ANTI-SUBMARINE WEAPONS

BY

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No previous article on this subject has appeared in the *Journal* although one most informative paper[1] was presented before the Institution of Mechanical Engineers, on the mechanical aspects of these weapons, in 1948. The present article will indicate the basic problems associated with anti-submarine warfare and will trace the development of the anti-submarine weapon systems from 1914 to the present day.

INTRODUCTION

The performance of the anti-submarine weapon has until comparatively recently lagged considerably behind the target which it was designed to destroy. At the outbreak of the World War I the only weapon in use was a towed explo-

[1] *Some Mechanical Features in Anti-Submarine Weapons*, by J. M. Kirkby, M.A., A.M.I.Mech.E., Principal Scientific Officer, H.M. Underwater Weapons and Countermeasures Establishment.

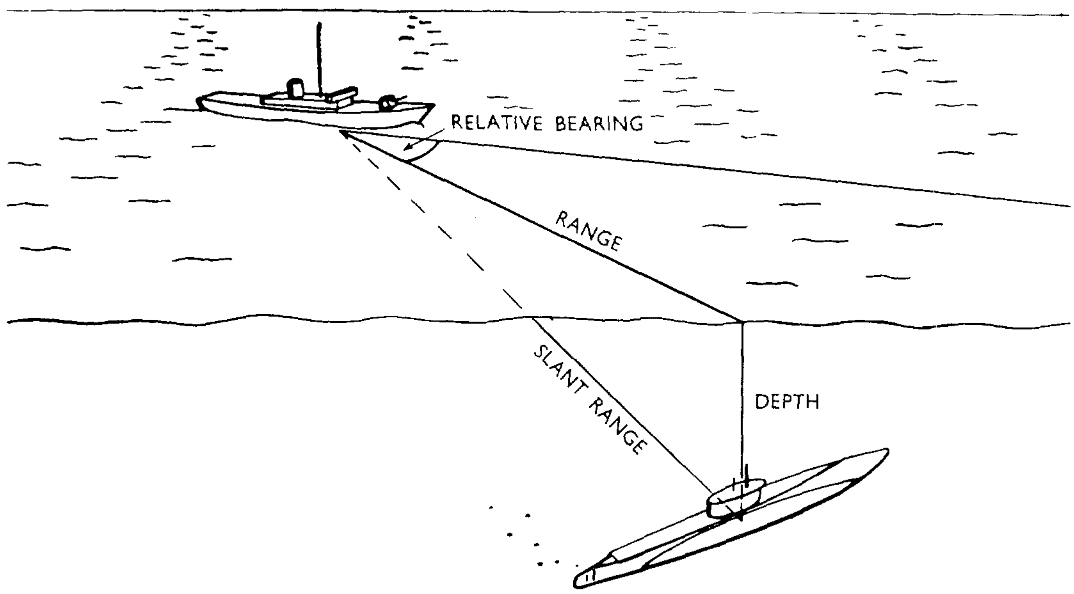

FIG. 1—THE BASIC PROBLEM

sive kite, kept at its depth by a skid on the surface, and towed and fired by a length of armoured electric cable. An improved sweep followed, consisting of a loop of cable the ends of which were secured to the ends of a beam towed astern. There were nine 70-lb explosive charges fitted to the sweep wire which were fired electrically from the towing ship when the beam swung, on fouling an obstruction. One submarine was destroyed by this device. A further improvement was an explosive paravane, containing 80 pounds of T.N.T., towed by an armoured electric cable. This was fired automatically as soon as the submarine touched the paravane or towing cable, or by hand from the bridge. This weapon was quick to stream and could be towed up to 25 knots. It was still in use at the end of this war, with four submarines to its credit.

It was fortuitous that, at the end of 1914, Admiral Jellicoe, then Commander-in-Chief, Home Fleet, requested the immediate development of hydrostatically fired mines for dropping over the stern of destroyers, at the same time as Mr. H. J. Taylor was completing his 'private enterprise' hydrostatic pistol designed at the Battersea Polytechnic for fulfilling this very function.

In the summer of 1915, Mr. Taylor accepted employment at H.M.S. *Vernon* to develop his ideas on depth charges and, by the end of the year, nine types were in use or under trial, about half being mechanically detonated and half hydrostatically. The mechanical detonation was achieved by permitting a float and lanyard to pay out as the charge sank. The length of lanyard decided the firing depth ; when all the line had paid out the buoyancy of the float pulled out the safety pin.

The hydrostatic pistol, designed by Mr. Taylor, was quite an achievement for its day. It employed, for the first time, the ball lock mechanism which has since become a very widely used design feature in this country and abroad. The largest depth charge developed at the time contained 300 lb of explosive and has survived to this day, with the pistol, almost without alteration.

The Basic Problem

The basic anti-submarine problem is shown in FIG. 1. When an attack is carried out with any weapon, a stage is reached when further information about the target is either not available or is of no further use. The period elapsing from this moment to the instant of the explosion is known as the dead

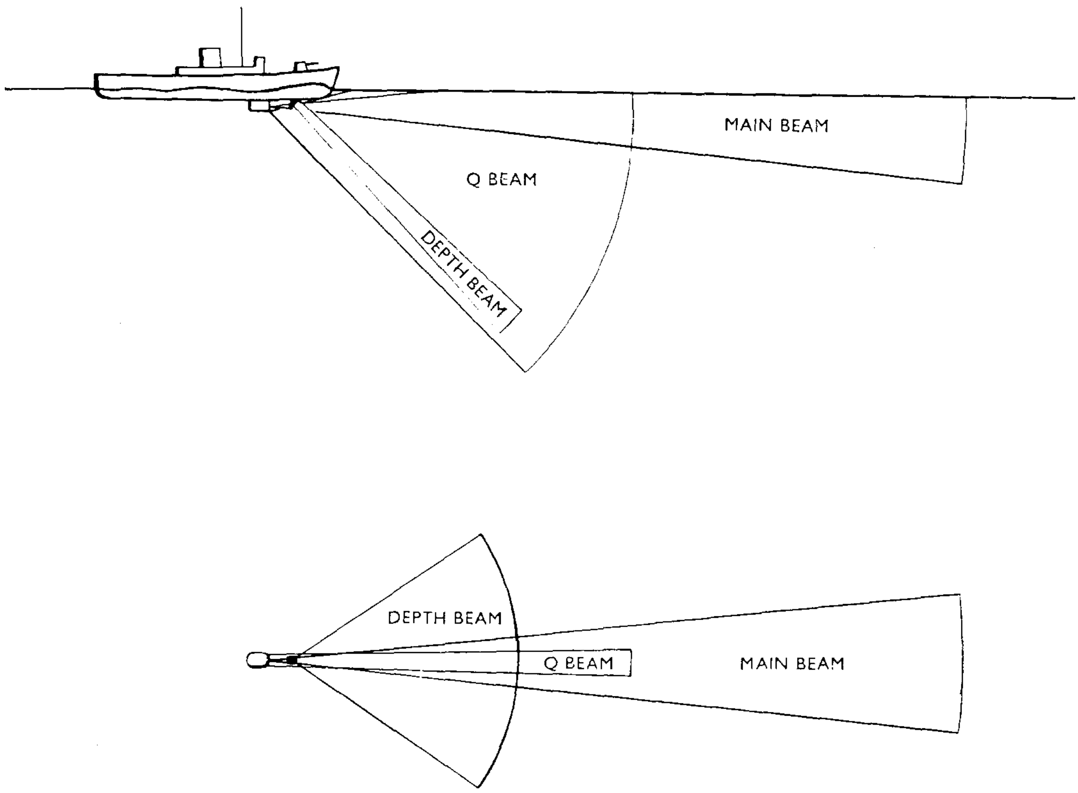

FIG. 2—THE THREE ASDIC BEAMS

time, and during this period no corrections for countering any evasive action of the target can be made. The effective anti-submarine weapon must obviously reduce this time to a minimum if it is to attain any reasonable chance of success and this requirement becomes paramount when deep and fast targets are concerned. While with modern developments it is possible to hold the target in asdic contact throughout the attack, there is a practical limitation to the reduction of the weapon blind-time, due to the time taken for the charges or projectiles to sink to the target depth. The requirements of the A/S weapon system, simply stated, consist of placing the charges in a computed position, arranging for them to sink as rapidly as possible, and for them to explode when they reach the target depth.

In order to understand the control problem involved, it is necessary to have some knowledge of the means available for detecting submarines and of the use to which this information can be put in directing the weapons on to the target.

DETECTION

Detection by underwater acoustics, during World War I was applied only to listening from almost stationary ships, and it is only credited with assistance in the destruction of two out of two hundred submarines destroyed. During the inter-war period, the emphasis of development was on detection equipment, with the general belief that if the target could be located accurately, destruction would be relatively simple. The successful development of asdics for efficient operational use was first achieved in this country, when its development abroad had been abandoned or had only limited success. The essential requirement is for the target to be continuously located within three co-ordinates, in this case relative bearing, range, and depth, in order to provide an uninterrupted flow of information to enable a properly computed attack to be made.

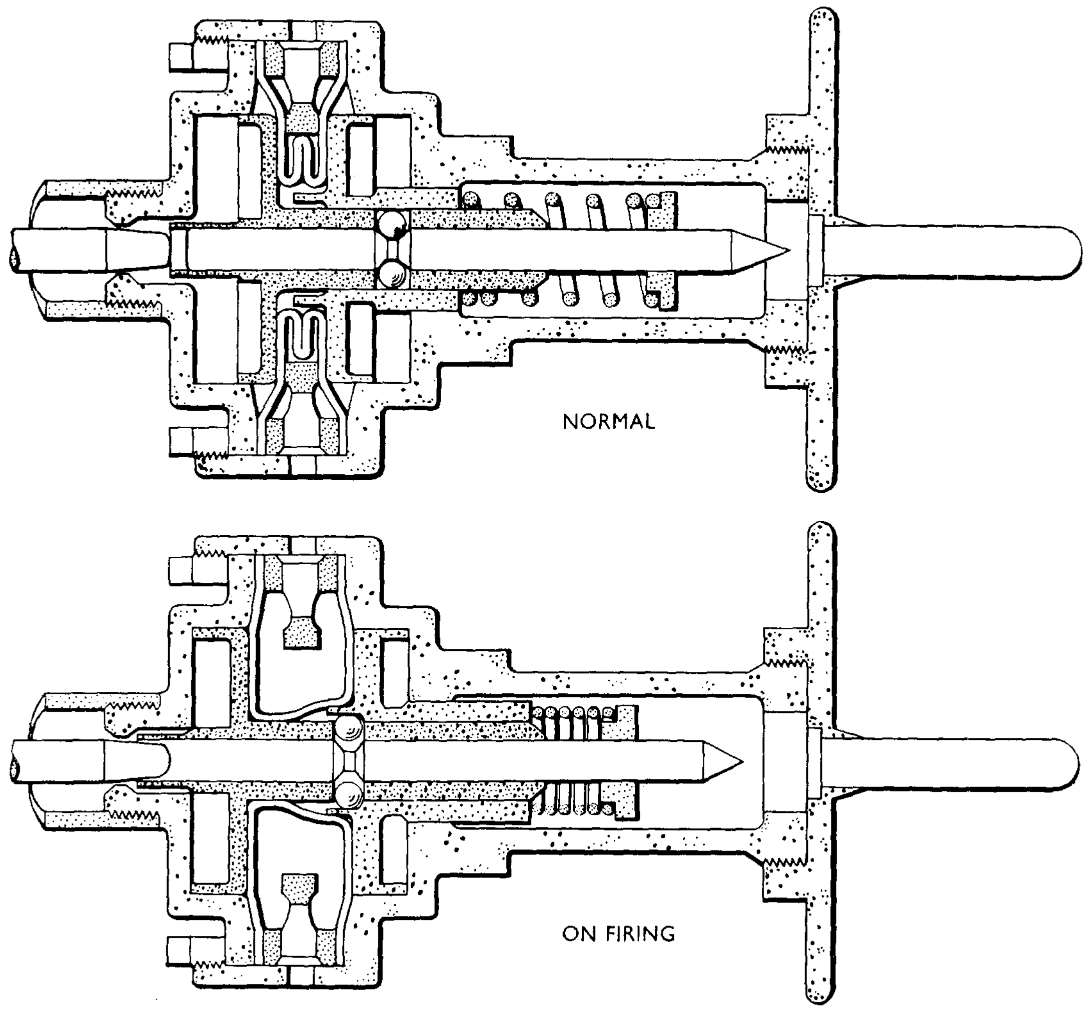

FIG. 3—DEPTH CHARGE FIRING MECHANISM
(*a*) NORMAL (*b*) ON FIRING OR RELEASING

The initial detection is done by the main search asdic set. This produces a beam emanating from a transducer, housed in a dome beneath the ship, which penetrates the water horizontally in much the same fashion as a beam of light. By virtue of the shape of the beam, contact can be lost when the range has been reduced to about five times the depth. To maintain contact, therefore, a second and shorter range set, known as a ' Q ' attachment, to the main set can be used. This includes a separate transducer, mounted below the main one and tilted downwards, producing a much steeper beam. It must be remembered that an asdic set measures the range along the beam, and consequently, at short ranges, significant differences occur between the slant range along the beam and the horizontal range to the position of the target. These asdic beams can be trained in azimuth and so can explore the extent of the target to obtain a mean centre bearing.

A special asdic set of the Type 147 Series is required for providing up-to-date depth information. This set has a tilting transducer placed ahead of the main dome and is usually run synchronized and as a slave to the main and ' Q ' sets to avoid interference. The beam of this set resembles a horizontal fan and provides accurate location of the target in a vertical plane, from which the depth is obtained. The wide angle of this beam makes a training facility unnecessary.

These three co-ordinates can be plotted as continuous traces on range, bearing and depth recorders which are the fire control instruments for the weapons.

The Range Recorder

This is the co-ordinating instrument for the weapon system. It records visually the echoes, received either by the main or ' Q ' asdic sets, on a moving strip of sensitized paper and provides a plot of the rate of change of range. The marks on the paper, representing the echoes, together with the aural presentation of the echoes have characteristics which are of considerable help to trained asdic operators in deciding whether an echo is from a submarine or not, and of the inclination of the target, without having to wait for a plot to form on the paper.

The correct time to fire the weapon is computed by the recorder and for this purpose an optical cursor is provided to assist in setting a firing bar parallel to the range plot. As the range closes to the firing range of the weapon, this bar touches a pin and initiates the firing switch. The position of the pin is adjusted for the various corrections necessary affecting the passage of the projectile to the target. Most of these adjustments are fixed and concern such things as the relative positions of the transducer and the weapon. The target depth, however, is variable and has to be kept corrected during the attack as it affects the dead time, the correction for slant range as already mentioned, and the part of the range which has to be covered by the underwater trajectory of the projectile.

The Bearing Recorder

This is an instrument which plots the target bearing against time in the form of a trace on a moving band of paper. This trace is used to calculate the deflection angle required for ahead-thrown weapon attacks, that is the angular amount the projectile must be thrown ahead of the target in order to hit it, after taking into account the submarine's and ship's components of speed across the asdic beam, and the time the projectiles take to reach the target. Having found the deflection angle the information is automatically transmitted to a Captain's Bearing Indicator on the bridge and thence at the discretion of the Captain to a Helmsman's Indicator in the wheelhouse.

The Depth Recorder

This is based on the same principles as the range and bearing recorders, except that the speed of the stylus is proportional to the sine of the angle of tilt of the transducer and so gives a direct depth reading on the trace. In the case of fused projectiles, it automatically controls the fuse settings.

DEPTH CHARGES

The Weapon

The Mark 7* depth charge used by A/S vessels is essentially a cylinder, 18 inches in diameter and 26 inches long, with a central tube for taking the firing mechanism consisting of a pistol and primer. The pistol operates when a head of about 50 feet of water has been built up between two opposed pistons. The rate of water entering the central tube can be varied by selecting one of a series of leakage holes by rotating a depth setting key on the end of the pistol, and so varying the time taken to build up the necessary firing pressure in the pistol chamber.

FIG. 4—HEDGEHOG MOUNTING BEING LOADED

To cover as much sea room as possible, the depth charges are laid in patterns of five or ten as single or double layers of centred squares. The three diagonal charges are laid from a chute into the wake, and the corner charges are thrown out on the beam by throwers. The charges from the rails fall into the most turbulent part of the wake, and rolling from the rails imparts a rotation which introduces a horizontal component, in the early stages of sinking, due to magnus effect. Both these factors give the rail-laid charges an initially slow sinking rate. The terminal velocity of ten feet per second is only reached after 200 feet. The thrown charges enter the water with a considerable velocity and no rotation. The difference of initial sinking rates is corrected to some extent by altering the laying intervals and using different leakage holes in the pistols, but it can be appreciated that to get a pattern to explode in the required position and depth, is probably a pious hope.

Method of Attack

The main difficulty of a depth charge attack is that due to the location of the weapon right aft and the properties of the asdic beam, contact is lost a considerable time before the attack is completed. By the time this occurs, the vessel should have been conned on to a collision course. In the absence of a depth finding asdic, the range of lost contact gives the only indication for pistol or fuse setting and this information is passed to depth charge positions by order instruments. The deflection angle, necessary to drop the charges the correct distance ahead of the target, can only be estimated. A bearing recorder, if fitted, can assist this estimation.

After contact is lost, the cursor on the range recorder is kept in line with the earlier range trace until the firing bar touches the firing pin. This contact initiates a series of timed electrical impulses to an electro-hydraulic release and firing system fitted aft, in order to achieve the pre-selected five or ten charge pattern. The laying sequence takes about 16 seconds, the depth charges exploding in succession as the pressure in the pistols builds up and compresses the firing springs. There are many errors which can accumulate during such an attack which make it inherently inaccurate, the probability of success being only about 5 per cent.

HEDGEHOG

Before the comparatively advanced development of ahead throwing weapons, the only method available for determining the depth of the target was from the range at which asdic contact was lost, coupled with a knowledge of the shape of the lower edge of the asdic beam. It was this and the limitations of the depth charge pistol depth adjustment, which were the principle deficiencies of the early equipment and decided the course of development.

The idea of throwing a charge ahead of the ship to a position where asdic contact was still maintained, was born just before the outbreak of the last war. Development began in 1940 on about six projects of this type. In view of the high order of deck thrust caused by the discharging gear, the trend was to discharge a number of small charges, at short time intervals, to form a calculated pattern on entering the water. As development proceeded, a weapon known by the code name ' Hedgehog ' emerged as the most promising for fleet use, and the remaining projects were ultimately dropped.

The Weapon System

The development of Hedgehog and its associated equipment was divided between the Ministry of Defence and the Admiralty, the projectile being designed at the Admiralty Mining Establishment.[1] The prototype weapon, built under contract by Messrs. Foster Wheeler and based on a design drawn up at the Anti-Submarine Experimental Establishment[2], underwent sea trials in 1941. It must be borne in mind that this weapon was developed during the most critical period of the war and consequently it was of supreme importance to get it to sea with the least possible delay. For this reason its design was kept as simple as possible.

The mounting consists of four beams each carrying six spigots mounted on fore and aft trunnions so that they can be rocked by hand control from a position behind the blast shield. The projectiles are fired electrically over a 2-second period by a ripple firing switch so that they enter the water together in an approximately circular pattern 120 feet in diameter at a range of about 210 yards. The original design was intended to replace the forward gun-mounting in escort vessels. In some cases it was particularly desirable to retain this gun, and for this reason the mounting was re-designed in two sections, each containing one pair of beams. One section was mounted each side of the ship, the starboard half being the controlling mounting and the port half a slave. The two half-mountings were connected by a telemotor link and were slightly set in to allow for their off-set from the ship's centre line. This version was known as the ' Split Hedgehog '. On the after end of the mounting behind the blast shield an operator manned the hand drive to the tilting beams, and matched a pointer linked to the beam drive with a gyro stabilizer pointer indicating the vertical datum. Given practice and fair weather, a reasonable degree of correction for roll was obtained. As the mounting is designed to fire ahead, however, it was necessary to arrange to compensate for small course

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[1] Formerly the Mine Design Department, H.M.S. *Vernon,* now the Underwater Countermeasures and Weapons Establishment, Havant.

[2] Now the Underwater Detection Establishment, Portland.

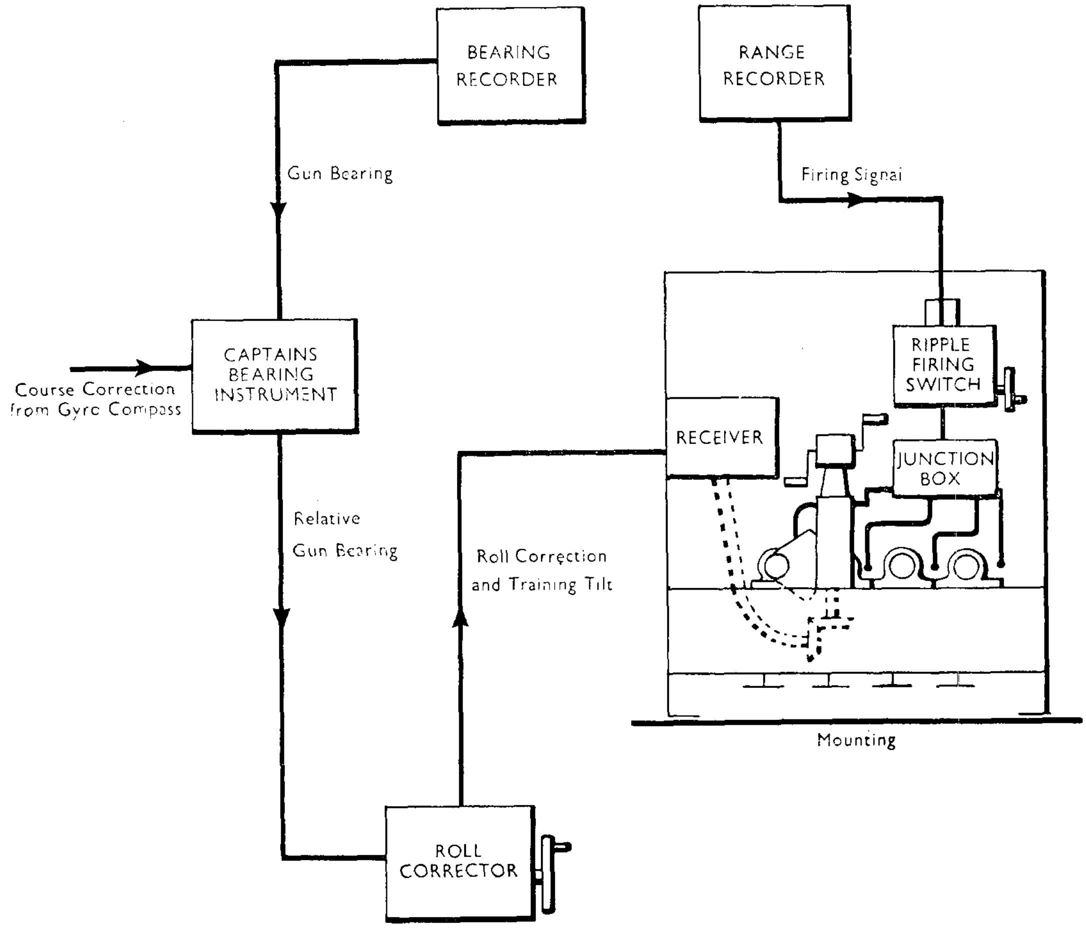

FIG. 5—THE HEDGEHOG SYSTEM

errors during the attack. This is done by controlling the vertical datum used for roll correction from the Captain's Bearing Indicator on the bridge. This is only possible for course errors up to 20° as any aim-off done in this manner distorts the pattern entering the water and reduces its lethal area.

Two types of fire control system were developed at the same time as the weapon, to provide vertical indication for the operator controlling the mounting.

The Type ' A ' fire control gear was specially designed and employed a self-erecting gyro, controlled by mercury-switch operated torque motors, to provide the vertical datum. The gyro casing was mounted at the after end of the mounting. Although this practice is now well established, at that time the use of mercury switches to control gyros was considered rather novel, and as a second string, the type ' B ' fire control gear was also developed. This was sited below decks near the centre of roll and used a standard Evershed and Vignoles fire control gyro with a powered follow-up drive working an ' M ' type transmitter. The receiver was fitted at the operator's position on the mounting. The gyro-wander was hand corrected through a differential using spirit levels as a datum.

The later versions of Hedgehog have the omissions, which were originally accepted in the cause of simplicity, rectified, and metadyne remote power control is fitted in conjunction with a Type ' C ' roll unit fitted below decks to provide automatic roll correction. The firing operation has also been made automatic by fitting a motor-driven ripple-firing switch operated from the range recorder firing contacts.

The projectile, developed at the Admiralty Mining Establishment, weighs 65 lb and contains 34 lb of explosive. Initiation of the charge is by means of a contact fuse, armed by the firing impulse, and also by its passage through the water. The tail fitted to stabilize its flight through air incorporates slightly 'set' radial fins to impart the rotational movement to centre the projectile while sinking. The tail tube, which fits over the mounting spigot, carries the cartridge containing the propellant. It is built in at the upper end with the primer making contact with the firing pin, housed in the top end of the spigot. The sinking rate of the projectile is about 29 ft per second. Once it is armed and it strikes a hard surface an inertia weight is dislodged which releases a spring loaded firing pin.

Method of Attack

The detection facilities available in the early Hedgehog fitted ships, were much the same as those already described when discussing depth charges. During the critical period, when Hedgehog was developed, it merely provided an additional armament for ships fitted for depth charge attack, consequently certain advantages of the ahead-thrown attack were not fully exploited in the early days. The addition of a bearing recorder, already mentioned, was the most significant contribution to achieving a controlled attack. There was no depth finding asdic, only a 'Q' attachment which considerably shortened the contact range without giving any positive information as to the target depth. In the absence of depth information, it was necessary to choose an optimum target depth of about 175 feet to enable a suitable allowance for blind time during the sinking period of the projectile to be made for the purpose of setting the range recorder. However, for deep targets, where blind time was large, the inaccuracies were too great and depth information became essential.

As the weapon is essentially designed to fire ahead, the attack procedure is to steer a centre bearing course deduced from the bearing recorder, and then, after making the appropriate settings to the range and bearing recorders to steer the deflection angle ahead of the target. Small errors in this angle are compensated by feeding continuous bearing information from the Captain's Bearing Indicator into the roll correction instrument as already described. Thus, when the range recorder firing contacts make, the position where the projectile pattern enters the water is properly computed with certain depth limitations.

The use of contact fuses can give rise to much debate. Their successful use denotes a certain hit, and the destruction of the submarine. Their unsuccessful use does not disturb the asdic conditions for a further attack. The overriding disadvantage, however, is the loss of the cumulative effect, materially and morally, of a number of near misses. Compared with a depth charge attack, where the effective radius of a pattern is about 260 feet, the Hedgehog had to be regarded as a precision weapon since, with contact fuses, the lethal radius became the radius of the projectile pattern, that is, about 60 feet.

It can be appreciated how the inaccuracies due to the sinking time of the projectiles mount up without accurate depth measurement of the target, and how much depends on the skill of the operators of the early roll correction arrangements. However, in the relatively confined waters of the English Channel at the end of the war, results from worked up ships showed a probability of success of 30 per cent. A significant improvement over the depth charge attack.

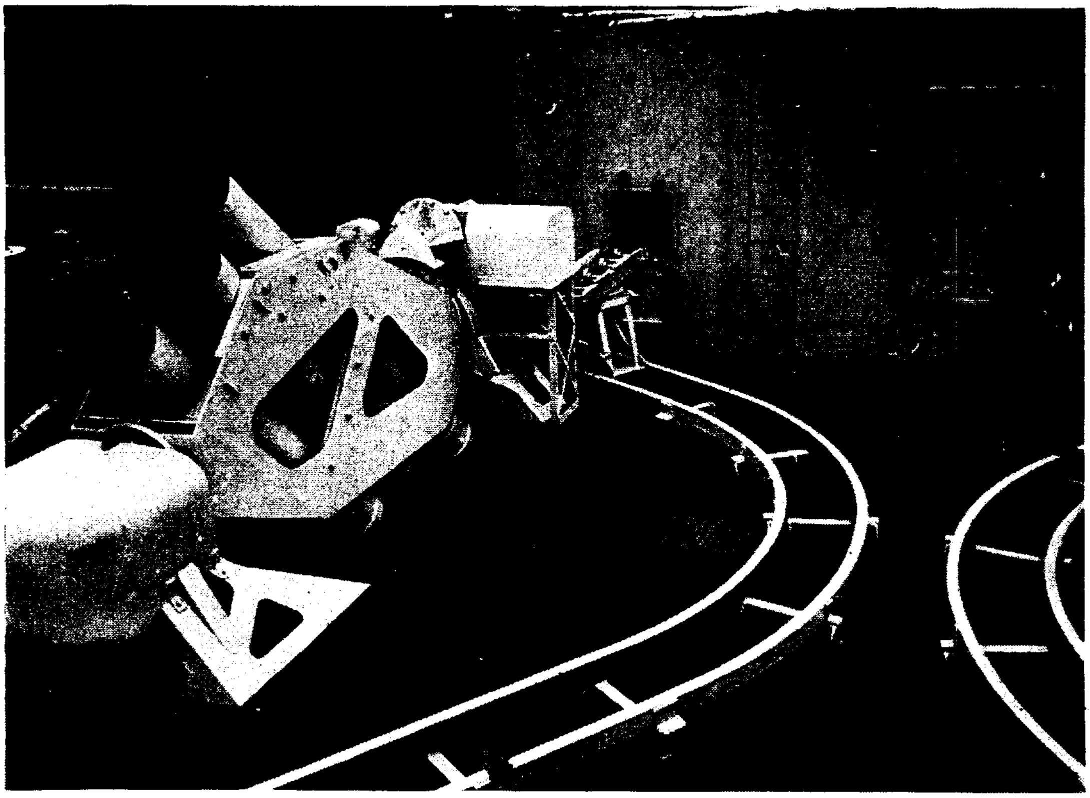

FIG. 6—THE SQUID MOUNTING AND LOADING ARRANGEMENTS

SQUID

The shortcomings of Hedgehog were rectified in Squid. The need for a weapon and an asdic set to overcome the depth location and fusing difficulties was appreciated in the early days of the development of ahead-throwing weapons, and, in 1942, it was decided to proceed with the development of a depth measuring asdic set and a weapon for firing fused charges. The asdic became the first of the Type 147 series and has been briefly mentioned in an earlier paragraph. The weapon was developed by the Admiralty Mining Establishment under the code name ' Squid '. The nature of the times in which Squid was developed was such that, in order to get these weapons to sea as soon as possible, the production orders were placed from the drawing board without waiting for the prototype trials. The first Squid fitted ship commissioned at the end of 1943.

The Mounting

The mounting is completely fabricated, the three 12 in bore barrels, made from unmachined solid drawn tubing, are arranged at a 45 degree elevation. The barrel lengths and angular relationships are such that the same propellant charge may be used to fire the projectiles 270 yards ahead of the ship to enter the water in a triangular pattern. When two mountings are fitted the port and starboard mountings are handed, so that the projectile patterns overlap and lie, in plan, approximately on a circle 145 feet in diameter. In this case the two patterns are arranged in layers 60 feet apart.

The mounting is power stabilized in roll, but by means of a change-over clutch the drive may be transferred in emergency to hand control, using a large handwheel and a roll corrected ' follow the pointer ' indicator, in much the same way as in the original versions of Hedgehog. Limit stops are provided at 43 degrees port and starboard with arrangements for tilting to 90 degrees inboard for loading. The firing thrust of the mounting, reduced by ripple-firing, is taken at the forward trunnion bearing to minimize the journal and bearing misalignment due to the pedestal and cradle deflections.

Fire Control

The control of the mounting follows the basic pattern set by Hedgehog. A self-erecting gyro-operated roll corrector measures the ship's roll and transmits it through a helmsman's indicator to a metadyne R.P.C. system controlling the mounting. It also operates the indicator fitted for controlling the mounting, by hand in emergency. Should the ship yaw off course, bearing information from the Captain's Bearing Indicator is superimposed on the roll correction signals in the Helmsman's Indicator and the mounting is aimed off accordingly. As the ship is brought back on course the Helmsman's Indicator is centred and the aim-off is wiped out.

The Projectile

The squid projectile weighs 390 lb and contains 207 lb of explosive. It is, therefore, eminently suitable for dealing with the stronger pressure hulls inevitable with deep targets. Like the Hedgehog projectile it is streamlined, apart from a flat nose. A piston ring is fitted as a gas check on firing, and its flight through the air is stabilized by a tail and heavy nose piece containing the fusing gear. Entry into the water is made at an angle of about 45 degrees and a velocity of about 160 feet per second. It decelerates to about 38 feet per second at 150 feet, when it throws off the cavitation effects and then accelerates slowly to about 41.5 feet per second, meanwhile advancing along the firing bearing at a continually diminishing rate. This underwater advance is automatically allowed for in the cut of the depth setting cam on the range recorder. The tail incorporates slightly helically set fins to cause rotation while sinking, and so avoids wander from the trajectory due to any lack of symmetry which may be present.

Since previous emphasis has been laid on high sinking speeds the necessity for a flat nose may not be obvious. When a projectile enters the water at the speeds used, it makes a large cavity which completely envelops it. The projectile has only its nose in contact with the water and being then top heavy it would, in the ordinary way, lie down on the bottom of the cavity and follow an erratic course. This situation is avoided by the flat nose, which by its tendency to set with its plane perpendicular to the direction of motion stabilizes the projectile and keeps its nose on to its trajectory. During this cavitating period, the drag coefficient is high and the forward motion is rapidly arrested. As speed reduces and depth increases the air envelope comes away reducing the drag coefficient which then depends mainly on the shape of the streamlined body and permits the projectile to sink at high speed.

The Fuse

The fuse incorporates an inertia arming device to operate on firing and an hydrostatic arming device to operate on entering the water. To minimize the risk involved from short ranging, the fuse will not arm unless the firing impulse is sufficient for a range of at least 160 yards. Firing is initiated by allowing the hand of a clock fuse started when the projectile enters the water, to spring up into the recess formed in a thick disc immediately above the clock mechansim. The relative positions of the hand and the recess in the disc are remote controlled from the depth setting control panel. If it becomes necessary to change the fuse settings they can be brought to the zero or ' home ' position using a hand-push, and are then ready for resetting in the normal manner. A check indication that all fuses are ' homed ' before commencing an attack, is provided

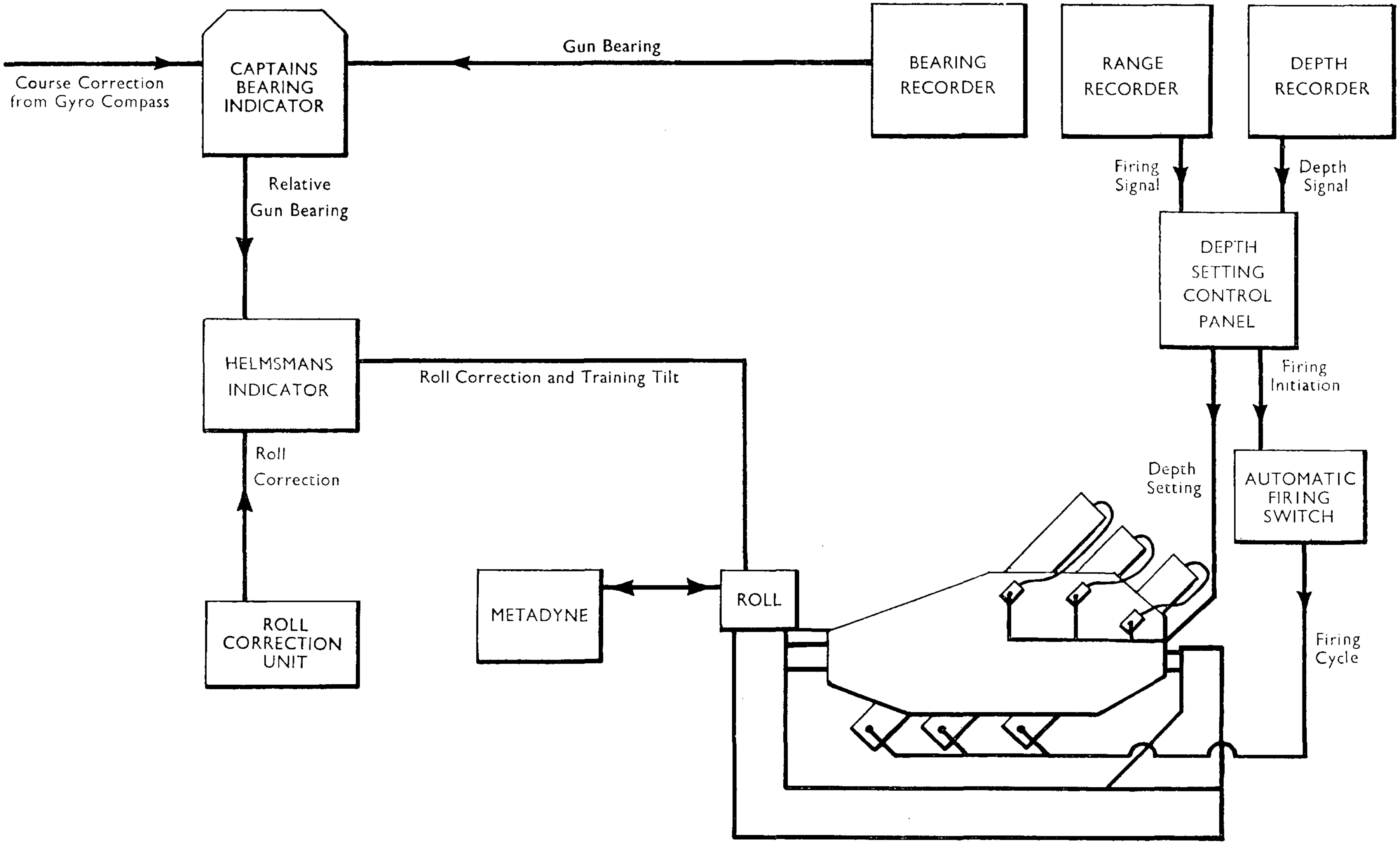

FIG. 7—THE SQUID SYSTEM

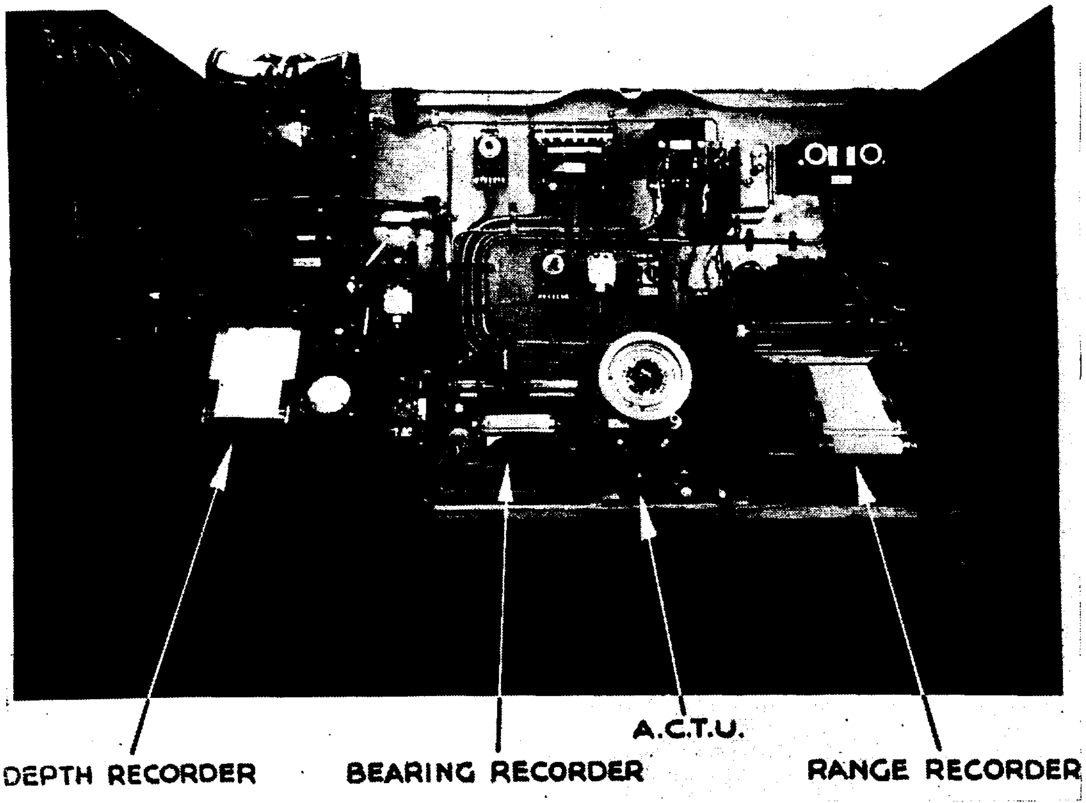

FIG. 8—CONTROL ROOM FOR A SHIP FITTED WITH SQUID

by indicating lamp circuits which are broken as the fuse slave motor moves away from the ' home ' position. The power supply and indicating circuits are connected to the fuse through a three-core electric lead plugged into the projectile, which is cut by the relatively sharp edge of the fuse as the projectile leaves the barrel.

Depth Setting

The fuse setting is decided automatically at the depth recorder and is set on the fuses by the depth setting control panel when the firing contacts make in the range recorder. As the depth setting cycle, which also converts the depth signal into a time interval, takes about five seconds to complete, arrangements are made for the firing contacts to make correspondingly early to ensure the correct time of firing. When a twin squid armament is fitted, the port and starboard patterns are fused in layers 60 feet apart. As the projectile sinking speed is not constant some approximation to a constant value is necessary to convert the target depth into a time interval for setting fuses. An approximation of the terminal sinking speed is made as it is most inaccurate at shallow depths where the sinking time is short and therefore of least importance. At greater depths, where the sinking time is correspondingly high and the trajectory is steep, the approximation is more accurate and of greater importance.

Loading Gear

Because of the size and weight of the projectile, special loading arrangements are necessary. These vary in general arrangement according to the class of ship, but generally, projectiles are stowed in a projectile room sited on the deck below the weather deck. They are hoisted by a bollard hoist into the projectile handing room on the mortar deck which provides the ready use stowage for the mountings. A hand conveyor is fitted to facilitate the transfer

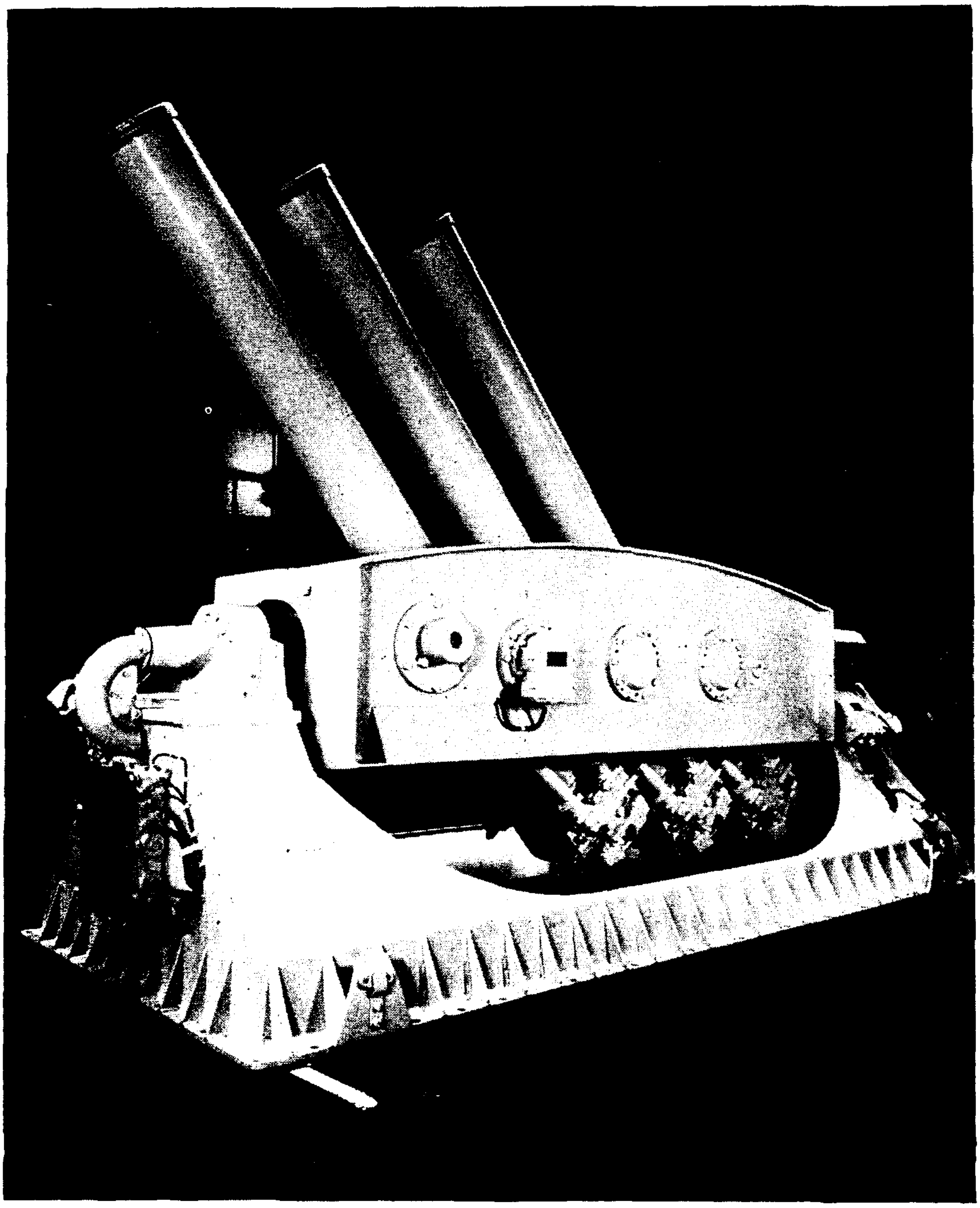

FIG. 9—A/S MORTAR MARK 10

of the projectiles out of the loading scuttle on to trolleys, which are man-handled on rails to the mortar loading position.

Method of Attack

On initial detection of the target by the search asdic, the ship is conned on to a centre bearing course, while the necessary investigations and settings are made to the recorders. The bearing recorder maintains up-to-date transmissions of gun bearing to the Captain's bearing instrument, and the depth recorder continuously keeps the depth setting control panel posted on the target depth. Once the bearing recorder operator has obtained a satisfactory deflection angle, the ship is conned entirely from the Captain's bearing instrument controlling the helmsman's indicator. At the predetermined range, the range recorder

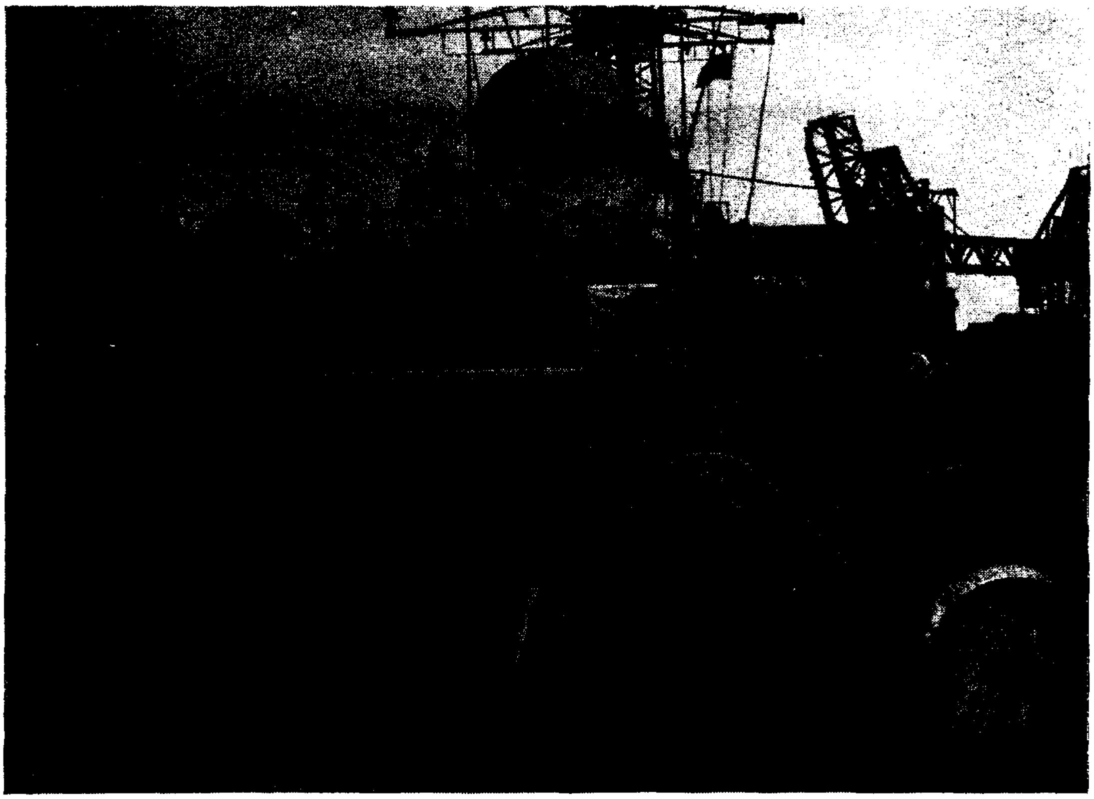

FIG. 10—AN A/S MORTAR MARK 10 IN THE LOADING POSITION

contacts make, initiating the operation of the depth setting control sequence and the automatic firing switch. This weapon system, comprising the asdic sets of Type 144 and 147 series in combination with Squid, provides a complete and very efficient weapon system for dealing with present day targets.

A/S MORTAR MARK 10

The Principle

After the appearance of the Type XXI and XXIII fast U-boats at the end of the war, the anti-submarine weapon was given a re-appraisal to keep it abreast the faster and more manœuvrable targets of the future. This type of target imposes limitations on the use of the principle of the ahead attack and its computing arrangements as exampled by the Squid system, especially under counter-attacking conditions. It is only possible to fire one salvo for each attacking run against the target. The A/S mortar Mark 10 and its associated directing and controlling equipment are designed to overcome these limitations.

This weapon's characteristics are based on firing Squid projectile patterns at a target without having to alter course to counter any evasive action. This is achieved by designing the mounting on the same lines as Squid but arranging also for the barrels to be tilted in ' pitch '. By a combination of cradle ' roll ' and barrel ' pitch ' motions, all round training is possible within the usual safety firing-arc limits. The barrels are fully stabilized, and are operated by metadyne remote power control from the control unit.

To take full advantage of the training capabilities, improved loading arrangements are necessary to enable a series of salvos to be fired at short intervals during one attack. This is arranged by building the projectile handing rooms alongside the mountings which can be trained 90 degrees inboard to line up with loading scuttles through which projectiles are power rammed into the barrels. Consequently reloading is a relatively rapid procedure.

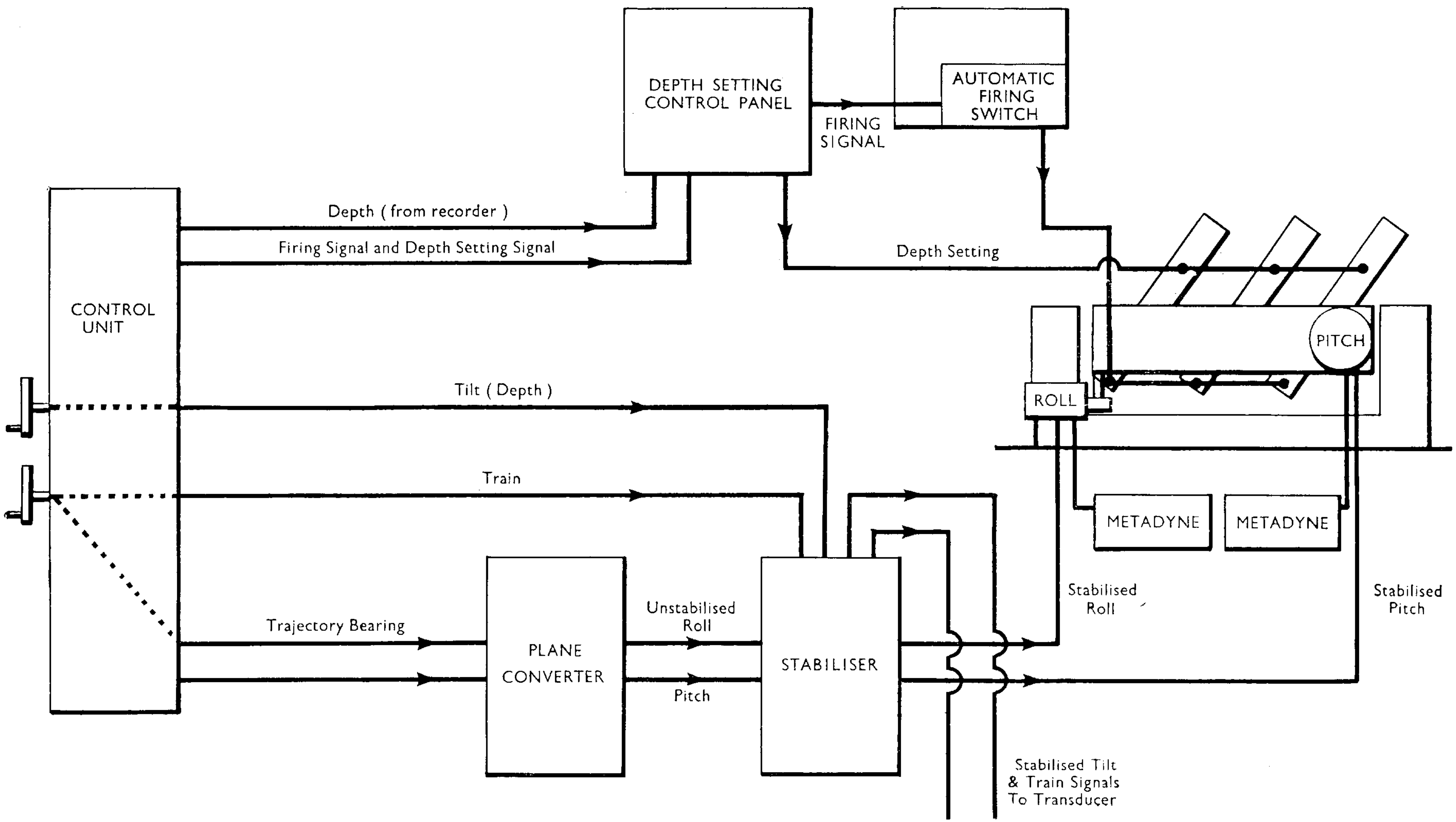

FIG. 11—A/S MORTAR MARK 10 SYSTEM

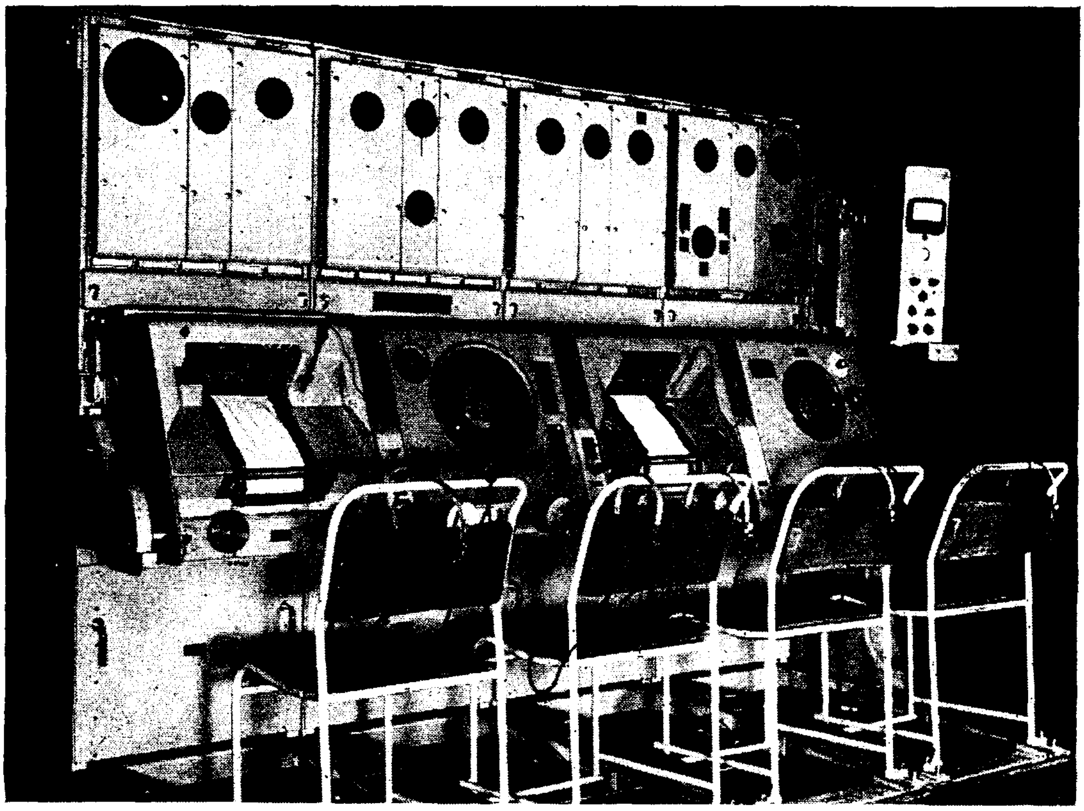

FIG. 12—CONTROL UNIT FOR SHIPS FITTED WITH A/S MORTAR MARK 10

Fire Control

Most of the control and computing instruments are built into a single control unit. Hand-operated transmissions for tilting and training the transducer are passed through a stabilizer, to compensate for the ship's movement, before passing to the tilting and training power unit in the asdic directing gear compartment. These transmissions also operate through the computor section of the control unit, which transforms them into mortar bearings along which the projectiles are to be fired. By means of a ' plane converter ', the mortar bearing information is converted mechanically into the required mortar mounting pitch and roll components. These are fed through the stabilizer to correct for ship's movement before passing to the mounting remote power control system. The depth setting controls are very similar to those in the Squid installation except that it became necessary to dispense with the plug and socket connection of the expendable electric lead to the projectile. For the A/S mortar Mark 10, the depth setting circuit has been redesigned to operate through a single contact on the projectile. This makes it possible to set the fuses and also to operate the fuse ' homed ' indicating lamp circuits without having to use a flexible lead.

CONCLUSION

It is hoped that it may now be more apparent how, in the course of the last forty years, the developments in asdic and weapons have ousted the submarine from its previous favoured state of immunity into a situation where, once detected, it can be attacked with comparative ease and accuracy.

As in all forms of warfare, the ultimate results are much affected by the tactics and counter-measures adopted on both sides. There are, also, natural conditions within the sea affecting asdic efficiency which it is not the purpose of this article to discuss, but which vitally affect the chances of success.

The fact that effective and efficient means must always be available for dealing with the high performance submarine of the future, cannot be questioned. With the present relative sizes of surface and underwater fleets, the ship-hours available for the destruction of the enemy will be severely limited.