a self-defense weapon or to commit suicide when capture of the vessel was imminent [137] [138]. The service pistol in *Ha-14* was found in the conning tower with the officer [139]. Figure 42 shows the Nambu Type 14 pistol and size of round on display at the Australian War Memorial.

Although no information on the type of pistol was found in the official historical reports, the Australian War Memorial holds one of the pistols in its collection, which is a semi-automatic 8mm, eight-round, Nambu Type 14 service pistol. Six of the original cartridges were still intact, and two had been discharged by those aboard to commit suicide [140]. The rounds for this pistol were low velocity (underpowered) and fired an 8mm cartridge [141], suggesting the propellant charge was low.

The 8mm Nambu was the standard Japanese service round as it fit many types of pistols and the Type 100 submachine gun. Although Japanese 8mm rounds came in 15 round boxes which would fit into a holster, it appears from the AWM collection that only 8 rounds were carried on board inside the pistol itself, which has been confirmed by Skennerton's [142] *Handbook of Japanese Service Pistols*. The round contained 0.29 grams of smokeless black powder or 4.5 grains [143]. The cartridges used a nitrocellulose propellant[144]. Japanese 8mm rounds typically were 1 ¼ inches long, with a 19/32 inch long projectile weighing 103 grams [145] (see Figure 43). Figure 44 shows a sectioned round with the projectile head, powder grains and primer cup.

---

[137] (**NAA #399556, p18**: Doc. 0043z/13, 23/6/1942): *Both submarines contained 2 repetition 2 bodies with revolver wounds in the Head.*

[138] (**NAA #413209, p. 27,28**: Doc. BS1749/201/37, 16/7/1942, p.3-4): *Midget 21: Both members of the crew had been shot through the head; demolition charges had been fired but the fuzes were drowned.*

[139] (**NAA # 398841, p41**: Doc. 496: 11/6/1942, p. 1): *Notes on submarines captured in Sydney Harbour: One submarine was blown up from inside by demolition charge…All electric wiring made of very heavy brass. …Interesting to note that of the two men found in the submarine one was an officer found dead in the conning tower and the rating was found in the stern shot obviously by the officer who himself committed suicide.*

[140] **Smith 2007**: 17, 88.

[141] **Rottman and Wright 2012**:95.

[142] **Skennerton 2008**:34.

[143] **Bryant 2005**

[144] **Allan pers comms** 16 August 2016.

[145] **WW2 2015**

Figure 42: Pistol and round recovered from *Ha-14* midget submarine on display at AWM, Canberra (Photo: Brad Duncan, Heritage Division).

Figure 43: Japanese Nambu pistol 8mm round (Image: After Bryant 2005).

Figure 44: Cutaway section of a Japanese Nambu 8mm round (Image: After Bryant 2005).

c. Torpedo Head / Pistol Mechanism - Sydney Attack Midget Submarines

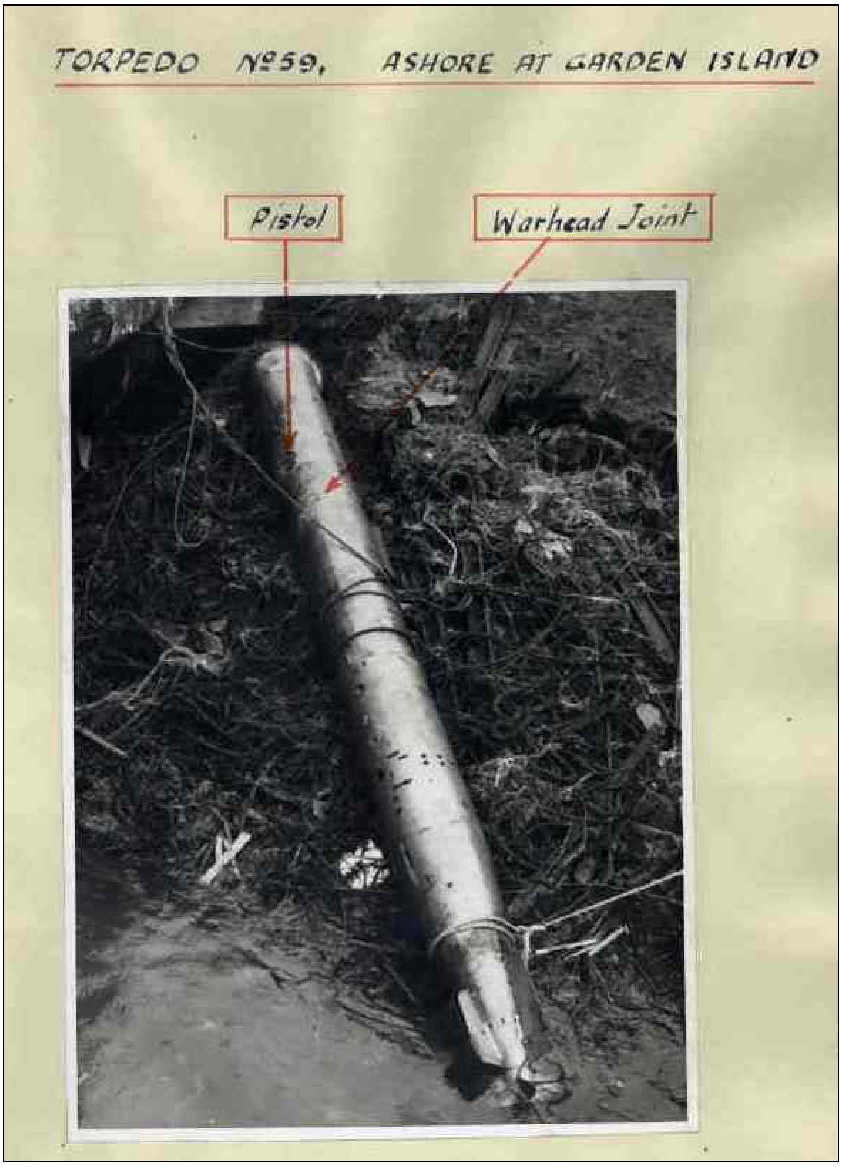


Figure 45: Torpedo from *M24* Midget Submarine on Garden Island (Source: NAA# 668555, Plate 32, and AWM 305005).

The Japanese Imperial Navy *Ha* Class Type A midget submarines deployed at Sydney were approximately 80.5 feet (24 m in length, of 46-7 tons, and carried two 18-inch Type 97 'Special' torpedoes (using pressure enriched air, oxygen, kerosene and seawater mixture), from the Kure Naval Yard [146] [147] [148] [149].

---

[146] **Smith 2007**: 18, 22.
[147] **Steven Carruthers, pers.comms 2007**: To Tim Smith, 30 July 2007
[148] (**NAA# AWM124 4/473 (1942-1943)):** *Report of investigation into Japanese torpedo fired from a Japanese submarine during the attack on Sydney Harbour. 7th-8th June 1942*. Torpedo School, Flinders Naval Depot, 14 January 1943. Australian War Memorial Collection.
[149] (**NAA #399556, p22**: Doc. TOO 1236z/23, 23/6/1942): *(ii) Displacement estimated 40 to 50 tons. Overall length 80.5 feet. Beam 6 feet as against 7ft and 5.5 ft. Endurance and speed not yet estimated. Plating five sixteenths inch as against quarter inch. Saw toothed net cutter above bows (five teeth) and upper side fore part conningtower (four teeth). Five compartments accessible to crew with water tight divisional bulkheads and two small compartments around torpedo tubes and one aft at stern, the latter filled with oil and all three inaccessible to crew. Estimated height of periscope above coning tower seven to eight feet as against five feet.*

Historical reports refer to an inertia pistol primer detonator (which was fitted to the side of the head), and two igniters used to fire the torpedo head (which consisted of 780 lbs of Hexamite and Dynamite [150] [151] [152] [153] [154] [155]. The torpedo heads were forwarded to the Maribyrnong Explosives Battery [156], and later to the Torpedo School at Flinders Naval Depot for further investigation. Specific details of the explosive head or mechanism were not found in the archives as it had not arrived there by January 1943 [157]. However, details of the mechanism were described in a brief technical analysis from January 1942 of the warhead mechanism recovered at Pearl Harbour:

> *The exploder mechanism, detonator, and booster are assembled in one unit… which can be removed from the warhead after turning the locking ring… which holds it in place…The exploder is contained in two cylindrical cases screwed together… The lower case contains all the explosives in this assembled unit i.e. detonator and booster, and no mechanism* [158].

This observation is important as it demonstrates that the exploder mechanism of the warhead would have to have been fitted prior to the submarine being deployed, and that as the torpedoes heads were carried in torpedo tubes which were external to the crew compartments (and could not be accessed by the crew) [159], then they could not have been replaced (in the case of a faulty exploder mechanism without surfacing the submarine.

Further research has concluded that the inertia pistol was fitted about 1m aft of the head of the torpedo (see Figure 45) and was not a pistol in the traditional sense (e.g. if associated with guns) that it was not fitted with cartridges. Instead the mechanism entailed an inertia spring which fired the inertia pistol when the spring reached a set pressure. It was set to arm at the minimum required safe distance from the submarine and explode using the arming range selector screw. The arming distance was calculated by water movement over an impeller rotating it a set number of turns. When the inertia spring was fully retracted, it released the inertia trigger, firing a pistol mechanism directly into the detonator, thus initiating the explosion sequence.

---

[150] (**NAA #399556, p65**: Doc. TOO 0938z/4, 4/9/1942): *Explosives filling for torpedo warhead is 780 pounds of following mixture: Hexamite: forty five per cent. TNT: fifty five per cent.*

[151] (**NAA #399556, p66**: Doc. TOO 0406z/15, 15/9/1942): *Torpedo had pistol primer detonator and two igniters.*

[152] (**NAA #399556, p209**: Doc. TOO 0800z13, 13/6/1942): *Torpedoes. Weight of explosive approximately 700 LBS. Type not yet ascertained. Yellow in Colour. Propulsion by compressed air with heater. Air vessel short and propellers small evidently short range and slow running. Cutter on head in form of cross centre portion being knife edged pyramidal devise comprising of four cutters at ninety degrees. This removable from additional saw like cutters extending back to full diameter of torpedo. Inertia pistol fitted to side of head.*

[153] (**NAA # 398841, p. 61**: Doc. 375/31: 25/8/1942, p. 3): *Secret NZ Naval Intelligence Memoranda. Serial No.11, 3rd September 1943:Japanese Midget Submarines, …Torpedoes: …Inertia type pistol fitted to side of head. …*

[154] (**NAA #413209, p. 39**: Doc. BS1749/201/37, 16/7/1942, Appendix 6, p.1). *Rear Admiral Murihead Gould Commendation Report: Recommendations for Recognition of Personnel….(9) Mr FJ Lingard (Torpedo Fitter): For the removal of pistols and primers from torpedoes, and demolition charges from submarines, this being carried out entirely voluntarily.*

[155] (**NAA #413209, p. 126, 127**: Doc. TOO 0900z/1, 1/6/1942): *No 1 Destroyed itself after apparently trying to penetrate the net defences…* (Midget submarines are) *Armed with Two 18" torpedoes and 300lb TNT demolition charge carried under the stern to permit self destruction or suicide attack.*

[156] (**NAA #399556, p163**: Doc. TOO 2254z/4, 2/6/1942): *Warhead and exploder should be forwarded A1/2 ASO Marybyrnong...*

[157] **(NAA# AWM 124, p. 7)**: *Report of investigations into a Japanese torpedo fired from midget submarine during the attack on Sydney Harbour, dated 7-8 June 1942. Torpedo School, Flinders Naval Depot. Report released 14 Jan 1943. Head not yet at Flinders naval Depot,*

[158] (**NAA #475195:** Doc. 910-3800, p1, 24 Jan 1942): *The exploder mechanism, detonator, and booster are assembled in one unit… which can be removed from the warhead after turning the locking ring… which holds it in place…The exploder is contained in two cylindrical cases screwed together… The lower case contains all the explosives in this assembled unit i.e. detonator and booster, and no mechanism.*

[159] (**NAA #399556, p22**: Doc. TOO 1236z/23, 23/6/1942): *Five compartments accessible to crew with water tight divisional bulkheads and two small compartments around torpedo tubes and one aft at stern, the latter filled with oil and all three inaccessible to crew.*

Figure 46 shows the mechanism discovered on the torpedo at Garden Island (from the *M24* submarine [160]. Figures 47 and 48 (respectively) show a diagrammatic views of known inertia pistol cartridges used on this type of torpedo [161] [162].

As the firing mechanism for the inertia pistol was self-contained in the torpedo, it would have been installed when the torpedo was loaded onto the vessel. Therefore, it is highly improbable that any spares, replacement explosives or inertia pistols would have been carried in areas accessible to the crew inside the *M24* submarine, and no comments on spare mechanisms inside the submarine have been found in any historical documentation to date.

The composition of the explosive is very similar (if not identical) to that discovered in the *Ha-19* midget submarine at Pearl Harbour [163] (also see Tables 2-3). Figure 49 shows the remains of the torpedo from *M24* which exploded under the HMAS *Kuttabu*l.

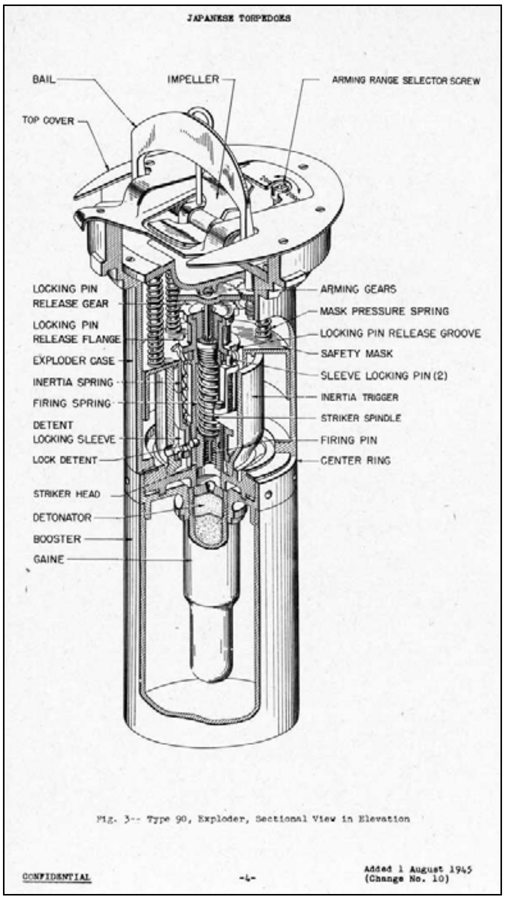


Figure 46: Type 90 inertia pistol exploder mechanism (U.S. Navy Bomb Disposal School, 1945).

Figure 47: Dismantled inertia pistol mechanism from *M24* torpedo at Garden Island (Image: from NAA #668555, Plate 34).

[160] **NAA# 668555**
[161] **U.S. Navy Bomb Disposal School 1945**.
[162] **NAA # MP1049/5, 1942**, p.12.
[163] **Submarine Squadron Four 1941**: 1, 9.

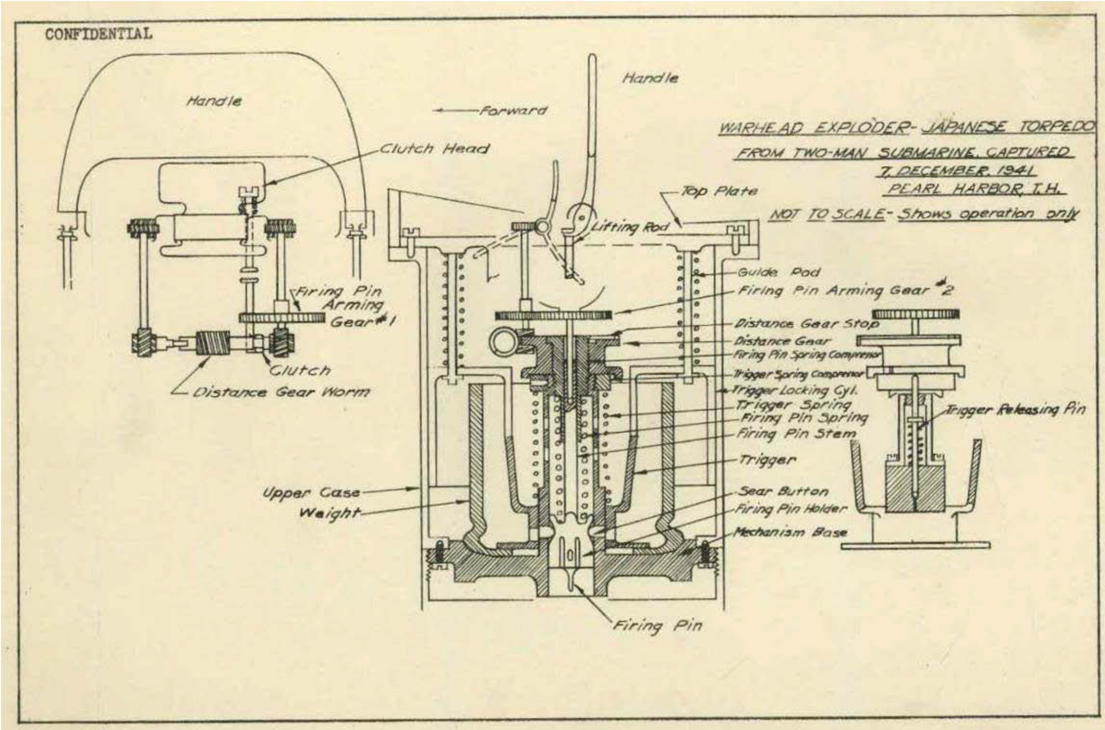


Figure 48: Details of Torpedo Exploder Mechanism from 2 man (midget) submarine at Pearl Harbour 1942 (Image: NAA MP1049/5, p.12)

Figure 49: Torpedo from M24 which exploded under HMAS *Kuttabul* at Garden Island. The torpedo is owned by the Australian War Memorial, and currently on display at RAN Heritage Centre, Garden Island. (Image: Stirling Smith).

5. MANAGEMENT ISSUES

a. Legislative Protection

M24 is protected as a Historic Shipwreck under the *Commonwealth Historic Shipwrecks Act 1976*. A Historic Shipwrecks Protected Zone has been declared around the site which prohibits entry into the 500m radius zone without a valid Permit. Any disturbance of the wreck site can only be undertaken in accordance with the conditions of a valid Permit issued by the NSW Commonwealth Shipwreck Delegate (Executive Director, Heritage Division).

The site is also listed on the State Heritage Register (SHR 01785) under the *NSW Heritage Act 1977* and is also afforded the protection of that legislation.

The continued operation of the Protected Zone around the wreck has to some extent minimised the risk of exposure to the UXO on board the vessel through the restriction of divers visiting the site.

b. Potential Risks Associated with UXO Aboard the M24 Wreck

i. Expert Advice on Demolition Charges/UXO Potential Volatility and Toxicity

Advice was sought from several UXO and corrosion experts in this field, including:

- Ex Commander Damien Allan (former MCDSPO Director, HMAS *Waterhen* - RAN*);*
- LCDR Matt Carroll and Chief Petty Officer Shaun Elliott, Australian Clearance Diving Team One (AUSCDT - RAN);
- Mr Robert Curran, Former Newington Armoury Logistic Manager;
- Kevin Slade, former Deputy Director Nautical Information and Publications, Australian Hydrographic Department
- Andrew Liddell (UK Ministry of Defence);
- Nick Jenzen Jones and Kenneth Fulmer (Armament Research Services - ARES)
- Dr Ian MacLeod, (Executive Director of Collections Management and Conservation at the Western Australian Museum, who has experience working with other WWII wrecks in Chuuk Lagoon, Guam and worldwide);
- David Detata, Chem Centre, Curtin University.

A summary and extracts of the advice given by these experts is presented below.

ii. Demolition Charge, Fuses and Detonators

- **Potential Volatility of Demolition Charges, Fuses and Detonators**

The greatest risk posed by explosives onboard the M24 midget submarine wreck is from the Shimose powder, whose reactive ingredient is picric acid powder. Picric Acid is classified as a flammable solid when wetted with more than 30% water, and is highly explosive with less than 30% water. In addition to being explosive, it is shock, heat and friction sensitive. It is also highly toxic when ingested, inhaled or absorbed through dermal contact, is a skin irritant and allergen, and produces toxic products on decomposition [164] [165].

Although water can be added to Picric Acid to be act as a desensitiser and the wetted product is considerably less shock sensitive than the dry acid [166].
Picric Acid is highly reactive with a wide variety of different materials (including copper zinc, lead, salts, plaster, concrete and ammonia), and is extremely susceptible to the formation of Picrate salts, which are even more shock sensitive and reactive than the acid itself. Picratic salts result from the reaction of Picric Acid with metals, metal salts, bases, ammonia and concrete. Metal picrates can be formed as a result of contact with iron, zinc, nickel, lead and copper, and are extremely sensitive. Accordingly, Picric Acid should never be allowed to dry out, especially on metal or concrete surfaces. Removal of Picric Acid should always be undertaken by explosives experts [167].

MacLeod [168] has suggested that the level of volatility of the charge will be dependent on the degree to which the canister has remained its waterproof integrity.
It is clear that there is a risk presented by the Picric Powder within the charges onboard. A number of risk scenarios are evident, which are dependent on the degree that the container has remained waterproof:

- **i. The interior of scuttling charge is dry**
  If the scuttling charge canister has retained its integrity and remained watertight, then there is a nominal risk presented by the picric powder as long as it has remained dry. If the picric powder has formed a contact with the canister walls, then there is the danger that the Picric Acid in the compound has formed metallic Picrate salts/crystals through corrosion with the canister housing, then this mixture will be even more volatile than the original explosive.

- **ii. The interior of scuttling charge is damp**
  If the scuttling charge canister has leaked water into the canister, but not flooded it, then it is likely that the interior of the charge is damp. In this scenario, it is likely that the ingress of seawater has exacerbated the production of corrosion products to form Picrate salts, due to the presence of salts and water in conjunction with the steel canister. This is likely to produce a more volatile mixture than the scenario presented above.

- **iii. The interior of scuttling charge is wet/saturated**
  If the interior of the canister has leaked and is wet/saturated inside, then although corrosive processes to form metallic salt Picrates may be progressing, they will be taking place at a slower rate than if the charge was dry/damp and may have reached equilibrium within the canister. Although the resulting mixture will be volatile, it will be less so than if the mixture was damp or dry.

- **iv. The canister has failed/corroded/disintegrated**
  If the canister has totally failed and seawater is freely penetrating to allow an exchange of corrosion products with the water outside the canister, then the explosives will be relatively less volatile, than the above scenarios. However, care should still be taken to avoid exposure of the charge to air or drying out, which could facilitate an explosion. Risks of toxic poisoning are also increased

[164] **UCSB n.d.:**1
[165] **Carroll pers comms 2016.**
[166] **UCSB n.d**.:1
[167] **UCSB n.d.:**1
[168] **MacLeod pers comms 2012**.

to those entering the submarine, particularly if the interior is not being flushed by exterior water movement.

- **v. The canister is buried in sand within the submarine**
  If the canister is buried in sand within the submarine, this increases the possibility that charge inside is damp or dry, thus increasing the possible volatility associated with scenarios i - iii.

  It should be noted that the canister is most likely buried under sand inside the submarine at this current time.

- **Canister Corrosion Issues**

Scott [169] provided further relevant evidence from the wreck of a midget submarine which was recovered from the Pearl Harbour attack and buried in landfill at the Ford Island Submarine Dock which has a bearing on the current situation. When it was recovered again for inspection in 1952, the submarine was *so badly corroded by chlorine gas from the electrical batteries that it was again reburied at the same location*.

MacLeod [170] provided an explanation of this process as being a product of seawater coming into contact with the batteries when they were still operational (producing a current), and the short circuiting of the battery with seawater produces chlorine as a result of the oxidisation of the seawater.

This scenario has direct implications for the steel demolition canister of the *M24* wreck if the submarine was only partially inundated with seawater, as it appears the battery compartment would either have been heavily affected by chlorine gas if the compartment remained partially dry with some inundation (but not total) of seawater. However, this scenario is unlikely as it is improbable that the submarine was only partially flooded given the pressures of the depth the wreck lies in.

If the submarine batteries (which were filled with sulphuric acid) were subjected to any sudden/ catastrophic inundation of the batteries with seawater, this would cause a rapid boiling of the battery acid as it dissolved in water to produce copious amounts of carbon dioxide to produce carbolic acid. In this scenario, the batteries might explode due to the sudden production of steam, and this might be visible through cracks or breaks in the battery cases. However, sulphuric acid dissolves quickly in seawater, meaning that the corrosive effect of the battery acid would be lessened. However, this may have led to contact between the steel canister and lead battery plates, which would begin a galvanic reaction that would begin corrosion of the canister [171].

The presence of the canister within the battery room may therefore have increased the potential for the canister to corrode, especially if the canister has come into contact with lead from fallen batteries. In this case, although the increased corrosion of the canister may have exposed the picric acid to water, the presence of lead within the immediate vicinity may also have led to the formation or lead picrate salts, which also are volatile when in contact with an electrical contact (they are used in detonators) and are also highly toxic.

[169] **Scott 2012**.
[170] **MacLeod pers comms 2016**.
[171] **MacLeod pers comms 2016**.

It is therefore probable that the canisters have been subjected to extensive corrosive forces and in all likelihood has flooded, but this cannot be guaranteed until the canisters are located onsite, as if the canisters were buried early then corrosion processes would be slowed down.

It is also highly probable that the canisters have failed along the entrance hole in the cover and perforated cardboard disk where the electric or safety fuse enters the canister. This would have permitted the ingress of salt water into the canisters. If this has occurred, then this has probably dissolved the picric acid in the explosives compound in the charge, which has possibly decreased its volatility, but this cannot be guaranteed given that the canisters have not been located and inspected, and there is a possibility that the explosives are still active/ unstable.

- **Deterioration of the Charge Submerged in Seawater**

Several UXO experts have provided comment on the likely chemical state of the demolition charge after it has been submerged in seawater.

Fulmer and Jenzen-Jones [172] of ARES Research Services (munitions disposal experts) provided the following analysis of the demolition charge and its likely volatility:

> *Based upon the extract of the draft M24 Report (dated 27 OCT 2015) provided to ARES, it can be assessed that though the picric acid (trinitrophenol) charges are most likely compromised due to degradation of the container, all efforts should be made to remove any explosive material from the site before the hull is surfaced* [Authors Note: there are no plans to raise the *M24* submarine for the present or in the future due to the wreck being considered a grave site by the Japanese and Australian Governments]. *Materials should be removed mechanically with minimal thermal or mechanical stress to the explosive components, and left for disposal in sea. Surfacing or allowing the containers to dry may cause picrate salts to reform in a highly unstable condition, greatly increasing the risk of unintentional detonation.*
>
> *Highly nitrated compounds (such as picric acid, TNT, DNT, NG dynamites) are naturally hydrolysed by exposure to sea water in a standard temperature range. This effect has been repeatedly observed in munitions of this age found in the Baltic Sea and off the American Atlantic coast that had been dumped at sea, lost to enemy action, or failed to function when fired. Munitions with a picric acid/Shimose powder fill present an additional complication in the development of picrate salts, also known as explosive salts, as a by-product of long-term contact with metal containers and other components. In normal conditions on land, the formation of salts may be reduced by the application of acetone as a solvent to temporarily reduce immediate hazards of handling and disposal by EOD personnel. In some extreme cases (of which some accounts may be apocryphal) EOD teams have disposed of the material in situ, being unable to safely remove any material without endangering the lives of the team members. Having been immersed in sea water for more than 70 years, the state of the explosive compounds cannot be fully ascertained due to variables beyond the control of the observer. It is thus wise to understand that while the likelihood of picrate salt formation is low due to the continual solvent and hydrolysing effects of sea water, it cannot be discounted*

---

[172] **Fulmer and Jenzen-Jones 2015.**

In light of this assessment, a risk-aware stance of removal for purpose of disposal at sea may be adopted to facilitate the recovery and preservation of the M24. After familiarisation with the layout of the vessel and potential configurations of the explosives container, cuts into the hull or mounting hardware should be attempted by mechanical means to remove explosive containers from the area of the continuing salvage operation. This method does cause additional damage to the hull structure, but presents the least hazard to continuing the work of preservation on M24.

Advice from LCDR Carroll [173] reinforces this statement:

They [the demolition charges] *could contain a high explosive composition of one of the following: TYPE 97 – Composed of HND 40% and TNT 60%; Shimose; or Picric Acid.*

Initiation of the charges could have been either electric or require a safety fuze to burn. Again, these initiation methods involve a detonator (primary Explosives) leading into a booster and are therefore dangerous and should never be disturbed unless remotely by trained personal.

While the Submarine remains undisturbed it could be assessed that there is minimal risk of a high order detonation from these charges. Risk would however increase exponentially if untrained personal attempted to gain access to the sub and manipulate and tamper with any internal components.
It would be my recommendation that untrained personal maintain separation from the wreck and not manipulate or tamper with the submarine in any way.

Liddell [174] provided the following excerpt from a UXO munitions study of the shipwreck *HMS Royal Oak* undertaken by NATO, which contained multiple shell rounds filled with Picric Acid based munitions:

Of all the ordnance present it is thought that the Lyddite (picric acid) and Shellite (70/40 picric acid/dinitriphenol) shell fillings would pose the highest risk to any work undertaken on the wreck. Picric acid is known to have an ageing problem through which metal picrates form, e.g. iron picrate. Such metal picrates are extremely sensitive energetic materials which can be initiated very easily. It is believed that there are considerable quantities of shells filled with these explosives, a common World War I filling, in particular, the 15 inch and 6 inch shells which are believed to be Shellite and Lyddite filled. No evidence has been found to suggest that these shells were filled with any other composition.

Picric acid fillings pose a greater hazard than TNT fillings because picric acid is more sensitive, is less stable and unlike TNT can produce highly sensitive decomposition products.

Due to the fact that there is a high likelihood that there will be extremely unstable materials in some or possibly all of the picric acid containing shells, initiation of which could result in a major explosion of a magazine, it is recommended that the wreck should not be disturbed in any way that could introduce shock into the vessel or alternatively cause movement of any of the stores or other debris which could impact onto a store [175]*.*

---

[173] **Carroll pers comms 2016**. Email from Carrol (LCDR AUSCDT) to Brad Duncan, NSW Heritage Division re: Advice on Unexploded Ordnance on the *M24* Japanese Midget Submarine Wreck, 22 January 2016.
[174] **Liddell pers comms 2012.**
[175] **Liddell pers comms 2012**, after **Albright 2012** p. 78.

Allan (2009) provided the following advice regarding the volatility of the demolition charge and fuses that possibly exist onboard:

> *Clarification on fuze material – a match fuze would contain gun powder (black powder). Det cord would use PETN. It is not totally clear what they found in the submarines, but references to Japanese demolition and booby trap charges in general refer to standard commercial type detonator options.*
>
> *I think the best you can hope for is that the canisters of both charges have corroded exposing the explosives which have decomposed long ago. Worst case is charges still watertight and in good external condition that have had 67 years to undergo some unpredictable chemistry that could make them more sensitive to rough handling. If only you could get a look at them from under several tons of sand in a diver inaccessible spot...* [176]

Allan [177] provided further advice on possible detonator composition and volatility:

> *The detonator contents appear to be:*
>
> - <u>*Electrical*</u>*: Powdered gun cotton used as initiator. Gun cotton is likely to decompose to safe condition over time if in presence of moisture. Some Naval electrical detonators use picric acid as the exploder. Picric acid is likely to be neutralised if it has been exposed to water for a long period. Problems arise if the container has remained watertight and the picric acid has reacted container material. The container is probably brass* [Authors Note: the canister is now known to be steel] *… Unfortunately, references specifically say that heavier elements such as iron will produce sensitive by-products, but light elements such as aluminium will be OK. No mention of copper or zinc, but tin is also OK, just in case you were wondering. .., still more questions than answers if the detonator has remained watertight.*
> - <u>*Percussion: Mercury Fulminate*</u>*. Also likely to decompose to safe condition over long period of time in presence of moisture.*
> - <u>*Safety or Match fuze*</u>*: Standard safety fuze is likely using gunpowder, which would be long be gone now. Japanese were known to use PETN in match fuzes. Safety fuzes often burnt to burning to a Mercury Fulminate /PETN /CE detonator.*
> - *Delay timer clocks tend to be electrical or mechanical (percussion). Additional info on T-88 composition: Absorbs little moisture and is comparatively insensitive to shock and friction. Stable in storage. Still no info on how really old stuff will react to handling.*
> - *Other things I will follow up is the detonator composition. Seems like Japanese used standard electrical or percussion detonators as well as detcord for demolition charges. References to midget submarines talk about battery packs, timers and match lit fuse. Assuming that the main charge may be intact and stable, the condition of the detonators may not be 178.*

---

[176] **Allan pers comms 2009.**
[177] **Allan pers comms 2009**.
[178] **Allan pers comms, 2009.**

Further evidence to consider regarding the volatility of contemporary underwater explosives was presented by Slade [179] and Carruthers [180]. They outlined how a WWII Type VII depth charge recovered from Sydney Harbour in the 1970s (which was probably associated with the Sydney Harbour attack and defences), was still live after many decades underwater. The depth charge was removed to La Perouse, when it exploded as part of the process of being destroyed at a NSW weapons range.

From the comments above, it is probable that the demolition charge container has failed (probably along the entrance hole in the cover and perforated cardboard disk where the electric or safety fuse enters the canister) to permit the ingress of salt water into the canister. If this has occurred, then this has probably dissolved the picric acid in the explosives compound in the charge, which has possibly decreased its volatility. **However**, this cannot be guaranteed given that the canisters have not been located and inspected, and there is a possibility that the explosives are still active/ unstable.

Other evidence relevant to this issue needs to be considered. There are several indicators that the wreck of the *M24* submarine may have been physically and catastrophically moved or rolled at some stage since its sinking, probably when it was caught in a commercial fishing net. When the wreck was discovered by the No Frills Divers in 2006, it was almost totally enclosed in a fishing net, and was only identified after part of the net was removed. Evidence of this event includes the remains of a wire net cable (which is wrapped repeated around and under the stern section of the wreck); and the presence of a 20m long fishing net caught under the bow. The lack of the conning tower and associated wire-cutter in situ suggests that the vessel may have been rolled after being caught in a fishing net sometime since its loss. If the wreck did undergo such a catastrophic event, then it is apparent that the demolition charges did not detonate, which may suggest that they were stable (and possibly inert) at that time. This may suggest that the canisters have indeed flooded and that the picric acid compounds have dissolved into the surrounding environment.

- **Demolition Charge Toxicity**

If the picric acid has leaked and dissolved at the site, then there is the added problem of potential toxic chemicals at the site. MacLeod [181] reiterated that picric acid is also highly toxic, and has the potential to cause sterility in males who come in close contact with it. This observation is supported by Carrol [182], who stated that the charges are: "*highly toxic and should not be handled*". MacLeod [183] has suggested that one way to detect whether the canister has leaked would be to take a slurp tube sample of water/ sediment from within the submarine, as any leakage would be detectable as diluted picric acid within the samples.

It is probable however that any high levels of toxicity would be contained within the wreck site as the canisters is likely buried under sand inside the hull.

[179] **Slade pers comms 2012.**
[180] **Carruthers pers comms 2016**.
[181] **MacLeod, pers comms 2012.**
[182] **Carroll pers comms 2016**.
[183] **MacLeod, pers comms 2012.**

iii. Ammunition Flare Gun from (Very Flare Pistol) and Personal Service Pistol

It is probable that the paper based cartridges of the Very flare gun have flooded, and the ingress of water have made the black powder based inert, particularly as although the rounds had a brass base, the waxed cardboard body would have softened and failed[184]. Furthermore, the service pistol cartridges are of low calibre and low velocity, meaning they have a low charge, and hence present a low risk to any personnel visiting the site. Allan has advised that these cartridges would be seawater saturated and inert now judging by other Japanese cartridges of similar era recovered from underwater[185].

Both Carroll [186] and Elliot [187] have advised that the cartridges from both the Very pistol and Service Pistol are unlikely to present any substantial danger to divers. If the cartridge is intact (which is highly unlikely) the service pistol rounds may still be volatile, but even if a cartridge was placed on one's hand, any subsequent explosion might (at worst) result in the loss of a finger.

iv. Torpedo Inertia Pistol

As outlined above, it is unlikely that any Torpedo Inertia Pistol mechanisms were ever carried inside the submarine, and there was no room for spare torpedoes to be carried inside or the ability to load them whilst at sea. Additionally, as the torpedo was assembled as a complete unit, it is highly unlikely that any replacement parts were carried inside the submarine (aside from the loaded torpedoes themselves in the torpedo tubes). Inertia pistols were not a pistol in the traditional sense of requiring ammunition, but were a spring loaded mechanism for initiating the explosion sequence; in the same way that a gun's pistol hammer ignites a percussion cap in a bullet cartridge. Therefore, as both torpedoes were fired by the *M24* prior to its disappearance, there are therefore no UXO issues associated with torpedoes or inertia mechanisms in the *M24* midget submarine.

---

[184] **Allan, pers comms** 16 August 2016.
[185] **Allan, pers comms** 16 August 2016.
[186] **Carroll, Matthew**, **pers comms 2016.**
[187] **Elliott, Shaun, pers comms 2016**.

6. SITE INSPECTIONS

a. Archaeological Site Inspections

Detailed inspections of the *M24* wreck site have been undertaken from 2013-2016 as part of the annual maintenance of the Historic Shipwrecks Protected Zone Buoy by Professional Diving Services.

Specific works have been undertaken to undertake:

- video and photographic survey of the exterior hull and to map breaks and exposures in the hull;
- corrosion measurements along the hull using an ultrasonic thickness meter,
- installation of an anode to attempt to arrest corrosion onsite.

The survey has revealed that a section of the stern battery compartment is exposed through a break in the hull close to the control room compartment Figures 50, 51). This has allowed video footage to be taken of this area which has revealed that the compartment is half full of sand (see Figures 52-53). No evidence of the explosives device could be seen in this area as a result [188]. Venturoni[189] has also indicated that he thinks that the forward battery compartment has flooded based on their observations of the open space extending beyond the control room compartment, indicating that the door to the forward battery compartment hatchway is open.

It does appear that there has been some discrepancies in the sand levels inside the aft battery compartment over time, indicating that sand may be moving in and out of this area.

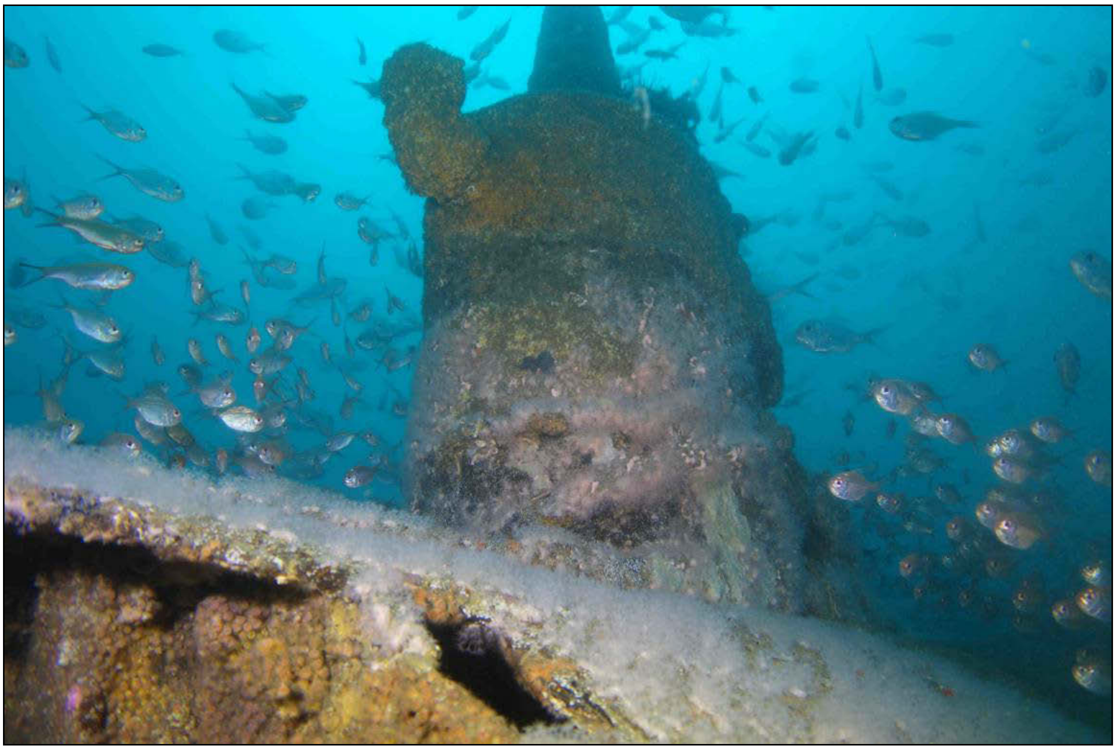


Figure 50: Conning Tower of *M24* midget Submarine from Starboard side showing the hull breach into the battery room on left hand side (Image: Venturoni 2015 Survey).

[188] **Venturoni 2013;** and **2015.**

[189] **Venturoni 2017, pers comms,** email to Brad Duncan 13 March 2017.