A Global Forum for Naval Historical Scholarship

International Journal of Naval History

October 2002
Volume 1 Number 2

Building a Doctrine:
U. S. Naval Tactics and Battle Plans in the Interwar Period

Trent Hone
Senior Associate, Rubicon Technologies

General Introduction

In the nineteen years between the Washington Naval Conference of 1922 and the surprise attack on Pearl Harbor in 1941, the United States Navy honed its skills in numerous Fleet Problems, and tactical exercises conducted both at sea and at the Naval War College. The most important product of these efforts was the introduction of a common doctrine allowing the Navy's officers to operate as a cohesive unit.

In the years immediately following the Washington Naval Conference of 1922, this doctrine did not exist, but the advantages of such a common doctrine were well recognized. Steps were taken throughout the interwar period to teach the Fleet to think as a single unit; to react to the changing circumstances of battle with one mind.

The importance of this doctrinal development has largely been ignored, primarily because battleships formed its centerpiece. The destruction of the Navy's battle line at Pearl Harbor and the ensuing dominance of the aircraft carrier in the decisive battles of the Pacific War have led investigators to focus on aircraft carriers when examining the prewar development of the Navy's doctrine. This article seeks to address that oversight.

Introduction

At the end of World War One, the Navy was in the midst of producing the most powerful collection of capital ships the world had ever seen. The battleships of the *South Dakota* class and battle cruisers of the *Lexington* class were designed to secure naval supremacy in the coming decades. The Washington Naval Treaty of 1922 disrupted those plans.

The treaty mandated that the Navy cease construction of its new ships and not engage in any new battleship construction for a decade. The Navy was forced to make do with its existing battle line; although it was one of the most powerful in the world, the diverse collection of ships had numerous weaknesses. These weaknesses were magnified by the lack of a common doctrine.

The Navy's initial efforts to rectify this deficiency focused on maneuver and aggressive offensive action to control the course of battle. Between the Washington Treaty of 1922 and the London Treaty of 1930, the Navy's doctrine developed to emphasize these two elements. Fluid maneuver would ensure that the Navy's ships would operate as a cohesive unit in battle, and a determined offensive would keep the enemy off balance.

After the First London Treaty of 1930, the Navy's doctrine continued to evolve; as it became more sophisticated, it began to reflect the capabilities and limitations of existing ships. The increasingly complex tactical doctrine of the 1930s was refined during Fleet Problems and exercises at the Naval War College. As new elements were adopted they were published in the Navy's Fleet Tactical Publications. Unpublished aspects of the doctrine can be found in lectures from the Naval War College and the annual reports of the Commander-in-Chief of the United States Fleet.

These sources illustrate that the U.S. Navy developed a sophisticated tactical doctrine during the last decade of the interwar period. This doctrine was based on controlling the pace of an engagement through seizure of the tactical initiative; it emphasized the coordination of all arms; and it stressed tactical flexibility. The adoption of this doctrine allowed the to Navy leverage one of its most important strengths, the ability and training of its officer corps.

Formulating a Doctrine 1922-1930

For clues as to how to conduct a successful engagement the Navy looked to the failure of the Royal Navy to decisively defeat the German High Seas Fleet in the only major fleet action of World War One, the Battle of Jutland. On the afternoon of May 31, 1916, the two battle fleets fought a large but indecisive action off the coast of Denmark. In the eyes of the U.S. Navy, the Royal Navy's failure was due to three primary reasons: poor approach dispositions, inadequate coordination and communication among the British formations, and the Royal Navy's inability to seize the offensive and control the pace of the battle.[1]

These observations formed the basis for several important lessons. The first of these, the necessity of fluid coordinated maneuver, could be addressed by the introduction of new tactical formations and cruising instructions. The others would prove more difficult. Aggressive offensive action was the key to success; it would allow the Navy to control the tempo of the engagement and impose its will on the enemy. But it would be impossible to coordinate the efforts of an entire fleet from a central location in the heat of battle; only the development of a common doctrine could guarantee that the Navy's ship commanders would be able to coordinate their efforts effectively.

The Introduction of Formations and Maneuvers

In the initial portion of the interwar period, the Navy stressed the importance of coordinated maneuver. Specific formations for cruising, approach and battle were developed. These were supplemented by a fleet publication, *Formations and Maneuvers of the Battle Line*. This document specified the organization of the battle line and detailed the numerous maneuvers the battle line was expected to perform in battle.

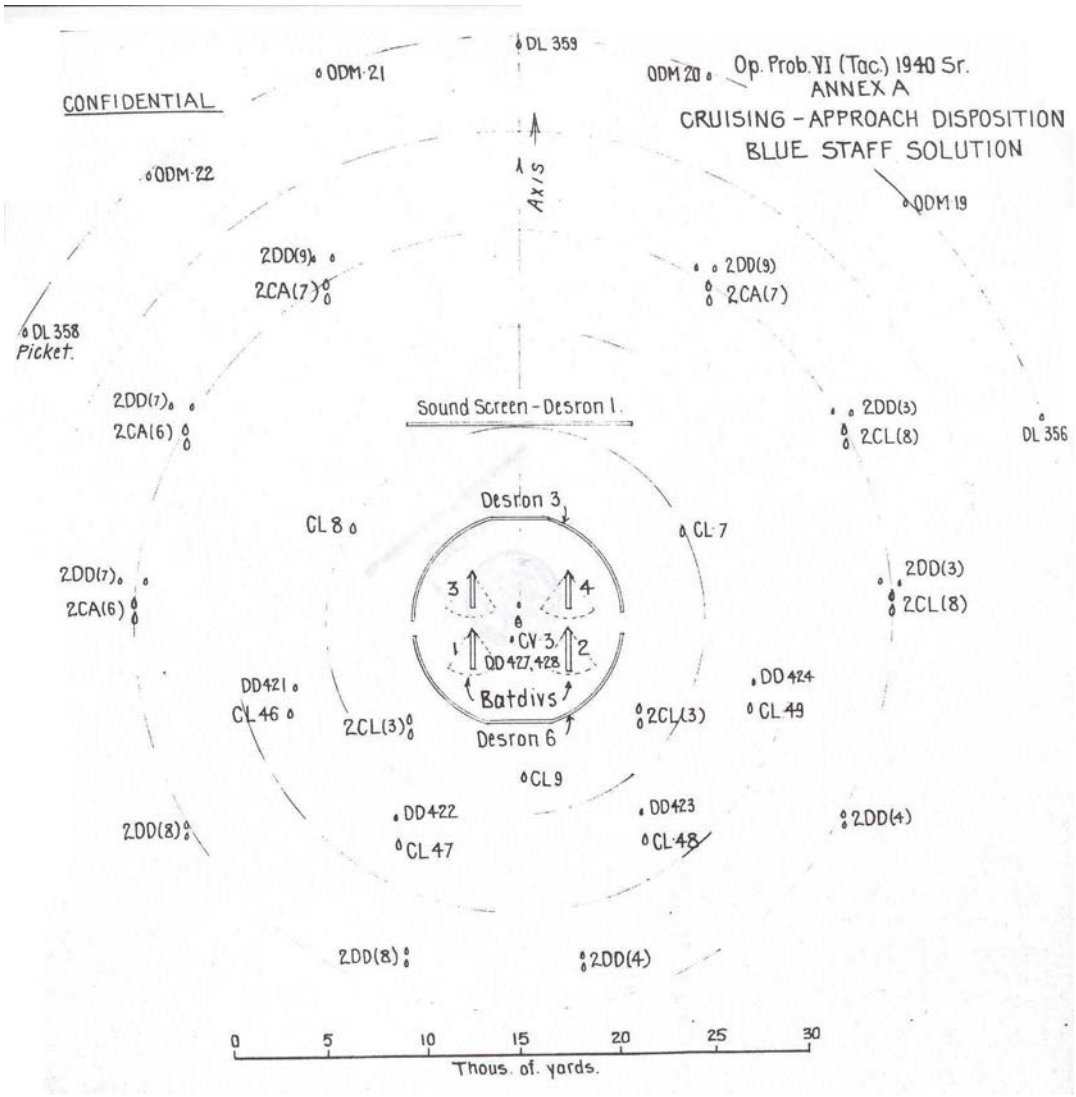
> For tactical purposes the battle line is organized in three squadrons, and a separate flagship of the officer in tactical command of the battle line…. The squadrons are designated as the strong squadron, intermediate squadron, and the weak squadron.[2]

> Each squadron would be composed of one or more three-ship divisions depending on the number of ships available. The weak squadron was always positioned at the center, with the strong and intermediate squadron to either flank.[3]

It was essential that the Navy's battle line maneuver as a cohesive unit; the division of ships into divisions and squadrons simplified this task. The maneuvers of the entire fleet were simplified by the introduction of new tactical formations.

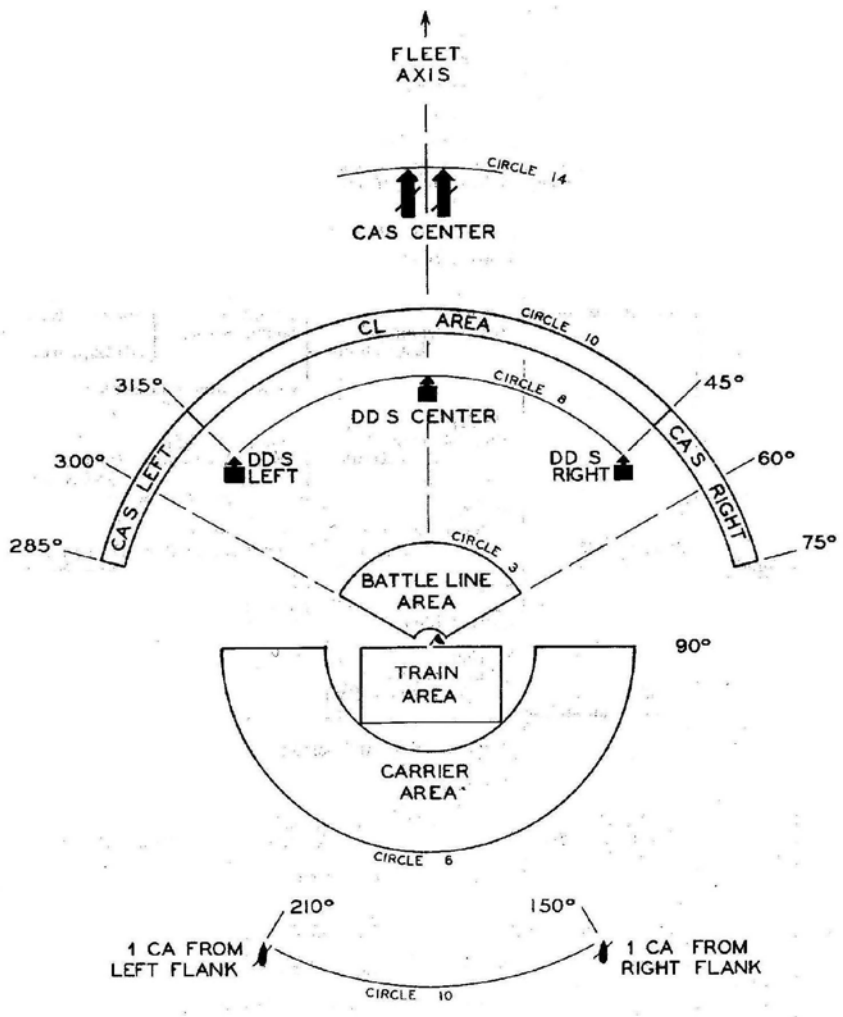
When the position of the enemy was unknown and the chances of contact were slight, the Navy would employ a cruising formation; these were designed to emphasize security. Concentric circles of light forces around the fleet guide would prevent a surprise contact with the enemy from immediately endangering the valuable ships at the center of the formation.[4]

Figure 1: Typical Cruising Formation[5]



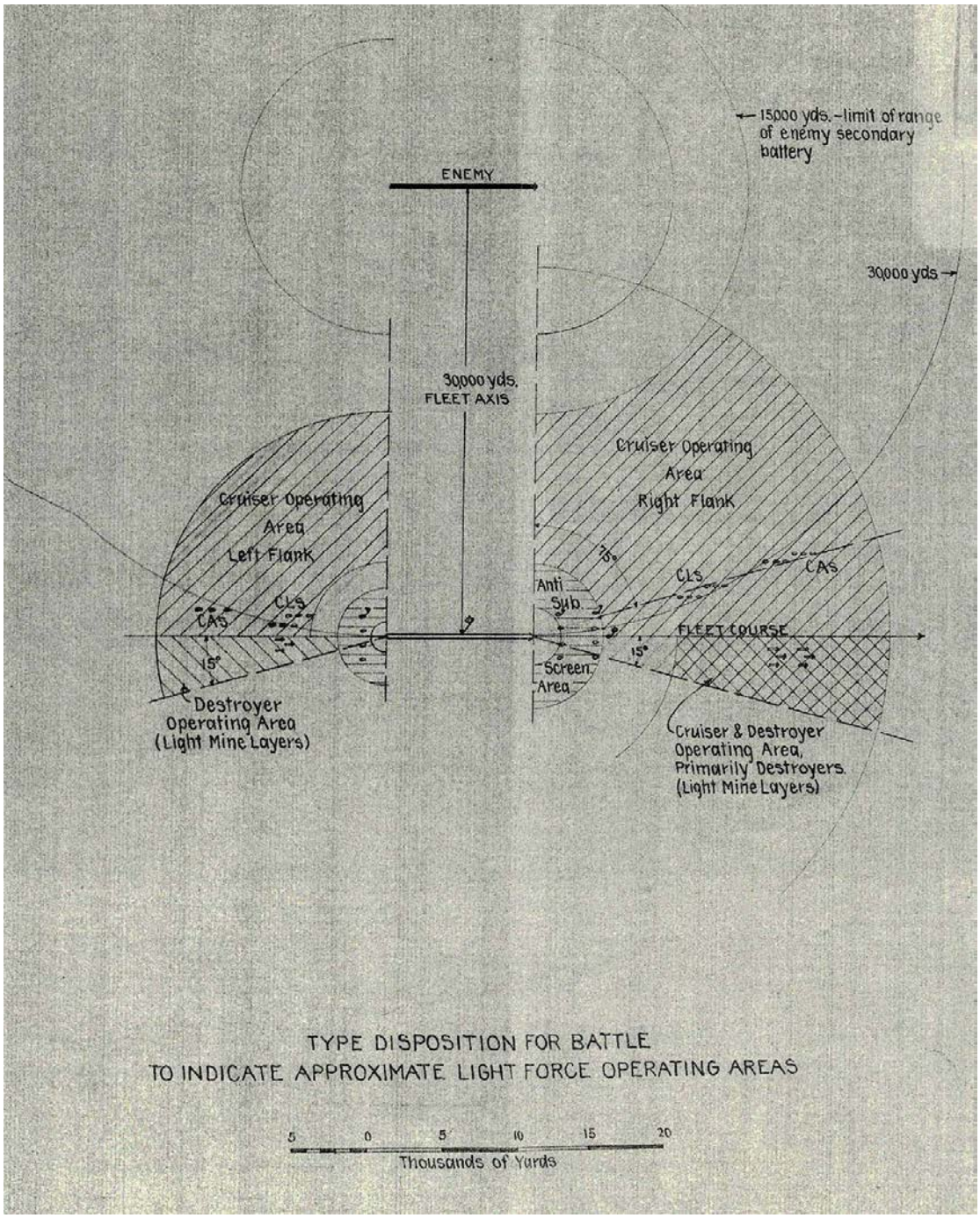
After the general location of the enemy had been determined, the fleet would shift into an approach formation. Approach formations featured greater concentration. They were designed to fix the location of the enemy and allow the fleet to deploy quickly into battle formation.[6]

Figure 2: Typical Approach Formation[7]



When contact with the enemy battle line was made, the fleet would turn ninety degrees and transition into battle formation. Battle formations represented the maximum concentration of force, and were intended to allow all elements of the fleet to focus on the destruction of the enemy battle line.[8] Light forces would concentrate at the head and rear of the formation. The exact ratio of this distribution would vary depending on the situation; placing two thirds of the light forces in the van and one third in the rear appears to have been the most common arrangement.[9]

Figure 3: Typical Battle Formation[10]



Lack of a Doctrine

The introduction of standard formations and maneuvers went a long way towards enabling the fleet to act as a coordinated unit in battle, but a coherent doctrine was still lacking. The Navy's doctrine was based on very basic tactical principles, which amounted to little more than platitudes.

"The fundamental tactical principle is that of superiority of force at the decisive point of contact." This was the underlying basis of the *War Instructions* of 1923.[11] It was hardly a doctrine. The limitations of this situation were well recognized. For some unaccountable reason the American Navy, and to a somewhat less degree the American Army, have never seriously endeavored to indoctrinate their officers, and thus to furnish as a basis for harmonious decisions during hostilities.[12]

Only a common doctrine would ensure that the Navy's forces could coordinate their actions in the heat of battle.

> … no plan, however well it may be expressed, can possibly be co-ordinately executed by a large force of vessels of several types operating against a strong and efficient enemy, unless the squadron, division and ship commanders have the same conceptions of war as their commander-in-chief and are well indoctrinated.[13]

The *War Instructions* made a similar observation, noting that victory would be aided by:

> Indoctrination of the forces, so that there may be mutual understanding of the intentions and plans of the commander in chief and so that there may be coordination in the means and methods employed in carrying out the tasks assigned and of the necessary procedure when without orders. [14]

However, the *War Instructions* provided little detail as to how such indoctrination was to be accomplished. Before it could begin, a doctrine had to be formulated; this became a major goal in the years following the Washington Treaty. The initial piece of the Navy's doctrine would be based around aggressive offensive action.

Aggressive Offensive Action and Long Range Fire

Jutland had shown that a decision could only be brought about by seizing the initiative. The Navy hoped that it could use aggressive offensive action to control the pace of battle and destroy an enemy battle fleet. Although the *War Instructions* of 1923 were noticeably lacking with regards to specific doctrinal concepts, the one point they make clearly is that victory could best be obtained through the "assumption of the offensive, which confers the advantage of the initiative and enables us to impose our plan on the enemy."[15]

In this regard, long range gunfire at the outset of an action was of the "greatest importance."[16] By opening fire at extreme range and possibly disrupting the enemy transition from approach to battle formation, the Navy hoped to seize the initiative from the outset of an action. If his deployment could be disrupted, the enemy would be placed at a disadvantage from which he might never be able to recover.[17] Other advantages would be conferred by long range fire as well.

Deck Penetration

As combat ranges increased, the steeper trajectories of plunging shells made it more likely that they would strike the deck of a target ship. This offered two distinct advantages. It increased the potential for penetration into the vitals of the target; no matter what target angle the enemy ship presented, if a shell struck the deck armor, the odds of a penetration would be the same. The Navy's own ships also were particularly well protected against such plunging fire.

Norman Friedman's numerous design studies have shown that the Navy's battleships enjoyed a relatively high level of protection against plunging fire. Beginning with the ships of the *Nevada* class, all the Navy's battleships had featured the "all-or-nothing" armor scheme. Employing only the heaviest armor over the most vital portions of the ship, "all or nothing" was the first battleship armor scheme specifically intended to

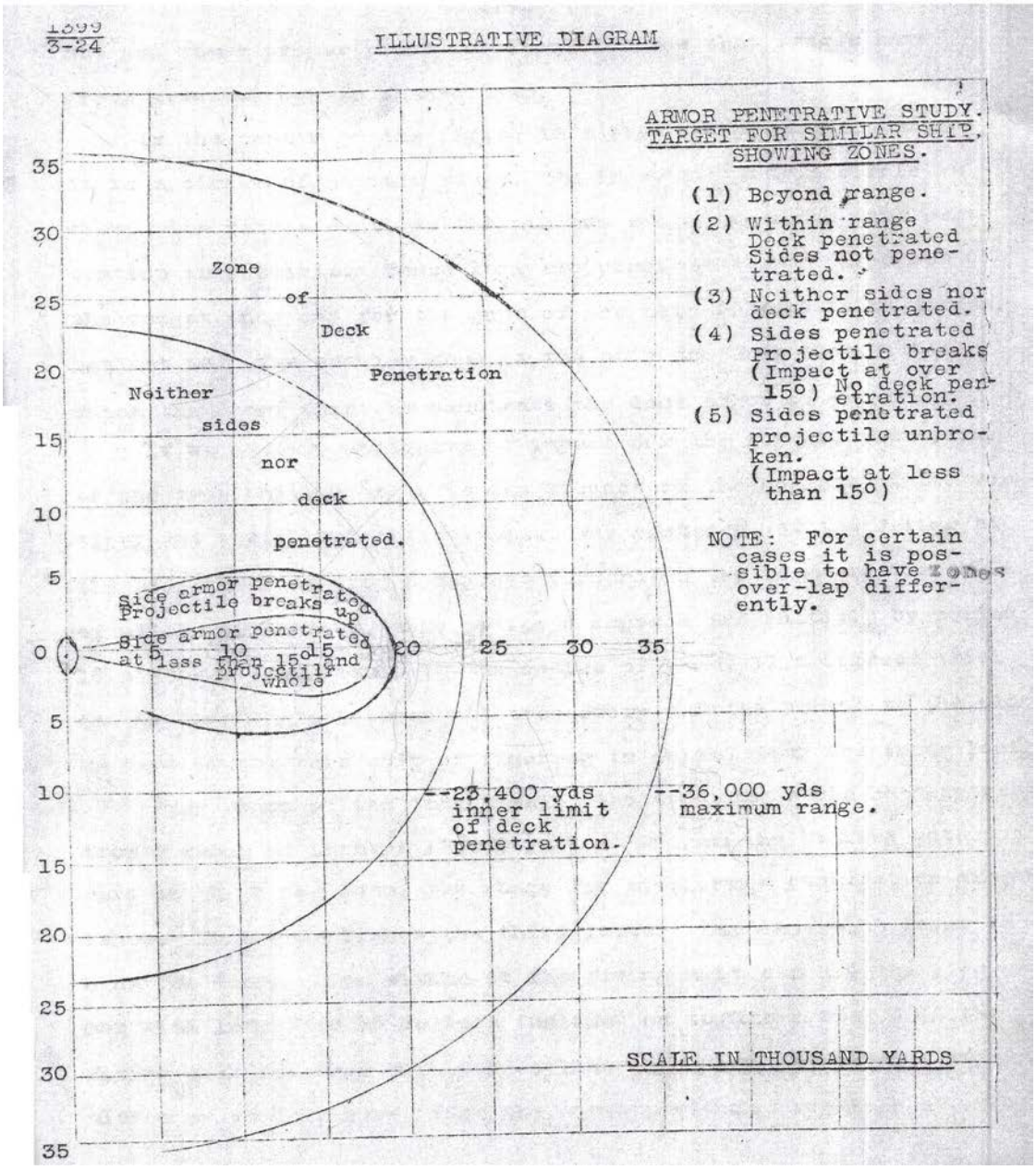
protect the ship in combat beyond 10,000 yards.[18] Twelve of the Navy's eighteen active battleships featured this scheme.

In contrast, the battleships of other navies had been designed with "incremental" armor schemes, a patchwork of armor of varied thicknesses designed to keep out shells fired from significantly shorter ranges. These schemes did not employ substantial deck protection, and were not designed to defeat shells fired from beyond 10,000 yards.[19]

As it developed, the Navy's concept of the immune zone influenced this preference for long range fire. The theory of the immune zone as developed in the US Navy is generally considered to have been a one-dimensional concept. The inner edge of the zone was defined by the minimum range at which a ship's belt armor would resist penetration; the outer edge corresponded to the maximum range at which the ship's deck armor would keep out a plunging shell. In between these ranges, the ship's vitals would be immune from penetration. Immune zones defined in this way were an important part of battleship designs of the interwar period.[20]

However, the Navy's understanding of the immune zone was in fact more complicated, taking into account not only the range but also target angle. As Figure 4 illustrates, it was a *two-dimensional* concept.

Figure 4: The Zone of Deck Penetration[21]



The majority of hits at close range, unless the target presented a target angle nearly perpendicular to the path of the shell, would be defeated by the oblique angle of impact. Shells striking at these angles would either break up upon striking heavy armor or glance off. Only under extremely favorable circumstances could decisive effect be obtained at close range. Long range fire presented no such complication.

At about 14,000 yards side hits and deck hits are equally numerous. At 30,000 yards 80% of the hits are on the deck, and all of the deck hits penetrate. They will be at least as destructive as penetrative hits on side armor at shorter ranges. If one chooses to fight at long range, and visibility and superior speed permit it, most of the sinking of ships will be done by this sort of plunging fire, which is very penetrative and very fatal…. The zone of deck penetration is enormous in area.[22]

When viewed in this light, the advantages of long range fire become obvious; even if fewer hits would occur at these ranges, the odds of a single hit being decisive were much greater. Once the preference for long range fire had been embraced, the problem then became how to hit at those ranges.

Aerial Spotting

In the 1920s and 30s, the accuracy of gunfire was dependent on the ability to spot the fall of shot; this in turn relied on the ability to see the impact of shells that missed the target. Spotters had to be able to see not only the masts and superstructure of the target ship, but more importantly, the ship's waterline. Without being able to gauge the distance between the target ship's hull and the splashes of missing shells, it was impossible to accurately adjust the fire control solution.

Because of these concerns, the maximum range of accurate gunfire was limited by the curvature of the Earth and the height of the spotting position. In practice, this confined the effective range of battleship gunfire to between 22,000 and 26,000 yards when spotting was restricted to the masts of the firing ship.[23] The only way to increase this distance was to increase the height of the spotting position. Masts could only be built so high; aircraft proved an ideal solution.

On the 17th of February 1919, the battleship *Texas* conducted a long-range firing exercise using aerial spotting. Radio was used to relay spotting data back to the *Texas*, and spotting from the plane proved much more effective than spotting from the masts of the

ship. Lieutenant Commander Kenneth Whiting, in his testimony before the General Board, estimated the increase in effectiveness to be as great as 200 percent.[24]

The increased effectiveness possible with aerial spotting was reflected in gunnery lectures at the Naval War College. In 1922 the College's assumptions about the accuracy of aerial spotting reflected Lieutenant Commander Whiting's experience.

Table 1: Accuracy of Battleship Gunfire[25]

Range	Percentage of Hits	
(Yards)	Top Spot	Plane Spot
12,000	12.3	---
14,000	8.9	---
16,000	6.2	---
18,000	4.2	---
20,000	2.6	4.3
22,000	1.5	3.4
24,000	0.7	2.7
26,000	0.1	2.2
28,000	---	1.8
30,000	---	1.5

The significance of these increasing capabilities was not lost on the Navy's leadership. As early as 1922, the Bureau of Aeronautics was advocating increased elevation for battleship guns because of the increased accuracy aerial spotting made possible at longer ranges.[26]

Technological Advances

Accurate long-range gunfire became even more effective with the introduction of the Ford Rangekeeper, a sophisticated fire control computer that could solve the differential

equation associated with the movement of two maneuvering ships.[27] First ordered in 1916, the Ford computers made possible the "very rapid postwar development of US naval gunnery."[28] By providing an accurate solution to the fire control problem, this system allowed the Navy's battleships to accurately predict the future location of an enemy ship and fire the shells at this location, increasing the chances of a hit. Friedman notes the importance of the device: "The success of the Ford Rangekeeper and its successors also convinced the US Navy that it was possible to hit consistently at very long ranges, so that aerial spotting was well worthwhile."[29]

In addition to the Ford Rangekeeper, the Navy's *Colorado* class battleships introduced the stable vertical, an artificial horizon designed for use at times when the actual horizon could not clearly be discerned.[30] This device increased the accuracy of long-range fire by ensuring that the guns of a battleship were fired at the correct point within that ship's roll. Previously, the visual horizon had been used, but it was not always visible, particularly at night or in conditions of poor visibility. Over time, the capabilities of the stable vertical were improved, and rather than serving as a supplement to the natural horizon, it became the primary indicator of the ship's inclination for fire control purposes. As older battleships were modernized, the device was added to their fire control systems.

Designs for Aggressive Doctrine – Battle Cruisers and Tinclads

The final design for the cancelled battle cruisers of the *Lexington* class reflected the Navy's emphasis on offensive action. Armed with eight sixteen-inch guns and with a design speed over thirty-three knots, the Navy's battle cruisers were intended to be an aggressive scouting arm. At the beginning of a fleet action they would locate and fix the enemy, forcing him to deploy and wresting the initiative from him. In order to achieve this heavy firepower and high speed, armor was sacrificed.

The final design for the *Lexington* featured seven inches of belt armor, only about half the thickness on contemporary battleships. Deck armor was closer to battleship standards; the total thickness of deck protection was three and one-half inches.[31] The greater

emphasis on deck armor reflects the importance the Navy assigned to engagement at long ranges approaching 30,000 yards.

The Washington Treaty prevented the construction of the new battle cruisers; "treaty cruisers" of up to 10,000 tons were allowed, and a naval race erupted in ships of this category. The Navy's priorities for these ships similarly reflected the emphasis on aggressive offensive action.

Since the size of cruisers is limited to ten thousand tons, it will probably be necessary in our new designs to forsake nearly all attempt at passive defense of these vessels – armor – in order to have weight available for the full development of speed, steaming radius and gun power. I think it is fundamental that once an American cruiser comes into contact with an enemy cruiser its gun power must be superior to the gun power of that enemy cruiser….[32]

The General Board's initial designs for new cruisers reflected this concept. In 1923, their preferred design featured twelve eight-inch guns and no armor.[33] Although other schemes with heavier armor were proposed, the Board eventually decided on a design with modest "antidestroyer" armor and ten eight-inch guns; this became the *Salt Lake City* class.[34]

Developing a Doctrine 1930-1941

By 1930 the Navy had begun to formulate a more sophisticated doctrine. The tactical publications and exercises of the period reflect the increasing level of sophistication and complexity.

Indoctrinating

The Navy possessed two valuable tools for the indoctrination of the fleet, the Fleet Problems, conducted on an annual basis through the 1930s, and the Naval War College. The latter was particularly well suited for testing and refining tactical concepts. Tabletop

exercises and simulations were a quick and inexpensive way to test new ideas and train officers.

We call it the Naval War College, but in reality this institution is more of a laboratory than a college. Here we study only enough to learn the sound principles on which successful warfare is based, the greater part of the time being devoted to actual operations and experiments carried out in chart maneuvers or on the game board. It is through such war games, conducted in miniature, that we can see the whole picture, that the student learns how to apply to actual war situations the principles he has learned through this study.[35]

As the Navy's doctrine became increasingly sophisticated, the Naval War College's importance increased. Officers were encouraged to attend; if they could not, correspondence courses were made available to disseminate doctrine.

The Naval War College had a correspondence course in strategy and tactics, and if you couldn't be there as we couldn't, why you were enjoined to enroll in this correspondence course, Strategy and Tactics. Well, I did, and that's where I became aware of this philosophy… which the standard tactical publications of the day expounded….[36]

The Fleet Problems were also an effective tool for familiarizing officers with the ideas contained in the tactical publications; as they were relatively infrequent, the opportunity presented was not to be missed.

It is especially during Fleet problems and tactical exercises that opportunities arise for familiarizing officers with "War Instructions", "General Tactical Instructions", and the various publications of the Fleet and type tactical orders and doctrine. Schools should be held on board each vessel as practicable for instructing officers in these important publications.[37] As the Navy's doctrine became more sophisticated, the importance of this familiarization increased. The tactical publications of the 1930s were far more comprehensive than those of earlier years.

Fleet Tactical Publications

In 1930, the Navy introduced the initial draft of a set of battle instructions, the first in a series of publications detailing the Navy's evolving tactical doctrine.[38] The ideas first presented in "Tentative Fleet Dispositions and Battle Plans, 1930" were later codified. *F.T.P. 143 War Instructions, 1934*, *F.T.P. 142 General Tactical Instructions, 1934*, *F.T.P. 188 General Tactical Instructions, 1940*, and numerous versions of *U.S.F. 10 Current Tactical Orders* refined the initial concepts. Together, these documents tell the story of the development of the Navy's doctrine in the years before World War Two.

The Development of Battle Plans

The most significant step forward in the 1930s was the introduction of battle plans. These were designed to be a general outline for the employment of the fleet in a major engagement. It is important to note that the plans were not rigid prescriptions. Rather, they were brief guides. Commanders were expected to develop their own plans reflecting the specific circumstances they faced using the plans in the tactical publications as a guide.

These plans allowed the Officer in Tactical Command (OTC), commander of the fleet in battle, an unprecedented level of flexibility. Plans would be distributed before an engagement and each would be identified by an alphanumeric code; the transmission of a specific code would signal the execution of the associated plan.[39] As each subordinate officer would already be familiar with his role in the plan, he could begin to fulfill his mission immediately upon receipt of the signal.

The Major Battle Plans

The tactical publications envisioned two basic types of action, normal action and reverse action, and four range bands, extreme, long, moderate, and close. Extreme range was considered to be 27,000 yards or more; long range was 21,000 yards to 27,000 yards; moderate range was 17,000 yards to 21,000; and close range was anything under 17,000 yards.[40]

In a normal action the opposing battle lines would steam on roughly parallel courses in the same general direction. It was assumed that a stronger force would seek this type of engagement, particularly if it possessed superior speed "so that it can impose an enveloping flank attack on the van flank of its opponent."[41] This was the traditional form of battleship action; it had been used at Tsushima, Jutland and in many engagements from the age of sail. The Navy appears to have assumed the enemy would expect this form of engagement.[42]

The second basic type of action was the reverse action. In this form of engagement, the battle lines would again steam on roughly parallel courses, but in opposite directions.[43] This unconventional approach was adopted to offset the slow speed of the Navy's battle line.

Alone among the world's major navies, the USN lacked battle cruisers. Both the Royal Navy and Imperial Japanese Navy had a substantial force of high-speed battle cruisers they employed as a detached wing at the head of their battle line. Against this, the US Navy had no effective counter, and it was feared that in a fleet engagement enemy battle cruisers would use their high speed to position themselves ahead of the Navy's battle line and force it to buckle or cross its "T".[44]

Experiments using a battleship force as a counter to an enemy detached wing were failures; the division of the battle line exposed it to defeat in detail.[45] Ultimately, the most effective solution to the problems posed by the enemy's detached wing came to be seen as unanticipated maneuver. The reverse action fit this design perfectly.

This is because it would place the enemy's light forces opposite our rear in a position from which they cannot make a successful attack, and a reversal of course by the enemy fleet will not improve the situation for the enemy unless a redistribution of light forces could be made.[46]

The enemy's detached wing of battle cruisers would similarly be out of position; "… it [a reverse action] offers a certain method of forcing the enemy to dispose his battle cruisers astern if he wishes to fight on a parallel course."[47] Reverse action was another extension of the Navy's desire to seize the initiative and control the pace of action.

Testing the Battle Plans

The Navy tested and refined its battle plans during the Fleet Problems; it was essential that they be proved effective in practice before they could be implemented in battle. The initial tests were performed in Fleet Problems X and XI, both held in 1930. The results were promising. Vice Admiral Cole, Commander of the Blue Fleet during the problems, offered the following comment:

The 'Tentative Fleet Disposition and Battle Plans, 1930' give to us the greatest single advance in fleet tactics I have known in my years of service in the fleet. It affords to the O.T.C. an extraordinary increase in the flexibility of control from the beginning of tactical scouting through the general engagement, and until the final dispersion of the enemy. Our greatest danger lies in an inflexible adherence to a conception of the enemy's strength and disposition made even under the best conditions of visibility for tactical surface and air scouting, but made with the fleets separate by forty to sixty thousand yards. We must have the tactical forms to admit of quick change, and the flexibility of mind to use them.[48]

Vice Admiral Bostwick, commander of the Black Fleet, had similar positive comments:

> The introduction of the Tentative Fleet Dispositions and Battle Plans, U.S. Fleet, 1930, has opened possibilities for advancement in the tactics of the Fleet. The new publication has been found simple to understand and use in operations…. The eager acceptance of this work by all that have used it brings out the need for a survey of all our instructions and manuals and a careful revision of the War Instructions and General Tactical Instructions, with the inclusion of the Tentative

> Fleet Dispositions and Battle Plans therein, also Formations and Maneuvers of the Battle Line.[49]

The battle plans were refined in the next few years and codified by the publication of *F.T.P. 142 General Tactical Instructions, United States Navy* in 1934. Continued testing during the 1930s did not reveal the need for any significant changes, and the plans were published again in 1940 in the revised version of the *General Tactical Instructions, F.T.P. 188*.

Using the Battle Plans

Due to the success of the battle plans, the use of a plan became a central foundation of the Navy's doctrine in the 1930s.

> Battle will be governed by a definite plan…. The battle plan may be prescribed by appropriate general signal, using the numerals and letters designating a typical battle plan from Chapter XIV, General Tactical Instructions, a plan contained herein, or other plan prepared by a responsible commander for a particular operation.[50]
>
> The Battle Disposition of forces present is wholly flexible and will be prescribed by the Senior Officer Present (O.T.C.). It will be based on his battle plan which, in turn, will depend on our Own and Enemy forces present.[51]

Battle plans were designed for a specific set of existing tactical and operational circumstances; effective plans were those that leveraged existing factors of strength while simultaneously emphasizing enemy weaknesses.

> Battle plans must utilize our own known or estimated factors of superiority in methods, skill, and material to defeat the enemy by taking advantage of his known or supposed weaknesses or by nullifying his elements of superiority.[52]

The prevailing circumstances would determine the Navy's plan of action. The ability to employ aerial spotting, the range of battleship guns, and the relative protection of battleships would be used to determine circumstances under which action would be advantageous.[53]

> The battle will be governed by a well defined plan. This plan will be based on the employment primarily of the weapon in which we are superior to the enemy. Other weapons will be employed in a manner contributing to the employment of our superior weapon.[54]

Succinct battle plans following a general format would allow the Navy's officers to plan for multiple contingencies and quickly transition between them in the heat of battle. Such a flexible approach to the inherently confusing nature of conflict would, it was hoped, allow the Navy to react swiftly to changing circumstances and remain one step ahead of potential opponents.

U.S. Naval Doctrine Refined

The emphasis on aggressive offensive action and the use of long range fire with aerial spotting remained staples of the Navy's doctrine through the interwar period. As the capabilities of carrier-based aircraft increased, the concept of attacking an enemy battle line with carrier planes, destroyer torpedoes and battleship gunfire at the outset of an action became part of the Navy's tactical doctrine. Although the focus on aggressive offensive action remained, ship designs during this period enjoyed a larger scale of protection, based in part on experience gained with less well-protected designs in the Fleet Problems and tactical exercises.

Aggressive Offensive Action

The desire to seize and retain the tactical initiative through determined offensive action was an essential part of the Navy's doctrine in the interwar period. In the words of Admiral Schofield, "I am of the opinion that we are stronger, quicker, and more effective when acting on the offensive than on the defensive."[55]

The Fleet Problems provided evidence of the advantages that could be gained through aggressive action. In Problem X, Black's smaller carrier force gained control of the air by using *Lexington* to seek out and attack the Blue carrier forces. With *Saratoga* and *Langley* both disabled, Blue was left at a severe disadvantage for the remainder of the problem. The Chief Observer concluded:

> The suddenness with which factors of strength can be destroyed and the completeness of success which may be achieved if tactical advantages are realized and seized in a modern action furnishes ample material for thought and reflection.[56]

In the words of historian Wayne Hughes, the Navy had learned the need to "attack effectively first".[57] This concept came to be stressed in the design of new equipment, research and development efforts, and the Navy's gunnery exercises.

Short Range and Long Range Battle Practices both emphasized the importance of scoring hits early. By getting on target rapidly, a ship could achieve a much higher score than another ship which achieved an equal or even greater number of hits, but got on target late.[58] Getting on target late in an exercise meant fewer points; in war it might lead to defeat.

With the realization of the decisive nature initial attacks could have, the Navy sought to procure equipment that would allow it to make such attacks. This was an important step in the development of the scout bomber.[59] This concept culminated in the SBD, an aircraft which enjoyed great success in World War Two, and was instrumental in the victory at Midway.

This desire for accurate fire immediately at the start of an action spurred the development of Radar and its integration into fire control systems. Early Radar sets lacked the ability to give accurate targeting information on their own. Their wavelengths were too long to

provide target bearing data sufficient for a fire control solution, but the range information they provided was more accurate than visual methods, particularly in conditions of low visibility.[60] Early Radar of this type proved itself in the Solomons in 1942.[61]

The Navy's principle of aggressive offensive action formed the basis for many important decisions in the interwar period. The doctrine was designed not only to cause the enemy physical harm, but also to reduce his effectiveness by keeping him off balance. The initiative would never be ceded to the enemy; it would be constantly imposed upon him.[62]

The Use of Maneuver to Seize the Initiative

In the 1930s maneuver became another way to seize and retain the tactical initiative. The reverse action detailed in the tactical publications is the most striking example:

> The Commander-in-Chief has devoted considerable attention to developing the technique of a fleet action on opposite courses. He considers that this type of action offers great opportunities to a well-drilled Fleet for gaining a decisive victory. Furthermore, it offers a certain method of forcing the enemy to dispose his battle cruisers astern if he wishes to fight on a parallel course…. It is true that if we elect to fight on a reverse course the enemy can do to us all the things we can do to him, provided he instantly detects our intentions and has a fleet perfectly drilled in the rapid execution of a new and complicated plan of action. Even in this case we will gain the advantage of the initiative and have a start of at least 5 minutes before the enemy can imitate our movements.[63]

Other examples took the form of deceptive maneuvers, designed to force the enemy to deploy in the wrong direction. Blue's battle instructions for Fleet Problem XV contained plans for such a deception:

> As the two fleets approach close to gunfire ranges this position of his battle cruisers [at the forefront of the battle line] is a considerable embarrassment to

> Gray, as he must avoid their being overwhelmed by the Blue Battle Line before the Gray Battle Line can enter the action. This compels Gray to commence the movement of his battle cruisers toward one battle flank some time before the deployment of the Battle Line. It is probable that he will commence this movement as soon as he gets the first indications of the direction of Blue deployment. It follows that Gray is very susceptible to deception on this point by Blue.[64]

The deceptive maneuver envisioned was a "change of course of the Battle Line by division column movement away from the intended direction of the fleet deployment."[65] Blue failed to use these deceptive measures because of the limitations of the prevailing visibility, but the intent to use maneuver in order to seize the initiative is obvious.

Long Range Fire with Aerial Spotting

The benefits of opening fire at maximum effective range had already been recognized. The tactical publications emphasized this preferred method of offensive action.

> Fire should be opened, normally, at the maximum range at which an effective fire can delivered under the conditions which exist at the time. The advantage of an initial superiority is so great that every effort should be made to establish early hitting. It should be remembered, however, that at extreme ranges the ammunition expenditure may be excessive as compared to the damage inflicted.[66]

Evidence that this concept was embraced in the fleet can be found throughout the Navy's exercises; numerous examples of battleships opening fire at extreme range are present.

In Fleet Problem X (1930), *New Mexico* opened fire at the extreme range of 35,000 yards.[67] In the mock combat of Fleet Problem XI (1930), the opposing fleets opened fire at 32,000 yards.[68] Fleet Problem XIII (1932) witnessed *Nevada* firing at 30,000 yards.[69] During problem XVI (1935) fire was opened at 38,000 yards.[70] In Fleet Problem XVII

(1936), maximum gun range was considered to be 35,000 yards; during Fleet Problem XX (1939), fire was opened at that extreme range.[71]

Problems at the Naval War College exhibited slightly shorter opening ranges, often because of visibility limitations. In *Tactical Problem III-1934-SR* of 1933 the battle lines engaged each other at ranges out to 27,000 yards; maximum visibility was 28,000 yards.[72] *Operations Problem II-1935-SR* (1935) saw engagement ranges of 27,000 yards.[73] In *Operations Problem III-1935-SR* (1935), visibility was restricted to 25,000 yards and this "prevented Blue from using her extreme range advantage."[74]

Fire at these ranges was considered to be very effective under the proper conditions of visibility, but would be nearly impossible without aerial spotting.

> The gunnery of the BLACK battleships was carried on with great precision under favorable conditions of light, sea and wind. The masts of the White Fleet showed up clearly. With aircraft control there would have been no difficulty in maintaining an effective fire and at 26,000 yards I believe we could have kept salvoes straddling the top spotting against the foremasts of the enemy. It was ideal weather and sea for long range gunnery. A heavy fire was delivered on the head of the enemy column when first contacted which would undoubtedly have inflicted much damage before he was able to deploy his forces on a more favorable course.[75]

Without aerial spotting, the maximum effective range of battleship guns was considered to be 28,000 yards. However, in the simulated combat of the Fleet Problems, the effectiveness of battleship gunfire was halved at ranges over 22,000 yards unless aerial spotting was employed.[76]

Estimates at the Naval War College predicted even greater effectiveness for aerial spotting; in 1935 it was assumed that at 29,000 yards air spot would deliver six times as

many hits as observation from spotters aloft.[77] It was therefore essential to ensure aerial spotting for effective long range gunfire.

Concentrated Gunfire

Aerial spotting could be combined with concentrated gunfire to quickly gain an advantage at the outset of an action. The Navy's first exposure to the potential effect of concentrated gunfire had come through cooperation with the Royal Navy in the First World War. "By 1917 British officers claimed that the massed fire of one or two battle divisions could break up an enemy line, as Nelson had done."[78] In the 1930s, concentrated gunfire was employed with great effect in the Fleet Problems and tactical exercises.

In Fleet Problem XVI, the *Idaho* was destroyed in six minutes by the concentrated fire of six enemy battleships and battle cruisers at extreme range. *Idaho* had been torpedoed earlier in the problem, but was still an effective unit before the enemy's concentrated fire put her out of action.[79] The other two ships of Battleship Division Three were overwhelmed in turn.

> It is considered that the damage adjudged against BatDiv Three was properly awarded by the Assistance Umpires, this division being under concentrated fire from enemy battleships and battle cruisers … for about 30 minutes….[80]

In Fleet Problem XX, *California* was wrecked by the concentrated fire of two Black battleships from the moderate range of 17,500 yards. After several minutes of sustained fire, *California* was severely damaged and forced to haul out of line.[81]

During the Naval War College's *Tactical Problem III-1934-SR* (1933) two Orange battleships were rapidly damaged by concentrated gunfire. The first was sunk by the fire of three Blue battleships; the second suffered 50% damage from a double concentration.[82]

However, it was recognized that there were limitations to the effectiveness of concentrated fire. The concentration of more than three battleships against a single target was believed to be wasteful, and not encouraged under normal circumstances.[83]

By 1938 the Navy had increased the complexity of the Umpire Rules governing the Fleet Problems. The effectiveness of concentrated gunfire was now specifically stated. "If two or more ships concentrate fire on a single ship the damage effect will be increased 50 percent."[84]

Earlier versions of the rules make no specific indication of the amount of damage resulting from concentration; it may be that in earlier exercises the concentrated fire of multiple ships was applied without penalty, so that if two ships fired at a single target, the resulting damage would be double that resulting from a single firing ship.[85] This may explain why concentrated fire was so effective in Fleet Problems before 1938.

Combined Arms Attacks

In order to increase the effectiveness of each of its weapons, the Navy sought to employ coordinated attacks against the enemy battle line. If these plans went as designed, battleship shells, destroyer torpedoes, and aerial bombs would all strike the enemy battle line simultaneously. It was hoped that this concentration of firepower would quickly overwhelm the enemy.

Rear Admiral Laning, in his pamphlet, *The Naval Battle*, stated it this way:

> With so many weapons carried on such different types of ships it is apparent that if we are to get the maximum effect of all weapons and make our blow the sum total of the blows of all, there must be perfect coordination between the types carrying them.[86]

This concept was extensively tested in tactical exercises. In the Naval War College's *Tactical Problem IV* of 1935 a coordinated attack by Orange patrol planes and torpedo

bombers damaged several Blue battleships while they were in the process of deploying into their battle formation. *Pennsylvania* sustained a total of 40% damage from the attacks.[87]

In Fleet Problem XV, the attack of carrier planes was well timed and coincided with the beginning of the battleship engagement. "It will be noted that the engagement of our Battle Line had been coordinated by the O.T.C. quite effectively with our air attacks."[88] Such coordination required planning and exact timing, but it was assumed that the benefits would make it well worthwhile. The Tactical Problem associated with *Operations Problem II-1935-SR* saw an air attack by Blue forces in the opening stages of the action, seriously damaging two Red battle cruisers.[89]

During Fleet Problem XX, attacks on battleships during the fleet action were very effective. The *New York* was destroyed by a combination of battleship gunfire and aerial attacks. Dive bombers and torpedo bombers inflicted a total of 33% damage, the majority of it early in the action. Battleship gunfire finished her off; she suffered 50% damage from gunfire overall.[90]

Much of the incentive for these coordinated attacks resulted from the perceived vulnerability of attacking aircraft.

> I doubt the advisability of a carrier plane attack against a battleship division in close formation unless the conditions are most favorable or unless executed in support of some other operation. I believe that such an attack would result in very heavy damage to the attacking planes and doubt if the resulting battleship damage would justify the operation.[91]

The Umpire Rules reflected this assumption. They specified that torpedo bombing, dive bombing and level bombing attacks would score twice as many hits if unopposed by antiaircraft fire and if the target ship was unable to maneuver. The effectiveness of attacks would be increased to a lesser extent if only one of these conditions prevailed.[92]

By delivering such attacks during a fleet engagement, the enemy would be forced to choose between maneuvering and reducing the effectiveness of his gunfire against the US ships, or maintaining a steady course and offering an easier target for aerial attacks.

The aerial attacks were also expected to assist the battleships by decreasing the effectiveness of enemy gunfire.

> It is hoped that the … air attacks will inflict serious injuries on the fire control equipment, the secondary batteries and the communication facilities of the Gray battleships immediately prior to or soon after the commencement of the action. It is also possible that certain Gray vessels will be reduced in speed and compelled to leave the battle line.[93]

By coordinating all of its weapons simultaneously against the enemy battle line, the Navy hoped to maximize the effectiveness of each. It was a natural extension of the Navy's emphasis on employing aggressive offensive action from the outset of an action to control the battle's tempo and destroy the enemy.

Designs with Greater Protection

Tests in the Fleet Problems and tactical exercises illustrated the vulnerability of the first two classes of heavy cruisers built under the auspices of the Washington Treaty. These "tinclads", as they came to be called, were particularly vulnerable in close range encounters at night. This situation was highly unfavorable for heavy cruisers. They would have been at the mercy of battleships and light cruisers, while even destroyer leaders could have punished them severely.[94] Admiral Laning, while commander of the Scouting Force, also took note of the vulnerability of these cruisers at close range. Laning concluded that in a fleet engagement the heavy cruisers would have to beat off enemy light cruisers inside 8,000 yards and enemy destroyers from point-blank range to 4,000 yards. The 4.7-, 5.1-, and 6-in gunfire would be extremely destructive at such ranges.[95] The solution was obvious. The cruisers needed more armor. Fortunately, improvements

in design allowed later ships to enjoy a substantially greater level of protection without sacrificing firepower or speed.

The result was the ships of the *Portland* and *New Orleans* classes. These ships were given sufficient protection over their magazines to offer resistance to eight-inch gunfire. Other vital areas were protected against five-inch shells at the close ranges Laning had anticipated.[96] The additional armor would serve the Navy well. In the night action fought off Guadalcanal on the morning of August 13, 1942, *San Francisco*, a ship of the *New Orleans* class, survived several hits from fourteen-inch shells.[97]

The Fruit of a Common Doctrine

As the Navy's officers became increasingly indoctrinated, their coordinated action in battle became increasingly assured. This allowed the Navy the freedom to leverage one of its most effective weapons, the talent and skill of its officer corps.

> The Commander-in-Chief considers that our officer corps is the most intelligent and best educated of any in the world. It is our greatest naval asset today. He desires that it be used to maximum advantage in battle. Therefore, he expects that every battle situation shall be judged strictly on its own merits, and not upon instructions printed long before. Decisive, positive, aggressive action suited to the actual situation, must be the guiding idea of every flag and commanding officer.[98]

In order to encourage flexibility and initiative, the Commander-in-Chief, Admiral Sellers, elected to cast aside the battle plans in Fleet Problem XV (1934):

> The second idea I have endeavored to emphasize is that of flexibility. As O.T.C. I commence a battle exercise with an entirely open mind. I have no set plan. The Fleet commences searching for the enemy and making air attacks. The Battle Line and its attached forces are handled in accordance with the situation that develops, whatever this may be. By the use of general signals it is possible to

> operate the Fleet in any way desired. Every situation is judged by its own merits. This is the only principle of naval tactics that is always applicable.[99]

Sellers was particularly interested in presenting the officers of the fleet with the challenge of evaluating a constantly changing situation. For Fleet Problem XV (1934) his plan was "to present to opposing commanders of all ranks a rapidly changing situation over an extended period."[100] The goal was to encourage officers to acknowledge and embrace the fluidity of a combat situation:

> Our tactical training thus far has been based almost entirely on the estimate of a single situation. While this may sometimes be appropriate under some conditions, it is believed that training in making a continuous or running estimate of a situation that is changing from hour to hour is far better preparation for war. War might be likened to a moving picture. As its story unfolds our minds must be alert in following its course.[101]

Admiral Reeves further emphasized the importance of flexible thinking when he presided over Fleet Problem XVI in 1935:

> An estimate of what the enemy will probably do is important, but we should not be surprised when the enemy does something else. The really important thing is what we do when the enemy has acted, and we know what his action is.[102]

The ability of the Navy to employ such a flexible approach to battle is an indication that by this time the efforts to produce a common doctrine had begun to bear fruit. It was starting to allow the Navy's officers to swiftly coordinate reactions to a changing situation without specific instructions. By Fleet Problem XV, major elements of the fleet were operating in this manner:

> It will be noted that the Commander-in-Chief gave no important orders to any of the detached forces, i.e., the Air Force, the Submarine Force, and the Scouting

> Force. These forces conducted their operations entirely by means of the current Battle Instructions, thus proving the great progress made in the indoctrination of the Fleet. After the exercise the Commander-in-Chief could think of nothing more to add to the Battle Instructions. In fact, these are now becoming so well known, that they are required mostly for new units joining the Fleet.[103]

When combined with a well-defined plan, this common doctrine would allow officers to understand their general role in the battle and act independently in furtherance of the objective.

> The O.T.C. intends that all subordinate commanders shall have the fullest freedom of action in the handling of their forces. If there is something that obviously should be done, he expects that no one will wait for orders to do it. The purpose of these instructions is to impart to subordinate commanders the present intentions and ideas of the O.T.C., which may be greatly modified by unforeseen conditions during the engagement. However, the O.T.C. expects that in any given situation all forces shall be used to their maximum capabilities.[104]

Success would depend on the ability of individual commanders to interpret their orders and act upon them while simultaneously taking into account their place in the overall plan and the current tactical situation.[105] Every officer was to be aware of the existing situation and alert for potential opportunities.[106]

The presence of a common doctrine allowed the Navy to utilize one of its most effective weapons, the training and education of its officer corps. The formulation of a specific plan of action increased the effectiveness of this doctrine by ensuring that all officers knew the plan of action and their specific role in the battle. This had been the goal all along, and in the years before Pearl Harbor, the Navy achieved it.

<u>Conclusion</u>

At the beginning of the interwar period, the Navy lacked a common doctrine. Initial steps to rectify this deficiency focused on two themes, the development of formations designed to coordinate the movement of the fleet in battle, and aggressive offensive action to seize the initiative at the outset of an action. The lack of a common doctrine made this second theme difficult to implement. At first, the Navy restricted its efforts to the development of the capability to engage in extremely long range gunfire.

By 1930, the Navy's doctrine was growing more sophisticated. A series of draft instructions were introduced in that year; they were intended to form the basis for more specific battle plans developed by commanders to reflect the expected conditions of an impending engagement. These instructions and plans proved to be very effective and were rapidly adopted into the Navy's doctrinal framework.

The focus on aggressive offensive action remained and was expanded. It influenced design decisions, research and development efforts, and formed the basis for gunnery exercises. Mated with the increasing capability of the Navy to strike the enemy at long range with aircraft or battleship gunfire, aggressive offensive action became a formidable aspect of the Navy's interwar doctrine.

As the Navy's officer corps became increasingly familiar with this doctrine, it became possible for the Navy to enjoy both coordinated action and a decentralized command and control structure, the primary goal of all doctrinal development. The increasing use of individual initiative in the Fleet Problems of the late 1930s reflects this trend.

On December 7th, the battle line, centerpiece of the fleet, was destroyed, but the doctrinal principles developed for that fleet could be readily applied to the Navy's remaining forces in the absence of the battle line. The ensuing battles, both those dominated by the aircraft carrier and the confused night action ruled by the torpedo, could be won through the application of the principles of the Navy's tactical doctrine. The emphasis on decisive offensive action, reliance on individual initiative, and development of

decentralized command and control are hallmarks of the effective doctrine that helped ensure victory in the Pacific War.

---

[1] The U.S. Navy took note of the numerous navigational errors that occurred among the British ships at the Battle of Jutland. See *Report of Tactical Exercises 3-5 October*, Commander-in-Chief, United States Fleet, October 12, 1933 (Roll 16, Target 2, Fleet Problem XV, Correspondence Regarding Concept of the Problem, Records of the Office of the Chief of Naval Operations, Record Group 38, National Archives. : RG38, NA), 12;
For criticisms of the British dispositions and failure to seize the offensive see *The Battle of Jutland, Lecture delivered at the Army War College 1925*, Captain J.M. Reeves, Head of Department of Tactics at the Naval War College, Naval War College, Newport, RI, May 1925 (Box 10, Strategic Plans Division Records, RG38, NA)
[2] *W.L. 4*, Formations *and Maneuvers of the Battle Line, United States Navy*, 1922 (Box 4, Strategic Plans Division Records, RG38, NA), 4
[3] *W.L. 4, Formations and Maneuvers of the Battle Line, United States Navy*, 1922 (Box 4, Strategic Plans Division Records, RG38, NA), 7
[4] *F.T. 45, General Tactical Instructions, United States Navy*, 1924 (Classified Operational Archives, Naval Historical Center, Washington Navy Yard, World War Two Command File. : NHC, WW2 CF, Box 106), Cruising Disposition No. 2, 27. I am very grateful to Navy archivist Kenneth Johnson, whose assistance in locating documents in the Naval Historical Center's Operational Archives was invaluable.;
U.S.F. 10, Current Tactical Orders, United States Fleet, 1934 (NHC, WW2 CF, Box 270), Cruising Disposition 4L, Diagram Number One;
Campbell, Mark Allen, *The Influence of Air Power Upon the Evolution of Battle Doctrine in the U.S. Navy, 1922-1941* (History Department, University of Massachusetts, Master of Arts Thesis, December 1992), 83-88
[5] *Operations Problem VI, Naval War College*, March 1940 (Box 25, Strategic Plans Division, RG38, NA), Cruising Disposition, Blue Staff Solution
[6] Campbell, *The Influence of Air Power*, 83-88
[7] *U.S.F. 10, Current Tactical Orders, United States Fleet*, 1938 (NHC, WW2 CF, Box 270), Cruising Disposition 6R, 13
[8] Campbell, *The Influence of Air Power*, 83-88
[9] Campbell, *The Influence of Air Power*, 89
[10] *U.S.F. 10, Current Tactical Orders and Doctrine, United States Fleet*, 1941 (NHC, WW2 CF, Box 270), Diagram Number One, 33
[11] *W.L 7, War Instructions, United States Navy*, 1923 (Box 5, Strategic Plans Division Records, RG38, NA), 90
[12] Knox, Lieutenant Commander Dudley W., *The Role of Doctrine in Naval Warfare*, Naval War College, Newport, RI, 19 May 1924 (Box 32, Strategic Plans Division Records, RG38, NA), 5
[13] Knox, *The Role of Doctrine in Naval Warfare*, 13
[14] *W.L 7, War Instructions, United States Navy*, 1923 (Box 5, Strategic Plans Division Records, RG38, NA), 90

[15] *W.L 7, War Instructions, United States Navy*, 1923 (Box 5, Strategic Plans Division Records, RG38, NA), 90
[16] *W.L 7, War Instructions, United States Navy*, 1923 (Box 5, Strategic Plans Division Records, RG38, NA), 103
[17] Campbell, *The Influence of Air Power*, 89
[18] Friedman, Norman, *US Battleships: An Illustrated Design History* (Annapolis, MD, Naval Institute Press, 1985), 101-102;
Friedman, Norman "USS Nevada: the 'all or nothing' Scheme of Protection", *Warship*, Volume 1, Number 2, 32
[19] The British battleships *Nelson* and *Rodney*, which did feature an "all or nothing" scheme, are not considered here because they were not completed until 1927, well after the acceptance of the Washington Treaty. The battle cruiser *Hood*, although her design was modified in light of experience at Jutland, had an "incremental" armor scheme.
Friedman, Norman, *Battleship Design and Development 1905-1945* (Greenwich, England, Conway Maritime Press, 1978), 54-66
[20] Friedman, *US Battleships*, 254-255, 310
[21] Schuyler, Commander G. L., *Recent Developments in Ordnance*, Naval War College, Newport, RI, 12 March, 1924 (Box 11, Strategic Plans Division Records, RG38, NA), Illustrative Diagram, 16
[22] Schuyler, Commander G. L., *Recent Developments in Ordnance*, Naval War College, Newport, RI, 12 March, 1924 (Box 11, Strategic Plans Division Records, RG38, NA), 18
[23] Friedman, Norman, *US Naval Weapons* (Annapolis, MD, Naval Institute Press, 1985), 37-38
Encyclopedia Britannica - http://www.britannica.com/eb/article?eu=41960&tocid=0
The range to the horizon in statute miles is equal to 1.224 multiplied by the square root of the height of the spotter in feet. This indicates that from a height of 120 feet, the height of the spotting tops on the Navy's battleships, the horizon is approximately 23,500 yards distant.
[24] Wildenberg, Thomas, "In Support of the Battle Line: Gunnery's Influence on the Development of Carrier Aviation in the U.S. Navy", *The Journal of Military History*, Volume 65, July 2001, 700
[25] Watts, Captain W. C., *Lecture on Gunnery for War College Class of 1923*, Naval War College, Newport, RI, 22 September 1922 (Box 13, Strategic Plans Division Records, RG38, NA), Table E, 46
[26] Friedman, *US Battleships*, 191
[27] A differential equation is necessary to solve the problem of predicting the location of two maneuvering ships because of the changes of course they can make; only in an ideal situation will both of them be moving in a straight line.

Consider the following example. A firing ship is steaming course 000 (North) at 12 knots. Its target is steaming course 315 (Northwest) at 12 knots. Initially, the relative bearing to the target ship is 090 (East) and the range 10,000 yards, just shy of 5 nautical miles (4.937 nautical miles, to be more exact).

If neither ship turns, then their relative positions five minutes later may be calculated with trigonometry. The firing ship will have moved 1 nautical mile along course 000 and the target will have moved 1 nautical mile along course 315. We know

that it has therefore moved 0.707 (sin(45) = 0.707) nautical miles along course 270 (West) and 0.707 (cos(45) = 0.707) nautical miles along course 000. Therefore, the distance between the firing ship's track and the target ship has decreased to 4.230 nautical miles and it has fallen behind by 0.293 nautical miles. These distances form the two sides of a right triangle, with the hypotenuse being the linear distance between the two ships.

Trigonometry and the Pythagorean theorem again allow us to determine the length of this hypotenuse and the angle of bearing of the target shi This distance is 4.240 nautical miles ($(0.293)^2 + (4.230)^2 = (4.240)^2$), and the angle is 86 degrees (arctan(4.230/0.293) = 86). As this is the angle between the firing ship's track and the target, which is now slightly astern, the relative bearing becomes 094. The distance converts to 8,588 yards.

This simplest of examples illustrates the basic principles involved in plotting the movement of two ships. A significantly greater magnitude of complexity would be introduced if the target ship were turning to come onto a parallel course to the firing shi An accurate calculation would then require a differential equation. Effectively an infinite series of trigonometric calculations like the example above would have to be calculated as the target ship traced through the arc of its turn. It was exactly those sorts of calculations that the Ford Rangekeeper was designed to solve.

[28] Friedman, *US Battleships*, 173

[29] Friedman, *US Battleships*, 173

[30] The horizon is important to accurate gunfire because it is necessary to fire the guns when the ship is at the midpoint of its roll, when the level of the deck is parallel to the horizon. Campbell, John, *Naval Weapons of World War Two* (Annapolis, MD, Naval Institute Press, 1985), 106.

[31] For details of the final *Lexington* design see, Friedman, Norman, *US Cruisers, An Illustrated Design History* (Annapolis, MD, Naval Institute Press, 1984), 99

[32] Schofield, Captain F. H., *Some Effects of the Washington Conference on American Naval Strategy*, 24 October 1923 (Box 11, Strategic Plans Division Records, RG38, NA), 4

[33] Friedman, *US Cruisers*, 118

[34] Friedman, *US Cruisers*, 121

[35] Laning, Harris, Admiral United States Navy, Retired, *An Admiral's Yarn*, Naval War College Press, Newport, RI, 1999, Appendix I, *Opening Address Delivered before the Naval War College staff and classes of 1931*, by Rear Admiral Harris Laning, 2 July, 1930, 399

[36] Interview with VADM Lloyd M. Mustin, August 1972, U.S. Naval Institute, Oral History Collection (Annapolis, MD), Vol. 7, 20

[37] *General Instructions for Aircraft, Battle Force, During Fleet Problem XVI*, Commander Aircraft Battle Force, 27 April, 1935 (Fleet Problem XVI, CINCUS Report, Sept. 15, 1935 (Enclosures A-I), Records of the Chief of Naval Operations, RG38, NA), 2

[38] The document "Tentative Fleet Dispositions and Battle Plans" was issued and first tested during fiscal year 1930. *Annual Report of the Commander-in-Chief, U. S. Fleet for the Period 1 July, 1929 to 30 June, 1930* (NHC, WW2 CF, Box 256), 17

Revisions of the document were further tested during the next two years. *Annual Report of the Commander-in-Chief, United States Fleet for the Period 1 July, 1930 to 30 June, 1931* (NHC, WW2 CF, Box 256), 10;
Annual Report of the Commander-in-Chief, United States Fleet for the Period 1 July, 1931 to 30 June, 1932 (NHC, WW2 CF, Box 256), 23

[39] *F.T. 143, War Instructions, United States Navy*, 1934 (NHC, WW2 CF, Box 108), 83-84

[40] *F.T. 143, War Instructions, United States Navy*, 1934 (NHC, WW2 CF, Box 108), 86;
F.T. 142, General Tactical Instructions, United States Navy, 1934 (NHC, WW2 CF, Box 108), 235;
F.T. 188, General Tactical Instructions, United States Navy, 1940 (NHC, WW2 CF, Box 108), 14-1

[41] *F.T. 143, War Instructions, United States Navy*, 1934 (NHC, WW2 CF, Box 108), 104

[42] The Japanese did indeed plan for a "normal" action on parallel courses. Evans, David C. and Peattie, Mark R., *Kaigun* (Annapolis, MD, Naval Institute Press, 1997), 282-286

[43] *F.T. 143, War Instructions, United States Navy*, 1934 (NHC, WW2 CF, Box 108), 107-108

[44] Crossing the "T" places an opponent's ships at a serious disadvantage. The traditional method involves steaming across the line of the enemy's heading. By doing so, all the guns of one's own ships can bear on the enemy, but only the forward guns of the enemy can return fire. Battleships of this era could typically fire only half their main guns forward, and sometimes less. As a result, when confronted with this situation, a battle line must turn to expose the rest of the main armament or risk being overwhelmed.

[45] See *United States Fleet Problem XI, 1930, Report of the Commander in Chief United States Fleet*, Admiral W.V. Pratt, U.S.N., 14 July 1930 (Roll 13, Target 7, Fleet Problem XI, CINCUS Report, July 14, 1930, General Records of the Department of the Navy, Record Group 80, National Archives. : RG80, NA), 60-2, and *Analysis of Operations Problem III-1935-SR. and Tactical Problem IV*, Department of Intelligence, Naval War College, Newport, RI, August 1935 (Box 21, Strategic Plans Division, RG38, NA), 12-13.

[46] *F.T. 143, War Instructions, United States Navy*, 1934 (NHC, WW2 CF, Box 108), 108;
F.T. 188, General Tactical Instructions, United States Navy, 1940 (NHC, WW2 CF, Box 108), 14-10 through 14-15

[47] *Report of Fleet Problem XV*, 1 June 1934 (Roll 16, Target 1, Fleet Problem XV, CINCUS report, June 1, 1934, Records of the Office of the Chief of Naval Operations, RG38, NA), 57

[48] *United States Fleet Problem XI, 1930, Report of the Commander in Chief United States Fleet*, Admiral W.V. Pratt, U.S.N., 14 July 1930 (Roll 13, Target 7, Fleet Problem XI, CINCUS Report, July 14, 1930, General Records of the Department of the Navy, RG80, NA), 65

[49] *United States Fleet Problem XI, 1930, Report of the Commander in Chief United States Fleet*, Admiral W.V. Pratt, U.S.N., 14 July 1930 (Roll 13, Target 7, Fleet Problem XI, CINCUS Report, July 14, 1930, General Records of the Department of the Navy, RG80, NA), 65-66

[50] *U.S.F. 10, Current Tactical Orders, United States Fleet*, 1941 (NHC, WW2 CF, Box 270), 32
[51] *U.S.F. 10, Current Tactical Orders, United States Fleet*, 1934 (NHC, WW2 CF, Box 270), 3
[52] *F.T. 143, War Instructions, United States Navy*, 1934 (NHC, WW2 CF, Box 108), 83
[53] *F.T. 143, War Instructions, United States Navy*, 1934 (NHC, WW2 CF, Box 108), 87
[54] *U.S.F. 10, Current Tactical Orders, United States Fleet*, 1934 (NHC, WW2 CF, Box 270), 3
[55] *United States Fleet Problem XIII, 1932, Report of the Commander-in-Chief United States Fleet*, Admiral Frank H. Schofield, 23 May, 1932 (Roll 14, Target 1, Fleet Problem XIII, CINCUS Report, May 23, 1932, Records of the Office of the Chief of Naval Operations, RG38, NA), Remarks of Admiral R.H. Leigh and Rear Admiral J.K. Taussig, 30,
[56] *Report of Fleet Problem Ten*, 7 May, 1930 (Roll 13, Target 1, Fleet Problem X, CINCUS Report May 7, 1930, General Records of the Department of the Navy, RG80, NA), 65
[57] Hughes, Wayne , *Fleet Tactics: Theory and Practice* (Naval Institute Press, Annapolis, MD, 1986)
[58] Jurens, "The Evolution of Battleship Gunnery in the US Navy, 1920-1945", 246; Interview with VADM Lloyd M. Mustin, August 1972, U.S. Naval Institute, Oral History Collection (Annapolis, MD), Vol. 7, 21-24
[59] See *Report of Fleet Problem Ten*, 7 May, 1930 (Roll 13, Target 1, Fleet Problem X, CINCUS Report May 7, 1930, General Records of the Department of the Navy, RG80, NA), 65
[60] Bates, Richard W., *The Battle of Savo Island, August 9th, 1942, Strategical and Tactical Analysis, Part 1* (Naval War College, Prepared for: Bureau of Naval Personnel, 1950), 243-244
[61] The battleship *Washington* used Radar ranging and visual bearing information to destroy the Japanese battle cruiser *Kirishima* on November 15, 1942. Reilly, John C., Jr., *Operational Experience of Fast Battleships: World war II, Korea, Vietnam* (Washington, DC, Naval Historical Center, Department of the Navy, 1989), 65
[62] *Report of Fleet Problem Ten*, 7 May, 1930 (Roll 13, Target 1, Fleet Problem X, CINCUS report May 7, 1930, General Records of the Department of the Navy, RG80, NA), 62
[63] *Report of Fleet Problem XV*, 1 June 1934 (Roll 16, Target 1, Fleet Problem XV, CINCUS report, June 1, 1934, Records of the Office of the Chief of Naval Operations, RG38, NA), 57
[64] *U.S. Fleet Battle Instructions No. 3-34, Effective 9 April 1934*, 27 March, 1934 (Roll 16, Target 3, Fleet Problem XV, Correspondence Regarding Preparations for and Conduct of the Problem, Records of the Office of the Chief of Naval Operations, RG38, NA), 6
[65] *U.S. Fleet Battle Instructions No. 3-34, Effective 9 April 1934*, 27 March, 1934 (Roll 16, Target 3, Fleet Problem XV, Correspondence Regarding Preparations for and Conduct of the Problem, Records of the Office of the Chief of Naval Operations, RG38, NA), 6

[66] *F.T. 143, War Instructions, United States Navy*, 1934 (NHC, WW2 CF, Box 108), 87
[67] *Report of Fleet Problem Ten*, 7 May, 1930 (Roll 13, Target 1, Fleet Problem X, CINCUS report May 7, 1930, General Records of the Department of the Navy, RG80, NA), 49
[68] *United States Fleet Problem XI, 1930, Report of the Commander in Chief United States Fleet*, Admiral W.V. Pratt, U.S.N., 14 July 1930 (Roll 13, Target 7, Fleet Problem XI, CINCUS Report, July 14, 1930, General Records of the Department of the Navy, RG80, NA), Battle ranges are shown on the track of the engagement provided between 58 and 59
[69] *Chronological Record of Events, Fleet Problem Thirteen*, Senior Umpire Blue (Roll 14, Target 4, Fleet Problem XIII, Senior Umpire, BLUE, Chronological Record of Events, Records of the Office of the Chief of Naval Operations, RG38, NA), 8
[70] *Report of Phase III, Fleet Problem XVI*, Commanding Officer USS Oklahoma, 25 May 1935 (Roll 20, Fleet Problem XVI, CINCUS Report, Sept. 15, 1935 (enclosures n-p), Records of the Chief of Naval Operations, RG38, NA), 5
[71] *Annex Cast, Green Battle Fleet Order No. 1-36, Fleet Problem XVII*, 14 May 1936 (Roll 21, Target 6, Fleet Problem XVII, US Fleet, BLUE, WHITE, GRAY, and GREEN Statements of the Problem with Estimates of the Situation, Plans, Orders, Instructions, and Organization, General Records of the Department of the Navy, RG80, NA); *Narrative of Events, USS Maryland*, Narratives of Fleet Problem XX, 2 March 1939 (Roll 28, Target 5, Fleet Problem XX, White Task Force, Task Group, Division, Squadron, and Ship Commanders' Narratives of Events and Track Charts, Records of Naval Operating Forces, Record Group 313, National Archives)
[72] MacFall, Captain R. C., *Tactical Problem III-1934-SR, Critique*, Department of Operations, Naval War College, Newport, RI., November 1933 (Box 19, Strategic Plans Division Records, RG38, NA), 7, 14
[73] *Analysis of Operations Problem II-1935-SR and Tactical Problem*, Department of Intelligence and Research, Naval War College, Newport, RI, March, 1935 (Box 21, Strategic Plans Division Records, RG38, NA), 10
[74] *Analysis of Operations Problem III-1935-SR and Tactical Problem IV*, Department of Intelligence, Naval War College, Newport, RI, August 1935 (Box 21, Strategic Plans Division Records, RG38, NA), 13
[75] *Report of Phase III, Fleet Problem XVI*, Commanding Officer USS Oklahoma, 25 May 1935 (Roll 20, Fleet Problem XVI, CINCUS Report, Sept. 15, 1935 (enclosures n-p), Records of the Chief of Naval Operations, RG38, NA), 4
[76] *Change No. 3 to U.S.F. 10*, 5 October, 1934 (NHC, WW2 CF, Box 270), 16; *Change No. 10 to U.S.F. 10*, 9 May, 1936 (NHC, WW2 CF, Box 270), 62; *Change No. 12 to U.S.F. 10*, 24 January, 1938 (NHC, WW2 CF, Box 270), 12
[77] Jurens, W. J., "The Evolution of Battleship Gunnery in the US Navy, 1920-1945", *Warship International*, vol. 28, Number 3 (1991), 246
[78] Friedman, *US Battleships*, 173
[79] *Critique of Fleet Problem Sixteen*, 15 June 1935 (Fleet Problem XVI, CINCUS Report, Sept. 15, 1935 (Enclosures A-I), Records of the Chief of Naval Operations, RG38, NA), Comments of Admiral Laning, 8

[80] *Fleet Problem Sixteen, Report of Commander-in-Chief, United States Fleet*, USS Pennsylvania, Flagship, 15 September 1935, Admiral J.M. Reeves (Fleet Problem XVI, CINCUS Report, Sept. 15, 1935 (Enclosures A-I), Records of the Chief of Naval Operations, RG38, NA), 27

[81] *Narrative, Fleet Problem XX*, USS Texas, 28 Feb 1939 (Roll 27, Target 1, Fleet Problem XX, Black Ships Operating Independently, Narratives and Track Charts, Records of Naval Operating Forces, Record Group 313, National Archives), 5-6

[82] MacFall, Captain R. C., *Tactical Problem III-1934-SR, Critique*, Department of Operations, Naval War College, Newport, RI, November 1933 (Box 19, Strategic Plans Division Records, RG38, NA), 12

[83] *F.T. 143, War Instructions, United States Navy*, 1934 (NHC, WW2 CF, Box 108), 96-97;
U.S.F. 17, Current Doctrine – Battleships, 1938 (NHC, WW2 CF, Box 272), 4

[84] *Change No. 12 to U.S.F. 10*, 24 January, 1938 (NHC, WW2 CF, Box 270), 12

[85] *Change No. 3 to U.S.F. 10*, 5 October, 1934 (NHC, NHC, WW2 CF, Box 270);
Change No. 10 to U.S.F. 10, 9 May, 1936 (NHC, NHC, WW2 CF, Box 270)

[86] Laning, Harris, Admiral United States Navy, Retired, *An Admiral's Yarn*, Naval War College Press, Newport, RI, 1999, Appendix II, *The Naval Battle*, by Rear Admiral Harris Laning, May 1933, 414

[87] *Analysis of Operations Problem III-1935-SR and Tactical Problem IV*, Department of Intelligence, Naval War College, Newport, RI, August 1938 (Box 21, Strategic Plans Division Records, RG38, NA), 13

[88] *Report of Fleet Problem XV*, 1 June 1934 (Roll 16, Target 1, Fleet Problem XV, CINCUS report, June 1, 1934, Records of the Office of the Chief of Naval Operations, RG38, NA), 57;
Fleet Problem XV, May, 1934 (Roll 16, Target 2, Fleet Problem XV, Correspondence Regarding Concept of the Problem, Records of the Office of the Chief of Naval Operations, RG38, NA), 12

[89] *Analysis of Operations Problem II-1935-SR and Tactical Problem*, Department of Intelligence and Research, Naval War College, Newport, RI, 1935 (Box 21, Strategic Plans Division Records, RG38, NA), 10

[90] *Narrative of Fleet Problem XX*, USS New York, 1 March 1939 (Roll 27, Target 1, Fleet Problem XX, Black Ships Operating Independently, Narratives and Track Charts, Records of Naval Operating Forces, Record Group 313, National Archives), 14

[91] *United States Fleet Problem XIII, 1932, Report of the Commander-in-Chief United States Fleet*, Admiral Frank H. Schofield, 23 May, 1932 (Roll 14, Target 1, Fleet Problem XIII, CINCUS Report, May 23, 1932, Records of the Office of the Chief of Naval Operations, RG38, NA), Comments of Rear Admiral J.R. Pringle, 28

[92] *Change No. 3 to U.S.F. 10*, 5 October, 1934 (NHC, NHC, WW2 CF, Box 270), 21-22;
Change No. 12 to U.S.F. 10, 24 January, 1938 (NHC, NHC, WW2 CF, Box 270), 21-22

[93] *U.S. Fleet Battle Instructions No. 3-34, Effective 9 April 1934*, 27 March, 1934 (Roll 16, Target 3, Fleet Problem XV, Correspondence Regarding Preparations for and Conduct of the Problem, Records of the Office of the Chief of Naval Operations, RG38, NA), 5

[94] *Report of Tactical Exercises 3-5 October*, Commander-in-Chief, United States Fleet, October 12, 1933 (Roll 16, Target 2, Fleet Problem XV, Correspondence regarding concept of the problem, Records of the Office of the Chief of Naval Operations, RG38, NA), 5
[95] Friedman, *US Cruisers*, 132
[96] Friedman, *US Cruisers*, 144-155
[97] Morison, *History of the United States Naval Operations in World War II*, Vol. 5: 247
[98] *Fleet Problem XV*, May, 1934 (Roll 16, Target 2, Fleet Problem XV, Correspondence Regarding Concept of the Problem, Records of the Office of the Chief of Naval Operations, RG38, NA), 13
[99] *Report of Fleet Problem XV*, 1 June 1934 (Roll 16, Target 1, Fleet Problem XV, CINCUS report, June 1, 1934, Records of the Office of the Chief of Naval Operations, RG38, NA), 66
[100] *Annual Report of the Commander-in-Chief, United States Fleet for the Period 1 July, 1933 to 30 June, 1934* (NHC, WW2 CF, Box 256), 11
[101] *Annual Report of the Commander-in-Chief, United States Fleet for the Period 1 July, 1933 to 30 June, 1934* (NHC, WW2 CF, Box 256), 11
[102] *Critique of Fleet Problem Sixteen*, 15 June 1935 (Fleet Problem XVI, CINCUS Report, Sept. 15, 1935 (Enclosures A-I), Records of the Chief of Naval Operations, RG38, NA), Closing Remarks of Admiral Reeves, 1
[103] *Report of Fleet Problem XV*, 1 June 1934 (Roll 16, Target 1, Fleet Problem XV, CINCUS report, June 1, 1934, Records of the Office of the Chief of Naval Operations, RG38, NA), 57
[104] *Fleet Problem XV*, May, 1934 (Roll 16, Target 2, Fleet Problem XV, Correspondence Regarding Concept of the Problem, Records of the Office of the Chief of Naval Operations, RG38, NA), 13
[105] *U.S. Fleet Battle Instructions No. 3-34, Effective 9 April 1934*, 27 March, 1934 (Roll 16, Target 3, Fleet Problem XV, Correspondence Regarding Preparations for and Conduct of the Problem, Records of the Office of the Chief of Naval Operations, RG38, NA), 7
[106] *F.T. 143, War Instructions, United States Navy*, 1934 (NHC, WW2 CF, Box 108), 108