# HMS *Howe* and the Walrus at Riverside Museum

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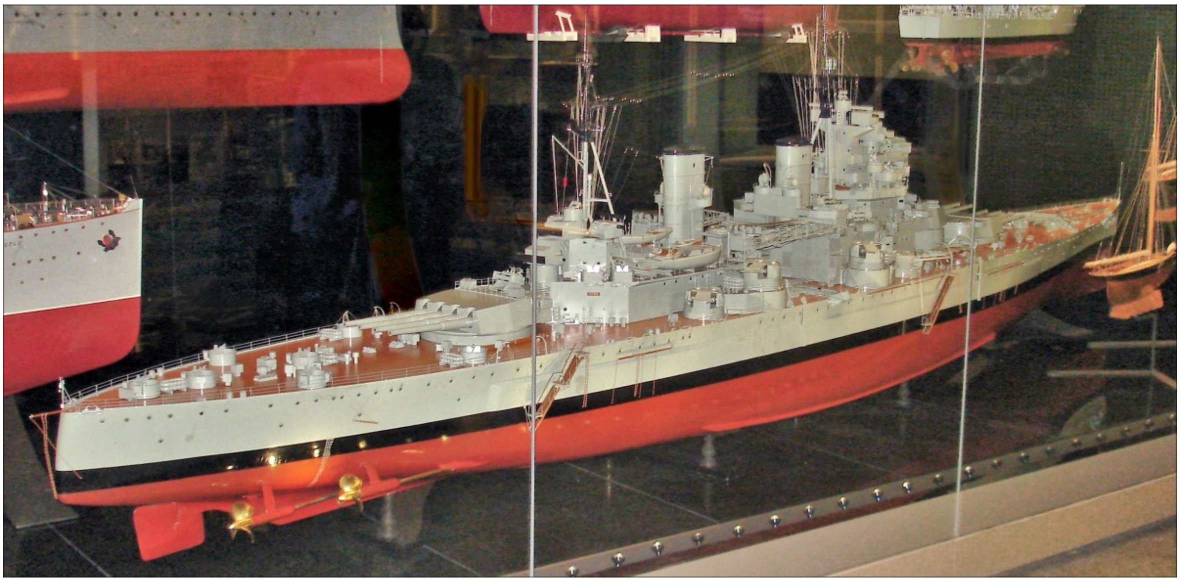
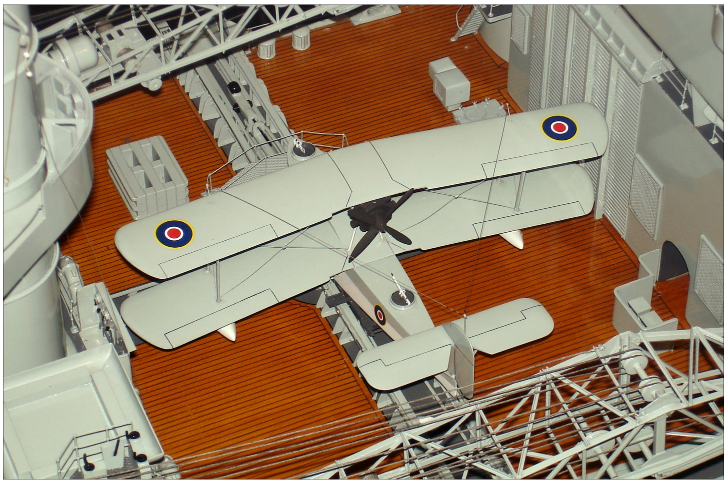
**1.0 Introduction**. The Glasgow Museums have an outstanding collection of almost 700 ship models many of which are on display at Glasgow's Riverside Museum of Transport and Travel. This Research Technical Note describes some of the features of just one of these ship models; the 1/48th scale model of HMS *Howe* (I.D. No. T.1962.5.c), one of the largest and finest models in the collection. The *Howe* was a British battleship that saw action in the Second World War. Visitors to the museum are often intrigued to see an aircraft, a Vickers Supermarine Walrus seaplane, on the deck of this battleship. This note briefly introduces HMS *Howe* and then explains some details and features of the Supermarine Walrus seaplane[1].



**2.0 HMS *Howe* (Pennant No. 32)**. HMS *Howe* was a *King George V* class battleship built on Clydeside by the Fairfield Shipbuilding & Engineering Company of Govan (now BAE Systems) and commissioned in 1942. This battleship was the 6$^{th}$ ship to be named after Admiral Richard Howe (1726 – 1799). Armed with 10 breech loading 14" (356 mm) Mark VII guns in three turrets. This main armament was limited by naval treaties of the 1920's and 30's. Fully loaded *Howe* had a displacement of 44,510 tons, was 744' 11.5" (227.1 m) overall length with a beam of 103' (31.4 m) and had a top speed of 27.62 knots, ref.1. She had battle honours in the Arctic 1942 – 43, Sicily 1943 and Okinawa 1945. After the ending of the Second World War *Howe* spent four years as flagship of the Training Squadron at Portland. Decommissioned in 1950 she was broken up at Inverkeithing in 1958, ref. 1.

Although radar had been fitted to *Howe* at her commissioning (ref. 1), it was still considered that a more established method of 'seeing over the horizon' and gunnery spotting was necessary. The fitting of a double-ended catapult amidships and cranes port and starboard allowed the launching and recovery of a Walrus seaplane. The surprising thing about this seaplane is that it was designed by the same engineer that designed the Spitfire – R. J. Mitchell – one of Britain's great aircraft designers.



**3.0 The Supermarine Walrus**. The Walrus was one of a remarkable series of seaplanes that R.J. Mitchell was involved with (see Appendix 1) and eventually cumulated in the Schneider Trophy winning designs and the Spitfire, ref. 3 & 4. The Walrus was one of the slowest and ungainly looking aircraft yet it also was a versatile aircraft that had a long service life of some 30 years. It was a true amphibian, it was both a landplane and a seaplane. It could be catapulted from a ship and recovered from the water. It could take-off and land on airfields, just like a landplane. It could take-off and land on water. It could take-off on water and land on an airfield (and vice versa). It could taxi up a slipway from water to land (and vice versa). It could be catapulted from a ship and recovered from the water. It could land and take-off from an aircraft carrier without the need for assistance; an arrester hook was never fitted, ref. 7.

It had a number of firsts: It was the first military aircraft in the UK to have a fully retractable undercarriage and the first aircraft acquired by the Fleet Air Arm with a completely enclosed cockpit, ref. 5. It was the first amphibious aircraft to be launched by catapult with a full military load, and had an all-metal fuselage, ref. 6.

The original name for the Walrus was the Seagull V. This was the name used by the Royal Australian Air Force (R.A.A.F.) who were the initial driving force in the development of the aircraft, ref. 5 & 7. The Air Staff got Supermarine interested in building a prototype. The prototype Seagull V was first flown on 21st June 1933 from Southampton Water, ref. 7. Following from successful evaluation by the Royal Navy Fleet Air Arm (F.A.A.) and the ordering of twelve aircraft in 1936, the name Walrus was adopted[2]. The basic Performance Data being[5]:

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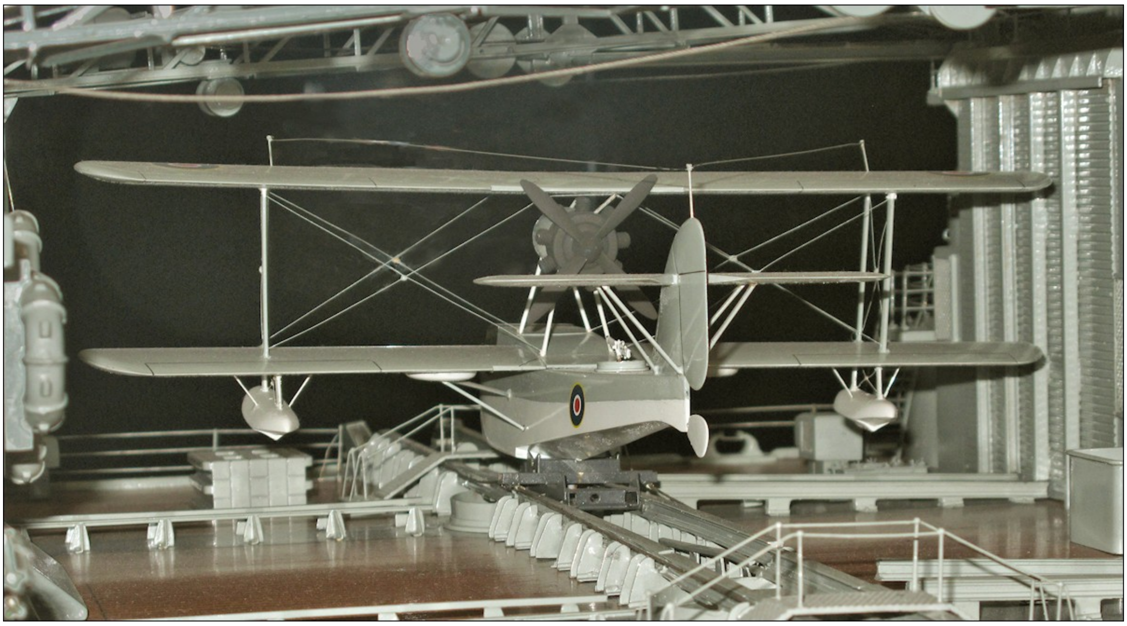
|---|---|
| • Maximum speed at 4,750 feet | 135 miles/hour (117 knots) |
| • Cruising speed at 3,500 feet | 95 miles/hour (82 knots) |
| • Landing speed | 57 miles/hour (50 knots) |
| • Service ceiling | 18,500 feet |
| • Range | 600 miles |
| • Weight (empty) | 4,900 lb |
| • Weight (with 3 crew & full load) | 7,200 lb |

The Walrus was specifically designed for naval reconnaissance, spotting and bombing. It later played a major role in air-sea rescue. In production from 1936 to 1944, the total number of aircraft built was over 700 in three major variants: Seagull V, Walrus I and Walrus II, ref. 6. Initially they were built by Supermarine, but as World War 2 progressed production was transferred to Saunders-Roe who built some Walrus I and later all the Walrus II aircraft, ref. 7.

The Walrus I was basically the same aircraft as the Seagull V but with some differences[3]. The Walrus II was basically a Walrus I but with a wooden hull so as to avoid the use of wartime stockpiles of light metal alloy. The wooden hull was heavier than the Mark I but was easier to repair. Walrus II were mainly used by training units, ref. 30.

**3.1 General Configuration of the Walrus**. The general configuration of the Walrus (ref. 5, 6, 7 and the manual ref. 2) is that of a biplane flying-boat. The fuselage or hull, that provides the main buoyancy, is of single step monocoque construction with flat sides and a hard chine to a vee bottom, see Appendix 2 for more information. There are small stability floats, with a single step, on the lower wings. The lower wings attach directly to the top of the fuselage sides. Single bay interplane struts support the upper wings. The wings and control surfaces were of composite construction of stainless steel spars and wooden ribs covered by fabric. The rudder was spruce framed.



The whole aircraft was compactly built and had folding wings to allow space saving. With the wings folded back the arrangement was only 17 feet 6 inches wide[5]. This was important as several warships, including HMS *Howe*, had hangers to allow more than one aircraft to be carried. When folded, ancillary struts commonly called jury struts supported the wing leading edge corners[6]. The struts could be stowed away (they are not shown in the model), in the aircraft hull, but the Walrus normally flew with the struts permanently in position, ref. 5. The wings, in normal flying position, were secured by latches and pins located in line with the wing main spars, ref. 7.

The main undercarriage was fully retractable[7][18]; the retraction being carried out by a hydraulic hand pump. By fully retractable what was meant here was that the main wheels could be folded away into wells in the lower wings. This reduced the drag during take-off from water and in the air. However, the wheel oleo leg (a combined oil pneumatic shock absorber) and radius-rod, hinged to the side of the hull, did not retract into the wing so strictly the whole arrangement was not quite fully retractable. Mitchell used an arrangement where the wheels retracted outward, rather than forwards, to avoid any change of trim when the wheels moved, ref. 4. The wheel unit comprised of Dunlop or Palmer type with high pressure tyres and air brake drum. An engine driven compressor provided the brake air supply, ref. 2.

The tail wheel did not retract. Originally the wheel was metal but later a pneumatic tyre was fitted. The wheel was supported by a rudder leg (torque tube) and oleo strut and was faired over to form a water rudder, which could be coupled to the air rudder, when taxying on water. It was essential to de-couple the tail wheel for take-off and landing. Not doing so could result in a crash and loss of the aircraft, ref. 5.

**3.2 The Crew**. The Walrus was designed for an operational crew of three[4]: Pilot, Navigator (observer), and Telegraphist Air Gunner. In the cockpit there were positions for the pilot, in the fixed left (port) seat, and a co-pilot under instruction. To starboard was a collapsible seat for the co-pilot. The control column was not a permanent fixture it could be disconnected at floor level. The spare control column and co-pilots pedals, stowed at hand, could be rapidly and simply connected by a horizontal shaft to the pilot's column, even in flight. The main rudder-bar had a permanent extension to which dual pedals were hinged so that they could be swivelled out of the way when not in use, ref. 5. This allowed access to the bow gun hatch, by a crawl way. Behind the cockpit was the navigator's compartment with side observation windows. Further aft was the telegraphist's desk and wireless set.

**3.3 The Engine and Propeller**. The single engine to power the Walrus is positioned between the wings and supported by struts. The engine type used was a Bristol Pegasus 9-cylinder, single-row, air-cooled radial engine in 'pusher' configuration[8]. This engine operated on the 4-stroke cycle and used poppet inlet and exhaust valves[9][10]. The prototype Seagull V used the Mark II L2P engine. All the Seagull V's and most of the first Walruses were powered by the Mark II M2 engine. The Mark VI, when it became available in quantity, became the standard power unit, rated a maximum output of 775 brake horse power at take-off, ref. 5. The Pegasus engine was designed and developed by the Bristol engine department (under Sir Roy Fedden) of the Bristol Aeroplane Company Limited and became the replacement for their very successful Jupiter engine, ref. 8. The 'pusher' configuration was used as it offered several advantages in an amphibian of this size, ref. 5:

1. The airscrew (propeller) was well shielded from water spray.
2. The pilot had a good forward view.
3. A safe working platform for passengers, crew or cargo over the bow.
4. Safety for the hooker-on, who had to prepare the slings for hoisting inboard.

The disadvantage with the 'pusher' arrangement was the propeller being so near the tail. There was a tendency for yaw being induced by the corkscrew effect of the slipstream on the tail. This disadvantage was solved by off-setting (anti-clockwise when looking downwards) the engine nacelle by two or three degrees, ref. 5. The propeller consisted of two 2-bladed propellers, of wooden construction, mounted beside each other at 90 degrees to form a 4-bladed arrangement.

Electrical services were provided by a 12 volt, 500 watt generator driven from the engine via bevel gears and shafting, ref. 2.

The engine was started by means of a inertia wheel (the Seagull V did also have a Royal Aircraft Establishment gas starter, and a few early Walrus did have a hand magneto), ref. 5. The inertia wheel was operated by a hand crank inserted through a hole on the starboard side of the nacelle. The normal procedure was for the pilot to operate the throttle and main magneto switches from the cockpit while a crewmember turned the crank handle[11]. When the inertia wheel was spinning sufficiently fast the engine was engaged by tug on a dog-clutch cable, ref. 5. The petrol tanks were in the upper wing with gravity feed to the engine.

**3.4 Marine Equipment**. Being an amphibian the aircraft had to carry marine equipment[5]. This equipment included: dinghy, anchor and line, boat hook, bilge pump, detachable bollards, towing bridle, drogues, grab rails (for Air Sea Rescue duty, ref. 7), mooring lamp and mast, marine distress signals, and a 'muffin bell' (to conform to the 'Rule of the Road at Sea', when on the water in low visibility this bell had to be rung, ref. 5).

**4.0 The Role of the Walrus**. By the start of WW2 the Walrus was in widespread use by the Royal Navy. Some of the roles carried out by the Walrus during this conflict included: Photo recognisance (an F24 Camera was carried), Artillery spotting, Ground attack and Bombing sorties, Anti-submarine patrols, Convoy protection, Communication duties, Air-sea rescue, and Pilot training.

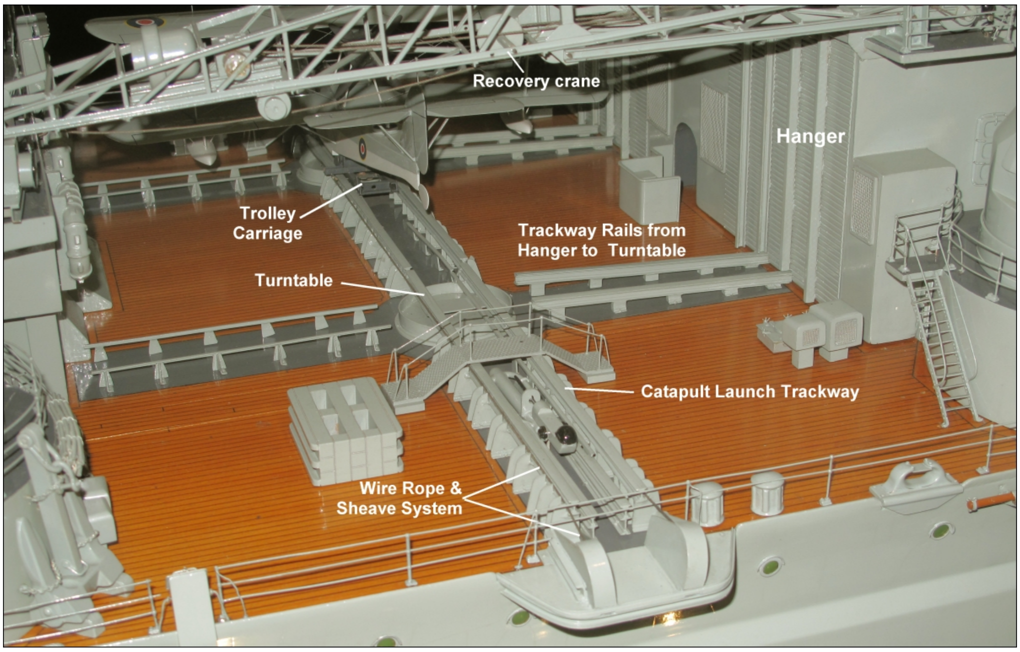
**4.1 Offensive Operations**. As well as its role as a recognisance or spotting aircraft, the Walrus was capable of offensive operation[(5)]. The circular bow hatch was fitted with a Scarff ring[(12)], while the rear hatch had a special mounting and a sliding hinged cover to give some protection from the slipstream[(13)]. Both positions permitted the mounting of a 0.303 inch Lewis Mark III or a Vickers 'K' machine gun.

Bombs and dept-charges could be carried. The course-setting portable bombsight, required for level bombing, could be mounted on a bracket on the starboard side of the bow hatch[(13)]. When in use the observer had to stand almost knee-high to the Scarff ring, bent over the instrument, giving hand signals to the pilot. His only security was a safety belt and a wire clipped to the aircraft's floor, ref. 5. The Walrus was credited with sinking or damaging at least five enemy submarines, ref. 31. In this task the crew was assisted by the introduction of Air to Surface Vessel (ASV) radar from 1941.

**4.2 Ship Operations – Catapult Launching**. A key feature of the Walrus was its ability to be catapulted from a ship with full military load, see Appendix 3 for a brief history of the of the ship catapult. The airframe was strengthened to allow this and the petrol system designed so that the engine would not be starved of fuel during the launch where the acceleration might amount to 3 or 4g, ref. 5.

The catapult fitted to HMS *Howe* is a double acting (double ended) D-III-H type (ref. 18), fixed athwartships at the widest beam. Catapults at this time were operated by compressed-air or cordite. In the case of the King George V battleships, like HMS *Howe*, the catapult was operated by compressed air on the Carey system of wire ropes and sheaves which drew a wheeled trolley (carriage) along a trackway. The catapult was capable of launching a 12000 lb aircraft with a 50 foot wing span, ref. 9. The Walrus had a weight of 7,200 lb with 3 crew and full load and a wing span of 45 feet 10 inches, ref. 5. When catapulted off, the Walrus on the trolley would be whipped forward from rest to 55 knots in as many feet and the Walrus thrown clear of the ship at flying speed, ref. 5 & 21. The trolley would be brought to rest on the trackway by an arrester system[(21)].

The use of the double ended catapult allowed the aircraft to be launched without delay, the cranes were not required to position the aircraft although they were required for recovery. The catapult launch trackway was fixed to the upper deck and incorporated two turntables. Most of the catapult mechanism is below deck[(14)]. The aircraft was kept on its launching trolley in the hanger with wings folded. When required the Walrus on its trolley would be wheeled out, along trackway rails, onto the turntable. It would then be turned to the direction of launch, port or starboard, and wheeled back to the start of the catapult run, at the down-wind end, and the wings secured ready for launching, ref. 12.




The launching trolley was a wheeled carriage that runs on the trackway and had four collapsible arms (these are not shown on the model) fitted with claw ends. The claw ends engage with spools (trunnions) protruding from the Walrus hull. Locking bolts (dedents) in the claws held the spools firmly in place. A procedure to launch a Walrus (based on a cordite launch) is given in Nicholl, reference 5. There is also an action film of a Walrus catapult launch, using cordite, available on the internet, reference 14.

**4.3 Ship Operations – Landing and Recovery** with reference to Nicholl ref. 5 and Catapult Training ref. 21. The recovery of the Walrus involved landing alongside with the ship underway. Close understanding and co-operation, between captain and pilot, as well as much practice, was necessary for the landing and recovery to be successful. Skilfully done, recovery times from 'touch-down' to 'hoist clear' could be achieved in one to one and a half minutes.

In fine weather, landing presented few difficulties. The pilot would aim to end his landing as close to the recovery crane as possible. If there was a wind, the ship held a course with it fine on one bow so the Walrus could be recovered on the lee side.

In rough weather the 'slick' method, evolved by the U.S. Navy, was used. This required the ship to make a fast turn from about 60° off to 30 or 40° beyond the wind, ref. 21. This caused the swinging stern to smooth out a patch of artificial calm water (the slick) on the lee quarter(15). The pilot would manoeuvre astern and come in at 60 knots and time his touchdown just inside the perimeter wave of the slick, ref. 21. He would aim to finish his landing run on the ship's lee and taxi close to the recovery crane. The Walrus being a 'pusher' type had the advantage of a clear forward view and could therefore use simpler equipment for hoisting clear.

Three recovery methods were found suitable:

**(1) The Direct Recovery method** was primarily used in calm seas. As soon as the Walrus touched down, the T.A.G. would climb up onto the centre section and secure himself to an eyebolt by his 'dog lead', to prevent slipping into the propeller. He would prepare the slings for hoisting (they were held in a compartment on the top wing) while the pilot taxied up to the crane(16). In the meantime, the ship's handling party would have prepared the hoisting mechanism and swung the crane. The crane was fitted with a patented mechanism called a 'Thomas Grab'. This grab could be temporarily split. The light lower half could be hoisted or lowered independently very quickly as the aircraft rose or fell in the seaway. The heavy top half, with ponder ball, was thus kept clear to avoid damage to the aircraft, ref. 21. Once hooked on, the top half would be lowered until the two parts automatically mated and the aircraft hoisted clear of the water.

**(2) The Towed Recovery method** was primarily used in rough weather(17). A boom, with a block on its outer end, would be rigged out from the forward side of the ship with a towline (also known as a grass line) and a spring hook, ref. 21. The T.A.G. would prepare the slings as before. The navigator would stand in the fore hatch and fish for the towline with a boathook. With the towline hooked, the end would be made fast to the towing bridle on the nose of the Walrus. The pilot would throttle back until the towline took the strain. The towline length was such that it brought the aircraft under the crane hoist. In rough weather it was sometimes necessary for the navigator to climb onto the starboard wing, hanging onto the interplane strut, to balance the aircraft and prevent the port float from 'digging in', ref. 7.

**(3) The Hein Mat Recovery method**. In the 1920's a German by the name of Hein invented a waterborne mat that could be towed by a line. The aircraft would be taxied over the mat (sled) and a hook on the underside of the hull bow or float (in the case of a floatplane) would engage one of the meshes of the mat. The mat and aircraft would then be aligned under the crane for hoisting in. Both the U.S. Navy and Royal Navy experimented with the Hein mat(19). On the Walrus the bow lower towing eye was strengthened to allow this method of recovery, ref. 7. However, the Royal Navy discarded the method as being unnecessarily complicated, as the Walrus had no propeller to obstruct the forward view and could use simpler equipment, ref. 5.

Whichever method was used, skilful station keeping was essential, as recoveries at speeds up to 15 knots or more were sometimes made, ref. 5. The pilot would keep the engine running until out of the water. Once clear of the water, the ship handling party would fend off the swaying aircraft with long padded poles and turn her nose towards the ship, ref. 23. The crane crew had to be skilled in all aspects of hoisting and manoeuvring of the crane. Two lines (heaving lines) would be thrown to the pilot and observer, who would attach them to the wing tip steadying wires clipped along each lower wing. In very rough weather a third wire could be attached to the after hatch if necessary. Under the control of the Directing Officer the aircraft would be hoisted inboard and lowered onto the trolley, ref. 5.

By 1943 catapulted launched aircraft were being phased out due to the much improved ship's radar. HMS *Howe*'s aircraft were removed during a refit at Devonport in December 1943, ref. 9. This saved considerable catapult and hanger space as well as the training and maintaining the skilled crews necessary to launch, fly and recover the aircraft. The risk of fire from the aviation fuel (AvGas) was also eliminated. The catapult deck space was then used for the stowage of the ship's boats.

**4.4 Air-Sea Rescue**. The RAF used the Walrus mainly for air-sea rescue. In this role the Walrus played a major role (there were no helicopters as we have today) as it could pick-up aircrew from the water. Many aircrews, including enemy as well as allied survivors, owe their lives to the Walrus and its dedicated crews. One survivor being Group Captain Duncan Smith the father of Iain Duncan Smith MP the one time leader of the conservative party, ref. 10. Even if the pick-up load and/or sea conditions were too rough, to allow take-off, the Walrus would taxi to the recovery ship or land base.

After the war the Walrus continued to see a limited role by the RAF, the Royal Canadian Navy and foreign (France & Argentine) navies, ref. 7. It also found a role in civil and commercial use, including a brief use by a whaling company, ref. 5, 6 & 7.

**5.0 Flight Experience**. The handling characteristics of the Walrus is discussed in Nicholl, reference 5. Perhaps the most remarkable characteristic was found from the very beginning – the Chief Test Pilot Joseph Summers looped the five-day old prototype at low altitude. There are several action films of the Walrus that can be downloaded from the Internet, ref. 13 & 14.

The general feeling you get when reading about the Walrus is one of affection. Nicknames like 'Shagbat' and 'Steam Pigeon' (from the steam produced by water striking the hot engine) were given to the aircraft, ref. 6. Having said that, not all comments were complimentary as First Officer Diana Walker, of the Air Transport Auxiliary, confirms that the control column would biff her in the bosom several times on take-off, ref. 11. Accidents did happen. Landing with the wheels down on water flipped the Walrus over[20], ref. 5 & 7. Alternatively, landing on airfields with the wheels up did surprisingly little damage to the aircraft, ref. 4 & 11.

Catapulting was, of course, fraught with potential risk but there appears to be only one recorded fatal accident due to catapult failure though there were several heavy landings onto the water, ref. 5.

**6.0 After the Walrus**. The Supermarine Sea Otter was the intended successor to the Walrus and was the last of the Supermarine biplane amphibians. The Sea Otter never completely replaced the Walrus. Both aircraft served in the air-sea rescue role in the latter part of WW2.

Post-war the intended replacement for the Walrus and Sea Otter was the Supermarine Seagull ASR I with variable incidence wings and contra-rotating propellers. It never got beyond the prototype due to abandonment of catapult ship policy, ref. 5. Today the helicopter carries out many of the roles that the Walrus was required to undertake.

**7.0 Preserved Aircraft**. According to reference 6 there are four surviving examples, none are flying:

1. **Seagull V, A2-4**. This is one of the original Australian aircraft, and was on display at the Royal Air Force Museum, Hendon, London but is believed to be no longer on display. This aircraft was still flying, in a private capacity in 1966, thirty years after its introduction, ref. 5.
2. **Walrus HD874**. This aircraft was with the RAAF Antarctic flight. It is held by the Royal Australian Air Force Museum, Point Cook, Victoria.
3. **Walrus L2301**. This is one of the aircraft flown by the Irish Air Corp during WW2. It is on display at the Fleet Air Arm Museum, Yeovilton, Somerset.
4. **Walrus W2718 (G/RNLI)**. This aircraft was part of the Solent Sky museum collection but has now been sold to James Lyle of Vintage Fabrics, Audley End, Essex, for restoration.

**8.0 HMS *Rodney*** There is on display at Riverside Museum, in the Clyde Model Dockyard display, a small (about 4" long) toy die cast model (ID No. Temp. 16887.3a & b) of HMS *Rodney*. Close inspection shows it to have a seaplane atop the 'X' turret (sometimes called the 'C' turret). The modelling actually shows a monoplane, probably because it would have been too difficult to die cast a biplane on such a small model.

**9.0 In summary**. The Supermarine Walrus was one of the most successful aircraft designed by R. J. Mitchell. His most successful aircraft was, of course, the Spitfire. The success of the Walrus can be put down to the fact that it came at the end of a long line of Supermarine seaplanes, designed by Mitchell, hence a great deal of experience was available to get the design 'right' from the start. Being designed for catapult launching meant that it was strongly built for the demanding roles that it was required to perform in wartime service during World War 2.

The Walrus was not a beautiful aircraft, some say it was ugly. The Spitfire, everyone would agree is a beautiful aeroplane. However, both these aeroplanes were designed by the same person. What does that tell us? That aerodynamic form and engineering function must take precedence over what is considered to be beautiful. The long service life of the Walrus can be put down to the wide variety of tasks that it was capable of doing; it was clearly a remarkable aircraft. Today, helicopters and sophisticated electronic surveillance devices carry out many of the roles the Walrus was required to undertake.

**10.0 Notes**.

(1) Not to be confused with the Westland Walrus a spotter/reconnaissance aircraft built by Westland Aircraft in the 1920's.

(2) It was not unusual for name changes to take place. Supermarine designed an amphibian named the Seal and a further development was the Seal II. The Seal II was renamed the Seagull I, and two further Seagull Marks followed prior to the Seagull V. Seagull Mark IV never seems have got beyond the drawing-board stage, according to Nicholl, ref. 5. However, reference 26 claims that "one Seagull II was rebuilt and fitted with Handley-Page leading edge slots and twin fin and rudders in 1928. This was considered to be the Mark IV, although Supermarine never designated it as such.".

(3) There were differences between the Seagull V prototype and the production aircraft. The former had: a Vickers-Potts air cooler on the engine nacelle to supplement, under tropical conditions, the main cooling system for the oil tank (this Potts cooler was found to be unnecessary), a small observer's window (this was elongated), a bulbous fairing over the oleo leg hull joint (this fairing was eliminated), a centre diagonal strut supporting the tailplane (this diagonal strut was removed), an extra water rudder (found to be not necessary following taxying tests at Rothesay), and no Handley-Page slots (a device to delay the 'stall' of an aerofoil, like a wing, ref. 27) on the top mainplanes. There were also differences between the Seagull V production aircraft and the Walrus, e.g. the former were fitted with Handley-Page slots, but because the aircraft responded well near stalling speed on all axes these slots were dispensed with on the Walrus. To permit the wings to be folded back, the inboard trailing edge of the lower wing folded downwards and forwards on the Seagull V but upwards and forward on the Walrus, ref. 7. There were other differences, these are discussed briefly by Nicholl in reference 5.

(4) A crew of three was usual, although four could be carried by using the co-pilot seating. When target towing only two crew were carried, ref. 5. Reference 7 shows a photograph of a Walrus towing a target.

(5) Nicholl reference 5, in appendices, gives details of the Walrus Air Frame – Leading Particulars, Engine Performance Data, and Equipment & Armament. The Manual, ref. 2, also has detailed information.

(6) References 7 and 19 show a Walrus with the wings folded back and with the jury struts in position at the leading edge corners.

(7) According to Nicholl, ref. 5, the first aircraft with a fully retractable undercarriage was the civil aircraft the Airspeed Courier. However, Nevil Shute in reference 20 mentions that the Lockheed Orion and an experimental Bristol type had fully retractable undercarriage prior to the Airspeed Courier.

(8) Propeller driven piston engined aircraft generally fall into two types: 'tractor' type where the propeller is in front of the engine and the aircraft is pulled through the air, and 'pusher' type where the propeller was behind the engine and the aircraft was pushed through the air. Supermarine produced both types. The Walrus was a 'pusher' type for the reasons discussed in the main text. Some manufacturers had both 'pusher' and 'tractor' types on the same aircraft, e.g. the Short S.19 Singapore III.

(9) The Pegasus engine was outstanding for its altitude records, including the first completely successful flight (in a Westland Wallace and Westland PV.3 aircraft) over Mount Everest in 1932, ref. 8. Provision was made, on the Walrus, for an alternative water-cooled engine such as the Rolls-Royce Kestrel (ref. 5), but as far as is known no Kestrel was ever installed, ref. 7.

(10) The Bristol engine department also produced a range of single sleeve-valve engines, such as the Perseus and Hercules, these were based on the Burt & McCollum / Barr & Stroud motor-cycle engine, ref. 8.

(11) The web site Maritime Quest, *Edwin C. J. Reed RN collection*, reference 23 shows a photograph of a Walrus being hand started. Note: the site describes the Walrus as a floatplane but I prefer to call it a flying-boat, see Appendix 2. The crewmember could attach a safety line to the forward end of the nacelle ,in the event of a slip, to prevent a fall into the propeller, ref. 2. Nicholl in ref. 5 describes how it was possible for a pilot, when flying solo, to start the engine. Some agility and some luck being a requirement.

(12) A Scarff ring is a machine gun mounting developed during the First World War by Warrant Officer W.F. Scarff of the Admiralty Air Department for use on two seater aircraft, ref. 24. It allowed the airgunner, in an open cockpit, to quickly swivel and elevate the gun and fire in any direction.
(13) The bombsight and bow hatch can be seen in a photograph in reference 25 as can the rear hatch and sliding hinged cover. Note this is actually the Seagull V at the Royal Air Force Museum, Hendon, London.
(14) Some details of catapults are given in references 15, 16, and 17. A photograph of a model D-IV-H athwartships catapult is shown in Marriott reference 12 and diagrammatics are given in reference 22.
(15) Reference 21 shows diagrammatically the 'slick' manoeuvre and towed recovery method. Photographs of a ship (HMS *Anson*, a sister battleship to HMS *Howe*) performing a 'slick' manoeuvre is shown in references 5 and 12.
(16) Photographs showing a Walrus alongside a ship and being prepared for hoisting aboard are shown in references 5, 7 & 21.
(17) The stalling speed of the Walrus was about 50 knots. It was found that the Walrus could land with maximum average height of waves of twelve feet, ref. 5. For take-off the maximum wave height was six feet (Sea State 3-4), ref. 7.
(18) On some Walrus the main undercarriage was removed and the wheel-wells faired over. The reduced weight and drag allowed a greater radius of action, ref. 7.
(19) Reference 12 shows photographs of the mat recovery system in action, as does reference 29 including a photograph of a Walrus being recovered.
(20) Following from the first accident, an undercarriage warning horn was incorporated into the design. The first known application of this device, ref. 7.
(21) The retardation requirements was the one limitation of the Carey type catapult system. Although the system of wire ropes and sheaves could launch the aircraft, the mass of all the moving parts had to be retarded at the end of the accelerating stroke and brought to rest. This imposed severe limitations on the end speed of the catapult. This limitation was the main reason for the development of the slotted cylinder type of steam catapult developed for aircraft carriers after WW2, see C.C. Mitchell, reference 28.

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## Appendix 1. Supermarine Seaplanes and R.J. Mitchell.

I do not intend to detail the history of the Supermarine seaplanes, that has been done by others (ref. 4 & 5). Sufficient to say that Supermarine was founded by Noel Pemberton-Billing in 1912 at Woolston on the East shore of Southampton Water. This site was chosen as the intention was to concentrate primarily on the building of seaplanes. As a trade name for his products 'Supermarine' was chosen. In 1916 Pemberton-Billing sold his interests to Herbert Scott-Paine, who changed the name from Pemberton-Billing Ltd. to Supermarine Aviation Works Ltd.

Before the end of the First World War, Supermarine built a two-seat 'pusher' flying-boat fitted with wheels to enable it to take-off from the deck of a battleship or carrier, the wheels being thrown clear in flight. In 1917 R.J. Mitchell joined Supermarine as a personal assistant to Scott-Paine, he previously had served an apprenticeship in a locomotive works (ref. 3 & 4). By 1919 Mitchell was appointed Chief Designer at the age of 24. As Chief Designer, Mitchell was responsible for some of the most significant seaplane developments of the 1920's and 30's. Mitchell died at the relatively young age of forty-two, in 1937, his work covered the whole of aviation development from the pioneering days until just before the jet age. Table 1 lists the twenty-two aircraft types that Mitchell was associated with, most of these being seaplanes, the most notable being the large Southampton flying-boat and the Schneider Trophy floatplanes S.4, S.5, S.6 and S.6B. As can be seen in Table 1 there was a significant number of medium-sized amphibian types that cumulated in the Seagull V/Walrus. In terms of numbers of aircraft built, Table 1 shows that his two outstanding aircraft were the Spitfire and the Walrus.

In 1923 Squadron Commander James Bird acquired Supermarine from Scott-Paine (who devoted himself to the development of fast powerboats). James Bird had experience of the manufacturing side of aviation and the construction of experimental seaplanes. In 1928 Vickers took over the Woolston works and the name was changed to Vickers Supermarine Aviation Works Ltd. R.J. Mitchell remained Chief Designer.

| Aircraft | Type | Number Built |
|---|---|---|
| Spitfire | Landplane | >20,000 |
| Seagull V / Walrus | Medium size amphibian | >700 * |
| Southampton | Larger flying-boat | 83 |
| Stranraer | Larger flying-boat | 57 |
| Seagull II / III | Medium size amphibian | 34 |
| Scapa | Larger flying-boat | 15 |
| S.6 / S.6B | Schneider Trophy floatplane | 4 |
| Scarab | Medium size amphibian | 3 |
| Sea Eagle | Medium size amphibian | 3 |
| S.5 | Schneider Trophy floatplane | 3 |
| Sea King II | Medium size amphibian | 2 |
| Seamew | Medium size amphibian | 2 |
| Air Yacht | Larger flying-boat | 1 |
| Commercial Amphibian | Medium size amphibian | 1 |
| Nanok / Solent | Larger flying-boat | 1 |
| Seal II | Medium size amphibian | 1 |
| Sea Lion II/III | Schneider Trophy flying-boat | 1 |
| Sheldrake | Medium size amphibian | 1 |
| Sparrow I/II | Landplane | 1 |
| Swan | Larger flying-boat | 1 |
| S.4 | Schneider Trophy floatplane | 1 |
| Type 224 | Landplane | 1 |

**Table 1**, R. J. Mitchell's 22 Main Aircraft Types and Numbers of Aircraft Built (based on reference 4). In terms of the number of aircraft built the Spitfire and the Walrus were his most outstanding aircraft.

* The numbers built depend on which references you are looking at and if Seagull V's are included. Here is my estimate based on references 6 & 7: 1 prototype Seagull V, 26 production Seagull V's, 551 Walrus I's and 191 Walrus II's giving a grand total of 769 aircraft.

## Appendix 2 – the Hull Shape of a Flying-Boat.

This is a brief summary of the hull shape of a seaplane, for more design details see Willford ref. 32 and Canamar ref. 33. A seaplane (in the early years they were often called a 'hydroaeroplane') is a fixed wing aircraft capable of taking off and landing on water. There are two types of seaplane: the flying-boat and the floatplane. The flying-boat (like the Walrus) has a fuselage (hull) that is the main source of buoyancy – like a ship's hull. For stability most flying-boats, including the Walrus, have small floats mounted on their wings. The floatplane has floats (usually two or one large centre float with two smaller wing floats) mounted under the fuselage and thus the fuselage does not come into contact with the water. Surprisingly, although we think of the Spitfire as a land plane, as well as the carrier borne Seafire, a small number of floatplane conversions of the Spitfire were built, ref. 4.

With reference to the flying-boat sketch below. The forebody is that part of the hull forward of the step. The step is a discontinuity in the bottom of the hull. The afterbody is that part of the hull aft of the step.

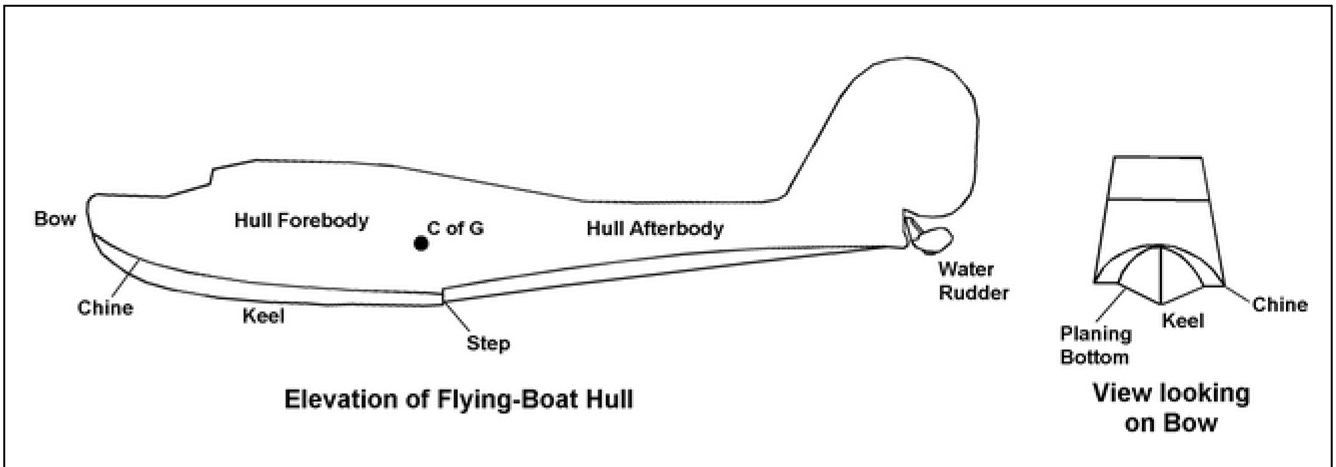
When at rest the flying-boat hull will float on the water borne entirely by buoyancy forces. At low speeds the buoyancy force is still mainly responsible for supporting the hull. As speed increases the hydrodynamic force increases causing the hull to lift out of the water and the buoyancy force decreases. The hull starts to plane over the water surface with the hull sitting on the step. This reduces the hydrodynamic drag, although considerable power is required to get the aircraft into this position for take-off. If, due to the state of the sea and/or the weight of payload, the Walrus could not get airborne it would taxi to its recovery ship or nearest land base.

The planing is aided by the shape of the forebody, which is designed very much like the bottom surface of a speedboat. In these designs the hull has a shallow 'V' bottom and vertical (or near vertical sides). The angle between the bottom and sides is known as a chine. Where the chine angle is sharp it is known as a hard chine. The chine helps to guide the water away from the surface of the hull and thus reduce the amount of spray generated as the hull planes through the water.

If the hull was continuous the downward suction force would be so great as to prevent take-off. The key to getting the aircraft airborne is the step. The step is positioned such that the aircraft centre of gravity is slightly ahead of the step. At the step the continuous water flow breaks down as it goes over the step and the suction force is much reduced in the afterbody part of the hull. In a flat calm it could be difficult to 'unstick', it was sometimes necessary to rock the Walrus onto the step and so avoid a long take-off run, ref. 5.

The water rudder is used when taxying. It would be disengaged for take-off and landing.

The Supermarine Walrus hull was of monocoque construction, which means single shell construction and a stressed skin, which carries most of the loads. The need for internal bracing is reduced, saving weight and increasing space. Prior to the Seagull V/Walrus the hull design of the Supermarine flying boats was based on the Linton Hope (after Lieutenant Linton Hope) boat construction of circular form, like that of the Seagull III. The flat-sided hull of the Walrus was largely as result of developments in metal hull construction and the shape of the Felixstowe flying boats designed by Lieutenant Commander John Porte during WW1, ref. 4 & 7.



## Appendix 3 - a summary time line of the history of the ship catapult.

(*based mainly on the book by: Nicholl, The Supermarine Walrus, The Story of a Unique Aircraft, ref. 5, Salmon in reference 16, US Navy History, and C.C. Mitchell in reference 28).*

**(1) U.S.A**. The idea of launching aircraft from a ship appears to be credited to the United States of America.

- 6th May 1896, Professor Langley, launched a 36 lb automatically controlled aircraft from a barge in the Potomac River, the mechanism being spring operated.

- 1909, following from the Rheims Aviation Meeting, Commander F.L. Chapin of the U.S. Naval attaché in Paris, stated "that aircraft could play a useful part in naval warfare, noting that one method that could be used for operating them from battleships would be the Wright brothers' launching device (a land catapult actuated by a falling weight)."

- 1911, Lieutenant T.G. Ellyson succeeded in taking off from an inclined wire rigged from beach to water at Hammondsport, New York State.

- 12th November 1912, Lieutenant Ellyson made the first successful launching in an A-3 aeroplane from a compressed-air catapult mounted on a coal barge at the Washington Navy Yard.

- November 1915, Lieut. Commander H.C. Mustin was launched from the stern of the ship USS '*North Carolina*' in Pensacola Bay in an AB-2 flying-boat.

- 12 July 1916, after the installation of a permanent catapult on the USS '*North Carolina*', Lieutenant G. de C. Chevalier was catapulted off on an AB-3 flying-boat.

- Gunpowder was being experimented with, and turntable catapults came into being.

- 24 May 1922, with Lieutenant C. McFall in a VE-7 and Lieutenant D.C. Ramsay as a passenger, the Americans considered that the routine operation of catapults in ships had started.

**(2) Britain**. Although aware of the United States Navy experiments, Britain appears to have been late in investigating the use of catapults.

- July 1916, a draft specification was prepared resulting in two prototypes. One by Armstrong Whitworth and tested from a hopper barge HMS *Slinger*. The other, by Weygood & Otis, a land type was tested at Hendon in November 1917. Although successful neither of these prototypes achieved the targets set for loads and launching speeds.

- Early 1920's, W.A.D. Forbes of the Department of Naval Construction, studied all the available records and drew up a specification for a new generation of Admiralty catapults with a stipulated maximum acceleration of 2.5g. This resulted in the development of two further types. One by R.A.E. Farnborough in 1924 designed by P. Salmon used the principle of telescopic rams. The second type designed by R.F. Carey incorporated a ram, wire ropes and sheaves, was made in Chatham Dockyard. Both types could be energised by compressed air or cordite. The practical testing was undertaken by Flight Lieutenant F. Kirk.

- 1925, forward guns on HMS *Vindictive* were replaced by a hanger for three or four aircraft and a Carey catapult on the roof. Trial launchings were made by Squadron Leader E.J.P. Burling in a Fairy IIID floatplane. This catapult was designed to launch aircraft up to 7000 lb loaded weight at a speed of 45 miles per hour over a run of 34 feet.

- November 1927, after trials ashore, the first R.A.E. air-operated catapult installed in HMS *Frobisher*, and in 1928 the first cordite operated version was built by MacTaggart Scott of Edinburgh and installed in HMS *York,* ref. 16.

- A third type of catapult known as a slider was manufactured by Ransome & Rapier. This employed a sliding structure which travelled along the main structure by means of a single ram and wire ropes over pulleys. The launching carriage travelled forward on the sliding structure, ref. 16 and 17.

- 1928 the Submarine M2 was fitted with a Carey catapult and Parnall Peto seaplane in a hanger, Marriott, ref. 12.

- Two designs subsequently became the most commonly used, the ‘D’ and ‘E’ types. Both types could be operated by compressed air or cordite and could be modified for use with light or heavy aircraft. These catapults were manufactured by MacTaggart Scott and a detailed description, mainly of the ‘E’ type, is given in reference 15. Both types used a similar launching trolley.

- The ‘D’ type or double acting fixed athwartships type was used on ships with a wide beam (like the battleship HMS *Howe*). The launching trackway was fixed to the deck, the trolley with the aircraft could swivel in either direction (port or starboard) by means of a turntable. The catapult actuating mechanism was housed below deck. The largest ‘D’ type was designed to operate loads up to 15000 lb at 70 knots, Marriott ref. 12.

- The ‘E’ type or extended-structure rotatable type, was invented by W.A.D. Forbes (patented April 1929), was for installation in smaller ships. This catapult actuating mechanism was above deck and the whole mechanism could rotate on a turntable to suit the direction of launch.

- From information by Jim Smith on 27-06-2012 in World Naval Ships Forums. The British catapults were designated by Type (the initial letter), the Mark number (Roman numeral), the last letter H or L for heavy or light. Type C for Chatham Dockyard, D for Double Acting (fixed athwartships), E for rotatable extending unit, F for Farnborough (RAE – Royal Aircraft Establishment), S for Slider (Admiralty designed cordite operated). However, Marriott in reference 12 states that the designation F signified Fixed in connection to the Hinged Structure Type. A suffix T indicated a variant sited atop a battleship’s main turret, like that on HMS *Rodney*.

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