

# Fire Control

A GUIDE FOR MODELLERS OF BRITISH WARSHIPS,  
MAINLY 1939-45 PERIOD

by Peter Hodges

IN the early 1930s, development began on an AA fire control system suitable for small ship installation; for there was an increasingly urgent requirement to provide Fleet destroyers—in particular—with a means of defending themselves using their main armament in predicted fire. None of the pre-war destroyer classes, up to and including the 'I' boats, were able to do this and they could only use their 4.7 inch guns in a form of deterrent barrage fire. The provision of an effective system was hampered to an extent by the low maximum elevation of these weapons, so that the problem was two-fold; and even after the small-ship system had come into service, the gun mounting elevation head-ache remained with the designers for many years.

## The Fuze-Keeping Clock and Associated Equipment

The system consisted of a lightweight, open director similar in many ways to the early HACS director; a calculator called the Fuze Keeping Clock—or 'FKC'—and a separate calculator for surface fire control.

The FKC worked on the same principles as the larger HACS Table and made the same assumptions regarding the target's course and speed. Unlike its big brother, however, it only calculated the special corrections for AA control (which were combined with the basic inputs to the associated surface calculator) and was therefore not a fully self-contained device.

The prototype installation was fitted experimentally in the sloop *Fleetwood* and the first production models were ready for the 'Tribal' class destroyers. In this class, the earlier open rangefinder was replaced by the new 'Rangefinder Director' in a similar position, abaft and above the DCT. In surface fire it functioned simply as a rangefinder but in AA it became a director in its own right.

The accelerating ship-building programme outpaced the production of this director, so unfortunately the 'J', 'K', and 'N' classes had to revert to the original simple rangefinder, but this was specially modified so that it could also be used against aircraft targets. Thereafter, the bulk of the destroyers built under the Emergency Programme had the standard 'Tribal' layout.

## Rangefinder Directors

**Mk I:** This was the experimental model already mentioned and was associated with prototype Fire Control calculators for both surface and AA fire. These were the FKC and the Fire Control Box—the latter, a miniature version of the Admiralty Fire Control Clock which had been the standard surface calculator in destroyers for some years.

**Mk II and Mk III:** These two marks were developed from the Mk I but had electrical transmission arrangements. The Mk II was designed for destroyer fitting, while the Mk III was a dual-purpose director used in conjunction with the twin 4 inch HA guns in sloops and certain other vessels. When thus employed, an extra crew member was required and in consequence, the Mk III was slightly larger and carried a crew of five.

Both directors were hand-operated through two-speed gear-boxes for the layer and the trainer, the fast speed being used to slew the director on to the target. The Control Officer had his own auxiliary handwheels but these were normally de-clutched to prevent them from back-driving when the director was under the normal control of the layer and trainer.

**Mk II(W) and Mk III(W):** The first models had been completely open mountings but it quickly became clear that more protection was needed for the crew. A drum-shaped wind shield was therefore added and all future production models conformed to this pattern, then having a suffix 'W' added to the mark



*HMS Norfolk in 1945. A veteran of the Bismark and the Scharnhorst actions, she was chosen to convey King Haakon back to Norway after his war-time exile in UK. Many of the equipments discussed in this series can be seen in the photograph. 'X' turret has been replaced by a pair of 'quad' pom-poms, with sided directors abaft the tripod mainmast. Superimposed above them is 'Y' turret's Barrage Director. Forward of the mast is the 8 inch Director Tower and a Height Finder Radar in the old HACS Director position. There is a pom-pom director for the starboard 8-barrel weapon just outboard of the 8 inch DT and the starboard director of the revised HACS layout is visible abreast the bridge superstructure.*

number.

As the war progressed, certain technical improvements were made including the addition of the familiar radar aerial array, but otherwise the appearance of the directors remained unchanged. All Mk II and Mk III variants were linked to the AFCC-FKC calculator-combination.

**Mk IV and Mk V Series:** These were very similar, except that their positional transmissions were conveyed to the compartment housing the calculators, by mechanical shafting. The Transmitting Station was thus immediately below the director and although this somewhat simplified the initial installation, it had the demerit of placing the TS in a more vulnerable position than was the usual practice.

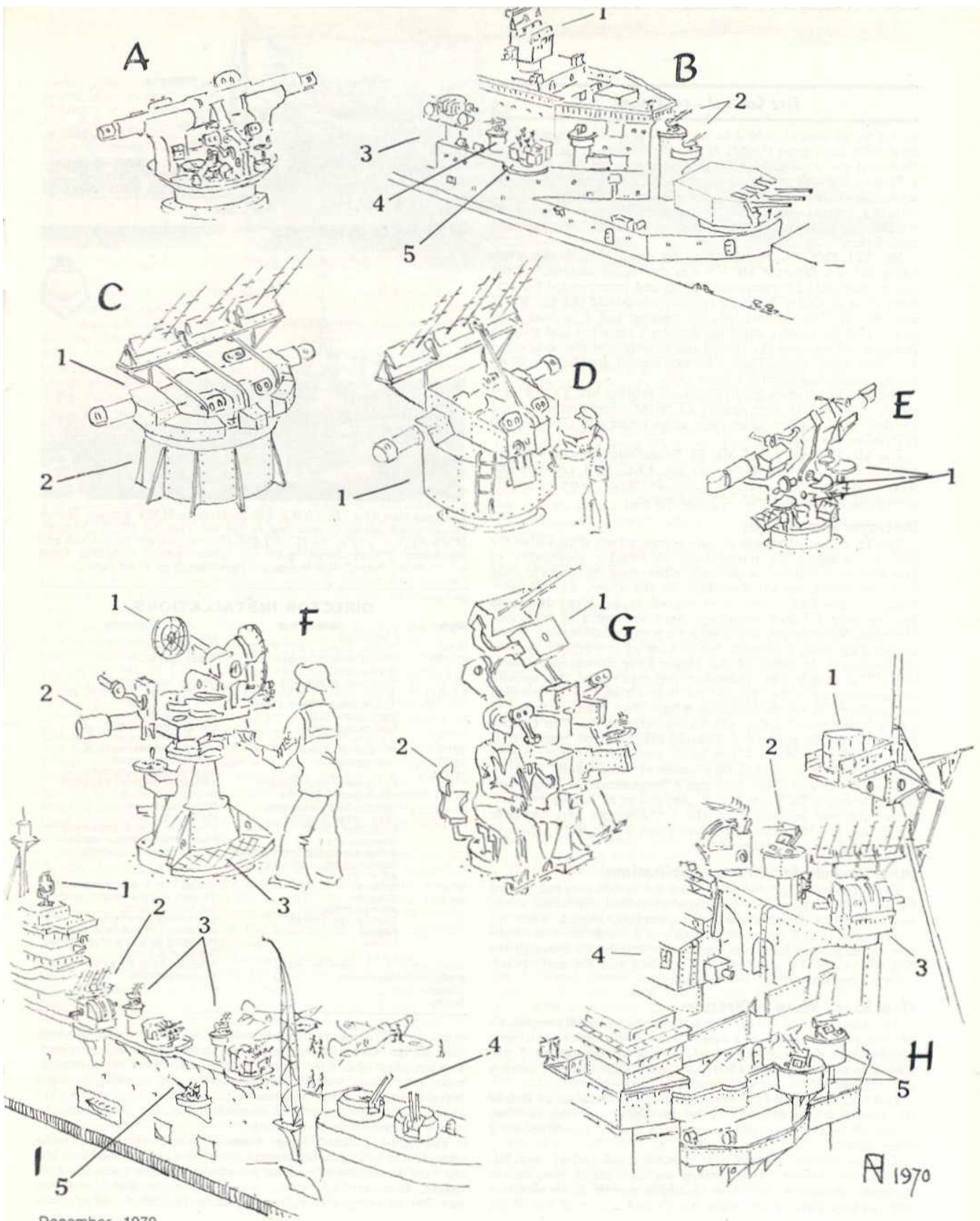
The Mk IV and Mk V, like the other marks, were open in the first instance, but were later modified to take a windshield,

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## Key to fire control equipment drawings shown opposite:

(A) Original Rangefinder Director Mk II. (B) General view of the forward superstructure on HMS *Swiftsure*: (1) 6 inch DCT; (2) Barrage directors for 'A' and 'B' turrets; (3) Starboard HA/LA Director Mk VI; (4) Pom-pom Director; (5) Starboard 'Quad' pom-pom. (C) Rangefinder Director Mk V\*: (1) Rotating windscreen; (2) Fixed casing. (D) Rangefinder Director Mk III(W): (1) Fully rotating windscreen. (E) Modified 'Three-Man Rangefinder': (1) Crew seats. (F) Pom-pom Director Mk II: (1) Control Officer's sight; (2) Rangefinder; (3) CO's platform. (G) Pom-pom Director Mk IV: (1) Gyro unit; (2) Bench seat for additional crew members. (H) Main superstructure of HMS *Howe*: (1) Surface Warning Radar; (2) Pom-pom director for 8-barrelled pom-pom on 'B' turret; (3) Port forward HA/LA Director Mk V; (4) Forward 14 inch DCT; (5) Pom-pom directors for 8-barrelled pom-poms abreast fore funnel. (I) Fleet carrier: (1) Height-finder radar; (2) Starboard forward HA/LA Director Mk V; (3) Pom-pom directors; (4) Starboard forward 4.5 inch battery; (5) Single 40 mm Bofors.

Previous articles on this subject appeared in the June and September 1970 issues.



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shown by an asterisk added to the mark number. Internal structural differences from the Mk II and the Mk III made it difficult to mount the windshield on the rotating director base: instead, a fixed casing was provided, on which a ring-shaped extension—itsself connected to the moving base—revolved. The training and elevating gearing was similar to the previous marks but power stabilisation was added in the elevation drives to the sights and rangefinder.

**Mk VI:** This director (NOT to be confused with the much larger HA/LA Director Mk VI) was the logical successor to the earlier 'mechanical transmissions' types and incorporated features from these as well as having a rotating windshield like the Mk II and Mk III. The Control Officer's position had a 'scooter' unit from which he could control the director's elevation and training in power follow; and the rear of the director was plated-in up to the radar aerial array. These additions almost doubled the all-up weight which rose to about three tons.

The Mk VI versions were rebuilds of existing Mk Vs and were mostly fitted to the later groups of 'Hunt' class destroyers and to 'Bay' class frigates when these ships underwent their normal refits after the war.

The Mk IV, Mk V and Mk VI Rangefinder Directors always controlled the armament through the FKC/FCB combination, and, except for the 'O' and 'P' class destroyers, were invariably associated with twin 4 inch HA mountings.

### Destroyer Installations

The TS in destroyers was already comparatively deep within the hull which made the transmission of director movements of elevation and training impossible other than by the electrical 'repeater' system already described. On the whole, the full capabilities of the FKC were rather wasted in the Fleet destroyers because their 4.7 inch mountings were so limited in maximum elevation. Nevertheless, it did give them the much-needed ability to use their main armament for as long as it was able to bear on the target. In many of the bigger Fleet destroyers, a high-angle 4 inch gun was added—at the expense of the torpedo armament—and in the 'Tribals' the twin 4.7 inch in 'X' position was replaced by the faithful twin 4 inch HA. When so armed, a special 'conversion' device was incorporated in the Fire Control system to enable guns of a different calibre to be employed at the same time; and the 4 inch could continue to engage targets when the 4.7s had reached their upper elevation limit.

Towards the end of the Emergency Programme, the long-established Destroyer DCT was phased out, and as an interim measure, before the new generation of HA/LA directors were available for fitting, the 'W' class ships were given a Mk III(W) director which fulfilled a dual-purpose role.

### Other Rangefinder Director Applications

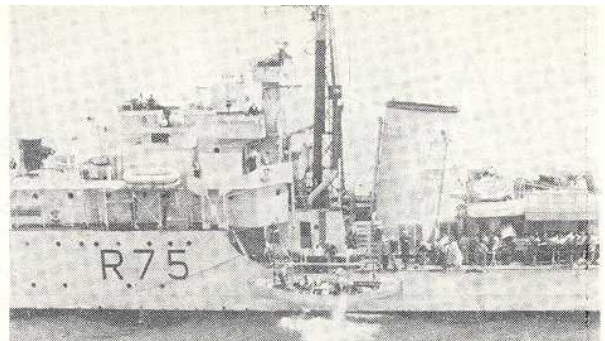
The accompanying table shows that the system was not limited to 'small ships' alone but was fitted elsewhere, especially where space or fitting-out time were at a premium. Indeed, when the complicated HACS was itself phased out towards the end of the war, its large calculator was replaced by the FKC, although the 'big ship' style HA directors were retained (see the early instalment in the June 1970 issue for details).

### Close Range Weapon Directors

The advantages of the director principle were equally applicable to close range weapons and well before 1939, a lightweight, open director was designed to control the big eight-barrelled 2 pdr pom-pom mounting with which all capital ships, aircraft carriers and the later classes of 8 inch cruisers were equipped.

This weapon, it will be remembered, was installed to defend the parent ship from attacks by low-flying torpedo bombers which, of necessity, needed to approach closely before releasing their 'tin-fish'.

Torpedo bombers usually carried out a good deal of 'ducking-and-weaving' before finally settling on their attack run, so the pom-pom mounting needed to be highly mobile in its elevation and training. Each of the eight barrels had a rate of fire of the



Close-up view of a Mk II(W) R/F Director in HMS Virago. Notice the servicing platform attached to the tall pedestal (P. A. Vicary). HMS Apollo, with a Mk III(W) R/F Director for her twin 4 inch gun mountings ('Navy News' postcard series—prints available from 'Navy News', RN Barracks, Portsmouth at 1s 6d each).

### DIRECTOR INSTALLATIONS

| Mark                        | Ship/Class                                                                                                                                                                                                                                           | Remarks                                                                                                                                                                                                                  |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| I                           | Fleetwood                                                                                                                                                                                                                                            | Prototype                                                                                                                                                                                                                |
| II or II (W)                | 'Tribal' class, 'Q', 'R', 'S', 'T', 'U' and 'V' class destroyers                                                                                                                                                                                     | In association with 'Destroyer DCT'                                                                                                                                                                                      |
| III or III (W)              | 'W' class destroyers<br>'Black Swan' and Modified 'Black Swan' class sloops<br>Some early sloops<br>Fast minelayers<br>Unicorn                                                                                                                       | Interim arrangement<br>Eg, <i>Stork</i> , <i>Egret</i><br>Eg, <i>Ariadne</i> , <i>Apollo</i> , etc.<br>Three directors on the 'Island'                                                                                   |
| IV, V or VI series          | 'O' and 'P' class destroyers<br><br>Some early destroyers converted to Escorts<br>'Hunt' class destroyers<br>'Bay' class frigates<br><i>Robisher</i> (2)<br><i>Hawkins</i> (1)<br>Some destroyer Depot ships;<br>Repair ships: Auxiliary<br>AA ships | Interim arrangement at commencement of Emergency programme<br>Replaced original Pedestal Director<br>Mk VI post war<br>Mk VI post war<br>Fitted for 4 inch armament on Emergency modernisation<br>Mostly 'ended' systems |
| IV or V series              | <i>Erebus</i><br><i>Roberts</i><br><i>Abercrombie</i><br><i>Gurkha</i> (ex-Larne)                                                                                                                                                                    | 'Sided' for 4 inch armament;<br>15 inch Aloft Director used for 15 inch turret                                                                                                                                           |
| V                           | <i>Legion</i><br><i>Lance</i><br><i>Lively</i>                                                                                                                                                                                                       | Controlled extemporary armament of 4 X twin 4 inch HA fitted in place of designed 3 X twin 4.7 inch                                                                                                                      |
| Modified 3-Man Range-finder | 'J', 'K' and 'N' class destroyers                                                                                                                                                                                                                    | Adapted from an existing LA Rangefinder                                                                                                                                                                                  |

order of 100 rounds per minute and the smoke and noise distraction to an on-mounting layer and trainer can be imagined. Further, their ability to 'change target' in the heat of an engagement might lose precious seconds. To comply with the usual Naval axiom of taking 'seamanlike precautions', local sights were also fitted to the mountings themselves, so that they could be aimed independently if necessary.

The eight-barrelled 'Chicago Piano' (as this pom-pom was nicknamed) was too large for general fitting throughout the Fleet but the need for a similar weapon for smaller warships was clear. A lighter, four-barrelled version was therefore produced and was installed in many classes, ranging from the 'Black Swan' class

Right: HMS *Paladin* was among the earliest of the 'Emergencies' and had a Mk IV\* R/F Director low-set on her bridge. Notice the make-shift armament of old 4 inch HA guns, all stowed muzzle-forward.



frigates, through to the big ships, where it supplemented the eight-barrelled version.

In ships where space (and crew) considerations were not pressing, the 'Quads' were also director-controlled; but in destroyers and below, the mountings could only be controlled from their own gun-sights, despite frantic juggling by their designers, who were always being invited to put a quart into a pint pot.

This small-ship problem led to the development of the fully-automatic radar-controlled close range weapons which will be described in detail in a future article.

### The Pom-pom Director

Like most comparable equipments, the director started its life as a simple sight but as time elapsed, it became more complex and moved from the Mk I to the Mk IV, with the usual sprinkling of sub-models. The Mk II and III series were already in service at the beginning of the war and had a crew of five. The rangefinder had a seat in the front of the director, behind his rangefinder, and the CO (Control Officer) stood on a platform in the rear, but the other crew members 'walked' round the rotating structure as it trained. In the later Mk IV, all had on-mounting seats.

All models were open; the layer and trainer tracked the target in the usual way; and the Control Officer (who fired the guns) had a separate sight. This was capable of independent movement and in the Mk II took the form of a conventional 'cartwheel' sight of concentric rings supported by radial 'spokes'. The sight rings represented aircraft speed in knots and by aligning the appropriate speed ring to the target—rather than the centre of the sight—the 'aim-off' was determined. This extra movement was added differentially to the initial tracking of the layer and trainer and the gun mounting electrical receivers registered the combined angles. The small rangefinder carried in the forward part of the director fed a measure of the target's present range into the calculating mechanisms, which also had a wind-speed and wind-direction input so that the director was in many ways its own Fire Control calculator.

Altogether, it was quite a practical arrangement because the director layer and trainer had only to bother with accurately tracking the target, while the Control Officer had only to concentrate on his task of applying the 'aim-off'. However, this was no easy matter and the point of aim was subject to the CO's estimation of the target speed. Thus, the accuracy of the fire ultimately relied on his ability and experience.

The difficulty was much alleviated by the addition of a gyroscope in the Mk III and Mk IV directors which automatically calculated the correct deflection; and by this time a radar aerial had been added as the primary range-measuring device. Meanwhile, the pom-pom mountings themselves had been adapted for Remote Power Control; the major proportion of the 'human error' had been removed; and they could pump out a well-directed and withering hail of fire. It must have taken a cool nerve indeed to fly unflinchingly towards the muzzles of a 'Chicago Piano' which was delivering a total of something like 800 rounds of HE 2 pdr high velocity shell per minute.

Because the director also acted as its own Fire Control Calculator, it paved the way towards the completely self-contained close-range mounting, and by incorporating the range-measuring and deflection-calculating devices on to the weapon itself, these ends were later achieved.

Each four-barrelled or eight-barrelled mounting had its own

director, and later, this principle was applied to some twin 40 mm Bofors mountings, but no single-barrelled close-range weapons of any calibre were director-controlled.

Other nations were adopting the same control principles, and most RN ships which were refitted in the United States during World War 2 emerged with American Bofors mountings controlled by their own close-range directors. Unlike the British, the Americans produced a 'quad' Bofors whose barrels were arranged in two pairs in a rectangular shaped mounting. HMS *Nelson* had a North American face-lift during the war, and returned to service with four of these US quads. They are parts 71, 75, 103 and 106 of the Airfix kit, and are quite well modelled. On part 102 the two short stubs represent the Bofors directors but care should be taken when positioning this platform. Its proper location is seen on the box lid, making the profile on drawing 4 of the instructions incorrect, where it is shown on top of the bridge superstructure.

Some British warships were fitted with an American pattern twin Bofors mounting, and this, too, was sometimes controlled from its own lightweight director.

### Barrage Directors

Before World War 2, a calculator was designed to enable the main armament of 8 inch cruisers and the 6 inch armament of *Nelson* and *Rodney* to augment the anti-aircraft fire of their AA weapons. It was known as the Augmenting Table and was mentioned in the first part of this series (June 1970).

The need for this device did not arise in the 'King George V' class battleships because they already had a substantial HA/LA secondary armament; neither was it justified in the classes of light 6 inch cruisers which followed the 'County' class ships.

The idea of using the main armament for AA fire re-emerged in the triple 6 inch gun cruisers, but a simpler method was evolved employing a compact Barrage Director. This was very similar in appearance to the Pom-pom director, and the earliest units were in fact converted close-range equipments. They were fitted to many of the 'Colony' class cruisers and also to some of the 'County' class, as can be seen by the photograph of *Norfolk*.

The comparatively slow rate of fire of guns of 6 inch and 8 inch calibre precluded their use as AA weapons in the normal sense, but their long range and great destructive power made them ideal as a means of breaking up formations outside the range capabilities of the conventional anti-aircraft weapons.

When the main armament was to be used in the AA role, the individual turrets were linked to their respective Barrage Director via a circuit change-over switch, and were entirely under its control. The guns were loaded with time-fused shells set to explode at a predetermined range, and the mounting followed its Barrage Director in training and elevation.

Like its Pom-pom Director cousin, the Barrage Director had a built-in prediction system, but in addition it worked through a radar unit through which the firing circuits to the guns passed. The radar aerial on the Director produced a continuous measure of the target's range, and when this reached a certain level, the guns fired automatically to suit the pre-set timed fuse set on their shells.

The degree of accuracy necessary for normal predicted AA fire was not so urgent because of the large destructive effect of 6 inch and 8 inch shell, and the scheme was effective against formations of both high level and torpedo bombers (because

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happily the 6 inch and 8 inch guns had an unusually high maximum elevation for conventional surface weapons).

Thus, attacking aircraft approaching in formation well outside normal AA gun range would suddenly find themselves flying through a barrage of shell splinters, which must have been disconcerting to say the least!

### **Other Barrage Arrangements**

Both the HACS calculator and the FKC, it will be recalled, had been designed to predict the future position of a target flying at a constant height and speed and on a steady course. They were thus unable to cope with the solution to the Fire Control problem created by a diving aircraft and under these conditions of attack, the long-range AA armament was used in a form of controlled barrage fire. Basically, this consisted of a 'Block Barrage' in rapid fire put up at a fixed range—or sometimes at several diminishing ranges—through which the aircraft would have to fly, if it persisted with its attack.

Examples of some of the equipments discussed in this article can be seen in the accompanying sketches, as well as other directors which were dealt with in more detail in the earlier notes.

*AIRFIX* magazine