FROM FELLSIDE TO FLYPLANE

How a very junior officer changed the whole course of RN Anti Aircraft fire control despite strong Admiralty opposition

IVILLE PORTEOUS

Commissioned Ordnance Officer

A Career in Naval Gunnery

1921 – 1952

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By Commander Roger Porteous RN

FROM FELLSIDE
TO FLYPLANE

Once, on this earth, once, on this familiar spot of ground, walked other men and women, as actual as we are today, thinking their own thoughts, swayed by their own passions, but now all gone, one generation vanishing after another, gone as utterly as we ourselves shall shortly be gone like ghosts at cockcrow.

G.M. Trevelyan, *An Autobiography and Other Essays*

but…

Lives of great men all remind us
We can make our lives sublime,
And, departing, leave behind us
Footprints on the sands of time;

H.W. Longfellow, from *A Psalm of Life*

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Roger Porteous

In memory of my parents
Iville and Nora Porteous

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My great thanks are due to my wife, Liz, who has patiently tolerated the gestation of this memoir about the father-in-law she never met; and, not least, my sister, Alison Leonard, who generously provided additional help and information.

Any errors or misinterpretation in the document are my responsibility alone, attributable to a navigator straying off track into the shoal waters of gunnery fire control.

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LIST OF ABBREVIATIONS AND ACRONYMS

AA	Anti Aircraft
ABE	Aircraft Bomb Experiments Committee
AEL	Admiralty Engineering Establishment
AGE	Admiralty Gunnery Establishment (for simplicity, this is also used to include ARL from 1942 to 1943
ARL	Admiralty Research Laboratory (the Fire Control section became AGE in 1943)
CA fuze	Continuously Adjustable shell fuze (AA time fuze set at the muzzle by DC voltage)
DD(G)	Deputy Director (Gunnery) of the Gunnery and Anti-Aircraft Warfare Division
D of GD	Director of Gunnery Division, Admiralty (up to 1928)
DEE	Department of Electrical Engineering, Admiralty
DNO	Director(ate) of Naval Ordnance (at Bath)
FKC	Fuze Keeping Clock
FPS	Flyplane Predictor System
Flyplane	Flyplane Predictor System
GRU	Gyro Rate Unit (fitted in HACS)
GRUB	Gyro Rate Unit Box (initially fitted in HACS, then redundant)
GRUDOU	Gyro Rate Unit Deflection Oil Unit (Upgrade fitted to HACS)
GRU Stabiliser	Gyro Rate Unit Stabiliser (Upgrade fitted to HACS with GRUDOU)
HA	High Angle (gun)
HACS	High Angle Control System
NAAGC	Naval Anti Aircraft Gunnery Committee (of 1921 and 1931-32)
NID	Naval Intelligence Directorate
NOD	Naval Ordnance Directorate
OA	Ordnance Artificer
OEG	Operational Evaluation Group
RCAI	Royal Commission on Awards to Inventors
SEDC	Simple Electric Deflection Calculator
STAAG	Stabilised Tachymetric Anti-Aircraft Gun
TM fuze	Time Mechanical shell fuze
TTB	Target Triggered Burst
VT fuze	Variable Time proximity shell fuze
XP	HMS *Excellent* Experimental Department

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IVILLE PORTEOUS

Commissioned Ordnance Officer &
Lieutenant Royal Navy
A Career in Naval Gunnery
1921 - 1952

'Flyplane can be said to have been born on the wrong side of the blanket as far as 'Official' Admiralty design was concerned. It was conceived originally by one very junior naval officer, and brought to fruition by him and three very junior civilian technical officers, none of whom had any business to be designing fire control systems at all. Every effort was made by the 'Official' design team to ensure that, whichever side of the blanket, the system should be stillborn. Fortunately, these efforts were in vain. [1]

H.G. Nelson

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'…and I would very much like to know who were the "very junior naval officer" and the "very junior civilian technicians" who conceived the system and brought it to fruition. They certainly deserve a modest place in the technical history of the period – regarding which the official records are woefully silent'.[2]

S.W. Roskill

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FOREWORD

The very junior naval officer referred to above was Commissioned Ordnance Officer Iville Porteous, Royal Navy, and the very junior civilian technicians were Edward Axbey, Humphrey Nelson and Peter Fairbairn. This is the story of how a bright young Ordnance Artificer (subsequently a Commissioned Ordnance Officer) was to change the whole course of naval Anti Aircraft fire control, despite strong Admiralty opposition.

This account has been drawn mainly from Iville Porteous's personal papers, which have remained largely untouched in two suitcases since the 1950s.

Iville Porteous was one of the first of a new breed – the Ordnance Artificer – and his seagoing service coincided almost exactly with the development and updating of the High Angle Control System (HACS) which was fitted in all large ships as the main fire control system for AA defence. He served continuously at sea from 1926 to 1942 in battleships and cruisers, and his growing dissatisfaction with the system led to him seizing an unexpected opportunity to make a major impact on naval AA fire control, notwithstanding the single thin stripe on his arm.

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[1] Naval Review Vol 65 October 1977 – H.G. Nelson letter. Nelson was the last living member of Iville Porteous's team of four.
[2] Naval Review Vol 66 April 1978 p.130 – S.W. Roskill article.

CHAPTER 1
IVILLE PORTEOUS - SEAGOING APPOINTMENTS

Iville Porteous was born on 14 February 1905 at 5 Fellside, Hexham, Northumberland, a house he was to own throughout his life. At about the age of seven, he set his eyes on the navy when he went to Cullercoats on holiday and saw the memorial to Admiral Lord Collingwood who was native to those parts. In 1916, when Iville was 11 years old, the Bridge family moved in next door and he met the youngest daughter of the family, Nora Bridge, a girl of his own age. They were to marry a quarter of a century later during WW2.

Following the end of WW1, and at the same time as the Naval AA Gunnery Committee (1919-21) was deciding the way ahead for AA fire control, Iville Porteous (IP)[3] was spending the last days of his childhood living with his parents at Hexham. His father was an agricultural machinery maker and wheelwright and his mother the daughter of a lawyer. Still aged 15, he left the Queen Elizabeth Grammar School, Hexham and armed with a knowledge of Hamilton's Quaternions,[4] he travelled to Devonport to join the navy as an Ordnance Artificer Apprentice. That first night, he slung his hammock on the main gun deck of the hundred-year-old HMS *Ganges*[5] which was one of the hulks forming HMS *Indus*. *Indus* was one of the training establishments arising from Admiral Lord Fisher's policy of the navy training its own artificers. The Ordnance Artificer scheme had been started two years earlier. Thus IP was one of the very first naval ordnance artificers, and received an engineering training that was second to none.

The Young Iville Porteous

Iville was a very clever young man who had longed to go to university. However he had abandoned an intended academic career owing to the illness of his father and the needs of their small family, to join the navy instead. After five years' of artificer training, he passed out top of his entry of Ordnance Artificer Apprentices and second of his term of about one hundred electrical, ordnance and engine room apprentices. (In all subsequent promotions in the Ordnance Branch he was first amongst those, who, at the outbreak of World War 2 were collectively responsible for the whole of the gunnery equipment of the Fleet.) In 1926, with a recommendation for accelerated advancement, IP shipped his fore and aft uniform and took up his first seagoing appointment as Acting Ordnance Artificer 4th Class in HMS *Revenge*.

HMS REVENGE (1926)

HMS *Revenge*

HMS *Revenge* was the flagship of the Commander in Chief, Atlantic Fleet (Admiral Sir Henry Oliver), where, after training, he became the ordnance artificer (OA) of 'B' turret. *Revenge* transferred to the Mediterranean Fleet in 1927. IP was in a very good place to consolidate his training. Extensive experience of heavy gunnery had been gained in the Grand Fleet during the Great

[3] 'IP' was the name he was known as by those who knew him. It is the abbreviation that is used in this memoir.
[4] This happened to be important knowledge for his future career. Quaternions are used in the mathematics of complex numbers, in particular for calculations involving three-dimensional rotations.
[5] *Ganges,* by then renamed HMS *Indus V* was built in Bombay in 1821.

War, and the lessons learnt were still much in people's minds. Commander George Mountbatten, Second Marquess of Milford Haven[6] was the keen and experienced gunnery officer of *Revenge*. He was an accomplished mathematician and an able and intelligent man. He was very keen on establishing parallelism of the gun bores of the main armament, eight 15-inch guns, a lesson that was not lost on IP. The ship's practice record was excellent, particularly the grouping of the 15-inch shot. The young IP was aware of the very important contributions of Admiral Sir Percy Scott to all aspects of gunnery connected with present position aiming, and took note that the 1912 director system fitted in *Revenge* yielded remarkably accurate fire at relatively motionless targets. IP said that *Revenge* had negligible anti aircraft (AA) defence at that time and did no AA gunnery practice.

HMS SUFFOLK (1928)

When *Revenge* paid off for refit[7] in early 1928, IP volunteered for service in China. He joined the heavy cruiser HMS *Suffolk* which was just completing building at Portsmouth

HMS *Suffolk*

IP - probably China Station late 1920s

dockyard. The ship's main armament was four 8-inch twin turrets and eight single 4-inch anti aircraft guns. IP was given the AA armament as his job. This proved to be a significant appointment, as the gunnery officer and the ship's Commander were respectively Lt Cdr H Drew DSC, and Commander C.E.B. Simeon. Together with Captain F.L. Tottenham (Commanding Officer, HMS *Excellent*, the naval gunnery school), these officers had been members of the Committee which had overseen the prototype HACS trials in the battle cruiser HMS *Tiger*. Unsurprisingly, Lt Cdr Drew was keenly interested in AA developments, and as the AA artificer, IP worked closely with him and became familiar with the lines of thought which had produced HACS Mk1. After a two year commission, IP left *Suffolk* to join HMS *Hood,* where he had his first experience of HACS.

HMS HOOD (1931)

IP joined *Hood* in September 1931 where, a week later, he was amazed to find that the ship was part of the Invergordon Mutiny.[8] *Hood* was the flagship of the Battlecruiser Squadron of the Atlantic Fleet, flying the flag of Vice Admiral W Tomkinson, CB MVO, and it fell to him, as acting Fleet Commander, to deal with it.

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[6] 'An accomplished mathematician, the Marquess "could work out complicated gunnery problems in his head" and "read books on calculus casually on trains". Queen Elizabeth II, his cousin and niece by marriage, said of him, "He was one of the most intelligent and brilliant of people."' (Wikipedia – quoting Hough, Richard (1984). Louis and Victoria: The Family History of the Mountbattens. Second edition).
[7] A High-Angle Control System (HACS) Mk I director was installed on the spotting top during the 1928-29 refit. (Wikipedia – HMS *Revenge*).
[8] IP wrote home a graphic description of the mutiny. (This letter is not in IP's gunnery papers).

IP was the fire control artificer responsible for low angle and high angle gun control. He disliked the ship's gunnery equipment which he described as *'concentrating on all sorts of futilities'*, giving the example that the main armament guns (four twin turrets of 15-inch guns) could be controlled from over 13 positions to cover breakdown possibilities.

He wrote *'This influenced me later when I was evolving the theory of the Flyplane Predictor System which either functions correctly as a whole without substitute alternatives or not at all'*, adding that his experience had taught him that *'secondary or substitute arrangements are futile in practice'*.

The *Hood* had one of the first sets of HACS Mk 1 fitted in the Fleet,[9] mounted compactly on the after superstructure together with four 4-inch Mk V guns on H.A. Mk III mountings using 198 powder fuzed ammunition. This was significant, IP said, as *'this early equipment gave*

HMS *Hood*

HMS *Hood* – 'A' Turret Crew
IP rear row - third from right

the best A.A. shooting I was ever to see with H.A.C.S.'. He added:

> *'The gunnery handbook Progress in Gunnery C.B. Series 1932 onwards will bear me out in this. Each later mark of* [HACS] *control system, gun, mounting and fuze produced decreasingly accurate results. This has usually been explained by saying that improved standards of marking* [photography] *explained this. That is not the case so far as my experience went. In HMS* Hood *we reckoned to shoot down the sleeve target with fair consistency every practice. In later years, I found this became an increasingly difficult achievement with later marks of equipment and I spent much time analysing the reasons'*.

HMS SUFFOLK (1933)

From *Hood*, IP returned to HMS *Suffolk*[10] in July 1933 for her third commission, again for service on the China Station where she was flagship of the Commander in Chief, China Fleet.[11] By now he was newly advanced to Ordnance Artificer 2nd Class and also 'Qualified for Warrant Ordnance Officer', and *Suffolk* had been fitted with HACS Mk 1.[12] (She was to be badly damaged by German bombers in 1940.)[13]

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[9] https://en.wikipedia.org/wiki/HMS_Hood.
[10] Captain Errol Manners RN.
[11] Admiral Sir Frederick C. Dreyer KCB, CBE; January 1934 – August 1934.
[12] www.navalhistory.flixco.info.
[13] https://en.wikipedia.org/wiki/HMS_Suffolk_(55).

The period 1933-35 was one of great financial stringency, leaving little money to spend on fuel oil or practice ammunition. The consequent limits on operational work left IP time to turn his attention to gunnery problems. Among these was the very bad spread (or 'grouping') of fall of shot in the 8-inch County Class heavy cruisers. He set about establishing the reason:

> *'I found, from a method of tilt testing which I evolved, that the method used by the dockyards of tilt testing (finding out by how much the plates of the various gun mountings are not parallel) with the ship touching the dock bottom, led to large errors when she became fully waterborne. As a result of this discovery I worked out new tilts and at our last shoot in that commission obtained the record small spread. See C.B. Progress in Naval Gunnery 1935. All ships are now tilt tested fully water borne'.*

Following a throw-off shoot (possibly the one mentioned above) *Suffolk* gained a commendation from Admiral F.C. Dreyer, the Commander in Chief, China Station for the excellent rangefinder results and the small salvo spreads obtained by *Suffolk.*[14] A few months earlier, during another shoot, the CinC had signalled *Suffolk,* copy to his flagship HMS *Kent,* as follows: *'The smoke screen made by the* Kent *which entirely ruined your chances in the 8-inch competitive firing was entirely the fault of my Flagship and is a matter of great concern to me. If they do that sort of stupid thing in action some of us will as a result be sunk'.*

During his time on the China station in the 1930s, IP was one of the few British naval people who had the opportunity to study foreign warships when he was able to examine a modern Japanese battleship and a cruiser. He thought they were poorly equipped, and considered that the war showed them to be *'useless gunnery ships by comparison with American ships.'* On the other hand, he was most impressed with the USS *Augusta* (commissioned in 1931), a cruiser, which in his words *'belonged to a different technical generation from my experience'.*

HMS REPULSE (1936)

IP joined HMS *Repulse* in 1936 for service in the Mediterranean Fleet. She had just completed a two-year refit and modernisation and had the latest anti-aircraft equipment. IP was the Chief Ordnance Artificer in charge of all gunnery control gear including AA armament. By this stage of his career he had arguably had more day-to-day sea experience of British AA equipment than anyone else in the Fleet. After trials, workup, practice shoots, although the main armament gave good results, he was concerned with the performance of the AA armament. He wrote home with his opinion that *'This ship is defenceless against air attack'.* At about the same time, Admiral of the Fleet Sir Ernle Chatfield, then First Sea Lord, was writing to Churchill, with no such doubts concerning the defence of merchant shipping (let alone warships) saying: *'even one A-A gun in a merchant ship'* would keep the aircraft at a height such that the chance of destroying the ship was *'very small'.*[15] IP considered *Repulse* so vulnerable to air attack because of '*the tardy operation of the HACS system. The dead time (i.e. the time elapsing between the moment prediction begins and the time the shell is fired) in the latest equipment was 10 seconds compared with about 5 seconds in the older… equipment'.*

[14] IP personal papers: (1) CinC Memo 583 dated 26 March 1935. The throw-off shoot was against HMS *Kent* on 22 January 1935 off Hong Kong; (2) CinC signal to *Suffolk,* copy to *Kent* dated 1140/14 Sep 1934.
[15] Letter Chatfield to Churchill 5th May 1936. Quoted by Roskill – 'Naval Policy Between the Wars' p.227.

Even though Admiral Fisher, the CinC Mediterranean, was aware by 1936 that the navy was effectively defenceless against dive-bomber attack,[16] it took some time before Chatfield was up to speed: *'Our present system of H-A control is very imperfect'* he wrote in 1937.[17]

On 10th December 1941 HMS *Repulse and* HMS *Prince of Wales* were sunk. *Repulse* was the first capital ship to be sunk at sea by aircraft.[18] DiGiulian argues that apparently neither ship shot down a single aircraft with the HACS-controlled guns, albeit they were initially hampered by poor fleet handling.[19]. They were, however, subjected to overwhelming air attack.

HMS *Repulse*

REPULSE was the last ship in which IP had specific responsibility for the testing, preparation and maintenance of the control arrangements of a single ship. He was promoted to Acting Warrant Ordnance Officer on 1 January 1937 and thereafter had Squadron responsibilities.

2nd CRUISER SQUADRON (1937)

On promotion IP was appointed Squadron Ordnance Officer, Second Light Cruiser Squadron, fortuitously accommodated in HMS *Newcastle* because of a shortage of cabins in the flagship HMS *Southampton*. This squadron was being re-equipped with the new 'City' class cruisers, which had the latest equipment, including 6-inch guns and an AA armament of 4-inch Mk XVI guns.

HMS *Newcastle*

IP was concerned about the overall quality of fire control in ships but was in a minority among officers in having this uneasiness. He attributed this to being alone in having progressed more or less from HACS Mk 1 to the latest Mk IV equipments, maintaining and using them at sea. He wrote *'As can be seen from CB.3001/1938 Progress in Gunnery the A.A. gun fire control had been steadily deteriorating and I spent much time trying to put my finger on where we were going wrong as the general view amongst knowledgeable technical ratings was "every improvement sets us back"'*. He discussed his disquiet particularly with the gunnery officer of *Newcastle*, Lieutenant Commander E.T. Larken, who came to hold IP's intelligence and ability in high regard. IP's dissatisfaction also came to the notice of the Squadron Gunnery Officer in HMS *Southampton* – Commander E.K. Le Mesurier.[20] Later, in the Directorate of Naval Ordnance, both of these officers were key supporters of IP. IP left the Second Cruiser Squadron after seeing HM Ships *Southampton, Newcastle, Glasgow and Sheffield* through their working up periods.

[16] Backhouse to Chatfield 27 March 1936. Quoted by Roskill - *Naval Policy between the Wars'*p.333.
[17] Chatfield to Backhouse 8 Oct 1937. Quoted by Roskill - *Naval Policy between the Wars* p.333.
[18] Hough, R, *Dreadnought.* Michael Joseph (1965).
[19] Middlebrook and Mahoney, 1977, p. 143-144, 182. Quoted by Tony DiGiulian article (*The British HACS*) updated 10 May 2009 (Tony DiGiulian – *The British High Angle Control System*). (http://www.navweaps.com/index_tech/tech-066.php) note13 accessed 28 January 2020.
[20] RCAI – 27 July 1954 p25 - Captain Le Mesurier evidence.

4th CRUISER SQUADRON (1938)

In July 1938 IP was appointed as Squadron Ordnance Officer to HMS *Gloucester*, building at Devonport. She was a Town Class light cruiser and flagship designate, Fourth Cruiser Squadron on the East Indies Station.[21] IP joined the ship six months before completion, which is when he had his first direct formal contact with Admiralty design officers. He persuaded them to re-arrange the layout of the high angle control position starting switches in the light of his experience gained in previous ships. After commissioning, *Gloucester* proceeded to the East Indies where she was joined by HM Ships *Liverpool* and *Manchester* of the same class.

HMS *Gloucester*

Gloucester was in Aden at the outbreak of war. In the following four months she spent 102 days at sea. The gunnery equipment functioned correctly to its design requirements, but IP hoped that Italy would stay out of the war as by that time he *'knew that the ship's AA fire control equipment…. was far too cumbersome in practice and would inevitably be ineffective under battle conditions'.* IP left *Gloucester* in 1940 (after a near-fatal road accident in Colombo) and was invalided back to UK. After convalescence he joined HMS *Fiji*,[22] another new ship, but left her after she was torpedoed as she set off en route to Dakar. She returned to UK for repairs. Both *Gloucester* and *Fiji* subsequently were sunk by air attack off Crete the following year.

HMS MAURITIUS (1941)

IP then joined HMS *Mauritius*[23] from *Fiji* at the end of 1940 when she was completing build at Newcastle. Taking the brief opportunity, he married Nora Bridge, the 'girl next door', at Newcastle on Boxing Day. She was a graduate of Durham University and had become a teacher. They were to have two children, a pigeon pair. He bid Nora a quick *au revoir*, as a few days later he was at Scapa Flow in *Mauritius*, doing trials and work-up. *Mauritius* was fitted with the latest equipment which provided IP with his first experience of radar. IP was the ship's Ordnance Officer, and a watchkeeping main armament control officer. She was bound for the East Indies Station, where, in October 1941, IP was promoted to the rank of Commissioned Ordnance Officer.

Iville Porteous

Nora Porteous

After nearly a year of operations in the East Indies, the ship berthed at Singapore for a major refit, partly to rectify major fire main defects.[24] The ships company was accommodated ashore with only a fire-party-cum-guns crew remaining aboard. One of three sections of the

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[21] The principal function of this squadron at that time was to protect trade from possible German surface raiders.
[22] A Crown Colony Class light cruiser.
[23] A Crown Colony Class light cruiser.
[24] The ship had been fitted with internal degaussing which induced severe corrosion to the ship's fire main which was made of copper, necessitating refits in Simonstown, Singapore and finally Devonport. www.wikipedia.org/wiki/HMS_Mauritius_(80).

AA armament had been kept operational. At about 0200 on the night of 7/8 December 1941 IP was woken up and told to go to the ship and as Air Defence Officer, man the after AA armament as Japanese aircraft had crossed the frontier with Malaya. The aircraft then crossed the perimeter of the Naval Base, and IP ordered 'Open Fire' before the *Prince of Wales (*which was lying ahead of *Mauritius*). *'The Mauritius was thus the first ship to fire against the Japanese Naval Air Force – ineffectively'* he wrote.

HMS *Mauritius*

Later that day Force Z including *Prince of Wales* and *Repulse* sailed. Two days later the ships were sunk, and the Japanese were expected to invade Singapore and attack with aircraft and submarines. *Mauritius* was deep in refit and there was concern that the ship might become trapped in Sembawang dockyard. As a result of the air raids on the dockyard the native workforce had panicked and then run off into the '*ulu'*. The ship was left to fend for itself and made strenuous efforts to reassemble stripped machinery and to ready the ship to move, if not to fight. This was achieved by 11th December and the plan was for the ship to move from the dockyard into the stream, await nightfall, and then move down the Johore Strait under cover of darkness.

Midshipman Leach, then onboard *Mauritius*, later said that CPO Dawson, the Chief Boatswain's Mate, detected an unhealthy atmosphere in the ship. There were three ship's cats onboard.[25] Before the *Prince of Wales* had sailed for the final time, its black cat had left the ship, and had come on board *Mauritius*. When *Mauritius* sailed, the cat could not be found and the ship's company thought it had left the ship and regarded this as a bad omen. However, all was well as the cat was found the next day, and on hearing the news, the ship's company cheered.[26]

Fortuitously, owing to the fire main defects and the refit, the ship did not take part in the Force Z or subsequent actions in the area, where there were to be heavy losses. Instead, from Singapore the ship sailed for Colombo with some of the survivors from the *Prince of Wales* and *Repulse* embarked and then returned to England via the Cape arriving in February 1942.[27] She was taken in hand by Devonport dockyard to finish the refit, and was berthed near to HMS *Delhi* which was of particular gunnery interest to IP.

The next chapter traces a brief history of the Anti Aircraft system HACS, the development and deployment of which was contemporaneous with IP's service from 1926-1942 in battleships and cruisers. His increasing disillusionment with this system, which he worked with from its entry into service, was to be the catalyst for the great changes that he was to bring to naval anti aircraft fire control.

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[25] Scruffy tabbies called Hodge, Mousse, and Hendrikson.
[26] Admiral of the Fleet Sir Henry Leach. IWM archives - oral history.
[27] On or about 11 February 1942. IP was to visit HMS *Delhi* with Hugh Clausen a few days later, on 24 February.

CHAPTER 2

NAVAL ANTI AIRCRAFT FIRE CONTROL DEVELOPMENT IN THE PRE WW2 YEARS

Early Developments

The development of anti-aircraft fire control systems started after the First World War. The Naval Anti Aircraft Gunnery Committee (NAAGC) of 1921 established a requirement for an AA gunnery control system which incorporated a high-angle (HA) stabilised director sight and prediction instruments. An ideal system would be able to use estimated aircraft height and relative course to provide initial generation of deflections and fuze length, with these results being updated by a height-finder and measured vertical and angular velocities. Various new pieces of equipment were to be used in initial trials in the cruiser HMS *Dragon* which took place in 1923. These were to include, notably, a gyro-stabilised director, an angular velocity (AV) meter to derive vertical and lateral deflections (both of which had been devised by Professor Sir James Henderson, the Admiralty Gyro Adviser) and a plotter/predictor designed by Colonel Hill.

High Angle Control System (HACS)

Subsequently, in 1926, trials continued in HMS *Tiger,* a 28,000 ton battle cruiser, by which time the gyro-stabilised director appears to have been replaced by a light-type director made in HMS *Excellent.* Henderson's AV meter, which was in the *Tiger* trials, after earlier promise, was overtaken by emergence of HACS. The trials in *Tiger* quickly led to the development of HACS, a decision which was signed off in 1926 by the Controller (Vice Admiral Chatfield) and First Sea Lord (Admiral Beatty). Among the Gunnery officers who had been involved in the evolution of the design were Cdr C.E.B. Simeon (D of GD[28] staff), the first person to realise that the HA fire control elements should be interconnected, and Lt Cdr M.M. Denny of HMS *Excellent* Experimental Department (XP) (later to become Admiral Sir Michael Denny).[29]

HACS trials in the gunnery practice ship *Tiger* were completed in 1926, and the job of designing a production prototype was given to Messrs Vickers. Ships in the meantime were ordered to equip themselves with a Standard Temporary System made up of parts of the Army's Hill Predictor system. The Hill Predictor system designed by Lieutenant AV Hill of the Royal Artillery was essentially a mechanism for forecasting the future position of a target given a stable reference frame – the earth – as a starting point. To use this basis for a temporary system might be construed as reasonable, but unfortunately it was also used as the basis for the HACS on trial in the battle cruiser *Tiger* – a large ship and steady platform and therefore in no sense a fair test of the difficulties of a naval system in any sort of seaway. This was not the only occasion when the influence of Army design was ill-suited to naval needs.

The first HACS system went to sea for trials in HMS *Valiant* in 1930, followed by installation in ships of the fleet. And so there entered into service a goniographic[30] system

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[28] Director of Gunnery Division.

[29] Denny was to spend much of his service career as either a gunnery officer afloat, at HMS *Excellent* in the experimental department in gunnery development, and, in the years immediately before WW2 in the Directorate of Naval Ordnance successively as Assistant Director, Deputy Director and Acting Director. During this period he was in charge of the fire control policy. He later gave evidence at IP's Royal Commission on Awards to Inventors.

[30] Goniographic (or goniometric): prediction using estimated inputs based on a series of discrete measurements of the target position. (Marland - Warship 2017 p.117).

which depended on estimated target movement inputs, rather than a tachymetric[31] system with gyro-based rate measurement instruments to which the NAAGC had aspired ten years earlier.[32] The NAAGC of 1931-32 made a range of recommendations for the improvement of defence against air attack. But in the following years many opportunities were lost, and there was an unwarranted degree of optimism about AA capability, particularly amongst very senior officers.[33]

By 1937 in the light of increasing concerns about the growth in aircraft capabilities, it had become apparent to the Admiralty that AA defence was in need of much improvement. This was underlined by a shoot attended by members of the ABE[34] committee and Admiralty Board members when a Queen Bee target circled the Home Fleet for two and a half hours without a shot going near it. Chatfield finally realized that all was not well with AA gunnery.

Queen Bee target awaiting launch (being witnessed by Churchill)

This led to steps being taken to try and overcome the shortcomings of HACS which was designed for high-level bomber targets moving at a constant, course, speed and height. However, as the nature of the air threat to ships evolved, it rapidly became clear that HACS was unable to cope with attacks by dive-bombing and air-launched torpedoes. Although there was a tachymetric element to the system,[35] its solutions were only approximate with performance depending on the Control Officer correcting the fire based upon shell bursts seen. Inter alia, development of a new system to replace HACS was initiated - Tachymetric System 1 (TS1). However it was not started until 1937 and remained incomplete by start of WW2[36] and was cancelled.

The HACS director weighed several tons, most measurements were unstabilised, optical ranging was difficult, and data feeds relied on somewhat unreliable 'step by step' transmission. The below-decks crew followed input pointers to set the table, leading to lagging errors against crossing targets, and slow gun training as there was no power drive for the gun mountings.[37] By 1945 the HACS Mk IV system required 17 operators,[38] with the consequent accrual of lagging errors.

HACS, which was to be modified many times during the years leading up to WW2, was widely fitted in the large ships. It had, however, been developed piecemeal by an organisation that was ill-suited to the demands of the time, and the result was a fire control system that was no match for the foe that it faced. How did this come about?

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[31] Tachymetric: prediction using continuous measurement of actual target rates, typically using a gyro-based instrument (ref BR1898(2)).
[32] Marland – (Warship 2017 p.117).
[33] Marland: DSTL letter dated 28 March 2013 covering a paper *Post-War RN Equipment Projects, and the background to Anti-Aircraft Fire-Control Development Between the Wars.*
[34] Aircraft Bomb Experiments Committee (1937).
[35] Marland (Warship 2017 p.117). This only drove the fuze number, the least important item of data needed.
[36] Freidman, *Naval Anti-Aircraft Guns and Gunnery* p.96.
[37] Marland, *HACS: A Debacle or Just-in-time?* Naval Review August 2017 p.262.
[38] BR 224/45 diagram reproduced in Tony DiGiulian paper – *'The British HACS'* updated 10 May 2009 (http://www.navweaps.com/index_tech/tech-066.php) accessed 28 January 2020.

Organisational Weaknesses

There are many reasons why the navy found itself lacking in AA capability at the onset of WW2 and these are well covered by Roskill[39] and Marland.[40] Not least, and in the particular context of this account, the lack of naval ordnance engineering expertise in fire control design had an ongoing detrimental effect to the development of fire control equipment. Arguably the employment of Royal Artillery officers in the absence of naval ordnance officers stifled innovation. The inter-war design and development of HACS, the system which was fitted to all large ships as the main protection against AA attack, suffered accordingly.

In addition to these factors, there was an underlying fundamental weakness in the policy, design, and procurement organisation. The NAAGC assessments of 1921 and 1931-32 each provided a comprehensive analysis of problems and solutions needed for the improvement of defence against air attack. However, the subsequent implementation and programme management of the decisions taken was very weak.[41] [42] There was no firm control by the authorities mainly concerned with naval fire control systems – the Admiralty Research Laboratory (ARL)/Admiralty Gunnery Establishment (AGE), working for the Director of Naval Ordnance (DNO) – and critically these organizations all lacked specialist naval ordnance engineering expertise.

Among the members of the NAAGC 1931-32[43] were Captain A.V. Kerrison Royal Artillery, (an Army officer who had been seconded from the War Office), Mr F. Landucci (technical assistant to DNO) and Mr E.T. Hanson. Hanson, who was the principal ARL Teddington worker on long-range AA prediction from 1922 to 1934, was an established senior scientific officer and a capable expert on his topic.[44] There was apparently no seagoing ordnance engineering specialist officer on this committee, unsurprisingly, as there was at that time hardly any opportunity for warrant rank promotion to commissioned officer. This was a crucial failing of the manpower organization.

The decision in 1926 to develop a system (HACS) which largely depended on estimating enemy aircraft movement rather than a tachymetric system which measured it, proved unsound. The speed of aircraft increased rapidly during the 1930s, and the onset of dive bombing in the early years of the war would prove more than a match for HACS. All this, coupled with a shortage of money, a lack of British designers and practical ordnance design

[39] Roskill S.W. *Naval Policy Between the Wars* pp.333-334.

[40] Marland, *HACS: A Debacle or Just-in-time?* Naval Review August 2017 p.255.

[41] The younger Hugh Clausen, later DNO's Chief Technical Officer, must have learnt much from observing this process; See Clausen's article *'Inventions and the Navy'* Naval Review October 1970 p.330.

[42] Marland, *HACS: A Debacle or Just-in-time?* (Warship 2017 p.123):'A key factor in the problems experienced with HACS was the fragmented organisational framework under which development took place. NAAGC'21 and '31 were specially-formed panels of "all the talents" that provided a comprehensive study of problems and solutions, with open-handed treatment of the options. In contrast, the subsequent "in-house" staffing by DofGD and DNO, covering decisions on what was to be implemented and how the programme was to be managed, was a deeply flawed process. In this environment, there was loose co-ordination between the seniors (1SL/CNS, CofN and ACNS) and DNO, but beneath this there was no specialist naval staff and only very skeletal research organisations: ARL/AGE, DTM's LP&FC section and *Excellent* XP. There are distinct echoes of the limitations of the Torpedo branch described by Franklin, and the need for independent high-level scrutiny'.

[43] Marland, *HACS: A Debacle or Just-in-time?* (Warship 2017 p.112): 'The NAAGC of 1931–32 was the second such committee. The full-time membership included a Rear-Admiral, two Commanders and a "gunnery officer with practical experience of HACS 1 firings' at radio-controlled Queen Bee targets" plus a secretary, and part-time membership of another eleven, including representatives from the other services, a Capt Kerrison (Army) seconded from the War Office staff, and Mr F Landucci (technical assistant to DNO). The committee started work on 1 October 1931 and reported on 29 April 1932 (see ADM 268/52).'

[44] Marland, *HACS: A Debacle or Just-in-time?* (Warship 2017 p.112). Hanson had published four papers in learned journals for optics, physics and maths between 1924 and 1938.

experience, and a light engineering industry ill-equipped for the needs of the moment, contributed to a deteriorating situation as war slowly became inevitable.

By 1937, whilst the Germans and Americans had tachymetric systems, the RN was committed to quantity production of an inefficient alternative. Roskill concluded that:

> *'The lessons to be derived from this failure are that British specialist officers were not properly trained in scientific design and armament engineering, and that they were far too slow to seek advice from those who were so trained….The Gunnery branch undoubtedly indulged in a great deal of self-deception and wishful thinking on these matters and the conclusion is inescapable that the severe losses suffered from bombing attacks, especially when ships were operating in coastal waters, would have been mitigated if greater foresight and less confidence had been shown, and better use made of the scientific skill and knowledge available'.*[45]

Ordnance Branch - Officer Structure

One reason for the paucity of naval ordnance engineering expertise at officer level was that the ordnance branch had only been formed in 1919 and was exclusively for artificer entry, with a training period of five years. There was no ordnance engineer specialisation in the officer structure. By the late 1930s the navy was experiencing other problems too with the officer structure. Various suggestions were made by Commanders in Chief and others, but came to nothing.[46] Class considerations such as parentage and education outweighed the importance of ability and intelligence. Well into the twentieth century there was class-based prejudice against engineering and technical education.[47] The navy is a technical service, as acknowledged by Admiral Chatfield, a gunnery officer, writing in 1942 in retirement:

> the *'navy is … a material Service equipped with…the latest developments that engineering in all its great branches can conceive. To understand and to be able to use these appliances is not enough. The naval officer must have knowledge of the engineering art behind the producer, must be able to get full value out of the machine, to keep it under repair, to teach others its good and bad points and suggest improvements. He is the skilled user of weapons. He alone can appraise their merits correctly and guide the designers and constructors as to future needs'.*[48]

But, unfortunately this insight was not available in the 1930s when it was most needed.

IP not only had an outstanding artificer training record but was first in all subsequent gunnery examinations for promotion. He qualified for Chief OA in 1931 with an examination result of 94% and two years later qualified for Warrant Ordnance Officer. Pre-war there was only very limited promotion of Warrant Ordnance Officers to commissioned rank, and in the Ordnance branch even promotion to Warrant Officer was a matter of dead man's shoes.[49] During the 1930s, only two ordnance officers annually were due for retirement.[50] IP was well aware of the limitations of promotion, but fortunately this did not concern him as his ambition was to become a genuine expert in gunnery material and practice. Accordingly he

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[45] Roskill S.W. *Naval Policy Between the Wars p.334.*
[46] Roskill S.W. *Naval Policy Between the Wars p.343.*
[47] Farquharson-Roberts M. *Royal Navy Officers from War to War 1918-1939* p.224.
[48] Farquharson-Roberts M quoting *Chatfield – The Navy and Defence* 1942 p.26.
[49] In June 1942 there were only 14 Commissioned Ordnance Officers in the navy, the most senior of whom was promoted in 1936. (Navy List June 1942). IP's seniority was 1 October 1941.
[50] IP personal papers – list of names.

had consistently volunteered for and been given appointments to progressively more modern ships. His gunnery education had therefore been continuous and incremental and he viewed his interest in gunnery as vocational rather than simply earning a living.

As there was no body of senior officers in his own branch above his rank, he found that he always carried much more weight than a junior officer could have done. As well as the successes it also allowed him the opportunity to make mistakes which were common knowledge throughout the ordnance branch. *'It is interesting in a way to find out as time goes on that it is much easier to have one's name known throughout the Fleet as a rating than an officer'* he later wrote.

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CHAPTER 3

THE GENESIS OF FLYPLANE

Background

Certainly up to the mid 1930s, in IP's eyes at least, the Admiralty seemed blind to the encroachment of war and the inadequacy of the existing AA fire control equipment on which all the major fleet units would have to depend for survival. IP's voice had been a lowly and lonely one. Others shared IP's views but similarly were too junior to hold sway against the complacency of those at senior level, who initially saw no problem and then, belatedly, no solution.

We left IP (in Chapter 1) knowing that HACS, the Anti Aircraft fire control system system with which they were fitted, left the many large ships vulnerable to air attack. By 1942 IP had been at sea in ordnance jobs in battleships and cruisers for 16 years, nearly all of which included responsibility for fire control. He had set to work the gunnery systems of several new build or post-refit ships (including *Repulse*) equipped with the latest modifications to HACS and knew exactly what the AA capabilities of these ships were. As both a ship's Ordnance Officer and Squadron Ordnance Officer, IP had been responsible for the setting to work, trials and efficiency of the gunnery and fire control systems of eleven cruisers.

For many years IP had an abiding interest in improving gunnery; once, in 1930 (when serving in HMS *Suffolk*), he opened a newspaper and found that he had been made an award (for which he had not applied) in connection with the design of a gunnery sight.[51] In subsequent years at sea he proposed many improvements in addition to those already mentioned, including oil motors for fire control installations, lining up HACS Mk 4 rangefinders, and a means of using HACS Mk 4 for crew training when no aircraft target was available. When the opportunity arose, he also experimented with new ideas, such as when he was in HMS *Mauritius* in the Indian Ocean in 1941. Subsequently he wrote: *'In my last ship we produced a 3 pdr with balanced recoil in our spare time just to prove that a self contained gland to hold compressed air could be made. It can*'. Speaking in later years he said *'I was making suggestions continually to the Admiralty, and the answer always was "We will consider this suggestion"'.*

It was IP's concern in 1936, when he was Chief Ordnance Officer of HMS *Repulse*, about the ineffectiveness of the AA fire control equipment that sowed a seed in his fertile mind. Making suggestions to the Admiralty had reaped no harvest, and so from 1937 onwards whilst serving as the Warrant Ordnance Officer of the 2nd and then the 4th Cruiser Squadrons, IP started thinking of a way to produce a fire control solution of shifting from one line of sight to another without going through any form of zero. His aim was to get rid of what he called 'crystallised mathematics' ie the very elaborate mathematical calculations required, by reducing them to simpler form. As a child, IP had an interest in geometry, and in 1920 when he was aged 15, his grammar school maths master, who was a friend of the family, introduced him to the theory of quaternions. Now, all these years later, quaternions offered the solution. (Subsequently, on hearing that IP left school at 15, the Chairman of the Royal Commission on Awards to Inventors (RCAI) in 1954, Lord Cohen (Eton and Oxford), said *'Then he learned a lot at school; that is all I can say').*[52]

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[51] IP personal papers. Undated newspaper clipping listing Naval Efficiency Awards – The Lott Fund: 'Ordnance Artificer [I] Porteous (Pom-pom field mounting sight) £12.'

[52] In fact, from the age of 15, IP was a largely self taught polymath – with his eclectic interests ranging widely, and far from engineering to subjects such as science, calculus, geometry, history, politics, philosophy, literature, and later space flight theory. This was reflected in the library that he collected during his lifetime.

The Flyplane Concept

Hitherto, gunnery fire control calculations had used three-dimensional coordinates for positional definition. This required all positional data to be 'taken through' the zero datum point and then out from it with the resultant mass of calculations. By applying quaternion principles, it would be possible to simplify the mathematical basis of the fire control problem considerably by using a 'flyplane' as the reference plane for two dimensional positional definition, rather than three-dimensional coordinates.

This thinking in the previous years had produced in IP's mind the outline of an automatic, stabilised, tachymetric fire control system, and this was the genesis of the Flyplane system. *'The essence of the Flyplane'* he said *'is that it is the simplest mathematically of all the systems which I have ever met'* and to him it was clear that this could lead to substantial improvements in AA fire control over the present systems. However, as a mere seagoing (and recently promoted) Warrant Ordnance Officer, there seemed to be no prospect of the Admiralty listening to what he was saying, let alone persuading those concerned with equipment design in the Naval Ordnance Directorate and the Admiralty Research Laboratory fire control section (which became the Admiralty Gunnery Establishment in 1943). But one junior officer did listen. This was Lieutenant Commander E.T. Larken, Gunnery Officer of HMS *Newcastle*, as mentioned previously.

It is interesting to note that even by this time, IP was making contacts outside the normal service channels, which a short time afterwards was to become his modus operandi for his subsequent work at DNO. He was also becoming known in the gunnery policy world. By 1937 he was in informal contact with one of the DNO technical officers, Reginald Clark. Clark showed one of IP's letters (doubtless brimming with ideas) to Mr Landucci - who said he was '*too enthusiastic*'. [53]

Desperate Remedies

By the time the war started, IP was thoroughly disillusioned by the poor performance of both the AA fire control systems fitted in the fleet's major warships and, no doubt, also of those responsible for equipment design. For several years he had not been alone in knowing that ships' anti aircraft gunnery was inadequate; he also knew that despite being possible, few effective improvements were being made:

> *'There are remedies but whether they can be applied I don't know. The years when we should have built up the part of a navy that matters – the hard technical core – was devoted to building sham castles. The enemy did not turn our flank until the* Illustrious[54] *and* Southampton[55] *affair. He* [the enemy] *could hardly believe that our A.A. gunnery was so far behind his – for it is overlooked at the beginning of a war* [that] *one is protected by the strength of the enemy's defences. He anticipates yours to be of the same order. I shivered when I read of* Southampton *and* Illustrious. *I then knew* [that] *German pilots knew as much about our gunnery as I did. They took quick advantage'.* [56]

[53] Correspondence in IP personal papers. The 1939 Navy List lists Mr Landucci as a Principal Technical Officer at DNO.
[54] *Illustrious* was damaged by dive bombers in January 1941 in the Mediterranean.
[55] *Southampton* was damaged by dive bombers and was then scuttled off Malta in January 1941.
[56] IP personal papers.

By the time he returned to England in February 1942, of the ships he knew well, *Repulse, Southampton, Fiji and Gloucester* had been sunk by air attack. He had served in three of these ships. *'On my return to England'* he wrote *'I was, possibly, the least surprised officer in the Navy for at least things had behaved rationally. I had expected a tremendous licking from aircraft and my pre-war words had not fallen on deaf ears'.*

For several years IP had been frustrated by the inadequacy of AA gunnery equipment, the apparent complacency at senior level and the policies being pursued. Even though he had considerable seagoing ordnance experience (which probably exceeded that of any single person in the RN by 1942), he was resigned to having very limited influence and certainly no power to influence anything as a rating, even as a Warrant Officer. As he ruefully observed: *'I would much rather be in overalls and know what I was talking about than be the objects of contempt so many senior officers are to many of the lower deck'.*

Suddenly, and unexpectedly, his fortunes changed dramatically. He was appointed to the Directorate of Naval Ordnance.

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CHAPTER 4

DIRECTORATE OF NAVAL ORDNANCE – 1942

IP joins Commander Larken

Commissioned Ordnance Officer Iville Porteous joined the staff of DNO at Bath as technical assistant to the Policy Commander on Fleet AA equipment, Lieutenant Commander E.T. Larken[57] at Larken's behest. He arrived at DNO at a time when many major decisions were being made regarding naval gunnery. This appointment had come about as follows. Lieutenant Commander Larken (G†), with whom IP had previously served, had been appointed to the staff of the Director of Naval Ordnance in January 1942 as the staff officer responsible for advising on policy for the control of medium calibre guns against aircraft targets. Previously he had been the Gunnery Officer of HMS *Newcastle* and then HMS *Ark Royal* until the latter was sunk.[58] He reported to Captain P.V. McLaughlin, the Deputy Director of Naval Ordnance responsible for fire control. Larken was one of the very few pre-war voices who said that ships could not shoot down aircraft. This was not a popular view to have at that time, and in the usual fashion, after having been proved right he was appointed to DNO and told to 'have a go'.

Larken's main immediate role was to get the most modern equipment fitted into ships which had been torpedoed or were otherwise under repair. This was in addition to dealing with the extremely pressing problem of getting improved gear to give ships something with which they could fight aircraft successfully. He was aware that there were many ideas from many sources offering ways to meet technical requirements including for example a large number of papers from Washington, some from Canada and others from UK sources. *'In my basket, which was already about 6ft high'* said Larken '[there] *used to arrive…large bundle*[s] *of clearly extremely interesting papers'.*

There was a tremendous amount going on in the department and Larken had to manage all this with no staff at all – not even a typist. The workload proved so heavy that he sought an assistant, someone with good technical knowledge and judgement who could read and assimilate a large amount of literature concerning development work, trials and experiments.

Fortuitously IP had arrived back in England unexpectedly in February 1942 onboard HMS *Mauritius.* Larken had served with IP four years earlier in HMS *Newcastle* and knew him as an *'extremely intelligent'* person who had considerable experience in the maintenance of fire control and gunnery equipment at sea. Thus, almost by chance, in May 1942, IP, with nearly 16 years at sea in ordnance appointments, found himself as a very junior officer in the Directorate of Naval Ordnance (DNO) assisting Larken. IP's job at that time was to assist Larken with the installation of existing equipment into ships which were being repaired after suffering action damage, and to examine various proposals for modifications and new equipment. Larken and IP both had similar opinions of the vulnerability of ships to air attack but there was no thought at that time that IP would be involved in design work, of which he had no experience at all. He and Larken had offices in the Royal School, Bath where much of the work was done. IP used the Matron's bedroom and Larken had her sitting room next door. Underneath these rooms was the school's music room with a magnificent piano at which the famous pianist Solomon[59] would practise for local concerts.

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[57] Lt Cdr E.T. Larken (G†) was appointed to DNO wef 27 January 1942. Promoted Cdr 30 June 1943.
[58] Gunnery Officer, HMS *Ark Royal*, 1940-41 prior to her sinking (by submarine torpedo attack) in November 1941.
[59] Solomon (1902-1988) – British pianist.

This serendipitous pairing of IP's technical ability and ideas, and Larken's support and rank was an inspired coalescence of skills which, unbeknown at the time, was to make a substantial impact on AA fire control in the years ahead. Effectively, subject to DNO and Board approval, IP was to '*have a one third voice in stating AA fitting and defence policy for the whole Fleet!!!*'[60] he wrote, almost unbelievingly. He was aged 37 and had been a warrant officer in the Far East a few months previously. Needless to say, right from the outset, the arrival of this very bright and extremely junior officer with radical ideas and considerable gunnery experience caused much eyebrow-lifting in the conservative heart of naval fire control design and development.

Ordnance Expertise at DNO/ARL in 1942

The Directorate of Naval Ordnance (DNO), directed naval gunnery policy which was then enacted by other agencies such as the Admiralty Research Laboratory/Admiralty Gunnery Establishment. There was a large body of gunnery expertise in the Fleet, but officer-structure policies over previous years had resulted in a complete dearth of ordnance engineer officers at the Admiralty in gunnery policy, design and development together with a lack of leadership and direction. In DNO, the officers who had the decision-making powers lacked the depth of ordnance engineering seagoing experience and knowledge. The Warrant and Commissioned Ordnance Officers in the Royal Navy had much practical gunnery expertise, but not the power to do anything - neither was it their role to design equipment. IP was not impressed by what he found at DNO and ARL:

> *'I have had more new ships during their working up period than any one else in the Service …. yet find when I arrived at N.O.D. that an engine room watch-keeping certificate and complete inexperience of sea going gunnery would probably have got me three rings and a directing voice'.*
>
> *'We have masses of technical* ability *…. but no leader and ruler to say we must have A. B. C. D. the necessity of which had been apparent for years…'*
>
> *'I am shattered to find on arriving at the Admiralty views expressed, by officers responsible for approval of design, that are little more than adolescent… Instead of being one of dozens with long practical experience of the technical problems involved in gunnery I find myself confronted with views and opinions I held in 1927 or 28 and which I spent putting to the test in the next few years'.*

Colonel A.V. Kerrison – Superintendent, Admiralty Gunnery Establishment

The nearest approach to practical naval ordnance engineering expertise lay in the hands of the then Captain A.V. Kerrison, Royal Artillery, who had joined ARL Teddington as the Army Liaison Officer in 1934. According to Marland[61] it seems likely that there was only one civilian working on long range AA prediction which was subsequently abandoned in 1936, the implication being that E.T. Hanson was marginalised and then moved on before Kerrison focused on his own No. 3 Bofors predictor for the Army, which, as a land-based system, did not require stabilization. (In 1952 Kerrison received an ex-gratia award of £10,000 for his Mk 3 Bofors predictor. His submission was effectively nodded through, and thus avoided the Royal Commission on Awards to Inventors (RCAI) process.)

[60] IP personal papers – letter to his wife 19 May 1942.
[61] Marland, *HACS: A Debacle or Just-in-time?* Naval Review August 2017 p.260.

Colonel Kerrison retired from the Army and in 1940 became Superintendent of ARL. Kerrison, for all his experience as a Royal Artillery officer, is unlikely to have held stabilisation, a fundamental element of naval fire control, in the forefront of his mind, and yet he had become head of the main Admiralty fire control research department. This was to impede later developments. (In 1943 the fire control group of ARL was to became the Admiralty Gunnery Establishment (AGE) under the control of the Directorate of Naval Ordnance with Kerrison heading it as Superintendent, AGE.) A Commander[62] was appointed as DNO's representative.

Marland, in his work on AA Fire Control development,[63] and his scrutiny of AGE papers in the National Archives and elsewhere, paints a less than flattering picture of Kerrison. He appears as an able individual who was not at his best with his equals and was difficult to please. After becoming Superintendent, AGE, Kerrison was inclined to exercise 'blindness' to work or individuals he disapproved of, and Marland was left with an abiding impression of a very hierarchical style of management that viewed any competing ideas as threatening the legitimacy or reputation of the establishment itself. (The work of IP and his team was certainly much hampered by this, as will be seen later.) After the war Kerrison left AGE and went on to other work in the Admiralty in the rank of Chief Scientific Officer in the RN Scientific Service. A retirement note summarised his career and mentioned the success of the Mk 3 Bofors (land) predictor but finished with the disingenuous comment that:

> *'the application of tachymetric principles to Naval fire control systems was a more complicated and difficult matter and it was a great disappointment to Kerrison that hardware embodying these principles did not find its way to sea as quickly as he had hoped'.* [64]

Other Gunnery Experts

IP found that everyone was friendly and helpful provided he kept off their 'patch', but he was surprised to find that none of the professional technical staff at the Admiralty were naval gunnery experts. They were all specialised but none had even the equivalent of a seaman gunners' course in 'gunnery' (which IP defined as the integration in use of all equipment required to hit the designated target).

It was apparent to IP that there was every reason to be alert to the air menace when he became aware of the credentials of the five principal technicians actually responsible for the provision to the Fleet of equipment for air defence. He later summed them up as follows:[65]

> *'Only one had been to sea and that time was in the Grand Fleet in 1914-18!'* [66]

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[62] Cdr Evelyn Ivor Robert Leighton OBE, RN, a gunnery specialist - Navy List April 1943.

[63] Marland – DSTL letter dated 28 March 2013 covering a paper *Post-War RN Equipment Projects, and the background to Anti-Aircraft Fire-Control Development Between the Wars* - Annex A pp.52-53 to the paper and elsewhere.

[64] Journal of the Royal Naval Scientific Service Vol 13 January 1958 page 35. (Quoted by Marland in DSTL letter dated 28 March 2013 covering a paper *Post-War RN Equipment Projects, and the background to Anti-Aircraft Fire-Control Development Between the Wars* – Annex D p.D-1).

[65] IP personal papers: quoted from draft letter to IP's counsel for RCAI 1953 or 1954. Comments edited and slightly paraphrased.

[66] This could only have been Hugh Clausen who served as a Temporary Lieutenant RNVR in the battleship HMS *Benbow,* flagship of the 4th Battle Squadron at Jutland.– Navy Lists 1915,1918 and 1919.

‘The second was a retired artillery colonel[67]*, Superintendent of the Admiralty Research Laboratory, (later Admiralty Gunnery Establishment).*

‘The third was an ex-draughtsman from Barrow in Furness naval yard who had answered an advertisement (at £350/year circa) for a job in the Admiralty. He was a man of great ability, completely dogmatic but without the slightest vestige of experience of navies, naval gunnery, or sailors.

‘The fourth, his [ie the ex-draughtsman’s] *assistant, was a draughtsman from Messrs Elliot Bros, Lewisham. Again, a man of great ability, capable of learning but without a vestige of idea of what really was required or what was feasible. He was capable of learning and did but that was too late for WW2.*

‘The fifth was a man with a chip on his shoulder. He was top cadet in his term at Dartmouth but was invalided for something trivial in the Geddes Axe period. He became a civil engineer and eventually joined the Admiralty as a fire control specialist. He was very able, completely wrong headed, devoted all Naval Ordnance fire control drawing office staff to the low angle gunnery equipment of the Vanguard *which, in our view, could not possibly be in the war – this was in 1942. He was a man of strong personality and as the Principal Technical Officer concerned easily overawed admirals. He made statements at meetings obviously straight from the Tablets or so it seemed but I had had too massive a direct experience on the substance of his pronouncements to be other than alarmed that a charlatan could be in his position. He died at the age of 45, knowingly beaten.*

‘Of the latter four above, one was fired, one retired, one went to a home for nervous disorders and one died’.

The consequence of this was that IP probably had a better overall view of ‘gunnery’ as he defined it than anyone else in the department (or arguably the navy). He was the third most junior of 14 Commissioned Ordnance Officers in the whole navy, and the second most junior of 45 listed uniformed officers at DNO.[68] Whilst aware of his limitations, he thought that his wide and deep experience of many ships’ equipments could be married to the great talent and capacity of the civilian technical officers, to tackle the difficulties and problems of the gunnery world. However, he said, *‘I was completely mistaken in this. The specialists at the Admiralty were of the opinion that they knew better’.* He saw a *‘democracy of ignorance’* where ignorance has no class privilege, and *‘can wear any uniform, formulate any policy and find supporters everywhere.’* This, he said, *‘is the clue to explain our recent history, both national and service.’*

IP’s date of appointment was June 1942, but he had joined DNO by May, and had started becoming involved much earlier. A fortnight after his arrival back in England in *Mauritius* he went to visit HMS *Delhi* which had been equipped entirely with American gunnery material – guns, mountings, stabilisers, remote power control, fuzes and ammunition - but not radar. IP visited *Delhi* with Hugh Clausen, Chief Technical Advisor to DNO[69] on 24-25 February 1942.

Hugh Clausen in later life

[67] Colonel A.V. Kerrison RA (retd).

[68] Navy List June 1942.

[69] At that time Hugh Clausen was Chief Technical Officer to the Director of Naval Ordnance. Navy List June 1942.

IP wrote:

> *'I went aboard her and was most impressed. For the first time in my experience I was able to examine in detail a completely integrated gunnery system such as I had always hoped would be possible'*
>
> and
>
> *'In conclusion, the outstanding impression one obtains, mechanically, is the complete unity of the gunnery system, each part merges naturally into the next, function by function. There are no sharp barriers between methods or details and no great discrepancies between the quality of design in one section and another'.*[70]
>
> Separately he commented *'I wrote a hurried and scrappy report which is of little significance except that it stung Clausen awake (so he says) and brought him back into the arena with a bang in fighting mood'.*
>
> *'Experience is an intangible thing'* he wrote *'for example when in the* Delhi's *firings first group,* [sic] *the firing circuits were wrong. I had the greatest difficulty in getting people to see it, let alone do anything about it. The ship was naturally blinded to its own imperfections'.*

IP was also startled to find that section by section within DNO, the American AA equipment with which he had been impressed, was being sneered at for the most trivial of reasons – cable leads, or clamps for instance. This was symptomatic of the malaise affecting AA fire control thinking at that time.

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[70] Clausen, H, Paper, 1942: *A Report on Questions Concerning the Gunnery Efficiency of His Majesty's Navy* which includes a technical report on HMS *Delhi* – Appendix to Part 1, para 12. Naval Historical Branch Archive Box P1024 - 19.

CHAPTER 5

HACS – QUO VADIS?

Preamble 1924 - 1942

The origins of IP's technical expertise lay far back. His first ship, the battleship HMS *Revenge* was fitted with the 1912 director system which Admiral Sir Percy Scott had developed and thrust upon a reluctant navy. As previously mentioned, Scott was an avowed advocate of the importance of present position aiming, and *Revenge* yielded highly accurate fire at almost stationary targets. (The mechanical precision of the equipment was such that the maximum error of the alignment between the director's telescope and the indication pointer at the gun was below ¾ minute of arc.) IP had concluded from this that present position accuracy was both possible and necessary.

By 1924 IP was taking a keen interest in the work of Sir James Henderson[71] concerning the use of gyroscopes for azimuth stabilisation, particularly with respect to ship motion and naval gunnery.

The promising beginnings espoused by Scott and Henderson sowed the seeds in IP for what would later become the Flyplane system. He thought

> *'that any interested youngster would expect important and logical developments to take place over the years. Unfortunately a number of policy decisions were taken which, in my considered opinion, caused the development of A.A. gun fire control to be side-tracked from the line of development one would have expected from the work of Henderson and others'.*

He gave examples of these decisions:

> *'to tie gunnery control to a geographical line – the True North – rather than a line of sight….[72]; to develop a remote power control system at the Admiralty Research Laboratory only; a refusal to accept an electronic approach to Remote Power Control; to proceed with large complex control systems without adequate components; to tie the navy's anti-aircraft system to an army system; to put an Army Colonel in charge of the Admiralty Research Laboratory development; and, last but not least, to concentrate in Naval A.A. gunnery on prediction of future position on the assumption that present position was accurately held – as it was in ideal conditions when the ship was comparatively motionless.*
>
> *'The upshot of all this'* he wrote *'was that, whatever else was happening, to one continually associated with each elaboration in its turn it was completely evident that we were well off the rails'.*

Systems under Development in 1942

Three fire control systems were being developed at the onset of WW2 – CRS1, MRS2 and TS1. Development of these was discontinued, however, and the navy therefore had only HACS as the medium range AA fire control system for larger ships and the Fuze Keeping

[71] Sir James Henderson (1871-1950). He was at the Royal Naval College, Greenwich 1905-1920, where for several years he was Professor of Applied Mechanics. He was also the inventor of many improvements in gunnery used by the Royal Navy. (*Grace's Guide to British Industrial History*).

[72] IP explained this decision: *'This was to enable ships fighting in line of battle to control one another in indirect fire in conditions of bad visibility. This depended on the production of an accurate North seeking gyro so their Lordships created their Research Laboratory with this as a principal object. Over the next 20 years many versions of a solution did sea trials – naturally none was successful but just near enough to be encouraging. As part of this geographical reference framework we developed much ingenious concentration equipment, to be used in the battles which never came.'*

Clock (FKC)[73] for escort-sized ships. The war would have to be fought using these systems. A decision had been made, however, to develop another director. Fortuitously this fitted well into the line of development that was to emerge as it incorporated the metadyne, a new concept, which enabled the automatic fine control of heavy equipment such as gun mountings and the new five or six ton directors. This new Mk 5 director was also able to incorporate second generation radar, giving very much improved potential. This was the only significant improvement (in medium range AA fire control) which was in hand when Lieutenant Commander E.T. Larken joined DNO in January 1942.

By the time IP joined DNO in May 1942, *'three major lines of development were being pursued in the close range control field and a very high proportion of the design talent available was being devoted to this field'.*[74] There was a hiatus in HACS Mk IV production because of the concentration of Vickers-Armstrong at Crayford on short range weapons. Fire control systems were soon to be needed for HMS *Implacable* and the Battle Class destroyers, and IP had formed the opinion that even if HACS equipment could be manufactured in time, with its current performance, it would not be much help.[75]

HACS Performance

Both IP and Larken had experience of using HACS against enemy aircraft and neither was impressed. IP said that in a well-trained ship the average time from alarm to opening fire was 35 seconds to one minute, and there was no way of reducing this. Larken said

> *'Undoubtedly there was a great deal of shooting…that went on in the war with the aid of HACS and FKC. In fact what happened was that a large number of bursts were put up in the vicinity of the enemy aeroplane and by hazard one occasionally hit it and shot it down; but I have seen a number of aircraft engagements and the wildness of the shooting produced with their assistance was quite staggering. One would see a formation of aircraft coming, and the bursts would appear all over the sky. That is no exaggeration. The reason for that…is the extremely cumbrous nature of the system'.*[76]

The existing control systems in HACS and FKC had proved ineffective against attacks by German and Japanese aircraft and it was Larken's job at DNO to find a means by which they could be improved. As we have seen, IP had thought for years that HACS was totally inadequate for modern battle conditions and fast aircraft. Now both he and Larken were working together in the policy department responsible for fire control. They were both able to speak from practical experience, most recently IP in *Mauritius* in Singapore, and Larken as Gunnery Officer in *Ark Royal.* Larken said of HACS and FKC that *'the systems we had were quite hopeless'* and that IP's very poor opinion of them

> *'was not overdoing it. They were really hopeless. I tried myself. I had seen the* Ark Royal *with the HACS and the most modern mark* [of it]. *It was terribly difficult with this enormous number of men – 19 or so in the crew – to get them all doing the right things at the right time. You required a degree of training which was practically impossible to reach in wartime'.*[77]

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[73] FKC concept designed by Mr F.A. Landucci (DNO) and hardware designed by Mr KH Nicholls (DNO).
[74] RCAI Statement of Captain E.T. Larken OBE RN.
[75] There is an assessment of HACS performance in Marland – Warship 2017 article *HACS – Debacle or Just in Time?*' pp.120-121.
[76] RCAI Evidence of Captain E.T. Larken 27 July 1954.
[77] RCAI Evidence of Captain E.T. Larken 27 July 1954.

Desk-bound Mr Landucci, a principal technical officer, designer of FKC, and head of DNO's anti-aircraft gunnery section thought otherwise. IP wrote: '*Mr Landucci, then head of the anti-aircraft gunnery section said "There is nothing wrong with H.A.C.S. - the Navy can't use it". Even if his first premise was right he was condemned by his second. Equipment must suit the men not the converse'*. However, it was Landucci's remark at a meeting that it would take at least two years to design a deflection mechanism to use with existing equipment, which spurred IP to start '*butting in on design matters'*.[78] IP thought two years was far too long given the urgent need to improve HACS accuracy sufficiently to persuade the Americans to supply proximity fuzes for use with guns controlled by HACS. After the war IP recalled:

> *'For approximately approaching targets, I thought that this was a most defeatist attitude to take and that we could produce something of sorts in weeks. Axbey agreed to help me and using angle of presentation oil units whose only virtue was that they were the only unit servo we had available at the time, we digested* [what became] *the G.R.U.D.O.U.*[79] *system which progressively went from 4 selected ranges to all ranges up to 5,000 yards…'*.

But this is running ahead of the story.

A Short-order Solution for HACS

For several years before his arrival at DNO, IP had been thinking about a design for a totally automatic fire control system, embodying a Gyro Rate Unit (GRU) stabiliser, which later was to be called the Flyplane Predictor System. The immediate concern, however, was HACS.

Two of the main weaknesses of HACS were (1) the very crude and ineffective means of stabilisation and (2) the fact that the deflections to be applied were based on estimation rather than measurement. A really worthwhile improvement in shooting accuracy under all sea-going conditions would involve developing effective stabilisation to overcome (1); and if (2) could be overcome by generating measured target data, there would be much-improved shooting in clear weather conditions. There was also another compelling factor.

The Proximity Fuze

At about the same time, matters came to a head with the invention of the proximity fuze which the Americans had put into production. They were reluctant to allow these very expensive fuzes to be supplied to the RN for HACS because they would be wasted on that system, which they knew had a very crude and ineffective means of stabilisation, and was unable to calculate deflections accurately (as they were calculated using estimation rather than measurement). *'The Americans had had observers in our ships and were highly sceptical of our ability to point our guns in the right direction'* IP wrote. Larken, whose support for GRUDOU was key to acquiring the fuzes, said the Americans *'did in fact say they were not prepared to waste their extremely expensive fuzes on what they would describe as such trash'.*

Admiral Sir Michael Denny had, as a Captain, been Assistant and then Deputy DNO in 1937 and 1938. By 1954 Denny was Commander in Chief Home Fleet. When cross-examined by Counsel at the RCAI he was rather defensive and reluctant to concede that the Americans' refusal to supply proximity fuzes resulted from the shortcomings of HACS. *'That was one professional opinion against another professional opinion – American professional opinion'*

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[78] IP personal papers.
[79] Gyro Rate Unit Oil Deflection Unit.

he said, although he did accept that as soon as the GRUDOU (of which more later) was fitted to HACS, the Americans agreed to supply the proximity fuze to ships which had GRUDOU. *'Of course, I do not think too much should be made of this.'* he said. Counsel also squeezed out of him that the navy had considerable difficulties with the fire control systems at the start of WW2: on being pressed he replied *'Yes; we were very conscious of the shortcomings of existing stuff'.*[80]

Seeking Improvements to HACS

By mid 1942 Larken and IP saw that there were no new ideas or systems under development which would provide an early resolution to the HACS shortcomings. None of the many ideas from sea or other sources showed much promise. So IP turned his mind to the problem.

Larken takes up the account:

> *'Both* [stabilisation and deflection calculation] *possibilities were discussed as opportunities offered within the department but the responsible Technical Officers, being already fully loaded with commitments, could offer no early prospect of coping with either. I was therefore most interested and encouraged when Mr. Porteous, on his own initiative, outlined to me a scheme he had thought up for a combined stabiliser and rate measurer which might be used in conjunction with a new director coming forward which was to be electrically powered on the metadyne system. He proposed that use should be made of certain techniques which were then novel. The idea seemed to me promising and I consulted Mr. Clausen who agreed that it was worth following up. This development, which was the beginning of the G.R.U Stabiliser, led in due course to the inception of the Flyplane system.*
>
> *'Meanwhile the introduction of measured deflections in existing systems became a matter of urgency in the light of the need to improve their accuracy sufficiently to satisfy the U.S. Authorities that they could justifiably supply V.T.* [i.e. proximity] *fuzes for use with guns controlled by those systems.*
>
> *There was already in service, in numerous directors, the Gyro Rate Unit which could measure target rate, vertically or laterally. This instrument had been intended to work with a unit called the G.R.U.B.*[81] *which, however, had not proved successful and the fitting of which had been stopped. It happened however that a subsidiary servo-unit was already in supply but which by reason of this change of policy had become redundant.*
>
> *Mr. Porteous, again on his own initiative, proposed to me that these units could be readily modified so that a function of range could be set, which, with the rate feed in from the G.R.U., would produce an output in terms of deflection based on measured data.*
>
> *I discussed his suggestion with Technical Officers but no support could be made available and I therefore allowed Mr. Porteous to follow up the idea himself'.* [82]

The initial proposal made by IP was for the GRU Stabiliser (as part of a projected fully automatic fire control system), and this will be returned to in more detail later in this account. As an interim solution for deflection calculation, he concocted a design for a deflection

[80] RCAI cross-examination 27th July 1954.
[81] Gyro Rate Unit Box.
[82] RCAI Statement of Captain E.T. Larken OBE RN.

calculator partly using redundant equipment. It became known as the GRUDOU which was essentially a newly designed Deflection Oil Unit working with inputs from the existing HACS Gyro Rate Unit. It combined the GRU measurement data with the target's present range, using an oil servo, to generate a close range fully tachymetric solution – i.e. it would quickly and cheaply turn HACS into a tachymetric system – something that had eluded fire control designers (of whom many were still at ARL/AGE and DNO) for many years. GRUDOU and GRU Stabiliser would be developed in tandem, but owing to the urgency of the need to improve the accuracy of deflection calculation, GRUDOU would take priority.

Of all the ideas which crossed Larken's desk for improving HACS performance, IP's proposal was the only one which appealed to Larken as being simple and practical. He therefore lent his support and placed his confidence in IP, despite official opposition. (Kerrison and Landucci who had been involved with HACS design since its inception in 1931, were, unsurprisingly, strongly against IP's maverick ideas.) Without Larken's key support, IP's vision for the future totally automatic Flyplane Predictor System (FPS) would not have come to fruition. Nor, of more immediate significance, would have his cheap and cheerful improvements to HACS.

IP proposed the broad principles on which a fully integrated and automatic system of AA fire control might be built; it could be developed in three major stages:

(1) Design equipment to produce automatically and continuously the Vertical and Lateral deflections – **GRUDOU**
(2) Develop simultaneously a stabiliser to make the Line of Sight independent of ships movements – **GRU Stabiliser**
(3) Make simultaneous plans to design the fully integrated and automatic system – the **Flyplane Predictor System**

Following discussions with Larken, by mid 1942 they decided that their priorities should be as above namely (1) a deflection calculator for HACS (GRUDOU); (2) the GRU Stabiliser for HACS (and subsequently Flyplane); and (3) the Flyplane Predictor System.

IP commented that:

> *'Stated in these simple terms and viewed in retrospect, this seemed the obvious course to adopt. Seen, however, as a complete revolution from established officially sponsored practice and in face of the development projects then going forward (e.g. the close, medium and long range systems known as CRS.1, MRS.1 and LRS.1) the problem of putting the ideas into practice seemed almost insuperable'.*

Larken wrote:

> *'There was no reason to suppose that his* [IP's] *training or experience would result in his producing his own ideas for the improvement of the existing equipment – far less that he should design new equipment. Indeed the organisation provided no opening for officers of his branch in the design field. Furthermore he was an extremely junior officer. Such naval officers in the department who had responsibilities either for designing or for supervising the design of gunnery equipment were from two to four grades senior to him'.*

It is axiomatic that a mature organisation seldom takes kindly to a new broom sweeping clean, and DNO/ARL-AGE was no exception. As previously mentioned, IP was unimpressed by the credentials of the senior technical staff in DNO and AGE involved in fire control policy development and design who were essentially the people who had designed HACS and FKC; they in their turn were inevitably unimpressed by a very junior upstart with no design experience, who had been appointed to DNO for something quite different, who nevertheless had fresh and unorthodox ideas on how to improve their designs, and was not at all encumbered by their relative eminence.

IP had no business to be designing equipment, and as with many a new idea thrust upon an old orthodoxy, they fell on barren ground. IP's developments *'were quite outside the ordinary current of development and he was quite outside the people who were normally engaged in that work*' said Larken, who discussed IP's ideas with the technical experts *'My impression'* Larken said *'was that his ideas were thought to be unsound and perhaps a little revolutionary; but, at any rate, they did not appeal to the people working there already as a solution of the problem'*.

IP was not the sort of person to be discouraged by such an obstacle. Since there was to be no official support for GRUDOU and the GRU Stabiliser, Larken, ever supportive, told IP that *'he had better go ahead and do it* [himself].'

And so he did.

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CHAPTER 6

IP's TEAM

IP had soon identified three very junior members of related agencies who he thought could help turn his ideas into hardware: E.H. Axbey (DNO), H.G. Nelson (Director of Electrical Engineering (DEE)) and P.R. Fairbairn (Admiralty Engineering Laboratory (AEL)). They, under the leadership of IP became the other members of the unofficial four-strong team that was to develop the GRU Stabiliser and the Flyplane system.

Edward H Axbey

Not long after he arrived at DNO in 1942, IP met another junior member of the technical gunnery staff, a civilian mechanical engineer called Edward Axbey

Axbey had joined DNO the previous year after being told that his services were urgently required by the Admiralty. He took up his duty in the rank of Temporary Experimental Officer at the Spa Hotel, Bath and was employed in a subordinate capacity in one of the design teams concerned with the problems of close-range fire control.

After leaving school, Axbey had taken a three year course in Engineering in the Northern Polytechnic Institution, North London and graduated with a B.Sc. Engineering. He then worked for Messrs G.H. Worssam & Sons Ltd for 15 years designing and perfecting automatic machines, brewery installations etc and becoming their chief designer. He was then successively Chief Engineer and Works Manager of the British Miller Hydro Co Ltd, and the chief designer at H Pontifex & Sons Ltd.[83] These jobs all involved the design and construction of a wide range of automated mechanical machinery including items as large as complete brewery installations. He was an experienced mechanical engineer and draughtsman with a flair for design work and this expertise suited IP's nascent needs admirably.

Humphrey G Nelson

Nelson was an electrical engineer in the Department of Electrical Engineering. He was DEE's liaison officer with DNO and he became acquainted with IP and Axbey during his frequent visits to DNO.

After leaving school, Nelson graduated from Liverpool University with an engineering degree (B.Eng) in 1930. He then worked for four years at Metropolitan Vickers Electrical Co. Ltd followed by three years at the North Wales Power Co. Ltd as Assistant Mains Engineer.

He joined the Admiralty's Director of Electrical Engineering Department (DEE) in 1937, wryly noting ten years later that his previous experience had little bearing on the Flyplane work *'except insofaras I was wholly unfitted for the type of work concerned'*. He underwent a year's training in naval electrical practice,[84] and during this, whilst at HMS *Vernon,* he noticed that although considerable efforts had been expended in fire control matters in order to produce very complicated calculating gear, little appeared to have been done towards producing a satisfactory Remote Power control system to replace the human element in the difficult task of controlling guns by the then used 'follow-the-pointer' system.

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[83] H Pontifex & Sons Ltd: a 200 year old machinery manufacturer which closed down in 2010.

[84] This consisted of four months being spent in each of HMS *Vernon* (then the naval electrical school, a seagoing ship, and a Royal Dockyard.

Having completed his training period he was transferred to Whitehall and appointed to the High Power Ship Fitting Section for small ships. He wrote that he cannot have been a very satisfactory member of this section as he spent most of his time trying to evolve an electrical system for the remote power control of gun mountings. Subsequently he was promoted Electrical Engineer in charge of the design section responsible for the Metadyne system, In early 1941 as a result of the success of the Metadyne system, Nelson was appointed to become a liaison officer between his department (DEE) and that of DNO. He paid three visits per week to DNO and gained a greater appreciation of the whole fire control field. At DNO's behest he started to develop an electrical 'scooter' control for Pom-Pom directors, Mark V Range Finder Directors and, later, Mk III and IV High Angle Control Directors together with developments on the Metadyne controlled Mk VI High Angle Director.

Soon after IP's arrival at DNO in 1942, Nelson met IP who discussed his idea for a gyro stabiliser and asked him if it could be made to work. This was the genesis of the GRU Stabiliser.

Peter R Fairbairn

After leaving school, Fairbairn was indentured for five years as a drawing office apprentice, during which time he also gained a City and Guilds Full Technological Certificate in Electrical Engineering. Following completion of this in 1936 he worked as a draughtsman in the design office of the Westminster Electric Supply Company. At the start of the war he was selected to join the Department of Electrical Engineering as an Experimental Assistant at the Admiralty Engineering Laboratory (AEL), West Drayton. Prior to this his experience had been largely confined to heavy power engineering and he was appointed to the Section dealing with switchgear, control gear and generating plant, where he carried out much work on high rupturing capacity circuit breakers, shock resistance of switchgear, generators and suchlike.

When the first experimental GRU Stabiliser was sent to West Drayton by Mr Nelson late in 1942, Fairbairn was in no way concerned with it. However, he became interested, in his spare time, with resolving the problems that were being experienced by IP and Nelson in developing a gyro follow-up system for the stabiliser, and his design for the very successful pick-up and follow-up system was the start of his liaison with the other team members.

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CHAPTER 7

GRUDOU

HACS Upgrade

As he knew nothing about fire control, Axbey's duties initially consisted of clerical work assisting Landucci's chief assistant, Mr Thomas Hosking[85] and helping with the installation of existing instruments in ships. Soon after joining he was attached to the team working on STAAG and designed an ammunition hoist for it. IP quickly discovered that Axbey was a highly experienced mechanical engineer and draughtsman with strong design and innovation skills who would be ideal to work with him in designing and developing the systems he had in mind.

There were regular informal meetings attended by Colonel Kerrison, Superintendent of ARL/AGE and others including IP. At one of the first meetings he attended, a proposal was made for a deflection calculator to improve HACS. (GRUB, which had been designed to turn HACS into a tachymetric system, had been unsuccessful and was no longer being fitted.)

As already mentioned, Landucci said that a deflection calculator could be produced in two years. IP thought this was far too long and said to Edward Axbey privately *'Mr Landucci will produce an apparatus which is too accurate for the purpose. Let us get cracking and get something rough and ready which will get to sea quickly and will do the job quickly.'* He explained to Axbey that his vision was to have a simple automatic system, controlled in the interim by not more than three operators and finally by one. First, though, they would work quickly on a deflection calculator for HACS. Axbey was very pleased to join IP in this work: *'I was glad of this addition to my official duties which, until this occurred had been really unimportant'* he wrote.

Axbey did all he could to gain knowledge in fire control in his spare time and succeeded to the point of being able to attend fire control trials in ships to check the performance of the Gyro Rate Unit (GRU) in conjunction with HACS and the Gyro Rate Unit Box (GRUB).

Attending ships' trials in many parts of the country, Axbey *'was appalled at the many operations which had to be performed'* by HACS before firing, and asked gunnery officers in several ships if they used it when in action. They said they used 'open-sights'. Axbey said

> *'I was to learn later that this was eye shooting using a cartwheel graticule for the aim off after judging the speed of the target. This astounded me so it can be imagined with what zeal I accepted Mr. Porteous's suggestion which can briefly be described as a simple automatic system'.*
>
> *'At this time'* Axbey wrote *'I was informed by my superior officer that I was too old for this type of work'*[86] *'This rebuff spurred me on to greater efforts and I was determined to take advantage of every opportunity which might occur to show my worth. It was now obvious to me that my status with the Admiralty was very low, and, until I resigned* [subsequently, in 1950] *the duties assigned to me by A.G.E., were of a comparatively insignificant nature'.*

[85] DNO – Senior Technical Officer.
[86] Axbey was 49; Clausen was 54; Kerrison was 46; Landucci was c.42; IP was 37.

'Less than a week after this incident – early 1942, Mr I. Porteous C.O.O. R.N., approached me intimating that as he and I were doing little to alleviate the dire need of the Navy would I join him and investigate, in my spare time, a new Fire Control system. I wholeheartedly agreed and there and then he divulged [what became] *the Flyplane system. He said we must first have a stabiliser to reduce the problem to dry land terms, also investigate an interim method which could be quickly fitted to H.M. ships to save, in the meantime, as many ships and lives as possible and I undertook to design suitable equipment'.*[87]

From that point on, by the middle of 1942 not long after IP had arrived at DNO, he and Axbey worked on the design for GRUDOU and also the GRU Stabiliser and subsequently the origins of the Flyplane system themselves, by 'moonlighting' entirely outside their normal duties. (This situation prevailed until December 1944 when Flyplane received official approval.) IP produced the ideas, and Axbey created the design drawings for the equipment – at home in a room laid aside for this work, using paper and material of his own, and largely at night-time, weekends and holidays. Axbey's official duties were less onerous than those of IP:

'As far as official duties were concerned, I had no official duties at A.G.E. Nobody took any notice. I could have done as I wished. I therefore chose to work for men who really knew their job and knew what the requirements were'

and

'….the making and despatch of prints from my drawings was the only assistance the Admiralty gave. This is not strictly true because the greatest assistance given me by A.G.E. was in that they completely ignored my existence as far as the work [on IP's projects] *was concerned except once or twice in endeavouring to persuade me to give it up'.*[88]

Axbey had only a little self-taught fire control expertise, but used his draughtsmanship and considerable engineering design experience to turn IP's ideas into detailed drawings and thence hardware. He felt confident that he could meet IP's needs and felt at last that he was making a contribution to the war effort with the skills that he had. He was very pleased to be working with someone whom he considered to be *'such a brilliant officer'*. Without Axbey's involvement at this crucial time it is unlikely that IP's Flyplane project would have reached fruition.

GRUDOU – 'Rough and Ready'

Numerous directors already in service were fitted with a Gyro Rate Unit (GRU) which could measure target rate, vertically or laterally. It was intended that this instrument would work with the unsuccessful GRUB unit. It so happened that GRUB had a subsidiary servo-unit which could be used, and many of these servo-units were readily available. IP had appreciated that the failures of the system arose, not from the inadequacy of the measuring apparatus or the mathematical approach but from over-complexity of the equipment producing unacceptable operational lags in application. To reduce these lags, elimination of human operator links was necessary together with a drastic pruning of mathematical complexities in order to allow the production in quick time of an elementary calculator with only one human link. IP, on his own initiative, proposed that the redundant servo-units could

[87] RCAI Claim C.454 GRUDOU; summary of the claimants' case Appendix 'B' – Statement by Edward Hunter Axbey.
[88] RCAI Hearing 27 July 1954 – E.H. Axbey cross examination evidence. and Claim C.454 Appendix 'B'.

readily be modified so that a function of range present could be set using, when it became available, radar data. This, with the rate feed-in from the GRU, would generate an output in terms of deflection based on measured data. It was a temporary measure, which was inexpensive and quick and easy to do, and produced a close range full tachymetric solution.

The GRUDOU consisted of two boxes each having dimensions of 17” x 11” x 13.5”. The vertical and lateral rate components were transmitted from the GRU by means of a magslip system to the GRUDOU. Vertical rate was received by one box and lateral rate by the other. IP invented this ingenious system of magslips, gearing and linkages powered by an oil pump servo. This enabled each deflection to be calculated by a combination of the respective rate input from the GRU and the time of flight which had been manually set. These deflections were then sent to the deflection torch in the HACS High Angle table, thus at last generating a tachymetric solution to the fire control problem. This speedily-produced concoction, with a design worthy of Rowland Emett,[89] was to result in a substantial improvement in HACS effectiveness.

GRUDOU – GRUB Comparison

The deflection errors inherent in the Deflection Oil Unit itself were negligible (in the order of 3 to 4 minutes of arc) for ranges up to 10,000 yards, the overall accuracy depending entirely upon the accuracy of the rate fed into it from the GRU. For a time of flight above 10 seconds these errors become unacceptably large, hence the Deflection Oil Unit was designed to cope with ranges up to 4,000 yards, the maximum range achievable with reasonable accuracy, given the accuracy of rates generated by the GRU.

The GRUB on the other hand, had been designed to adapt the data provided by the GRU to the solution of the long range H.A. control problem. It also gave the required accuracy up to 4,000 yards range after which it was entirely dependent on correct rate input. The equipment was considerably more complicated and physically about 20 times the size of GRUDOU. Whereas GRUDOU produced the answer continuously and automatically with a fraction of a second’s delay, GRUB, which required two or three operators, was slow to generate the equivalent data, resulting in much loss of time and accuracy.

GRUDOU Prototype and Trials

Axbey had made drawings from IP’s design ideas for GRUDOU by mid 1942. Larken gave approval for two prototype units to be manufactured and Axbey took the drawings himself to a small engineering company in Bath, the Horstman Gear Company.[90] (At about the same time a similar procedure applied to the manufacture of the prototypes of the GRU Stabiliser. Another company, the Coventry Gauge and Tool Company[91] also became involved in the manufacture of the early prototypes of possibly both GRUDOU and GRU Stabiliser; in particular they made the bases for the stabilisers that subsequently were to be fitted to the aircraft carriers.) Few questions were asked about paperwork during wartime for developments such as this: an ‘instruction to proceed’ was issued by the policy officer

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[89] Rowland Emett OBE (1906-1990), was an inventor of whimsical machines, not least his railway (The Far Tottering and Oyster Creek Branch Railway) at the Festival of Britain in 1951. When asked how he came up with his strange designs, Emett remarked, "It is a well known fact that all inventors get their first ideas on the back of an envelope. I take slight exception to this, I use the front so that I can incorporate the stamp and then the design is already half done”. (Wikipedia quoting ‘*How designers think: the design process demystified’* by Bryan Lawson).

[90] Founded 1854; wound up 1947 and became a private company manufacturing various specialised equipments.

[91] A manufacturer of precision tool equipment founded in 1913. Now Matrix Machine Tool (Coventry) Ltd.

concerned – Cdr Larken – and another DNO officer – Cdr Harper – dealt with the paperwork the following month.

The prototype GRUDOU was given a trial at Fraser Battery, Portsmouth[92] at the end of 1942 or early 1943. At this trial, four sleeves were shot down in six runs. As IP put it:

> *'Trials were made with GRUDOUs with the object, I should say, of shooting them down rather than the planes. At that trial, Col. Kerrison attended, and he said, as I said before, that it was just nonsense'.*
> and
> *'We proved to my satisfaction and Kerrison's disgust at Fraser battery firings that we could knock a sleeve down using C.A.[93] fuzes with practically every round. The excellent results we obtained at Fraser Battery were of course on dry land and therefore, perfectly stabilised. I had long been aware of the necessity of good stabilisation and had been pursuing that matter since August, 1942, with the Gru stabiliser of which the first had been made and tried at A.E.L'.*[94]

This had been achieved with no official encouragement (other than from Larken and his principal), and strong opposition to all of IP's ideas. In particular, Kerrison, was a real impediment to IP. When asked about this later at the Royal Commission hearing, IP replied *'The Admiralty Gunnery Establishment exists to advise the Director of Naval Ordnance. The Superintendent of the Gunnery Establishment always spoke against any further Flyplane development. He characterised GRUDOU as nonsense. Those were the actual words used to me. I considered that opposition'.*[95] The results however, were not 'nonsense': they were the highest consistent sleeve destruction figures so far attained by British equipment;[96] and that, most importantly, convinced the Americans to supply proximity fuzes for ships fitted with GRUDOU.

Following the success of these trials, it was decided to fit GRUDOU in all ships which had 'HACS with GRU' and this was achieved by the end of 1944. The later models of GRUDOU incorporated modifications. These included: successive improvement to range setting, and finally fitting an automatic range feed to the Unit; adding a Tangent Elevation Unit, a Dip Mechanism and an Azimuth Conversion Unit which obviated the use of the HACS Table thus making the transmission of Deflection to the guns entirely automatic; and fitting a constant pressure valve in place of the oil valve fitted in the original oil unit which was sluggish in operation.

Improvement Achieved

An indication of the improvement in performance of HACS following the fitting of GRUDOU (and the consequent availability of VT fuzes) can be seen by the figures calculated by H.W. Pout.[97] Prior to fitting GRUDOU/VT fuzed shells, for targets at 4,000 yards range,

[92] At Eastney.
[93] Continuously Adjustable: an anti aircraft time fuze set at the muzzle by D.C. voltage.
[94] IP letter to Commander (E) J.W. Evans, Admiralty, Bath. Estimated date c1949.
[95] RCAI hearing 27 July 1954.
[96] RCAI Claim C.454: GRUDOU - Summary of the claimants' case. Page 10.
[97] Marland – Warship 2017 article *HACS – Debacle or Just in Time?* pp.120–121 quoting Pout's analysis: Pout, H.W., *Weapon Control in the Royal Navy*, in Kingsley F.A. (Ed), *The Applications of Radar and Other Electronic Systems in the RN in World War Two*, p.45–146, Naval Radar Trust and Macmillan (London 1995).

HACS Mk 4 achieved only 1500 to 1400 shots per kill. With GRUDOU and VT fuzed shells this reduced to 70 shots per kill. This was a dramatic improvement.

The equipment was generally available for HM Ships in the various landing operations in the Mediterranean in 1943 and for the Normandy D-Day landings in 1944, and later in operations against the Japanese. The great reduction in comparative losses of HM Ships to air attacks in these operations as compared with losses in earlier operations (for example, the defence of Crete and Singapore), was mainly due to improvement in the AA gunnery of HM Ships brought about by the use of this equipment and the proximity fuze.[98]

By the end of 1953, 239 pairs of GRUDOU had been fitted at a cost of £400 per pair, a total cost of £95,000. For a comparatively small expenditure (a cost equivalent to three HACS), the initial fit of GRUDOU alone had made a marked improvement in effectiveness of 239 systems. At the RCAI hearing, Admiral Denny agreed, saying that there could not be any doubt that fire was more accurate when the GRUDOU system was in use than it had been hitherto.

Summary

In summary, GRUDOU was produced from scratch in a very short time at low cost by two very junior 'outsiders'. It was thought of in 1942 and it was being fitted in ships in 1943, whereas for 17 years the Admiralty had been troubled by the lack of a tachymetric system for AA fire control, producing many ideas but no hardware. It showed IP and, no doubt, Commander Larken, that it was possible to work round the ARL/AGE hegemony to the great benefit of the navy.

Whilst work on GRUDOU proceeded, IP's attention was also on the design and development of the GRU Stabiliser.

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[98] RCAI Counsel submission 27 July 1954.

CHAPTER 8

GRU STABILISER

Origins of the GRU Stabiliser

At the same time as GRUDOU was being developed to deal with deflection measurement, IP was also considering the means by which effective stabilisation could be introduced to HACS. He had originally envisaged the concept of the GRU Stabiliser as being the core of the Flyplane system design, but saw that it could first be developed as a stabiliser for HACS.

Stabilisation had long been a significant problem for designers of fire control systems. At the start of the war, under the aegis of Colonel Kerrison, the official policy was to try and incorporate plane stabilisation into the various systems under development. This was a stable plate concept whereby, effectively, a piece of dry land is replicated in the ship by mounting a land-type predictor on a base plate which is then stabilised. This system was in the design for the long range system - Tachymetric System 1 (TS1) - which was started in 1937 in response to concerns about HACS.[99] It was abandoned early in the war on grounds of expense and being unworkable.[100]

In 1942 HACS not only had a cumbersome method of calculating the future position of the target, but also had an equally cumbersome method of stabilising the Director – and thus indirectly stabilising the Line of Sight in the GRU on which all subsequent calculations in the system depended. This Director stabilisation was derived from two gyroscopes which measured the components of ship's motion along and across the Line of Sight. Further calculating mechanism was then used to work out and feed the necessary stabilising motions to the director. This combination did not allow accuracy of stabilisation of much better than +/- 30 minutes of arc at the sight line, and, in rough weather, much worse than that.

Stabilisation in Close Range Systems

Much of the design manpower at ARL/DNO in 1942 was being devoted to close range systems. Larken wrote:

> *'At this time three major lines of development were being pursued in the close Range control field and a very high proportion of the design talent available was being devoted to this field. It was a feature of all three projects (including the STAAG) that they made use in one respect or another of an additional axis. In the field for which I was responsible the Navy was committed to separate guns and directors with bi-axial mounting. The introduction of an extra axis appeared to be impracticable within the foreseeable future. Progress if any would in fact be made only within limits imposed by gear already existing or coming forward working in bi-axial terms'.*

STAAG made use of a third axis. This was possible as the final weight to be stabilised accurately was the sight line, represented by a prism in the gyro box and the Bofors gun barrel, weighing in total about half a ton. The stabilisation problem faced by IP was of a different order to that of STAAG.[101] IP set out to stabilise a director weighing about six tons, working on a bi-axial basis, that is, with a training base which moved with the ship, with elevation measured from that base, something which was much harder than the STAAG

[99] Marland – Warship 2017 article *HACS – Debacle or Just in Time?* p.114.
[100] RCAI Captain Larken evidence 27th July 1954.
[101] RCAI Captain Larken evidence 27th July 1954.

solution. Additionally, director and guns were both to be stabilised by a gyro remote from them.

Larken wrote:

> *'The STAAG development was, of course already in hand but Mr Porteous did not, as far as I am aware obtain any direct help from it; although similar, in that the line of sight was the basis of stabilisation, Mr. Porteous's idea had important points of differences which have no doubt been already made clear. It should perhaps be emphasised, however, that Mr. Porteous's development aimed at stabilising remotely a large mass using only two axes. This, although highly desirable, was more ambitious than the STAAG and I was myself very doubtful in the early stages whether it could in fact be achieved. But the potentialities of success were so great that I was in no doubt that the development was worthwhile pursuing – particularly as it would not take effort off the other urgent projects already in hand'.*

Principle of the GRU Stabiliser

IP outlined to Larken a scheme he had devised for a combined stabiliser and rate measurer which might be used in conjunction with a new, electrically powered, Mk 6 director that was then being developed.[102] Larken wrote:

> *'He* [IP] *proposed that use should be made of certain techniques which were then novel. The idea seemed to me promising and I consulted Mr Clausen who agreed that it was worth following up.'* Larken *'doubted at first whether he would succeed. We arranged for him to have a working model made, which was subject to trial and so on; and it gradually became apparent that he was on an extremely good thing'.*

This was the start of the development of the GRU Stabiliser. The aim of the design was to provide a stabiliser to work with GRUDOU and thus improve its performance in rough weather, without holding up the provision of GRUDOU for immediate use without a stabiliser.

Mindful of the lessons he learnt from Sir Percy Scott and *Revenge* 16 years earlier and developing Sir James Henderson's ideas dating from 1921, IP conceived the idea of stabilising the Line of Sight for AA gunnery and automating the whole process. He set out to do this by designing the Gyro Rate Unit Stabiliser. His neat and ingenious solution turned Henderson's gyroscope theory into hardware which both stabilised the system and used the same gyro for target rate measuring and thus deflection calculation. This key development provided for the first time a means by which all ships' movements could be translated instantly into equal and opposite movements of the parts (i.e. guns, director etc) of the whole gunnery system it was essential to stabilize. (See Annex F for details.)

Expediency dictated the line of development of the GRU Stabiliser. A Mk 2 Gyro Rate Unit mounted on a Mk 3 Pedestal Base was taken by Axbey and modified in such a way that the new GRU Stabiliser could be incorporated in existing equipment to obviate the extensive manufacturing problems which would have resulted from any such basic redesign – which was a most important factor at that stage of the war.

[102] The GRU Stabiliser first was fitted into one of the aircraft carriers (HMS *Implacable)* probably with Mk 5 directors, however all the subsequent FPS systems ran on the newer Mk 6. Some of the earlier components that were trialled might have been with Mk 4 or 5 directors. (Information supplied to the author by P. Marland).

GRU Development

As with GRUDOU there was no support for the GRU Stabiliser from the ARL/DNO technical staff. Larken was kept informed of the proposals and work was able to proceed for nearly the next two years on an unofficial basis working outside normal duties. IP and Axbey foresaw that electrical and electronic expertise would be required in addition to their own ordnance and mechanical expertise respectively, and IP enlisted the unofficial help of H.G. Nelson (Electrical Engineer, DEE) for the electrical work, and P.R. Fairbairn (Experimental Assistant, AEL) for the electronic equipment. IP had first mentioned his ideas to them when he met them in mid 1942.

To start with, a GRU Mk 2 was taken for modification and the mechanical changes to this first elementary model were undertaken by IP, Axbey and Nelson. These were completed by the end of 1942 and this first experimental GRU Stabiliser was sent to AEL, West Drayton, where trials were carried out unofficially early in 1943. Considerable difficulties were experienced with the gyro follow-up system, and Fairbairn first became involved in the project joining the others in IP's ad hoc development team. Being interested, he gave much thought to the problem, and after some private experimental work, again all in his own spare time, he produced a form of magnetic pick-up and follow-up system. This was very successful and was adopted in all future models of the GRU Stabiliser.

The results of the trial at AEL were so promising that, after a demonstration given to Commander Larken, a decision was made to attempt to stabilise a Mark 5 'M' Director at the works of Vickers Armstrong Ltd, Crayford. Unfortunately the stabiliser was damaged in transit and the trial proved abortive. In December 1943 a second demonstration with a Mk 5 'M' Director was given at Eastney Gunnery (Fraser) Range, Portsmouth. An Admiralty Progress Report on the trial stated *'While the stabilisation was reasonably satisfactory, the control side had not been fully developed and this demonstration was not, therefore, very convincing to the general public'*.[103] A further demonstration of the development model took place at AEL on 21 March 1944 as a result of which official recognition was finally given to the GRU Stabiliser project and Porteous, Axbey, Nelson, and Fairbairn were assigned to the job of designing this equipment for production as part of their service duties. (This work also incorporated the Flyplane project.) It had taken nearly two years of great perserverence and private endeavour to gain official acceptance of the equipment, such was the official opposition to it.

Wartime Use of GRU Stabiliser

An order was placed on 12 April 1944 with the Sperry Gyroscope Co. Ltd. for the design and manufacture of two prototypes. One of these was to be fitted in HMS *Implacable*, a new aircraft carrier, if this could be done before completion of the ship. The first prototype was built during the summer, and on 25 August officers from DNO saw it before final assembly at Sperry's and delivery to AEL three days later. On 12 September a demonstration of the stabiliser was given in conjunction with a Mark III 'W' Rangefinder/Director modified for power control. The following day the stabiliser left by road for Greenock, arriving on 14th, and was fitted in *Implacable* by 24 September with Fairbairn being personally responsible for the installation. He subsequently took a ten day operational cruise to assess the equipment and assist the ship's gunnery team in learning to use the system. The complete GRUDOU and GRU Stabiliser system:

[103] December 1943 extract quoted in RCAI Claim No. C455 – Statement of the Claimants' case.

> ‘*provided tachymetric deflections and ballistic data automatically added to the transmissions from a fully stabilized director, automatically power controlled, and fed to the guns which were also stabilized and automatically power controlled. The advantages of speed and automacity were held far to outweigh such minor approximations as were made in the interests of simplicity’.*[104]

Subsequently Admiral Vian[105] reported favourably on the performance of the equipment in *Implacable* against Japanese air attacks. In a signal in June 1945 to Admiral Fraser, CinC British Pacific Fleet, he said: *‘I recommend that* Illustrious *be fitted with this gear and that requisite gear be sent to Sydney for fitting in other carriers during the refits. If approved, suggest Mr. Fairbairn, of Admiralty Electrical Laboratory be sent as technical adviser for installation and trials’.*[106]

Meanwhile, DNO proposed, despite little support from elsewhere, that GRU Stabilisers should be fitted to the 1943 *Weapon* class destroyers then building. (Seven sets were subsequently fitted.) However, after the encouraging reports from *Implacable* together with other factors,[107] it was decided to go ahead, and 25 sets were ordered.

The total number of sets of the ‘GRUDOU plus GRU Stabiliser’ ordered by January 1953 was 124 at a cost of £310,000, and the Admiralty assessed the anticipated future use of the system after January 1953 to be ‘large’.

Summary of GRU Stabiliser Achievement

The key point to make with GRU Stabiliser and its use in Flyplane is that it was based on an entirely new idea with regard to sighting. The prevailing policy at the time for what was known as plane stabilisation, i.e. reproducing on the ship a piece of dry land by means of gyroscopes. IP thought this approach was wrong; it was extremely difficult to do and nobody had succeeded in doing it. He had the idea that by using the flyplane and the line of sight, the same result could be achieved much more simply and more quickly, and the hardware could be put into production much more easily. Nevertheless, there was considerable official discouragement over a long period, and it was not until IP and his team were able to demonstrate that the prototype hardware really worked that they were able to make any headway at all with the official technical staff. It took nearly two years before GRU Stabiliser development was officially sanctioned. It says much for the persistence and determination of IP and his team that they pursued and developed these ideas in their own time, in addition to their normal jobs, despite great discouragement, and it demonstrates the outstanding leadership qualities of this most junior of officers.

With the GRU Stabiliser settled and the first automatic fire control system entering service (as an enhancement of HACS), IP and his team moved their attention to Flyplane. Many more months were to pass before Flyplane gained official sanction.

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[104] RCAI Claim No. C.456 Schedule II p.27.
[105] Rear Admiral Sir PhilipVian, Flag Officer Commanding 1st Aircraft Carrier Squadron, British Pacific Fleet, and Second in Command, British Pacific Fleet.
[106] Quoted in RCAI Claim No. C456 – signal dated 6.6.45.
[107] In particular, the urgent need was to cut out some of the alternative deflection arrangements proposed for the 1943 Weapon class ships and to simplify the layout of their Transmitting Stations. (1944 Flyplane progress report – quoted by Cdr M.J. Ross (IP personal papers).

CHAPTER 9

FLYPLANE PREDICTOR SYSTEM

Origin and Concept of the Flyplane System

Throughout WW2 it was painfully apparent that the anti-aircraft equipment of the Fleet was woefully inadequate. At the start of the war, the Fleet was equipped with gear (particularly HACS) that was theoretically accurate, and provided the ship was stationery and in harbour (i.e. no roll, pitch or yaw), it would produce reasonably accurate results when certain key information was fed into the system. Unfortunately, some of this information depended on the judgment of human operators who 'estimated' such important information as 'Target Speed' and 'Angle of Presentation' and it was very difficult to judge accurately this vital information in the heat of battle. Given these circumstances and a ship which was moving, even in a moderate sea, it was not surprising that the hitting rate at targets was disastrously poor: stabilisation of the sights and gun was never better than 0.5º, and operators simply could not track the target with sufficient accuracy to enable accurate prediction.

IP started thinking about how to tackle the AA fire control problem in the 1930s. He had seen how successive modifications to the HACS system to improve accuracy seemed to reduce, not increase, the effectiveness of the system. In part, this was due to the increasing time taken to produce a firing solution. Modifications resulted in an increasing number of operators to perform the various functions, and each additional operator caused added time lag with a consequent stale firing solution.

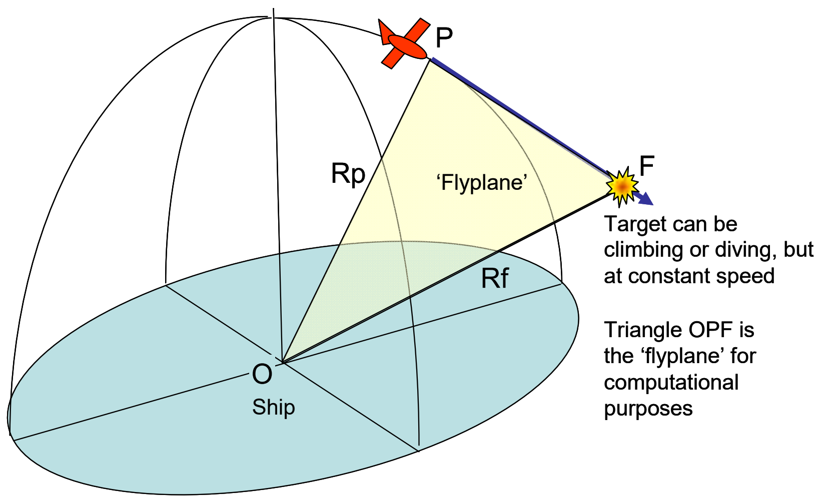


Diagram defining the 'Flyplane'
(Source: P Marland)

It became evident to IP that a radically different approach was needed to achieve any sort of success against aircraft targets and that the first necessity was a means of stabilizing both sights and guns against ship's movements. As previously mentioned, it had become apparent to IP that the system in use by the Fleet for surface gunnery gave very good results, and that applying a similar principle to aircraft targets seemed to be a logical line of approach. The basic problem was to reduce the aircraft target from a three dimensional one (which was the basis of the system then in use) to one of two dimensions. He chose a Flyplane solution based on Hamilton's Quaternions as the theoretical basis for the various computations. As was his modus operandi, IP found a mathematician to help him, Professor Basil Brown of the Royal Naval College, Greenwich, with whom he corresponded over a number of years concerning solutions to the complex spherical trigonometry involved in the design of the gyros and the Flyplane prediction and regeneration units.[108]

By the end of 1943 the appearance of new electrical components led to a decision to do all the computing by electrical means and this made it possible for the initial designs and the preliminary experimental work carried out by IP and his team to be developed more easily. From then until the end of 1944 the preliminary work was carried to a much more advanced stage by IP and his team working on the problem very largely in their spare time.

'*The Flyplane predictor was not a brilliant inspiration'* IP said, it was *'the result of many years' matured experience in separating the worthwhile from the mass of equipment used in the Fleet over the past 40 years'*. He envisaged a fully automatic fire control system, but before his arrival at DNO there was no prospect at all of a mere Warrant Ordnance Officer's ideas being turned into hardware. A decision had been made before the war to stick with HACS, rather than continue with developing a main contender to replace it (MRS1/TS1) which had been discontinued. The GRU Stabiliser was not only to be used to improve GRUDOU and HACS but a derivative of it, the GRU Stabiliser Mk 2, was also the heart of IP's envisaged Flyplane system. At the same time IP was taking forward the design work for Flyplane with his team of Axbey, Nelson and Fairbairn.

Early in 1944 Commander Larken left DNO and was relieved as AA Policy Commander by Commander M.J. Ross DSC RN. Larken had done a great deal to change the course of AA fire control development. His support for IP in the face of considerable opposition from the 'establishment' gunnery technical staff had been vital, as was the ongoing policy support from Commander Ross and Captain Le Mesurier. It enabled HACS to become considerably improved during the war by GRUDOU and GRUDOU with GRU Stabiliser, and this in turn persuaded the Americans to supply the RN with their new proximity fuzes which were very expensive and in short supply. It also led to Flyplane to becoming the first automatic system to be fitted in the fleet after the war. Without Larken's confidence and trust in IP and his team none of this would have been possible. In his turn, Commander Ross gave IP and his team strong support, and believed that *'the inventor of the* [Flyplane] *system has a real message for the Navy in his ideas on fire control…'.*[109]

Captain E.K. Le Mesurier joined DNO in September 1944 as the Deputy Director Naval Ordnance (F) with responsibility for Fire Control. He had previously been the Squadron Gunnery Officer, 2nd Cruiser Squadron in HMS *Southampton* in 1937 when IP was the Squadron Ordnance Officer. He had spent the two years before joining DNO in the USA dealing with liaison on gunnery equipment between the USA and UK. The decisions to fit GRUDOU and GRU Stabiliser had been taken, and he was aware that IP and his team were working on the Flyplane system. It had reached quite an advanced state of design on paper, but was not an officially sponsored project.

At this time there was no other system in prospect (other than the American Mk37 system) either as a replacement for existing equipment or for future builds. Had the Flyplane system

[108] IP personal papers, which contain Professor Brown's letters to IP.
[109] IP personal papers: M.J. Ross memorandum 14 May 1946.

not been approved it is not clear what would have been available before the late 1950s, as AGE did not produce any workable system designs. Flyplane's successor was to be an English copy of another American system (the US Mk 56) which incidentally used almost identical principles for stabilising and tracking as those of the Flyplane system.

Flyplane System – Official Approval Obtained

During the autumn of 1944, various schemes were under consideration for (a) obtaining gun (as well as director) stabilisation, (b) obtaining a measure of the 'rotation of the sight line', and (c) increasing the scope of prediction. IP drew sketch designs of how (a) and (b) could be achieved, Axbey prepared detailed drawing for a development model of a second gyro system (the GRU Stabiliser Mk 2), and Messrs Horstmann (at Bath) started manufacture of this early in 1945.

IP had been working on item (c) which was the product of his overall vision: to develop a medium/long range fire control system based on line of sight stabilisation and flyplane prediction. Le Mesurier was convinced that IP's team was probably right in using line of sight stabilisation which had proved successful in the GRU Stabiliser: the mechanical calculating mechanism was simpler and he had seen the Americans taking the same approach. However, the Superintendent of AGE, Colonel Kerrison, (acronym SAGE - perhaps an unfortunate oxymoron in this context) was an advocate of the stable plane/plate method of stabilisation, and the whole of the AGE experts had been working on that for a number of years.[110] They were convinced that theirs was the right way to tackle stabilization and that IP's method would not work. (Incidentally, Larken thought it would have been '*a disaster*' had development of the stable plane method continued.)[111]

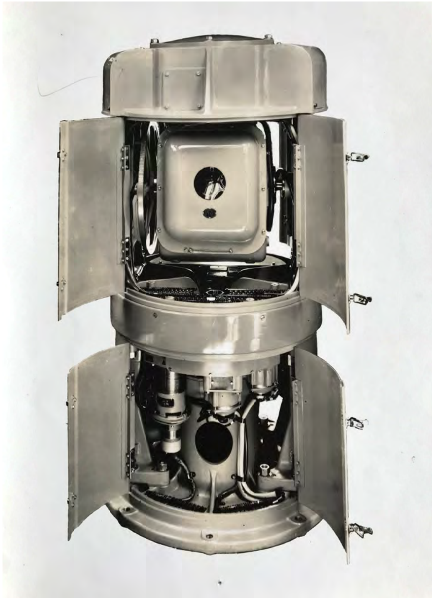
Monthly meetings were held between DNO and AGE to review present and future policy and determine what should be done. At one such meeting at the end of 1944, Le Mesurier, who had considerable confidence in IP's team, decided, despite continuing opposition from official advisers, that Flyplane should be made an officially sponsored project. *'They looked like a good set of dark horses; they had won one or two races already and I was prepared to put my money on them to win another one.'* he said.[112] After preliminary discussions with DEE, the Flyplane Predictor System was officially launched at a meeting held at the Admiralty, London on 20 December 1944, and official sanction was given to make and erect at AEL, West Drayton, an experimental model for trials. This was the point at which it became possible, finally, to produce a staff requirement for the system.

Although official approval had been obtained, the whole of the development work remained solely in the hands of IP and his team for at least another 18 months as there was little help available, notwithstanding the very pressing need in the Fleet. The total number of people working on the system was variable but didn't exceed about a dozen. Meanwhile, the Admiralty Gunnery Establishment, official technical advisors to the Director of Naval Ordnance *'were continuously and absolutely opposed to the Flyplane System and steadfastly refused to have anything to do with it'.*[113]

There also seems to have been a measure of unease in some quarters about the unorthodox methods of the 'bottom up' user-led design and development team for the Flyplane system.

[110] RCAI – Day 6 p.26 Captain Le Mesurier evidence.
[111] RCAI – Day 6 p.13 Captain Larken evidence.
[112] RCAI – Day 6 p.27 Captain Le Mesurier evidence.
[113] RCAI – Summary of Claimants' Case - C.455 p.4.

The authority, probably Director of Gunnery Division (DGD), drafted an appraisal of the design, apparently uncomfortable with a user (i.e. IP) hijacking the normal peacetime design process, which starts with a formal Staff Requirement. With Flyplane the process was ending with a staff requirement, and the speed of development was such that normal procedures were left lagging. Eighteen months previously there had been no 'Staff Requirement' for it and DNO's technical advisers even then were strongly opposed to it. Coupled with this, IP's team was very small, it had done a great deal of work, and had had little time to issue documentation, (which, understandably, was the least of their concerns). DGD (probably) had thus asked DNO to supply him with expected performance figures for Flyplane and stated that he wished to issue a formal Staff Requirement. For the time being performance comparisons could only be made with the draft Staff Requirements for LRS 1 dated October 1944)[114].



GRU Stabiliser Mk 2

Main Components of the Flyplane Predictor System

Work proceeded throughout 1945. A major element of the system – the GRU Stabiliser - had been proved at sea, and effort was now concentrated on the other parts of the system. The main components of the system, as for the construction method, were novel and the conception and execution of the whole system was claimed to be considerably in advance of any so far designed or fitted in the British or any other Navy.[115]

The main parts of the system as described in 1945 were:

1. **Stable Element.** This is the GRU Stabiliser, which produced a bi-axial stabilisation accuracy under all reasonable ship motion of better than plus or minus 2 minutes of arc. It was also used as a target rate generator producing accuracy better than plus or minus 3 minutes per second of rate.
2. **Regenerative Tracker.** This part of the equipment, together with the Angle Solver Part I (see below) and the Range Control Unit, produced a completely regenerative solution of the target tracking problem. This relieves the operators of the need for continuous tracking, and also feeds the Predictor with data for calculating deflection and fuze prediction.
3. **Angle Solver Part I.** This produces the hitherto difficult-to-obtain quantity of rate of change of Angle of Presentation. (For various reasons it was not used in the final version of the system.)
4. **The Predictor.** This receives data from Tracker and Angle Solver Part I. and converts it, in conjunction with Angle Solver Part II, to Gun Training, Gun Elevation, and Fuze Numbers (including Dead Time).

[114] IP personal papers: Undated draft paper *Flyplane Predictor System: An outline of the considerations underlying the design*. Date most probably 1945.
[115] Paper summarising submission written in Sept 1946 written by IP's team of four.

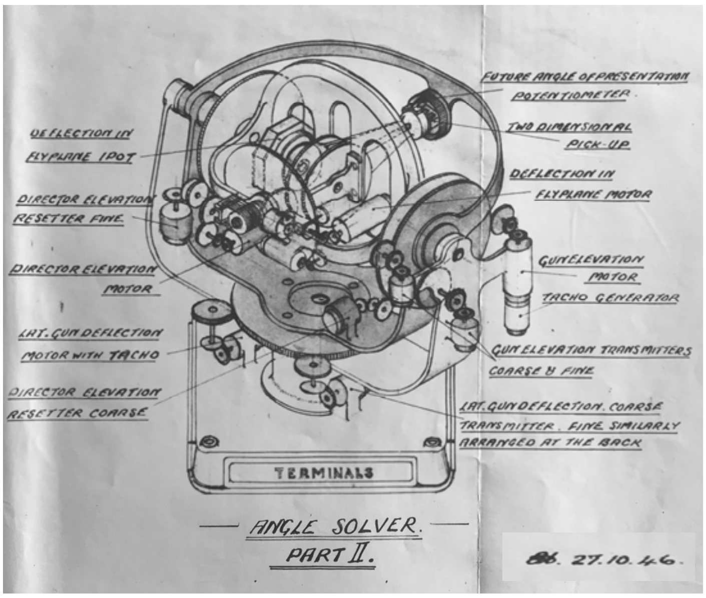
5. **Angle Solver Part II.** This item, in conjunction with the Predictor and G.R.U. Stabiliser, converts gun deflection in Flyplane terms plus ballistic corrections to Gun Training and Gun Elevation in Deck Plane terms.
6. **General.** The system has been designed to operate with existing Mark VI HA/LA Directors and Type 275 Radar and any bi-axial gun mounting.

This all-electric system could very easily be adapted for use with any calibre of gun and different types of fuze. Easy adjustment was also provided for a change of 'dead time',[116] with the gun being fired automatically upon its expiration.

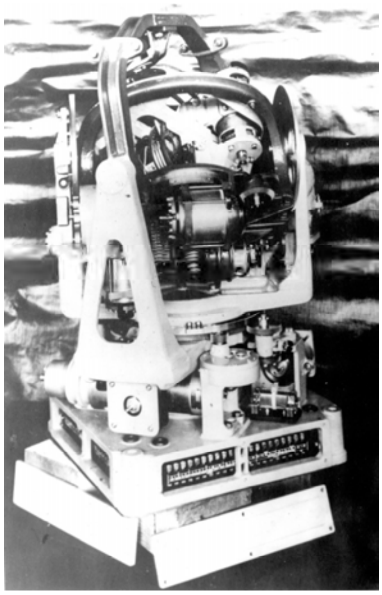
The Angle Solver Part II deserves particular mention. Described by Mr Clausen as *'a distinctly novel piece of spherical geometry in hardware'* it was conceived by IP and drawn by Axbey (as with IP's other inventions), and it went straight from the drawing board to production of the first prototype (illustrated below[117]). Clausen wrote:

> *'It was the first completed model of the first prototype, and in spite of the fact that interference of the various parts in their compound angular movements is difficult to examine properly without a model, no model had ever been made, and this particular mechanism came straight off the drawing board. It is a very fine piece of work – one of the best pieces of design of this type that I have seen in a very long time'.*

From Clausen, this was praise indeed of Axbey's (and IP's) professional excellence.



Angle Solver Part 1I Initial Drawing



Angle Solver Part II Prototype

By mid 1945 IP had been doing a great deal of work on converting the theory of the Flyplane system into hardware. This is well summarised in a letter dated 18th May 1945 to Tom Larken,[118] (then serving as Fleet Gunnery Officer on the staff of CinC British Pacific Fleet), summarising the progress to date.

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[116] 'Dead time' is the time lapse between the point the shell left the fuze setting machine and the point it was fired from the gun.

[117] The initials and date on this illustration have been moved from lower down the sheet on the original copy.

[118] The demi-official letter in IP's papers is typed on embossed paper and is ready for signature, but it is not clear whether this is a copy, or that the original was not sent. Nevertheless, it provides a clear account of IP's thinking at this time.

Here are a few extracts:

> *'We have settled down now, that is a team largely* [of] *volunteers or people who have drifted into the orbit by inclination, consisting of the originals Nelson, Fairbairn and Axbey, and newcomers, Higgins and Heward….'*
>
> *'I have had some long and arduous sessions with Clausen but have managed to drag him over all the obstacles and hurdles eventually'.*

A particular difficulty concerned the apparent slow twisting of the 'flyplane' as originally defined. The complex mathematics required to overcome this would have cost about £5,000 in machinery. IP found a much simpler solution: he changed the definition of the 'flyplane', which considerably simplified the problem and also rendered the low angle problem as being the same as the high angle one. (IP considered that mathematics was *'a representation of reality not a clue to it'*.) He continued:

> *'Turning this lot into a functional diagram has been a slow but steady process, I of course thinking in terms of mechanisms largely and putting the gunnery conception over to Nelson by analogy. We have between us thrashed out a flyplane predictor which, starting with the G.R.U. stabiliser as the generator of the present position line, is controlled by a thing called the Tracker which is built up on a Meccano basis using standard components, only 4, split field motor, potentiometer, magslip resolver and another part. These allow us to do multiplication, division and quite a lot of trigonometry if geared together by a simple chain. We have got a firm making these units to fit the standard framework, much on the lines of a filing cabinet, in which each little servo which may be doing multiplication etc. has alongside it its little amplifier, the pair of them not being much larger than a couple of your shoe boxes'.*

IP's strength lay in his ability to reduce complex mathematical issues to simple solutions, and in persuading Clausen and others to see the light. He did this with many of the key components of the Flyplane system, including the G.R.U. Stabiliser as well as with his earlier inventions. He was not beyond teasing his seniors:

> *'We have developed the stabiliser to the point where we think we can get both H.A. and L.A. solutions out of it, using one gyro for the gun and one gyro for the director sight line. (I might mention in parentheses here that a proposal has emanated from A.G.E. recently to solve the director sight line problems using a pick-a-back turned through 90º and needing no 3/2 axis convertors. If you look at it carefully you will see it is a very ingenious method of making two gyros do the work of one. I remarked this to Mr. C.*[119] *He looked at me over his glasses, not being quite sure whether I was tugging his leg or not)'.*

IP also makes a passing reference to the eventual successor to Flyplane:

> *'The Americans are pushing on well with the Mark 56 I believe, which you remember as their version of what we are doing but they have managed to make it considerably more complicated than we have. We are using 120 slip rings and they are using about 250 I think'.*

[119] Reference to 'Mr C'assumed to be to Mr Clausen, DNO Chief Technical Officer.

The British MRS 3 system which superseded Flyplane in later years was an anglicised version of the US Mark 56.

By autumn 1945 trials were proceeding at the DEE Laboratories, West Drayton, of experimental models of elements of the system including the GRU Stabiliser Mk 2 and its photo-electric leveller and the regenerative tracking system.

Drayton Hall

The Prototype takes Shape

By early March 1946 a contract had been placed with Ferranti for the building of two prototypes by the end of the year, despite Superintendent AGE considering that all work on Flyplane should stop. A team of six were working with Nelson in his office at DEE, West Drayton, drawing plans so fast that IP's team had trouble keeping up with them in refining the design detail of some items.

Meanwhile the first trial GRU Stabilisers had been tested and linked to a director with excellent results – much better than IP had dare hope. He saw the experimental Tracker regenerate for the first time, and he was *'very pleased indeed'* with the predictor performance which *'worked at a frantic speed'.*[120] Of his team, IP wrote:

> *'Our small team of four had each his own corner to hold in this business. I handled the problem as a whole and made the decisions on approach to the problem, solutions to the problem and general design of mechanical elements – Angle Solver I, Angle Solver II and the additional upper gyro system of the G.R.U.D.O.U. Mark II. Axbey helped me with Angle Solver I and Angle Solver II in the production drawing stage. I dealt with Sperrys direct and made the original motor drawings for* [the] *upper gyro system myself before collaborating with Sperrys. Nelson prepared the supporting diagrams with me. I laid them out in mechanism fire style and he converted them into electric fire control methods. Fairbairn did the experimental work that we required as we went along and general detailed supporting work, especially on the electronic side. We worked all the time as a team, each attending to his own business which I think is by far the best way, each accepting the views of the other in his own corner. The proof of the pudding of that method is, I think, in the eating.*
>
> *'As the work went along step by step being tried either ashore or at sea, the line of development has always been checked by reality and unless there was any change in improvement, it was not considered worth bothering about. I have always had strong views on the difference between change and progress having seen the increasing complexity of our equipment so often producing no improvement only expense and difficulty in maintenance.*[121] *That is the general story of the development'.*[122]

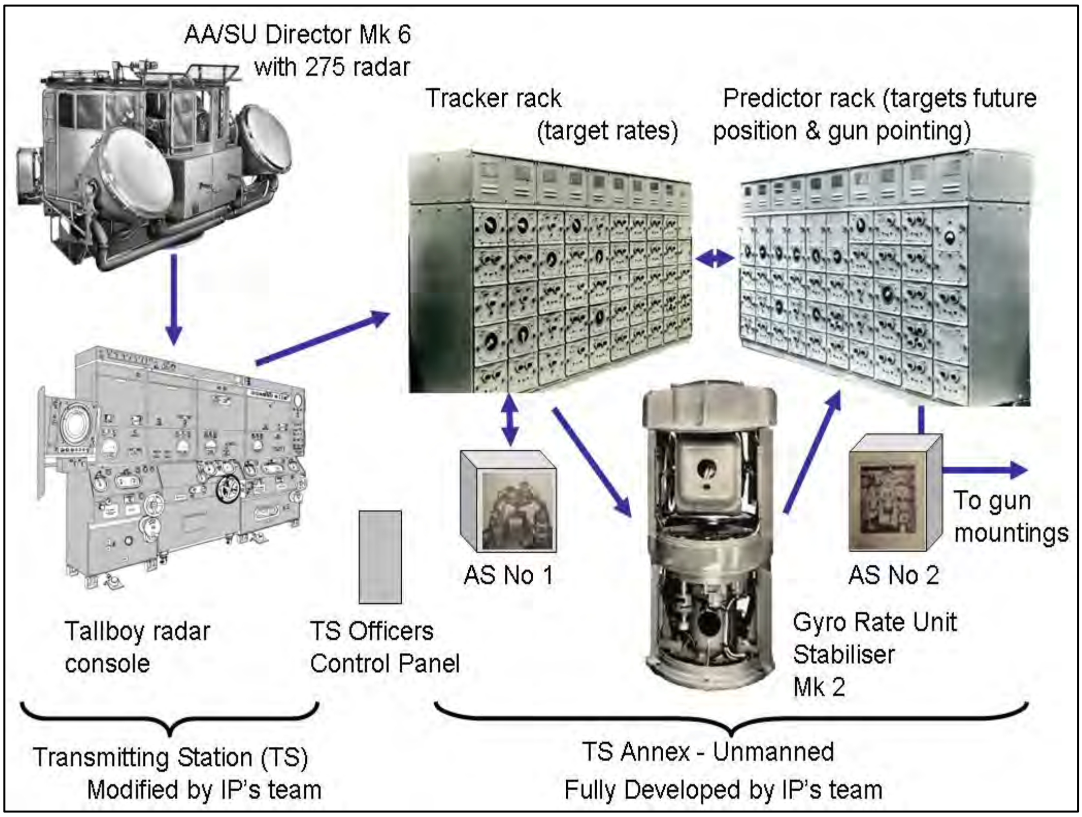
[120] IP personal papers: IP letter to Mr A. Britton 8 March 1946.
[121] This is a reference particularly to HACS. IP was to retain his views on change and progress (in many contexts) to the end of his life.
[122] IP personal papers: IP letter to Commander (E) J.W. Adams RN, Admiralty, Bath; written in latter half of 1949.

IP (in uniform) making a point, on a visit to The Sperry Gyroscope Co. Ltd in 1948

By September 1946, the system in its final form was recognisable. It was described as a complete all-electric High Angle Gunnery Fire Control system which will cater for target speeds of up to 400 yds/sec (720 knots) assuming the target flies straight and at constant speed. It was designed to have a maximum range of 15,000 yards and a maximum effective range of 10,000 yards. It would require only three operators – which was a quantum leap from the crew of 14 to about 19 required for HACS.

In early 1948 IP visited the Sperry Gyroscope Co. Ltd. to see a demonstration of the first prototype of the GRU Stabiliser Mk 2. In the accompanying photograph a GRU Stabiliser Mk 2 can be seen in the background.

The method of construction adopted for the Flyplane, consisting of a built-up unit system, enabled a substantial reduction in design time from the years usually taken for this class of



Schematic Diagram of Flyplane System
(With acknowledgements to Peter Marland)

work, to months. This was largely due to the reduction of the number of different details to about one tenth of that normally associated with a Fire Control system of this nature.[123] The manpower production cost was therefore reduced to a minimum as was the maintenance load,

[123] IP personal papers: Interim submission for award – Flyplane Electric Predictor System.

as defective units could be quickly replaced. This is all 21st century standard practice, but in post-war Britain it was highly innovative.

Captain D.M. Lees, the Director of Naval Ordnance outlined the future plans for the Flyplane system in September 1946.[124] If the initial trials were successful, the system would be fitted in HMS *Broadsword* (prototype), and the *Daring* Class of Destroyers: it would also be used as the main replacement for HACS and FKC systems in existing ships of the Fleet when they were modernised.

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HMS *Cavalier*

The sole surviving example of a Flyplane Predictor System is in HMS *Cavalier*, a '*Ca*' Class destroyer which is preserved in Chatham dockyard. Although *Cavalier* was fitted with the later FPS Mk 5 Mod 1, the components and technology would be familiar and instantly recognizable to IP.[125]

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[124] IP personal papers: DNO (Captain D.M. Lees) memo dated 26 Sep 1946.
[125] Information supplied by Peter Marland.

CHAPTER 10

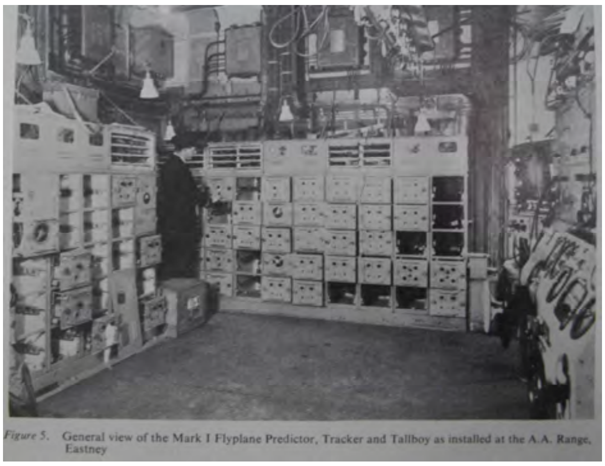
SEA TRIALS IN HMS *BROADSWORD*

HMS *Broadsword*

The second prototype, incorporating modifications made to the first, was fitted in HMS *Broadsword.* She was the second ship of the *Weapon* Class destroyers. Built by Yarrows, she was launched in 1946.

By June 1947, IP was re-appointed from DNO to HMS *Excellent* (presumably to join XP, the Experimental Department for work associated with Flyplane) for five months before joining *Broadsword,* building on the Clyde. His work on board was to oversee the installation of the Flyplane system and ready the ship for the gunnery part of the sea trials. The ship completed on 4 October 1948 and first proceeded to Portsmouth. The following month she was in Chatham for modifications which were completed by the end of the year. As it happened, the main part of the ships company were on leave on New Year's Eve, and no youngster being available to ring in the new year with the traditional 16 bells, they chose by far the oldest person on board – oldest by about 10 years – and that was IP. Perhaps that is the only time that a 45 year old has rung 16 bells in a commissioned ship.

Assessment and development trials of the Flyplane Predictor System continued in the early months of 1949, ashore using the rolling platform at Fraser Gunnery Range, Eastney, with Seafire and Meteor as target aircraft, and at sea in *Broadsword*.



Flyplane Predictor System Mk 1 Prototype at Fraser Gunnery Range

Early in January *Broadsword* commenced sea trials of the Flyplane Predictor System 1 (FPS1). On 17 January 1949, *Broadsword*, doing sea trials off Portland, fired its 4-inch gun using the Flyplane system - the first time a completely British automatic fire control system had worked at sea.[126] IP watched as the first shots were successfully fired, and turned to the Captain and said *'We are there'*. Seven years after IP had first conceived the idea, against strong opposition - from AGE in particular - and still with a single stripe on his arm, this was a notable achievement.

[126] IP personal papers: letter to his wife 18 January 1949.

Coincidentally, later that month there was a less satisfactory occasion when *Broadsword,* lying alongside Fountain Lake Jetty, Portsmouth, accidentally fired a 4-inch shell over Portsmouth. Fortunately it was a practice shell which fell into the sea off East Wittering, nine miles away.[127] It was not caused by the Flyplane system. IP was on leave at the time and, on hearing of the incident, he wrote to the Captain of the ship, Lieutenant Commander Jack Bitmead DSO, RN. Bitmead replied, saying there was nothing for IP to worry about: *'It was good of you to offer to accept the moral responsibility, but you will undoubtedly go to the slaughter enough times during the remainder of your life without me hastening it for you'.*[128]

Sea trials continued for the next few months. In early May 1949, days after promotion to Ordnance Lieutenant, IP returned home from the sea for the last time. He was reappointed to HMS *Excellent*[129] for a few days en route to taking up his final appointment, in the Naval Intelligence Division (NID). Thus IP was not on board *Broadsword* for the main firing trials. This seems to have arisen from a decision that the Flyplane system could be best assessed if the trials were conducted using the ship's regular staff rather than having IP to oversee them. If this were the case, it would seem an odd decision, given that these trials were of the prototype of a completely new generation of fire control equipment. In the event, there was some limited DEE expertise on board for the trials.

Broadsword went on to conduct two sets of sea trials. The first one was in Malta from 7 to 29 June 1949. Its objectives were to establish the effectiveness of fire controlled by FPS1, and to report on the reliability of the system. DD(G),[130] commenting on the trial report, considered the results achieved to be most encouraging. The trials were very much handicapped by lack of suitable targets, but the report stated that FPS was as accurate as the US Mk 37 (fitted in HMS *Delhi*) or more so, and that the fuze prediction of the system was consistently accurate. The system was reliable, said DD(G), but this new generation of equipment pointed the way to the future, demonstrating the need for a new type of highly trained maintenance rating. DD(G) ended his paper with a general comment:

> *'There is a tendency to decry F.P.S. in some quarters by comparing it with future systems. Quite apart from the fact that it may not in fact prove very much inferior to M.R.S.3 in performance in the long run and is 5 years ahead of it in time (as far as fitting in the British Fleet is concerned), I think it would be much better for the morale of naval gunnery to spread the doctrine that we have at last got an A.A. control system worthy of the name, that it is an all-British production, and that the cost of its development was a minute fraction of that of the U.S. Mark 56 system which we are now copying'.*

Perhaps the *'some quarters'* to which he referred included the Admiralty Gunnery Establishment and its Superintendent, who simply could not come to terms with the success of FPS, and could not abandon their residual antipathy towards the small team that had got on and done what A.G.E. should have done.

Broadsword's trials off Malta had been badly handicapped by lack of suitable targets, and approval was given for the ship to be attached to the US Navy Operational Development Force operating from Norfolk, Virginia for a further series of trials using N81 VT fuzes and their wireless-controlled drone targets. These trials took place from 7 June to 22 August 1950. They had several objectives including, primarily, to continue evaluation of the FPS1 when engaging AA targets in both visual and blind modes, and to make assessments of

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[127] IP personal papers: The Times report, 26 March 1949.
[128] Undated letter (prob April 1949) from Jack Bitmead to IP.
[129] Supernumary 23 May 1949.
[130] IP personal papers: DD(G) was the Deputy Director (Gunnery) of the Gunnery and Anti-Aircraft Warfare Division. Undated internal memorandum.

maintenance and availability of the system. Overall the trials were highly successful and this was made known to the world in what appears to have been a press release.

As the press put it…

Our guns stagger American chiefs

THE accuracy of radar-controlled guns aboard one of Britain's latest destroyers, demonstrated in trials that have just taken place in the Atlantic, has staggered American naval chiefs.

The guns succeeded in hitting high-speed targets that United States gunners had never been able to get near.

The destroyer concerned was H.M.S Broadsword, one of the Weapon class.

The Americans invited the Admiralty to send Broadsword to take part in their manœuvres after gunnery trials in the Mediterranean in which Broadsword shot down six Queen Bee radio-controlled target aircraft.

Aboard Broadsword when she crossed the Atlantic were backroom boys and scientists, anxious to find out how the ship's highly secret radio-controlled gun room would come out in a test stiffer than anything undertaken before.

The targets, built for testing America's latest anti-rocket weapons, are launched from ramps and reach a speed of over 1,000 m.p.h.

Broadsword tracked their images on her radar screens, and once they were in gun range, shot them down easily.

The Americans first thought it was luck. To prove that it wasn't, the British gunners at once shot down three or four more targets.

The People
23 October 1950

IP (who had left the ship before the trials) later recalled that high speed targets were required for the US trials. The Americans said they could provide one hundred of them at a cost of £1,000 each, to which the Treasury surprisingly agreed. The Americans thought that *Broadsword* would fire, miss the targets which would fruitlessly fall into the sea. It was otherwise. The ship fired two rounds at each target (with one extra in case of gun or ammunition failure). All one hundred targets were shot down with two or three shells per target which amazed the Americans who said UK could have the targets without charge. Thus it can be argued that *Broadsword's* shooting saved UK £100,000[131] in a fortnight.

Later Axbey told IP of a meeting in 1953 with Eric James *'an electrician in charge on HMS* Broadsword *while on gun trials in America'*. (James had joined Ferranti after leaving the Service.) James told Axbey that '*24 rocket targets were sent over the American guns – they missed every one – and then on over the* Broadsword's *guns and they accounted for 23 out of the 24. The one was out of range'.*[132]

Trial Results[133]

Malta trials – were against a towed winged target with 32′ wingspan flying at 170 knots and constant height of 5000 feet. FPS 1 achieved 0.715 Target Triggered Burst (TTB) per weighted shot.

US trials – were against a TD2C drone target with 30′ wingspan doing a 17º dive attack against an offset consort, at 750 yds ahead or astern of the firing unit, and pulling out at a height of 1000 feet. FPS 1 achieved 0.253 to 0.292 TTB per weighted shot.

The US trials were also evaluated against equivalent firing by the US Mk 37 system. Overall, the Operational Evaluation Group (OEG) broadly equated FPS 1 to the US Mk 37 system; the Malta performance was roughly 1.5 to 2.5 times better than the US trials (OEG attributed this to certain features in the UK targets); and the OEG commented that FPS1 was somewhat more reliable than US systems containing the same number of components.

Summary: HACS v. Flyplane

Comparison between systems of shots per kill for a target is very difficult. Available analysis can however offer some measure of the order of improvement achieved between 1942 and 1950, the period IP was involved with the two systems. As already quoted, Pout estimated that against a target at 4,000 yards, HACS Mk 4 required between 1,500 and 1,400 shots per kill. With GRUDOU/VT fuzed shell fitted this improved greatly to an estimated 70 shots per kill.

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[131] Nearly £3.5 million at 2020 prices.

[132] IP personal papers: letter from E.H. Axbey to IP dated 15 November 1953.

[133] IP personal papers and P Marland unpublished notes. See also sources in footnote 97.

In comparison, on the *Broadsword* trials, as demonstrated above, Flyplane achieved a further marked improvement in efficacy. The US trials indicate that Flyplane achieved about 4 shots per TTB (i.e. about 20 times better than HACS with GRUDOU/VT fuze). Applying Pout's suggestion that 3 TTB = 1 kill, it follows that Flyplane might have achieved about 12 rounds per kill. These figures suggest that Flyplane was at least five times better than HACS with GRUDOU/VT and vastly better than the HACS Mk 4 that IP had experienced at sea.

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CHAPTER 11

THE AFTERMATH

The Dispersal of IP's Flyplane Team

By 1948 the first prototype Flyplane system was at sea, and the design team's work was done. The team began to disperse.

Humphrey G. Nelson resigned from DEE, Admiralty, in June 1948 and became the Chief Development Engineer in the Instrument Department of Messrs Ferranti Ltd, Manchester, and in 1950 was made Chief Engineer of the newly constituted Fire Control Department. He died in 1982 aged 73.

Peter R. Fairbairn resigned from the Admiralty Engineering Laboratory, West Drayton in July 1948 and joined the Marine Department of the Esso Petroleum Company Ltd, as Electrical Engineer. He died in 1965 aged 49.

Edward H. Axbey had initially joined the Naval Ordnance Department, Bath in 1941 as an Experimental Officer. He was nominally transferred to AGE in 1944 although much of his own time was spent on development projects (including Flyplane) working closely with DNO, DEE, and AEL West Drayton. From these departments came a recommendation for permanent establishment of his position and promotion to Senior Experimental Officer in 1946. However, in 1950, AGE stopped his liaison with the other departments, and gave him subordinate work to do on another system they were developing – MRS 3. This was shabby treatment by AGE, consistent with their whole approach to the Flyplane project and its creators. He was not impressed with MRS 3. *'Am up to my eyes on the MRS 3 servos. How anyone could sanction a system like it is beyond me'* he wrote.[134]

Axbey, not unnaturally felt very strongly about this 'frustration' (as he described it),[135] and had heard that Ferranti Ltd had received the Contract for the production of the MRS 3 Predictor. He resigned from the Admiralty on 1st December 1950 despite the fact that in doing so he sacrificed the pension benefits for which another 12 months service would have qualified him. On leaving he paid a valedictory visit to Captain Le Mesurier and Commander Ross at the Admiralty where he spent a convivial November afternoon with them. They assured him of their full support with the RCAI claims and were pleased about his forthcoming move to Ferranti. Axbey had applied to Ferranti for a job and was warmly welcomed by them, where he joined his former colleague Humphrey Nelson. Despite his reservations about the MRS 3 system, he completed the design for the mechanics of the MRS 3 Predictor, and went on to design other fire control instruments and commercial mechanisms. Axbey was an outstandingly loyal and hardworking public servant who was key to the successful development of the GRUDOU, GRU Stabiliser and the Flyplane System. The manner in which he was casually discarded by an ungrateful AGE was greatly to its discredit.

Axbey died in Macclesfield in April 1964 aged 72.

Iville Porteous

Whilst IP had been onboard *Broadsword* for the initial sea trials of the ship and the Flyplane System, it had become clear by May 1949 that he would be moving on to other employment. IP wrote, without rancour, of his departure from Flyplane:

> *'This is the stage where I was unceremoniously detached from the development until I had seen the results of firings at this stage. I, of course, was willing to mark time. The firings of the* Broadsword *in the Spring of this year* [1949] *showed me that I had*

[134] IP personal papers – Axbey letter to IP 2 May 1950.
[135] RCAI – Claim C455 Flyplane Electrical Predictor System p34 (Annex B).

got the answer from the gunnery point of view. What went on in the Mediterranean could not go far wrong so far as I could see.'

He was correct – as indicated previously, the results were outstanding, and far exceeded those being achieved by HACS in 1942 when he joined DNO.

In the same letter,[136] IP provided a short history of the Flyplane development for the benefit of the then current generation of DNO officers. It finishes with a fizzing, optimistic and forward-looking account of the future plans he had in mind for the next stage of development of the Flyplane system: higher speed targets and those with curved trajectories; targets with smaller effective area; those that are guided such as glide bombs; and to incorporate target acceleration in the prediction process – the general plan for which was well advanced, he wrote.

Concerning gunnery hardware, he saw no need to modify existing components such as directors or gun mountings which served their purpose, whilst accepting that in the long term there must be a replacement gun mounting. However, he did not think that mounting should be the 3-inch 70 project (then under development) which he considered was *'completely off the rails'*. *'My reasons for this are'* he wrote, (using typical IP analytical logic):

> *'that the chance of hitting a target, either in theory or practice, is only increased if you increase the number of bullets fired at it. Now either mathematically or in practice with high speed targets the difference in position of the target at the intervals of which the rounds are fired is such that every round is in effect a single round at a new target.[137] The chances of hitting, therefore, do not go up at all above those of any single round or any single target or the part of the equipment being equal* [sic] *so there is no point in developing these fantastically rapid mountings – they just won't give more hits'.[138]* He concluded his letter with a further thought: *'The final item for development is in connection with the fuze. The supersonic target gives us a delightful little hook to hang our fuze problem on. I don't think anybody has spotted it yet'.*

And with that letter, his seven-year spell in naval gunnery development ceased. He had completed a job well done, against all the odds.

It is not clear why, after the initial sea trials, he was no longer involved in the Flyplane ongoing development and naval ordnance design in general, but possibly this was the Admiralty Gunnery Establishment taking the opportunity to remove the young upstart who had exposed the shortcomings of AGE. Or perhaps it was simply time for him to move on. Either way, the navy lost a brilliant gunnery design engineer at the early age of 44. His report from the Director of Naval Ordnance said: '*A most capable technical officer with a flair for design work which he has used with great advantage to the Navy*'.

IP, knowing that he was to leave *Broadsword* and the Flyplane project by May 1949, had asked for an appointment at Elswick – presumably at the Vickers-Armstrong armament

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[136] IP personal papers: quotations on this page are taken from IP undated letter to Commander (E) J.W. Adams RN, Admiralty, Bath, written in the latter half of 1949 after he had joined NID; his address was Room 301, 6/11 Bryanston Square, London W1. Adams was Personal Asssistant to Deputy Chief Gunnery Engineer Officer (D) in the Naval Ordnance Department, Reseach, Development, and Design section.

[137] The original requirement was for a rate of fire of 120 rounds per minute but after ammunition feed breakdowns it was reduced to 90 rounds per minute. At 90 rounds per minute, between rounds the target would move 113 yds (at 300kts), 151 yds (at 400kts) and 188 yds (at 500kts).

[138] In the RN, the 3 inch/70 gun was fitted only in the three *Tiger* class cruisers, rather than the wider fit originally envisaged. (Instead, the 4.5 inch Mk 6 became the gun of choice for the post-war generation of escorts). The author served as Navigating Officer of HMS *Blake* near the end of the ship's life: the ammunition feed was still jamming 30 years after IP had written his comments (see footnote preceding this one). *Blake* paid off in 1979.

factory – as this was near his home in Northumberland. Ferranti Ltd was also interested in employing him as a civilian, but he decided to remain in the Service.

In the normal course, IP's natural home would have been the technical design staff, where he still had much to contribute, but maybe it would have been too much for Colonel Kerrison, Superintendent, AGE, to accept such an appointment with good grace.

His final appointment in the navy was to NID as Officer in Charge Technical Gunnery Section, 1st Division Naval Staff (Intelligence) Admiralty in June 1949 in the rank of Lieutenant. Although excelling at the analysis work involved with foreign powers' gun performance, this was far from capitalising on his flair for design work. Nevertheless the Director of Naval Intelligence was pleased to have IP on his staff, and writing what was his final report in the Royal Navy, he said: '*An exceptionally capable and hard working staff officer whose work has been of very great value to Naval Intelligence*'.

He was invalided from the navy in February 1952, and considered an offer made by Ferranti Ltd where he would have joined two former members of his team (Axbey and Nelson) in the fire control section. But it was not to be: he did not see a long-term future for fire control development in the company,[139] nor he did not want to raise his young family in bleak post-war Manchester. Instead, in 1955, he took up a job in S.Smith & Sons Ltd[140] as a Research Engineer, in Bishops Cleeve, Cheltenham where he worked for 12 years until the Central Research Unit was closed down. IP died in Cheltenham on 21st May 1970, the anniversary of his son's birthday. This would have suited him well: he always liked the precision of a perfect dovetail.

Summary of Equipment Ordered

The Admiralty stated the total numbers ordered of the various equipments up to 1953 were:

GRUDOU: Total number ordered up to 31 December 1953: 239 pairs (£400 per pair) Total costs £95,600.[141] (Fitted or available for fitting in nearly all large ships in the Royal Navy).

GRUDOU with GRU Stabiliser: Total number ordered up to 31 January 1953: 124 at a total cost of £310,000. Used during the war on a small scale and after the war on a large scale. Anticipated future use *'Large'*.[142]

Flyplane Predictor System: total number ordered: 83 at a total cost of £3,320,000. *'Small user'* since the war; Anticipated *'Large future user'* from 31 Jan 1953.[143]

Fitting in Ships

The first prototype Flyplane Predictor System Mk 1 was fitted in HMS *Broadsword,* one of the first of the new-build *Weapon* Class. Subsequent FPS Mks 2 and 3 were fitted in RN *Weapon* Class (3), RAN *Battle* Class (2) and early RN *Daring* Class destroyers. FPS Mk 5 (there was no production of Mk 4) was fitted in a variety of RN and foreign new-build frigates and destroyers, among which were *Daring* Class destroyers, '*Ca*' Class destroyers, and the new build Types 12, 41 and 61 frigates.[144] The system was also to be used as the main replacement for HACS and FKC systems in existing ships of the fleet when they were modernized.

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[139] IP personal papers – IP draft letter to E.H. Axbey 30 December 1952.
[140] Later this company became Smiths Industries Ltd.
[141] RCAI C.454 (GRUDOU) page 10.
[142] RCAI C.456 (GRUDOU and GRU Stabiliser) p.8.
[143] RCAI C.455 (Flyplane) p.13.
[144] Marland: Warship 2014 article *Post-War Fire Control in the Royal Navy* p152; and *Post War Project Notes* page 38 under cover of dstl letter 28 March 2013.

CHAPTER 12

ROYAL COMMISSION ON AWARDS TO INVENTORS

Preparations for the Hearing

In 1946 the Director of Naval Ordnance, Captain D.M. Lees, Royal Navy had put down a marker for the future regarding the team working on Flyplane:

> *'DNO's object in opening this paper now, is to ensure that a record exists of the names of the officers primarily responsible* [for the Flyplane Gunnery Control System]. *This design for a control system was started during the late War, when the need for a fully automatic system capable of easy production in quantity was being brought forcibly to the notice of D.N.O. and D.E.E. by the difficulty of satisfying the ever increasing demand for accurate fire control apparatus in time to meet ship's completion dates….*
> *'….D.N.O. does however definitely consider – so far as it is his province to say so – that the four officers concerned have exhibited skill and ingenuity considerably in excess of that to be expected of them in the course of their normal duties. Should this control system be successful, very great benefit to the Royal Navy will result'.* [145]

This paper was accompanied by a submission from Commander M.J. Ross DSC RN which inter alia said that the Flyplane Predictor System had a very difficult passage in the early days and that if the project were a success the team would deserve a substantial reward:

> *'To our successors it will merely be one of the "approved" projects and they will not realise that 18 months ago there was no "Staff Requirement" for it and that D.N.O's technical advisers* [A.G.E.] *were strongly opposed to it and that it was only the confidence of the team working upon it that kept it alive at all. In these circumstances, the contribution which this team has made to fire control development and to the equipment of the Fleet is likely to be overlooked and they are likely only to receive criticism for the teething troubles which will inevitably occur.'*
>
> *'If this paper prevents this from occurring and puts this project into the right perspective it will have served its purpose'.*

These were prescient words, for in the decades following, the progenitors of GRUDOU, GRU Stabiliser and Flyplane disappeared almost without trace. Thirty years later, in 1978, even Captain Roskill, gunnery specialist and historian of the Royal Navy, was unaware of the origins of Flyplane.[146]

The first interim claim for an award for the Flyplane system was put in to the Admiralty following the successful trial firings by *Broadsword* in 1949. From the outset IP's team had agreed that a joint claim would be made, with each of the four receiving an equal amount of any award that was made. Even though IP was the driving force of the intellectual development and possessed the determination to overcome all the opposition to the work, he knew that Flyplane and all the associated inventions could only have been brought to fruition by the individual complementary efforts of his team of four. It was typical of his generosity and lack of self regard that he insisted on this arrangement.

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[145] IP personal papers: DNO paper G09919/45 dated 26 Sep 1946 and enclosure thereto.
[146] Naval Review Vol 66 April 1978 p.130.

The interim claim was followed up by submission at the end of December 1949 to the Director of Navy Contracts (Patents). It had to be made by the end of that year otherwise it would not have been eligible for consideration by the Royal Commission on Awards to Inventors. In their covering letter the team's lawyers suggested that the parties could arrive at an agreed figure for the award without the necessity of a Royal Commission hearing.

Thirteen months later, Director Navy Contracts replied,[147] saying that the position regarding GRUDOU was clear and that a decision concerning the claims would be notified in due course. Evidence regarding the performance and future potential of the Flyplane System would not be available until 1952 and therefore consideration of Flyplane and the GRU Stabiliser would be deferred until early 1952.

However, by the Spring of 1952 it appeared that the three claims were to be placed before the Royal Commission on Awards to Inventors, rather than the Admiralty Awards Committee, at the Admiralty's instigation, and this was done on 2 October 1952.[148] IP's legal counsel said *'We have been brought here against our will.'* It meant that whilst GRUDOU and GRU Stabiliser were used during the war, the Flyplane system was not, and therefore fell outside the Commission's remit. Thereafter this involved much additional preparation work in conjunction with the team's lawyers, Bristow, Cooke and Carpmael and their barrister, Mr Graham.[149] IP was well aware of the difficulties that lay ahead. In an early scene-setting letter to Mr Cooke, he wrote *'In the nature of things the whole Flyplane concept is an implicit criticism of My Lords and their Civil Service henchmen. They are individually human and won't like being told too bluntly that their inadequacy is the sole reason for the existence of a fire control system alternate from their own'.*

Much of the team's preparatory work was co-ordinated by the ever helpful and willing Edward Axbey. There was so much to do that by September 1953, Axbey wrote, that *'the preparation definitely has taken up more time than the whole development and* [was] *actually more difficult than my part in it'.*[150]

When the claim was submitted, DNO, supportive from start to finish, minuted that:

> *'DNO considers that the ingenuity, ability and design capacity were of the highest order when based on contemporary standards.* [para 2e].
>
> *'DNO considers, and reports from HM Ships confirm, that the operational value of the Flyplane System is high and represents a major advance on anything used previously. As events have proved, it became the first and only medium range tachymetric anti-aircraft system in the Fleet, and it will remain so until superseded by later Fire Control systems at present under development.* [para 2f].
>
> *'Very little technical assistance was given to the Claimants until the point was reached where trial gear showed promise. Arrangements were then made between DNO and DEE for the work to proceed further'.* [para 8].[151]

[147] IP personal papers: Director of Naval Contracts letter C.P.Br.Patents 5506/49 dated 19/1/51.

[148] Marland paper: *Post-War RN Equipment Projects, and the background to Anti-Aircraft Fire-Control Development Between the Wars: Annex A – Background (Sources, Research Establishments and Flyplane)* (covering letter 28 March 2013) page A-50 quoting from TNA file ADM1/31001 dated 13 & 26 January 1953.

[149] This firm and the barrister were specialists in presenting technical cases to the RCAI.

[150] IP personal papers: Axbey letter to IP 4/9/53. Axbey was under-playing his vital role in the whole project.

[151] Source quoted by Marland - The National Archives ADM 1/31001 note dated 14 May 1946.

However, DEE suggested that it was largely a matter of chance that the officers were employed upon this particular task, and although the initiative and ingenuity they displayed were commendable, they were not more than DEE would expect. DEE also demurred that technical assistance and supervision were in line with that available to all their other officers: *'At no time and in no respect were they just left to their own devices so far as DEE is concerned'.* This was far from the truth in the first years of IP's work, as was vouched by DNO: no help at all was forthcoming until the end of 1944.

The RCAI Hearings

At last, after interminable delays, the RCAI hearings were set to start at Somerset House, Strand, London, WC2 on 18 June, with a further two days' hearings on 26-27 July 1954. The Royal Commission was chaired by a judge, Lord Cohen,[152] with counsel handling evidence prepared by solicitors. It had a detailed portfolio of evidence concerning the history, principles, chronology and value to the navy of the inventions.

Prior to the start of the proceedings, Hugh Clausen gave a briefing to the Commission members and the legal team, and a visit was made to Ferranti Ltd at Moston, Manchester to see a prototype Flyplane Predictor System. (Later, during the hearings, Lord Cohen said *'I am appalled to think that this is what somebody describes as a simple thing.'* Counsel reassured him, saying that many of the elements of the tracker and predictor units were identical and some had only slight differences.)

The Commission heard the team's joint claim for the three main equipments: GRUDOU, GRU Stabiliser and Flyplane Predictor System. During the three days' hearing various people were called to give evidence, in particular IP, Captain Le Mesurier, and Captain Larken. They were cross-examined by counsel 'in camera' and presented the facts of their involvement in the early days of 1942 to 1944 in a strong, accurate and clear manner.

Admiral Sir Michael Denny also gave evidence. Denny was, in 1954, Commander in Chief Home Fleet, but previously, as a gunnery specialist, he served in gunnery appointments including DNO with responsibility for fire control just before WW2. Earlier in his career, in the 1920s, he had been involved in the evolution of HACS. Denny was unenthusiastic about IP's inventions: he grudgingly was drawn by counsel to concede that GRUDOU, for comparatively small cost (£90,000) had made a very great difference in £7.5 million worth of HACS equipment. When questioned on Flyplane, he reluctantly conceded that (other than FKC)[153] Flyplane was the only medium calibre system of any type, let alone a fully automatic one, that had been turned into hardware and fitted in ships since 1934. He agreed that many fewer operators were required to man the system compared with HACS (a reduction in crew from at least 13 to 3), and also that far less time was required to open accurate fire at a target (from about one minute down to a few seconds which in battle would make a large difference). He agreed that there would be large future use of the system.

The evidence was covered thoroughly, and it was stressed that IP and his team were very junior people in their respective departments and had no business to be designing the equipment they did between 1942 and 1945. They did so solely in their own time and against strong opposition from the Admiralty Gunnery Establishment and its Superintendent. GRUDOU was quickly and inexpensively produced. It was widely used during the war as a significant enhancement to HACS and to the great benefit of the ships so fitted. In particular,

[152] Lord Cohen (1888-1973). Chairman of the Royal Commission on Awards to Inventors 1946-1956.
[153] FKC Mk 2, a simplified HACS designed by Mr Landucci, was a manpower intensive, non-tachymetric AA fire control system first fitted in 1938.

it persuaded the Americans to supply the proximity fuze which they had previously declined owing to the poor performance of HACS.

The combined GRUDOU and GRU Stabiliser equipment was fitted to one ship towards the end of the war and thereafter was fitted in many more ships.

Flyplane had been in IP's mind since the late 1930s, and there it would have stayed but for his serendipitous appointment to DNO. The GRU Stabiliser was the first part of it to be designed, and thereafter in late 1944 the system received the go-ahead from DNO. Development took place and the first Flyplane system entered service in 1949. By 1954 it had been fitted in many ships and the Admiralty considered it had potential large future use.

The Awards

The Commission was exercised by the inclusion of Flyplane in the claims. Its purpose was to assess inventions which were used in wartime, not peacetime. The difficulty with IP's claims was that it included both: GRUDOU/GRU Stabiliser were wartime but Flyplane was under development in wartime and in use post-war. The submission had originally been referred to the Admiralty Awards Committee, but was then passed on the RCAI as it was decided that the three inter-related claims should be assessed together. The Admiralty 'Department's Answer'[154] says *'No use was made of the said invention during the war but the Department will invite the Royal Commission to entertain this claim as one made by service inventors to the Admiralty Awards Committee'*. This may have seemed logical to someone, but it was most unsatisfactory so far as Lord Cohen, the Commission Chairman, was concerned. The Flyplane system had not been used in wartime and was still in its early days of service in peacetime. The outcome of its use was yet to be seen. *'That is why'* said the Chairman *'it is quite unsatisfactory to ask us (and I hope it will not be done again) to deal with an invention that was not used in the war'*. This most probably fatally undermined the case for a significant (or possibly any) award in respect of the Flyplane system. Had it been made under the Admiralty Awards Committee auspices, it would at the very least have stood comparison with the £10,000 award made to Colonel Kerrison for his Mk 3 Bofors Predictor.

IP and his team were entirely unclear as to what amount would be awarded. Their counsel had argued for a very significant award. The Commission, however, was more concerned with the wartime utility of the claims, and a comparison with other comparable awards already made by the Commission. They seemed less concerned with the outstanding performance of the team which had been to the great benefit of the navy, the widespread fitting, the substantial cost savings, and the great improvement achieved in naval AA gunnery when there was no alternative in sight.

The outcome was announced about two months after the hearing. For the three inventions the team was awarded a total of £8,500 (2018 value: £230,000) - £2,000 each with £500 for legal fees. £2,000 (2018 value: £55,000) was enough in 1954 to buy a house.

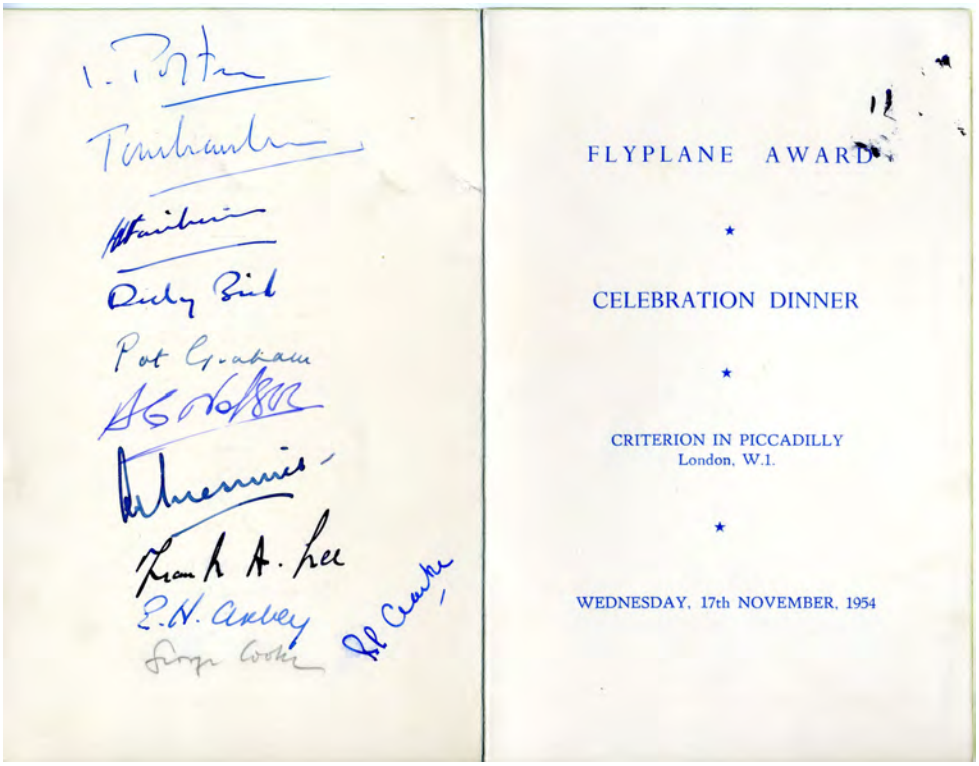
This was far short of what the team's counsel had argued for, although there is no record of what the team thought. Larken considered that the award was *'not bad but that Iville deserves more'*.[155] Marland, after studying comparable awards concludes that *'In 1954 terms the sums were still significant….however the £8.5k total award look*[s] *derisory when set against the*

[154] IP personal papers. Form 5 'Department's Answer' to C.455 Statement of Claim (Flyplane Electric Predictor System).
[155] IP personal papers: Peggy Larken to Nora Porteous, undated letter, probably Autumn 1954.

context of 57 Flyplane *systems deployed afloat at circa £40k each, giving a capital outlay of £2.28M at 1954 prices'.*[156]

There may not be any surviving written conclusion and rationale for the award made: there is nothing in IP's personal papers. It remains conjecture about how the Commission determined the level of award. Did they concentrate primarily on GRUDOU which was widely fitted and very successful? Did the fact that Flyplane was a post-war system mean that it was largely or totally disregarded in terms of an RCAI award? Certainly the Commission Chairman was unhappy about having to consider a system which was not used in wartime. Perhaps Flyplane fell into the crack between the Admiralty Awards Committee and the RCAI. If so, maybe that was the inevitable outcome for a system which had spent its life being much needed but not much wanted by the Admiralty's gunnery technical hierarchy, or as Humphrey Nelson put it, a system which had been born on the wrong side of the blanket.

At the end of it all, there were various celebrations in Manchester and London to thank all those who had helped IP's team. In London, the team of four – IP, Axbey, Nelson and Fairbairn – met, most probably for a final time, on Wednesday 17th November 1954, at the Criterion restaurant in Piccadilly where they dined on Filet de Sole St Germain, Filet de Boeuf Perigourdine and Annanas Voilé à l'Orientale, accompanied by Bollinger and Chateau Gruard Larose. Among their eight guests were members of the legal team who presented their case at the Royal Commission, and, of course, Captains Tom Larken and E.K. Le Mesurier without whom IP's fire control conceptions would not even have been stillborn.



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156 Marland states 57 systems were deployed afloat at that time. The Admiralty stated in evidence to the RCAI that 83 sets had been ordered by January 1953 at a cost of £3.32M: RCAI C.455 (Flyplane) p.13.

CHAPTER 13

AFTERWORD

Conclusion

Iville Porteous, quite by chance, became involved in fire control system design. He had been at sea as an ordnance artificer for many years, and had become progressively more and more dismayed by the shortcomings of the anti-aircraft gunnery systems being produced by the Admiralty's civilian technical gunnery staff, hardly any of whom had any seagoing experience. IP had no experience in design work, was a recently promoted Commissioned Ordnance Officer aged 37 and was the most junior of 44 commissioned officers in the Directorate of Naval Ordnance.

Not long after his arrival at DNO for an entirely different job, he persuaded his boss that he thought he could improve HACS considerably and also design a completely new, fully automatic anti aircraft fire control system. He built a small team of three volunteer like-minded civilian technical officers with no previous gunnery experience. Working in their own time and with the support of DNO staff, IP and his team first designed and produced GRUDOU, a modification for HACS, in a few months. It made a marked improvement in HACS performance, which the Admiralty Gunnery Establishment had failed to achieve over many years. This, crucially, also led to the US providing proximity fuzes for RN use. He then designed the GRU Stabiliser, which further enhanced the HACS performance, and after that went on to design and develop the Flyplane Predictor System. All this was done despite enduring opposition from the Admiralty Gunnery Establishment.

IP's experience in trying to introduce an entirely new automatic fire control system has echoes of Admiral Scott's experience 40 years previously when the Admiralty, in Scott's words, *'were moving heaven and earth to prevent director firing being adopted'*.[157] During his career Scott '*proved to be an engineer and problem solver of some considerable foresight, ingenuity and tenacity'*.[158] These words could equally well be applied to IP, who like Scott had the temerity to challenge the navy's gunnery orthodoxy.

The Flyplane project was finally officially adopted (against the recommendation of AGE) two and a half years after IP had commenced design work on it. None of this could have been achieved without the unerring support of Commander Larken, Comander Ross and Captain Le Mesurier amongst others who had placed their trust in IP and his team from the outset in 1942.

The Flyplane system was designed from scratch by IP. It was the first, and only, fully automatic British-designed tachymetric AA fire control system the navy was ever to have, and was built at a fraction of the cost of the equivalent US Mk 37 system. The eventual successor to Flyplane was MRS3, an expensive British copy of the US Mk 56 system. Flyplane was also the only entirely new AA system to have been developed into hardware and fitted in ships for twenty years. It was the progenitor of a new generation of design as it operated almost completely automatically and achieved much greater target lethality.

Marland,[159] in a wide-ranging analysis of post-war equipment projects, writes:

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157 Scott, Admiral Sir Percy - *FiftyYears in the Royal Navy* Chapter XV Section 247 (https://naval-history.net/WW0Book-Adm_Scott-50YearsinRN.htm).

158 https://en.wikipedia.org/wiki/Percy_Scott. (Scott also invented an electric lawn mower in 1920).

159 Marland – dstl covering letter dated 28 March 2013 to paper *Post-War RN Equipment Projects, and the background to Anti-Aircraft Fire-Control Development Between the Wars*. Also see article *Post-War Fire Control in the Royal Navy* (Warship 2014).

'The overall conclusion remains that AA fire control was the one area that UK had failed substantially, and that the saviour was Mr Porteous and his Flyplane team, who delivered one third of all post-war analogue fire control systems, in the teeth of opposition by their line management. The only other success was the subsequent MRS 3 family, and this required large government involvement and a prime contractor, under complex control arrangements. This supports the proposition that innovators do not prosper in a peacetime corporate environment'.

That Flyplane should have been developed at all is remarkable given the state, at that time, of the Admiralty Gunnery Establishment. That it was conceived and designed against all the odds by an officer wearing one thin stripe is even more remarkable.

*****

A Note by the Author

I am IP's son and was conceived at the same time as GRUDOU and Flyplane. I too had a career in the navy. When I went for my Admiralty Interview Board in 1961, the President of the Board, Rear Admiral Tom Larken, said to me: 'Your father is a brilliant engineer. Why do you want to be a seaman officer?' I don't remember what I replied, but the real answer was probably 'Because my father suggested it'. I surmise that IP would have suggested it perhaps recalling his own experience: in his day all power lay in the hands of the executive branch, not the engineers. (Incidentally, I passed the board, and became a seaman officer and navigation specialist.) My sister Alison also joined the navy as a Wren, then had a long and interesting career at a well-known government agency in Cheltenham where she still lives. In another 'dovetail' which would have appealed to IP, her career took up the type of work that had occupied IP in his last job in the navy.

As a midshipman, I served in a Flyplane (FPS5) ship, HMS *Jaguar*, and remember IP once commenting that those who inherited the original Flyplane (FPS1 and 2), took over an essentially simple system and proceeded to complicate it, or words to that effect.[160]

Over half a century later, long after I had retired, and 40 years after IP's death, I met Rear Admiral Richard Hill by chance at a lunch and the subject of IP and Flyplane came up. His appraisal of Lieutenant Iville Porteous was brief and to the point: *'Cleverest man in the navy'* he said.[161]

I seldom heard my father speak much about Flyplane, beyond knowing that there were some important papers in the attic. When he stepped ashore from HMS *Broadsword* for the final time, he must have been satisfied but sad to bid farewell to the fledged Flyplane, but he never expressed any regrets that at such a young age his considerable experience and expertise so soon had become superfluous to the navy's needs. He placed no stock on fame or fortune nor sought it, but it seems regrettable to me that this naval story of David and Goliath has gone unnoticed for so long.[162] (It is interesting to note that Post Office engineer Tommy Flowers, the inventor of 'Colossus' at Bletchley Park, had much the same obstruction from his principals, who subsequently enjoyed preferment whilst he slipped into oblivion with an MBE and a modest Award to Inventors.)[163]

[160] For example, on a schematic diagram for 'Proposed Wind Corrections' (which he eschewed) for a later version of Flyplane, he scribbled *'This is all rubbish; after my time'*. His erstwhile office colleague and friend, Aylwen Britton sorting IP's papers after his death, added *'Typical comment from IP'*.

[161] This was generous approbation from Rear Admiral Hill, himself *'One of the most intelligent naval officers of his generation'*. (Daily Telegraph obituary 3 May 2017). Author, and former editor of the Naval Review, amongst many other things.

[162] Other than by Marland in his papers – op cit.

[163] McKay, S: The Secret Life of Bletchley Park, Aurum Press 2011 pp.265-271.

At home when I was growing up, I, and those he came into contact with, found IP to be a fascinating person. He had a keen intellect, was a voracious reader and was very well informed on all manner of subjects. A true polymath and born lateral thinker, he always enjoyed the company of lively minds. He liked people and relished ideas and debate wherever he found them, be they in gilded halls or his local pub. (*'You can argue about opinions, but not facts'* he would counsel us.) He was, in his words, a Greek living in Rome.

During my adolescence and early years in the navy, IP worked at Smiths Industries, Bishops Cleeve, as a research engineer and became a colleague and good friend of Reg Legg, a mathematician. They both had joined Smiths to work initially on the design of a guided weapon control system and subsequently worked on other inventions. Several years after IP's death, and in a final comment on his life, Legg recalled in a letter to Rear Admiral Searle:[164]

> *'I soon discovered that he was no ordinary engineer and I must say that we, his graduate colleagues, appeared very dull in comparison.*
>
> *He was the most provocative and stimulating thinker I have ever met, interested in a broad range of topics covering the Natural Sciences, Philosophy etc as well as engineering matters.*
>
> *Always inclined to take the not-so-obvious viewpoint he would probably be described today as a natural "lateral thinker" – an undoubtedly remarkable man – intensively self-educated, keenly interested in all manner of scientific matters to a degree not normally encountered in the run-of-the-mill graduate engineer.*
>
> *We soon became close personal friends and in travelling to and from work had many an interesting discussion on whatever was the latest topic, perhaps evolution or Galton's work or some anthropological item, invention etc.*
>
> *It was inevitable that, with our common interest in Control System design, I should, over the years, become acquainted with some aspects of his work with the Navy.*
> *Hugh Clausen, whom he greatly admired and Professor Brown of the Royal Naval College, Greenwich, became familiar names to me.'*

*****

And so we end where we started. Roskill wrote: *'They* [IP and his team] *certainly deserve a modest place in the technical history of the period – regarding which the official records are woefully silent'.*[165] I once suggested to IP that he should write the story of Flyplane, mindful of one of his favourite stanzas.[166] 'No' he said, that would be for me to do. Well, at last I have done so, and hope that I have managed to shed some light on Iville Porteous's 'footprints on the sands of time' so that they one day might offer inspiration to others who are struggling within the constraints of orthodoxy.

May 2020

Roger Porteous
Holly Hatch
Owslebury
Hampshire

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[164] IP personal papers: R.C.F. Legg letter to Rear Admiral M.W.St. L. Searle CB CBE dated 6 June 1978, (Adml Searle's son Simon shared an office with IP at Smiths).
[165] Naval Review Volume 66 April 1978 p.130.
[166] From Longfellow's 'A Psalm of Life': 'Lives of great men all remind us/We can make our lives sublime/And, departing, leave behind us/Footprints on the sands of time'.

ILLUSTRATIONS PORTFOLIO

This material is taken from the Claimants' submissions to the Royal Commission on Awards to Inventors

NON-TECHNICAL SUMMARY OF THE GUNNERY PROBLEM SOLVED BY THE FLYPLANE PREDICTOR SYSTEM

(Source: Transcript from Royal Commission on Awards to Inventors – Schedule C.454)

‘The following details outline the broad principles of the problem which is relevant to this Claim. The terminology itself is taken, for the sake of simplicity, from the Flyplane System which is the subject of a later claim.

Let us imagine a target coming in from the distance flying in a vertical plane in a steady course towards the Observer. A side view of the resultant vertical plane is shown in Fig.1. The LINE OF SIGHT is the line running from the Observer at O to the target at P.

The angle that this line makes with the horizontal is termed the ANGLE OF SIGHT. In order to hit the target it is necessary to aim the gun (also at the point O) off by the angle POF.

This angle is termed the DEFLECTION and depends upon the distance travelled by the target while the projectile is moving from O to F; the time taken being equal to the time taken for the target to move from P to F.

When looking along the Line of Sight the target appears to be moving from Q to F. The rate at which it appears to be so moving is termed the BEARING RATE IN THE FLYPLANE.

If gravity could be neglected, the projectile would travel in a straight line from O to F but, in fact, it is necessary to aim the gun off by an additional Angle (Fig.2) depending upon the muzzle velocity and the distance from O to F. This angle is termed the TANGENT ELEVATION.

Thus, in order to ensure that the projectile hits the target it is necessary to elevate the axis of the gun by the Angle of Sight plus the Deflection plus the Tangent Elevation.

The distance from O to P is the PRESENT RANGE and that from O to F the FUTURE RANGE.

As no Fire Control system can predict the position F with absolute accuracy – the projectile has to be fuzed to burst after a determined TIME OF FLIGHT (no such fuzing is of course necessary when proximity fuzes are used) in order to destroy the target without actually hitting it – thus the Time of Flight is the time taken for the projectile to travel from O to F.

The problem becomes a little more complex when the Flyplane P.O.F. is not vertical i.e., when the target is travelling to the left or right of O. See Fig.3.

Again looking up the Sight Line OP the line QF appears at an angle to the vertical but the rate at which the target appears to move from Q to F is still the Bearing Rate in the Flyplane. Let ZQ be at Right Angles to OP in the vertical plane, Fig.1, then the imaginary circle with FQ = ZQ = the radius, is in a plane at right angles to the sight line OP.

The angle FQZ is termed THE ANGLE OF PRESENTATION.

Now, in order that the projectile shall hit the target at F or burst in its vicinity, it will not only be necessary to elevate the axis of the gun but also to train it. See Fig.4.

From Fig.4 it can be seen that the axis of the gun has to be trained from the "Present" vertical sight plane (angle QOT) as in Figs 1 and 2, through angle SOT and elevated through angle QOT (which equals angle ROS) plus angle FOR plus angle TE.

Angle ROQ is termed the LATERAL DEFLECTION and

Angle FOR is termed the VERTICAL DEFLECTION.

Note also that FQ is the hypotenuse of the right angled triangle RFQ. Similarly the rate by which the target appears to move from Q to F can be resolved into a lateral rate from Q to R and a vertical rate from R to F.

It is from these LATERAL and VERTICAL RATES that, through the medium of the invention described on the next page that the degree of Lateral and Vertical Deflection is calculated rapidly and continuously, the very essence of this invention.'

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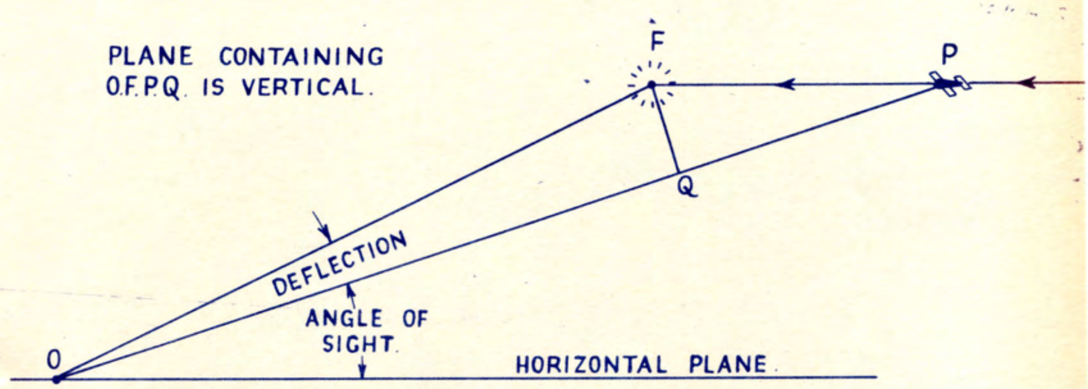

PLANE CONTAINING
O.F.P.Q. IS VERTICAL.
F
P
Q
DEFLECTION
ANGLE OF
SIGHT.
O
HORIZONTAL PLANE.

FIG. 1.

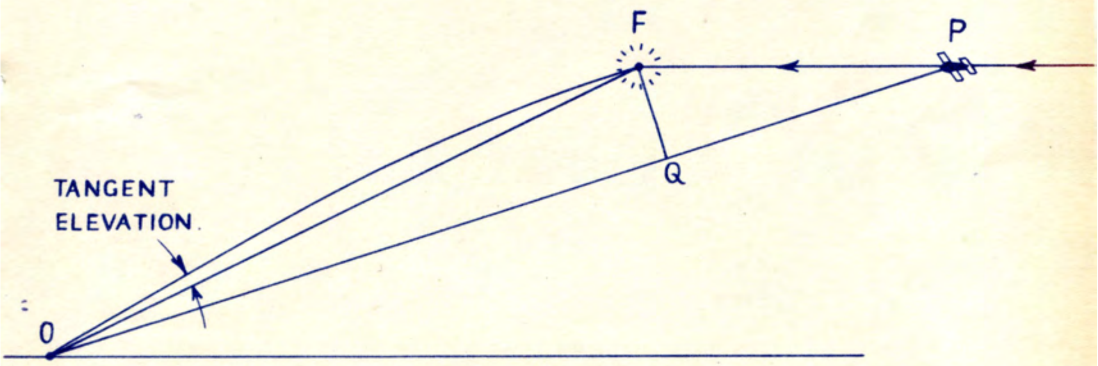

F
P
Q
TANGENT
ELEVATION.
O

FIG. 2.

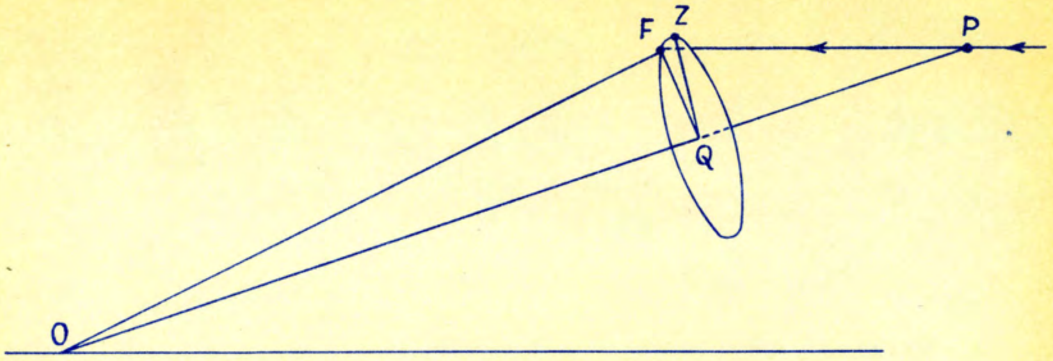
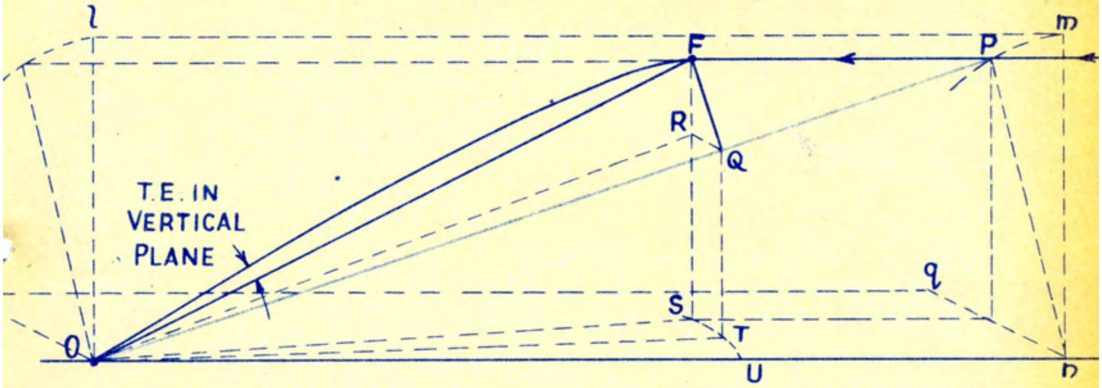


FIG. 3



O.l.m.n. IS THE ORIGINAL VERTICAL FLYPLANE.

O.p.q.n. IS THE HORIZONTAL PLANE.

FIG 4

ANNEX B

GRUDOU – Mechanism Diagram

Page 5 12

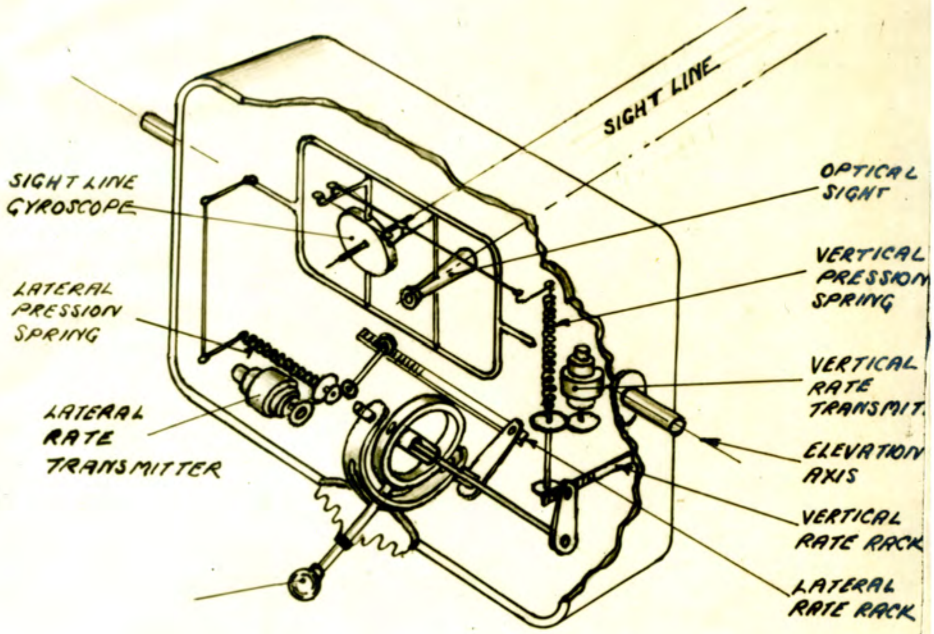


FIG. 5.

ANNEX C

GRUDOU – Schematic Plan of HACS with GRUDOU

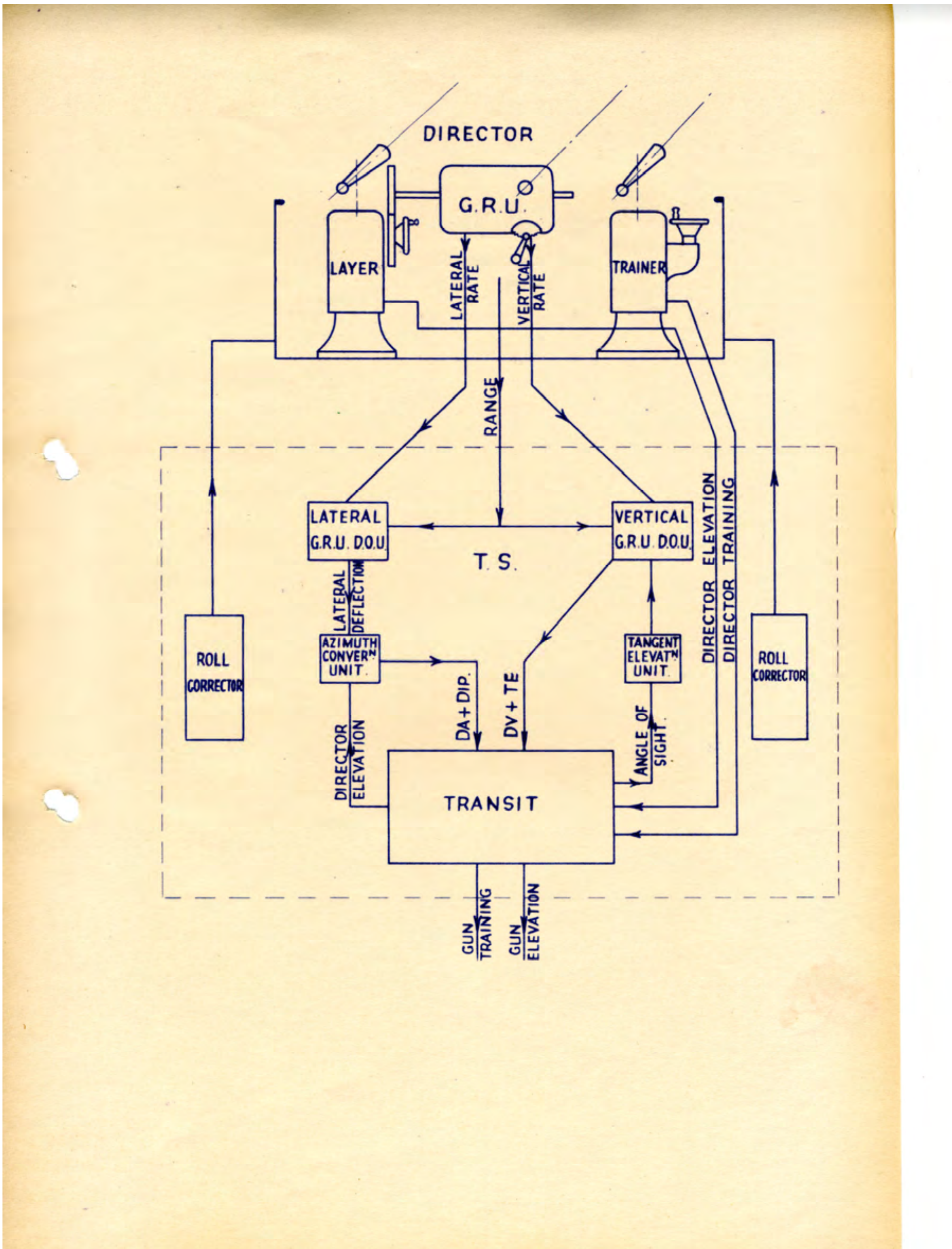


FIG. 6

ANNEX D

GRUDOU with GRU Stabiliser – Schematic Plan of HACS with GRUDOU/GRU Stabiliser Mk1

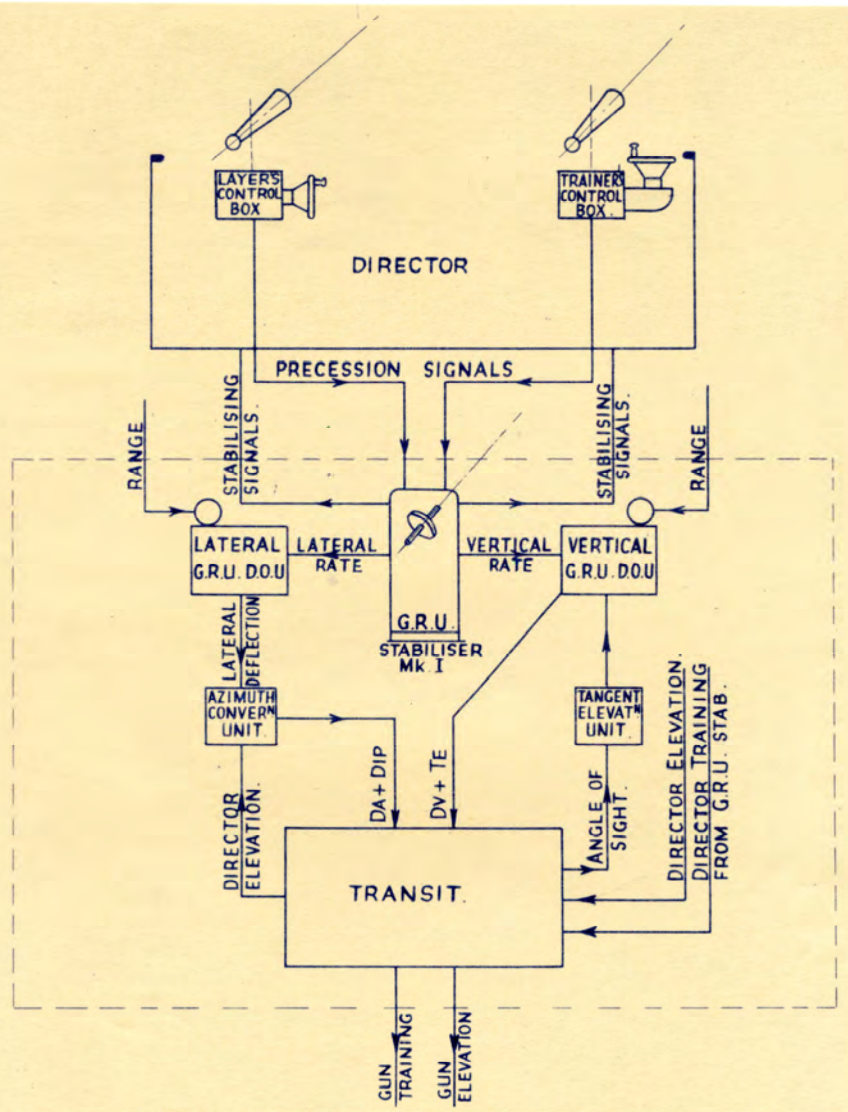
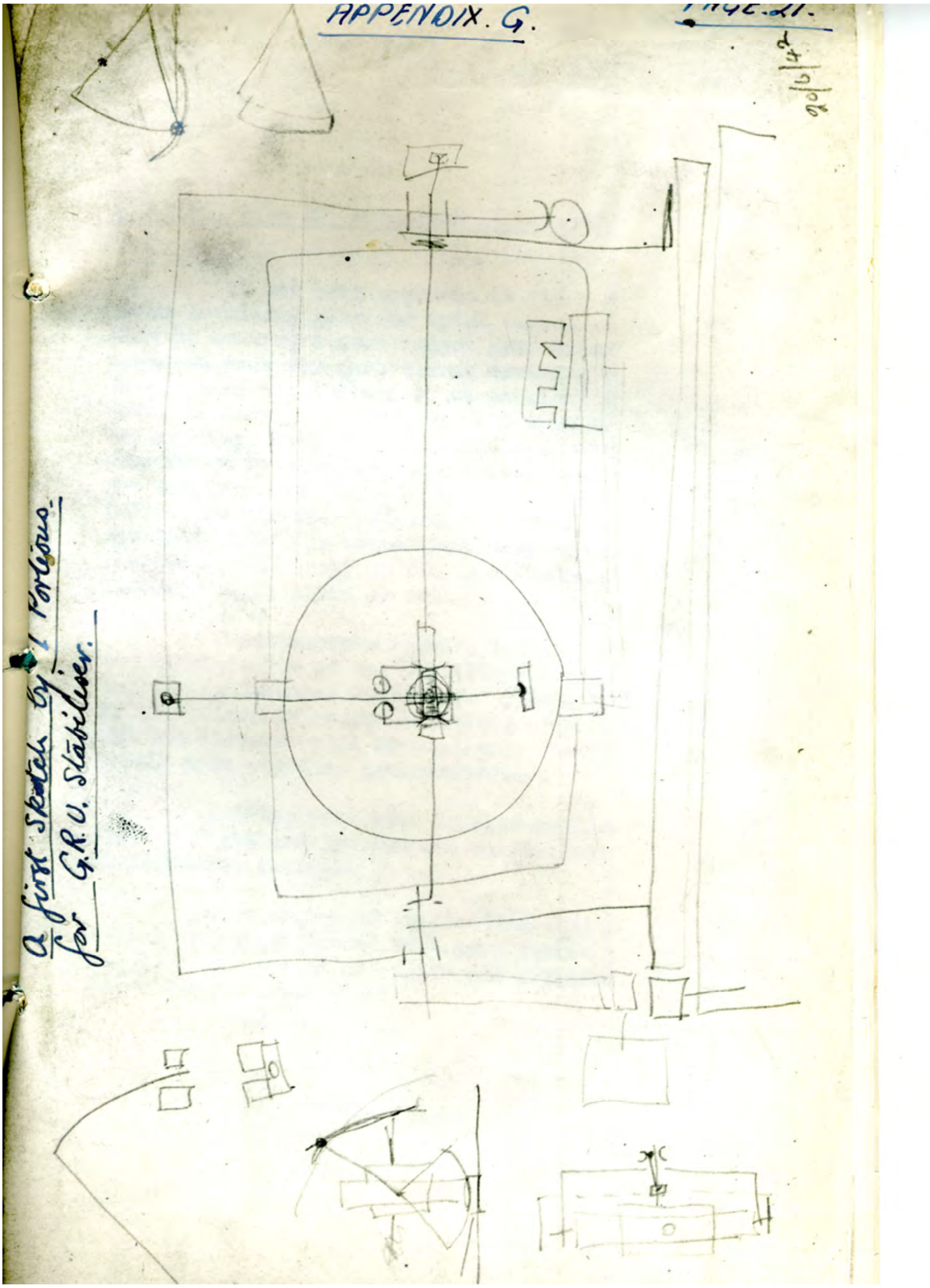


FIG. 7

ANNEX E

GRU Stabiliser Mk1 – The start of Flyplane: First diagram of GRU Stabiliser design



GRU Stabiliser Mk1 – Mechanism Diagram

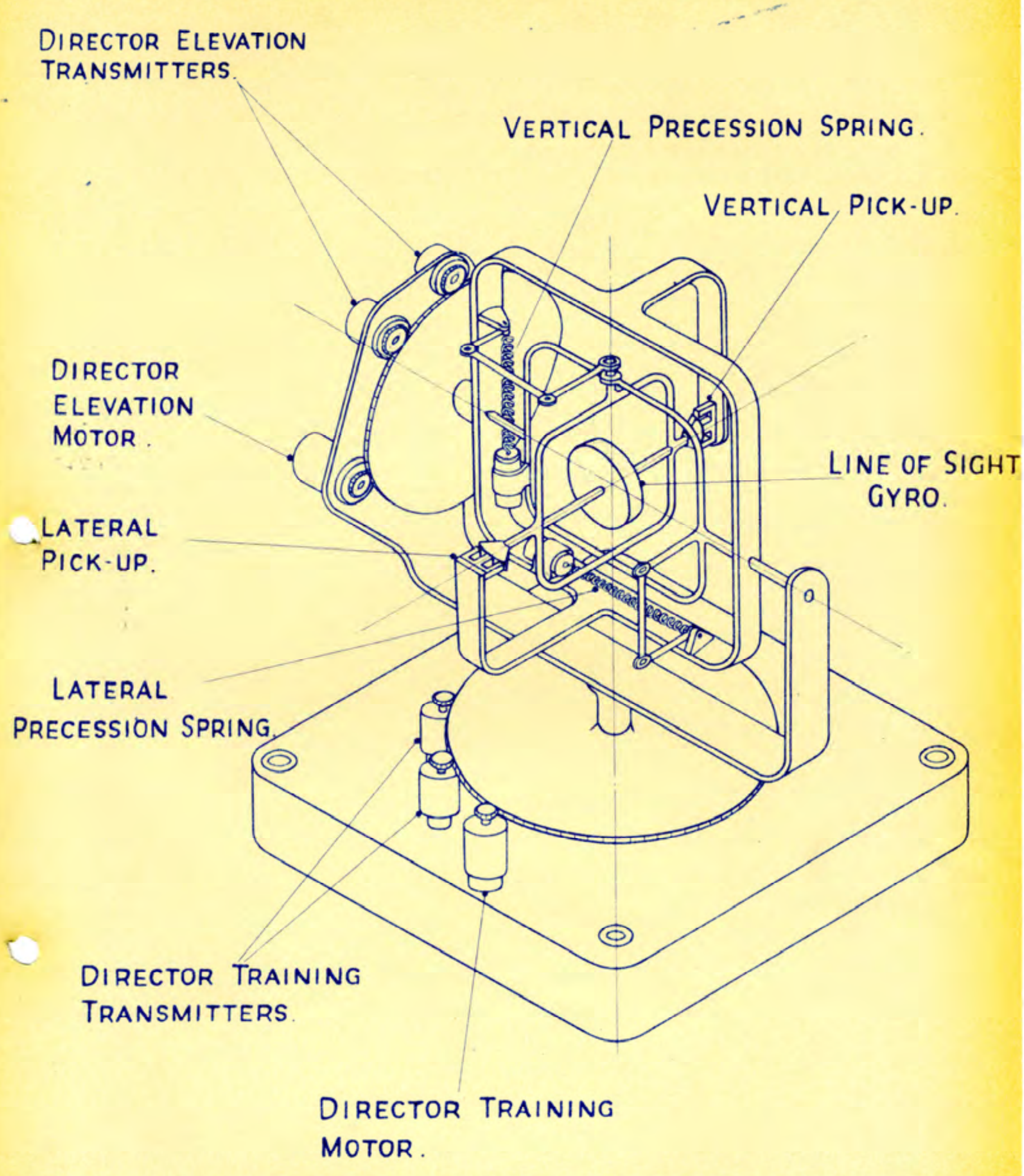


FIG. 8

ANNEX F-2

GRU Stabiliser Mk 1 - Method of Operation

The diagram at Annex F-1 is a simplified diagram of GRU Stabiliser Mk 1 which shows the essential components of the unit. This stabiliser was used with GRUDOU. The image at Annex F-3 is a photograph of the GRU Stabiliser.

The telescopes of the Layer and Trainer in the Director are pointing in the same direction as the Line of Sight gyroscope in the GRU Stabiliser. Hitherto it had been very difficult for the Layer and Trainer to keep their telescopes on the target, whilst also having to make continuous corrections with their hand-wheels for all the movements of the ship.

If the casing in which the Line of Sight gyroscope is housed and the casings in which the telescopes are housed could be held steady against ships movements it would be equivalent to having all these units on dry land with all the consequent greater prediction accuracy.

Therefore a mechanism was required in the GRU Stabiliser to ensure that the casing will follow the gyroscope. This was achieved by having Vertical and Lateral precession springs which actuate Elevation and/or Training motors to move the casing back into alignment with the gyroscope whenever they are out of alignment caused by ship's movements. The amount by which the respective Elevation and Training motors run is copied by the transmitters which cause motors to run in the Director. When the Elevation motors run, the housing for the telescopes is elevated or depressed by exactly the same amount. When the Training motors run the whole of the Director housing runs in a clockwise or anti-clockwise direction dependent on the direction of the Director Training Motor.

These compensating training and elevating motions are also transmitted through the system and thence to the guns. Thus, to all intents and purposes, all ship's movements are translated instantly into movements of the parts it is essential to stabilise but in precisely the reverse direction and by exactly the same amount.

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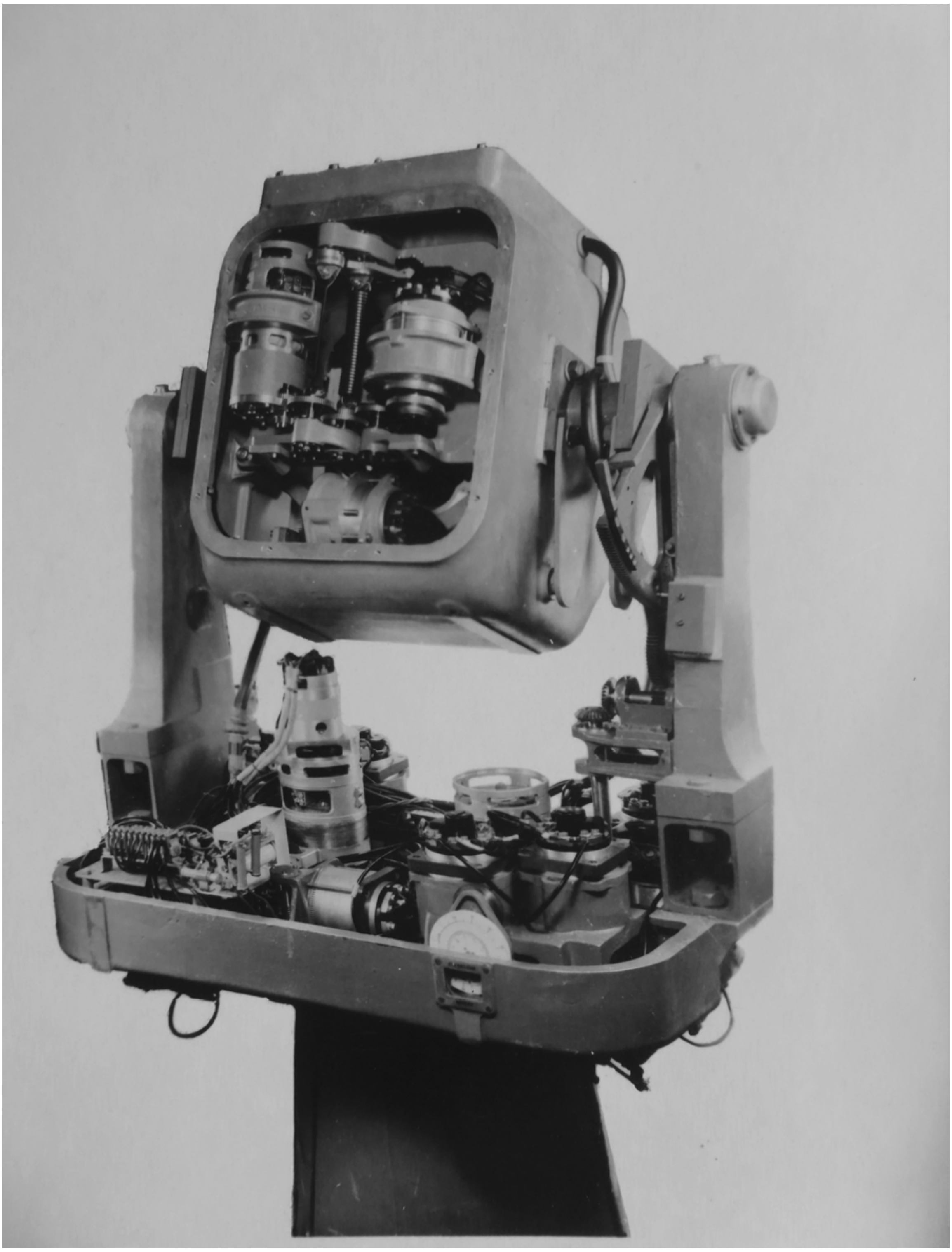
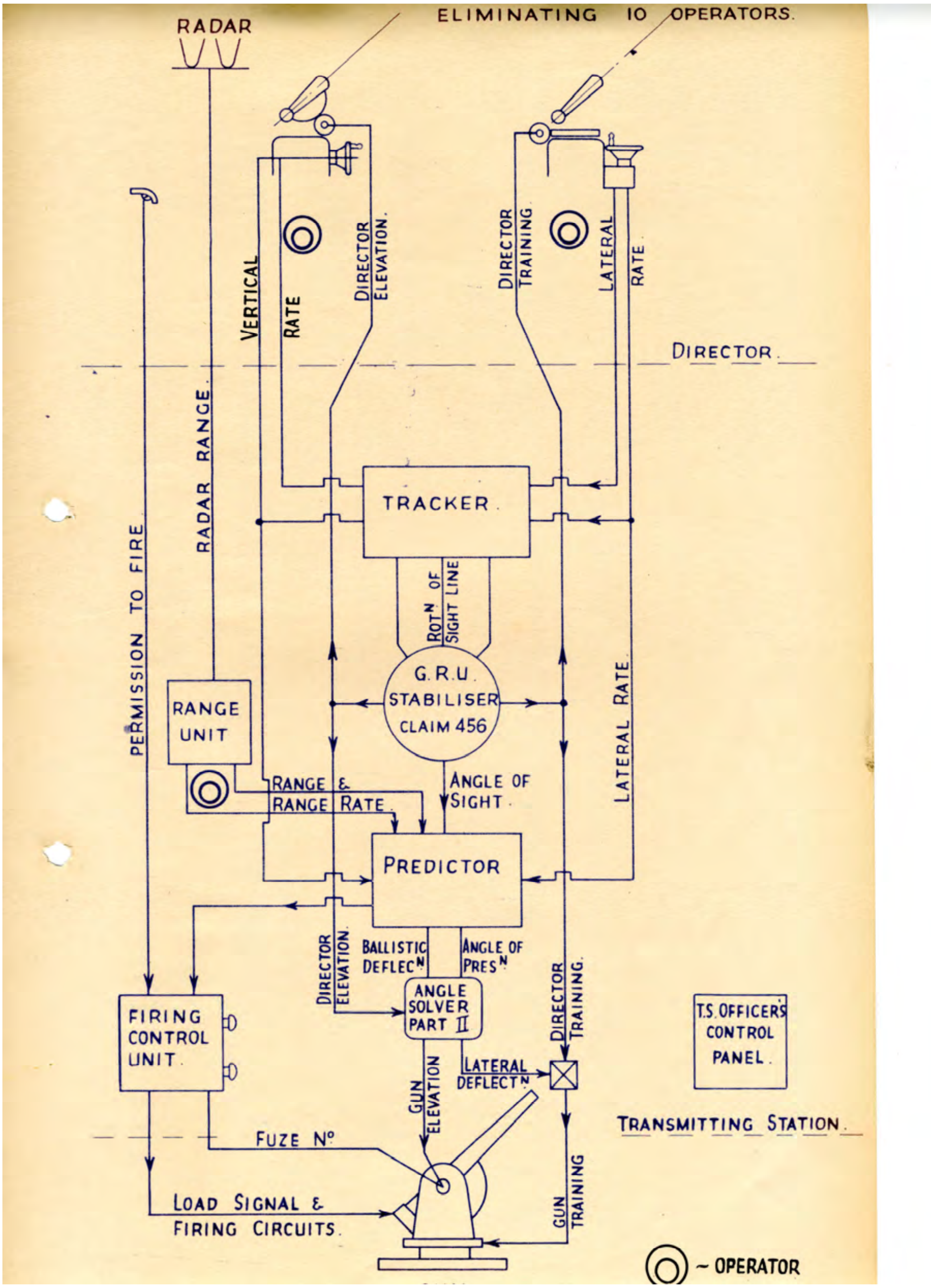
ANNEX F-3

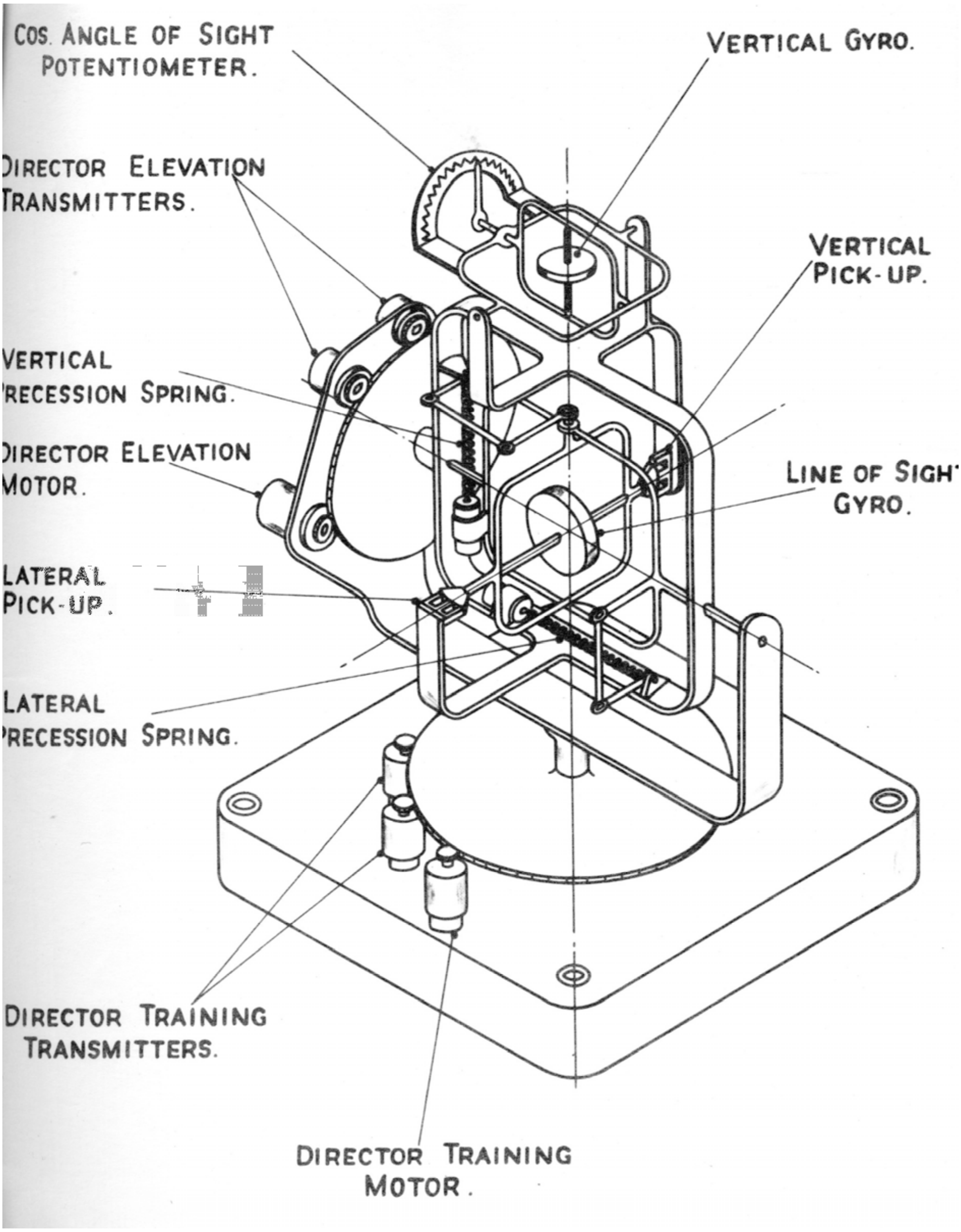
GRU Stabiliser Mk1 – Photograph



Flyplane Predictor System – Schematic Plan

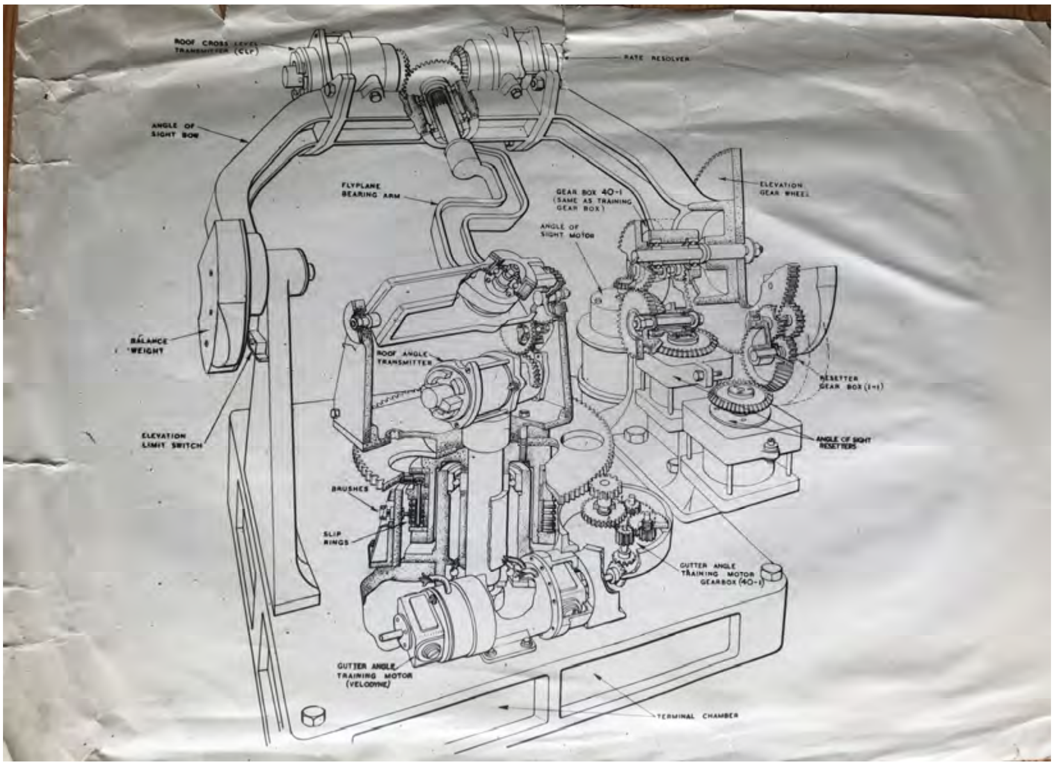


Flyplane Predictor System - GRU Stabiliser Mk2 – Mechanism Diagram



ANNEX I

Angle Solver Part 1



Angle Solver Part 1 Initial Drawing

Angle Solver Part 1 Prototype

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This memoir tells the story of the naval career of a remarkable man, Commissioned Ordnance Officer Iville Porteous, and how he, with one thin stripe on his arm, confounded naval gunnery orthodoxy by designing and developing vital anti-aircraft fire control equipment during and after the Second World War.

Porteous led a small team of volunteers who, in their own time, worked on his inventions in the face of strong opposition. Needless to say, those responsible for designing gunnery systems were not comfortable with the dawning realisation that their inadequacy was the sole reason for the existence of a fire control system other than their own.

The author is the son of Iville Porteous whose personal papers have lain untouched in two suitcases in various attics for 65 years. The memoir has been largely drawn from this primary source material and illuminates for the first time a corner of naval gunnery history which hitherto has been shrouded in shadows.

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