Danger From The Deep
Torpedo Reference

Introduction

The torpedo was one of the most expensive, and most technological delicate, and advanced, weapons of world war 2. As such, it suffered from several problems.
A torpedo is made up of six elements:
the torpedo itself, the shell, the propulsion system, a guidance system, the explosive charge/warhead, the detonator/pistol, and the depth control system, that kept a constant depth along the torpedo runs.
One of the main lessons that was learnt during world war 1, was the need to create a torpedo that left no bubble trail (the torpedos were propelled via compressed air, and this left a visible bubble trail, that shown clearly the position of the attacker, as well as the torpedo heading), and the first electrical powered torpedo was ready in 1918.
Altough forbidden by the Versailles Treaty, the development of this torpedo continued secretly, under a german company, operating in Sweden, in 1923, and first tests were made in Karlskrona, in 1929.

Fig.1: TI G7a "Ato" torpedo

In second world war, the Kriegsmarine used 21 inch diameter torpedos (553m), that had a length of 7,16 meter. This standard measure wasn't used in some very specific cases, like for instance, the torpedos designed by professor Walter, that had a lenght of 5 meters.
The torpedos had as designation, the letter T, followed by a number in roman numeric format (for instance, TIII), and sometimes, an suffix letter as well, to designate a subvariant (for instance, TIIIa).
All torpedos had as initial designation, the letter G, followed by a number which indicated his lenght (5 or 7), and a final letter that indicated the propulsion system (a for air propulsion, e for electric, w for walter turbine).
Basically, in world war two, two main types of torpedos were used, the G7a, and the G7e, both 21 inch in diameter, and 7.16 meters in lenght. Both took the same explosive charge, were controlled by a conventional system of depth control, and the direction system was gyroscopically controlled, in fact, the only difference between those torpedos, was the propulsion system.

Fig.2:
Steam propulsion

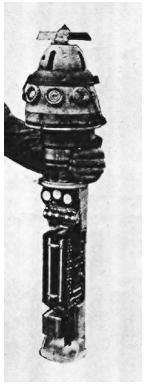


Fig.3:
Pi2 contact pistol

The G7a torpedo, was propelled by an compressed air engine, which, in the beginning of the war, allowed three possible speed adjustements, 44 knots with a total run of 5000 meters, 40 knots with a total run of 7500 metrs, and 30 knots, with a total run of 12500 meters. Experience has shown that the 44 knots settings, damaged the engined, and this setting was never used until mid of world war two, when the propulsion system was changed.
As the G7a was air propelled, it left a visible bubble trail, and thanks to this, it was mostly used in night attacks. Other of the problems of the G7a was that it was a very sofisticated and expensive weapon to manufacture, and great quantities of strategic materials were employed in its fabrication, as, for instance, 370Kg of copper, and some 3730 hours of work, with a total cost of around 24000 Reichsmarks.
At the begginning of the war, the torpedo was totally redesigned, and whithout having its performance affected, its use of copper was reduced to 169Kg, hours of work reduced to 1707 hours, and total cost was reduced towards 13500 Reichsmarks.
The G7a was designed to impact the side of the hull, and for that motive, was equipped with a contact pistol (Aufschlagzündung).

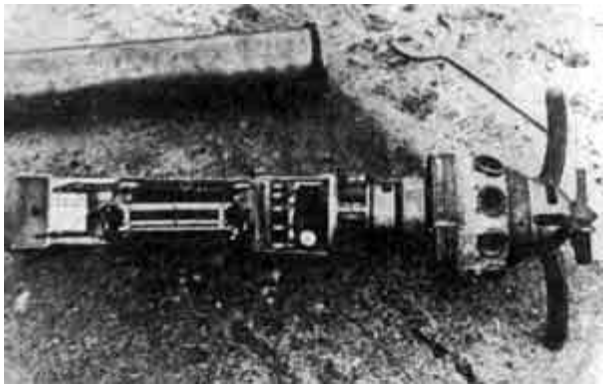


Fig.4:
Pi4 contact pistol

As for the G7e, it has an electric propulsion system, which was powered by means of an electric battery (13T210, but number and types differ on models, as later mentioned), 2,44m long, and that weighted 711Kg. The battery had 52 cells, that were capable of producing 92A/hour. These cells were assembled in an container that could be extracted from the torpedo, via rails.
An important aspect, was that the battery was equipped with an heating system, that could be activated via external energy, to increase the temperature up to 30°C. This preheating increased the range of the torpedo between 40-60%.

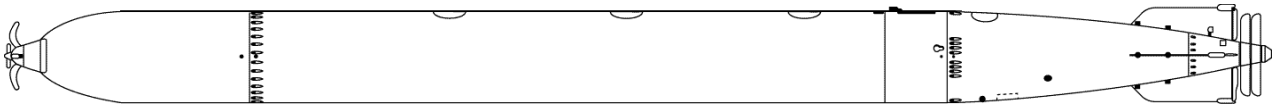


Fig.5:
TIII G7e "Eto" torpedo

The battery powered an electric motor, that gave an power of 94cv at 1755rpm, for around 5,6minutes. The G7e had a maximum range of 5000 meters, at 30 knots, that were reduced to 1700 meters, if the battery wasn't preheated before launch.
Altough it shared many elements with the G7a (explosive charge, gyroscope, pistol, and depth control device), it was much cheaper to make.
Surprisingly, the allies had no knowledge of the existence of the electric powered torpedos, until some were recovered from the bottom of Scapa Flow, after U47 sunk the battleship Royal Oak.

Torpedo Guidance

FaT

A new direction control system was ready at the end of 1942, the FaT (Federapparat Torpedo, but some sources also refer to this as the Flächenabsuchender Torpedo).
This system allowed the torpedo runs to be set before the torpedo launch, in fact, programming a pattern of direction. For instance, you could set a torpedo, so that after an primary run of 1200 meters, it changed direction for 400 meters, and then returned back to its original course, creating in this manner, a search pattern.
If no impact occurred after the primary run, the torpedo turned back, and then again, until any vessel was hit, or until the maximum run lenght was achieved. The ideal was for this torpedo to be launched behind a convoy.

The FAT device was installed first in the G7a torpedos, and since they left a visible bubble trail, its use was limited to night attacks.
A slight modification of the FAT device, the FATII, was installed first in the G7e torpedos, that were then renamed, TIII G7e FaTII, from March 1943. These should be launched from the stern, to attack an escort chasing an uboat. After the first run, the torpedo would run circles, always turned to the left.
The FaTII entered service in May 1943, but it didn't had good results, thanks to its short autonomy (5000m), and thanks to this, a new version was built, the TIIIa FaTII (G7e), that, with a larger battery capacity, allowed a range of 7315 meters.

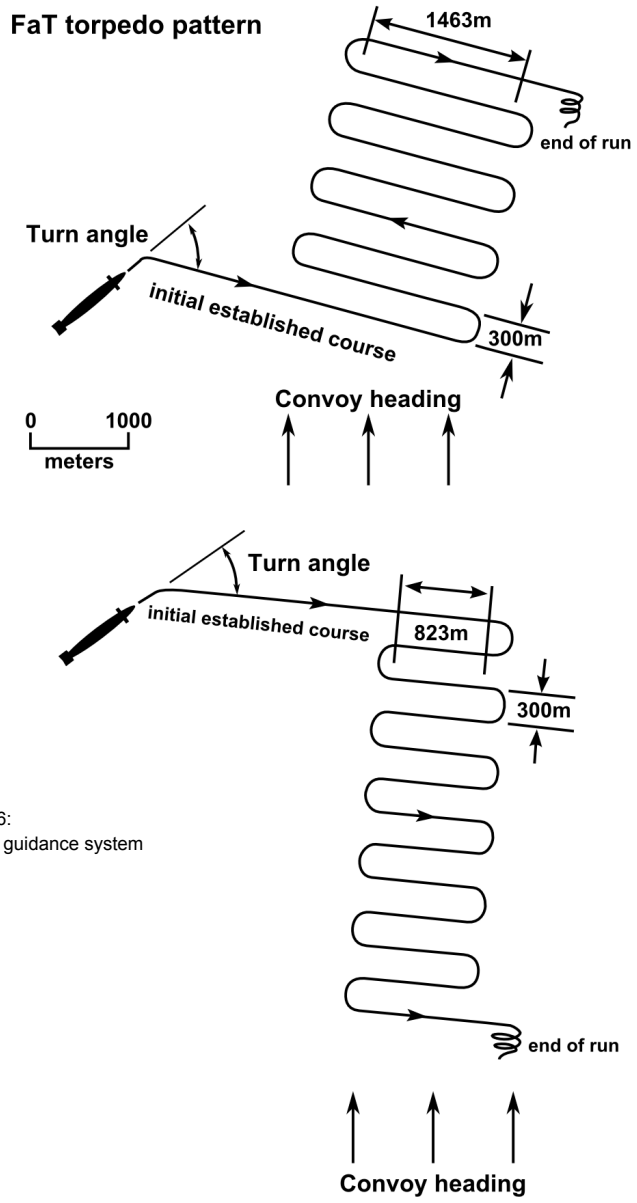


Fig.6:
FaT guidance system

LuT

In March 1944, a new torpedo guidance device appear, the LuT (Lagenunabhängiger Torpedo), which was developed from the FaT design, but that incorporated some improvements in the search pattern.
Now it was possible to set a new course, after a primary run, this new course, allowed the torpedo to follow the course of the convoy, to then start a zigzag search pattern. This zigzag distance, would be set to be anything from 0 to 1600 meters, while on the original FaT, only 2 options were available.

The velocity of the torpedo was also improved, and its speed could be set between 5 to 21 knots. The LuT was installed in the G7a (TI LuTI G7a), and in the electric version of the same (TI LuTI G7e), with increased autonomy.

A new version, the LuTII, allowed changes of course, of 180°. The LuT wasn't used in combat until 1944, and only some 70 of them were used operationally.

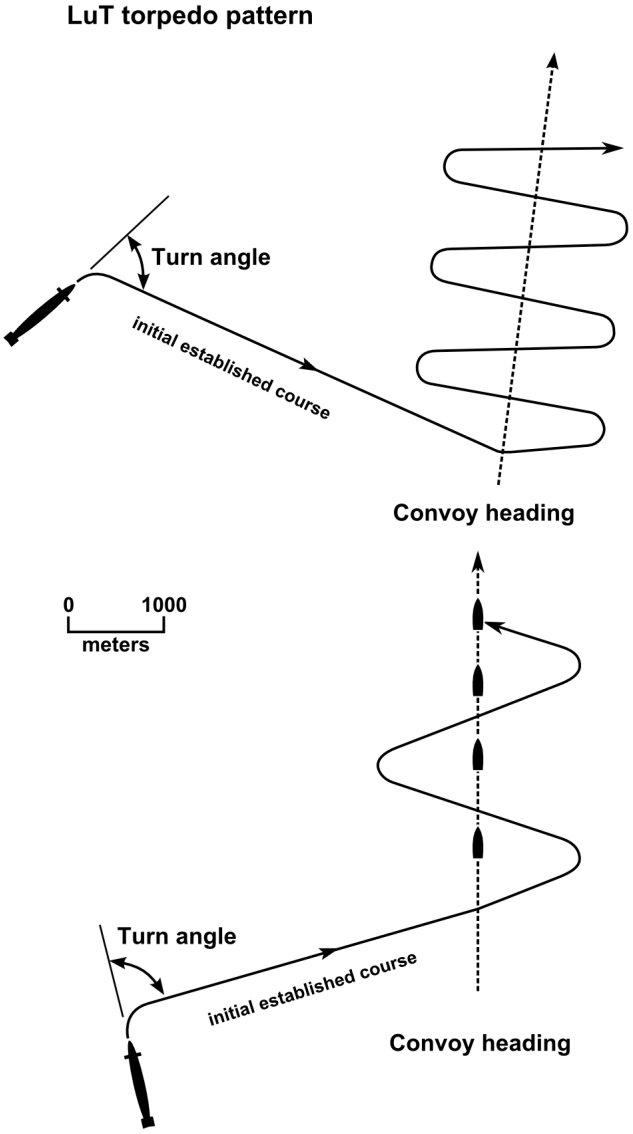


Fig.7:
LuT guidance system

Detonators

Pi.1 pistol

In september 1939, the standard detonator for the G7A and G7E torpedoes, was the Pi.1, that could either be of impact type (Aufschlagzündung), or magnetic type (Magnetzündung-pistol). The magnetic detonator consisted in a longitudinal structure, that had assembled an propeller like shape in the frontal area of the head. When in concact with an magnetic field, an electric circuit was connected via a relay, and detonated the charge. It had a safety device that armed the warhead after the first 250m of the run.

The impact detonator was very simple, and it was used already in WW1. It was made of a single triggering fuse, and 4 mechanical sensors, connected in the frontal section of the torpedo. By detecting contact with an object, any of the 4 mechanical sensors, triggered the fuse, and detonated the warhead. After hostilities started, many captainsinformed of multipl,e faillures in the torpedos, amongst them, detonating before they were supposed to.

Fig.8:
Pi.4 contact pistol

The designers of the contact pistol knew that you could have dud torpedoes, the majority caused by the incorrect use of the detonators, but other faults could be caused by the following:

1) the magnetic field of the earth varies according to latitude and this could cause some problems in the magnetic diferential measurements that triggered the detonator and warhead detonation (this mostly occured in passive magnetic detonators).

2) vibrations (from torpedo run, etc...) could cause a variation of the magnetic field of the torpedo itself, or its internal mechanisms, again, causing a change in the magnetic diferential that triggered the detonator to explode the warhead (this problem affected mostly active magnetic detonators).

The designers at the Torpedoversuchanstalt (TVA, department of torpedo tests) knew about these problems, and made the error of relying their work in theoretical calculations, not in practical tests of the different situations that a captain could face in the midst of hostile engagement, this lead to a failure of standardization of torpedo parameters, with the consequence increase in failures.

The first measure that Döenitz took when facing these problems with magnetic pistols, was in the 2nd of October of 1939, by ordering the Unterseebootwaffe to use only the contact pistols until new orders.
Then, it was found that the contact pistols didn't worked correctly either, and the cause of this was found to be a poor design of the 4 mechanical sensors in the contact pistol, which failed to trigger the detonation when the impact angle was higher than 20 degrees. An example of this took place in the 30th of October 1939, when U-56, commanded by Wilhelm Zahn, fired a spread of TI G7a torpedos, against the british cruiser HMS Nelson. Wilhelm Zahn saw 3 impacts, but no detonation.

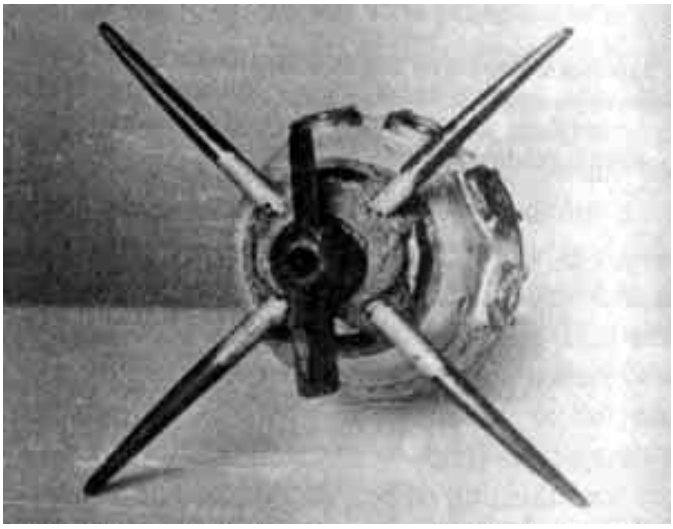


Fig.8:
Detail of Pi.4 contact pistol

Permission to use magnetic pistols again, was given in the 10th of November of 1939, but new problems forced more tests, and finally, the designers were forced to admit that the system was faulty. These problems were accentuated in the Norwegian campaign, due to the already mentioned variations in magnetic field diferential (it was also found that the norwegian fjords geology, had an added impact in aggravating the problem that the latitude presented, and all this combined with the poor design of the magnetic pistols, made the uboat crews very unhappy with consecutive torpedo failures).

All torpedo attacks were analyzed, and Grand Admiral Raeder, acused several members of the TVA, of the failures of pistol designs, for which they were judged. There were cases of torpedo designs being sent to the front, without having had passed the necessary trial tests. The TVA, which was formed until then, by civilian personnel, was totally remodelled, and naval officers were placed in charge of each department.

Until a solution was found to these problems, Döenitz ordered that all torpedos were to be equipped with the contact pistol, and that they were to be launched at shallow depth. With this new order, sucesses were rising again.

Pi.2

The Pi.2 combined in a single pistol, two detonation systems, an impact and a magnetic detonator. This pistol was only used in the G7e torpedos. The impact detonator was similar to the Pi.1 pistol (which was a simple contact pistol only). On the other side, the magnetic pistol was of a totally new design. This new design activated the detonator when the magnetic field went over a predetermined treshold. Another novelty, was the possibility of, by means of a switch, to select the use of the contact detonator only (and not contact + magnetic). The energy for the magnetic detonator was supplied by the torpedo's batteries.
(Read appendix A for some extra information about this subject.)

Pi.3/MZ3

Thanks to the numerous problems with its pistols, Germany asked for help to its allies, and Italy sent Germany, in August of 1943, a series of S.I.C magnetic pistols, which the Kriegsmarine called MZ3.
The contact detonator system was similar to the Pi3, but on the other side, the magnetic detonator was of a totally different design, which was later manufactured in Germany under the designation MZ3a.

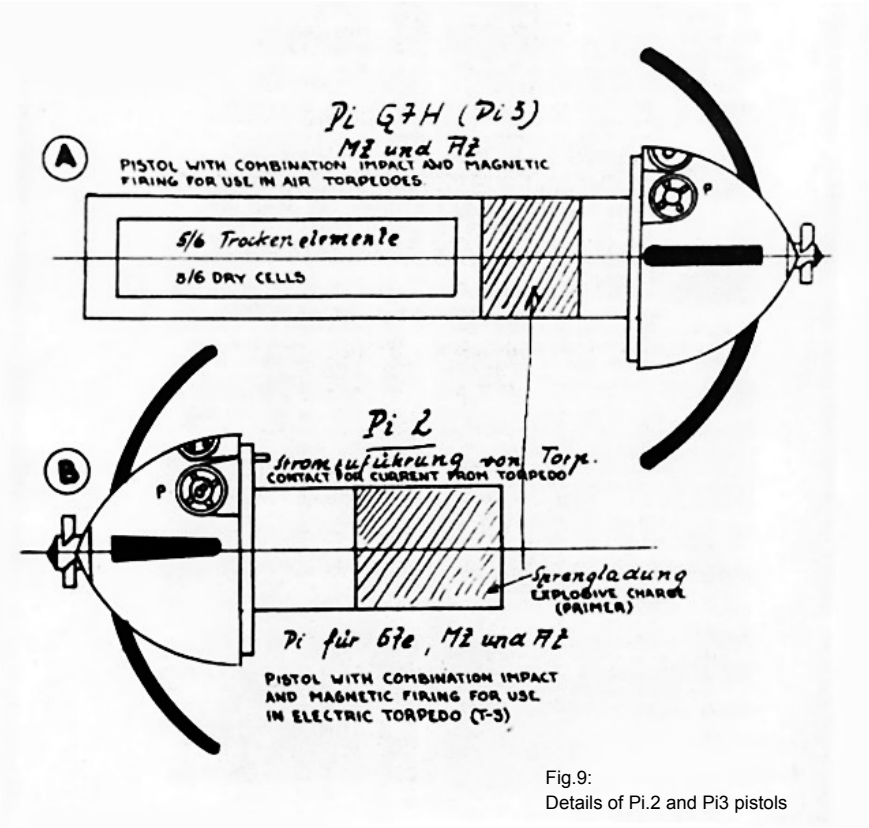


Fig.9:
Details of Pi.2 and Pi3 pistols

TZ5/Pi4c

It was very clear when designing the TV torpedo, that the acoustic sensors should be placed in the front of the torpedo, which forced a complete redesign of the warhead and detonation system. This meant that the contact detonation system coulnd't be based in teh actual system of mecanical sensors which were trigged when they impacted the objective, and that the magnetic detonation system could not be based in variations of magnetic field.
Also, the guiding system should be capable of performing sudden changes of direction, and that detonation systems should be able to deal with this sudden changes of direction.
These premises lead to two new types of detonators. The TZ5 was an active magnetic pistol, which meant it generated its own magnetic field, that when changed by another magnetic field (like the magnetic field of a ship's hull), activated the explosive charge (while passive magnetic pistols relied on the variation of the environmental magnetic field to pass a preset treshold to trigger the detonation). The Pi4c contact pistol, was an inertial contact pistol, placed in the back of the warhead, which worked with two penduluns. According to all data, this was the best german pistol(s) used in ww2.

Depth control devices

Tiefen Apparat I (TA I)

Both the G7a and the G7e were equipped at the beginning, with the TA1, a conventional depth maintaining equipment, based on a pendulum system and an hydrostatic valve.
Unfortunately, this system wasn't tested enough before the war, since there was the assumption that there would be an widespread use of magnetic pistols, not contact pistols, which meant that it wasn't at all crytical to maintain constant, the depth of the torpedo.
Thanks to all the problems with both the contact and magnetic pistols, the BdU issed orders for all torpedos (with contact pistols, while problems in magnetic pistols were being sorted out) to be fired at a minimum depth. Reports from British intelligence, mainly gathered after the U-570 capture, have shown that in the Spring of 1941, these problems were still a major headache to the Unterseebootwaffe.

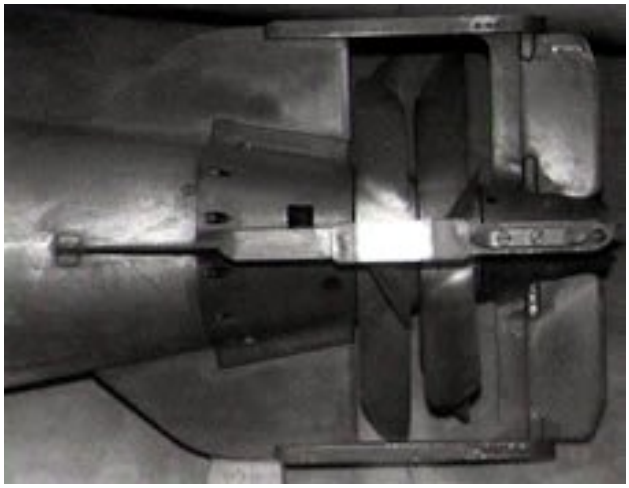


Fig.10:
Torpedo Depth Control device, TA1

Tiefen Apparat II (TA II)

4 problems forced the development and deployment, in 1943, of a new system to control the depth of torpedo runs, the TA II.
First, the problems with the TAI, and second, torpedos equipped with FaT and LuT guidance systems, were desestabilized by ship's hull displacement + propeller cavitation, and tended to jump off the surface.
Third, the TIIIa and FaTII torpedos, were equipped with heavier and heavier batteries (17T210) to increase their range. This extra weight increased the negative boyancy of the torpedo, which wasn't then capable of retained constant run depth.
And fourth, uboats were being forced to launch their torpedos from ever increasing depths, and the TA1 system took too much time in stabilizing the torpedo.

The TAII was meant to solve all these problems, and had a few improvements. The maximum run depth of the torpedo went from 12 meters, to 15 meters and the control system was redesigned, so that torpedos could be launched from a depth of up to 40 meters.
The TAII also solved in part, the stabilization problems of FaT and LuT torpedos, since these torpedos were equipped with extensions in the horizontal stabilizers that were activated by compressed air. This made them more stable, but increased autorotation ratio, so a similar system was installed in the vertical stabilizers as well.

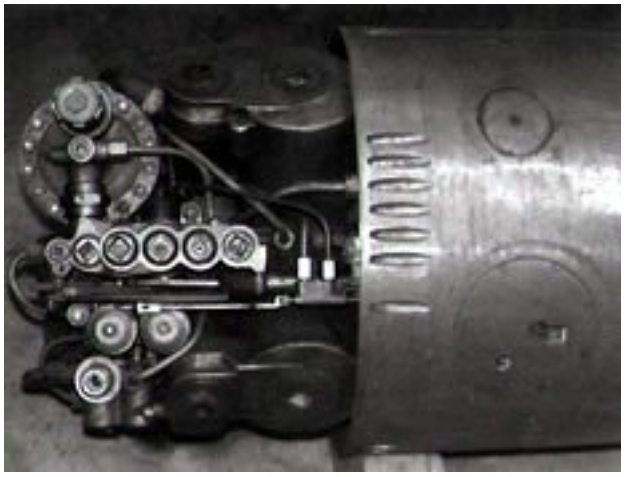


Fig.11:
Torpedo Depth Control device, TA2

Enddetonierersicherung

All torpedos were designed sink automatically, if they had reached their maximum range, without any impact, but sometimes, torpedos detonated when they impacted marine ground, or by pressure collapse of the detonator.
To avoid this, it was designed the Enddetonierersicherung (prevention of detonation at end of run). It consisted of an hydrostatic valve, that flooded the detonator when the torpedo reached a depth of 150 meters.

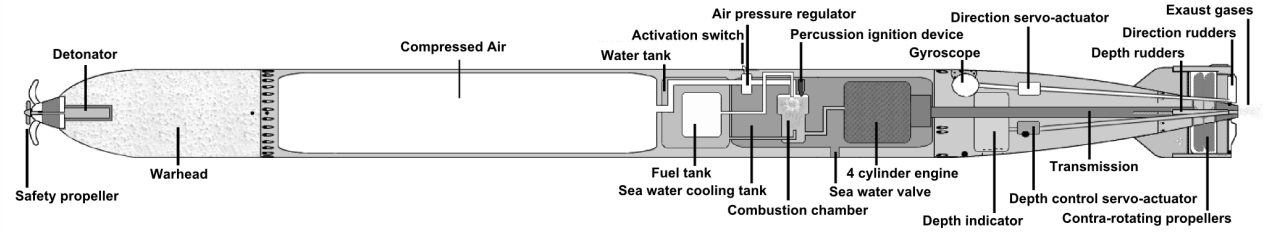


Fig.12:
TI G7a diagram

Propulsion:

At the beginning of ww2, there were 2 propulsion systems in the torpedos.
The first one, was the internal combustion engine installed in the G7a (Ato) torpedos, that used Dekalin (decahydronaphtalene) as fuel, and compressed air as oxidizer. It rendered a power of 350cv at 1470rpm, which permitted 3 possible settings of speed/range, 44 knots at 5000m, 40 knots at 7500m, and 30 knots at 12500m. However it was noticed that the 44knots settings broke the engine, and thus, this setting wasn't used until the propulsion system was modified.

The second system, was the electrical engine of the G7e (Eto) torpedos. His primary advantage was that it didn't left a trail of bubbles like the G7a. The batteries that feeded the engine were DC current, measured 2.8m and weighted 711Kg.
The batteries had 52 cells that were capable of producing 92A/hour. The cells were assembled in boxes that could be extracted from the torpedo by means of special rails. An important aspect was that the battery was equipped with an heating system, that should be activated via external power, to increase the temperature to 30'C. This preheating increased the total run lenght of the torpedo, by up to 60%.
In both systems, the engines controlled two contrarotating propellers (to eliminate autorotation)

Fig.12:
Battery detail

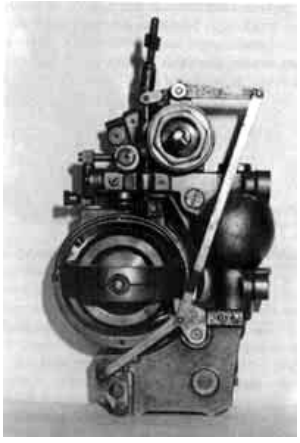
Typical loads
up to 1943, there wasn't much choice, G7a and G7e, but in May of 1943
the typical load aboard a Type VII was
in the bow, 4 TI FaTI G7a and 6 TIII G7e.
in the stern, two TIII FaT II G7e

In April 1944, the variety increased, and typical load was
in the bow, 3 T5 G7es Zaukonig, and 5 LuT or 2 FaTI + 3 FaTII
in the stern, two TV G7es Zaukonig

The entrance of server of the Type VII and IX in 1938, happened at the time when gyroscopes were being introduced, which allowed torpedos to take a heading of +/-90' in 1' steps, and of a new torpedo computer to calculate the firing angles (T.Vh.Re.SI)

Fig.13:
Loading of torpedos on a type VII uboat

Fig.14:
Gyroscope in detail



The data to feed to the TDC was:
- estimated distance to target
- speed and angle relative to uboat
- speed of torpedo
- correction factor for uboat balancing + parallax

from this, the TDC computed the firing angle, direction angle, convergence, and maximum distance, and transmitted this via dials to the torpedo room.
The torpedo officer took this information and set the gyro angles on the torpedos accordingly.

At the beginning, the convergence computation and direction angle, were computed separatly, but from 1939, these calculations were made directly in a new TDC called T.Vh.Re.S2

Combat experiences shown numerous errors and difficulties in using the new systems. There was a need to automate the feeding of data directly in the torpedos. Also, the new FaT and LuT torpedos were about to be used, and this forced a redesign of all systems. The new TDC, called T.Vh.Re.S3 (Siemens S3), was very sensitive to humidity, and couldn't be installed in the conning tower, were the attack periscope was installed, so it was installed in the control room (zentral).

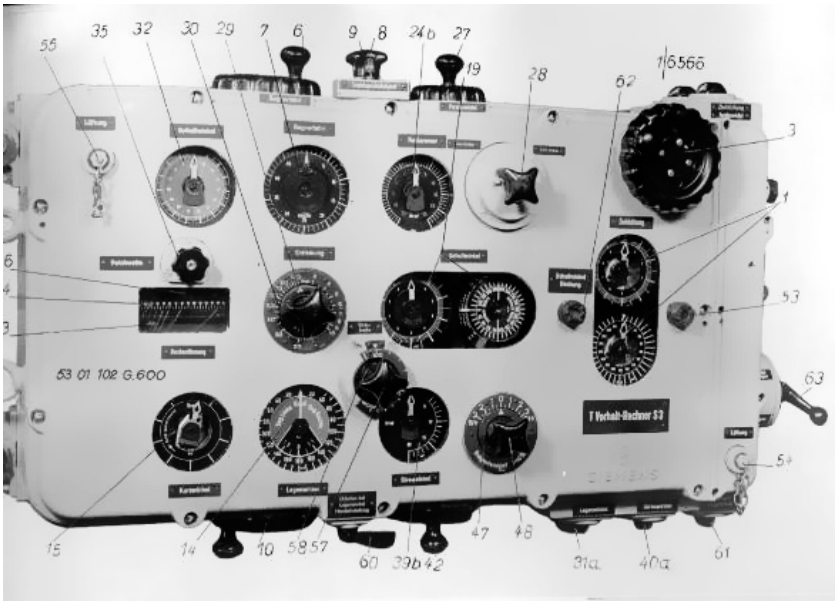


Fig.15:
Siemens S3 torpedo computer

The new TDC had a new control panel where the weapon officer could feed and visualize all the data directly, from the conning tower. Torpedo launching was also made from the conning tower, and included a 2,5seconds retarder, for torpedo spreads.

A simple angle computer was designed for use in the XVII uboat (Walter), but it never got into server, however, an evolution of this TDC was installed in the Type XXIII uboats, the T.Vh.RGM.3d.

Surface Attacks

Surface attacks were carried out by normally 1 weapons officer and in the Type IA and TypeII, it was used a Torpedo U-Boot Ziel Apparat Nº1 (TUZA1), which was too slow and complicated, and had to be disassembled and reassembled for each attack. A new version was built by Karl Zeiss in 1936. The first version, TUZA2, wasn't submersible, and therefore, it also needed to be disassembled and reassembled for each attack. The new version however, the TUZA3 was submersible, up to a depth of 90 meters.

In 1939, a new system entered service, also manufactured by Karl Zeiss, the Uboot Ziel Optik (UZO). There were 2 versions, the UZO1 for the Type VII uboat, and the UZO2 for the Type IX. The 2 versions were identical, except for the mounting support of UZO2 which was higher than the one in UZO1, to compensate for the greater height of the Type IX bridge. However, uboats kept on carrying aboard, a TUZA3, that could be installed in the UZO support, in case the UZO was damaged.
The UZO had lots of disadvantages, it was complicated to use, and required a special learning course, and the bridge limited its field of view to +/-110', and the UZOs had watertight problems from 90m upwards.
Despite all this, a new version was made, and 4 different companies presented their prototypes. The Siemens UZS4 was the chosen one. It was equipped with Zeiss 10x80 binoculars.

Fig.16:
Torpedo attack on a freighter

Torpedo type reference

TI G7a "Ato"

Geräte-Nr.:	12
Diameter:	533,4mm
Weight:	1538Kg
Length:	7163mm
Charge:	Ka, or Kc280 warheads, 280Kg (Hexanite).
Pistol:	Pi1 or TZ3 with Pi3 (contact or contact coupled with passive magnetic).
Arming:	250m (pre 1943) 150m (post 1943)
Boyancy(%):	21
Range/Speed:	6000m/44Kn (not used in early war) 7500m/40Kn (early war) 12500m/30Kn (early war) 6000m/44Kn (later in the war) 8000m/40Kn (later in the war) 14000m/30Kn (later in the war)
Power:	Decahydronaphthalene (Decalin) Wet-Heater, 4 cylinders 108hp at 940U/min (early war) 241hp at 1270U/min (early war) 300hp at 1500U/min (early war) 255hp at 1280U/min (later in the war) 350hp at 1470U/min (later in the war)

Notes:
44knots settings were found to overload the engine and weren't used during the early years of the war. The early models used in 1939 had ranges about 20% less than the standard specified of 6000m/44Kn, 8000m/40Kn, 14000m/30Kn, being in fact of 7500m/40Kn and 12500/30Kn. Power also changed, from 108hp/940U/min, 241hp/1270U/min, 300hp/1500U/min, to 255hp/1280U/min, and 350hp/1470U/min. The warhead was a Ka280 or Kc280, with 280Kg of Hexanite. Explosive charge was usually 60%TNT and 40% hexanitrodiphelylamine, in various mixes:

SW18: 50% TNT, 24% HND, 15% aluminium.
SW36: 67% TNT, 8% HND, 25% aluminium.
SW39: 45% TNT, 5% HND, 30% amonium nitrate, 20% aluminium.
SW39a: 50% TNT, 10% HND, 5% amonium nitrate, 35% aluminium.

Note, wake was much more visible at 40Kn, since air consuption changed from 13.6 atü at 30Kn, to 24.3 atü at 40Kn.

TI G7a "Ato" FaT I

Geräte-Nr.:	12
Diameter:	533,4mm
Weight:	1538Kg
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FaT stands for "Flächenabsuchenden Torpedo" or for "Federapparattorpedo". After a primary run of between 1600m to 3200m, if nothing was hit, it would turn 90 or 180 degrees to the left or to the right, and make secondary runs of either 800m or 1600m, until either a target was hit, or batteries were exausted.
On the firing of a FaT torpedo, other uboats had to be warned, otherwise they would risk being hit by friendly FaT torpedos.
Standard procedure was to dive to 50meters depth.
Note that the FaTI guidance system was only coupled to the TI G7a torpedo, while the FaTII guidance system, was only coupled to the TIII G7e torpedo.

TI G7a "Ato" LuT I

Geräte-Nr.:	12
Diameter:	533,4mm
Weight:	1538Kg
Length:	7163mm
Charge:	Ka, or Kc280 warheads, 280Kg (Hexanite).
Pistol:	Pi1 or TZ3 with Pi3 (contact or contact coupled with passive magnetic).
Arming:	250m (pre 1943) 150m (post 1943)
Boyancy(%):	21
Range/Speed:	6000m/44Kn (not used in early war) 7500m/40Kn (early war) 12500m/30Kn (early war) 6000m/44Kn (later in the war) 8000m/40Kn (later in the war) 14000m/30Kn (later in the war)
Power:	Decahydronaphthalene (Decalin) Wet-Heater, 4 cylinders 108hp at 940U/min (early war) 241hp at 1270U/min (early war) 300hp at 1500U/min (early war) 255hp at 1280U/min (later in the war) 350hp at 1470U/min (later in the war)

Notes:
44knots settings were found to overload the engine and weren't used during the early years of the war. The early models used in 1939 had ranges about 20% less than the standard specified of 6000m/44Kn, 8000m/40Kn, 14000m/30Kn, being in fact of 7500m/40Kn and 12500/30Kn. Power also changed, from 108hp/940U/min, 241hp/1270U/min, 300hp/1500U/min, to 255hp/1280U/min, and 350hp/1470U/min. The warhead was a Ka280 or Kc280, with 280Kg of Hexanite. Explosive charge was usually 60%TNT and 40% hexanitrodiphelylamine, in various mixes:

SW18: 50% TNT, 24% HND, 15% aluminium.
SW36: 67% TNT, 8% HND, 25% aluminium.
SW39: 45% TNT, 5% HND, 30% amonium nitrate, 20% aluminium.
SW39a: 50% TNT, 10% HND, 5% amonium nitrate, 35% aluminium.

LuT I ("Lagenunabhängiger Torpedo") version of TI G7a torpedo.

TI LuTII G7a

Geräte-Nr.:	29
Diameter:	533,4mm
Weight:	1538Kg
Length:	7163mm
Charge:	Ka, or Kc280 warheads, 280Kg (Hexanite).
Pistol:	Pi1 or TZ3 with Pi3 (contact or contact coupled with passive magnetic).
Arming:	250m (pre 1943) 150m (post 1943)
Boyancy(%):	21
Range/Speed:	6000m/44Kn (not used in early war) 7500m/40Kn (early war) 12500m/30Kn (early war) 6000m/44Kn (later in the war) 8000m/40Kn (later in the war) 14000m/30Kn (later in the war)
Power:	Decahydronaphthalene (Decalin) Wet-Heater, 4 cylinders 108hp at 940U/min (early war) 241hp at 1270U/min (early war) 300hp at 1500U/min (early war) 255hp at 1280U/min (later in the war) 350hp at 1470U/min (later in the war)

Notes:
44knots settings were found to overload the engine and weren't used during the early years of the war. The early models used in 1939 had ranges about 20% less than the standard specified of 6000m/44Kn, 8000m/40Kn, 14000m/30Kn, being in fact of 7500m/40Kn and 12500/30Kn. Power also changed, from 108hp/940U/min, 241hp/1270U/min, 300hp/1500U/min, to 255hp/1280U/min, and 350hp/1470U/min. The warhead was a Ka280 or Kc280, with 280Kg of Hexanite. Explosive charge was usually 60%TNT and 40% hexanitrodiphelylamine, in various mixes:

SW18: 50% TNT, 24% HND, 15% aluminium.
SW36: 67% TNT, 8% HND, 25% aluminium.
SW39: 45% TNT, 5% HND, 30% amonium nitrate, 20% aluminium.
SW39a: 50% TNT, 10% HND, 5% amonium nitrate, 35% aluminium.

LuT II ("Lagenunabhängiger Torpedo") version of TI G7a torpedo.

TII G7e "Eto"

Geräte-Nr:	20
Diameter:	534,6mm
Weight:	1608Kg
Lenght:	7163mm
Charge:	Ka280, 280Kg
Pistol:	Pi1 (Pi G7a AZ contact pistol)
Arming:	250m
Boyancy(%):	21

Range/Speed: 5000m/30kn at 1700U/min, preheated at 30'C
3000m/28Kn not preheated.

Power: Siemens GL231/75 E-Motor, 100hp, 2x 13T210 batteries

91V/950A	72KW at 1755U/min (preheated at 30'C)
83V/885A	60KW at 1590U/min (not preheated at 30'C)

Notes:
This unit used a 100hp Siemengs GL231/75 electric motor, that drove two contra-rotating propellers. The above range and speed of 5000m/30Kn could be reached only if the batteries were preheated to 30'C. These torpedoes had to be serviced every 3 to 5 days in order to maintain their reliability.
Not pre-heated ranges are 3000m/28Kn. Some sources mention a 300Kg charge.

TIII G7e "Eto"

Geräte-Nr:	20
Diameter:	534,6mm
Weight:	1608Kg
Length:	7163mm
Charge:	Ka280, 280Kg
Pistol:	Pi2 (Pi G7H AZ/MZ (contact pistol coupled with passive magnetic pistol)
Arming:	150m
Boyancy(%):	21
Range/Speed:	5000m/30kn at 1700U/min, preheated at 30'C 3000m/28Kn not preheated.
Power:	Siemens GL231/75 E-Motor, 100hp, 2x 13T210 batteries 91V/950A 72KW at 1755U/min (preheated at 30'C) 83V/885A 60KW at 1590U/min (not preheated at 30'C)

Notes:
This unit used a 100hp Siemengs GL231/75 electric motor, that drove two contra-rotating propellers. The above range and speed of 5000m/30Kn could be reached only if the batteries were preheated to 30'C. These torpedoes had to be serviced every 3 to 5 days in order to maintain their reliability.
Not pre-heated ranges are 3000m/28Kn. This version used an influence pistol, the Pi2 (Pi G7H AZ/MZ), which had an impact pistol, similar to the Pi1 impact pistol, coupled with an passive magnetic TZ3 pistol.
The torpedo could be set via a switch, to either use only the impact pistol (AZ), or the impact+magnetic (MZ).
The warhead used TNT+HND (Trinitrotoluene+Hexanitrophenylamine)

TIII FaTII G7e

Geräte-Nr:	20
Diameter:	534,6mm
Weight:	1620Kg
Length:	7163mm
Charge:	Ka280, 280Kg

Pistol: Pi2 (Pi G7H AZ/MZ (contact pistol coupled with passive magnetic)

Arming:	150m
Boyancy(%):	21

Range/Speed: 5000m/30kn at 1700U/min, preheated at 30'C
3000m/28Kn not preheated.

Power: Siemens GL231/75 E-Motor, 100hp, 2x 13T210 batteries

91V/950A	72KW at 1755U/min (preheated at 30'C)
83V/885A	60KW at 1590U/min (not preheated at 30'C)

Notes:
This unit used a 100hp Siemengs GL231/75 electric motor, that drove two contra-rotating propellers. The above range and speed of 5000m/30Kn could be reached only if the batteries were preheated to 30'C. These torpedoes had to be serviced every 3 to 5 days in order to maintain their reliability.
Not pre-heated ranges are 3000m/28Kn.
This version used a influence pistol, the Pi2 (Pi G7H AZ/MZ).
The warhead used TNT+HND (Trinitrotoluene+Hexanitrophenylamine).
This was the FaT version of the TIII G7e.

TIIIa FaTII G7e

Geräte-Nr:	20
Diameter:	534,6mm
Weight:	1760Kg
Length:	7163mm
Charge:	Ka280, 280Kg
Pistol:	Pi2 (Pi G7H AZ/MZ (contact pistol coupled with passive magnetic pistol)
Arming:	150m
Boyancy(%):	32
Range/Speed:	7500m/30kn at 1700U/min, preheated at 30'C 4500m/28Kn not preheated.
Power:	Siemens GL231/75 E-Motor, 100hp, 2x 17T210 batteries, 125A/hour

Notes:
This unit used a 100hp Siemengs GL231/75 electric motor, that drove two contra-rotating propellers. The above range and speed of 7500m/30Kn could be reached only if the batteries were preheated to 30'C. These torpedoes had to be serviced every 3 to 5 days in order to maintain their reliability.
Not pre-heated ranges are 4500m/28Kn. This version used an influence pistol, the Pi2 (Pi G7H AZ/MZ), which had an impact pistol, similar to the Pi1 impact pistol, coupled with an passive magnetic TZ3 pistol.
The torpedo could be set via a switch, to either use only the impact pistol (AZ), or the impact+magnetic (MZ).
The warhead used TNT+HND (Trinitrotoluene+Hexanitrophenylamine)
This was the FaTII version of the TIII G7e (note that TIII G7e's only had FaTII guidance devices, FaTI were only used on TI G7a torpedos).
This torpedo used two 17T210 batteries, with a larger capacity of 125 Amperes/hour, compared to the 13T210 batteries, which had a capacity of 93 Amperes/hour.

TIIIa LuTI G7e

Geräte-Nr:	20
Diameter:	534,6mm
Weight:	1760Kg
Length:	7163mm
Charge:	Kb280, 280Kg
Pistol:	Pi2 (Pi G7H AZ/MZ (contact pistol coupled with passive magnetic pistol)
Arming:	150m
Boyancy(%):	32
Range/Speed:	7500m/30kn at 1700U/min, preheated at 30'C 4500m/28Kn not preheated.
Power:	Siemens GL231/75 E-Motor, 100hp, 2x 17T210 batteries, 125A/hour

Notes:
This unit used a 100hp Siemengs GL231/75 electric motor, that drove two contra-rotating propellers. The above range and speed of 7500m/30Kn could be reached only if the batteries were preheated to 30'C. These torpedoes had to be serviced every 3 to 5 days in order to maintain their reliability.
Not pre-heated ranges are 4500m/28Kn. This version used an influence pistol, the Pi2 (Pi G7H AZ/MZ), which had an impact pistol, similar to the Pi1 impact pistol, coupled with an passive magnetic TZ3 pistol.
The torpedo could be set via a switch, to either use only the impact pistol (AZ), or the impact+magnetic (MZ).
The warhead used TNT+HND (Trinitrotoluene+Hexanitrophenylamine)
This was the LuTI version of the TIII G7e torpedo.
This torpedo used two 17T210 batteries, with a larger capacity of 125 Amperes/hour, compared to the 13T210 batteries, which had a capacity of 93 Amperes/hour.

TIIIa LuTII G7e

Geräte-Nr:	20
Diameter:	534,6mm
Weight:	1760Kg
Length:	7163mm
Charge:	Kb280, 280Kg
Pistol:	Pi2 (Pi G7H AZ/MZ (contact pistol coupled with passive magnetic pistol)
Arming:	150m
Boyancy(%):	32
Range/Speed:	7500m/30kn at 1700U/min, preheated at 30'C 4500m/28Kn not preheated.
Power:	Siemens GL231/75 E-Motor, 100hp, 2x 17T210 batteries, 125A/hour

Notes:
This unit used a 100hp Siemengs GL231/75 electric motor, that drove two contra-rotating propellers. The above range and speed of 7500m/30Kn could be reached only if the batteries were preheated to 30'C. These torpedoes had to be serviced every 3 to 5 days in order to maintain their reliability.
Not pre-heated ranges are 4500m/28Kn. This version used an influence pistol, the Pi2 (Pi G7H AZ/MZ), which had an impact pistol, similar to the Pi1 impact pistol, coupled with an passive magnetic TZ3 pistol.
The torpedo could be set via a switch, to either use only the impact pistol (AZ), or the impact+magnetic (MZ).
The warhead used TNT+HND (Trinitrotoluene+Hexanitrophenylamine)
This was the LuTII version of the TIII G7e torpedo.
This torpedo used two 17T210 batteries, with a larger capacity of 125 Amperes/hour, compared to the 13T210 batteries, which had a capacity of 93 Amperes/hour.

TIIId G7e "Dackel"

Geräte-Nr:	20
Diameter:	534,6mm
Weight:	2220Kg
Length:	11000mm
Charge:	Kb280, 280Kg
Pistol:	PiZ
Arming:	150m
Boyancy(%):	1,5
Range/Speed:	57000m/9Kn at 505U/min
Power:	Siemens GL231/75 E-Motor, 100hp, 4x 17T210 batteries 5KW at 505U/min

Notes:
This was a very long range, slow speed, version of the TIII G7e torpedo, intended for use in harbours, or restricted bays. It could be programmed with a specific circling, or legs, at the end of a straight run.
It had four 17T210 bateries. Due to the extremely long runs, torpedo preheating didn't made much of a difference.

TIV G7es "Falke"

Geräte-Nr:	37
Diameter:	534,6mm
Weight:	1937Kg
Lenght:	7163mm
Charge:	Kd280, 274Kg
Pistol:	Pi4a
Arming:	150m
Boyancy(%):	?
Range/Speed:	7500m/20kn at 1125U/min, preheated at 30'C 4500m/16Kn not preheated.
Power:	Siemens GL?/? E-Motor, 32hp, 1x 13T210 batteries 24KW at 1125U/min (preheated at 30'C) 20KW at 985U/min (not preheated at 30'C)

Notes:
The first passive homing torpedo. Homing was made by a simple noise measurement. Intended to use against merchant ships, so the low speed was acceptable.
The T4 Model was the adjunct of the earlier T3 model in nearly every way. However, this was no ordinary straight running torpedo, but the world's first acoustic homing torpedo.
In early 1933, Germany started development and testing of acoustic homing mechanisms for torpedoes. From the outset of submarine warfare, it had been a dream to be able to aim and fire torpedoes without the aid of a periscope. because the periscope gives away the location of a submarine, and because a hull-penetrating periscope greatly weakens a submarine's pressure hull and limits the depths to which it can dive. U-boats also had to come to very shallow depths to use their periscopes, generally about 15 m, leaving them greatly exposed to bombing, depth charging, and even gunfire.
With the introduction of Falke, U-boats could remain more deeply submerged and fire at convoys with nothing to give away their position but the noise of their screws. Rather than aiming with a periscope, the torpedo could be roughly aimed at a sound contact as detected by a U-boat's hydrophones, and the homing mechanism could be trusted to find the target without the need for precise aiming.
Falke worked much like a normal straight running torpedo for the first 400 m of its run, whence its acoustic sensors became active and searched for a target. The sensitive sound sensing equipment in Falke required the torpedo be as quiet as possible, hence it ran at only 20Kn; in addition, the firing U-boat was forced to stop its motors. Falke was intended to home on merchant targets, however, so Falke's slow speed was not a great hindrance.

TV G7es "Zaukönig I"

Geräte-Nr:	45
Diameter:	534,6mm
Weight:	1495Kg
Lenght:	7163mm
Charge:	Ke1, 274Kg
Pistol:	TZ5, Pi4b, Pi4c
Arming:	150m with Pi4c and TZ5, 400m with Pi4b.
Untertrieb(%):	11
Range/Speed:	5750m/24.5kn at 1125U/min, preheated at 30'C 3750m/20Kn not preheated.
Power:	Siemens GL?/? E-Motor, 55hp, 1x 13T210 batteries 40KW at 1350U/min (preheated at 30'C) 32KW at 1175U/min (not preheated at 30'C)

Notes:
This torpedo was meant to be used against convoy escorts. Designed to home in on the caviation noise of around 24.5KHz which was equivalent to propellers on an escort travelling at 10 to 18Kn. First sucessful combat use was made in September 1943.
There were two main variants:

Flat-nosed version which contained two sets of magnetostriction hydrophones.

Round-nosed version which contained two magnetostriction hydrophones inside a funnel shaped baffle.

The TV also introduced the TZ5 (active) magnetic pistol, which was basically a metal detector with two coils, and solved much of the problems of early magnetic pistols. An improved TZ6 pistol could be fitted to any G series torpedo (53.3cm diameter), but was only approved for use as the war ended.
Most torpedos used whisker-type impact pistols, but these could not be used on homing torpedos. Therefore these types of torpedos used an inertial pistol in the rear of the warhead, and the TV could use a coupled magnetic and inertial impact pistol.
The acoustic homing device would only lock to the loudest noise after a run of 400m from its launch, with a Pi4b pistol, and 150m from its launch, with a Pi4c pistol, to avoid locking on the launching uboat. In such cases, standard orders were to dive imediatly to a depth of 60 meters, after launch, if the launch was made from a bow tube. If the launch was made from a stern tube, complete uboat silence was required.

TVb G7es "Zaukönig I"

Geräte-Nr:	45
Diameter:	534,6mm
Weight:	1495Kg
Lenght:	7163mm
Charge:	Ke1, 274Kg
Pistol:	TZ5, Pi4b, Pi4c
Arming:	150m with Pi4c and TZ5, 400m with Pi4b.
Untertrieb(%):	11
Range/Speed:	8000m/21.5kn at 1210U/min, preheated at 30'C 5750m/20Kn not preheated.
Power:	Siemens GL?/? E-Motor, 40hp, 1x 17T210 batteries 30KW at 1210U/min (preheated at 30'C) 26KW at 1050U/min (not preheated at 30'C)

Notes:
This torpedo was meant to be used against convoy escorts. Designed to home in on the caviation noise of around 24.5KHz which was equivalent to propellers on an escort travelling at 10 to 18Kn. First sucessful combat use was made in September 1943.
The TV also introduced the TZ5 (active) magnetic pistol, which wasbasically a metal detector with two coils, and solved much of the problems of early magnetic pistols. An improved TZ6 pistol could be fitted to any G series torpedo (53.3cm diameter), but was only approved for use as the war ended.
Most torpedos used whisker-type impact pistols, but these could not be used on homing torpedos. Therefore these types of torpedos used an inertial pistol in the rear of the warhead, and the TV could use a coupled magnetic and inertial impact pistol.
The acoustic homing device would only lock to the loudest noise after a run of 400m from its launch, with a Pi4b pistol, and 150m from its launch, with a Pi4c pistol, to avoid locking on the launching uboat. In such cases, standard orders were to dive imediatly to a depth of 60 meters, after launch, if the launch was made from a bow tube. If the launch was made from a stern tube, complete uboat silence was required.
This variant had an increased range, thanks to an larger capacity battery, the 17T210, and 2 auxilliary boosters ("Zusatztröge"). The TVa was the S-boot version of this torpedo.

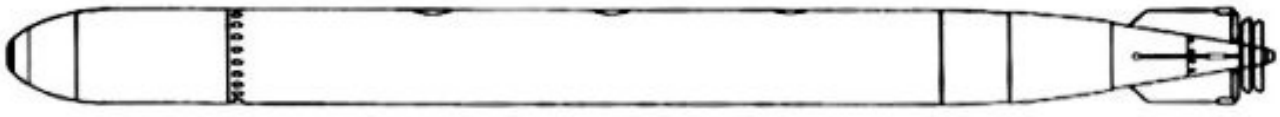

Fig.17:
TV G7es "Zaukönig I" torpedo

Appendix A

Appendix to B.d.U.'s War Log of 1.7.1944.

Summary of the development of the torpedo arm in operational U-boats.

Situation as of 1.7.1944.

A. Following on the summary given in the War Log of 10.5.43 and the memoranda on T V in War Logs of 24.9.43, 1.12.43 and 1.5.44, herewith a further review of the development of the torpedo arm on operations, under the following headings:

1) Pistols: Pi 2 and TZ 3 (Pi 3))
2) FAT I and II
3) L.U.T.
4) T III a
5) T V with TZ5 and Pi 4
6) Net-passing pistols and torpedoes
7) Equipment of boats with torpedoes.

B. 1) Pistols Pi 2 and TZ 3)Pi 3):

Pi 2 has now been used for 18 months as non-contact pistol for the G 7E. Although relatively few Pi 2 have been fired as conditions of U-boat warfare have changed, it can nevertheless be said that this pistol has continued to prove satisfactory even with the new depth settings in force since March 1943. Operational experiences permitted the following relaxations of previous operational restrictions:

a) August 1943: "MZ in" permitted in all weathers and at depth settings of 7 meters and below.

b) March 1944: "MZ in" permitted even if there had been severe explosions close to the boat, provided the testing of the gyroscope showed no defects; the gyroscope was shown to be more liable to damage than the MZ-unit of the pistol.

Development of a non-contact pistol for the G7A from the Italian "Pi S1C" was begun in January 1943. It became ready for operational use in August 1943 under the designation "torpedo firing unit 3" (TZ 3) and "Pi 3". The term "torpedo firing unit", used here for the first time, is used to indicate the MZ-unit which is fixed in the head.

Now only the impact pistol - Pi 3 - has to be fitted into the head on board, as hitherto, before loading into the tube.

Fig.18:
Pi4 detonator details

The same operational restrictions and depth settings apply to TZ 3 as to Pi 2.
Operational experiences are similar to those with Pi 2. They are not unfavorable, but the number of operational shots fired is not enough to give a final opinion.

State of equipment:
with Pi 2 all operational boats.
with Pi 3 about 50% of operational boats.
The reason for the lack of TZ 3 (Pi 3) lies in difficulties of production mainly due to the collapse of Italy.

In spite of considerable efforts on the part of torpedo experimental stations, it has not so far been found possible to eliminate end-of-run detonators, as so firmly demanded by B.d.U. It has not even been possible to discover fully the reasons for them, as attempts to cause artificial end-of-run detonations by sinking torpedoes in deep water have not been successful. In theory the reasons are believed to be:

a) Firing of the impact unit when hitting the bottom;
b) Vibration of the MZ unit when the torpedo sinks to some depth and the current fails to be switched off.

Efforts are being made in the first instance to develop a current cut-off for all MZ pistols. Until this is ready the tactical disadvantage and the uncertainty as to whether or not a hit has been made at the end of the run shown in the firing tables will continue, especially with electric torpedoes. This is particularly the case with the electric torpedo, because the end of its run cannot be fixed exactly and one has to reckon with a certain additional run at a decreasing torpedo speed, which in FAT shots, has some importance. As conditions of attack have become more difficult for the boats and firing ranges have therefore increased, boats constantly have difficulty in deciding whether or not the detonation of the torpedo means a hit, when the explosion is only heard.

App. 1. (See Serial Order No. 45, attached).

Nothing is known of any enemy countermeasure to our non-contact pistol, except a suspicion on the part of U 532 (Junker) that magnetic gear was being used, which has not so far been confirmed.

2) FAT I and II:
G 7A FAT I continues to prove satisfactory.
G 7E FAT II has also brought good results within the limits of its short run, which is not very suitable for FAT.
In no case however has any success been achieved with the circling shot i ntended for use against destroyers. One of the main reasons for this is the fact FAT II has hardly been used since T V has become operational.

3) LUT (torpedo which can be fired independent of angle on the bow).
LUT is a development of FAT I and II. By inserting a new link in the loop mechanism the "LUT" course can be set parallel to the enemy's course in each instance, so that the torpedo can be fired from any angle on the bow. The loop pattern is in the form of a saw, the speed of advance of which can be set at between 5 and 21 knots. Consequently hitting prospects against convoys are increased. Further possibility of employment as anti-destroyer torpedo. Immediate use is only in G 7E (T III a, see paragraph 4)).
This torpedo raises fire control difficulties. In addition to the firing angle, speed of LUT, preliminary run and supplement of the track angle must be passed to the tubes.
LUT was first used operationally in February 1944. On 1.7.44 about 50 operational boats had been equipped. New LUT setting gear has to be fitted.
As yet there are no operational experiences or successes.

4) T III a:
This torpedo is a T III with high powered battery. Its run is 7,500 meters, with FAT and LUT it is effective up to 9,000 meters.
It became operational in February 1944.
By 1.7.44. nearly all Atlantic and Mediterranean boats had been equipped with it.

5) T V (Zaunkönig) with T Z and Pi 4:

a) TV was used:
in the Atlantic from September 1943
in the Mediterranean from October 1943
in Northern Waters from January 1944
in the Black Sea from April 1944,
from the following bases, equipped with testing gear: Brest, Lorient, St. NAzaire, La Pallice, Kiel, Toulon, Pola, Narvik, Trondheim, Constanza.
Although desirable, it will not be possible to set up further fitting-out stations before the end of 1944, owing to the difficulty in obtaining the complicated testing gear.
Deliveries of TV for operations have not so far reached the required numbers. The reason is difficulties in delivery due to enemy action. The equipment of individual boats had therefore to be temporarily reduced during February and March from 4 to 2 Zaunkönig. At present boats are being equipped on an average with 4 Zaunkönig, and in a few bases with 5.

b) TV successes have remained at the level of 60% hits. The torpedo has continued to fill the promise it showed after its first use in September. Details of results are:
By the end of June 1944 341 operational shots had been reported to B.d.U. of these:

175 hits and 20 probable hits = 58%

67 explained misses

44 unexplained misses

4 emergency shots

2 unexplained shots

33 failures.

The failures resolved them selves into:
17 tube runners
7 prematures
3 duds
1 tube-sticker
1 surface breaker
1 torpedo failure
3 unexplained failures.

Sunk with TV:

1 cruiser
128 destroyers and escort vessels and 23 probables
3 submarines
18 freighters
2 tankers.

c) A large number of reports received since about March/April show that the enemy is making great efforts to produce countermeasures to TV. The reports speak of widely-varying types of noises observed in enemy destroyers, escort vessels, and anti-submarine vessels. The noises were described as being like a circular saw, a continuous gnawing, the rattle of a DKW engine. These are probably cases of the anti-TV towed noise-box. In the case of other noises, such as a singing-saw and humming, it is not known whether they derive from a new location gear or from a TV countermeasure. In 4 cases the TV hit, even when noises had been heard, in 3 cases it is suspected that the torpedo was diverted by a noise-box, in one further case the torpedo is believed to have been destroyed by depth-charges with shallow setting dropped into the wake.
Further development is therefore concentrating on fitting which will

avoid similar enemy countermeasures, as well as on the requirements for the new types of U-boat (1700 angled shot, deep shot, adjustable safety distance).

6) Net-passing pistols and torpedoes:
The development of torpedoes and pistols suitable for penetrating nets (pistols without lever, net cutters in the head and tail of the torpedo, slanted suspension lug) has been proceeding since the summer of 1943. By April 1944 there was a sufficient quantity of such gear available. There is no i immediate need to equip all boats. Information received shows that the enemy is abandoning the use of anti-torpedo nets, mainly for reasons of seamanship. At present only boats proceeding to the Indian Ocean are being equipped with this gear, and Black Sea boats for the purpose of penetrating harbor barrages if necessary.

7) Equipment of boats with torpedoes:
The large number of types of torpedo available with different characteristics has made it necessary to fit boats out with several types in order for them to be equipped for many eventualities. The consequent difficulties of loading the tubes for day and night and the fresh decisions to be made by the Commanding Officer in each case have had to be accepted. It is aimed gradually to equip the boats with TV and LUT only, which means that the G 7A will become redundant. Type VII are now only carrying 10 torpedoes, for reasons of weight and stability, and Type IX only 2 upper deck containers for reasons of safety.

Appendix I

Serial Order No. 45.

With immediate effect the following are to be taken as guiding principles for the assessment of hits and torpedo detonations at the end of run of the G 7E calculated from firing tables:

1. Behavior of the torpedo:
Under the most favorable working conditions (torpedo adapted to oil-filled tail-piece, heated, battery fully charged, a full charge of air) the electric torpedo will make a run of 5,000 meters at a constant torpedo speed. This corresponds to a running time of 5 minutes 30 seconds. In addition a further run of 2,000 meters may be expected at a decreasing torpedo speed, during which the torpedo will continue to steer approximately the depth and course set. After about 8 minutes it will have made a run of 7,000 meters. The speed of the torpedo then drops quickly as the distance increases. After about 12 minutes (9,000 meters run) the control units main switch usually cease to function. In one exceptional case the torpedo was observed to run up to 17 minutes, without control, and the current failed to switch off.
In the case of torpedoes in which the above conditions are not fulfilled, that is to say in most cases, the running times and distances cited are less.

2. Behavior of the pistol:
During the torpedo's run according to the firing tables, the Pi 2 (with "MZ-in") is fully effective. Over and above this non-contact firing can be expected to take place up to a running time of 7 minutes. The effective firing depth decreases however as the torpedo speed decreases.

3. End-of-run detonators:
In isolated cases, dependent on the condition of the torpedo, end-of-run detonations occur sooner or later and may overlap in time with possible hits. The reasons for them are not yet fully understood. They can be caused by:

a) Impact firing hitting the bottom;

b) Vibration of the MZ unit when the torpedo sinks to some depth if at the same time the current fails to switch off.

4. Conclusions for the assessment of hits:
From a technical point of view, under the best conditions, the electric torpedo is only fully reliable up to the end of the run shown in the firing tables (5,000 meters). It has a limited use over and above this up to 7,000 meters. Above 7,000 meters (= 8 minutes running time) the torpedo has no further practical value. Under favorable conditions, therefore, there is some likelyhood that detonations which are only heard, and which occur within 7 minutes, can be regarded as hits, provided that the restrictions applicable with "MZ-in" have been observed. There is further a very slight possibility of hitting by impact firing between 7 and 8 minutes running time.

5. When following doubtful explosions in future the following are to be given: size of target, whether loaded, depth setting, MZ-in or out, temperature of acid on firing, time of last topping-up of battery, running time, depth of water.

Appendix 2

Serial Order No. 40.
April 1944 issue.
Equipment with torpedoes.

1) Each type of boat is in future to be equipped with torpedoes as follows. All previous orders are cancelled:

a) Atlantic:

Type VIIC	forward	3 TV, 2 FAT I, 3 T III FAT II (or 5 T IIIa FAT II)
	aft	2 TV
Type VIIC (LUT boats)	forward	3 TV, 5 T IIIa LUT
	aft	2 TV
Type VIID	forward	2 TV, 2 FAT I, 4 T III FAT II
	aft	2 TV
Type IX B and C North Atlantic		
	forward	3 TV, 3 FAT I, 4 T IIIa FAT II (or 7 T IIIa FAT II)
	aft	2 TV, 2 T III FAT II
Type IXD	forward	2 TV, 8 T III FAT II (or T IIIa FAT II)
	aft	2 TV, 2 T III FAT II
	upper deck	9 FAT I (or T I)
Type XB	aft	2 TV, 5 T III (or FAT II)

b) Northern Waters:

Type VIIC	forward	3 TV, 5 T III FAT II
	aft	2 TV

c) Mediterranean:

Type VIIC	forward	3 TV, 5 T IIIa FAT II
	aft	2 TV

d) Black Sea:

Type II	forward	1 TV, 4 T III

2) Boats are to be equipped in accordance with paragraph 1) as far as the torpedo stocks at the base permit. They are to be given T III in lieu of types of torpedo not available.

3) Exceptions:

a) TV equipment for Northern Waters, Mediterranean and Black Sea is to be altered if necessary by the responsible Flag Officer U-boats according to the operational situation and torpedoes available.

b) Northern Waters boats are to be equipped with 3 FAT I forward instead of T III as soon as G 7A can be used in this area.

c) Upper deck equipment for Type XB will be decided separately in each case.

d) The equipment of Atlantic boats with 5 TV will be the subject of a Special Order.

4) Old "Serial Order No. 40", (issue of September 1 1943) is to be removed and destroyed.

Naval War Staff (2nd Division)/B.d.U. Op.
00816W.

Appendix B

Group Headquarters West

A conference was held in Wilhelmshaven with representatives of the Torpedo Experimental Command because of renewed unexplained torpedo failures. The main matter under discussion was the suspicion held by B.d.U. for some time now that MZ could fail to fire, even if shot under. There have been repeated cases of shots fired at close range with good firing data which have not brought results and the reasons have been obscure even to the Torpedo Inspectorate (U 470). These cases have increased particularly recently (U 24, U 15, U 20, U 59, U 60). The Director of the Torpedo Experimental Command reports that U 20's shots cannot be explained. Even if the speed had been wrongly estimated, at least one shot should have hit. The only possible explanation for the failure of the 3 torpedoes to fire would be the fact that the size of the ship had been very much over estimated. The Commanding Officer of the boat denies this possibility. I have reached the following conclusions with regard to these and similar failures!

All the Torpedo Experimental Command's analyses of shots are possible for the particular case under consideration and possibly correct in some cases. But I cannot believe that, with a whole series of failures of this kind, there are other reasons in every case. I am convinced that there is a connection between all these so-called unexplained shots and there is a common cause for their failure which has not yet been discovered.
Up to now I have believed that in many cases boats have fired past, due to misinterpretation of the firing data or aiming mistakes. In individual cases I have sent the boat for further training. But now, with these failures of shots fired under the most simple conditions by a series of the best-trained Commanding Officers and torpedomen, I cannot accept this explanation any longer. Some of these C.O.'s have undergone 2 years of training in peacetime and all of them, when reexamined, were found to have good or very good skill in firing.

From now on, I shall regard all such shots at closest range, where a detailed examination of the circumstances and the firing data exclude the possibility of a miss, and which so far have been regarded as unexplained, as failures of the firing unit. It has happened again and again in these cases that the Torpedo Inspectorate has held the view that the boats have missed or made incorrect observations, only because the reason for the possible failure was not known and could not therefore be made to apply and that afterwards their view was turned out to be incorrect. See, for instance, premature detonations, detonations half-way through the run, firing under with impact firing.
The attitude to be adopted to this problem is therefore, other unknown causes of failures are possible. Otherwise we shall never get anywhere.

18.1 There is still uncertainty about the actual possibilities of supplying in Spain and a practical experiment is therefore necessary. U 44, at present off the west coast of Spain, can be used for this; she can then operate together with boats which are sailing up to 14 days after her. Supply has therefore been ordered for 25/26 in Cadiz.

19.1 Nothing to report.

20.1 Ice is beginning to have a direct effect on plans for operations. Firing and diving training in the Baltic will have to be suspended for the present. There is a choice between delaying the operation of several boats with new C.O.'s until the cold spell is over or sending them on to operations before they have completed the scheduled working up and firing practice periods. As they are all officers whom I believe already capable of handling difficult situations, I have decided to send them on to operations immediately. They will first of all go to operations areas where comparatively little patrol is to be expected. As soon as possible all boats will be transferred from the Baltic to the North Sea.

21.1 U 34 reported that she had carried out her minelaying operation off Falmouth. She has managed it very quickly.

Further sinkings indicate the presence of U 44 off the northwest coast of Spain. Several U-boat warnings show that the enemy is taking action.

The Director of the Torpedo Inspectorate telephoned me today. Trial shots have been made against T 123, which did not fire, and magnetic measurements have been made on torpedoes in store, with the result that the Torpedo Inspectorate considers the possibility of torpedoes not firing is proven.

The fact that its main weapon, the torpedo, has to a large extent proved useless in operation has been the greatest difficulty with which the U-boat Arm has had to contend with since the beginning of the war and it has had a most serious effect on results. At least 25% of all shots fired have been torpedo failures. According to statistics covering all shots up to 6.1., 40.9% of unsuccessful shots were torpedo failures.

1) In August 1939, before the boats left port during the emergency period, a conference held in the Torpedo Trials Department during which the doubts expressed by B.d.U. with regard to the proper functioning of the pistol were dismissed as unfounded by Rear Admiral Wehr, Director of Torpedo Trials Department.

2) On 14.9 U 29 reported by radio that 2 torpedoes had fired prematurely after covering the safety distance. The Torpedo Inspectorate first wished to make out that the U-boats had made an error in position of 30-60 miles. I would not accept this explanation. The Torpedo Inspectorate then recommended setting the pistol 2 zones lower, in order to lessen its sensitivity. This meant that they would not be certain to fire against merchant ships under 3,000 BRT if shot under and such ships would therefore have to be attacked with impact firing. An order was accordingly given to the U-boats by B.d.U. on 14.9.

3) Failures were not eliminated however. Further premature detonations were reported.(U 27 reported that the explosion caused slight damage to the boat). Until the cause was discovered, the Torpedo Inspectorate arranged for the torpedoes to be fitted with an "A" setting of the switch, which made it possible to cut out electric firing.

4) After the "A" setting of the switch had been fitted, B.d.U. ordered on 2.10 that only impact shots were to be fired. This meant that for the present the danger of premature detonation was eliminated. The step was taken for the sake of safety of the boats, until such time as the cause of premature detonation was discovered.

5) At the beginning of October the Torpedo Inspectorate stated that the cause of premature detonation in the G7e had been traced to a bad cable lay-out. The cables had now been laid differently and the G7e could once more be fired under. In the case of the G7a mechanical disturbances were causing premature detonation and the G7a could therefore still not be fired under until the question was finally cleared up.
I expressed doubts on these different explanations for premature detonations, but as the Director of the Torpedo Inspectorate assured me that the G7e was now safe, I decided to try and I released the G7e for firing under with "MZ".

6) On 18.10 U 46 reported a premature detonation of a G7e in an attack on a convoy.
It was therefore established beyond question that the pistol was not safe in the G7e despite the adaptation made. I again ordered impact firing only also for the G7e, with electric firing cut out (switch setting "A").
We were thus back where we were in 1914/18. But I had to make this difficult decision to abandon the much-vaunted, much-discussed magnetic firing in order to avoid losing boats, directly or indirectly, through our own weapons and in the interests of U-boat successes.

7) On 20.10 the Director of the Torpedo Inspectorate informed me by telephone that he had discovered that day that the torpedo (G7a and G7e) was keeping a depth 2 meters below that indicated. Numerous reports from boats, stating that the torpedoes had failed to fire with impact firing units despite good firing data, also indicated that the torpedoes were running deeper than their setting and therefore passing under the target.
I therefore ordered on 20.10 that torpedoes with impact firing were to be set at a maximum depth of 4 meters. At the suggestion of the Torpedo Inspectorate, I ordered further that torpedoes with impact firing were to be set at 2 meters or less than the draft of the target. But in order to avoid surface breaking and consequent cold running the minimum depth setting had to be fixed at 3 meters, and 4 meters in an Atlantic swell.
This meant that torpedoes could not be fires at targets with a draft of less than 5 or 6 meters, e.g. destroyers could not be attacked.

8) On 23.10 a conference was held in Wilhelmshaven between B.d.U., Director of Torpedo Inspectorate and Director of Torpedo Trials Department and Torpedo Experimental Command, in which the following points were confirmed:

a) variations in depth considerably greater than hitherto assumed were to be expected.
b) that the cause of premature detonation had not yet been established.
c) at B.d.U.'s request, it was agreed that at least the explosion at the end of the run which had also frequently occurred, should be eliminated in the near future.

It was thus established that the effective functioning of the torpedo was very limited indeed:

with impact firing, danger of passing under with "MZ" shot, danger of premature detonation.

9) On 5.11 a new (adapted) pistol was brought out and it was hoped that, by stabilization of the needle, it would be proof against premature detonation. The pistol was designated Pi(A-B). With this pistol use of magnetic firing was again permitted. Depth was to be set at draft of target plus 1 meter. All our hopes were now centered on this pistol and further reports received of failures of the present pistol seemed less important.

10) U 28 and U 49 were the first boats to sail with Pi(A-B), on 8.11 and 9.11 respectively. On 19.11 U 49 reported one G7a premature detonator after the safety distance had been covered, one G7e probably failed to fire, 2 G7a detonated after covering 2000 meters. This was a bitter disappointment and our best hopes were dashed in one blow. Apparently there was no improvement on previous conditions. Further reports followed from other boats of premature detonations and failures to fire.

11) Some of the specialists in the Torpedo Inspectorate suggested that the pistols should be set 2 zones below the setting shown in the chart in order to reduce sensitivity and so avoid premature detonation. The depth setting should be the same as the draft of the target and the torpedo thus brought closer to the ship so that the firing field would be effective even at the reduced pistol sensitivity. I was against this and the Director of the Torpedo Inspectorate and the remaining specialists agreed with me.

12) Small alterations to the pistol (insulation of the copper cap, smoothing a thrust collar) did not bring any improvement. Every now and then premature detonations seemed to become fewer for a time and firing under was adhered to, because firing with impact firing units would again have meant many failures due to passing under.

13) Report of shots, in which the pistol failed to fire, despite certain firing data, became more and more numerous. The Torpedo Inspectorate believed that the pistol could not fail to fire if shot under and refused to accept any idea that failures could be caused by this section of the pistol. I had all shots, which the commanding officers believed to be failures to fire examined by the Torpedo Inspectorate. They thought that these must be due to misses or be regarded as unexplained. I can no longer accept this explanation. in view of the large number of reports of shots failing to fire with certain firing data. I consider that in many cases the failure of the pistol to fire is proven and I made this quite clear in a conference with Torpedo Experimental Command on 19.1 (see War Log of 17.1).

14) Experimental firing at T 123 afterwards showed that in fact several pistols failed to fire when shot under. The Torpedo Inspectorate now admits the possibility of failures to fire and issued the following instructions, to be passed on to the boats, on 21.1:

1. For targets under 4,000 BRT, destroyers and surfaced S/M's, depth setting 4 meters.
2. The pistol may fail to fire against targets under 1,000 BRT.
3. For all other targets, depth setting draft plus 1 meter, even in bad weather. The results remain to be seen.

15) In addition to the negative results of trial firing at T 123, recent magnetic measurements of the body of the torpedo and the battery compartment have shown that these exercise an irregular, unstable magnetic effect on the pistol and may cause a strengthening (premature detonators) or a weakening (firing failures) of the magnetic unit. The torpedoes in store are to be demagnetized. The Torpedo Inspectorate doubts if this will be successful. The causes of the failures have therefore by no means been mastered.

16) The Commanding Officers' and crews' confidence in the torpedo is very much shaken. Again and again the boats have tried, in the face of strong enemy activity, to fire their torpedoes under the best possible conditions and often when they have made a daring attack they have been rewarded with failures and even danger to themselves. At least 300,000 tons, which might have been sunk, can be reckoned lost through torpedo failures. I think it is certain, for instance, that U 47 Lieut.(s.g.) Prein's shot at the London class cruiser was a premature detonator. It is very bitter for Commanding Officers and the executive control to find that the U-boat Arm cannot achieve the success expected of it, in spite of a thorough peacetime training, because of torpedo failures.

I will continue to do all I can to keep up the fighting spirits of the U-boats in the face of all the setbacks. We must continue to fire torpedoes in order to discover the causes of the defects and remove them. But commanding officers and crews will only gradually regain full confidence in the torpedo if lasting technical improvements can be made.

Appendix C

VI. General:
Operational use of G7ES:

A) General:
The development of the G7ES was pursued with all speed in the second half of 1942 with the purpose of introducing for operations the anti-destroyer torpedo repeatedly requested by the Flag Officer Commanding UI-boats. The first step to this was the G7 ES - Falke, which could only be used against slow, deep draught targets, owing to its low Vt (speed) and lack of non-contact pistol.

B) G7ES (Falke):

1) Torpedo characteristics: Vt = 20 knots, impact pistol range according to heating 5,000 - 7,000 m, can be used against deep draught vessels with Vg (speed) 7 - 13 knots from position 0 to 180. Limited as regards seaway and depth (not more than seaway 5, not shallower than 3 m). Not to be used in the tropics.

2) The first operational trial with Falke was made in February/March 1943 on 6 boats with 2 torpedoes each in the North Atlantic. The training of officers and gunners took place in a two-day course at the Torpedo Experimental Establishment at Gothenburg. Use was limited to the stern tube owing to the fact that the pistols were not secure against sticking in the tubes. The same reason led, in the course of operational use, practically to the cessation of this. However, from the 12 torpedoes used 3 were fired, these being 2 firings from U 221 (Trojer), 1 firing from U 382 (Juli) with the following result:

1 hit with seaway 6 - 7 on a 5,000 ton freighter sunk.
1 hit on freighter without closer observation
1 misfire owing to faulty setting.

The operational possibilities were, therefore, fundamentally proved. Further, considerable experience was gained for further development. Requirements for further use of Falke were extension of the arming range (locking of the S-apparatus) from the present 720 m. to 1,000 m. as well as absolute security of the pistols in the tube.

3) For general operational use the Falke became available with the required improvements, as from 1.7.43, from the Western bases. Further use was intended in the Mediterranean (as from 1.9.43). The operational use of the improved G7ES anti-destroyer torpedo, originally intended only at a later date but accelerated considerably under pressure of conditions and proving preferable, led to only 5 boats being equipped with the Falke. Results from these are not to hand. Further use of the Falke had to be given up for the reasons mentioned.

C. G7ES - Zaunkönig:

1) General: Operational readiness of the G7ES Zaunkönig (anti-destroyer torpedo) was not anticipated, in the normal course of trials, before the beginning of 1944. However, conditions necessitated, already in May 1943, the boats being given as quickly as possible a defensive weapon against enemy escorts in their increasingly difficult campaign against convoys in the North Atlantic. The Commander in Chief of the Navy therefore ordered operational readiness of the Zaunkönig for 1.10.43 and later (on 13.7.) for 1.8.43. This entailed, on the one hand, a great risk owing to lack of the normal course of tests, and , on the other hand, great sacrifices in other preparations of important war weapons not only of the Navy but also of the other branches of the service. This was only possible owing to the close personal cooperation of the Commander in Chief of the Navy and the Minister of Armaments and Ammunition. The fact that 80 torpedoes were actually ready on 1.8.43 in the Western bases for equipping 20 boats represented a great achievement by all departments concerned.

2) Torpedo Characteristics: Vt = 24.5 knots, non-contact and impact-pistol, range heated 3,700 m., unheated 5,000 m., can be used against all vessels of a speed between 10 and 18 knots from all positions.
Use is limited to a certain extent in seaway over 6. The short arming range of 400 m. was necessary in order to keep the minimum firing distance as low as possible, but this makes it necessary for the boat firing the torpedo to crash dive after firing owing to the danger to itself, or when only firing from the stern to withdraw at a certain speed. In the first use of the torpedo as certain inappreciable percentage of self detonations was to be anticipated from the non-contact pistols, and about 10% of depth-keeping faults from the apparatus.

3) The Zaunkönig was made available for the first operational use in the period from 20 to 24 September 1943. In a convoy engagement in the North Atlantic there were 17 boats equipped with the Zaunkönig Each boat had 4 torpedoes (2 each in the bow and stern). Use was entirely successful. 13 hits were made with certainty and 3 probably (54%) with 24 firings. Out of 7 misfires 4 were due to overrunning. In addition one failed in the tube (tube-runner). 12 destroyers and 1 freighter were sunk by Zaunkönig, and 3 destroyers probably sunk. The firings were made for the most part from position 0 at distances around 30 hm. It is a disadvantage for the boats that they are forced to dive after firing. The short arming range would not have been necessary in the vast majority of firings owing to the fact that firing distance was long enough.
The necessity for an arming range which can be adjusted as desired must, therefore, be met as soon as possible.
Apart from the present range, there must be one which enables the boats to remain surfaced in every case without being endangered (about 800 m.).

4) Further use of the Zaunkönig, is intended by the continuous equipment of all boats based in the West, as from 21.9.1943 of all boats in the Mediterranean Sea as from 3.10.1943 of all operational boats proceeding from home waters.

Appendix D

Current Order No. 34

December 1943 Edition

1) In recent convoy operations a situation has occurred again and again in which the convoy has passed over the boat without its being able to make use of a single opportunity to attack, afterwards being left in a hopeless position astern of the convoy.

2) The great number of recent unsuccessful submerged attacks also shows that boats were not able to break through the screen without being located or picked up on the hydrophones.

3) For this reason in future attacking at periscope depth will have to be given up and attempt made to fire blind from a great depth with the new, specially designed torpedoes.

4) Even if the available hydrophone and location apparatus do not at present give a definite estimate of enemy course, speed and formation, nevertheless in the event of approaching or being passed over by the enemy, the best possible use must be made of even defective data for a blind torpedo attack.

5) The following procedure is to be aimed at in future.

   a) As up to now it has only been possible to fire torpedoes at depths of up to 22 meters. Remain as far as possible at a depth of 20 meters in case torpedo attack is possible.

   b) Under normal circumstances tubes are only to be loaded with "F.A.T." or "Zaunkönig". These have the advantage in that even when fired according to uncertain firing data, the usually hit something when there are a number of ships together.

   c) In cases of being passed over by convoy the boat usually has a rough idea of the enemy course, so that it must therefore be possible to fire a fan of F.A.T. torpedoes at right angles to enemy course.

   d) As hydrophone apparatus makes it possible to distinguish between propellers of steamer and escort vessel, the boat can estimate to a certain extent its relative position to the main bunch of the formation. This data must suffice for firing of F.A.T. torpedoes in accordance with position of convoy with following settings.
   In case of convoy passing directly overhead the shortest preliminary

run and a long loop.
If submarine is to port or starboard of the convoy a medium to long preliminary run according to signal strength on hydrophones, and long loop.

e) In order to ensure greatest possible success in the event of a blind attack torpedoes in all tubes must be fired.
It must be remembered however that unless the Zaunkönig is fired in quite a different direction, an interval of at least 10 minutes must elapse between it and the firing of F.A.T. torpedoes.

f) In firing non-contact pistol boat must dive to 40 - 50 meters immediately after firing in order to be safe from explosion of torpedo passing overhead. It is therefore best to fire in the shortest possible time either a fan or quickly successive single shots.

Appendix A, B, C, D, possible thanks to www.uboatarchive.net
Particularly, Kriegstagebücher (KTB) Des Führers/Befehlshaber der Unterseeboote (F.d.U./B.d.U.)
War Diary of Commander in Chief, Submarines

The records in appendix A, B, C, are an Office of Naval Intelligence translation of the German original.
The original translated BdU KTBs are in the custody of the Operational Archives Branch of the Naval Historical Center, located at the Navy Yard, in Washington, D.C.

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