THE BREDA TWIN 40L70 COMPACT NAVAL GUN MOUNTING

BY

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Introduction

During the last twenty years, the role of the gun has been progressively rejected in favour of missile systems for ship defence against aircraft and missile attack. Recently however, a number of factors have rekindled new interest in close-range gunnery and many new small-calibre gun mountings are now available on the world market. Examples of these are:

Calibre	*Maker*	*Rate of Fire*
20 mm Single	Oerlikon GAM-B	1000 RPM
30 mm Twin	Oerlikon GCM-A	1300 RPM
35 mm Twin	OE/OTO	1100 RPM
40 mm L70 Single	BOFORS	240–300 RPM
40 mm L70 Twin	BREDA BOFORS	600 RPM

A dominant factor in this development is the very large and increasing demand by many nations for fast patrol boats, off-shore patrol vessels, and small frigates.

It is generally accepted that the destruction of aircraft or anti-ship missiles is most successfully achieved at the longer ranges by surface-to-air missiles, but, at close range, the advantages are less clearly defined: it can be argued that an accurate gun system having a quick response and high continuous rate of fire has an equal or better chance of success at ranges below 3 km. Moreover, in fast patrol boats, the choice may have to be made between a limited salvo close-range missile designed primarily for air defence or a high-performance

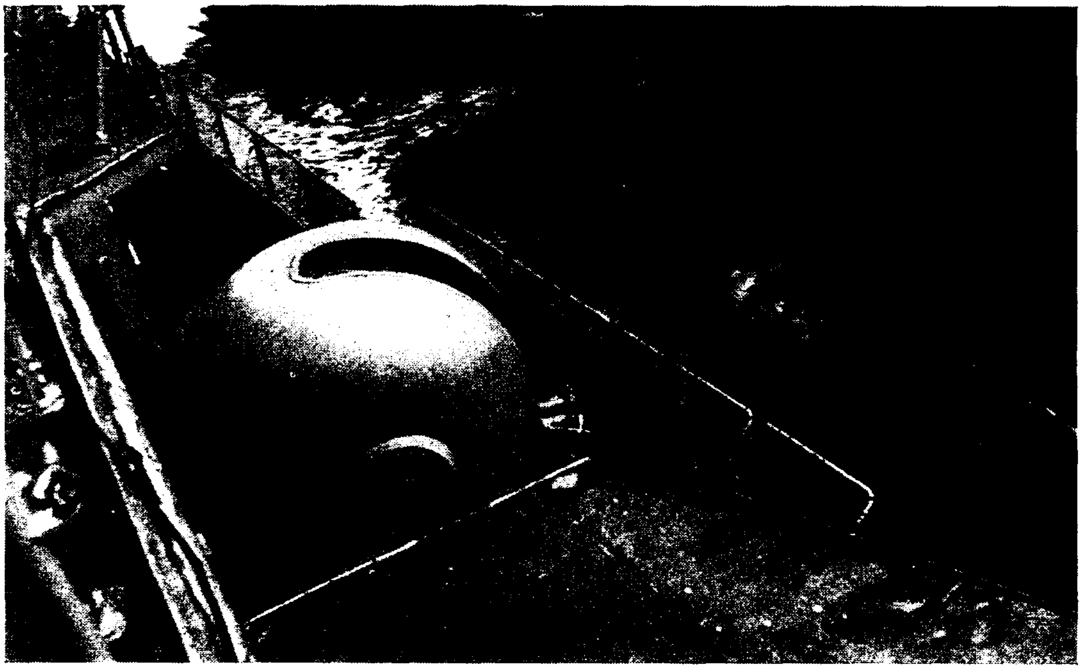

FIG. 1—BREDA MOUNTING IN THE ITALIAN NAVY SHIP 'LUPO'

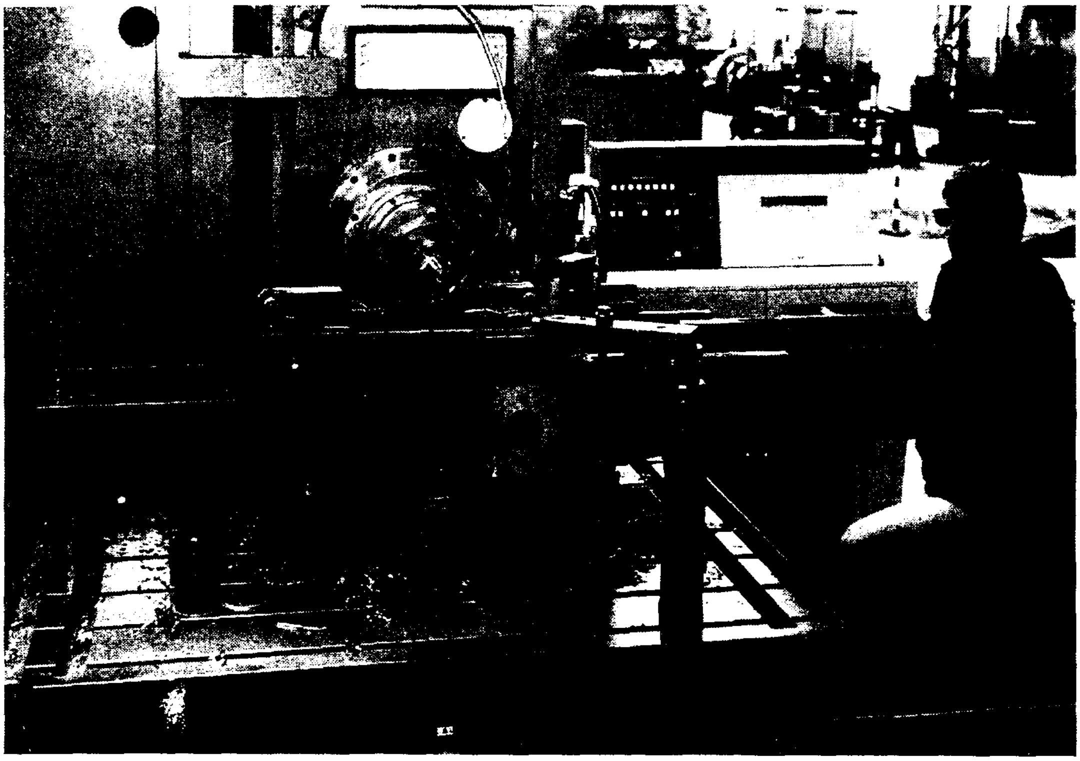

FIG. 2—MOUNTING CRADLE BEING REAMED ON A CERUTI CN MACHINE

close-range gun system: in these ships, the versatility and overall cost effectiveness of the latter become important considerations.

Recent advances both in computerized fire control and RPC systems has made possible major improvements in gun accuracy. In addition, since the 1939–45 war, the rates of fire of gun mountings have been substantially increased by the use of fully automatic feed systems. Unfortunately, however, high rates of fire have frequently been achieved at the expense of reliability and maintainability.

This article examines some of the advanced engineering features of the Breda Twin 40L70 Compact Mounting which represents a new generation of close-range gun mountings. The starboard Breda mounting of the Italian Navy Ship *Lupo* is shown firing in FIG. 1.

Breda Compact Mounting Characteristics

The mounting is based on the very reliable Bofors 40 mm L70 gun which is made under licence at the Breda Works in Brescia, Italy. A twin cradle, having the gun bores only 30 cm apart and an alignment accuracy of 0·2 milliradians, has been designed by Breda. In FIG. 2, a cradle is shown being reamed on a Ceruti CN Machine programmed by an ELSAG MAC3C Numerical Tape Control Unit. This machine is typical of the capital equipment installed at the Breda factory which has been completely re-equipped since 1946.

The Breda mounting is the first successful attempt to provide a small-calibre gun mounting with the following facilities usually associated with large gun mountings:

(*a*) Fully automatic feed system with large supply of ammunition immediately available, a high rate of fire, and barrel cooling.

(*b*) Totally enclosed, weatherproofed gun house.

(*c*) Advanced, stable RPC system giving accurate performance.

(*d*) Capable of operation in NBC environment.

(*e*) VT, AP, and DA ammunition available.

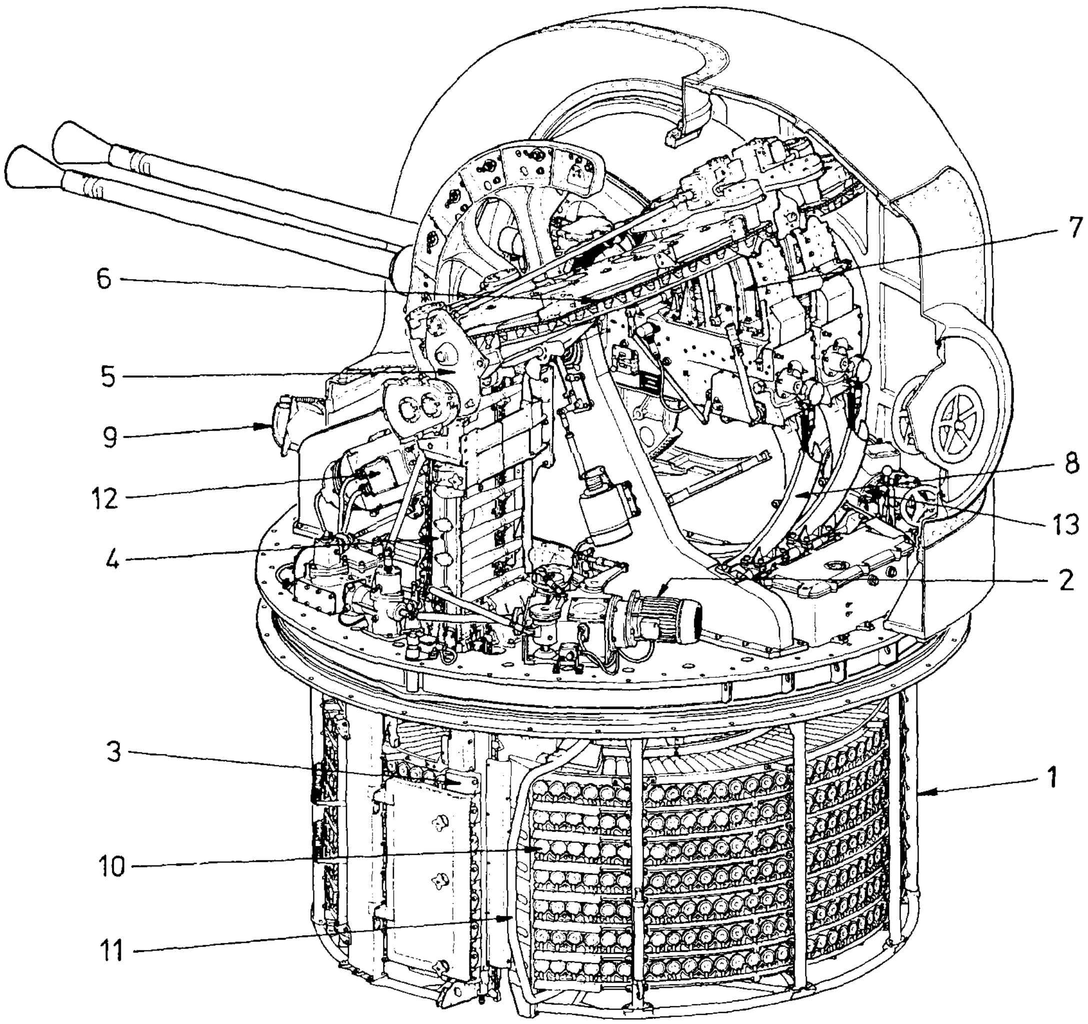

FIG. 3—BREDA TWIN 40L70 COMPACT NAVAL GUN MOUNTING—CUTAWAY VIEW

The total weight of the mounting and 736 rounds of ready use ammunition has been limited to 7·3 metric tons by the extensive use of light alloys and reinforced glass fibre for structural and lightly stressed components. Thus, the large reserve of ammunition accounts for 25 per cent. of the total weight.

The mounting is unmanned: the run-up time is limited to a few seconds and, although a Captain of the Mounting monitors performance from an adjacent Local Control Panel, the mounting may be fired in remote control from the Operations Room.

VT Ammunition has been successfully developed for the 40L70 gun, 40 mm being the smallest calibre which can accommodate a worthwhile payload due to the size and weight of the VT fuze. This ammunition significantly increases the neutralizing/kill probability of the Breda Mounting against small air targets at ranges out to 2·5 km.

Operation of Breda Mounting

Ammunition Feed System (FIG. 3)

The ammunition is stored radially in layers in a cylindrical magazine (1) which rotates with the mounting. The magazine is available in two sizes having either seven or four layers of ammunition supplying 736 or 444 rounds without reloading. The feed system to each gun is totally independent and the magazine is split vertically into two halves, each half supplying its own gun. As the supply arrangements to each gun are similar, the feed system of the left gun only will be described.

The various components of the feed system are phased together and driven by a 440 V, 60 Hz motor (2) mounted on the gunhouse deck. The feed motor drives a gearbox which has a slow and fast output. Synchronized pawls, driven by the slow output, drive all the rounds in one half of the magazine, in an anti-clockwise direction towards a lower endless-chain ammunition hoist (3). The slow output also controls rotating scuttles which, being synchronized with the movement of rounds in the magazine layers, transfer a round from each layer simultaneously to the lower hoist.

When the gun is firing, therefore, seven rounds are transferred to the lower hoist approximately every second and the lower hoist passes these to the upper endless-chain hoist (4) and (FIG. 4) without gaps occurring in the flow of ammunition. The fast output from the motor (2) drives both the lower and upper endless-chain hoists, the two being synchronized together to ensure a smooth transfer of ammunition at a position just above the gunhouse deck (FIG. 4). The fast output also drives the Scuttle (5) at the top of the upper hoist and this transfers the ammunition onto a fan-shaped shifter (6) which elevates with the gun. The purpose of the fan-shaped shifter, which is also powered by the fast output, is to rotate the axis of the rounds through 90° and to feed the rounds into the Bofors L70 automatic feeding device (7). To ensure that gun starvation cannot occur, the fast output is in excess of the nominal 300 RPM rate of fire of the gun. Empty cases are ejected from the mounting to the upper deck via the chute (8) and tube (9).

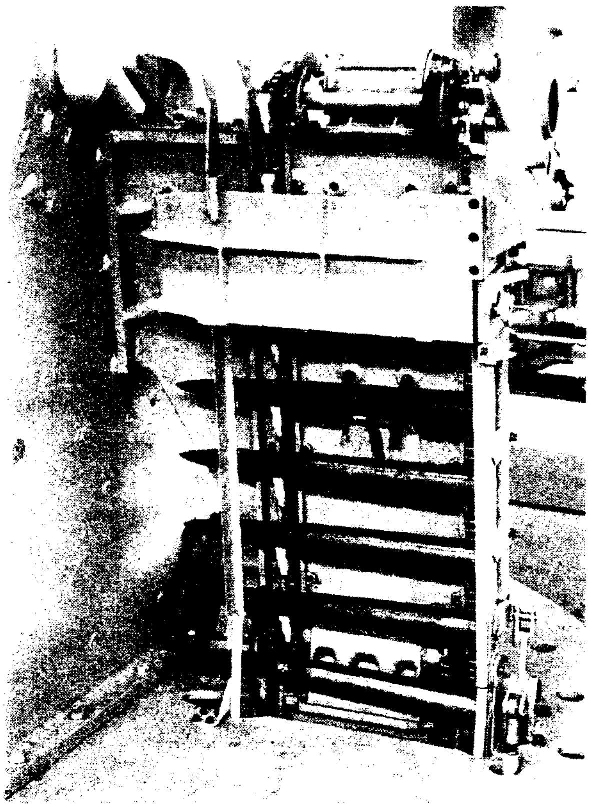

FIG. 4—UPPER ENDLESS-CHAIN HOIST

The feed-system motor runs continuously but movement of the feed system is controlled automatically by a clutch and brake assembly to meet the guns demand for ammunition. This arrangement is augmented by additional clutches and brakes to prevent damage in the event of a stoppage to one gun.

The magazine is loaded by placing the clips of four rounds on each layer at the loading station (10). The loading station for the left gun is 180° away on the other side of the mounting. The grounds are then advanced manually, anticlockwise, towards the lower hoist using the large handle (11) and the process is then repeated until both halves of the magazine are full.

The feed system of both guns can deliver VT rounds in burst firing at 600 RPM: this is equivalent to 50 rounds being placed in the path of a Mach 1 missile engaged between 2·5 km range future and 1 km. The large reserve of ammunition allows successive AA engagements or saturation of a surface target without reloading.

Remote Power Control

The training and elevating motions are controlled by third-order servo systems giving zero acceleration lag. The servo system consist essentially of the following components:

(*a*) Elevating and training servo motors.
(*b*) Elevating and training gearboxes.
(*c*) Elevating and training synchro boxes.
(*d*) Servo amplifier box.
(*e*) Converter.
(*f*) Power supply rack.
(*g*) Local control panel.

The training and elevating servo motors are mounted in the gunhouse (FIG. 3, (12) and (13)) and train and elevate the mounting through epicyclic gearboxes. Positional error is sensed by coarse and fine synchros and feed back is provided by tacho generators, all of which are housed in the elevating and training synchro boxes and driven by the servo motors.

The heart of the elevating and training control system is the servo amplifier box and this is mounted in the gunhouse on the trunnion support. The circuitry is engineered in solid state and printed circuit electronics and power is directed to the elevating and training servo motors by thyristor control. There are no tuning adjustments and the system is very stable: comprehensive 'rule-of-thumb' fault finding instructions are provided to resolve any defect resulting in sub-standard performance.

The converter consists of an asynchronous 440 V, 60 Hz, 3-phase motor driving two motor generators. One motor generator supplies the elevating and training servo motors via the power supply rack with up to 50 kVA at 440 V, 130 Hz. During peak demands, the converter acts as a flywheel, supplying the large power requirements during the acceleration phases and providing regenerative braking during the deceleration of the mounting. In this way, peak power demands can be kept within the capabilities of small ships. The other motor generator supplies 1·5 kVA at 200 V, 260 Hz for the auxiliary services via the power supply rack.

The power supply rack is sited adjacent to the mounting and is fed with 440 V, 60 Hz from the ships electrical supply. Power from the converter is routed through the power supply rack to drive the elevating and training servo motors, and other incoming supplies are transformed to provide loading control and all other auxiliary voltages. In addition, all the fire control system, barrel cooling, and loading control orders are fed through the power supply rack. The unit is compact and reliable and, like the servo amplifier box, is based on the extensive use of printed circuits and solid state electronics.

The mounting is normally under the direct and immediate control of the fire control system. A local control panel is provided adjacent to the mounting and its prime function is to monitor the performance of the mounting. In particular, it is used for the following functions:

(*a*) Loading and unloading ammunition.
(*b*) Maintenance purposes.
(*c*) Monitoring of barrel cooling.

A local/remote control switch enables control to be assumed locally to fulfil these functions.

RPC Performance

The mounting is capable of high training and elevating accelerations, 120°/second^2 and can train at 90°/second and elevate at 60°/second. The dummy director response to burst firing shows that there is virtually no elevation throw off, the centre line of the barrels passing through the trunnion axis. In training, the throw off is limited 4–5 minutes and the gun recovers to about 1 minute of arc for each successive round. Thus, gun accuracy is well within the designed

1 milliradian dispersion at the gun. In practice, this represents 50 per cent. of rounds falling within a one metre radius circle at 1 km.

The dispersion of the 40 mm L70 gun is approximately linear out to 4 km. Thus, when controlled by a modern system, the mounting is capable of accurate and concentrated fire against air and surface targets.

Fire Control Systems

The mounting can be linked to any modern analogue or digital fire control system and it is currently in service with the ELSAG NA10 and DARDO Systems in the Italian and Peruvian Navies. It is understood that it is also likely to be fitted with other systems such as CASTOR II, SEA ARCHER, FLY-CATCHER.

Engineering Features

Feed System Safety Devices

Reliability: A stoppage in the ammunition supply to one gun will not affect the other, since the ammunition supply arrangements are totally independent. In addition Breda claims that in an independent trial during which 18,000 rounds were fired, a stoppage rate of 1280 rounds on the left gun and 1000 rounds on the right gun was achieved. The failures were all either highly stressed gun components, e.g. extractors, or small feed system items, e.g. pawl springs, and the mean time to repair was 30–40 minutes. Nevertheless, feed system stoppages are ultimately inevitable in any advanced automatic loading system and the Twin Compact Mounting is fitted with feed system protection devices which are designed to avoid damage and minimize downtime.

Feed System Protection (FIG. 3): Basically, the principle employed is to detect the stoppage immediately it occurs and to absorb feed system momentum by the use of slipping clutches and brakes.

The protection equipment to each gun consists essentially of the following components:

(*a*) A clutch and brake fitted between the feed-drive motor (2), and the slow and fast output drives.

(*b*) A clutch, signalling device, and brakes in the fast drive to the automatic ammunition feed to the gun from the fan-shaped shifter (6).

(*c*) A clutch and signalling device in the slow drive from the feed system drive motor (2) to the magazine circumferential feed.

(*d*) A clutch and signalling device in the slow drive from the feed system drive motor to the rotating scuttle between the magazine circumferential feed and the lower hoist.

(*e*) An alternator speed sensing device fitted to the fast output from the feed system drive motor.

The supply of ammunition is designed to be in excess of gun demand and, when the gun is firing, the fan-shaped shifters and associated transfer spiders attempt to feed more rounds into the L70 gun automatic feeding device (7) than are required. The resulting contact between the rounds increases the torque in the drive to the transfer spiders and causes their clutch to render. At the same time, a microswitch is operated which disengages the clutch fitted to the feed system drive motor (2) and applies a brake to the feed system. Concurrently, brakes are applied to each chain of the fan-shaped shifter gearbox causing the feed system to stop instantly. This operation happens repeatedly in normal operation during a long burst and any damage to the feed system would therefore be prevented should a jam occur at the gun. A sectional view of the fan-shaped shifter gearbox is shown in FIG. 5. The fast drive from the feed system drive motor is connected to the gearbox by a bevel pinion mating with bevel

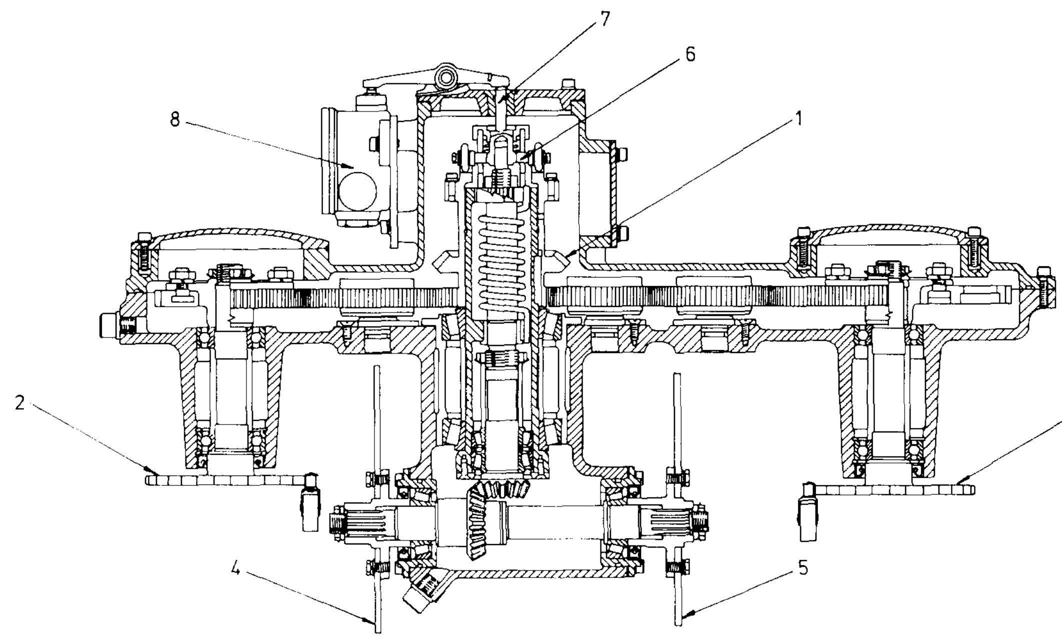

FIG. 5—FAN-SHAPED SHIFTER GEARBOX

pinion (1) and the latter drives the chain wheels (2) and (3) at different speeds to feed the rounds from top of the upper hoist to the automatic feed of the gun. The input pinion also drives the feed spiders (4) and (5) through a roller/ramp type slipping clutch (6). When the gun automatic feeding device is full, the rollers override the ramp and the rocker-arm control piston (7) rises to operate a microswitch (8) and the sequence of events already described is initiated.

The slipping clutches fitted to both the slow outputs from the feed system drive motor, although different mechanically, operate in a similar manner and instantly disengage the feed system drive motor clutch and apply the brakes, at once stopping the feed system of the affected gun.

The electric alternator speed sensing device detects any major changes in speed in the fast drives to the hoists or fan-shaped shifter, as would occur in the event of a jam. The resulting signal from the alternator is used to disconnect the feed system drive motor and stop the system as previously described.

There is no doubt that the damage limiting arrangements can stop the system instantly: Breda engineers demonstrate the effectiveness of the safety devices by deliberately inducing a jam while the feed system is running, clearing the jam and then successfully restarting the system and recycling more ammunition.

Training and Elevating Gearboxes

The training and elevating gearboxes are compact, robust, and stiff. These qualities are achieved through the use of epicyclic gearing and large diameter chrome alloy steel shafts well supported in large bearings.

A cross-section of the training gearbox and lower roller path is shown in FIG. 6. The input bevel pinion mates with pinion (1), and the large splined shaft (2) supported in pre-loaded tapered roller bearings meshes with the planet wheels of the epicyclic reduction gearing (3). The output from the gearbox is transmitted by the massive output shaft (4) and the straight spur pinion (5) which engages with the training rack (6).

The worm and worm wheel hand maintenance drive (7) is engaged through the dog clutch (8) and is interlocked by the microswitch (9).

The positioning of the whole gearbox can be adjusted in the mounting by turning the eccentric geared bush (10) by means of the toothed adjuster (11). Thus, backlash between the gearbox and the mounting can be minimized. After shop hysteresis testing, final acceptance of both training and elevating

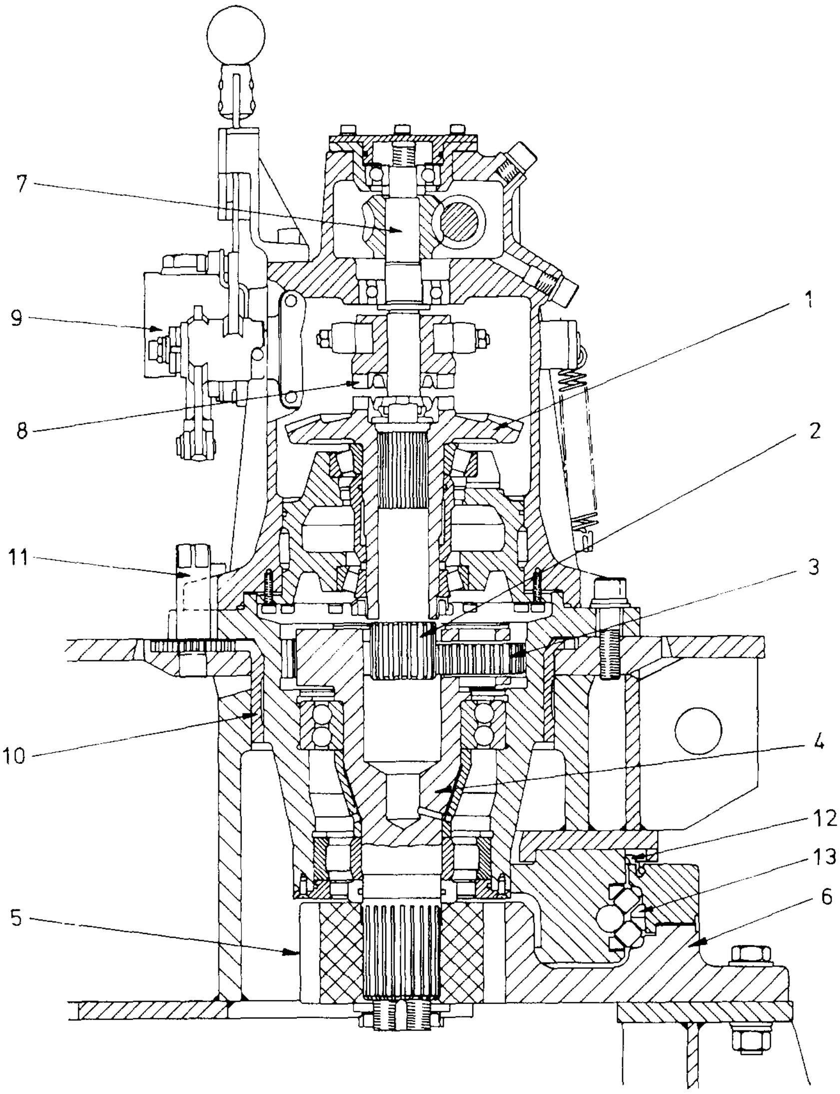

FIG. 6—EPICYCLIC TRAINING GEARBOX

transmissions is completed after installation and a total of 2 minutes overall power backlash is mandatory.

The weight of the mounting is supported on a proprietary wire race bearing made by Rothe Erde (13). This reduces friction torque to a minimum and allows the use of lightweight alloys for the training base of the mounting thereby affecting a 60 per cent. reduction in weight. The bearing is sealed by a lip and garter type seal (12) immediately above the bearing and the seal is shielded against damage by the rotating structure. The seal is grease lubricated and, unlike traditional labyrinth packings, provides total protection for the bearing.

Barrel Cooling

The Bofors L70 barrel has a life of about 2500 rounds if fired in short bursts of about 25 rounds. Barrel wear increases non-linearly with temperature and wear rate becomes excessive after about 150 rounds in burst firing. Bofors recommend then a barrel change to preserve barrel life, unless the barrel can be allowed to cool down before firing is resumed.

In order to capitalize on the large and immediate reserve of ammunition, the Breda mounting is fitted with barrel cooling of an unusual design. After 160 rounds have been fired, the Captain of the Turret is warned by a light flashing at the local control panel. If the operational state is favourable he can then apply cooling. If not, firing may safely be continued for a total of 260 rounds per barrel, the high rate of barrel wear being accepted.

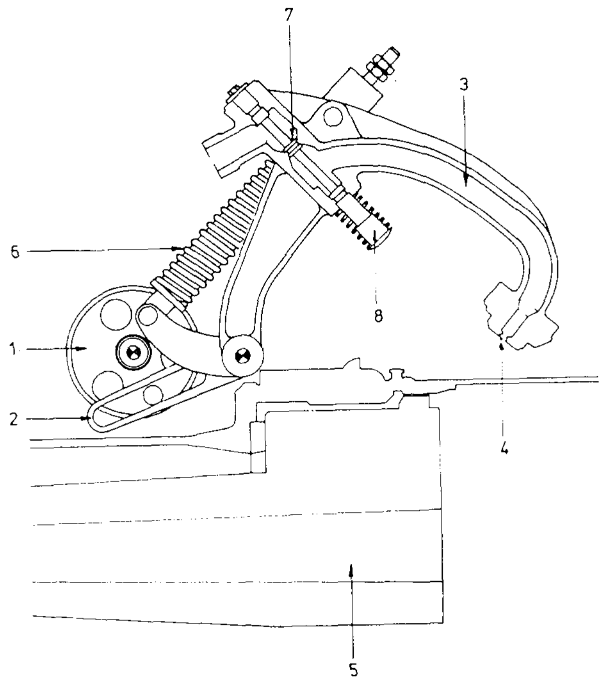

FIG. 7—BARREL COOLING SUPPLY AT GUN

The cooling arrangements for one barrel are shown diagrammatically in FIG. 7. When cooling is ordered, a motor mounted on the gun cradle rotates two discs. One disc not shown on the diagram, interrupts the firing circuits. The other disc (1) drives a pin which, sliding in the slot in (2), rotates the cooling supply pipe (3) until the nozzle jet (4) is engaged in the gun chamber (5) and is firmly seated by spring (6). The cooling supply valve (7) is opened automatically by the spring loaded plunger (8) striking the breech ring and cooling water is then sprayed directly into the barrel. Finally the water is cleared from the barrel automatically by an air blast from the same nozzle jet (4).

The cooling process lasts for a total of about 3 minutes, the nozzle being automatically removed and indication provided at the local control panel that the gun is ready in all respects to resume firing. In emergency, the gun may be brought back into action in a few seconds during the cooling process.

Weatherproofing

The majority of gun mountings leak due to the poor design of their upper deck sealing arrangements. Sea-water causes severe corrosion of the equipment which is normally in an inaccessible position and provides the unfortunate maintainer with endless nugatory work. The most vulnerable areas to leakage are undoubtedly the mantlet plate, training base and access doors.

Conscious of the widespread fitting in small ships, the designers of the Compact Mounting have given careful attention to these problems. The gunhouse is made of reinforced fibreglass and three circular access hatches are fitted which can be opened quickly and easily by handwheels mounted on either side of each hatch (FIG. 8). A connecting shaft (1) has a star wheel (2) mounted on it and this controls six connecting rods (3) which rotate bellcrank levers (4). To lock the door, the handwheel is turned and the connecting rods rotate the bell crank levers and force their rollers to engage with the inclined pads (5) on the hatch coaming. The circular construction allows the mating surface of the hatch coaming to be machine turned and to be flat and co-planar: thus, the resulting wedging action applied to the seal circumferentially and with uniform pressure makes a watertight joint.

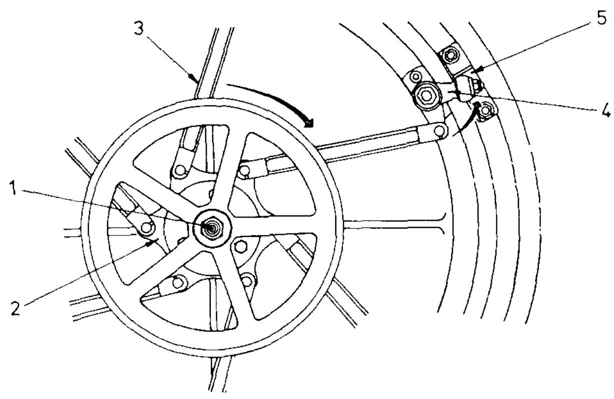

FIG. 8—GUNHOUSE ACCESS HATCH

The mantlet plate consists of a large cylindrical section aluminium fabrication which is machined in one piece to ensure concentricity (FIG. 9). When fitted to the

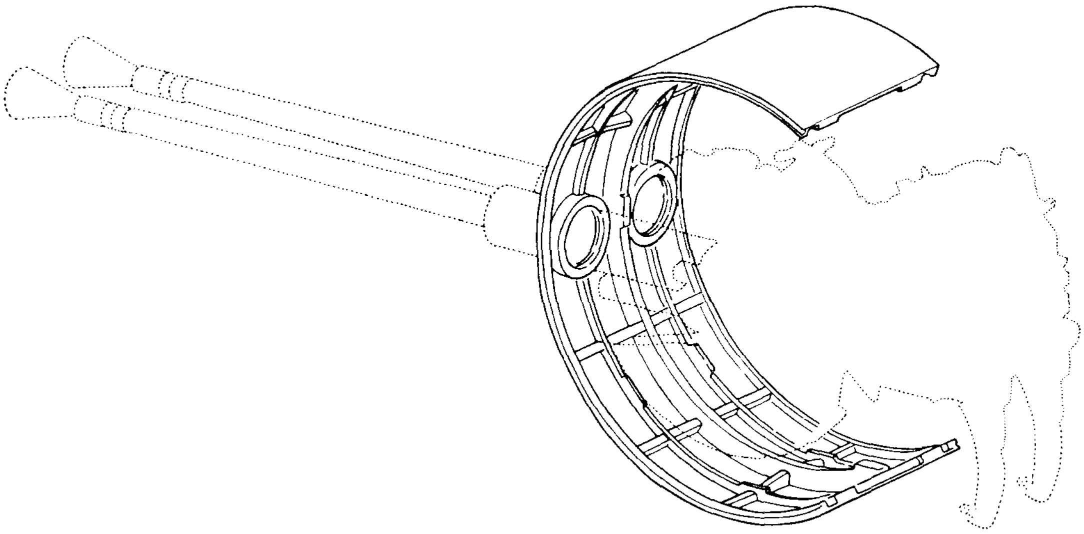

Fig. 9—Mantlet plate

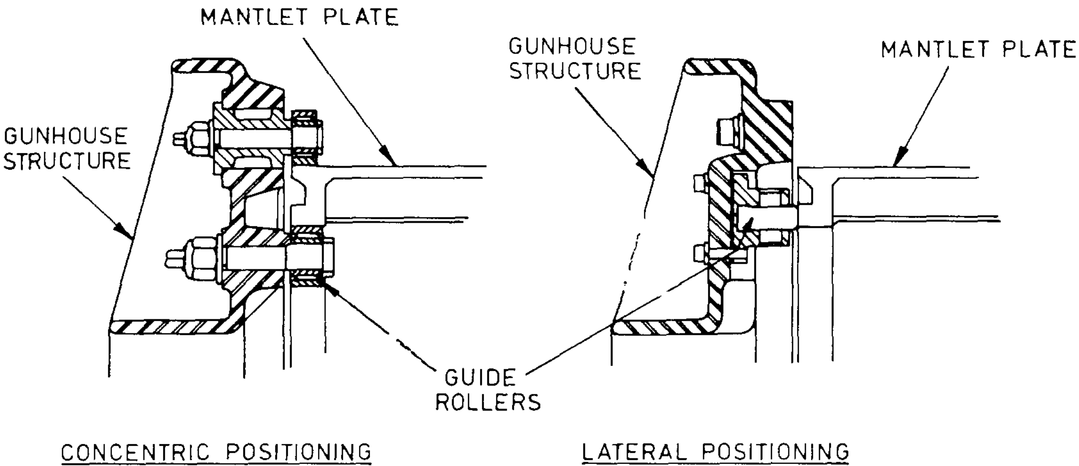

Fig. 10—Mantlet plate guide rollers

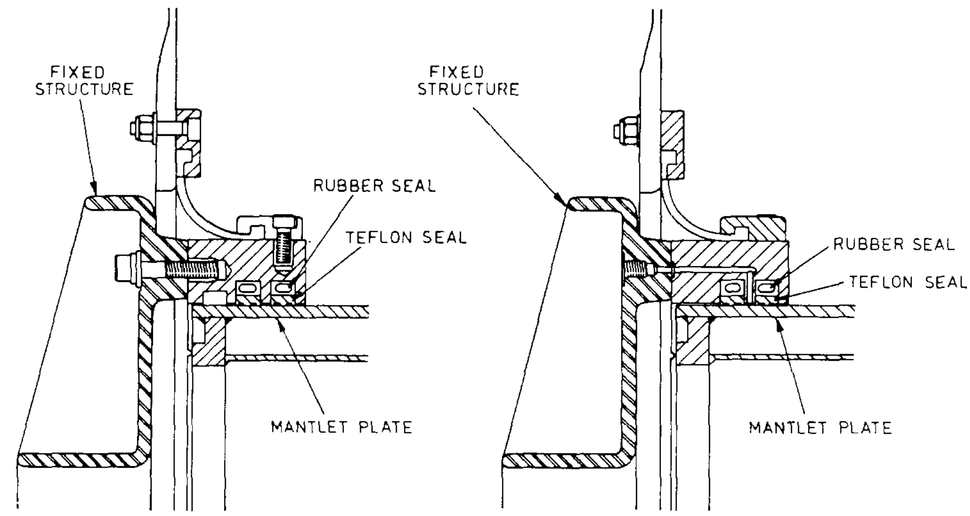

Fig. 11—Mantlet plate sealing arrangements

mounting, the mantlet plate is supported circumferentially in rollers to maintain precisely its concentricity and alignment (Fig. 10). Pneumatic weathering, so often ineffective or defective, is not used: instead, a low friction teflon seal mates with the Sandford anodised surface of the mantlet plate and the seal is held firmly in contact with the mantlet plate by continuous neoprene rings, the whole assembly being packed with grease (FIG. 11).

Since the concentricity of the mantlet plate is maintained to within fine limits, the resulting clearance between the supporting structure can be reduced to one millimetre, thereby improving still further the effectiveness of the sealing arrangements.

Similar care and attention has been given to the sealing arrangements of the training base which have already been discussed.

Conclusions

When matched with a modern fire control system and effective target acquisition facilities, the Breda Twin Compact Mounting provides a versatile and effective close-range anti-aircraft/missile and surface armament for fast patrol boats or other small ships.

The mounting employs a number of engineering features which places it in the van of the new generation of close-range guns. The automatic barrel-cooling arrangements allow a high rate of fire to be sustained from a large reserve of ammunition: the widespread use of light alloys for structural components reduces inertia and weight to a minimum and increases the mountings speed of response: accuracy is achieved by the use of an advanced RPC system, stiff gearboxes, and cradle design minimizing throw off.

The mounting is gaining a good reputation for reliability as is shown by its increasing deployment, over 100 mountings being supplied to countries in Europe, Africa, South America, and the Middle East. This reliability is based on the use of the well-proven Bofors 40L70 gun, an automatic feed system with effective protective devices, and a stable, solid-state control system having no tuning adjustments. Particular attention has been given to weatherproofing the gunhouse and training base to protect the equipment from corrosion and avoid nugatory work.

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The views expressed in this article are those of the author, and do not necessarily reflect those of the Ministry of Defence.