B.R. 1919 RESTRICTED

HANDBOOK

FOR

40MM. BOFORS TWIN R.P. 50 MARK 5 MOUNTING

1950

B.R. 1919 RESTRICTED

HANDBOOK

FOR

40 MM. BOFORS TWIN R.P. 50 MARK 5 AND 5* MOUNTING

This book supersedes B.R. 1249 and B.R. 1278 both dated 1945, all copies of which should be disposed in accordance with the instructions in B.R. 1.

Naval Ordnance Department,
ADMIRALTY

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12	P 506/58	29. 8. 59	
13.	P. 268/59.	12, 1. 61	

Admiralty,
26th *June*, 1950

G. 0216/49

B.R.1919 (Restricted) *Handbook for 40 mm. Bofors Twin R.P. 50 Mark 5 and 5A Mounting*, 1950, having been approved by My Lords Commissioners of the Admiralty, is hereby promulgated for information and guidance.

B.R.1249 (Restricted) *Preliminary Pamphlet for the 40 mm. Bofors Twin R.P. 50 Mark 5 Mounting*, 1945, and B.R.1278—*Instruction and Maintenance Book Type MD/AC for Metropolitan-Vickers Electrical Company's System of Metadyne Power Control, 40 mm. Bofors Twin R.P. 50 Mark 5 Mounting*, 1945, are hereby superseded and copies should be disposed of in accordance with the instructions in B.R.1.

Attention is specially directed to the notice printed below.

By Command of Their Lordships,

To Flag Officers, and
Commanding Officers
of H.M. Ships and
Vessels concerned.

NOTICE

Suggestions for improvement of the text or illustrations, which can be incorporated by way of amendment or in any future revision of the book, will be welcomed and will receive careful consideration; they should be forwarded to the Secretary of the Admiralty through the usual channels.

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(G. 4041/55.—Amendment No. 8.)

NOMENCLATURE

In accordance with current instructions regarding the nomenclature for 40 mm. guns and mountings, the following revised terms or their equivalents are to be taken as read throughout this handbook :—

" 40/60 guns " *in lieu of* " 40 mm. Bofors guns ".
" 40 mm. mounting " *in lieu of* " Bofors mounting ".

(*Amendment No. 12.*)

INTRODUCTION

The Mark 5 mounting carries two 40 mm. Mark 11 water-cooled Bofors guns which fire H.E. shell with direct action fuzes at a rate of 120 rounds/min. per gun at 60 degrees elevation, and 140 rounds/min. per gun at 0 degrees elevation. These rates of fire should be maintained as near as possible on mountings in service. The shells are self-destroying at approximately 3500 yards.

Capabilities and Tactical Use of the Mounting

The capabilities of the mounting vary, according to the type of director controlling it: either a Close Range Blind Fire Director (C.R.B.F.D.) or a Simple Tachometric Director (S.T.D.) may be fitted. With the former, the mounting is auto-operated and can be used for both "blind" and "visual" fire since the C.R.B.F.D. is fitted with radar Type 262. There is very little difference in accuracy between these two methods and both show a considerable improvement on previous equipments.

The maximum effective range of the mounting when controlled by the C.R.B.F.D. is 2,500 yards but fire against aircraft should be opened at 4,000 yards to allow for the rapid closing rate during the time of flight.

With the S.T.D., the mounting is again auto-operated but only visual fire is possible as radar is not fitted. Due to the limitations of the sight in the S.T.D. the maximum effective range is reduced to 1,200 yards and fire should be opened when the range is 3,000 yards.

Continuous fire is maintained, so long as the supply of ammunition to the loader is maintained.

A present day aircraft will be destroyed by two direct hits and quite possibly one, although the neutralisation of a suicide bomber by disintegration before it can reach own ship would almost certainly require more.

The mounting should be effective by day or night with the C.R.B.F.D. and by day only with the S.T.D. against:—

aircraft;
guided missiles, flying bombs, etc.;
E-boats;
light superstructures of small ships.

The limits of elevation and training of the mounting are 15 degrees depression to 90 degrees elevation and 360 degrees training.

There are three method of operation:—

auto—by director;
joystick—using the type 6 sight;
hand—following receivers or using eyeshooting sights.

Historical

Early in 1944 it became clear that the ensuing months were likely to see a serious deficiency of 40 mm. close range weapons due to the large increase in requirements for re-arming the fleet and also to production difficulties being encountered with such complex mountings as the Bofors Mark 4 and S.T.A.A.G.

To expedite manufacture, it was decided to design a simple twin Bofors mounting based on the orthodox principles already in service, embodying the training base and sections of the elevating and training power drives on the 2 pdr. R.P. 50 Mark 7 mounting. This mounting became known as the 40 mm. Bofors twin R.P. 50 Mark 5 mounting.

General

The mounting is equipped with the all-electric R.P. 50 metadyne system of auto so that movement in elevation and training are normally automatically controlled from the director.

A Type 6 Mark 2 gyro gun sight is fitted for use of the joystick operator on the mounting and 300 knot eyeshooting sights for the layer and trainer. Elevation and training receivers type C.M. Mark 1* or 1** are fitted, which receive magslip indicator transmissions from the director.

The firing of the guns may be electrically operated from either the director or joystick, or may be manually operated by a firing pedal convenient to the layer.

The guns may be fired as a pair or separately, provision being made to allow a rendering of the associated firing gear when a gun is set to Trigger Held.

A ready-use supply of ammunition of six clips per gun is carried in trays at the rear of the mounting.

A protective shield is built around the mounting, the front thickness being $\frac{1}{2}$ inch and side thickness $\frac{1}{4}$ inch. Doors are provided for quick and easy access to the mounting.

The exposed steel surfaces on this mounting have been "parkerised" during manufacture. This process provides a rust-proof surface, and every care should be taken to see that no abrasives are used for cleaning exposed steel surfaces, as such treatment will remove the rust proofing.

References

B.R. 1057/1953	Handbook for 40-mm. Guns in Naval Service Marks 4, 9, 10, 11 and N1 Series.
B.R. 1592	Handbook for the Simple Tachometric Director Mark 1.
B.R. 1592 (Addm.)	Addendum No. 1 for Simple Tachometric Director Marks 1 (Mods. 1 and 2), 2 and 3.
B.R. 1851	Handbook for the Close Range Blind Fire Director.
B.R. 1851N	Addendum No. 1 for C.R.B.F. Directors Marks 2M, 3, 4, 6 and 7.
B.R. 1205 (50)	Handbook for Type 6 Mark 2 Gyro Gun Sight.
B.R. 1842	Technical Handbook for Type 6 Mark 2 Gyro Gun Sight (*Issued to Dockyards only*)
B.R. 1282	for 40 mm. Twin R.P.50 Mark 5 Mod. 0 Mounting.
B.R. 1107	' Officers' Drawings for 40 mm. Twin R.P.50 Mark 5 unting.

(*Amendment No. 12.*)

TABLE OF PARTICULARS

The Mounting	*tons*	*cwt.*	*qr.*	*lb.*
Two guns, with jackets filled (6½ galls.)	1	0	3	23
Fixed base plate, including training rack and rollers	0	11	1	0
Carriage, including elevating and training gears firing and safety firing gears and receiver drives	2	11	3	3
Sighting gear	0	0	3	6
Shields, platforms and cooling system filled (20 galls.), training balance weight	1	13	0	13
Ready-use ammunition racks and chutes	0	3	3	20
Miscellaneous electrical fittings and cables	0	4	0	0
Ready-use ammunition (sixteen clips)	0	3	0	0
TOTAL	6	8	3	9

"Off Mounting" Gear	*tons*	*cwt.*	*qr.*	*lb.*
Amplifier	0	1	3	17
Metadyne Generators—				
British (MD75/74a)	0	5	0	8
Canadian (2xMD70CZ)	0	10	3	8
Contactor Control Panel	0	0	3	6
Starter	0	0	3	6
TOTAL off mounting weight—				
British	0	8	2	9
Canadian	0	14	1	9

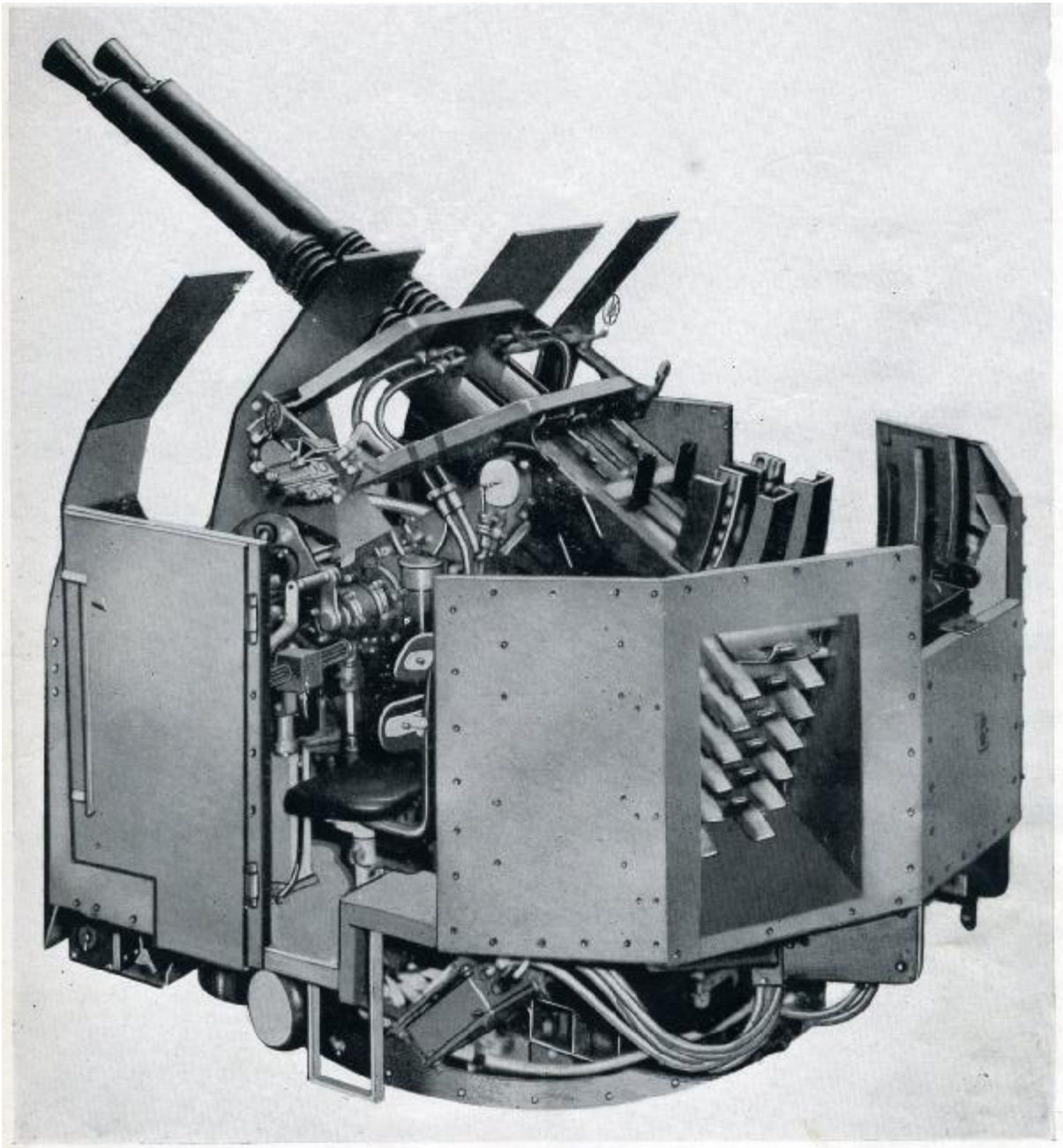
Other Details

Shield	½ in. thick protective plate at front. ¼ in. thick protective plate at sides.
Deck Forces—	
Upward lift	1·6 tons.
Downward blow	4·8 tons.
Maximum force of recoil	4 tons.
Working radius	7 ft. 6 in.
Maximum platform radius	5 ft.
Maximum elevation	90°.
Maximum depression	~~15°~~ 14°
Maximum training	360°.
Training speeds	Power: 35°/sec. Max. Acceleration 15°/sec.². Hand: 3·72° per turn of handle.
Elevating speeds	Power: British Mtgs. 28°/sec. Canadian Mtgs. 35°/sec. } Max. Acceleration 15°/sec.² Hand: 3·72° per turn of handle.
Training and elevating efforts in hand	10 to 12 lb.
Position of trunnions—Height	66·5 in. from base of mounting.
Distance from vertical through centre pivot	4 in. to the rear.

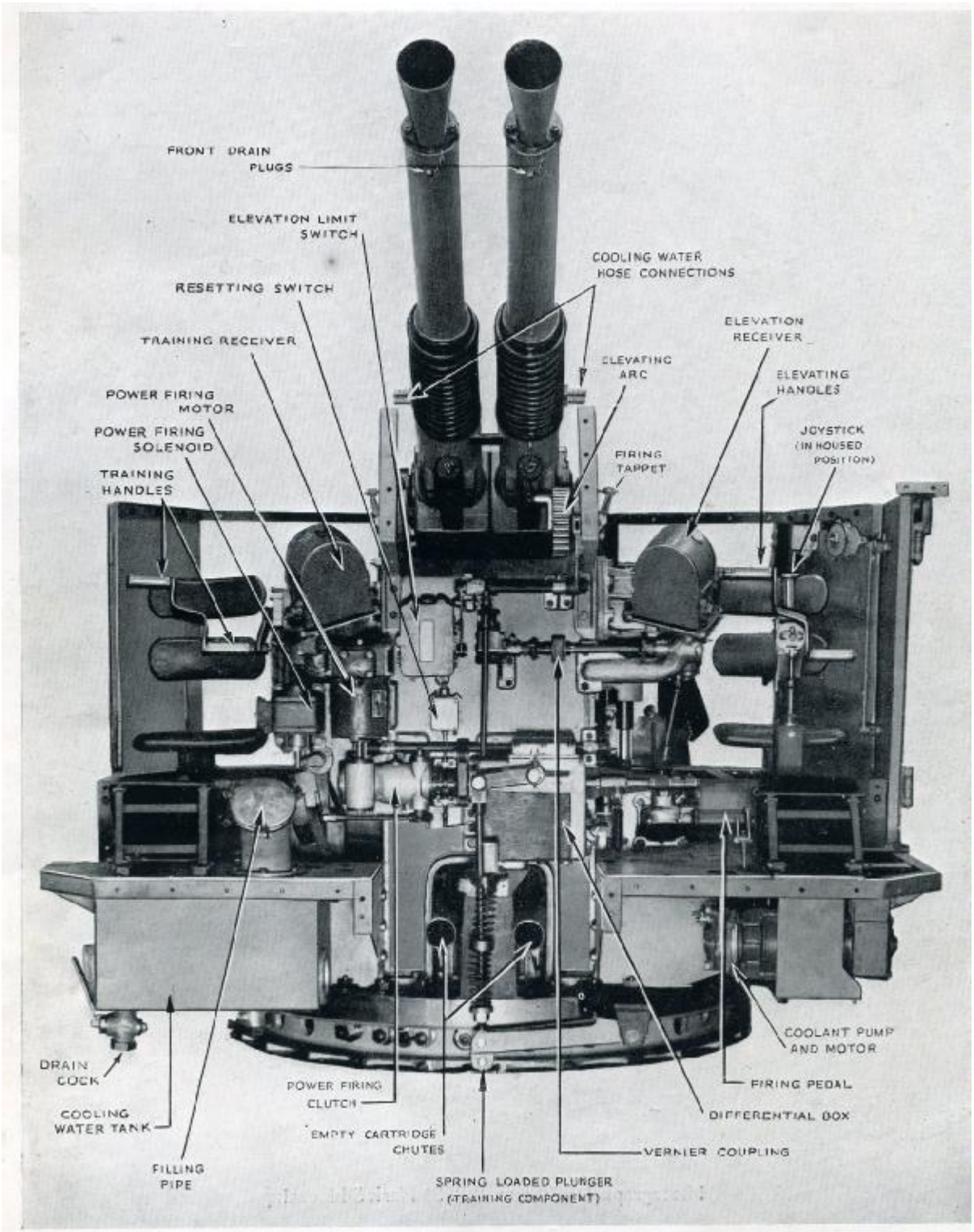
Metadyne System. (When fitted with Mark 15M Amplifier.)

	Motion A (Elevation)	*Motion B* (Training)
Fine Grid Transformer Ratio (*see* page 41)	35/16 *or* 32/35	35/16 *or* 32/35
Coarse Grid Transformer Ratio	35/14	35/14
Coarse/Fine Change-over Winding	35/160	35/160
Standing Current in Milliamps	27·5	35
Maximum Current in Milliamps	55	70
Maximum Metadyne Current	65 amps	50 amps
Maximum Limit Current	16 amps	20 amps
Metadyne Current per 6 minutes misalignment	54 amps	37 amps
Coarse to Fine Change-over Voltage (N.B.—not fine to coarse)	1·2 volts	1·2 volts
Approximate initial setting for fine sensitivities	75	75
Approximate initial setting for fine pre-retardation	Pos. 2	Pos. 2
Approximate initial setting for coarse sensitivity	100	100
Approximate initial setting for coarse pre-retardation	0·1 mfd.	0·1 mfd.

Note.—Some cases may be found where Motion A is training and Motion B is elevation due to Ship wiring errors.



Photograph 1. 40 mm. R.P. 50 Mark 5 Mounting



Photograph 2. 40 mm. R.P. 50 Mark 5 Mounting—Front View

CHAPTER 1

GENERAL DESCRIPTION OF EQUIPMENT (*Plates 1, 2, 3*)

SECTION 1. THE MOUNTING

1. The two gun casings are bolted together, and the outer sides of the gun casings carry the trunnion pins; there is no cradle. Trunnion bearings are fitted to the pins, and housings are formed at the top of the carriage to receive the trunnion assembly. There is one elevating arc secured beneath the left gun. The carriage is bolted to the upper base plate of the mounting. The gyro sight and eyeshooting sights are supported by brackets, secured directly to the guns.

2. The upper base plate of the mounting, which rotates for training, carries, in addition to the carriage, two loading platforms, a protective shield, the training and elevating driving motors, gearboxes and coincidence transmitters, equipment for gun cooling, firing, R.U. ammunition, etc.

On its under surface it carries the upper roller path which is supported on the training rollers, mounted on axis pins screwed into a live roller ring. The lower roller path is a surface machined in the lower fixed base plate. Lateral thrust is taken by a centre pivot bearing and the mounting is prevented from "jumping" by clip rollers which engage under a flange on the lower fixed base plate. Guard plates are fitted to the fixed base plate and give protection to the internal parts of the training base.

[illegible] the trainer's side of the mounting and an elevation locking [illegible] respectively.

Elevation and training zero alignment indicators are fitted to gun arc and mounting baseplate buffers.

(*G. 3041/57.—Amendment No. 9.*)

5. The guns may be fired electrically from the director or joystick and mechanically by the layer's firing pedal.

6. Safety firing gear is fitted for interrupting fire on dangerous bearings. For this purpose a cam rail is fitted round the base of the mounting and is secured to the deck. Its contour is cut to suit the ship and position of the mounting.

7. Barrel cooling fresh water is circulated through the gun jackets by a centrifugal pump driven by an electric motor. The water is taken from a 20 gallon tank situated at the front right hand of the mounting. The tank is fitted with an immersion heater to prevent the water freezing under low temperature conditions.

8. Ready use ammunition racks for six clips per gun are fitted to the rear of each loading platform.

9. The various switches and instruments associated with the operation of the mounting are conveniently grouped together in two groups, and are secured to the side shield plating.

Secured to the side shield beside the layer are the following:—

(*a*) Joystick/Auto C.O.S.;
(*b*) metadyne set starting switch;
(*c*) On/Off push box for applying power to both motions;
Note: It is not possible to have mixed operations, *i.e.*, both motions must be operated in either hand or power.
(*d*) indicating lamp box showing A.C. ON, POWER ON and METADYNE RUNNING;
(*e*) firing isolating switch for interrupting the firing circuit;
(*f*) power firing motor on/off switch;
(*g*) gyro sight type 6 Mark 2 range unit (No. 40, Mark 1);
(*h*) gyro sight type 6 Mark 2 dimmer unit (No. 4, Mark 1);
(*i*) check fire bell;
(*j*) check fire lamp;
(*k*) illumination switch;
(*l*) bridge communication call up;
(*m*) training sector control switch.

10. Secured to the side shield abaft the joystick operator's position are the following:—

(*a*) cooling pump motor on/off switch;
(*b*) loading light dimmer unit;
(*c*) gyro sight type 6 Mark 2 regulator unit (No. 1C, Mark 1);
(*d*) telephone stowage box.

The switch for the immersion heater is located on the right-hand side of the mounting near the water tank. Telephone plugs are located under the layer's seat. An armament broadcast speaker may be fitted to the mounting on the rear shield on the trainer's side.

SECTION 2. SUMMARY OF R.P. 50 METADYNE SYSTEM

EQUIPMENT

11. In the R.P. 50 metadyne system, two separately excited D.C. motors are required to train and elevate the mounting. These motors are situated on the mounting itself, and drive through suitable gears and clutches. Magnetically-released spring-applied drum brakes are built into the motors to hold the mounting firmly when power is switched off the mounting. These brakes are necessary as the power drive is reversible, *i.e.*, the mounting can drive back through the gear drive and tend to rotate the armature of the driving motor.

12. Arrangements for hand elevating and training are provided to enable the mounting to be moved for maintenance work, and for use in the event of failure of the power drive. Hand-operated clutches are therefore fitted, which enable the mounting to be clutched either to the power-drive motors or to the handles, the clutch levers being arranged to operate electrical interlock switches that prevent the application of power to both the training and elevating motors unless both clutches are to POWER. In addition, local operation of the power drives is provided by the fitting of a joystick. A simple two-position electrical change-over switch enables an instantaneous change to be made from auto operation to joystick operation, or vice versa.

13. On the mounting are :—

(*a*) an on/off switch for starting the metadyne set, situated between decks ;

(*b*) pushes for applying power to or removing power from the mounting, when the metadyne set is running ;

(*c*) indicator lamps to show when the metadyne is running ("metadyne running" lamp), when power is applied to the training and elevating driving motors ("power on" lamp), and A.C. supply is made to the amplifier ("A.C. on" lamp). A "power on" lamp is also provided at the director.

14. Coarse and fine magslip coincidence transmitters are permanently geared to both the training and elevating motions, and in conjunction with corresponding transmitters in the director, provide the signals which control the [illegible] and

In order that the electrical system may be accurately aligned in elevation and training, zero alignment indicators are fitted as follows :— itters

(*a*) For elevation alignment, a pointer plate and associated indication plate are fitted to the rear of the carriage on the layer's side and on the inner face of the elevating arc, respectively. t the ector ting,

(*b*) For training alignment, a pointer plate and an indication plate are fitted to the upper racer plate and the guard plate, respectively, on the trainer's side of the mounting. und. nged ctor.

In both instances the indication plate is required to be scribed after the mounting is installed in a hip. ined ig to

(G. 3941/57.—Amendment No. 9.)

15. To prevent the mounting being brought up hard by the limit stops in power operation, limit switches have been provided on the mounting for both training and elevation. Each limit switch is operated by a cam a few degrees before the mounting reaches one of the mechanical stops ; contacts in the switch cause a braking torque to be applied to the driving motor so that the mounting is reduced to a low speed before it reaches the stop. Other contacts in the switch are arranged to limit the current that can flow through the armature of the stalled motor to a value that will not overheat it, and yet will be sufficient to hold the mounting firmly against the stop if the position of the director requires this. The limit switches are a special quick-resetting type to ensure that the mounting follows the director with the least possible delay when the director returns to the mounting arcs.

16. The main power supply and operational apparatus is situated in a compartment between decks. Each gun-driving motor on the mounting is supplied with power from a separate metadyne generator. In mountings of British manufacture the two generators are driven by a common driving motor, which is supplied from the ship's 220 volt D.C. supply. These are started by means of an automatic starter, which may be operated either remotely by an on/off switch at the mounting or locally by a switch contained in the auto starter itself. In mountings of Canadian manufacture, two separate metadyne sets are used, one for training, the other for elevating. The two metadyne generators (training and elevation) are driven by individual driving motors supplied from the ship's D.C. supply. The two metadyne sets, which are identical, are started simultaneously by means of a common automatic starter, which can be remotely operated from the mounting, or locally operated by a starting switch in the starter itself.

The field or main variator windings of the metadynes are fed from a thermionic valve amplifier, also situated between decks. This amplifier modifies and amplifies the signals from the high frequency magslips into a suitable form for use in the variator windings on the poles of the metadyne generators.

17. The high frequency (H.F.) power supply for the amplifier is obtained from a central source between decks. The H.F. supply for the magslip transmitters is obtained from the amplifier.

The other apparatus between decks consist of a contactor control and output relay panel, which contains a double-pole contactor, the training and elevating output relays, resistors, fuses and links. The double-pole contactor serves to energise the gun motor field and brake coils, the joystick controllers and the limit relays in the amplifier. The output relays, when energised, switch over the amplifier output from the dummy load resistor in the amplifier to the metadyne main variator windings, at the same time disconnecting the latter from the joystick controllers.

OPERATION OF THE EQUIPMENT (*Diagram 3*)

18. The mounting may be power operated by two methods :—

(*a*) *Auto Operation*—By director, moving the mounting in elevation and training using the magslip controlled metadyne system.

(*b*) *Joystick Operation*—By operation of the joystick on the left side of the mounting controlling the elevating and training driving motors of the metadyne system, and using type 6 Mark 2 gyro gun sight.

Auto Operation

19. Auto operation is the normal method of operating the mounting. Two sets of apparatus are required, one for training and one for elevating. As the construction and operation of the two sets are similar, only the system used for the training motion is shown in simple diagrammatic form in Diagram 3 and discussed in the following paragraphs.

20. A magslip transmitter is geared to the director and electrically connected to a magslip coincidence transmitter geared to the mounting. The magslips are adjusted so that when the director and mounting are lined up, the magslips are also in alignment. With A.C. supply switched on, any subsequent misalignment between transmitter and coincidence transmitter will cause a voltage signal, generated in the rotor of the coincidence transmitter, to be fed to the amplifier.

Here it passes through the various stages of the amplifier and this signal is modified and amplified, and then applied to the main variator windings of the metadyne generator.

21. The signal from the amplifier is in turn amplified by the generator and is used to energise the gun driving motor armature in such a manner that the mounting and the coincidence transmitters are driven until the coincidence transmitters and transmitters line up. In this position the misalignment signal fades out and the mounting is driven into line with the director.

22. It is seen in Diagram 3 that there are actually two magslips at the director and two at the mounting ; one coarse magslip at the director and one at the mounting, providing the signals when the misalignment is large, the other pair of fine magslips being employed to give greater accuracy when the misalignment is small. Only one pair is used at a time, a relay in the amplifier automatically selecting the signal depending on the size of misalignment.

Joystick Operation

23. Joystick operation is provided to enable the mounting to be power operated without the director, magslips or amplifier. It is therefore useful as an emergency method of operation in the event of damage to these units and enables the mounting to be power driven using either a type 6 sight or an eyeshooting sight under the control of a single operator.

24. When in joystick operation the metadyne generator main variator windings are fed from the ship's D.C. supply through rheostatic controllers. These controllers, for the training and the elevation metadynes, are coupled to a single joystick. A turning motion of the central spindle of this joystick operates the training controller and a twisting motion of the handles operates the elevating controller. When the joystick is moved the currents fed to the main variator windings of the metadyne generators cause output current to flow through the gun driving motor armatures to move the mounting in the direction indicated by the joystick movement.

25. There are a few mountings in commission with only the "joystick operation" system. Such mountings will be found in ships not fitted with a director system and hence local operation is the only requirement.

In cases like these, however, a second training receiver is fitted on the layer's side, and connected to the training receiver drive by a flexible drive. This receiver is used for target indication to the joystick operator and it is not intended that the operator should attempt to follow the pointer, because the flexible drive does not provide any degree of accuracy.

CAPABILITIES OF THE SYSTEM

26. The design requirements of this equipment are briefly as follows :—

The mounting should be capable of following the transmitting position when in auto operation, so that the misalignment shall not exceed 3′ of arc (except as may be otherwise stated) under any of the following conditions :—

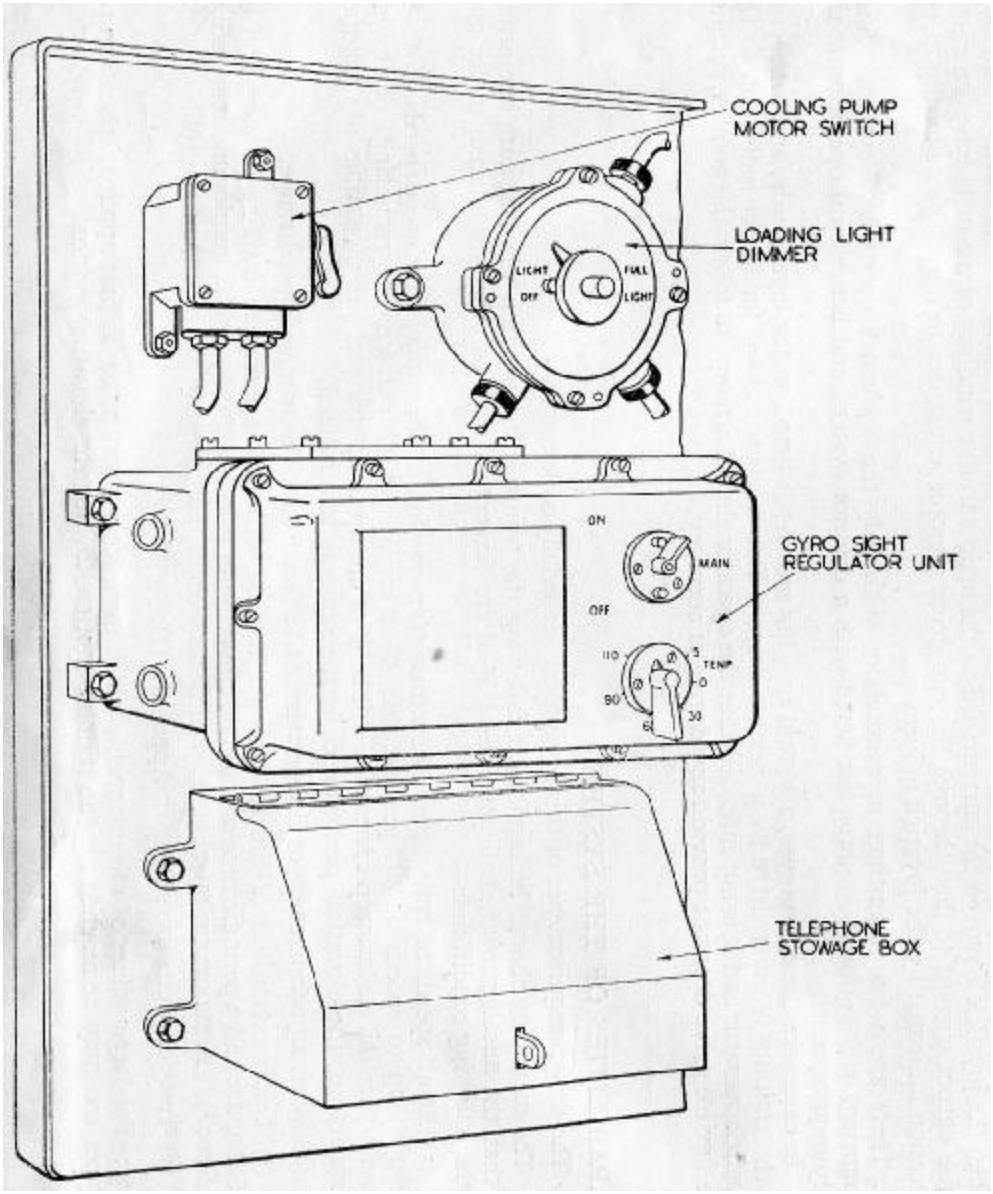
(*a*) At all speeds of training and elevation transmission in the range, from creep speeds of 4°-8° per min. up to speeds of 20° per sec. and 4′ of arc up to 30° per sec. In mountings of British manufacture the elevation performance will be 4′ of arc up to 25° per sec. In mountings of Canadian manufacture, the elevation performance is the same as for training.

(*b*) With an acceleration or deceleration of 15°/sec.^{2} over the specified speed range.

(*c*) Under conditions of simple harmonic motion, with an amplitude in training or elevation of ± 30° of arc and a periodic time of 9 seconds (maximum velocity 20·9° per sec., maximum acceleration 14·6/sec.^{2}). A maximum misalignment of 6′ may occur momentarily at the end of the roll.

(*d*) Test schedules are shown in Appendix III.

Note : For large values of misalignment, which may occur when power is first applied, speeds up to 35° per sec. may be reached for the training motion, 28° for the elevating motion.


COOLING PUMP
MOTOR SWITCH
LOADING LIGHT
DIMMER
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FULL
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STOWAGE BOX

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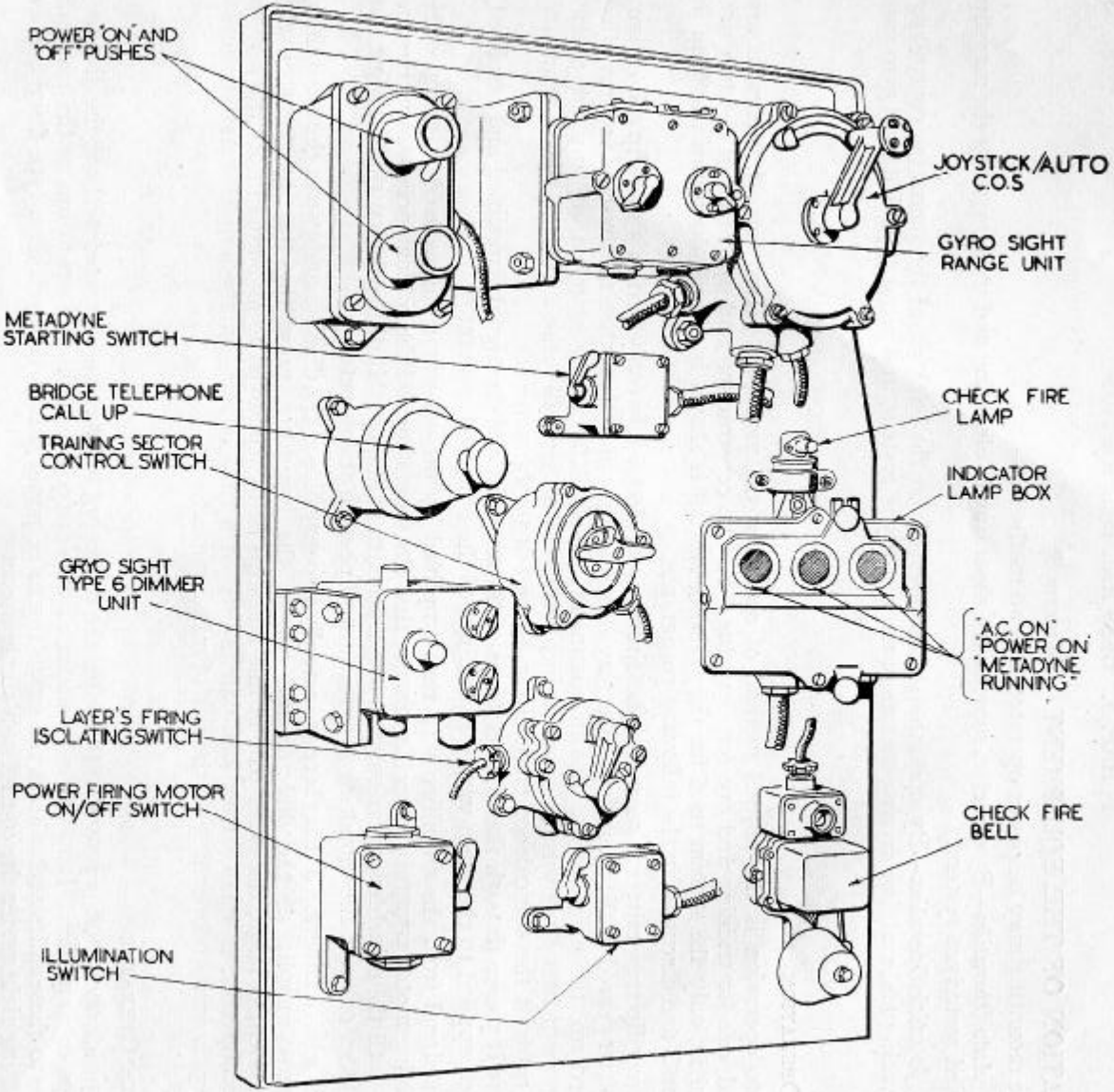


Diagram 1. Switch and Instrument Panels

SECTION 3. STARTING UP INSTRUCTIONS

STARTING UP FOR AUTO OPERATION

NORMAL STAND-BY STATE OF EQUIPMENT

27. Diagram 1 shows the disposition of the various switches mentioned and Diagram 2 the positions of the apparatus. See that the A.C. on lamp on the mounting is burning. This indicates that :—

(*a*) the H.F. supply is available ;

(*b*) the amplifier main switch is to ON ;

(*c*) the test switch on the amplifier is to RUN.

28. See that the clutches situated on the mounting are in the position for power operation.

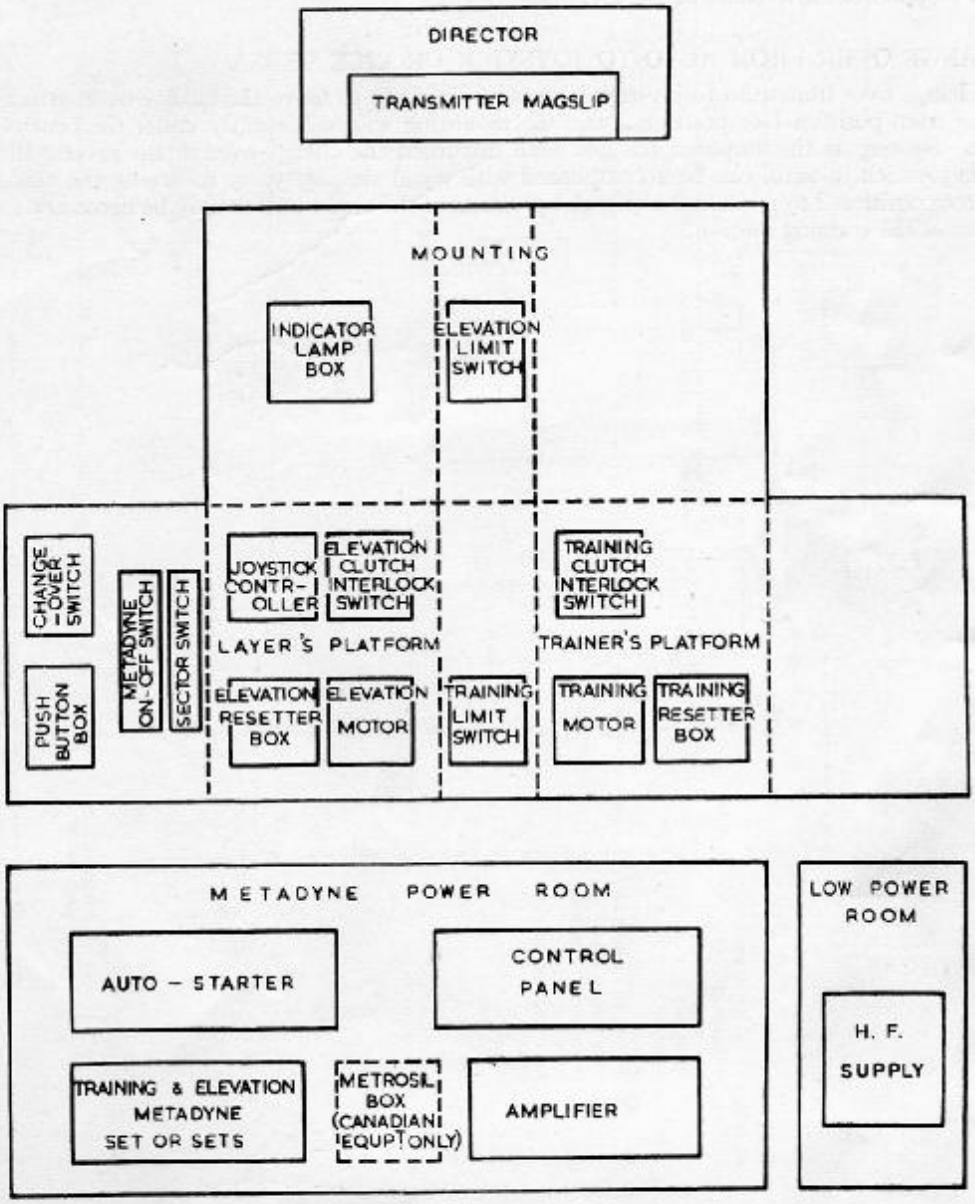
29. See that the change-over switch situated on the mounting is in position 1, the auto position.

TO START UP

30. (i) Start the metadyne set or sets by means of the starting on/off switch on the mounting. The Metadyne Running lamp should now burn.

(ii) Press the on push button on the mounting until the power on lamp burns. The mounting is then operative in both motions.

(iii) If necessary, operate the training sector control switch on the mounting to bring the latter approximately into alignment with the director, and then release the sector control switch.



DIAGRAM

Diagram 2. Position of Apparatus

31. The mounting will then pull into line as indicated by the receiver mechanical and electrical indicator pointers lining up, and will automatically train and/or elevate as required by the director.

TO SHUT DOWN

32. (i) To remove power from the gun driving motors press the off push button on the mounting. The mounting will quickly come to rest and will be held there. It will become fully operative again immediately the on push button is pressed.

(ii) To shut down completely, switch off the metadyne starting switch at the mounting.

(iii) The A.C. on lamp on the mounting will still be burning indicating that the amplifier valve heaters are energised.

STARTING UP FOR JOYSTICK OPERATION

PRELIMINARY PREPARATION

33. (i) See that the clutches situated on the mounting are in the position for power operation.

(ii) See that the change-over switch on the mounting is in position 2, the joystick position.

(iii) See that the joystick handles are in the operative (horizontal) position.

(iv) Ignore the A.C. on lamp.

TO START UP

34. (i) Start the metadyne set or sets by means of the starting on/off switch on the mounting. The metadyne running lamp should now burn.

(ii) Press the on push button on the mounting until the power on lamp burns. The mounting will now respond to movements of the joystick.

TO CHANGE OVER FROM AUTO TO JOYSTICK OR VICE VERSA

35. To change over from auto to joystick it is only necessary to move the change-over switch on the mounting from position 1 to position 2 and the mounting will be instantly under the control of the joystick. So long as the amplifier has not been disturbed the change-over in the reverse direction, *i.e.*, from joystick to auto, can be accomplished with equal simplicity, by returning the change-over switch from position 2 to position 1 although operation of the sector switch may be necessary to secure alignment of the training motion.

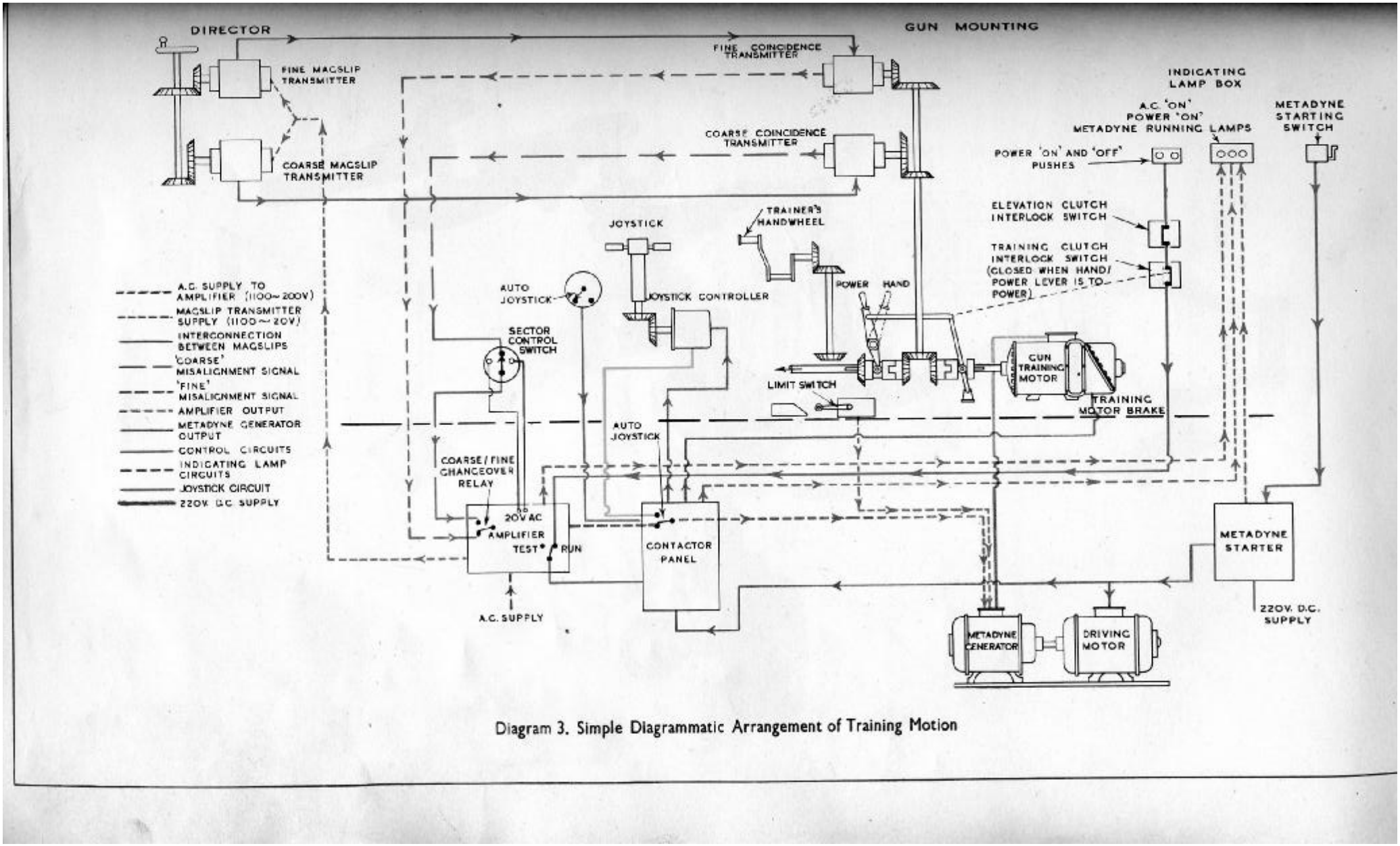


Diagram 3. Simple Diagrammatic Arrangement of Training Motion

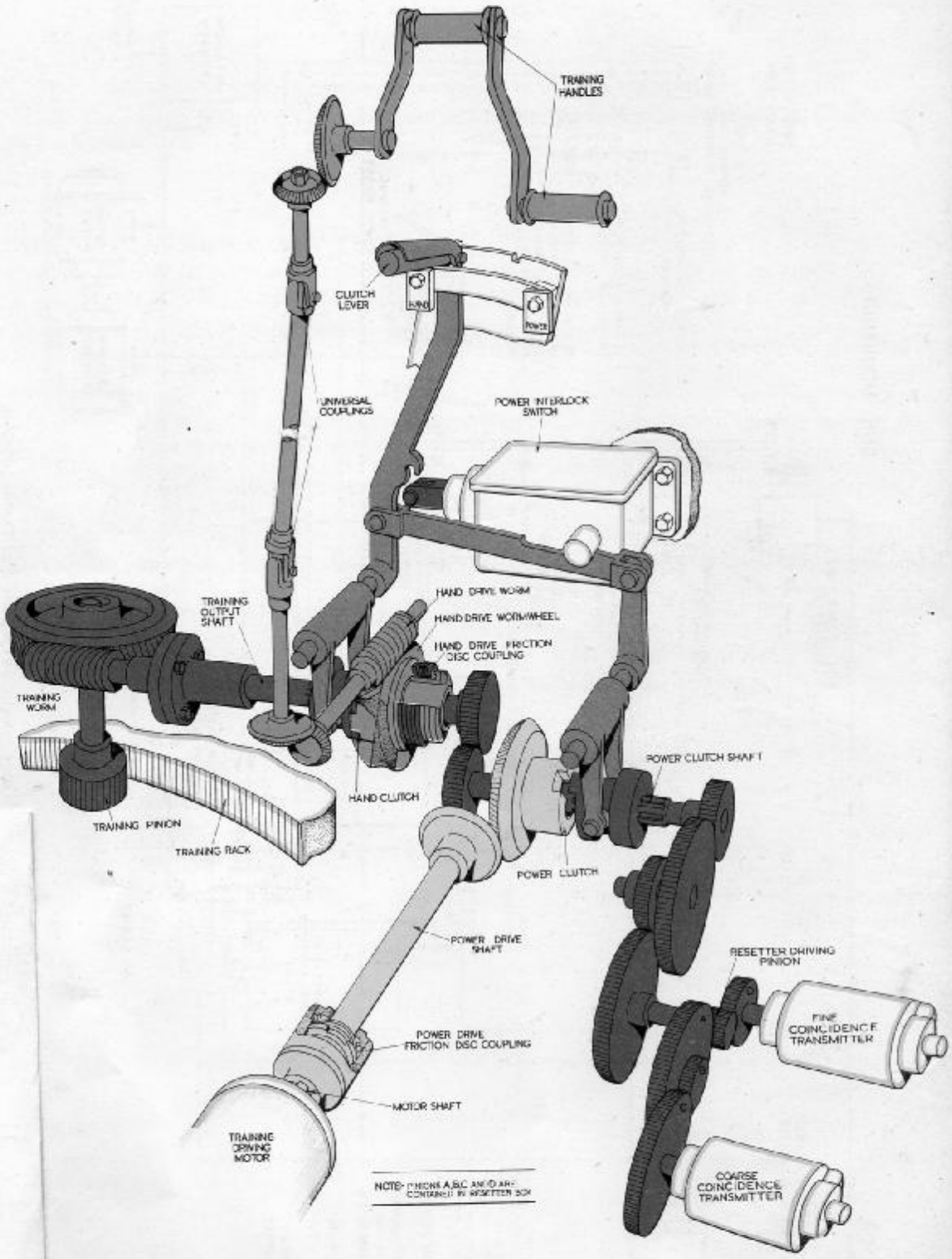


Diagram 4. Training Gear

Note : For clutch setting gear *see* Diagram 4A.

(G. 181/57.—Amendment No. 9.)

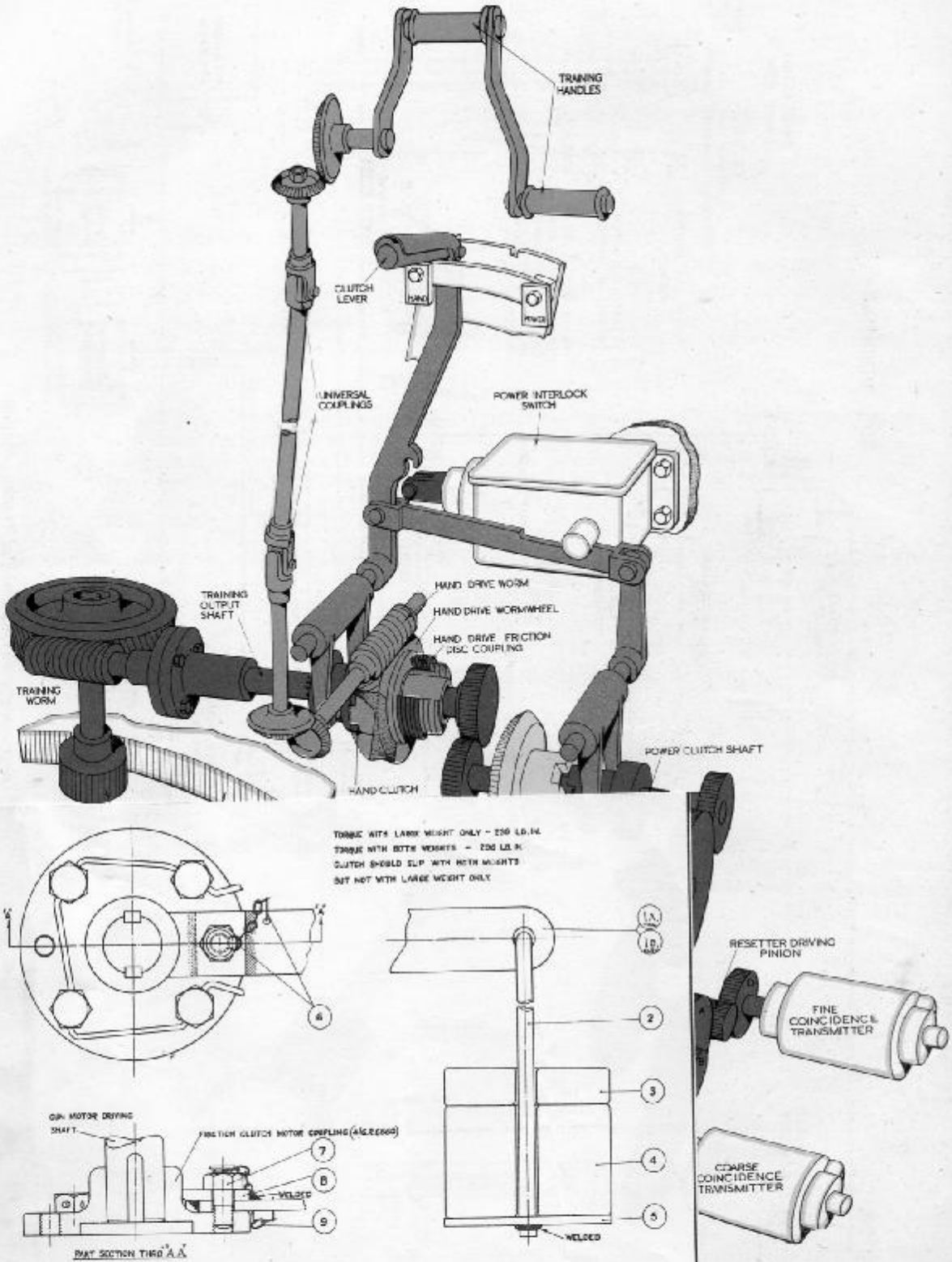


Diagram 4A. 40 mm Twin Mark 5 Mtg.
Training & Elevation Friction, Clutch
Slipping Plates, Test Setting Gear.

To face Page 7 of B.R./919

Note : For clutch setting gear *see* Diagram 4A.

NOTE.—*Where the part is named in a Plate, it is printed in bold type the first time it appears in the description, the operation and the stripping of the mechanism.*

CHAPTER 2

TRAINING BASE AND CARRIAGE, AND THE TRAINING AND ELEVATING GEARS

SECTION 1. TRAINING BASE AND CARRIAGE (*Plate 4*)

1. The training base consists of two principal parts, the lower **fixed base plate,** which carries the **lower roller path,** and the rotating **upper base plate,** which carries the **upper roller path.**

The lower base plate is mounted on a machined deck ring, and secured by twenty-four holding-down bolts.

The upper base plate, to which the carriage is attached, is supported on 36 **training rollers,** rotating between the upper and lower roller paths. These rollers are mounted on **roller axles,** which are equally spaced around and screwed radially into a **live roller ring.** The roller axles are prevented from rotating by spectacle plates, which lock the square outer ends of each pair of axles.

Two **gaps** are provided in the upper roller path to facilitate withdrawing any of the rollers without the necessity of lifting the carriage and upper base plate, and are situated directly below the horizontal centre line of the trunnions each side.

2. The **centre pivot,** through which pass the electric cables from the fixed structure to the revolving portion of the mounting, is secured to the upper base plate, and rotates in a **roller bearing** which is housed in the fixed base plate and secured by a **retaining ring.**

The centre pivot can be removed by lifting upwards, and the roller bearing by lowering after removing the retaining ring.

Holding down **clip bolts** are provided, eight at the front and six around the rear of the upper base plate. The clip bolts are fitted with **belleville spring washers,** and carry **clip rollers** which engage with a circular flange on the fixed base plate, and oppose vertical movement of the carriage when the guns are fired.

3. The **training rack,** in which engages the training pinion, is secured to the fixed base plate. **Guard plates** are fitted to the fixed base plate, and give protection to the internal parts of the training base.

4. The carriage is a fabricated steel structure which provides support for the guns and various gear boxes and brackets.

Plate 4 shows the carriage bolted on to the upper base plate. Trunnion **bearing housings** are formed at the top of the left and right carriage side plates which support the **roller bearings** for the **gun trunnions.** Each bearing is covered by a trunnion **bearing cap.**

SECTION 2. TRAINING GEAR (*Diagram 4, Plates 4, 5, 6, 8*)

5. The D.C. electric motor is coupled to the training gear drive through a friction disc coupling. The latter limits the torque that the motor can transmit to 24 lb-ft. to keep the stresses set up within the safe limit. The power drive is fully reversible, and the friction coupling acts as a safety device by slipping and thus limiting the stresses set up in the drive when the mounting and motor are in opposition.

6. To change from "hand" to "power" operation, or vice versa, the clutches are operated by the clutch lever, which is conveniently situated in front of the trainer below his handles.

A weight is carried abreast the training motor to give balance for training at any angle of heel.

THE POWER DRIVE (*Diagram 4, Plate 5*)

7. The power drive is used for either auto or joystick operation, and comprises a bevel reduction gear and a reversible worm gear.

The **motor shaft** is connected to the **power drive shaft** by a **friction disc coupling.** This coupling consists of an **outer casing** splined to the motor shaft, and has four cut-away portions into which enter projections on the periphery of a **friction disc.** Between the inside face of the outer casing and the friction disc is the flange of a **hub** keyed to the power drive shaft. The friction disc is loaded by a set of **belleville spring washers** and a **distance piece,** the compression on the washers being applied by a bush screwing into the outer casing. The setting of this bush is adjusted so that the maximum torque transmitted is limited to 24 lb-ft. using clutch setting gear shown on drawing D.N.O. 898

Carried on the other end of the power drive shaft, and contained in the main gear box, is a bevel pinion which meshes with a large bevel gear carried freely on the **power clutch shaft.** The hub of the large bevel gear has internally-cut involute teeth, which form part of the **power clutch.**

Splined to the power clutch shaft is the sliding member of the power clutch, cut externally with involute teeth so that these teeth may engage in the internal teeth cut in the hub of the large bevel gear.

Note: For the sake of clarity these are shown as ordinary dog clutches in Diagrams 4 and 5.

Precaution

The mounting should be at rest before the clutch lever is operated and alignment of the appropriate clutch for engagement should be attained only by means of the training handles; press "off" push before changing from "power" to "hand", and do not press "on" push until in "power".

RESETTER BOX (*Diagram 4, Plate 5*)

14. The resetter box contains two magslip coincidence transmitters (a "fine" and a "coarse") with gearing, the wheels and pinions of which are alternately of fabric composition and steel.

The resetter boxes on the training and elevating gears are interchangeable as a whole.

The complete resetter box is bolted horizontally to the outside of the reduction gear box attached to the main gear box. The drive to the magslips is transmitted by a train of gears, the first pinion of which is attached to the power clutch shaft, and the ultimate pinion, the **resetter driving pinion,** which enters the resetter box. The resetter driving pinion meshes direct with a pinion on the **fine coincidence transmitter** and also with the larger wheel of a compound idler, the smaller wheel of which meshes with a pinion on the **coarse coincidence transmitter.**

15. The ratio of the fine coincidence transmitter to the mounting is 9 to 1, *i.e.*, the magslip makes nine revolutions for one revolution of the mounting, and thus registers the position of the mounting over an arc of 40 degrees of training.

The ratio of the coarse coincidence transmitter to the mounting is 1 to 1, *i.e.*, the magslip makes one revolution for one revolution of the mounting, and its sector value is 360 degrees. With this value the mounting will always try and pull into line by the shortest route. This is not possible, since the mounting has a limit stop which will prevent alignment by the shortest route in given circumstances. A sector switch is, therefore, provided to enable the operator to take the correct route when a misalignment of more than 180 degrees exists.

TRAINING HOUSING STOP (*Plate 4*)

16. A T-shaped handle projecting above the platform on the trainer's side actuates a stop plunger, which slides vertically in a guide bracket secured to the upper base plate. In the housed position the bottom of the plunger engages into a hole in a block secured to the lower base plate.

TRAINING BUFFER (*Plate 6*)

17. The training buffer is of the common oil-retarding spring recovery type, and is carried in a casting fixed to the upper base plate at the rear of the mounting. The two projecting ends of the **piston rods** are linked by a **clamp frame** which passes under the buffer cylinder, a downward projecting **stop block** being secured to the clamp frame. The extremities of the piston rods slide in bushes in the supporting casting.

Within the buffer cylinder are two opposed **pistons** kept apart by a **spring.** The piston rods project outwards through glands in the **retaining nuts** which keep the pistons in their normal position against the outward action of the spring.

The space within the buffer cylinder is filled with oil, the medium which produces the resistance when the mounting trains on to the **training limit stop.** The resistance of the spring is merely incidental as its primary function is to cause either piston to reassert itself after training off the stop. Above the cylinder barrel is an **oil reservoir** which is permanently connected to the cylinder by a small hole, and also by a larger port which is fitted with an **adjusting valve** for varying the size of the opening through which the oil passes. The normal setting of this valve is 1½ turns open. An **oil level plug** is fitted on the side of the reservoir and an **oil filling cap** is provided at the top. This cap is screwed down on a washer and locked with a locking plate and the system is then totally enclosed. An **air vent plug** is provided at the same level as the adjusting valve to allow air to escape from the cylinder when filling up the system.

Each piston incorporates a **spring loaded ball valve** which closes a port connecting one side of the piston with the other. It will be observed from the part section of the buffer that the port closed by the ball valve is drilled axially towards the piston rod to meet four smaller holes drilled radially inwards from the opposite side of the piston.

ACTION OF TRAINING BUFFER

18. When the mounting approaches the end of its permissible arc of training the stop block comes into contact with the training limit stop, and the piston rod and the piston is forced inwards. This inward displacement of the piston forces oil into the reservoir through the small hole and also through whichever orifice the adjusting valve has been set to give; other oil escapes to the opposite side of the piston via the clearance between the piston and cylinder bore. The spring loaded ball valve seats itself more firmly under the rising pressure of oil and closes the port opening. Each buffer pinion is allowed a travel of 1·5-inch after which metal to metal contact takes place between the stop block and training stop.

When the mounting is trained off the training stop, the spring forces the piston outwards, and the oil trapped between the piston and retaining nut flows inwards through the four holes in the piston rod and lifts the ball valve off its seat, thus returning to the centre again with a minimum delay.

A pinion on the left end of the power clutch shaft engages another pinion on the right end of the **training output shaft,** used in both the power and hand drive, and which is connected, through the side plate of the carriage, by a flanged **coupling,** to the training worm shaft in the worm gear box.

8. The **training worm** is solid with its shaft, and is supported in the gear box at each end by a roller bearing. A duplex ball bearing is fitted to the left end of the worm shaft to take the lateral thrust on the worm, the adjustment being made by the screwed **end cap,** the outer rim of which is serrated to receive the teeth of a locking plate. This end cap should always be hammered up tight, the working clearances necessary being allowed for in the design of the duplex bearing. The right gland nut through which the worm shaft passes is similarly locked, but serves no purpose as an adjustment.

The worm engages the **training worm wheel,** which is splined to the training pinion shaft and secured by a nut screwed on to the latter. The shaft is carried in roller bearings, one being housed in the spigoted worm gear box **cover plate,** and two in the lower spigot of the gear box. A duplex ball bearing is located between the two lower roller bearings, spacing rings being fitted above and below. Adjustment of the duplex bearing is provided by a **castellated screwed bush** inside the gear box; the bush is locked by a plate, the tongue of which engages in one of the castellations. The bush should always be hammered up tight, the working clearances necessary being allowed for in the design of the duplex bearing.

The **training pinion** is solid with the pinion shaft, and engages the **training rack** secured to the lower base plate.

9. The worm gear box is filled with oil, and **oil seals** are therefore provided in the right gland nut and in the training pinion shaft thrust adjusting screwed bush to prevent oil leakage.

Two diametrically opposed tapped lifting holes are provided in the worm wheel to facilitate its removal.

Grease lubrication from remote grease nipples on the side of the carriage is provided to the upper and lower roller bearings of the training pinion shaft.

The overall gear ratio from motor to mounting is 254 to 1.

HAND DRIVE (*Diagram 4, Plate 5*)

10. The hand operation is carried out by the two **training handles,** which are unsupported at their middle point. The inner boss of the handles is supported in a ball journal thrust bearing carried in the side **cover** of the **hand drive gear box,** and is splined internally to receive the bevel gear spindle, the other end of which is supported in a ball journal bearing housed in the gear box.

A bevel gear is splined to this spindle, and is secured by a nut, with washer and split pin. The bevel gear meshes with a bevel pinion carried on splines on a short vertical shaft, the latter being supported in two ball journal bearings carried in a lower projecting boss of the gear box. The bevel gear is secured to the shaft by a nut with washer and split pin.

The lower end of this shaft forms half of a **universal coupling**; the other half is carried on an intermediate shaft, similarly connected to a bevel gear shaft emerging from the main gear box. Carried on the bevel gear shaft is a bevel gear which meshes with a bevel pinion carried on the end of the hand drive worm shaft.

11. The **hand drive worm** which is splined to this shaft is carried in two ball bearings, one of which is a duplex bearing, in the main gear box, and meshes with the **hand drive worm wheel.** This is frictionally connected through the **hand drive friction disc coupling** to a clutch hub free to rotate on the training output shaft. The frictional connection is obtained by means of a friction disc loaded into contact with the lower surface of the worm wheel by a set of belleville washers and compression bush, the compression on the washers being applied by a nut screwing on to the clutch hub. The coupling renders at an effort of about 90 lb. applied to the training handles.

The left end of the clutch hub has internally cut involute teeth, which form part of the **hand clutch.** Carried on splines on the training output shaft is the sliding member of the hand clutch, which is cut externally with involute teeth so that they may engage in the internal teeth cut in the hand clutch hub.

The drive from the training output shaft drives the worm, worm wheel and training pinion, as described for the power drive, the power clutch shaft also being rotated.

The hand drive worm gear is irreversible, and consequently the friction disc coupling described above prevents undue loads being transmitted to the worm gear teeth, which might occur if the mounting took charge and attempted to drive the gear train in reverse.

The overall ratio from handles to mounting is 96·8 to 1.

HAND AND POWER CLUTCHES AND POWER INTERLOCK SWITCH (*Plate 5*)

12. The hand and power clutches which are, as already described, of the involute teeth type, are simultaneously operated by a single **clutch lever** mounted convenient to the trainer. The clutch lever operates in a quadrant, an extension of the hand grip engaging in either of two notches cut in the quadrant to retain the clutch lever in the desired position.

The clutch lever is pivoted on the axis of the **hand clutch fork,** and is connected by a link to the axis of the **power clutch fork.** The linkage is arranged so that as one clutch is engaged the other is disengaged, but both clutches are never completely disengaged together; this is necessary to prevent the mounting from taking charge during the changeover.

13. Mounted adjacent to the clutch lever is the **power interlock switch,** the purpose of which is to isolate power to both driving motors when the drive is clutched to "hand". The switch is spring-operated to break the circuit, but is made by the action of a hooked lug on the clutch lever; this hooked shape also assists the internal spring to break the switch.

A pinion on the left end of the power clutch shaft engages another pinion on the right end of the **training output shaft,** used in both the power and hand drive, and which is connected, through the side plate of the carriage, by a flanged **coupling,** to the training worm shaft in the worm gear box.

8. The **training worm** is solid with its shaft, and is supported in the gear box at each end by a roller bearing. A duplex ball bearing is fitted to the left end of the worm shaft to take the lateral thrust on the worm, the adjustment being made by the screwed **end cap,** the outer rim of which is serrated to receive the teeth of a locking plate. This end cap should always be hammered up tight, the working clearances necessary being allowed for in the design of the duplex bearing. The right gland nut through which the worm shaft passes is similarly locked, but serves no purpose as an adjustment.

The worm engages the **training worm wheel,** which is splined to the training pinion shaft and secured by a nut screwed on to the latter. The shaft is carried in roller bearings, one being housed in the spigoted worm gear box **cover plate,** and two in the lower spigot of the gear box. A duplex ball bearing is located between the two lower roller bearings, spacing rings being fitted above and below. Adjustment of the duplex bearing is provided by a **castellated screwed bush** inside the gear box; the bush is locked by a plate, the tongue of which engages in one of the castellations. The bush should always be hammered up tight, the working clearances necessary being allowed for in the design of the duplex bearing.

The **training pinion** is solid with the pinion shaft, and engages the **training rack** secured to the lower base plate.

9. The worm gear box is filled with oil, and **oil seals** are therefore provided in the right gland nut and in the training pinion shaft thrust adjusting screwed bush to prevent oil leakage.

Two diametrically opposed tapped lifting holes are provided in the worm wheel to facilitate its removal.

Grease lubrication from remote grease nipples on the side of the carriage is provided to the upper and lower roller bearings of the training pinion shaft.

The overall gear ratio from motor to mounting is 254 to 1.

HAND DRIVE (*Diagram 4, Plate 5*)

10. The hand operation is carried out by the two **training handles,** which are unsupported at their middle point. The inner boss of the handles is supported in a ball journal thrust bearing carried in the side **cover** of the **hand drive gear box,** and is splined internally to receive the bevel gear spindle, the other end of which is supported in a ball journal bearing housed in the gear box.

A bevel gear is splined to this spindle, and is secured by a nut, with washer and split pin. The bevel gear meshes with a bevel pinion carried on splines on a short vertical shaft, the latter being supported in two ball journal bearings carried in a lower projecting boss of the gear box. The bevel gear is secured to the shaft by a nut with washer and split pin.

The lower end of this shaft forms half of a **universal coupling**; the other half is carried on an intermediate shaft, similarly connected to a bevel gear shaft emerging from the main gear box. Carried on the bevel gear shaft is a bevel gear which meshes with a bevel pinion carried on the end of the hand drive worm shaft.

11. The **hand drive worm** which is splined to this shaft is carried in two ball bearings, one of which is a duplex bearing, in the main gear box, and meshes with the **hand drive worm wheel.** This is frictionally connected through the **hand drive friction disc coupling** to a clutch hub free to rotate on the training output shaft. The frictional connection is obtained by means of a friction disc loaded into contact with the lower surface of the worm wheel by a set of belleville washers and compression bush, the compression on the washers being applied by a nut screwing on to the clutch hub. The coupling renders at an effort of about 90 lb. applied to the training handles.

The left end of the clutch hub has internally cut involute teeth, which form part of the **hand clutch.** Carried on splines on the training output shaft is the sliding member of the hand clutch, which is cut externally with involute teeth so that they may engage in the internal teeth cut in the hand clutch hub.

The drive from the training output shaft drives the worm, worm wheel and training pinion, as described for the power drive, the power clutch shaft also being rotated.

The hand drive worm gear is irreversible, and consequently the friction disc coupling described above prevents undue loads being transmitted to the worm gear teeth, which might occur if the mounting took charge and attempted to drive the gear train in reverse.

The overall ratio from handles to mounting is 96·8 to 1.

HAND AND POWER CLUTCHES AND POWER INTERLOCK SWITCH (*Plate 5*)

12. The hand and power clutches which are, as already described, of the involute teeth type, are simultaneously operated by a single **clutch lever** mounted convenient to the trainer. The clutch lever operates in a quadrant, an extension of the hand grip engaging in either of two notches cut in the quadrant to retain the clutch lever in the desired position.

The clutch lever is pivoted on the axis of the **hand clutch fork,** and is connected by a link to the axis of the **power clutch fork.** The linkage is arranged so that as one clutch is engaged the other is disengaged, but both clutches are never completely disengaged together; this is necessary to prevent the mounting from taking charge during the changeover.

13. Mounted adjacent to the clutch lever is the **power interlock switch,** the purpose of which is to isolate power to both driving motors when the drive is clutched to "hand". The switch is spring-operated to break the circuit, but is made by the action of a hooked lug on the clutch lever; this hooked shape also assists the internal spring to break the switch.

TRAINING LIMIT SWITCH (*Plate 6*)

19. One corner of the training buffer supporting casting is bored to receive a **plunger,** in the bottom of which is carried a roller. Mounted directly in front of this plunger is the training **limit switch, Mark 1*,** the **operating arm** of which carries a **roller** which engages the top of the plunger.

20. A double incline **cam** is fixed to the lower base plate so that, when the mounting reaches a position 10 degrees from its training limit in either direction, the plunger roller strikes one or the other of the cam slopes; after the mounting has moved about 1 degree, the roller rises sufficiently to operate the limit switch which applies a braking torque to the driving motor to bring the mounting slowly to rest on the training buffer. A slipping clutch inside the limit switch box renders for the remaining 9 degrees. When training away from the stop, the first one degree of gun travel restores the contacts to normal, thus removing the braking torque; the slipping clutch renders for the next 9 degrees travel after which the roller rides clear of the cam.

TRAINING RECEIVER DRIVE (*Plate 8*)

21. The bearing of the mounting is transmitted mechanically to its training receiver and is recorded by a **split spur pinion** which engages the training rack.

The split spur pinion is shown meshing with its rack. The top fixed half of the pinion is keyed to the vertical shaft projecting from the **bevel gear box,** which is secured to the carriage below the trainer's platform; the bottom half of the pinion has a limited rotational movement. The anti-backlash device embodied in the split spur pinion consists of a strong "C" spring acting on both halves and tending to force the teeth of the two halves out of alignment, thus taking up any wear or clearance on the teeth of the pinion or the training rack.

22. From the recording pinion, the operating gear for the receiver drives through a pair of bevel wheels in the bevel gear box to the inclined shaft, connected by a **flexible coupling** to another shaft, the upper extremity of which carries a **vernier coupling.** From the upper side of the vernier coupling a short shaft is connected by another flexible coupling to the shaft carried in the training g

receiver support bracket, secured to the carriage in front of the training handles. The receiving

To prevent the ingress of water into the training receiver support bracket, a G.A.C.O. "Hat" g packing is fitted into the hole of the support bracket, through which the receiver driving shaft passes, the rim of the packing being "nipped" between the receiver and its bracket. To ensure satisfactory r, contact a liner ring may be fitted underneath the rim of the packing.

(*Amendment No. 11.*)

SECTION 3. ELEVATING GEAR. (*Diagram 5, Plates 4, 7, 8*)

23. The elevating gear has the same characteristics as the training gear, inasmuch that the complete equipment for the training gear is repeated for the elevating gear. The worm gear box is, however, made opposite hand, as are the hand drive gear box and the main gear box. The main gear box is mounted on the left side of the carriage so that the output shaft rises vertically from the box, and is connected by a similar coupling to the worm shaft of the worm gear box, the latter being situated just below the left trunnion. The elevating pinion meshes with an elevating arc attached to the underside of the left gun casing.

The main gear box casing is sub-divided by an oil seal fitted in the output shaft lower bearing housing. Thus, there is an upper and a lower oil bath, and each is provided with an oil filling plug. The various other oil filling and drain plugs are resited as necessary to provide suitable positions for filling and draining.

The elevating driving motor is situated to the rear on the left side of the upper base plate.

24. The resetter box is secured to the top of the reduction gear box, which lies horizontally in the elevating gear. The gear ratios for the coarse and fine coincidence transmitters are the same as for the training gear, viz., 1 to 1 and 9 to 1 respectively. However, as the maximum permissible relative arc of movement between the guns and director in elevation is less than 180 degrees, they are unable to lose alignment by getting out of sector. A sector control switch is not, therefore, fitted for the elevating motion.

25. The **bevel gear box** transmitting the drive from the lower **universal coupling** to the **hand drive worm** is turned through 90 degrees in relation to the main gear box, so that its input shaft rises vertically as before.

The action of the power drive, hand drive, clutches and interlock switch is identical with that described for the training gear (paras. 5-13).

The bearings in the worm gear box are lubricated directly by nipples on the box, and not by remote connections as in the training gear.

To reduce muzzle preponderance in order to provide balanced elevating efforts, balance weights have been fitted. They are secured to the rear of the breech casing of each gun, and weigh about 65 lb. each.

The overall gear ratio from motor to guns is 253·2 to 1.

The overall gear ratio from elevating handles to guns is 96·8 to 1.

ELEVATION AND DEPRESSION BUFFER AND LIMIT STOPS (*Plate 4*)

26. The elevation and depression buffer is secured to the carriage on the trainer's side of the elevating arc and is of the common double-ended oil-retarding spring recovery type. The projecting ends of the piston rod engage with the **elevation and depression limit stops** fitted to the extremities of the elevating arc, in order to bring the guns gently to rest at 90 degrees elevation and 15 degrees depression respectively. SEE ALSO PARA 28A.

ELEVATION LOCKING BOLT (*Plate 4*)

27. An elevation locking bolt is fitted to enable the gun casings to be locked in elevation for safety during such operations as the exchange of barrels. The **bolt** passes through the left side of the carriage and engages a hole drilled in the elevating arc. It is operated by a **hand lever** situated convenient to the layer's right hand, the hand lever being locked by a **pin.**

ELEVATION AND DEPRESSION LIMIT SWITCH (*Plate 8*)

28. This switch is a Mark 1S and is secured to the front of the carriage above the firing gear. It is operated by a small **cam** rotated through a 5 to 1 step-up gear connected to the **cross shaft** of the elevating component of the safety firing gear. When the guns reach a position, 7 degrees from the [illegible] and 1 degree of gun

28A. In some ships, due to pendant obstructions to the line of fire it has been necessary to restrict the maximum elevation to elevations below the standard 90 degrees. To achieve this the stop on the elevating arc has been repositioned as necessary and the cam operating the limit switch has been modified to suit. Care should be taken in reassembling modified cams on these mountings as the cams are no longer symmetrical.

(*Amendment No. 12.*)

29. The elevation of the gun is transmitted mechanically to its elevation receiver and is recorded by a **split spur pinion** which engages with the main elevating pinion. From the split spur pinion, the operating gear for the receiver drives into the bevel gear box secured to the carriage, where a cross shaft connected by **flexible couplings** and incorporating a saw toothed **vernier coupling,** drives into the **elevation receiver support bracket** secured to the left side of the carriage in front of the elevating handles. The elevation receiver (type CM mark 1 * or 1 **) is mounted on a prepared surface on this support bracket.

The vernier coupling is fitted to enable adjustment of the mechanical pointer of the elevation receiver. To prevent damage to the receiver drive coupling dogs when fitting the elevation receiver, a **sliding coupling** is fitted to the receiver driving shaft.

To prevent the ingress of water into the elevation receiver support bracket, a G.A.C.O. " Hat " packing is fitted into the hole of the support bracket, through which the receiver driving shaft passes, the rim of the packing being " nipped " between the receiver and its bracket. To ensure satisfactory contact a liner ring may be fitted underneath the rim of the packing.

(*Amendment No. 11.*)

Note : For clutch setting gear *see* Diagram 4A.

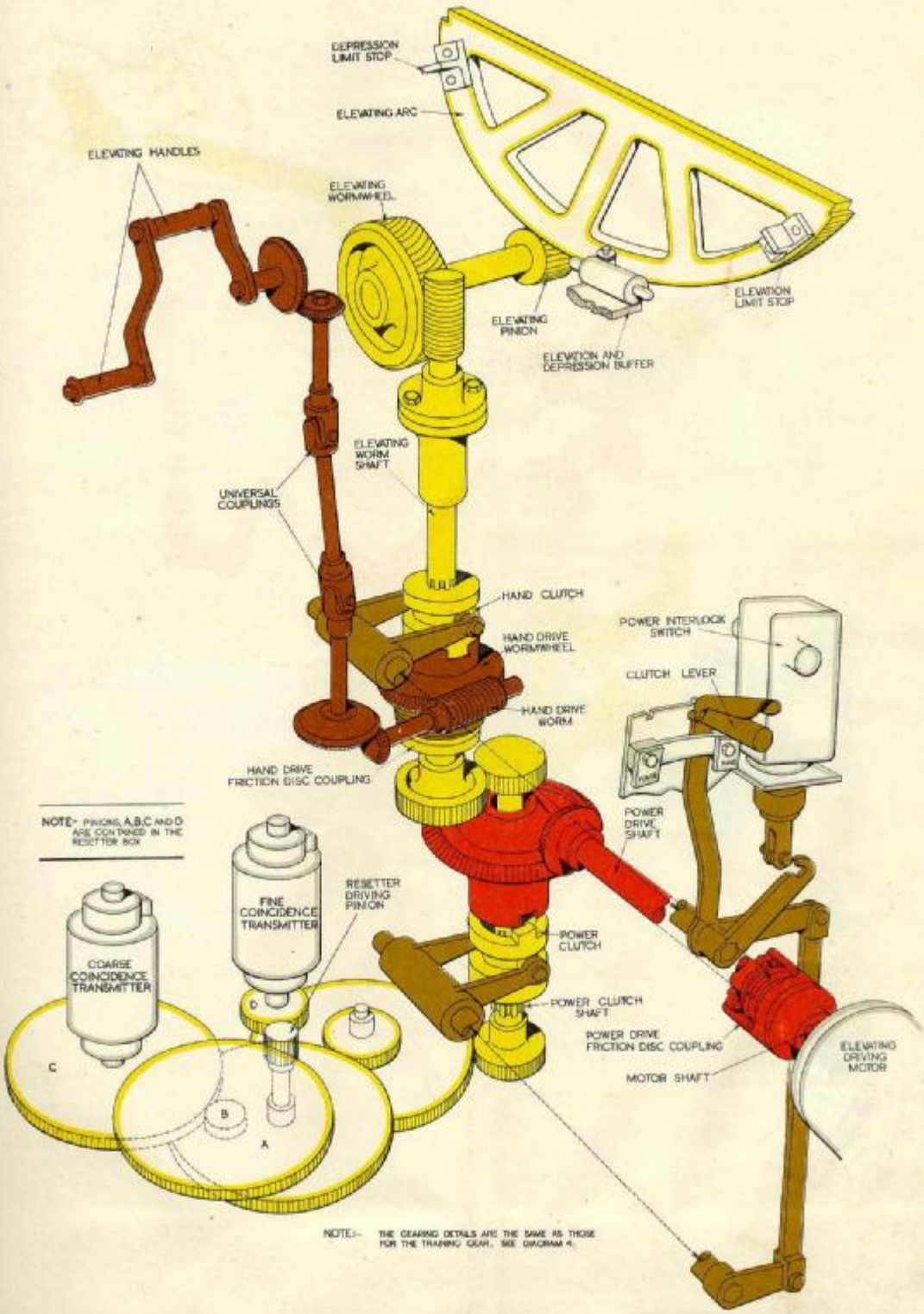
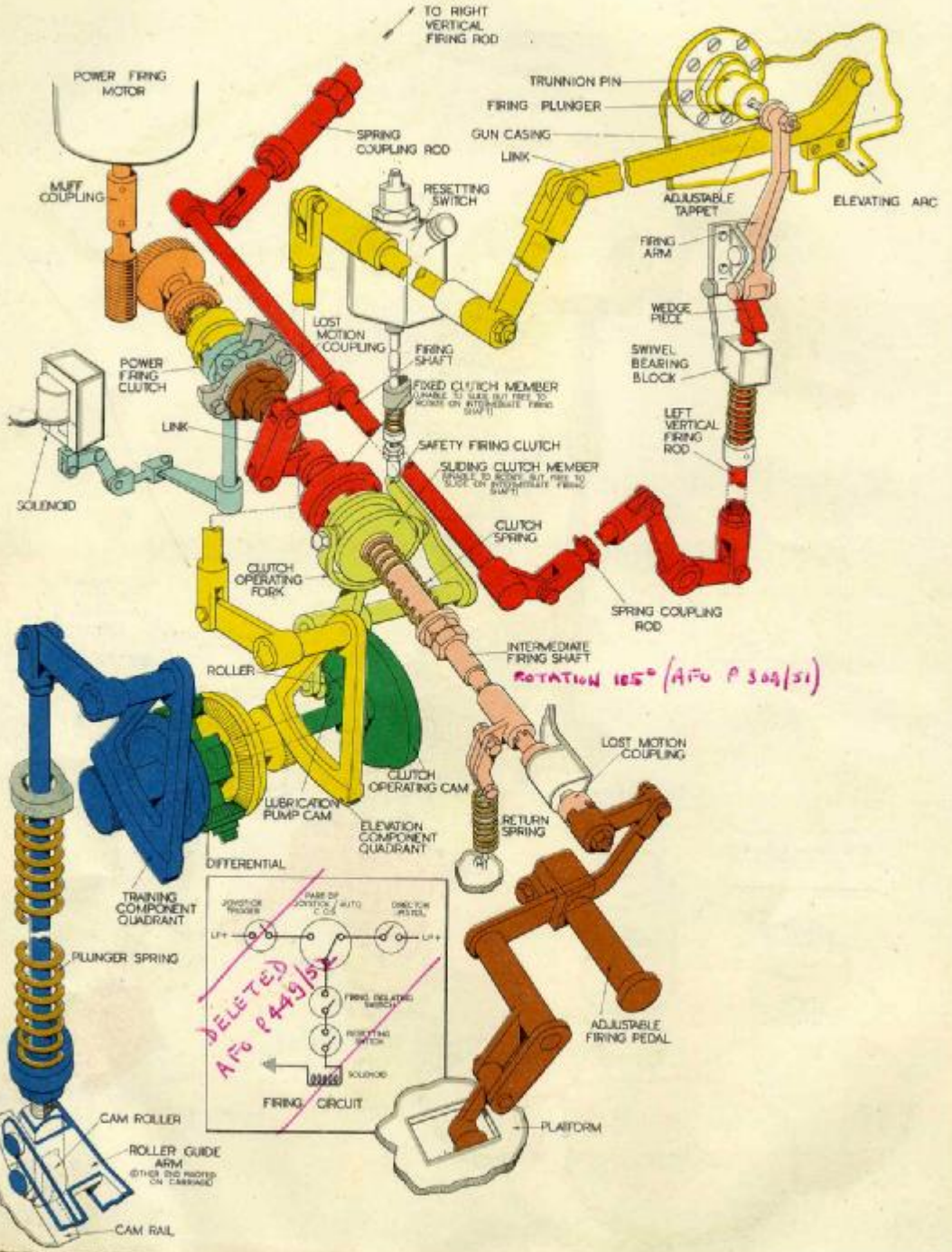


Diagram 5. Elevating Gear



ERRATA

The extension of the Intermediate Firing Shaft beyond the Fixed Clutch Member to the Lost Motion Coupling should be coloured pink (in lieu of brown).

(Amendment No. 11.)

Diagram 6. Firing and Safety Firing Gear

CHAPTER 3

FIRING AND SAFETY FIRING GEAR *(Diagram 6, Plates 9. 10)*

1. The gear has been designed to provide :—

(*a*) pedal firing, in which the firing gear is pedal operated by the gunlayer ;

(*b*) joystick firing, in which the firing gear is power-operated, the power source being controlled by a firing trigger on the joystick ;

(*c*) director firing, in which the firing gear is power-operated, the power source being controlled by a firing trigger at the director ;

(*d*) the firing of both guns is interrupted whenever the line of fire approaches an obstruction on the ship's structure.

These features are provided as described in the following paragraphs.

PEDAL FIRING *(Diagram 6, Plate 9)*

2. In this form of firing the operation of the gun firing mechanisms is initiated by a **firing pedal** carried on a bar, pivoted on a link, which in turn is pivoted on the platform. The other end of the bar is connected to a lever, the boss of which forms one half of a **lost motion coupling.** The motion of the firing pedal is thus a combined vertical and lateral movement, and requires to be moved sufficiently to provide about 90 degrees rotation of the **intermediate firing shaft** to ensure the guns will fire.

The other half of the lost motion coupling is carried on a short shaft carried in a bracket on the front of the carriage, and the shaft is joined to the intermediate firing shaft by a muff coupling. A lever extension of the muff carries a double link, which is connected to one end of a **return spring,** the other end of which is connected to the platform.

Carried on the intermediate firing shaft is the **sliding clutch member** of the **safety firing clutch,** which is free to slide on the shaft but unable to turn independently of the shaft. Normally, the sliding clutch member under the influence of the **clutch spring** engages the fixed clutch member, which is unable to slide but free to rotate on the shaft. A lever extension of the **fixed clutch member** is connected by a link to a similar lever pinned to the **firing shaft.**

The firing shaft projects in both directions across the front of the carriage, and carries a small lever at each end ; from here onwards the gear is duplicated, one set being fitted each side of the carriage. A horizontal spring coupling rod connects each of these small levers to one arm of a bell crank lever.

3. The **vertical firing rod** is connected to the other arm of the bell crank lever, the rod being supported in a bearing block which is part of the firing arm bracket. The lower end of the rod is fitted with a length adjustment eye, and a spring is fitted between the bearing block and a collar on the rod to restrain the rod downwards. The rod terminates above the bearing block in a **wedge piece** which slides under a roller carried in the yoke end of a **firing arm,** pivoted in a bracket secured

"There should be a clearance of 0·01 in. between the **adjustable tappets** and the **firing plungers** of the guns when in the " safe " position, and the tappets should depress the plungers about 0·75 in. in the " fire " position. These values should be obtained when the **intermediate firing shaft** rotates about 105 degrees."

(G. 03750/50.—A.F.O. P.309/51.)

4. On moving the firing pedal, the intermediate firing shaft ... return spring and through the safety firing clutch, and the link will rotate the firing shaft. The firing shaft, through its end levers, will operate the rods and bell cranks, and push up on the vertical firing rods against the action of their return springs. The wedges at the top of the rods will be forced between the roller on the firing arm and the roller pivoted in the bracket, and will thus rotate the firing arm about its pivot, and through the tappet, will push in on the gun firing plungers and so fire the guns.

JOYSTICK AND DIRECTOR FIRING *(Diagram 6, Plate 9)*

5. Depending upon the position of the auto/joystick change-over switch, either the pistol at the director or the trigger on the joystick energises a **solenoid,** which engages a **power firing clutch.**

The power firing clutch relays to the **intermediate firing shaft,** through a **lost motion conpling,** part of the movement imparted to the clutch by a constantly-rotating electric motor, the total movement amounting to approximately 105 degrees rotation of the intermediate firing shaft. The remainder of the gear used, and its action in these two forms of firing, is then the same as in pedal firing.

POWER FIRING MOTOR AND CLUTCH *(Diagram 6, Plate 9)*

6. The **power firing motor** is a ½ h.p. 220 V. D.C. totally enclosed motor, which rotates at 1,750 r.p.m., and is secured in a vertical position to a bracket on the front of the carriage. It is connected to the [illegible] clutch by a **muff coupling**.

" 6A. The power firing motor for the Mark 5* mounting is a ½ h.p. 440 volt, 3 phase, 60 cycle squirrel cage induction motor running at 1,700 r.p.m. It has a ' direct on ' 3 pole switch for starting. Full load is 0·6 amps."

(G. 4041/55.—Amendment No. 8.)

7. The left-hand section contains the two start left-hand worm reduction gear, driven through the muff coupling by the motor. The worm shaft is supported in two ball bearings, one in the casing, the other in the cover plate, the latter also containing an **oil seal.** The **worm wheel** is carried on splines on the **running shaft,** to which it is secured by a nut and locking washer.

The **running clutch member** of a ratchet-tooth clutch is formed solid with the runningshaft, the whole being supported in two ball bearings, one in the left end cover and the other in the **casing mid-section.** The running member projects into the right-hand section of the casing, and is recessed internally to carry a ball bearing.

8. In the right-hand section, and surrounding the running member but secured to the mid-section of the casing, is the **fixed cam plate,** which has two raised cams opposite each other on its right-hand surface.

A **clutch shaft** carried in two ball bearings is contained in the right-hand section of the casing. A spigot on the left end of the shaft is located in the ball bearing in the recess of the running clutch member, the other bearing being in the right **end plate.** The right end plate also contains an oil seal, which bears on a sleeve fitted on the shaft.

The clutch shaft is splined for part of its length, each spline having a **raised projection** near its root end. The shaft extends through the end cover, and carries in the normal position a stop on the end plate.

Fitted on the shaft, and free to slide on the splines, is the **sliding clutch member** of the ratch[illegible] cams, at the same diameter as those on the fixed cam plate. In the normal position the two raised cams are about 90 degrees clockwise behind those on the fixed cam plate. A step of larger diameter is provided to the right of the sliding clutch member, and the right-hand face of the latter is cut with two dogs similar to a dog clutch.

" If the **sliding clutch member** is assembled relative to the **clutch shaft** so as to give only about 45 degrees angular rotation, adjustment to obtain the correct angular rotation can be made by re-positioning the **clutch shaft** in the **coupling disc** by moving the **clutch shaft** back (i.e. against the direction of the firing movement) one spline relative to the **coupling disc.**"

(G. 03750/50.—A.F.O. P.309/51.)

Mounted on the plain portion of the clutch shaft is the **holding clutch,** which is free to slide on the shaft, and inside of which the shaft is free to rotate. Two keys on the outside of the holding clutch slide in two keyways in the casing, and so prevent the holding clutch from rotating. The inside of the clutch is recessed to accommodate a strong **spring B,** the other end of which bears against a washer which, in turn, bears against the projections on the splines of the clutch shaft, and so tends to keep the clutch to the right under normal conditions. The outside of the clutch is reduced in diameter to the right, and is grooved circumferentially, to engage the pins of a **clutch fork,** keyed to a **clutch operating shaft** carried in plain bearings in the casing. An oil seal is fitted at the lower bearing.

ACTION OF CLUTCH *(Diagrams 6, 7, Plate 9)*

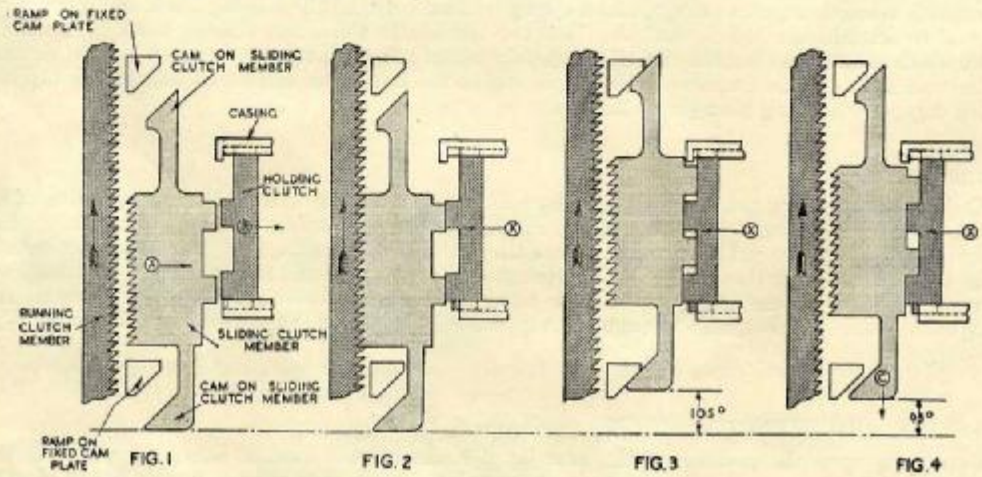


Diagram 7. Operation of Power Firing Clutch

10. The left face of the holding clutch is cut with two dogs of smaller angular dimensions, but similar to those on the sliding clutch member, and normally in line with those on the latter. The outside of the clutch is reduced in diameter, and threaded to receive the **retaining sleeve,** which is screwed on

and located by a set-screw. The retaining sleeve is reduced in diameter internally at its left end, and takes over the large diameter of the sliding clutch member. This makes one assembly with the holding clutch, but with such a clearance that the dogs of both clutches can be in line and just clear of each other, in the normal position.

11. With the motor running, the worm and **wormwheel** will be driven through the **muff coupling**, and will therefore rotate the **running clutch member** continuously, in a clockwise direction (viewed from the right end of casing) ; the rest of the gear remains in its normal position, as described above and as shown in Fig. 1.

If the **clutch operating shaft** is now rotated anti-clockwise (viewed from above), the **holding clutch** will be moved to the left (X) against the action of **spring B.** As the dogs of the **sliding clutch member** are in line with those of the holding clutch, as soon as the clearance is taken up, the sliding clutch member will be moved to the left also, against the action of spring A.

This will engage the ratchet teeth of both clutch members and the sliding clutch member will then rotate with the running clutch member, and, in doing so, will turn the **clutch shaft,** and operate the firing gear (*see* Fig. 2).

As the angle of rotation reaches 90 degrees, the dogs of the sliding clutch member will come into line with the larger recesses in the holding clutch. At the same time the raised **cams** on the sliding clutch member will ride up the similarly raised cams on the **fixed cam plate,** and before reaching 105 degrees the sliding clutch member will be forced to the right, assisted by spring A (*see* Fig. 3).

As the ratchet tooth clutch is disengaged, the return action of the firing gear would tend to rotate the clutch shaft, and hence the sliding clutch member, in the reverse direction back to normal This is prevented by the dogs of the sliding clutch member entering the recesses in the holding clutch, which are now in alignment, and thus keeping the gear in the firing position, although the shaft does rotate about 10 degrees until the sides of the dogs are in engagement (*see* Fig. 4).

12. If the solenoid is now de-energised, spring B will assert itself and force the holding clutch to the right, resetting the clutch operating shaft, and withdrawing the recesses off the dogs of the sliding clutch member, so leaving the latter free to rotate. The firing gear return action will then cause the clutch shaft and sliding clutch member to rotate back to their original position, the projecting stop on the coupling disc coming against the stop on the right end plate.

The dogs on the sliding clutch member will again be in line with those on the holding clutch, and the whole gear will be in readiness for a repetition of the same cycle of events whenever the solenoid is energised.

The clutch shaft, through a projection on the outside of the coupling disc engaging a similar projection on another disc carried on the **intermediate firing shaft,** rotates the latter.

This shaft enters the differential box, and from thence onwards the action is the same as in pedal firing wherein the pedal shaft similarly operates the intermediate firing shaft.

13. The **lost motion couplings** are fitted so that in joystick or director firing the pedal does not depress and, when in pedal firing, the clutch shaft of the power firing clutch is not rotated.

Note : In some mountings, particularly those fitted in aircraft-carriers, it has been necessary to provide alternative firing arcs. In these cases the pedal firing gear has been disconnected, as, in the alternative arcs, safety firing is achieved by electrical means only and would not prevent manual firing in a dangerous arc.

(*Amendment No. 12.*)

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before firing can be resumed on returning to a firing zone, it is necessary to release the foot pedal, whereas in director or joystick firing the pistol or trigger may remain pressed and fire will be automatically resumed.

Interruption of the firing is achieved by disengaging the **safety firing clutch.** In any form of firing, the connection between the **intermediate firing shaft** and the **firing shaft** will be broken, the operation of the clutch being controlled by a differential mechanism which, together with the safety firing clutch, is contained within the differential box.

To define the firing zone, it is necessary to provide inputs to the safety firing gear from both the elevation and training motions.

15. The elevation component is obtained by link gear connected to the elevating arc (this link is shown connected to the gun casing in Diagram 6 which is only diagrammatic), the last lever of the gear being splined to a shaft emerging from the differential box.

16. The training component is obtained from a **cam roller** attached to the lower end of a spring plunger mounted at the front of the mounting. This roller trains round with the mounting, and is lifted when necessary against the action of the **spring** by a **cam rail** secured to the deck. This cam rail is cut to suit the situation of the mounting in the individual ship, and its contour is governed by the height and width of the obstruction produced to a plane at right angles to the right or left gun bore.

A **roller guide arm** is connected at one end to the lower end of the spring plunger, and its other end is pivoted on the upper base plate. It is fitted to take the side thrust imposed on the roller when it is riding up an inclined surface of the cam rail. The top of the spring plunger is connected to a lever which is splined to a shaft emerging from the differential box.

Differential Box (*Diagram 6, Plates 9, 10*)

17. A bevel gear type **differential** is contained within the box, and its outer elements are driven by two quadrants splined to the two shafts previously mentioned.

The input from the elevating arc is connected to the **elevation component quadrant,** the teeth of which engage with a pinion cut solid with the left outer element of the differential.

The input from the spring plunger carrying the cam roller is connected to the **training component quadrant,** the teeth of which engage with a pinion cut solid with the right outer element of the differential.

The sum or difference of the two inputs is thus driven to the centre element of the differential, which is connected by a shaft passing freely through the centre of the right outer element to a **clutch operating cam.**

The **clutch operating fork,** which disengages the **sliding clutch member** of the safety firing clutch, is pivoted in the differential box, and carries a **roller** on its lower extension. This roller travels around the periphery of the clutch operating cam, being made to follow its contour by the restraining action of the clutch spring.

The contour of the cam is circular on two diameters, the larger diameter disengaging the clutch and the smaller diameter permitting the clutch spring to engage the clutch.

18. An extension of the pivot of the clutch operating fork carries a tappet lever, which operates a vertical tappet rod, which in turn operates a **resetting switch.** This switch is so arranged that when the clutch is engaged, the circuit through the switch is complete, and when the clutch is disengaged the circuit is interrupted. The switch, which is single pole and spring constrained to "make", is in series in the circuit energising the solenoid.

19. A small **lubrication pump cam** is fitted on the same shaft as the clutch operating cam, and it oscillates a small **oil pump** which supplies oil to the **gravity feed box** for lubricating the gear inside the differential box.

Action of Safety Firing Gear

20. Components of the elevating and training motions driving into the differential produce a positive or negative result in the centre element of the differential. When positive, the **clutch operating cam** is rotated so that the **roller** is in line with its lesser diameter, and the **safety firing clutch** is engaged by its spring; at the same time the **solenoid** circuit is completed through the **resetting switch.**

When negative, the cam is rotated so that the roller is in line with its larger diameter, and the safety firing clutch is disengaged by the **clutch operating fork** against the action of its spring, and at the same time the solenoid circuit is broken, in the resetting switch.

When the line of fire is in the firing zone, the output of the differential will be positive. If the gun enters a non-firing zone, the output of the differential will become negative, the clutch will be disengaged, and the firing gear from the **fixed clutch member** onwards to the **firing arms** will be returned by the combined action of the **vertical firing rod** springs and the return action of the gun **firing plungers.**

21. At the same time, the resetting switch will interrupt the circuit to the solenoid. If the firing gear is being controlled by either the director pistol or joystick trigger, the solenoid will be de-energised and the power firing clutch disengaged. The intermediate firing shaft and the sliding clutch member of the power firing clutch will be returned to the normal position by the action of the return spring on the shaft, until the stop on the coupling disc engages the stop on the right end plate of the power firing clutch. The entire gear has now been reset to the normal position, except that the safety firing clutch is disengaged and the solenoid circuit broken.

If the guns are elevated or the mounting is trained to return the line of fire to a firing zone, the roller will leave the larger diameter of the clutch operating cam, the clutch will engage under the action of the clutch spring, and the resetting switch will complete the circuit to the solenoid, under the action of its own spring. Thus, if either the director pistol or the joystick trigger has been kept pressed, the complete cycle of the firing operation will commence as soon as the solenoid circuit is completed through the resetting switch.

22. In pedal firing, however, until the pedal is released the dogs on the sliding clutch member of the safety firing clutch will remain out of line with the recesses on the fixed clutch member. When the cam has rotated to enable the clutch to be engaged, the spring will only bring the dogs of one half of the clutch into contact with the dogs on the other half.

In pedal firing it is therefore necessary to release the pedal and then operate it again before firing can be resumed.

Notes (*a*) The return action of this gear is entirely dependent on the action of certain springs. It is therefore essential in the interests of safety that a high standard of maintenance be achieved to prevent stiffness of the working parts overcoming the force exerted by the springs.

(*b*) To ensure safety and to release the breech closing spring tension, the breech should normally always be kept *closed*, otherwise at depression, or with a list on the ship, a round may slide clear of the rammer claws into the breech—even with the safety lever at the "trigger held" position—with sufficient impetus to close the breech and fire the gun.

Details of the gun will be found in B.R.1057.

(*c*) When checking safety firing arcs it is most important that the clearance distance (*see* B.R. 292, Appendix 17) from each obstruction should be checked for pedal firing as well as electrical firing as mal-adjustment of the resetting switch in relation to the safety firing clutch could lead to a safe clearance distance established by an electrical firing check being unsafe in pedal firing.

(*Amendment No. 11.*)

23. In some mountings, particularly in aircraft carriers, it has been necessary to provide alternative firing arcs because of the existence of portable obstructions.

The additional safety firing gear necessary to achieve this is called **supplementary safety firing gear**. In such cases, the pedal firing gear has been disconnected, as, in the alternative arcs, safety is achieved by electrical means only, which would not prevent *pedal* firing in a prohibited zone.

SUPPLEMENTARY SAFETY FIRING GEAR

24. In mountings fitted with supplementary safety firing gear, the normal safety firing gear cam is cut to obtain firing arcs with the usual safeguards, as laid down in B.R.292, Appendix 17, without reference to the portable obstruction.

An additional safety firing gear training cam rail is provided to operate a switch on the mounting, the contacts of which are in the firing solenoid circuit, and the circuit is thereby opened when the mounting is trained on bearings dangerous to the portable obstruction.

Where desirable, this feature may be supplemented by a similar device in the elevation motion. A cam fitted to a convenient shaft in the elevating safety firing gear drive, operates a microswitch, the contacts of which are in the firing solenoid circuit.

The two switches, when both are fitted, are wired in parallel, so that when the mounting is at angles of training and elevation which would endanger the portable obstruction, the electrical firing arrangements are rendered inoperative. Variations of this supplementary safety firing gear have been developed to suit particular applications and are described below.

Permissive Fire Across The Flight Deck

25. Introduction of the angled flight deck on certain aircraft carriers, necessitated the removal of part of the armament, resulting in an unprotected sector on the port side.

In order that armament on the starboard side of the ship could provide cover for that sector, it became necessary, under certain circumstances, to permit firing across the flight deck at low angles of sight. The normal safety firing gear cam is cut to permit firing across the flight deck at low angles of sight with the usual structural safeguards laid down in B.R. 292, Appendix 17, Table 1, Paragraph (*a*) (i) to (iii) only.

The supplementary safety firing gear, consisting of both the training and elevating portions, is arranged to ensure that, when operating aircraft, the guns cannot fire over the flight deck at angles of elevation below that which is necessary to provide a deck clearance of 17 ft. 6 in. at 10 ft. 9 in. radius from the mounting. The arrangements are such that the normal state of the mounting is with the supplementary safety firing gear in operation.

A **foot operated spring loaded switch** at the aimer's position, short circuits the supplementary safety firing gear when permission to fire across the flight deck is granted by the Gunnery Direction Officer, this permission being given by means of a **permissive order lamp** at the aimer's position.

An additional switch, fitted with a Castell type lock and special key, and wired in series with the foot operated switch is fitted at the trainer's position. This special key cannot be withdrawn when the switch is closed, and is normally kept on the Officer of the Watch's keyboard.

Under action conditions, and during permissive firing across the flight deck, the trainer is able to open the switch by means of this key, and thus interrupt firing at his discretion.

Periscope Protection

26. In ships fitted with an operations room periscope, which would, when erected, obstruct part of the firing arc, supplementary safety firing gear is fitted to open a switch in the firing circuit at all angles of elevation over the training arc which extends 12 degrees from the nearer gun to each side of the periscope, during the time that the periscope is raised.

The mounting is fitted with the training portion only of the supplementary safety firing gear.

In parallel with the supplementary safety firing switch on the mounting, is a switch at the periscope position which is normally closed when the periscope is lowered. Thus the firing circuit remains intact through this arc until the periscope is raised, when both switches will be open and the firing circuit interrupted.

The periscope is arranged to break its switch, not less than half a second before rising into the danger zone.

Whip Aerial Protection

27. Where a whip aerial for an emergency transmitter is sited in such a position that when rigged it is endangered by gun fire or gun blast, supplementary safety firing gear is essential to provide protection for this important aerial.

The mounting is fitted with both the training and elevating portions of the supplementary safety firing gear as described in paragraph 24, and this gear is adjusted to safeguard the aerial within the limits laid down in B.R. 292, Appendix 17.

When the aerial is not rigged, the supplementary safety firing gear on the mounting is overridden by a patent keylock switch on the mounting, which is in parallel with the supplementary safety firing gear switches. This special key cannot be extracted when the switch is closed, and a tally plate adjacent to the switch on the mounting warns that the switch must be kept on the Hazards board when the aerial is rigged.

A prominent tally on the whip aerial mount, draws attention to the fact that care must be taken to ensure that the key of the overriding switch on the mounting is on the Hazards board before the aerial is rigged.

28. In some ships, due to pendant obstructions to the line of fire, and because of the inability of the existing safety firing gear to deal with such obstructions, it has been necessary to restrict the maximum elevation to elevations below the standard 90 degrees. To achieve this, the stop on the elevating arc has been repositioned as necessary, and the cam operating the limit switch has been modified to suit.

Care should be taken in reassembling modified cams on these mountings as they are not symmetrical.

Rocket Flare Launchers

29. Mountings fitted with Rocket Flare Launchers need additional safety firing gear for the launchers.

An additional cam rail is fitted around the base of the mounting, and this cam rail, in conjunction with a roller on the mounting, breaks at dangerous bearings a switch which is inserted in the current supply to the firing gear of the launchers. The launchers being at fixed angles of elevation, no elevating safety firing gear is required.

CHAPTER 4

OTHER DETAILS

SECTION 1. JOYSTICK AND CONTROLLERS (*Diagram 8, Plates 11, 12 and 16*).

1. Joystick operation is provided to enable the mounting to be power operated in the event of damage to the amplifier, the director or the sensitive magslip chains. The equipment in use is the joystick with associated controllers, the gun driving motors, the metadyne set, its starter and control panel.

THE JOYSTICK

2. The joystick is fitted on the left hand side of the mounting directly behind the elevating handles. It is so arranged that the **joystick handles** may be rotated about the vertical axis and twisted about their horizontal axis simultaneously, mounting speed being dependent on the angular movement of the joystick handles in either or both planes. The maximum movement of the handles about either axis is limited by **stops,** those for elevation being on the casting carrying the handles and those for training on the column.

Training Operation

3. The training motor is operated by rotating the joystick handles up to 20 degrees right or left about the vertical axis of the column. The joystick handles are connected through a bracket to a training tube, which rotates in a supporting pedestal. To the **training tube** is attached a **quadrant** which moves the **pinion** of the training controller. The handles are returned to the centre position by a return spring.

Elevation Operation

4. The elevating motor is operated by twisting the joystick handles up to 30 degrees in either direction about their horizontal axis. The handles are connected by means of sliding **rods** and a **quadrant** and **pinion** to the **elevation controller.** The handles are returned to the centre position by a return spring. A **balance weight** is fitted to the quadrant of the elevation controller to balance the weight of the vertical rods, etc., and thus provide balanced efforts at the handles for elevation and depression motions.

5. Provision is made to house the joystick handles in a vertical position when it is desired to operate the mounting by hand using the elevating handles. A locking catch is also provided to lock the elevating handles when the joystick is in use.

6. A **firing switch** is fitted to the right handle of the joystick, and the **trigger** is pressed by the first and second fingers of the right hand.

THE CONTROLLERS (*Diagram 8, Plate 12*)

7. The controllers are identical for training and elevating and are interchangeable. Each controller has two sections of resistance which are not electrically connected. These two sections will be referred to as the **main** and **auxiliary controllers** because of their association with the **main** and **auxiliary variator** windings of the **metadyne** generator. From ~~Diagram 8~~ PLATE 16 it will be seen that with the **changeover switch** to Joystick position, the output relay coil is de-energised. The metadyne main variator winding is thus connected in series with the main controller across the ship's D.C. supply. The joystick position of the change-over switch also connects the metadyne auxiliary variator winding in series with the auxiliary controller across the metadyne output terminals. Operation of the on push button on the mounting closes the supply contactor, thus exciting the training and elevating motor fields and the joystick main controller circuits. Movement of the joystick in the training or elevating direction operates the corresponding main and auxiliary controllers simultaneously.

8. The pinions of the controllers, which are moved by the quadrants of the joystick, are each keyed to the end of a spindle protruding from their respective controller casing. On the opposite end of this spindle is keyed the contact finger carrier arm, to which are secured at each end a pair of **finger contacts** for the **main resistance** and a pair of finger contacts for the **auxiliary resistance.** At the centre of the carrier arm are two short arms, each of which carries an insulated pin for operating the **snap switch** for opening the auxiliary control circuit. Direction of rotation of the spindle decides which pin operates the switch. The spindle rotates through 83½ degrees either side of the central position to obtain full speed in either direction. A centring register and stops at full displacement are provided in the controller.

Operation

Main Controller—" Off" Position to " Half-displacement "

9. On moving the spindle through approximately 4 degrees either side of the central position, the main control circuit is completed through a high resistance by the main outer finger contact " making "

with the first fixed contact, and the main inner finger contact with the inner segment. Further movement of the spindle reduces this resistance in steps. Each step is equal to 1·8 degrees, there being 19 steps. When the spindle has rotated approximately 38 degrees, therefore, all the variable resistance in the main control circuit is cut out. The first half of the joystick movement thus gradually increases the main variator current, resulting in gradually increasing metadyne output current and consequently in gradually increasing torque from the gun driving motor.

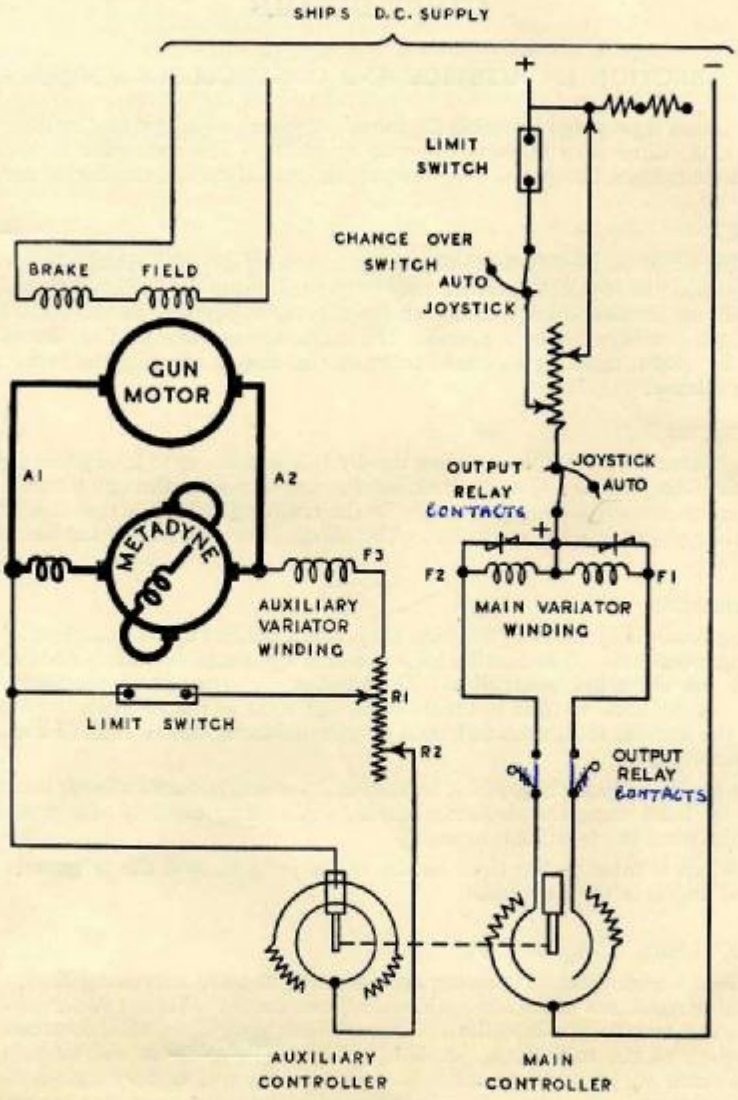


Diagram 8. Joystick Controller Circuits

Auxiliary Controller—" Off " Position to " Half-displacement "

10. Whilst the main variator winding current is increasing, the auxiliary controller maintains a constant resistance in the metadyne auxiliary variator circuit, and as this winding is connected to oppose the main variator winding, the resulting metadyne output current voltage characteristics all have approximately the same value. The number of turns and the resistance of the auxiliary variator windings are so designed that these output current voltage characteristics are high between the " off " position and stud 20 for either backward or forward motion. Consequently, if the mounting friction, out of balance, recoil or windage torques vary whilst the joystick remains stationary in a given position, the necessary torque is coming from the motor with very little variation in mounting speed. This feature leads to easy control of the mounting at creep speeds.

" Half " to " Full " Displacement

11. For further movement of the joystick and hence the spindle, the finger contact for the main variator circuit leaves the last fixed contact. The finger contacts for the auxiliary control circuit " make " the auxiliary control circuit, the outer finger contact on stud 20, and the inner finger contact with the inner segment. This resistance is gradually increased in 16 steps, each step equal to 1·8 degrees, reducing the effect of the winding, the main variator current remaining unchanged at its maximum value. The excitation of the auxiliary variator winding is gradually cancelled until the

spindle has rotated through approximately 69 degrees, when all the resistance has been inserted. A further 12 degree movement of the spindle and the snap switch is operated by the pin on the carrier arm opening the auxiliary variator circuit. The maximum inherent metadyne output current-voltage characteristic is then obtained. This results in the mounting attaining maximum speed.

12. On returning the joystick to the central position, the reverse sequence of operations take place, the main variator circuit being opened when the joystick is central.

SECTION 2. SIGHTING GEAR (*Diagram 9, Plate 13*)

13. The mounting is equipped with 300 knot **eyeshooting sights** for use of the layer and trainer when the mounting is being operated in hand control.

In addition, a **gyro gunsight,** type 6, Mark 2, is fitted on a special **bracket** on the layer's side, for the use of the joystick operator, when the mounting is being operated by the joystick. The regulator box for the gyro sight, which is calibrated for Bofors gun ballistics, is mounted on the shield [illegible] joystick operator, and the range and dimmer units are mounted on the shield plate [illegible].

The bolts that secure the lugs on the after-sight bracket to the gun casing must not be longer than the designed length, as shown on Drawing G.R.6888. The horizontal lugs require bolt item 2 (plain ½-in., and screwed ½-in., making a total under the head of 1-in.) and the vertical lugs require item 8 (plain ⅜-in., screwed ½-in., making a total under the head of ⅞-in.). Care should be taken when assembling that the correct bolts are used, and that the Grover washers (item 4) are inserted. The fitting of longer bolts, that penetrate into the inside of the gun casing will cause a jam.

1,500 yards. (*G. 0511/54.—Amendment No. 5.*)

ADJUSTMENTS

14. (*a*) The eyeshooting sights are adjustable for line by **elongated holes** in the plate supporting the rear bead sight.

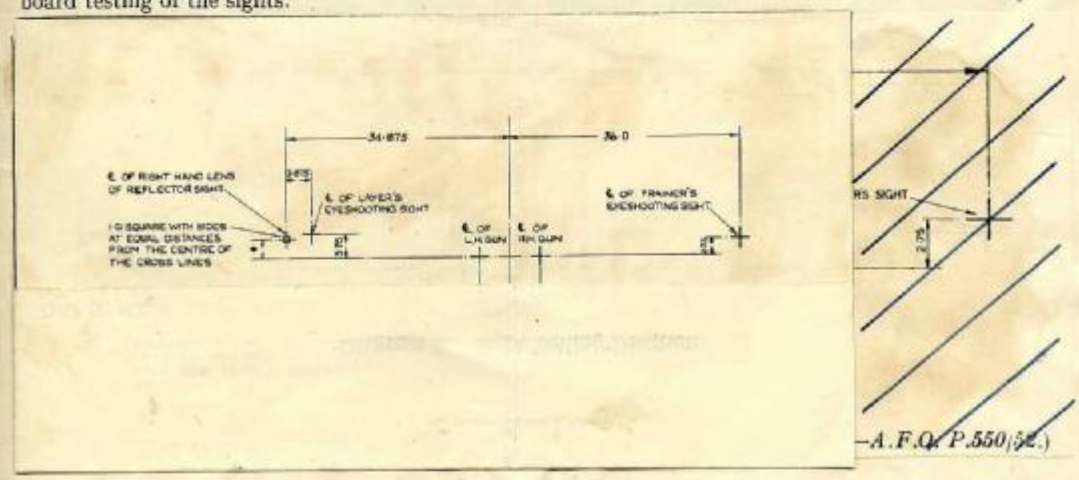
(*b*) The eyeshooting sights are adjustable for elevation by the screwed posts carrying the rear beads. After alignment of the sights has been obtained, the cap carrying the posts should be rotated approx. one turn so as to raise the beads to provide tangent elevation adjustment, a stop being provided to limit the movement of the cap. A spring is fitted under the cap to prevent it moving by vibration.

(*c*) The gyro sight is adjusted for line and elevation by **eccentric bolts** in its supporting and mounting brackets.

Note: A set of special adaptors is provided for use in the gun for sight-testing purposes. Where these have not already been received, they may be obtained from G.E.D., Coventry.

SIGHT TESTING (*Diagram 9*)

15. Sight testing should normally be carried out on a distant object of not less than 1,000 yards range, but where this is not possible the sight testing diagram gives the dimensions between the axes of the gun bores and the axes of the three sights, from which a suitable board may be constructed for board testing of the sights.



—*A.F.O. P.550/52.*)

PROCEDURE FOR ALIGNING TYPE 6 GYRO SIGHT

16. (*i*) Check that the left hand type 7 socket of the sight (see "7" on the end of moulding) is connected to the corresponding type 7 junction unit (see "type 7" on the end moulding also "type 7" cast on the junction unit).

(*ii*) Unplug the right hand type 6 socket of the sight from the junction unit type 6, thus disconnecting the tangent elevation circuit of the sight.

(*iii*) See that the range switch is set to 1,200 yards.

(*iv*) Switch on main supply, and set the temperature of the day (switches on the regulator unit).

(*v*) Switch on the gyro motor and spot lamp switches, leaving the circle lamp switch to "off". The gyro should run to speed immediately and the spot appear.

Note: The "circle" may be used, instead of the "spot", when conditions are unfavourable (such as when the ship rolls sufficiently to move the "spot" relative to the gun).

(*vi*) Ship the bore sighting telescope in the gun and lay and train the gun bore on to the object. Observe the "spot" when the mounting is steady and adjust it to the object, using the adjustments provided on the sight supporting bracket.

Note: When using the sight testing board, at a distance of 30 feet or under, the field of view stop (to be found in the transit case) should be fitted over the lenses before making final adjustments of the sight.

SECTION 3. COOLING SYSTEM (*Plate 14*)

GENERAL DESCRIPTION

17. The guns are water-cooled, the barrels being enclosed by jackets through which a constant flow of water is circulated by means of a centrifugal pump. The **pump** is driven by a 0·6 h.p.

"17A. The water circulating pump motor for the Mark 5* mounting is a ½ h.p. 440 volt, 3 phase 60 cycle squirrel cage induction motor running at 1,715 r.p.m. It has a 'direct on' 3 pole switch for starting. Full load 0·85 amps.

The immersion heater for the Mark 5* mounting is controlled by a 2 heat switch with 2 off positions. The switch is wired to connect the heater elements in delta or star, the first position giving 3 k.W. output and the second 1 k.W. output."

(*G. 4041/55.—Amendment No. 8.*)

18. A **strainer** is fitted between the tank and pump, and a **non-return valve** is fitted to the pump discharge, as it is essential to prevent reversal of rotation when switching off the motor, such reversal would tend to unscrew the impeller from the motor spindle. When filling the system the guns should be elevated to 5 degrees and the front drain plugs on the gun should be removed so that all air can be eliminated from the system.

Care should be taken to ensure that the immersion heater is covered with water before switching on the pump motor. Except in emergency, only fresh water should be used for filling the system. Should other water be used, it should be drained off at the very first opportunity, and the whole system thoroughly flushed with fresh water before final filling with fresh water.

19. It is of great importance to ensure that the supply lead from the pump is connected to the rear connection on the gun jacket. Failure to ensure this may incur inefficient cooling and the formation of an air lock.

THE PUMP (*Plate 14*)

20. The pump **impeller** is screwed on to an extension of the motor armature shaft, and a **square recess** is provided in the impeller to facilitate assembly. The **pump cover** is made watertight by a **sealing ring**, against which a rotating **carbon ring** is pressed by a **spring loaded rubber washer.** The **supply to the guns** is taken from the top of the pump casing, and the casing is provided with an **air cock** and a **drain plug.** The suction from the tank is central in the casing, and forms an outer bearing for the impeller.

A **drain plug** is also fitted in the bottom of the end cover of the pump motor, and this should be removed periodically to check the efficiency of the gland and to prevent an accumulation of water seeping into the motor itself.

CHAPTER 5

THE R.P. 50 METADYNE SYSTEM

SECTION 1. THE SENSITIVE CONTROL

FUNCTION OF SENSITIVE CONTROL

1. The sensitive control provides a means by which the power unit on the mounting is made to align the mounting with the director. High frequency magslip elements are used to measure the misalignment of gun and director in magnitude and direction in terms of an alternating E.M.F. The mounting is operated from the director as a normal operation.

MAGSLIPS: GENERAL

2. Two transmitter magslips are provided at the director and two coincidence transmitters at the mounting for each motion, *i.e.*, training and elevation; one coarse magslip at each position, providing the signals when the misalignment is large and the other pair of fine magslips giving greater accuracy when the misalignment is small. The misalignment signal is only taken from one pair at a time for each motion, a relay in the amplifier automatically changing from coarse to fine and vice versa at the appropriate time.

3. The magslips used for auto operation have a single phase rotor winding and a three-phase delta connected stator winding, the stator of each transmitter magslip at the director being connected by three wires to the corresponding coincidence magslip stator winding at the mounting. With the mounting and director set in the same direction each pair of magslips is lined up so that with A.C. excitation of the transmitter rotor winding no voltage is induced in the rotor winding of the coincidence transmitter. As soon as any misalignment occurs a voltage appears at the coincidence transmitter rotor terminals and this is compared in magnitude and phase with the exciting voltage of the transmitter magslip. The error measuring stage of the amplifier produces a D.C. signal which is amplified and phase-advanced, and finally applied to the variator winding of the metadyne generator.

The magslips are 3-inch type of special high frequency construction. The nominal working frequency is 1,100 cycles/sec. The transmitters are Admiralty pattern 10428 and the coincidence transmitters, Admiralty pattern 10429.

MAGSLIP VOLTAGE

4. For 20 V. A.C. rotor excitation applied to a transmitter magslip the voltage appearing at the corresponding magslip coincidence transmitter rotor terminals is given by :—

$$V1 = 35 \sin \theta_1$$

where $V1$ = coincidence transmitter rotor voltage

and θ_1 = angular misalignment of magslip in degrees.

The maximum voltage at the coincidence transmitter will occur when the misalignment between the two magslips is 90° and according to this formula the maximum voltage will be 35 V.

Note: This is only true for the case of 1 transmitter connected to 1 coincidence transmitter.

For other combinations, the maximum voltage will be less than 35 V.

For small angular misalignment of a pair of magslips, $\sin \theta_1$ can be taken approximately as proportional to θ_1. Taking into account the magslip gear ratios and also expressing the voltages in terms of misalignment between director and mounting the following relationships hold for *small misalignments* :—

(*a*) for 40° fine magslips : $V1 = 5{\cdot}5\,\theta g$

(*b*) for 360° coarse magslip : $V1 = 0{\cdot}61\,\theta g$

where $V1$ = coincidence transmitter rotor voltage for 20 V. at the transmitter and θg = angular misalignment between mounting and director in degrees.

5. This voltage is either in phase or 180° out of phase with the supply depending on the direction of misalignment. The amplifier design makes use of this fact to produce a rectified signal the polarity of which depends on the direction of misalignment. This is how the system discriminates between left and right training or elevation and depression.

MAGSLIP GEARING

6. The magslips are geared to give the following shaft values :—

TRAINING—		Angle of rotation of the director or mounting for one revolution of the magslip.
Coarse transmission	360°	
Fine transmission	40°	
ELEVATION—		
Coarse transmission	360°	
Fine transmission	40°	

With the magslips geared to give the above sector values, no loss of sector will occur in elevation as the maximum arc of movement is within one-half of the coarse sector value. But in training, reversal of direction will occur, should misalignment between director and mounting exceed 180°. The mounting always endeavours to regain alignment the shortest way round.

A training sector control switch is provided to facilitate reversal of direction of training of the mounting, so that when the director passes the mounting limit stop bearing, and continues on the target, alignment can be regained the other side of the stop by operation of the sector control switch, to drive the mounting the long way round.

RESETTER BOXES

7. The coincidence transmitters on the mounting are assembled in resetter boxes of watertight construction, one box being provided for each motion. A resetter box contains a coarse and a fine coincidence transmitter, coupled through suitable spur gearing with means for adjusting and clamping the stators. The drive to the coincidence transmitters from the outside of the box runs at fine magslip speed, and is geared to the power drive of the mounting.

RESETTER BACKLASH

8. Backlash in the gearing between the motor and the fine coincidence transmitter magslip must be kept small to prevent hunting of the system. For this reason the resetter gears have been accurately cut and assembled. Whilst it is difficult to fix a permissible value of backlash, and backlash should always be kept as small as possible, it can be said that if the total backlash at the fine coincidence transmitter with the motor locked exceeds about 1 minute when referred to the mounting, *i.e.*, about 9 minutes at the magslip, hunting is liable to occur.

SECTION 2. AMPLIFIER MARK 15M TYPE MD. 31 (*Photographs 3, 4, Plate 15*)

9. This amplifier is of the single tray type now almost universally used in the Service. Two separate amplifier circuits referred to as Motions " A " and " B ", together with a common power supply pack, are built on the one chassis. Motion " A " is used to operate the elevation metadyne, while Motion " B " operates the training metadyne.

CONSTRUCTION OF AMPLIFIER

10. The amplifier unit consists of a chassis and a steel case. This case houses a cradle carrying a plug-board and two sets of rollers. The chassis is fitted with a socket-board and runners that rest on the rollers in the case. The socket-board and plug-board are accurately aligned so that when the chassis is pushed into the case the two sets of contacts engage smoothly. " Hair pin " type spring contacts are used on the plugs and the movement in the spring is sufficient to allow for slight inaccuracies in the alignment (*see* Photograph 4 for view of plugs).

11. The chassis is made up of a front panel welded to two side members forming the runners. A sheet steel plate is carried on top of the runners and accommodates the transformers, valves, condensers, resistances, etc. On the front panel are mounted the instruments and most of the control potentiometers and switches, the functions of which are described in Section 3.

Locking clips are provided at the front for clamping the chassis when it is firmly pushed home and safety catches are provided to prevent accident when the chassis is being removed. The catches check the chassis when sufficiently withdrawn to enable a firm grip to be taken inside the chassis. The catches must be released by hand before the chassis can be fully withdrawn.

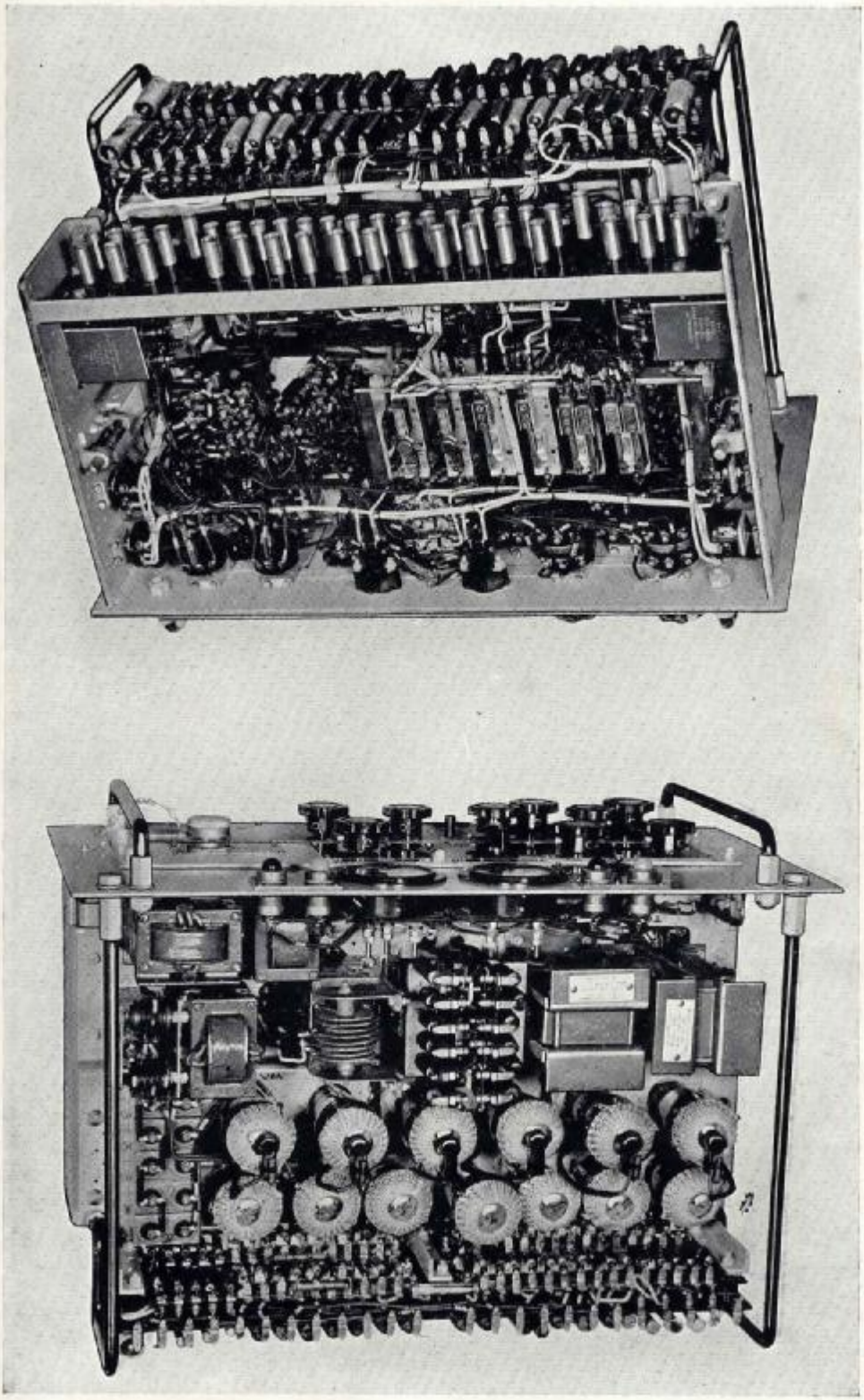
FUNCTION OF AMPLIFIER

12. The main functions of the thermionic amplifier are :—

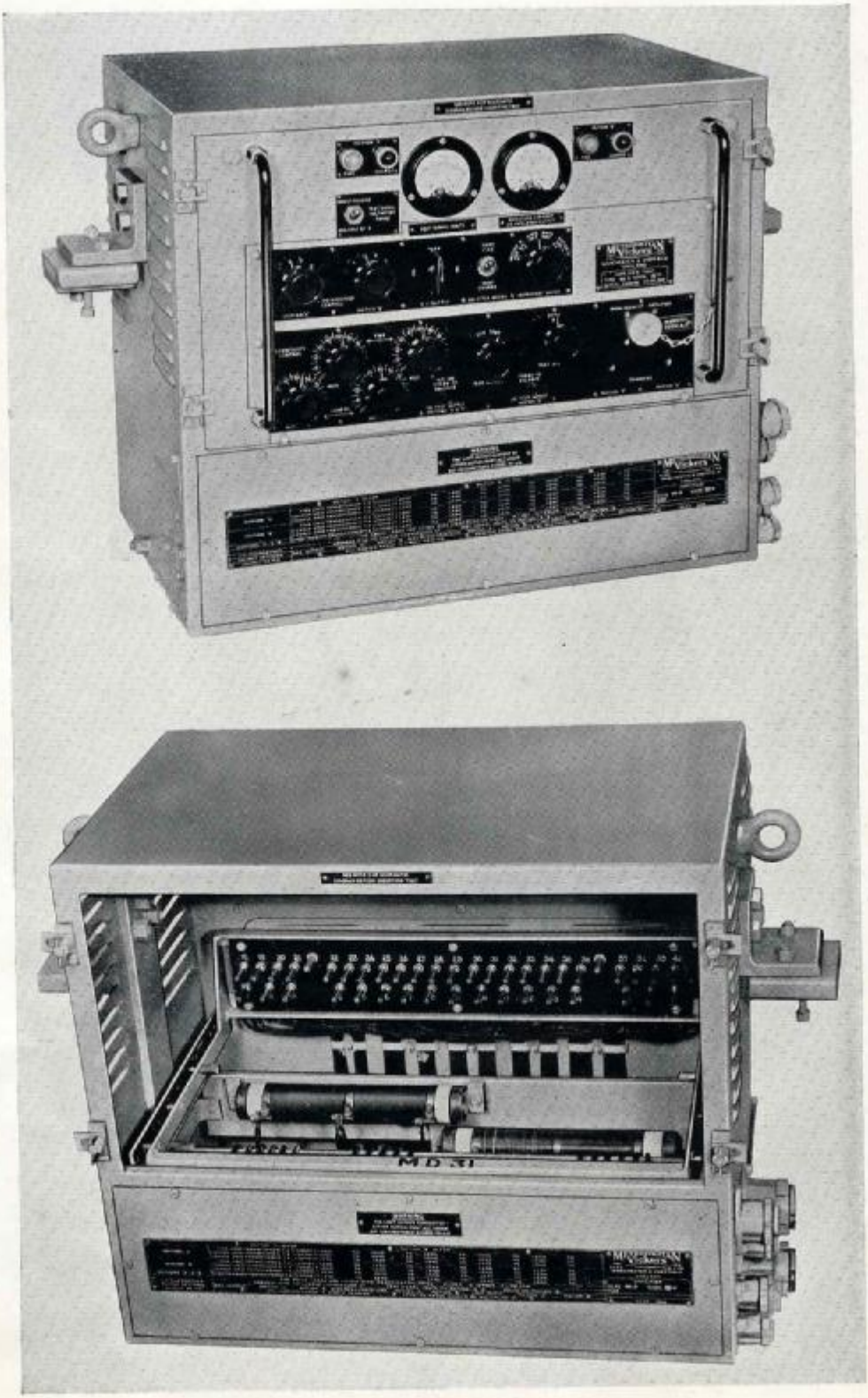
(*a*) to convert the A.C. signal voltage from the magslip coincidence transmitters into a D.C output current depending upon misalignment in magnitude and direction ;

(*b*) to amplify the A.C. signal so that the D.C. output current is sufficient to control the metadyne ;

(*c*) to provide pre-retardation of the mounting which will operate ;
to oppose overshoot when running into alignment, and
to prevent hunting or oscillation about the alignment position ;



Photograph 3. Amplifier Type M.D.31



Photograph 4. Amplifier Type M.D.31

(*d*) to provide automatic limitation of the maximum value of D.C. output current so that excessive metadyne output current, and thus motor torque, is not obtained;

(*e*) to provide coarse/fine change-over.

WORKING OF AMPLIFIER

13. The amplifier has four stages. The first stage rectifies the A.C. magslip signal to a D.C. voltage proportional to the signal and adds to this D.C. voltage a pre-retardation component, *i.e.*, a component depending upon the rate at which the misalignment is changing. The second stage amplifies the first stage output voltage and adds a further rate of change component. The third stage is a further stage of amplification. The output stage converts the voltage signal received from the previous stage into an output current depending upon misalignment in magnitude and direction and depending also upon the rate at which misalignment is changing.

In the description only one motion is given as the second motion is identical apart from the lead numbers.

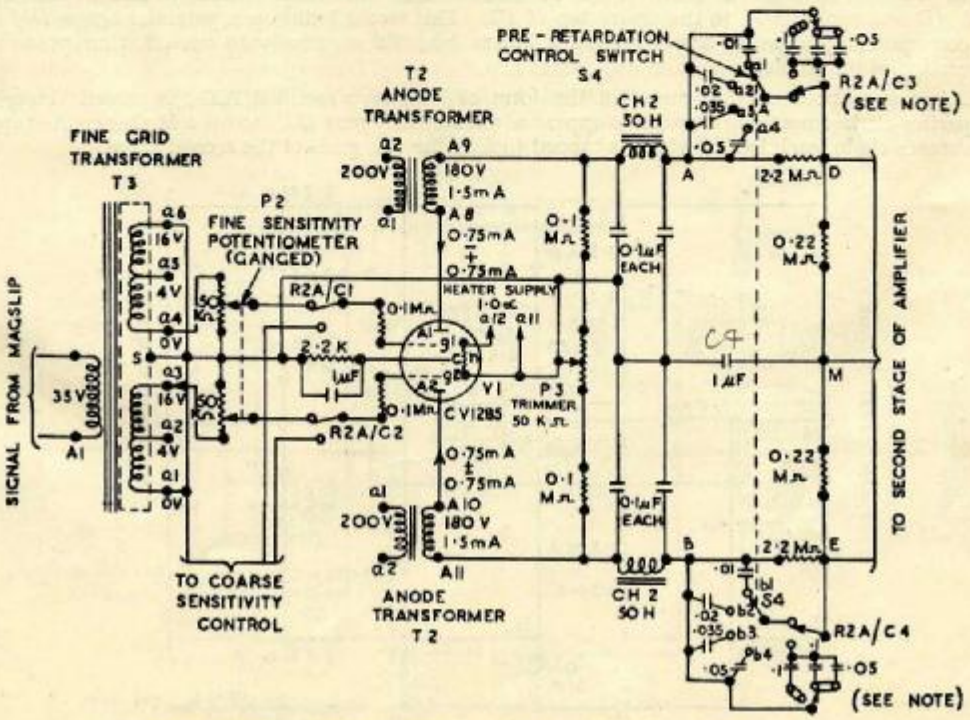
PRE-RETARDATION

14. Fundamentally the torque of the motor driving the mounting must operate to reduce misalignment but if there is to be no overshoot or undue oscillation around the point of alignment the torque must in addition be reduced and reversed when alignment is being approached.

15. Consider the mounting approaching alignment at maximum speed. The misalignment will be decreasing, but, without pre-retardation, a driving torque will be applied by the motor until misalignment is zero. As the equipment must be very sensitive to give accurate following a very small misalignment will give full motor torque, the amplifier then saturating to prevent excessive torque. Without pre-retardation the mounting would therefore run right through alignment with considerable overshoot. The reversed misalignment would then drive the unit back towards alignment with further overshoot in the other direction and the mounting would continue to oscillate about the alignment position until brought to rest by friction.

16. Now if a signal is obtained due to the decreasing misalignment and arranged to oppose the misalignment signal and reverse the torque before alignment is reached, the overshoot will be reduced. If too much pre-retardation is applied the unit will be checked before lining up so that it crawls into line. It will also be seen that if decreasing misalignment is arranged to oppose the misalignment signal, increasing misalignment will assist the signal. Thus, if the mounting moves right through alignment, *i.e.*, overshoots, the torque to re-align it will be quickly built up.

17. Pre-retardation is derived in this amplifier by means of a resistance-capacitor network. If the misalignment is steady, the capacitor passes no current, but whenever the misalignment is changing (providing the amplifier stage is not saturated and the rectified D.C. current is changing) the capacitor will absorb or give out current to provide the pre-retardation component.



Note.—Earlier amplifiers fitted with only two 0.1 m.f. condensers for coarse circuit.

Diagram 10. First Stage Circuit

Approaching alignment at maximum speed is not the only condition which has to be taken into account in determining the condenser value. Lining up from low speeds and intermediate speeds must be considered. Also, the capacitor value must be chosen to give sufficient phase advance to damp oscillations at the frequency at which the whole system would tend to hunt. Too small a value results in low frequency hunting and too high a value in high frequency dither.

18. The coarse pre-retardation capacitor provides separate adjustment of the amount of pre-retardation applied when coming in from large misalignments.

AMPLIFIER CIRCUITS

FIRST STAGE: *Phase Conscious Rectifier, and Partial Phase-Advance*

19. This stage contains a double triode CV. 1285 valve, the anodes of which are supplied with 180 V. 1,100 cycles/second A.C. from the same source as the magslips transmission system. In the absence of any misalignment signal the grids simply receive a steady negative bias sufficient to cause each valve half to conduct half its maximum output. This bias is derived from the voltage drop across the bias resistor in the valve cathode circuit which receives half-wave rectified A.C. from the valve anode supplies. This is smoothed by the capacitor in parallel to give a reasonably steady D.C. bias.

20. An incoming A.C. misalignment signal from the magslip coincidence transmitter is split by the push-pull centre-tapped grid transformer into two antiphase components which are supplied to the two grids of the valve. The conductance of that anode circuit receiving grid signal in phase with anode voltage will increase while that of the other anode circuit receiving the anti-phase grid signal will diminish. If the misalignment is reversed the polarity of the magslip signal will be reversed and the effect upon the conductances of the two valve circuits will be reversed also. This provides discriminate rectification. The D.C. bias will remain constant since the combined conductance of the complete valve, and thus the cathode current, remains sensibly constant under all signal conditions.

21. The current in each of the two anode circuits consists of half-wave rectified A.C. and the magnitude in either circuit depends upon the conductance of that valve half. The transformer secondary windings in the anode leads provide the alternating H.T. supplies and both anodes are supplied in phase so that they rectify the same half wave. The anode circuits are completed through a centre-tapped loading resistance to the cathode. Current, therefore, flows from the centre tap to each anode, and in the absence of magslip signal, will produce the same voltage drop in each half so that no potential difference normally appears across the complete loading resistance. A magslip signal will produce a net potential difference and the polarity will be according to the direction of misalignment.

The purpose of the capacitor *C4* is to insulate point *M* from the centre top of the potentiometer *P3* to D.C. voltages whilst providing a return path to earth for alternating potentials for the negative return circuits of *V1*. If this capacitor were not fitted and *M* was connected directly to *P3*, the D.C. potential between the centre top of *P3* and say *B1* would cause current to flow in the circuit *B1 AD* returning via *M* to the centre top of *P3*. This would build up a potential across *DM* and a corresponding potential across *EM* sufficient to bias *V2* negatively to cut off, thus preventing operation of the amplifier.

22. Any such potential difference, in the form of half-wave rectified A.C., is passed through a capacitor-choke smoothing network to appear as a reasonably pure D.C. across a further centre-tapped resistance chain, each half of which is tapped to feed the two grids of the second stage.

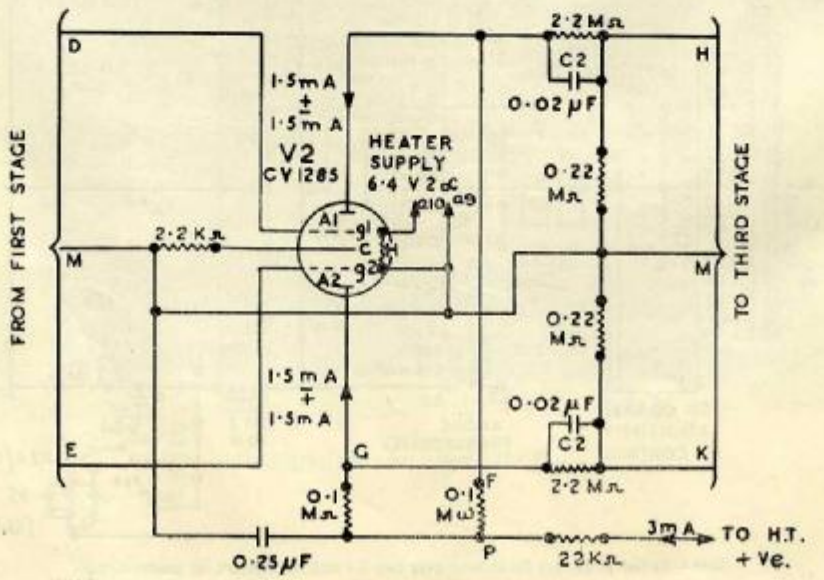


Diagram 11. Second Stage Circuit

Phase advance is obtained by coupling the first stage smoothed output to the second stage grids through selected capacitors in addition to the resistance network.

SECOND STAGE : *D.C. Amplifier and further Phase-Advance*

23. This stage contains a double triode CV. 1285 valve, similar to that in the first stage. Its high tension supply, however, is derived from the main D.C. H.T. supply.

The grids, as in the first stage, are normally biased so that each anode conducts half its maximum output. This bias, negative relative to the cathode, is derived as in the first stage from the voltage drop across the cathode bias resistor which, since the valve receives D.C. H.T. needs no smoothing capacitor. The cathode bias resistor is connected to the previous stage output network at the mid-point *M*. A signal from the previous stage, causing a voltage drop across *DE*, unbalances the grid potentials and, as in the first stage, increases the conductance of one anode circuit and reduces that of the other, the direction of the unbalance depending upon the signal polarity.

24. The anodes derive their H.T. from corresponding tapping points *F* and *G* on two similar resistance chains *PF HM* and *PG KM* across the H.T. supply. The conductances of the two anode circuits are connected respectively in parallel with the portions *FM* and *GM* of the chains, so that the potential drops across these are varied from initial equality by a magslip signal. The H.T. line resistance *R* serves to drop the H.T. potential of the valve to a suitable value which, since the total cathode current remains sensibly constant, will be unaffected by signal. The intermediate tapping points *H* and *K* will experience the same relative potential change as *F* and *G*, but reduced in magnitude and will have, in addition, a further phase advance component due to the capacitors. The points *H* and *K* feed the next stage.

THIRD STAGE

25. The maximum phase-advance provided by a resistance-capacity network is dependent upon the ratio of the potential divider circuit. The greater this ratio the greater the maximum phase advance of the network, but smaller is the proportion of the steady signal passed on to the succeeding stage. It is necessary to provide a large phase-advance, together with high sensitivity. To achieve this a high ratio is used in the two phase-advance circuits, and an extra stage of amplification is provided to compensate for the sacrifice in sensitivity.

The third stage functions in a similar manner to the second stage already described, the only difference being that the output of the third stage is not phase-advanced. A simplified diagram of the third stage is not included as it is similar to that for the second stage, with the exception that the capacitors are omitted.

OUTPUT STAGE

26. This stage includes a pair of CV 1189 pentode valves operating in push-pull to amplify the signals received from the previous stage. The magslip signal in this way causes a difference in the current in the output stage anode load circuits.

As the grid tapping points are on resistance chains across the H.T. supply the grids are at fairly high potentials. This is counteracted by providing a higher potential drop than is normal along the cathode resistor carrying the joint cathode currents of the two valves.

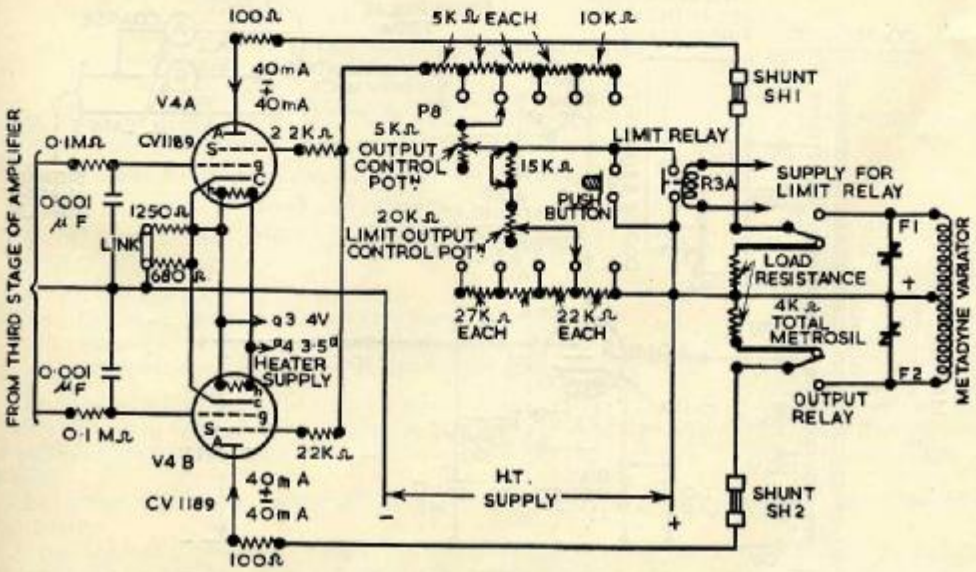


Diagram 12. Output Stage Circuit

27. The H.T. supply reaches the valve anodes through the external load circuits which consist of the two opposed halves of the metadyne variator winding, so that provided the standing anode currents are equal no effective ampere-turns can be produced on the metadyne. Incoming magslip signals will result in ampere-turns corresponding in direction and magnitude to misalignment.

28. Metrosil discharge resistors are fitted to prevent the valve and highly inductive load circuits being subjected to excessive voltages. The discharge resistors may be mounted in the amplifier or on the control panel.

Operation from Large Misalignments

29. During normal operation the mounting follows the director very closely, the misalignment being of the order of a few minutes of arc. To achieve this accuracy it is necessary for the controlling magslips to amplify the misalignment by making several revolutions for one revolution of the mounting. In these circumstances there will be occasions when the misalignment between the director and the mounting is very large, *e.g.*, when first commencing operation. It is then necessary to override the fine control to obtain approximate alignment with the director, otherwise the mounting would follow the director with a constant misalignment equal to a multiple of the fine sector value. Two possible methods of bringing the equipment into correct sector are "Sector Control" and "Coarse/Fine Control."

"Sector Control"

30. Approximate alignment can be achieved manually by applying a fixed signal to the amplifier by operation of a sector control switch, thus moving the controlled unit until it is brought within the correct sector.

"Coarse/Fine Control"

31. Alternatively, approximate alignment can be obtained automatically by fitting a "coarse" magslip with a large sector value so that the coarse transmitter and coincidence magslips cannot get out of sector; and arranging a relay to change over the amplifier connections from the "fine" to the "coarse" magslip at a pre-determined misalignment.

Coarse/Fine Amplifier Features (*Diagram* 13)

32. With either method of control, the mounting, in lining up, will reach its maximum speed, and, unless effective pre-retardation is provided, will overshoot the point of coincidence and oscillate about this point before lining up. The phase advance network will provide the necessary pre-retardation if the value of the capacitor is increased considerably, compared with that required to give stable following under conditions of small misalignment.

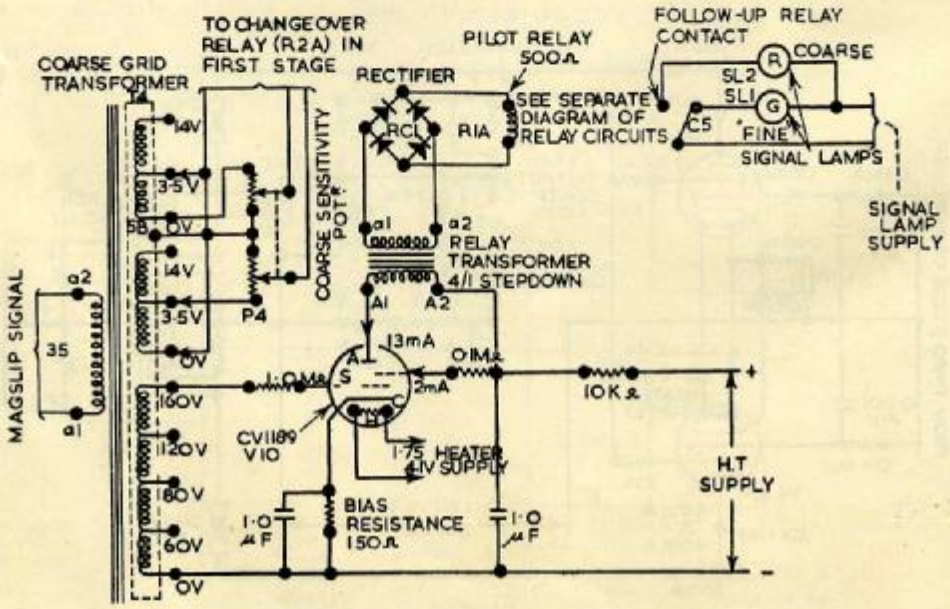


Diagram 13. Coarse/Fine Change Over Circuits

33. For pre-retardation to be effective from maximum speed it must commence several degrees before alignment is reached. The amplifier is normally saturated before the misalignment approaches one degree (refer to the curve "Test Signal volts/anode current" for the output stage circuit in the section "Amplifier Test Data, etc.") and the pre-retardation condenser cannot be effective unless the amplifier current, in the stage concerned, changes as the misalignment changes. To obtain pre-retardation from maximum speed it is therefore necessary, as well as changing the capacitor value, to change the input grid transformer ratio so that relatively large misalignment signals do not saturate the amplifier. These are termed coarse capacitors and grid transformer values. The capacitor value and grid transformer ratio must also be changed back to the correct value for normal following, *i.e.*, the "fine" settings, as soon as the misalignment falls to a small value. These changes are carried out automatically by a valve operated relay in the following manner.

34. The misalignment signal from the coarse coincidence transmitter magslip is applied to the grid of a pentode valve type CV 1189, through a transformer. This A.C. signal is amplified by the valve and fed into the primary of a transformer. The output from the secondary winding is rectified by a bridge-connected metal rectifier and the rectified current, proportional to the signal up to the point of saturation of the valve, circulates through the coil of a pilot relay. This pilot relay is arranged to pick up when the misalignment exceeds a predetermined value. The pilot relay, when operated, energises a multi-contact change-over relay which changes the amplifier sensitivity and pre-retardation settings from fine to coarse. When the misalignment falls slightly below pick-up value the pilot relay drops out and de-energises the change-over relay thus restoring the fine settings.

Power Supply to the Amplifier

35. The amplifier is supplied with single phase 200 V. A.C. at a frequency of 1,100 cycles/second. This supply is taken to the L.T. and H.T. transformers in the amplifier through a double pole supply switch. The valves take approximately twenty seconds to warm up and the amplifier is ready for use in about thirty seconds, although a slight drift in the amplifier balance may occur up to 15 minutes after switching on.

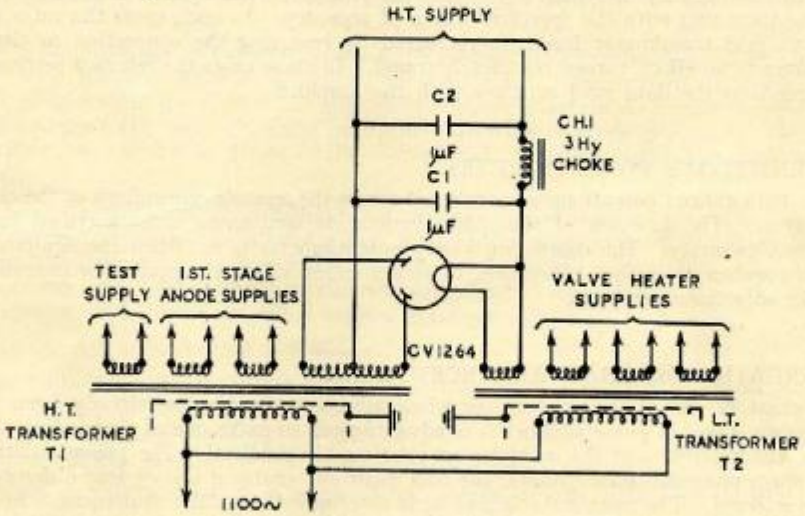


Diagram 14. Power Supply Circuit

36. The amplifier power supply unit feeds two amplifier motions incorporating the circuits already described. These are known as Motion "A" and Motion "B".

The secondary windings on the H.T. transformer provide :—

(*a*) A.C. voltage for the anode circuits of the first stage valves ;

(*b*) A.C. input to the rectifier which provides the D.C. H.T. supply ;

(*c*) 20 V. A.C. to provide :—
a signal for testing the amplifier,
the sector signal for the sector control,
excitation of the transmitter magslips,
supply to the "follow-up" relays for the coarse/fine circuits.

37. The winding which feeds the rectifier circuit is centre-tapped and feeds the anodes of the type CV 1264 full wave rectifier valve in antiphase. The cathode current, which is thus unidirectional and pulsating, is smoothed by the capacitor-choke filter and supplied as D.C. to the amplifiers at 400 volts.

The secondary windings on the L.T. transformer feed the valve heaters and the coarse-fine signal lamp circuits.

A test cable is provided to enable the chassis to be operated when withdrawn from the case. This facilitates the location of faults, because the various voltages which should exist between different points of the circuit may be checked immediately with a voltmeter.

SECTION 3. ADJUSTMENTS PROVIDED ON AMPLIFIER MK. 15M, TYPE MD 31.

Photograph 4

BALANCING POTENTIOMETER—MOTIONS "A" AND "B"

38. If the amplifier is to satisfy the condition that zero misalignment signal shall produce zero output current from the metadyne that it controls, it is clear that provision must be made to compensate for inequalities of the pairs of components of the push-pull amplifier and also the two halves of the main variator winding of the metadyne generator push-pull control winding. This is achieved by including a balancing potentiometer in the anode resistance circuit of the first stage valve. The ratio of the resistance in the two anode circuits is adjusted by varying the position of the slider as much as required to give zero metadyne output current for zero amplifier input signal.

The procedure to be adopted when balancing the amplifier is described in the section "Testing the Amplifier."

FINE SENSITIVITY POTENTIOMETER

39. This is a twin ganged potentiometer connected across the secondary windings of the fine input grid transformer. The function of this potentiometer is to give smooth adjustment of the effective transformer ratio. Rough adjustment is provided by tappings on the transformer windings. With these adjustments the sensitivity of the amplifier may be varied smoothly over a wide range. This potentiometer is set when the equipment is first installed and should normally remain at this setting in service, unless changed amplifier or mounting (friction or backlash) characteristics make re-adjustment necessary.

Note: In some cases it has been found that the stiffness of the system is not sufficient to drive the mounting with the specified degree of accuracy. In such cases the ratio of the fine input grid transformer has been increased by reversing the connection so that the transformer is, in effect, turned completely round. In these cases the relevant settings will be recorded on the data card supplied with the amplifier.

COARSE SENSITIVITY POTENTIOMETER

40. This is a twin ganged potentiometer connected across the secondary windings of the coarse input grid transformer. The function of this potentiometer is similar to that described for the fine sensitivity potentiometer. The coarse sensitivity potentiometer is set when the equipment is first installed and requires no further adjustment in service unless changed amplifier or mounting characteristics make adjustment essential.

PRE-RETARDATION (OR PHASE-ADVANCE) SWITCH

41. The function of the pre-retardation (or phase-advance) circuits has already been explained. As there are two stages of phase advance it is advantageous to make one of them adjustable so that the dynamic characteristics of the amplifier may be readily modified. The pre-retardation switch, in the first stage phase-advance circuits, has four positions enabling one of four different capacitor values to be selected. The most suitable setting is determined when the equipment is first installed and no further adjustment should normally be required in service unless changed amplifier or mounting (friction or backlash) characteristics make a re-adjustment necessary.

COARSE PRE-RETARDATION ADJUSTMENT

42. In order that one type of amplifier should be standard for several applications where the maximum speed and inertia of the controlled units differ greatly, it is necessary to provide adjustment of the coarse phase-advance capacitor. This is done by providing three capacitors and arranging the connecting links between them so that the value in circuit can be adjusted. The capacitors are mounted on top of a choke immediately behind the instruments. They are easily accessible with the amplifier chassis removed from the case. The capacitor value will be set when the equipment is installed and no re-adjustment will be required in service unless changed amplifier or mounting characteristics make re-adjustment necessary.

OUTPUT STAGE BIAS RESISTANCE LINK

43. In the output stage the bias resistors are arranged so that one, or two in parallel, may be selected by a link. For the correct positioning of this link *see* B.R. 1530, Chapter 1, paras. 49 and 50.

(G. 181/57.—Amendment No. 9.)

~~curve. The position of the link (i.e., either in or out) that gives the sharpest saturation, with the push-button pressed, will be used.~~

OUTPUT CONTROL POTENTIOMETER

44. This is a potentiometer in the output stage screen grid circuit to give fine adjustment of the maximum output of the amplifier with the limit relay energised or the push button pressed. A coarse adjustment is provided on the resistance board in the form of a floating lead which can be connected to several alternative tappings. The potentiometer spindle is provided with a locking clamp which should be loosened before adjustment and retightened afterwards.

REDUCED OUTPUT POTENTIOMETER

45. This is also a potentiometer in the output stage screen circuit. It provides a fine control of the amount of resistance that is switched into the screen circuit when the limit relay is de-energised and therefore controls the reduced output from the amplifier. Coarse adjustment is provided on the resistance board in the form of a floating lead which may be connected to several alternative tappings.

46. In some applications it is not necessary to reduce the amplifier output as much as usual, and another lead is therefore provided so that the fixed resistance in series with the limit output control potentiometer may be short-circuited. In such cases great care should be taken to see that the amplifier output current under limit conditions does not exceed 70 milliamperes. A greater value may burn out the potentiometer.

LIMIT OUTPUT RELAY

47. A limit relay is fitted in each motion to reduce the amplifier output when the limit switch operates. With the mounting against the stop, *i.e.*, the gun driving motor stalled, the armature current must be limited or the armature will overheat. Sufficient current, however, must flow to provide the necessary torque to hold the mounting against the stop or to move the mounting away from the stop when the transmission signal is reversed. To achieve this the amplifier output is reduced.

48. To reduce the main variator excitation when the limit switch operates, a normally closed contact in the limit switch is connected in series with the limit relay coil. During normal operation, therefore, the relay is energised and the amplifier is adjusted to deliver a certain maximum output. When the limit switch operates, the relay circuit is interrupted and the relay de-energised. This introduces extra resistance into the screen circuit of the output stage and reduces the maximum output from the amplifier.

49. When the test switch is to TEST the limit relay is de-energised and the reduced output is obtained from the amplifier. A push button is provided on the front panel marked PRESS TO TEST OUTPUT which enables the limit relay contacts to be short-circuited and full output obtained.

The maximum and limited armature currents are adjusted with the amplifier connected to the metadyne windings and a large test signal applied to the amplifier.

50. The adjustments are carried out as follows :—

(*a*) Maximum armature current is adjusted by means of the output control potentiometer with :—

the limit switch not operated ;
the push button pressed.

(*b*) Limited armature current is adjusted by means of the reduced output potentiometer with :—

the limit switch operated ;
the push button not pressed.

51. It is necessary to operate the limit switch as called for when making the adjustments referred to, so as to connect the auxiliary variator winding in circuit. Although the motor is stalled when the equipment is against a stop, sufficient voltage drop is present in the motor armature, motor brushes and cables, to send a definite current through the auxiliary variator winding with consequent reduction in current.

TEST SWITCH

52. This is an 18-pole switch with two positions referred to as RUN and TEST.

Run position. In this position the input of each motion of the amplifier is connected to the rotor of the corresponding magslip coincidence transmitter and the test switch contacts in the control contactor circuit are closed.

Test position. With the switch in the TEST position, the input grid transformers of both motions are disconnected from the coincidence magslips and reconnected to the 20 volts test circuit through the coarse/fine selector switch. Also, when in auto, the control contactor circuit is interrupted in order to ensure that the motor fields are de-energised and brakes applied. This is necessary as during the testing of the amplifier, with output stage connected to the metadyne control windings, metadyne output current flows, and if the motor fields were not de-energised the mounting would move.

53. In joystick operation, the amplifier can be balanced against the dummy load resistance (in the amplifier) without using the metadyne windings. Whenever possible, testing should be carried out using the metadyne main variator windings.

Warning

When applying a test signal it should be borne in mind that the armature current produced is passing through a stalled driving motor armature, and high output currents from the metadyne, if maintained for any length of time, will cause damage.

TEST VOLTMETER SWITCH

54. The voltmeter has two effective ranges :—

(*a*) 0—1 volt ;

(*b*) 0—5 volts.

These are obtained by connecting a potentiometer across the voltmeter and arranging, by means of a two position switch, to pass on to the input grid transformers either :—

a predetermined portion of the test signal measured, or

the full test signal.

In (*a*) one-fifth of the voltage measured is passed on to the input grid transformers, so that it is necessary to divide the voltmeter reading by five (or multiply by 0·2). In (*b*) the voltmeter readings give the test signal voltage direct.

55. The potentiometer is pre-set and requires no adjustment in service. If it should be necessary to replace the potentiometer for any reason the following procedure should be adopted in setting it.

Remove the tally plate covering the potentiometer spindle after noting the DIRECT READING and MULTIPLY BY O.2 positions of the switch. Put the test voltmeter switch to the DIRECT READING position and apply a 1 volt test signal. Observe the currents in *F1* and *F2* output stage circuit, then put the voltmeter switch to the MULTIPLY BY O.2 position and apply 5 volts test signal. Adjust the potentiometer to obtain the same currents in the output stage as before. Clamp the potentiometer spindle and replace the tally plate.

INSTRUMENT SWITCH

56. This is a 2-pole, 6-way switch by means of which it is possible to measure the current in any one of six circuits. These currents are as follows :—

Amplifier output current in *F1* circuit,

Amplifier output current in *F2* circuit,

Metadyne output current,

for both motions, *A* and *B*.

The variator current is measured in milliamperes and the instrument gives direct reading. The motor armature current is measured in amperes and the multiplying factor to give true values is given on the amplifier case. Milliameter shunts are located in the amplifier while the ammeter shunts are in the metadyne terminal box.

The instrument switch can be used with the test switch to RUN or TEST.

TEST COARSE/TEST FINE SELECTOR SWITCH

57. With the test switch to TEST the test signal is applied to the input grid transformers of both motions via a double-pole selector switch. With this switch to TEST FINE the signal is applied to the fine grid transformers, and with the switch to TEST COARSE to the coarse grid transformers.

TESTING THE AMPLIFIER

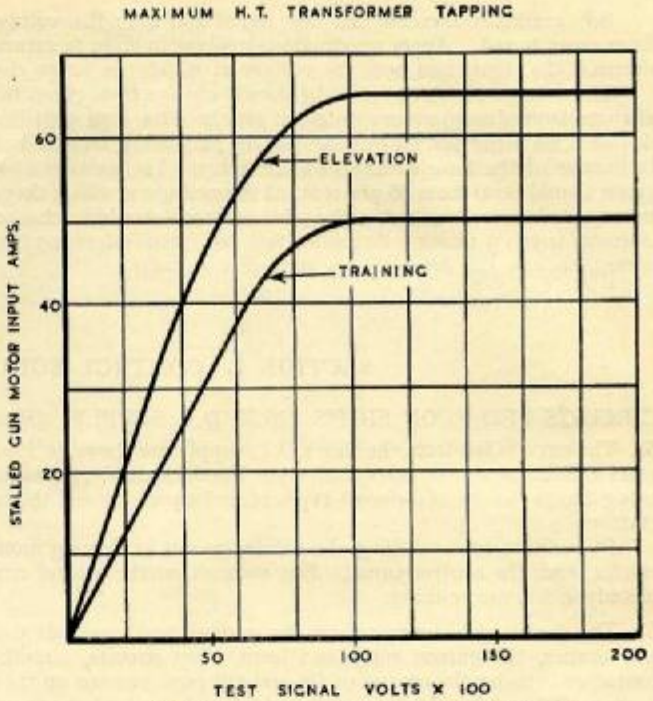
58. The test signal is provided by means of a centre tapped potentiometer supplied from the 20 volts winding on the H.T. transformer. Clockwise rotation of the potentiometer from the centre position provides a voltage of the same phase as that obtained from the magslip coincidence transmitter when the mounting rotates clockwise or elevates. The test signal is applied to the primary windings of the input grid transformers (coarse or fine depending upon the selector switch position) of both motions and currents are set up in the various stages of the amplifier in exactly the same way as by a misalignment of the same magnitude and phase from the resetter. The unequal anode currents thus set up in the output stage circulate in each half of the main variator winding and cause a metadyne output current to flow. The magnitude of the current is measured on the ammeter while that of the test signal is measured on the test voltmeter. This voltmeter has a dual range scale as described under " Test voltmeter switch."

59. By observing the metadyne current for a number of test signal voltages, it is possible to check the performance of the equipment. An overall sensitivity curve of the "armature current-test signal volts" (Diagram 15) is given showing the approximate performance to be expected. Also, by measuring the current in each half of the metadyne main variator winding and comparing the results obtained with the output stage "anode current—test signal volts" curve, given in the section "Amplifier test data, etc." it is possible to check the amplifier performance.

Warning

Where a test signal is later called for it must be borne in mind that this will result in a current through the stalled armature of the gun driving motor (except when testing on dummy load) and the higher currents must not be maintained for any length of time or the motor will be overheated.

Note also that the application of a test signal results in an output current for both motions.



Divide by actual sensitivity setting used for true volts.

Note.—These curves apply to both British and Canadian mountings. The test signal volts scale is calculated for an amplifier grid transformer ratio of 35/16 — 2.19. If another ratio is used the new scale may be obtained by multiplying the existing test signal volts × 100 scale by $\frac{\text{new G.T. ratio}}{2.19}$ and substituting this scale in space provided.

Diagram 15. Armature Current—Test Signal Curve

60. To test either motions of the amplifier proceed as follows :—

(i) switch off the H.F. supply switch and adjust the zeros of the meters mounted on the front panel ;

(ii) turn the H.F. supply switch to the ON position and allow at least 15 minutes for the valves to warm up ;

(iii) make sure that the limit switch on the equipment is not operated, *i.e.*, that the equipment is not near a stop ;

(iv) turn the instrument switch to the ARMATURE CURRENT position for the motion to be tested ;

(v) put the test voltmeter switch to the DIRECT READING position ;

(vi) turn selector switch to TEST FINE and test switch to TEST ;

(vii) see that the test signal potentiometer is set to zero. This potentiometer has a small dead zone at its zero setting which can be found by observing where the test signal voltmeter needle is stationary as the potentiometer is moved through the centre position ;

(viii) turn the test voltmeter switch to the MULTIPLY BY 0·2 position and check ;

(ix) using the trimmer for the motion under test, adjust to obtain zero metadyne output current ;

(x) apply clockwise and then anti-clockwise test signals, changing over to DIRECT READING on the test signal voltmeter at the appropriate voltage (*i.e.*, 1·0) and measure the metadyne output current. If the amplifier performance is suspected also measure the amplifier output current by turning the instrument switch to the required position. The figures obtained should be fairly close to those given on the output stage "anode current—test signal volts" curve in the section "Amplifier test data, etc."

Note : The *Push Button must be pressed* during tests (*i*) and (*j*) ;

(xi) at the end of the test check the balance of the amplifier. This should still be correct ;

(xii) turn test switch to RUN.

The amplifier is now ready for use.

TEST OF COARSE/FINE CHANGE-OVER

61. The coarse/fine features of the amplifier should be tested as follows :—

(i) balance the amplifier as already described with the selector switch to FINE ;

(ii) put the selector switch to COARSE ;

(iii) gradually increase the test signal and note the voltage at which the signal lamps change from green to red. Apply maximum test signal in order to saturate the relay valve and then gradually decrease the signal and note the voltage at which the lamps change from red to green.

The voltage at which the light should change from green to red, an indication that the amplifier changes from fine to coarse, is given on the data card provided with the amplifier. If test results do not agree with the data card figures, the pilot relay, mounted underneath the chassis, can be adjusted by means of the knurled knob on the relay. The voltage at which the lamps change from red to green should be at least 50 per cent. of the voltage at which they change from green to red. If a fault is suspected the voltage across the pilot relay coil should be checked for a number of test signal voltages. A curve is given under "Amplifier test data, etc." showing the characteristics to be expected;

(iv) repeat test (iii) but with reverse test signal.

SECTION 3A. STANDARD AMPLIFIER ASSEMBLY E.C. 178 (MARK 29AA)

Later 40-mm., Mark 5 and Mark 5* mountings will use the Standard Amplifier Assembly E.C.178 (Mark 29AA) consisting of the following cubicle layout :—

27M	8D TRG	17TU	8D ELEV	27M
BLANK	5MA	22P	5MA	BLANK
SPARE 27M	BLANK	SPARE 22P	BLANK	SPARE 8D
RELAY PANEL MARK 38CP (MET. VICK. No. C.P.38)				

27M—Amplifier	D.P.6208
8D—Coarse/Fine Change-over Unit	D.P.6858
5MA—Misalignment Amplifier	In course of publication
22P—Power Unit	D.P.6275
38CP—Control Panel	—
17 T.U.—Test Unit	D.P.6793

Details of the above Units will be found in the relevant B.R's. which are now in course of publication. In the meantime, ships fitted with standard amplifier assemblies are issued with the maker's handbook or COLLINGWOOD publications together with test instructions. The COLLINGWOOD Publication numbers are shown above in the right hand column.

Mountings fitted with the standard amplifier assembly have an additional lamp indication which will burn if the amplifier cubicle fan fails, being controlled by an air pressure switch.

(G. 4041/55.—Amendment No. 8.)

mounting. Arrangements are also made to reduce the current through the gun motor armature when

"66A. In the Mark 5* mounting the 220 volt D.C. supplies are normally taken from a transformer/rectifier, situated locally at each mounting.

The control circuits are fundamentally the same as those for the D.C. mounting and are shown on Plate 17A. A metrosil is fitted across the training limit switch to limit the maximum training speed to 35°/Sec.

In addition to starting the driving motor of the metadyne set, the starter has a contactor which energises relay I.R.1 (*see* Plate 17A), which connects the 220 volt D.C. supply to the control panel. The control circuits are thus only energised when the metadyne set is running.

The D.P. contactor quoted in paragraph 63 is contactor C.C.1 (Plate 17A) for the Mark 5* mounting."

(G. 4041/55.—Amendment No. 8.)

A lamp on the mounting labelled A.C. ON indicates whether the amplifier is ready for use. It burns only when the following three conditions are fulfilled :—

(*a*) central H.F. supply is available ;

(*b*) main switch on the amplifier is closed ;

(*c*) test switch on the amplifier is to RUN.

Under these conditions the L.T. transformer in the amplifier is energised and thus the valve filaments are heated so that when the On push button is pressed the amplifier will be operative immediately.

"67A. The H.F. power supply for the amplifier in the Mark 5* mounting is taken from a motor alternator fed from the ship's main supply system."

(G. 4041/55.—Amendment No. 8.)

SECTION 5. THE METADYNE SET

GENERAL PHYSICAL ARRANGEMENT FOR BRITISH EQUIPMENT (MD 75/74A)

68. The metadyne set driving motor and the training and elevation metadyne generators are constructed as one unit with spigot location between machines. The two metadynes are built as a twin machine having a common yoke barrel and two armatures mounted on a common shaft. The metadynes are driven from the motor shaft through a Renold cruciform rubber insert type coupling.

On the top of the set are two terminal boxes. The smaller of these houses the terminal for the driving motor whilst the larger carries the terminals for the elevation and training (driving end and non-driving end) metadyne generators. The latter box also contains the auxiliary control resistance units, the two shunts for the metadyne output current ammeter and the compensator diverter resistor for the training metadyne.

Note: Diagrams 16 and 17 show the internal windings of the metadyne set, together with the connections in the terminal box.

VENTILATION

69. The set is self-ventilated by means of a double bladed fan mounted on the metadyne shaft. This fan draws air through two paths, one through the metadyne and one through the motor exhausting at the centre of the machine set. Temperature rises above Class 2 will be obtained if the set is run with either the removable coupling inspection cover or driving and metadyne commutator inspection cover out of position, as this will result in air being drawn in by the fan without passing through the whole of the ventilating circuit. Warning notices are affixed to the covers in question.

Note: Class 2 temperature rises are as follows :—

Insulated windings	40° C.	Permissible temperature rise over the temperature of cooling air or environment. Temperature measured by thermometer.
Commutators	45° C.	
Bare windings such as commutating poles wound strip on edge	50° C.	

POWER RATINGS

70. The power required to operate this set is taken from the ship's 220 V. D.C. supply and the normal running speed is 2,800 r.p.m. on no load with the machines cold and the line voltage at the nominal value. These machines have been designed for Class 2 temperature rise with a continuous power output of 1·2 kW. from the training metadyne and 0·7 kW. from the elevation metadyne. With this total output the motor will take approximately 15 amps. from the 220 volt supply, and with both [illegible] approximately 30 amps.

"70A. The power required to operate the metadyne set in the Mark 5* mounting is taken from the ship's 440 volt, 3 phase, 60 cycle supply. The motor is a 3·5 h.p. squirrel cage induction motor running at 3,500 r.p.m. Full load 5·6 amps."

(G. 4041/55.—Amendment No. 8.)

LUBRICATION

71. Four grease nipples are provided on the metadyne set. These are all readily accessible from outside the machine. For the amount and frequency of lubrication *see* Chapter 6.

GENERAL PHYSICAL ARRANGEMENT FOR CANADIAN EQUIPMENT (2x MD/70CZ)

72. Each metadyne set comprises a driving motor and a metadyne generator, constructed as a 2-bearing machine, with the motor and metadyne armatures mounted on a common shaft. The motor and metadyne field systems are situated at opposite ends of a continuous yoke barrel. On the top of the set is the terminal box which houses both motor and metadyne terminals, a compensator divert resistance and a limit braking auxiliary control resistor.

VENTILATION

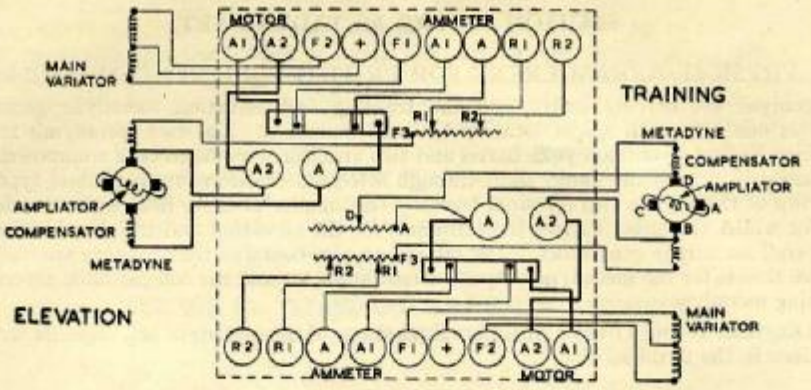
73. The set is ventilated by means of a radial bladed fan on the metadyne shaft end. Air is drawn into the set through the louvred commutator chamber covers at the motor end of the yoke, over the motor commutator, the motor and metadyne armatures and the metadyne commutator, and is then forced radially out of the machine through mesh openings in the lower half of the fan guard. Temperature rises exceeding Class 2 values would be obtained if the set were run, even on no-load, with the metadyne commutator chamber covers removed, as this would result in the normal air paths through the machine being short-circuited. Warning notices are fitted to the covers in question.

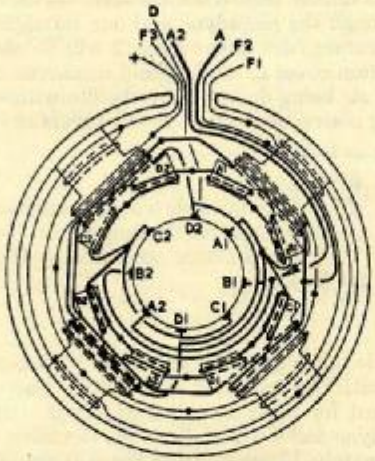
POWER RATINGS

74. The power required to operate the pair of training and elevation metadyne sets is taken via the common starter, from the ship's 220 V. D.C. supply. When running light the current input to the starter will be about 9 amps. This current will rise to a maximum of approximately 38 amps., with both metadynes giving peak output simultaneously.

LUBRICATION

75. Two grease nipples are provided on each metadyne set ; both are readily accessible from outside the machine. For details of the frequency and amount of lubrication *see* Chapter 6.





DIAGRAMMATIC VIEW OF CONNECTIONS LOOKING AT COMMUTATOR END OF METADYNE GENERATOR

METADYNE EXCITER BRUSH BOXES AND LEADS ARE COLOURED TO THIS TABLE				
BRUSH BOX AND LEAD	A	B	C	D
COLOUR	RED	YELLOW	BLUE	GREEN

Diagram 16. Windings and Terminals of the Metadyne Set

SECTION 6. ASSOCIATED ELECTRICAL EQUIPMENT

AUTOMATIC STARTER (used on British Equipment) (*by Metropolitan-Vickers Electrical Co. Ltd.*)

76. An automatic starter is provided to enable the metadyne set to be remotely started up from a control switch situated on the mounting. A rotary starting switch is also provided on the starter panel so that the metadyne set may be started up locally if required. This local starting switch must normally be left in the OFF position so that the metadyne may be started and shut down by the switch on the mounting.

77. As will be seen in Plate 16, starting is effected by operation of either of the starting switches, the closing of which puts into circuit the operating coils of a pair of main contactors, one of which is in each line. The closing of both these contactors inserts an economy resistance in series with their operating coils, and an auxiliary contact, on the contactor in the positive line, closes to complete the circuit of the accelerating contactor coil. Under these conditions the accelerating contactor coil is, in effect, shunted across the metadyne driving motor armature, so that the current passing through the coil is proportional to the back E.M.F. of the armature. When this back E.M.F. has risen to a pre-determined value, the accelerating contactor picks up and cuts out of circuit the single step of starting resistance. Immediately afterwards a pair of normally closed auxiliary contacts on the same contactor open to insert economy resistance in the accelerating contactor operating coil circuit.

78. The supply to the control panel is taken from the starter through a second auxiliary contact on the accelerating contactor, thus ensuring that the metadyne sets cannot be loaded during the starting period. A pair of METADYNE RUNNING lamp fuses, an ammeter and the necessary links and terminals, etc., are also provided in the starter whilst the metadyne driving motor shunt field regulating resistance is housed on top in a drip-proof box.

AUTOMATIC STARTER (used on Canadian Equipment) (*Plate 17*) (*by Metropolitan-Vickers Electrical Co. Ltd.*)

79. An automatic starter is provided so that the metadynes may be started up from a control switch situated on the mounting. A rotary starting switch is also provided on the starter panel so that the metadyne sets may be started up locally if required. This local switch must normally be left in the OFF position so that the metadynes may be started and shut down by the switch on the mounting.

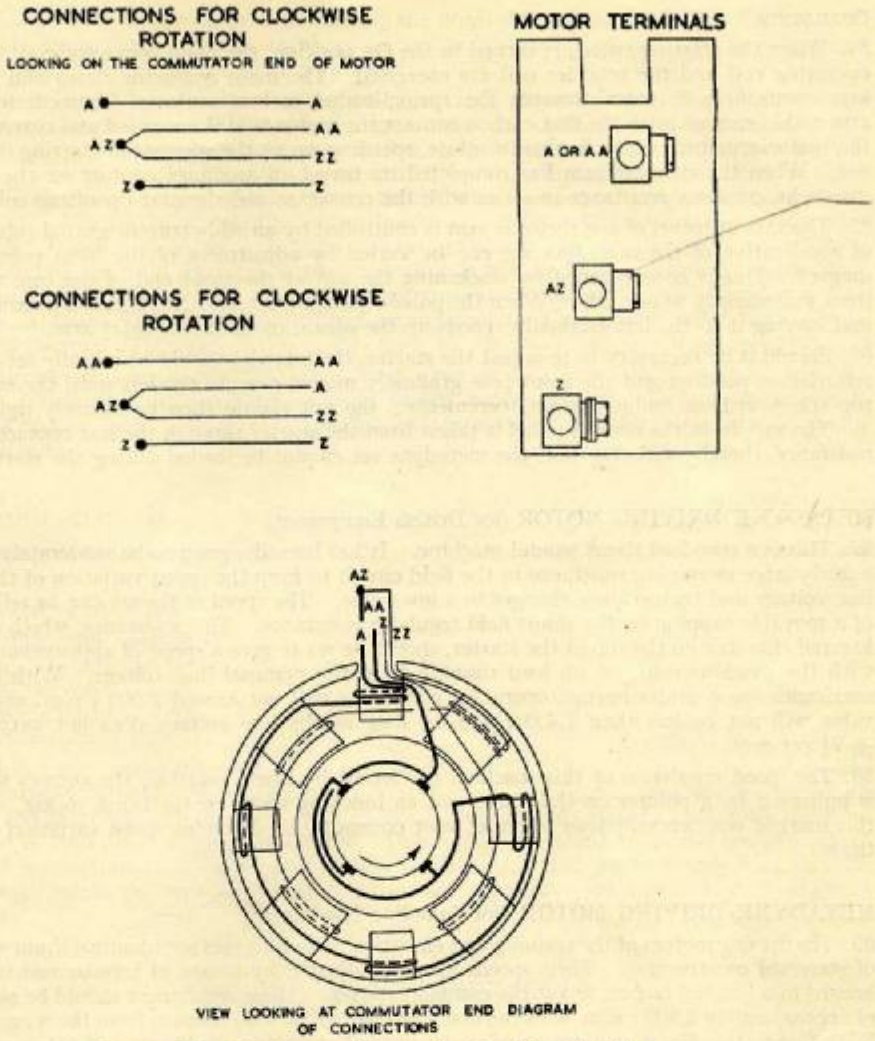


Diagram 17. Windings and Terminals of the Metadyne Set

The metadyne sets are started up simultaneously by the automatic starter, which is of the back E.M.F. type. The motors are connected in parallel and a common starting resistance is used. Each motor, however, is provided with a separate overload relay.

80. There are two line contactors which pick up when the control switch is closed. The common starting resistance limits the peak starting current and is short-circuited by a third contactor which picks up when the voltage across the motor armatures reaches a pre-determined value. All three contactors are fitted with normally closed auxiliary contacts which open when the contactors are energised and insert economy resistances in series with the operating coils.

81. The supply to the control panel is taken from the starter through a further auxiliary contact on the accelerating contactor, thus ensuring that the metadyne set cannot be loaded during the starting period. Two METADYNE RUNNING lamp fuses, an ammeter and the necessary terminals are also provided in the starter. In addition, the control resistances for the shunt fields of the metadyne driving motors are housed on top of the starter in a drip-proof box.

220 VOLT AUTOMATIC STARTER

(by Watford Electric and Manufacturing Co. Ltd.)

FUNCTION

82. An automatic starter is provided so that the metadyne set may be started up from a control switch situated on the mounting.

GENERAL DESCRIPTION

83. The starter switchgear consists, of a single pole main contactor with magnetic blow-out coil, a hand reset overload relay, an eddy current geared retarder controlling a multi-contact accelerating rheostat and a field weakening resistance, fuses for the control and METADYNE RUNNING lamp circuits, an ammeter shunt and armature current ammeter and the necessary terminals and links.

OPERATION

84. When the starting switch is turned to the ON position, the main contactor coil, the rheostat arm operating coil and the retarder coil are energised. The main contactor closes and the accelerating arm commences to move towards the spring-loaded carbon contacts. Immediately the rheostat arm makes contact with the first carbon contact the motor field is energised and current flows through the motor armature which begins to rotate, speeding up as the sections of starting resistance are cut out. When the rheostat arm has completed its travel an auxiliary contact on the arm opens and inserts an economy resistance in series with the contactor and rheostat operating coils.

85. The rate of travel of the rheostat arm is controlled by an eddy current geared retarder. The rate of acceleration of the metadyne set can be varied by adjustment of the front pole of the retarder magnet. This is accomplished by slackening the nut at the front end of the core and moving the front pole slightly to one side. When the pole is vertical, the retarder exerts its maximum retardation and moving it to the left gradually speeds up the operation of the rheostat arm.

86. Should it be necessary to re-adjust the starter, the retarder should be initially set at its maximum retardation position and the front pole gradually moved over to the left until the set accelerates to top speed without undue current increments; the nut should then be securely tightened.

The supply to the control panel is taken from the starter through the last contact on the starting resistance, thereby ensuring that the metadyne set cannot be loaded during the starting period.

"440 VOLT, 3 PHASE, 60 CYCLE, AUTOMATIC STARTER

86A. An automatic starter is provided to enable the metadyne set to be operated remotely from the mounting by push button. A push button is also provided on the starter so that the metadyne may be started locally if desired. The starter is a 3 pole 'direct on' type, operated by a line contactor fed from a 440/115 volt transformer situated in the starter. (Plate 17A.) This transformer is supplied from one phase of the ship's main supply through fuzes situated in the starter.

Relay I.R.1 (Plate 17A) is energised when the starter is made, but is fitted with a time delay mechanism which ensures the metadyne set is run up before the control circuits are energised."

(G. 4041/55.—Amendment No. 8.)

± 7½ per cent.

88. The speed regulation of this machine is affected by brush position, the correct setting of which is indicated by a pointer on the frame and an indexing mark on the brush rocker. Deviation from this marked position may lead to either poor commutation or undue speed variation or instability of the set.

METADYNE DRIVING MOTOR (for Canadian Equipment)

89. The driving motors of the training and elevation metadyne sets are identical shunt wound machines of standard construction. Their speeds may be adjusted by means of tubular resistances which are housed in a louvred box on top of the common starter. These resistances should be set to give speeds of approximately 2,800 r.p.m. with the machine cold, on no load running from the nominal line voltage. With this setting the maximum speed under normal operating conditions will not exceed 3,000 r.p.m. and the minimum value will not be less than 2,450 r.p.m. as long as the line voltage does not vary by more than ± 7½ per cent.

90. The speed regulation of this machine is affected by change of brush position, the correct setting of which is indicated by a pointer on the brush rocker and an indexing mark on the frame. Deviation

"METADYNE DRIVING MOTOR MARK 5* MOUNTING

90A. This is a 440 volt, 3 phase, 60 cycle squirrel cage induction motor of 3·5 h.p. running at 3,500 r.p.m. Power factor at half load 0·5. Power factor at full load 0·75."

(G. 4041/55.—Amendment No. 8.)

91. Separate motors are fitted on the mounting for elevation and training. They are separately excited shunt wound motors the armatures of which are supplied with current from their respective metadyne generators. The field coils are excited by the ship's D.C. supply.

In series with the field coils are brake coils; thus, if power supplies are broken the brakes will be applied and the mounting held still. The connection of the brake coils to the field coils is made in the terminal box of the motor and this connection must be undone before removing the brake shoes for adjustment or repair.

The terminal box also carries the motor field and brake discharge rectifier unit.

All removable covers have either metal to metal joints which are made watertight by the application of a continuous layer of luting, or have langite jointing gaskets.

METROSIL RESISTANCE UNIT FOR METADYNE OUTPUT CONTROL

92. These units are fitted across the main variator windings of the metadyne generators in British and Canadian equipment, elevation and training motions.

There is an additional metrosil fitted in the auxiliary variator winding circuit for elevation. This is only incorporated when a Canadian manufactured metadyne is used. Its use is to limit the output of the metadyne and consequently the speed of the driving motor to a safe value (*see* Plate 17).

$$\text{Current} = \left(\frac{\text{voltage}}{k}\right)^4$$

$$\text{or Voltage} = k \times (\text{current})^{\frac{1}{4}}$$

The constant k of these equations is controlled by the dimensions of the material. The material can be worked at temperatures similar to those obtaining on normal wire-wound resistances on micanite formers and its properties are quite permanent.

93. From the above it will be seen that the metrosil resistance passes comparatively little current at lower metadyne voltages but as much as one ampere when the voltage across the disc reaches a value equal to k. In this particular application the constant k for a unit comprising two discs in parallel is approximately equal to 80. This "Metrosil" unit is permanently connected in series with the metadyne auxiliary variator winding across the metadyne output terminals and the auxiliary variator excitation is arranged to oppose the main variator excitation. The main variator excitation will be completely cancelled by about 1·3 amperes flowing through the auxiliary variator winding. Under these conditions the total drop across the metrosil unit will be approximately 85 volts whilst the voltage drop across the auxiliary variator winding amounts to about 13 volts, making a total terminal voltage of about 98 volts. This voltage corresponds to a maximum mounting speed of approximately 33°/second. Therefore it sets a safe limit to the maximum mounting speed.

94. The metrosil material is in the form of thin discs sprayed on each face with brass to improve the contact surface. These discs are clamped between tinned copper plates. The particular unit in question consists of two discs connected in parallel and fitted with contact plates, metal spacing washers and cooling fins.

SECTOR CONTROL SWITCH

95. A training sector switch is provided, on the mounting, to enable the mounting to be brought into line :

when the mounting attempts to line up through the permanent stops ;

when the transmission carries the mounting on to permanent stop and then trains on through the "dead" arc. The mounting can be sectored round to line up with the transmission as it enters the "free" arc at the other side of the permanent stops.

Once the misalignment is reduced to less than 180° the sector switch can be released and the mounting will automatically pull into alignment.

96. The switch has three positions and is spring-controlled so that when the handle is released the switch always returns to the control (normal running) position. In this position the coincidence magslip is connected to the amplifier. In the other two positions the magslip signal is disconnected from the amplifier and a 20 V. A.C. signal substituted. This signal is derived from the power pack of the amplifier and is directional. Clockwise movement of the handle will cause the mounting to train left. Under sector control the mounting will have the same maximum velocity and acceleration as in auto operation.

GUN DRIVING MOTOR BRAKES

Initial Adjustment

97. The brake is adjusted before leaving the works so that with the coils energised the shoes clear the drum and allow it to rotate freely. The spring is also set to the length required to give the torque stated on the brake nameplate.

The clearance between each shoe and the drum is the same when both lever arms are vertical and any balance necessary may be made by means of the locked adjusting bolts behind the brake shoes.

Adjustment to Compensate for Brake Lining Wear

98. When the fabric lining of the shoes wears away, the airgap between the two magnet pole faces when the brake coils are de-energised gradually increases. If there were no restrictions to this travel the airgap would reach such a value that the strength of the magnet when energised would be insufficient to overcome the force of the main spring, and the brake would fail to release.

It is desirable to maintain this airgap at the minimum possible setting necessary to free the drum when the magnet is energised. This will ensure maximum use of the lining and less frequent adjustment. The minimum gap is approximately ·02-in.

99. When adjustment is required (this can be checked by measuring the airgap with a feeler gauge and observing whether it approaches the maximum value given on the brake nameplate) the procedure is to slacken off the shoe adjusting bolt locknut and adjust the bolts by turning each an equal amount in a clockwise direction until the airgap is reduced to the minimum value. After adjustment, care should be taken to ensure that the shoe bolt locking nuts are securely tightened The brake should be adjusted in this way shortly after installation, *i.e.*, as soon as the linings have had time to become bedded and thereafter they should be readjusted at regular intervals.

Equalising Shoe Clearances

100. Release the brake by operating the hand release lever and measure the clearance between the lining and the drum on each side of the drum when the magnet pole faces are in line. Any adjustments here can be carried out by centralising the brake shoe position by means of the shoe adjusting bolts. On completing adjustments and before putting the brake back into service, make sure that the hand release lever is returned to its original position so that the shoes grip the brake drum.

inserted. Remove the pegging tool, and, taking great care to move the rotor pinion no more than is absolutely necessary, remesh the pinion. It will now be necessary to carry out the pegging as described above, taking care that the clamping screws are finally securely tightened.

CHECKING COINCIDENCE TRANSMITTER ROTOR VOLTAGE

116. Put mounting to power with change over switch to JOYSTICK. Ensure that director is at zero elevation and zero or 180° bearing according to whether it is a forward or after director. Train the mounting slowly over 40 degrees and measure the signal volts on motion " B " in fine at the amplifier. Record the voltage. Similarly, elevate the mounting slowly over 40 degrees and measure the fine magslip volts on motion " A " at the amplifier. Record the coincidence transmitter volts on motions " A " and " B " in coarse in a similar manner except that the mounting can be trained and layed at a much faster pace, and also the mounting should be trained a full 360 degrees and elevated to the top stop.

These recorded magslip voltages should show a sine wave with a maximum of approximately 32 volts to 35 volts. As a further check for the magslip system the above can be repeated by keeping the mounting stationary and operating the director.

DIRECTION OF ROTATION

117. Before lining-up the magslips it is necessary to ensure that the electrical connections in the ship's wiring are correct, so that the mounting lines up approximately with the director, and follows in the correct direction. Mechanical conditions governing the direction of the magslip rotation may necessitate changes in the electrical connections, although the ship's wiring is correct.

118. The following changes only are to be made in the magslip connections when necessary, due to the mechanical conditions governing the direction of rotation of the magslip when in coarse or in fine control :—

(*a*) When the mounting lines up approximately correct, but moves in the opposite direction to the transmission : change SX and SY, and change 1 and 2 at the coincidence transmitter of the motion under test, *i.e.*, coarse coincidence transmitter when testing in coarse control and fine coincidence transmitter when testing in fine control.

(*b*) When the mounting lines up approximately 180° out with the director, and moves in the opposite direction to the transmission when in coarse control : change 1 and 2 at the coarse coincidence transmitter.

Note : In elevation, the mounting will not line up 180° out, but will run to the stop.

(*c*) When the mounting lines up approximately 20° out with the director, and moves in the opposite direction to the transmission when in fine control : change 1 and 2 at the fine coincidence transmitter.

(*d*) When the mounting lines up approximately 180° out with the director, but follows correctly when in coarse control : change SX and SY at the coarse coincidence transmitter.

Note : In elevation, the mounting will not line up 180° out, but will run to the stop.

(*e*) When the mounting lines approximately 20° out with the director, but follows correctly when in fine control : change SX and SY at the fine coincidence transmitter.

The phase lines 1, 2 and 3 should not be stepped round in any circumstances.

FINAL LINING-UP OF MOUNTING AND DIRECTOR

119. (*a*) Insert pieces of paper to make a wedge in the coarse/fine change over relays in both motions of the amplifier so that both motions are kept to coarse control.

(*b*) Switch on the 20 volt supply to the director receivers, and the central motor alternator supply.

(*c*) Switch to auto operation of the mounting. By means of the adjustment pinion, carefully adjust the coarse coincidence transmitter for the training control at the mounting, and arrange that the amount of lag of the mechanical pointer behind the indicator electrical pointer in the receiver at the mounting for slow left training is equal to the amount of lag for slow right training. Similarly, adjust the elevating coarse transmission.

(*d*) Switch to joystick operation. Remove the pieces of paper from the coarse/fine change over relays.

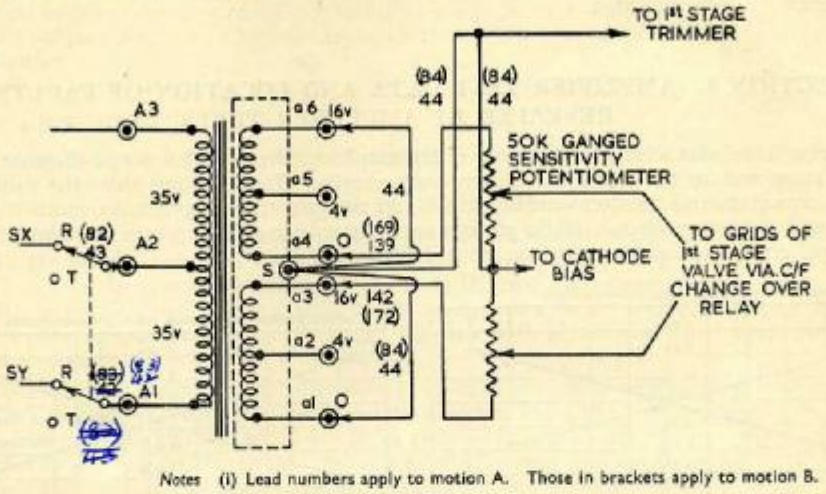
(*e*) Switch to auto operation. By means of the adjustment pinion, adjust the fine training coincidence transmitter in the mounting, so that the amount of lag of the mechanical pointer behind the electrical pointer in the receiver at the mounting for slow left training equals the amount of lag for slow right training. Similarly, adjust the fine elevating coincidence transmitter at the mounting, but in this case arrange that the mechanical and electrical pointers in the receiver are in line during slow elevating of the director, lag only occurring whilst depressing.

SETTING UP STIFFNESS OF MOUNTING

120. Determine the test signal equivalent to 6 minutes misalignment. This is the maximum fine coincidence transmitter volts multiplied by the sine of 54 minutes. With the mounting change over

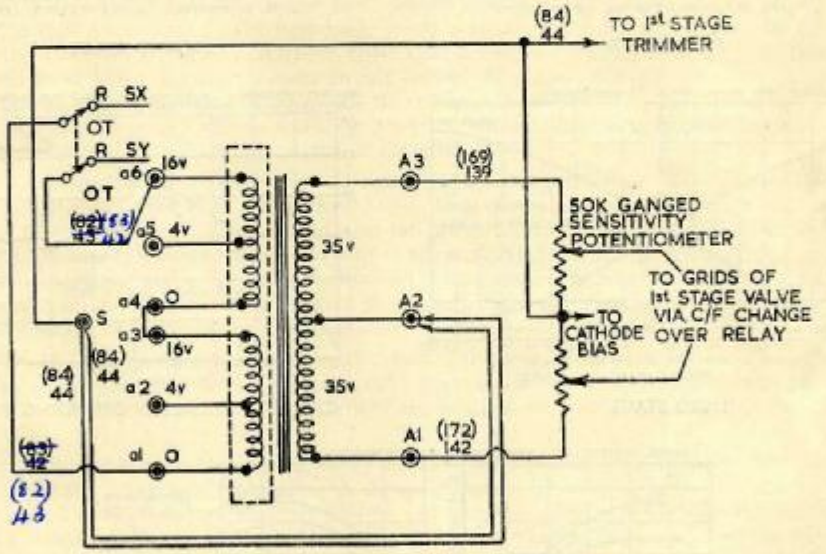
switch to AUTO, amplifier to TEST FINE, apply a signal representing 6 minutes misalignment. Adjust the fine sensitivity potentiometers until a reading of 37 amps is registered for training, and 54 amps for elevation is recorded. Try test signal in each direction.

Note: If it is not possible to obtain these figures with a sensitivity of 100 per cent. the grid transformer connections can be altered as shown in Diagram 18. Fig. 1 shows the normal grid transformer tappings used, while Fig. 2 shows connections when extra sensitivity is required to obtain the above figures.



Notes (i) Lead numbers apply to motion A. Those in brackets apply to motion B.
(ii) Maximum sensitivity 35/16.

Fig. 1.—Fine grid transformer connections (simplified) as used as present.



Note.—Sensitivity now 32/35 (i.e., 35/38.4).

Fig. 2.—Fine grid transformer connections (simplified) giving extra sensitivity ~~required for transmitter coincidence transmitter magslip chain~~

Diagram 18. Fine Grid Transformer Connection—Increased Sensitivity

121. With mounting in power, change over switch to AUTO, amplifier to RUN. Offset training by sector switch in each direction about 90 degrees from alignment with director. Release the sector switch, and the mounting should run into line with no hestitation and with minimum overshoot. Adjust for satisfactory running by altering the coarse sensitivity setting on training and if necessary altering the coarse pre-retardation capacitor value.

ELEVATION

122. Put the mounting change over switch to JOYSTICK, offset the mounting approximately 40 degrees from director in either direction, put change over switch back to AUTO, note performance of run into alignment and correct as for training.

Note: In general, a high sensitivity and low value of coarse pre-retardation produces a large overshoot with attendant large number of oscillations to settle. A low coarse sensitivity and a high coarse pre-retardation value tend to make the mounting drag before reaching

alignment, and can result in the mounting sticking in coarse control. The fine pre-retardation can be varied from a setting of 2 according to the stiffness of the following of the mounting. It should *not* be adjusted to vary the running into alignment. Too high a fine pre-retardation setting can produce a jerky following movement of the mounting, while too low a setting can produce an apparent " sloppy " follow up.

Complete following tests of the director can now be carried out by using a type 6 sight in the director and a bore telescope in the barrels of the mounting. Any appreciable error of the mounting to the director will be indicated.

SECTION 8. AMPLIFIER TEST DATA AND LOCATION OF FAULTS AS REVEALED BY AMPLIFIER TESTS

123. Section 2 includes schematic diagrams of the amplifier circuits. A separate diagram is provided for each stage and for the coarse/fine change-over circuits. The diagrams show the values of phase advance capacitors and resistors actually fitted and the grid transformer ratio which it is expected will be used. Average characteristic performance curves using the average transformer ratio and for 100 per cent. sensitivity setting are given in Diagram 19.

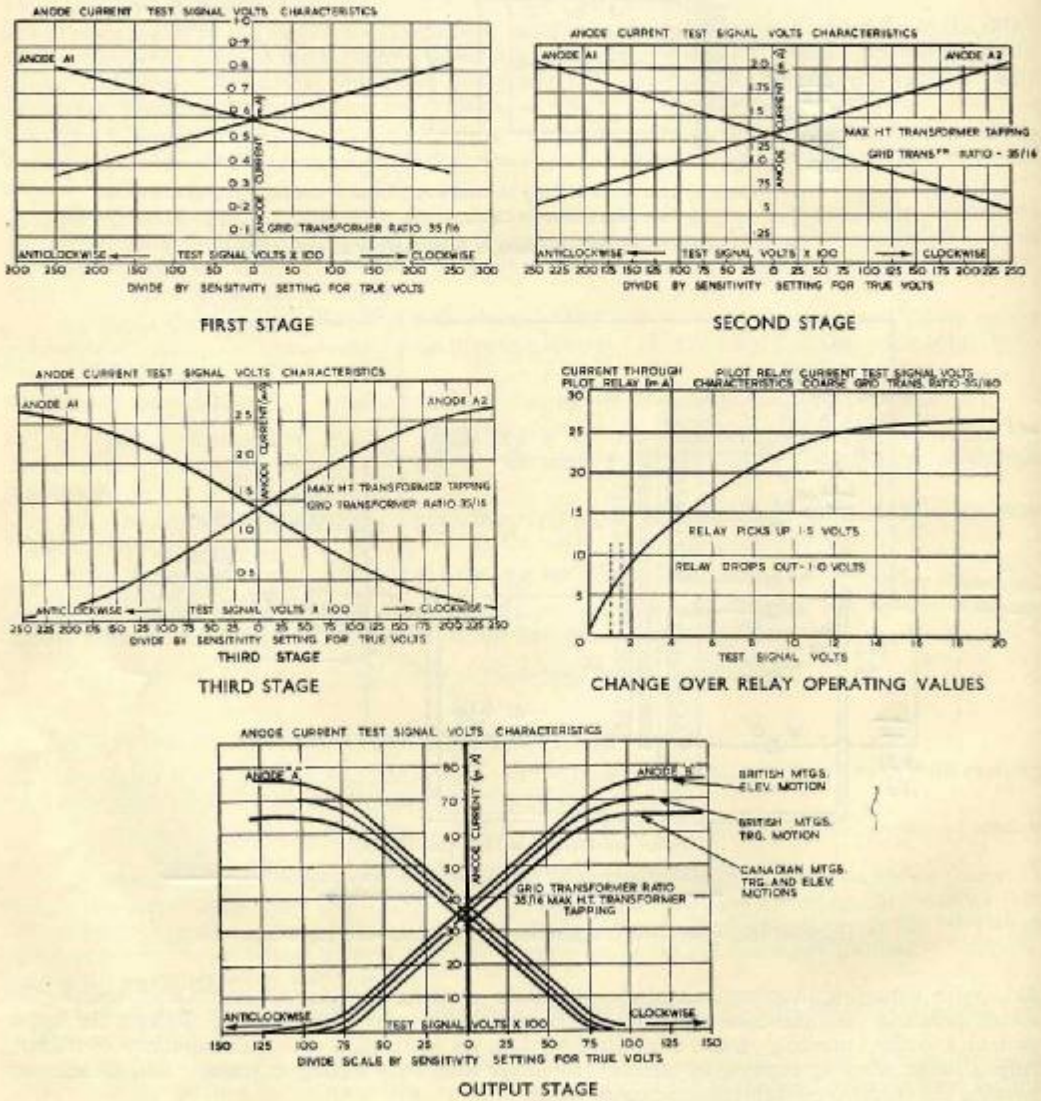


Diagram 19. Average Characteristic Performance Curves

USING THE AMPLIFIER PERFORMANCE CURVES

124. For a particular equipment the sensitivity setting adopted on the final trials will most probably be lower than 100 per cent. and a simple adjustment must be made when using the curves ; the " Test signal volts × 100 scale " must be divided by the sensitivity setting used.

Example : If the sensitivity setting is 75 then the reading 75 on the " Test signal volts × 100 " indicates the currents which will be obtained with 1 volt test signal.

Note: If the input grid transformer ratio is changed, further correction to the amplifier characteristic curves will be required, multiply the "Test signal × 100" scale by the ratio :—

$$\frac{\text{New transformer ratio}}{\text{Transformer ratio given on curve}}$$

A space is provided on the curves for inserting the new scale figures obtained and the sensitivity correction required can be carried out as before using the new scale.

The final settings adopted on a particular equipment will be recorded on the DATA CARD supplied with the amplifier.

LOCATION OF FAULTS

125. If the output current for a specified test signal is widely different from that obtained from the curve, or the amplifier is behaving abnormally, such as giving no output, or cannot be balanced in any position of the trimmer, it is evident that one of the components has developed a fault.

126. It is suggested that the best method of locating the fault is to check each stage, methodically starting with the test circuit, then the power pack, the output stage, third, second and first stages in turn. To do this the chassis should be pulled out of the case and placed somewhere near the case so that it can be reached with the test lead, which consists of a socket board and a plug board, the corresponding contacts on each being connected together with about nine ft. of lead. One end is plugged into the case and the other into the chassis.

127. The value of each component, the current and variation of current with signal in each circuit and the transformer voltages are marked in the schematic diagram, Plate 15. With the help of this diagram and using a high resistance voltmeter it should be possible to check each circuit ; by measuring the voltage across two points in the circuit, calculating the current and comparing it with the figure obtained from the "anode current-test signal volts" characteristic shown.

128. A high impedance voltmeter is necessary for checking the various stages since using a voltmeter of low impedance will load the circuit under test, giving a lower reading than otherwise.

The potential divider circuits in the first, second and third stages cannot be included in the general instruction above due to the extremely small currents involved and it may be advisable to disconnect the resistors concerned to check their ohmic values. Faults occurring in these circuits, however, will most likely be due to open circuit caused by wire breakages.

The current in the common portions of the push-pull circuits, *i.e.*, bias resistors and screen resistors in the output stage, will be sensibly constant, since diminishing current in one-half of the circuit will be balanced by increasing current in the other half.

129. As stated earlier the "anode current-test signal volts" characteristics shown are for 100 per cent. sensitivity and the expected grid transformer ratio. For greater transformer ratios the initial slope or steepness of the curve will be increased and for lower transformer ratios and/or sensitivities the slope will be decreased, directly in the ratio of the transformer ratio and/or sensitivity setting.

If a high resistance voltmeter is not available the currents in the various circuits can be measured by the use of a milliammeter. This method is actually more accurate but requires valve adaptors and may necessitate unsoldering some connections.

130. It should be borne in mind that the actual values of the components and the emission of the valves may vary by ± 10 per cent. from the theoretical figures. When an abnormal reading is obtained, a study of the circuit should enable the origin of the fault to be traced and the defective component replaced.

131. To facilitate the checking of wiring every wire is numbered and the numbers are shown in the Amplifier Schematic Diagram, Plate 15. A component can be located in the chassis by obtaining from the schematic diagram the reference numbers of the wires connected to it. If reference is then made to the Amplifier Detail Wiring Diagram in the ships officers' drawings, and the wires bearing these numbers be found on it, the exact position of the component in the chassis will be indicated ; the detail wiring diagram shows the correct relative positions of the components.

IMPORTANT

Should it be necessary to replace any amplifier component or to disturb the amplifier wiring for any reason, great care must be taken to ensure that the wiring is replaced exactly as found, or disastrous results due to stray coupling effects may occur.

See Appendix II for Fault Finding Table.

CHAPTER 6

MAINTENANCE (*Plates 19-21*)

1. Experience gained with the 40 mm. Bofors Mark 5 Mounting has shown that a regular maintenance routine is essential. The gear situated beneath the platforms is exposed to the weather and care must be taken to ensure that the watertightness of resetter boxes, junction boxes, etc., is maintained. Particular attention must be paid to those parts of the mounting which are spring-operated in order to prevent stiffness of the working parts overcoming the force exerted by the springs.

To facilitate access to items situated below the platforms, access holes covered by plates are provided in the platforms. A door is fitted in the front of the shield for ease of access to the front of the mounting.

All external steel surfaces have been "parkerised" during manufacture. This process provides a rust-proof surface, which should not be removed by the use of abrasive materials, only oil such as paraffin being used for cleaning.

B.R. 292—~~Manual for the Maintenance of Naval Ordnance and Gunnery Equipment is to be followed for types of lubricants to be used.~~ MANUAL ORDNANCE ENGINEERING MANUAL.

TRAINING BASE

2. The training rollers and their axles are lubricated by means of oil cups, mounted in groups around the carriage and connected to the upper box [illegible]

ADJUSTMENT OF CLIP ROLLERS

3. The clearance between the clip rollers and the flange on the fixed box plates is to be between 0·003-in. and 0·008-in. This clearance is NOT adjustable in service, being achieved during manufacture by depth of machined counterbore in upper racer plate. For this reason it is most important that roller assemblies should ALWAYS be replaced in their original position. When replacing roller assemblies after examination the following check should be made to ensure the correct pre-load is being obtained :—

(*a*) Tighten clip bolt nut until the spring washers will just not turn. Note rotary position of nut.

(*b*) Tighten nut with a spanner until it is seated hard against shoulder on bolt. This should occur between 50° and 60° rotation of nut in the case of the rear clip bolts, and between 100° and 120° for the forward bolts.

(*c*) If rotation is either side of the above limits the spring washers should be checked to drawing GR.6521 as they have probably taken a set in which case they should be replaced.

Note : The designed preload is 0·015-in. per washer, i.e. 0·030-in. front clips and 0·015-in. rear clips. This also is not adjustable and can only be maintained by use of replacement washers when necessary.

(*G. 181/57.—Amendment No. 9.*)

4. The firing gear, although protected by the shield, is liable to be subjected to sea spray and washing down. As freedom of the gear is essential for reasons of safety as well as correct functioning, it is most important that this gear should receive frequent attention, and its return action, which is entirely

To ensure freedom of the power firing clutch solenoid core to reset on interruption of the firing circuit, the amount of grease injected into the nipple supplying the bush of the solenoid (Plate 20, No. 49) SHOULD BE LIMITED TO THE MINIMUM NECESSARY TO ENSURE SATISFACTORY LUBRICATION.

(*Amendment No. 11.*)

ADJUSTMENTS OF FIRING GEAR

5. (*a*) The adjustable tappets are to be set to give 0·01 in. clearance from the firing plunger of the gun.

(*b*) Adjustments for length are provided in the two vertical firing rods to synchronise the point at which each gun commences to fire.

(*c*) The tappet rod operating the resetting switch has an adjustable tappet at its lower end for adjusting its length to synchronise the point at which the solenoid circuit is completed with the point at which the safety firing clutch becomes nearly fully engaged.

(*d*) Adjustments are provided in the vertical rods of the elevation and training component link gears to allow adjustment of the point at which the safety firing clutch is disengaged. These are adjusted at the manufacturer's works, and are then pinned. They do not require further adjustment.

ELEVATING AND TRAINING GEARS

6. Regular attention is to be given to the universal couplings in the drive from the hand drive gear box to the main gear box.

The resetter boxes require no lubrication, being fitted with fabric gears; watertightness of the resetter boxes must be carefully maintained.

The plungers of the power interlock switches must receive frequent attention although their spring action is assisted by a hooked lever.

SETTING OF HAND AND POWER DRIVE FRICTION DISC COUPLINGS

7. The setting of the friction disc couplings is made at the manufacturers and the design is so arranged that no subsequent alteration should be necessary. If it is considered that the loading of a friction disc coupling is too low, a spare set of belleville spring washers should be fitted. These washers are provided in adjusted sets which should give the correct setting when tightened up in the coupling.

Note: To renew a set of these washers in a hand friction disc coupling, the training or elevation main gear box will have to be stripped.

In the case of a power friction disc coupling, the appropriate driving motor will first have to be removed. A minor adjustment may be made, however by opening out the coupling with the motor in position, as described in Chapter 7, para. 6, and adjusting the thickness of the distance piece.

JOYSTICK

8. The joystick controllers and the centring springs are below the platform and therefore very exposed. Frequent inspection of the link gear, toothed quadrants and centring springs is therefore necessary.

TRAINING AND ELEVATION AND DEPRESSION BUFFERS

9. These are provided with means for filling and should be kept topped up to correct levels.

TRAINING AND ELEVATION RECEIVER DRIVES

10. Excessive elevating and training efforts can frequently be traced to stiffness in their associated receiver drives and these should therefore receive attention at the same time as the elevating and training gear. Due to the very high pressure that can be reached by the modern grease gun the bearing bushes in the receiver drives may be forced apart thus causing excessive end loadings and hence high rotational torques. Modification No. 33 provides grease relief grooves in those bushes fed by grease nipples Nos. 33, 34, 35, 107 and 108.

(*Amendment No. 11.*)

pump gland, and to ensure water does not accumulate and seep into the motor windings.

The water level in the tank should be checked periodically to ensure the immersion heater is covered.

AUTOMATIC STARTERS (British and Canadian Equipments)

12. The main contact tips of the contactors should be examined periodically and smoothed to remove the large globules of copper which may be formed by frequent arcing. The matt surface which develops on contacts is, however, in no way detrimental and in fact actually reduces the contact resistance. The contact tips are to be renewed when worn half way through. The normally closed auxiliary contacts on the contactors should be cleaned periodically with a rag to remove any deposit which may have formed on the contact surfaces. The moving contact arms should be free to rock so as to make contact with both fixed contacts.

The bearing pins of the contactors, the push rod on the overload relay and the normally closed auxiliary contacts should be lubricated with a drop of approved light oil. This need only be done two or three times a year.

AUTOMATIC STARTER (WATFORD ELECTRIC)

13. Before starting up, the dashpot on the overload must have the necessary amount of oil inserted. The sliding clip on the motor shunt field regulating resistances must be securely set to the position required to give the specified speed of operation of the metadyne set (*see* Chapter 5, para. 103).

Whilst in service the starter should be kept clean and all oiling points attended to periodically.

ROTATING MACHINES

14. The general maintenance of all the rotating machines is quite similar to that for any other rotating electrical machinery.

BEARINGS

15. Bearings and housings are filled with sufficient grease before leaving the manufacturers and require no further attention before putting the machine into operation. Under normal conditions a machine will run for many months without replenishment of the grease but the amount of lubrication required is best determined after inspection of the bearings at suitable intervals, by removal of the outer bearing caps. No definite ruling can be laid down, for lubrication is affected by climatic conditions and the number of hours running that occur. *Do not overgrease*: damage is more often done through this practice than through undergreasing. A comfortable warmth to the hand placed on the bearing cap indicates that the bearing is running under the best conditions. Before removing any bearing caps,

dirt and moisture is to be carefully wiped from the vicinity. Caps and bearings when removed are to be kept covered with clean paper. If the bearing is dirty, or the grease has deteriorated the bearing must be removed completely. The procedure for this will be quite clear from a study of the relevant ship's officers' drawing, if it is remembered that the outer races are a push-fit in the housings while the inner races are a press-fit on the shaft. After the armature has been withdrawn from the yoke, ball bearings can be removed from the shaft by pulling on the outer race, care being taken not to pull on the cage. Roller bearings can be removed from the shaft by pulling on the inside lip of the inner race with the inner bearing cap. This may be done by screwing into the bearing cap three long studs which project beyond the end of the shaft, placing on the end of the shaft a rigid steel plate having three clearance holes through which the studs can pass, screwing nuts on to the studs and uniformly tightening them up to the plate.

16. Washing of bearings should be carried out with two successive petrol baths, the second being kept clean.

When recharging the bearings with fresh grease over-charging must be avoided. The space between rollers or balls must be well filled with grease and the outer caps about two-thirds filled so that the grease is in contact with the bearing and yet there is room for expansion of the grease.

Commutators, Brushes and Brushgear

17. These parts require careful inspection and attention. Grease and moisture must not be allowed to accumulate; the carbon brushes should be free in the holders without being slack, stiffness of movement or flogging of the carbons must be remedied without delay and the brush tension spring should press firmly on the brush and move freely with the brush.

Metadyne Set Brush Tensions

18. Because of the long periods of continuous running that are likely to occur and also because brush friction contributes a high percentage to the total machine losses, the correct brush tensions must be closely adhered to on the metadyne sets. The brush tensions when measured with a new brush should be as follows :—

	British	*Canadian*
Metadyne brushes	10 oz./brush	8 oz./brush
Metadyne driving motor brushes	10 oz./brush	12 oz./brush

Care is to be taken when fitting new brushes to use the correct grade as specified on the ship's officers' drawing.

Fitting New Brushes

19. Care should be taken when fitting new carbons to ensure that they bed correctly to the commutator. The metadyne driving motor brushes may be bedded to a commutator by placing round the commutator a strip of carborundum cloth or glass paper (not emery cloth), long enough to overlap by an amount at least equal to the circumferential distance between adjacent brush boxes, rough surface uppermost, so that when the brushes are lowered on to it and the commutator is turned, the cloth becomes tightened. A few turns of the armature will then be sufficient to grind the brushes to the curvature of the commutator. After removal of the carborundum cloth the carbon dust must be removed from the machine. This may be done by blowing out with clean dry compressed air. Finally, the brushes should be wiped clean.

20. The metadyne carbons will be rather more difficult to bed due to the small circumferential clearance between brush boxes. It is therefore suggested that brushes may be bedded by taking out all metadyne carbons and bedding four at a time in the motor end. When using this latter method care must be taken to ensure that all brushes are placed the right way round in their holders each time.

21. When commutator and brush dimensions are such that only a small amount of carbon has to be removed to bed a brush, bedding can be carried out by applying a brush bedding stone—not a commutator stone—to the commutator with the machine running at normal speed and the brushes lowered on to the commutator. A brush bedding stone is a soft stone which powders easily and cuts the brush surface without cutting the face of the commutator. The stone should be fairly rapidly traversed across the commutator surface during the operation. All brushes must be removed and wiped clean after bedding.

22. A new carbon after bedding should be short enough for the brush spring to rest squarely on the top of the brush. If a spring rests against the side of a brush it will probably result in the brush being trapped and held off the commutator. Should a spring become bent, reform it and then check that it can travel over its complete range without fouling the brush box.

Commutator Maintenance

23. A commutator surface should be polished, of uniform colour and free from irregularities or burning. If the commutator is badly burnt or out of alignment a temporary clean up may be made with a commutator stone shaped to the curvature of the commutator. This may involve removing one or more brush arms. It is essential when performing this operation that the armature is run at full speed otherwise "flats" or hollows will not be removed but will be accentuated.

24. Metadynes may easily be run at full speed by their driving motor and a metadyne commutator may be stoned under no-load conditions. The metadyne driving motor may be run with two brush arms removed but care must be taken to avoid accidental shock to the operator.

25. After stoning a commutator or re-turning a commutator in a lathe, the edges of the commutator bars are to be carefully examined and any " fashes " or " slivers " of copper removed, by cutting very minute chamfers along the commutator bar edges with a sharp tool which does not turn up edges on the commutator surface. A sharp penknife has been found to perform this operation satisfactorily but a specially prepared cutting tool is preferable.

26. After machining the commutator, the micas must be recessed to the dimensions given on the ship's officers' drawing. A scraping tool prepared from a hack-saw blade is suitable for this operation. It is important when undercutting micas, to ensure that *no mica is left on the sides of the commutator bars* flush with, or proud of, the commutator surface. Proud mica is a well established cause of commutator " flatting ".

LUBRICATION

27. The colours of the symbols in the lubrication charts indicate the frequency of the lubrication each grease nipple or oil cup should receive. This period should be the minimum allowed to elapse, more frequent attention being given as weather conditions and experience deem necessary. A grease gun is included in the spare gear box.

A number of the lubricators for the training base assembly are remotely fitted and connected to the various items of gear by pipes. Care should be taken when stripping not to damage these pipes by flattening, etc.

SHIP'S OFFICERS' DRAWINGS

28. Each ship will be issued with a volume B.R. 1107 containing coloured plates of general arrangement drawings, including electrical drawings. The purpose of these drawings is not only for guidance of ships' officers and depot ships in the function of the equipment, but also to provide a certain amount of data, such as item numbers, for reference when ordering replacement parts, and these drawings should always be consulted before action is taken to order such replacements.

Illustrated " C " and " D " spares lists will be found at the back of the volume of drawings.

AUTO AMPLIFIER

29. In order to reduce deterioration the auto amplifier when not in daily use should be energised for a few hours each day, and switched on continuously for as long as practicable before being required for operational or exercise periods.

Where independent H.T. or L.T. switching is provided the amplifier should be energised with the H.T. *off*. Any valve deterioration which may arise from this procedure is not of sufficient importance to outweigh the advantages to be gained in overall reliability, safer operating conditions and reduced fire risk.

This procedure should be implemented with due regard to fire risk and safety in locked and unattended compartments; cases of difficulty should be reported to the Admiralty.

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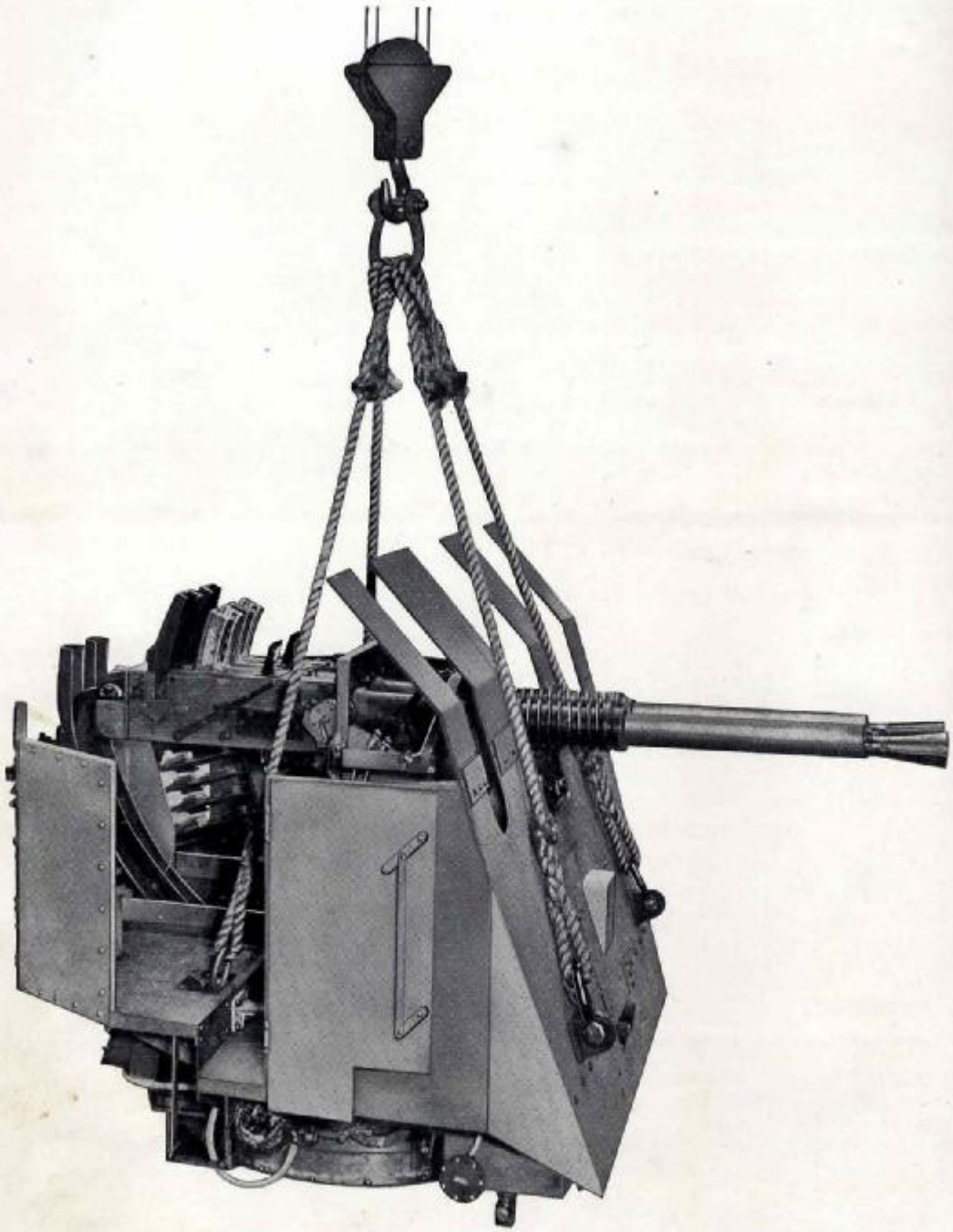
Mating of Guns to Mountings.

30. The two Mark 11 guns are mated to their particular mounting with the registered number of the mounting to which they belong stencilled on the elevating arc. Pairs of guns may not be readily interchangeable. When considering replacement of the guns it should be ascertained that the necessary facilities are available for carrying out the work which, among other things, may involve adjustment of the elevating arc of the exchange guns or of the pinion of the mounting.

31. R.N.A. Depots hold G.B.006 gauge, checking, elevating arc (G.5164). Occasions may arise when, notwithstanding that the arc of a pair of guns has been checked with this gauge, unacceptable backlash may be encountered when the guns are fitted in a particular mounting. If this occurs adjustment of the arc or of the pinion may be necessary.

(G.3426/54—Amendment No. 7.)



Photograph 5. Mounting in Lifting Slings

CHAPTER 7

STRIPPING

1. The mounting should be lifted, for examination and cleaning of roller paths, rollers and centre pivot, in accordance with instructions given in B.R. 292.

TO LIFT MOUNTING (*Plate* 4)

2. (*i*) Remove the lower **ring retaining** the **centre pivot roller bearing.**

(*ii*) Withdraw the cage downwards, complete with rollers.

Note : There are two diammetrically opposed ½-inch Whit. tapped holes in the cage for fitting withdrawing screws.

When the retaining ring and roller cage have been removed they must be suitably supported to prevent damage to the electric cables.

(*iii*) Remove the nuts securing the **clip bolts** (fourteen in number).

Note : ~~On some mountings these nuts are fixed by grub screws which must first be removed.~~ These nuts are locked by Hexagon Socket Headed Cap Screws which must first be slacked back. A.L.6.

Five of the rear clip bolt nuts are situated inside the brackets supporting the driving motors and in some cases it may be necessary to remove both motors in order to gain access to these nuts.

(*iv*) Sling the mounting by shackling four strops to the permanent lifting eyes secured to the mounting. Two of these eyes are secured to the front shield and the other two are situated below the platform immediately abaft the layer's and trainer's seats. The positions of these lugs are so arranged that the strops are centred on the crane hook so that a spreader is unnecessary.

(*v*) The mounting can then be lifted sufficiently to enable examinations, etc., to be carried out.

Note : Before commencing any work underneath, the mounting must be chocked.

Care must be taken not to damage the electric cables running through the centre pivot glands.

TO REMOVE GUNS FROM MOUNTING (*Plate 4*)

3. (*i*) Engage the **elevation locking bolt.**

(*ii*) Disconnect the electric leads running to the gyro sight and the loading lamp box, and remove the clips securing the leads to the sight brackets.

(*iii*) Remove and stow the gyro sight.

(*iv*) Unbolt and remove the sight support brackets.

(*v*) Drain the water from the gun jackets and then disconnect the flexible water pipes.

(*vi*) Remove the left and right firing arms at the trunnions.

(*vii*) Take out the screws securing the trunnion bearing **cover plates,** and remove the plates.

(*viii*) Disconnect the safety firing link from the elevating arc.

(*ix*) Unbolt and remove the **trunnion bearing caps.**

(*x*) Sling the guns, and then remove the elevation locking bolt.

(*xi*) The guns can then be lifted from the **carriage.**

TRAINING GEAR

TO REMOVE A TRAINING ROLLER (*Plate 4*)

4. (*i*) Remove one section of **guard plates.**

(*ii*) Train the mounting until one of the **gaps** in the **upper roller path** is over the **training roller** to be withdrawn.

(*iii*) Remove the split pin securing the **spectacle plate,** unscrew and remove the **roller axis** from the **live roller ring.** These are accessible through one of the gaps in the upper roller path and one of the holes in the vertical web of the lower base plate.

(*iv*) Remove the roller.

Note : Care must be taken to ensure that the roller axis is screwed up hard to the shoulder in the live roller ring. Failure to do this may prevent the lubricating oil reaching the inside of the roller, and may also mean that the axis is not truly radial to the live roller ring.

TO DISMANTLE TRAINING DRIVING MOTOR POWER FRICTION DISC COUPLING

(*i*) Unbolt and remove the ammunition rack. Remove the screws and lift away the floor plate directly above the motor.

(*ii*) Disconnect the electric leads to the motor junction box and remove the conduit tubing which protects the leads running from the junction box to the motor.

(*iii*) Sling the motor and then remove the four holding down bolts.

(*iv*) Withdraw the motor (approximately 3-inches) together with the friction disc coupling until the coupling disengages from the power drive shaft of the main gear box.

(*v*) The motor together with the coupling can then be lifted away.

(*vi*) Motor can be removed without removing friction disc coupling by unscrewing the bolts securing motor coupling to friction coupling.

Note : When re-assembling motor and coupling, always assemble coupling on the gear box shaft first, do not attempt to slide motor with friction coupling attached on to the gear box shaft since the oil-seal in the coupling would be liable to damage.

To Open Out Power Friction Disc Coupling (*Plate 5*)

6. Minor repairs and adjustments to the friction disc coupling can be effected with the motor in position as follows :—

(*i*) remove the seat and floor plate directly above the friction coupling ;

(*ii*) drain off the oil ; and Shakeproof washer.

(*iii*) remove the **set screw** locking the **retaining nut** to the coupling **outer casing.** Unscrew the retaining nut and slide it along the **power drive shaft** ;

(*iv*) the **distance piece,** controlling the friction, which is in halves can then be removed.
Note : After re-assembly, fill with oil. (*ii*) The shakeproof lockwasher should be renewed.

TO DISMANTLE HAND DRIVE GEAR BOX (*Plate 5*)

7. (*i*) Disconnect the upper **universal coupling.**

(*ii*) Remove six bolts securing the gear box to the distance piece. The box together with the training handles can then be removed to the bench for stripping down.

TO STRIP DOWN HAND DRIVE GEAR BOX (*Plate 5*)

8. (*i*) Drain off the oil.

(*ii*) Remove the screws securing the **cover.**

(*iii*) Lift off the cover together with handles, spindle, bearings and bevel gear.

(*iv*) Remove the split pins and nuts securing the bevel gears.

(*v*) Remove the gears from their splined shafts.

Note : When re-assembling, the inner ball-race on the handle spindle should be pressed on with spindle in place and the inner cover plate put on finally.

TO DISMANTLE TRAINING MAIN GEAR BOX (*Plate 5*)

9. (*i*) Unbolt and remove the right ammunition rack.

(*ii*) Unbolt and remove the trainer's foot rest, seat and seat support bracket.

Note : The seat support bracket and mounting lifting eye are secured by the same bolts.

(*iii*) Remove the screws and lift away all floor plates with the exception of the one supporting the cooling water tank.

(*iv*) Unbolt and remove the cable guards fitted around the right cartridge chute.

(*v*) Remove six securing bolts and lift out the right chute.

(*vi*) Disconnect the electric leads from the resetter box and clutch interlocking switch.

(*vii*) Remove the resetter box.

Note : The coincidence transmitter magslips must be removed before re-assembling this box, and great care taken to avoid damaging the fibre gear wheels when meshing them with the resetter driving pinion.

(*viii*) Sling the training motor and remove the four holding down bolts. Also unbolt the training motor junction box. Withdraw the motor (together with the junction box) approximately 3-inches to disengage the **motor shaft** and the friction coupling, from the **power drive shaft.**

(*ix*) Remove the split pins, and the bolts, from the **coupling** connecting the **output** and the **worm shafts.**

(*x*) Tap out the taper pin securing the coupling to the worm shaft. The half of the coupling on the worm shaft can now be moved along to clear the spigot.

(*xi*) Disconnect the hand drive lower **universal coupling.**

(*xii*) Sling the main gear box and remove the four holding down bolts. The box can then be lifted away from the upper base plate.

Note: The gear box must first be lifted vertically approximately ¾-inch to disengage the spigot, fitted on the underside of the casing, from the recess in the upper base plate.

TO STRIP MAIN GEAR BOX (*Plate 5*)

10. For stripping purposes the gear box may be conveniently divided into three sections. They should be stripped in the following order :—

To Strip Resetter Reduction Gear

(*i*) drain off the oil ;

(*ii*) remove the **resetter driving pinion** ;

(*iii*) unscrew the eleven securing bolts and remove the reduction gear box **cover.** This cover forms the housings for two bearings supporting the reduction gearing ;

(*iv*) withdraw the gears complete with their shafts and bearings ;

(*v*) remove the split pin and nut securing the **first reduction pinion.** Remove the pinion.

To Strip Centre Power Drive Section

(*vi*) take out the securing bolts and remove the reduction gear box casing ;

(*vii*) remove the split pin connecting the **power clutch operating shaft** to the **clutch fork.** Withdraw the shaft and the fork ;

(*viii*) remove the roller bearing and distance piece from the **power clutch shaft** ;

(*ix*) withdraw the power clutch shaft together with the clutch, bevel wheel and spur gear ;

(*x*) remove the split pin and nut securing the spur pinion to the output shaft. Withdraw the pinion ;

(*xi*) remove four bolts securing the housing for the power drive shaft bearings ;

(*xii*) remove the **bearing housing,** together with the **power drive shaft,** bevel pinion and bearings.

To Strip Hand Drive Section

(*xiii*) remove the four bolts securing the **bevel gear box** ;

(*xiv*) remove the box complete with shaft, bearings and bevel gear ;

(*xv*) remove the split pin and nut securing the bevel pinion to the hand drive worm shaft ;

(*xvi*) remove the bevel pinion and distance piece ;

(*xvii*) remove the cover plate from the main gear box casing, exposing the **worm** ;

(*xviii*) remove the keep plate and unscrew from the casing the **end cap** retaining the worm shaft ;

(*xix*) withdraw the worm shaft and bearing. Remove the worm ;

(*xx*) remove the four bolts securing the **bearing housing** for the **output shaft** ;

(*xxi*) remove the housing complete with gland nut, bearing and **oil seal** ;

(*xxii*) remove the split pin securing the **hand clutch operating shaft** to the **clutch fork.** Withdraw the shaft and fork.

(*xxiii*) the output shaft together with the clutch, **wormwheel, friction disc coupling** and inner bearing can then be withdrawn.

Re-assembly

11. Re-assembly takes place in the reverse order to that in which the parts were removed.

(*i*) All gears and moving parts to be adequately lubricated.

(*ii*) At each stage of assembly check that all parts are free moving.

(*iii*) With coupling 13 and 14/GR.6571 secured, backlash at friction clutch GR. 6560 not to exceed 1°-22′·4 or ·345 movement on 15-in. pointer with applied torque of 8-lb. ft.

(*iv*) With resetter drive GR. 6562 secured, backlash at friction clutch G.R. 6560 not to exceed 1° 49′ or ·475 movement on 15-in. pointer with applied torque of 1-lb. ft.

(*v*) With rack secured, backlash at friction clutch G.R. 6560 not to exceed 12° 42′ or 3·32 movement on 15-in. pointer with applied torque of 8-lb. ft. Backlash figures are for full right to left deflections.

(*vi*) Duplex bearing should be hammered up tightly, necessary clearances being allowed for in the bearing.

TO DISMANTLE TRAINING WORM GEAR BOX (*Plates 4, 5*)

12. (*i*) Unbolt and remove all cable guards surrounding the empty cartridge chutes.

(*ii*) Unbolt and remove both cartridge chutes.

(*iii*) Remove the centre two front clip bolts.

(*iv*) Ease the compression on the spring plunger of the safety firing gear and remove the pin connecting the plunger to the roller guide arm.

(*v*) Remove the pin connecting the top of the plunger to the crank of the differential gear box.

(*vi*) Drain the water tank and remove the pipe connecting the tank to the pump.

(*vii*) Unbolt and remove the spring plungers support bracket.

(*viii*) Tap out the taper pin securing the **coupling** to the worm shaft and remove the coupling bolts. The half of the coupling on the worm shaft can now be moved along the worm shaft to clear the spigot.

(*ix*) Disconnect the grease pipes to the worm gear box and remove the holding down bolts.

(*x*) Remove oil filling plug.

(*xi*) Lift the worm box until the dowel and **training pinion** are clear, and slide the box out to the front under the safety firing gear differential box.

Note: Lifting holes, tapped ½-inch Whitworth, are provided in the top cover to facilitate the removal of the worm gear box.

With main pinion 7/GR. 6552 secured, backlash at couplings 13 and 14/GR. 6571 not to exceed 0° ·51′ or ·22 movement on 15″ pointer with applied torque of 40-lb. ft.

With rack secured, backlash at couplings 13 and 14/GR. 6571 not to exceed 2″ 18′ or ·6 movement on 15-in. pointer with applied torque of 40-lb. ft. Backlash figures are for full right deflection to full left deflection.

TO STRIP WORM GEAR BOX (*Plate 5*)

13. (*i*) Drain off the oil.

(*ii*) Remove the keep plate and unscrew the **end cap** from the worm casing.

(*iii*) Remove the split pin and nut retaining the worm shaft.

(*iv*) Withdraw the **sleeve** and two worm shaft bearings.

Note: A strongback is provided for this.

(*v*) Remove the keep plate and unscrew the worm shaft **gland nut.**

(*vi*) Withdraw the **training worm** and shaft (by unscrewing it from the **wormwheel**) together with the roller bearing which is secured to the shaft by a lock nut.

(*vii*) Unbolt and remove the top **cover** exposing the wormwheel.

(*viii*) Remove the split pin and nut retaining the wormwheel.

(*ix*) Remove the top pinion shaft roller bearing.

(*x*) Withdraw the wormwheel.
Note: A strongback is provided for this.

(*xi*) Withdraw the pinion and shaft.

(*xii*) Remove the keep plate and unscrew the **castellated bush** retaining the lower pinion shaft bearings.

(*xiii*) The bearings, with distance pieces and **oil seal** can then be removed.

Re-assembly

14. Re-assembly takes place in the reverse order to that in which the parts were removed.

(*i*) All gears and moving parts to be adequately lubricated.

(*ii*) At each stage of assembly check that all parts are free moving.

(*iii*) Duplex bearings should be hammered up tightly, necessary clearances being allowed for in the bearing.

ELEVATING GEAR

15. When dismantling any part of the elevating gear, always first engage the elevating locking bolt.

16. The instructions for dismantling the elevating driving motor and power friction disc coupling, and for stripping the elevating gear boxes are similar to those given for the training gear.

TO DISMANTLE HAND DRIVE GEAR BOX (*Plate 7*)

17. (*i*) Disconnect the upper **universal coupling.**

(*ii*) Remove six bolts securing the **gear box** to the elevating worm box.

(*iii*) The gearbox, together with the **elevating handles,** can then be removed to the bench for stripping down.

TO DISMANTLE ELEVATING WORM GEAR BOX (*Plate 7*)

18. (*i*) Remove the hand bevel gear box as above.

(*ii*) Remove the guard from the **coupling** connecting the worm shaft to the **output shaft** of the main gear box.

(*iii*) Tap out the taper pin securing the coupling to the worm shaft and remove the coupling bolts. The half of the coupling on the worm shaft can now be moved along the worm shaft to clear the spigot.

(*iv*) First taking care to sling the box, remove six bolts securing the box to the carriage. The box together with the **elevating pinion**, can then be withdrawn and lifted away.

Note. When replacing the worm gear box, ensure that the elevating receiver drive split pinions are in the closed position before they are meshed with the elevating pinion.

With main pinion 7/GR. 6552 secured, backlash at couplings 13 and 14/GR. 6571 not to exceed 0° ·51′ or ·22 movement on 15-in. pointer with applied torque of 40-lb. ft.

With rack secured, backlash at coupling 13 and 14/GR. 6571 not to exceed 2° 18′ or ·6 movement on 15-in. pointer with applied torque of 40-lb. ft. Backlash figures are for full right deflection to full left deflection.

TO DISMANTLE ELEVATING MAIN GEAR BOX

19. (*i*) Remove the left ammunition rack.

(*ii*) Unbolt and remove the layer's seat and support bracket.

Note : The seat support bracket and the mounting lifting eye are secured by the same bolts.

(*iii*) Remove the screws and lift away all the floor plates excepting the two directly above the circulating water non-return valve, and the pump motor.

(*iv*) Remove the joystick assembly as described in para. 26.

(*v*) Disconnect the upper and lower **universal couplings** and remove the **hand drive shaft.**

(*vi*) Disconnect the electric cables to the resetter box and clutch interlocking switch.

(*vii*) Withdraw the elevating motor as described for the training motor in para. 5 to disengage the motor shaft and friction coupling from the **power drive shaft.**

(*viii*) Sling the gear box and remove the four securing bolts. The box can then be lifted out from the mounting.

FIRING GEAR

TO DISMANTLE POWER FIRING CLUTCH (*Plate 9, Diagram* 6)

20. (*i*) Disconnect the electric leads to the **firing motor.**

(*ii*) Unbolt and lift the motor to disengage the **muff coupling.** Remove the motor.

(*iii*) Remove the pin from the link connecting the power firing clutch **lever** to the solenoid.

(*iv*) Unscrew the bolts securing the power firing clutch and withdraw the clutch by sliding it apart from the **coupling** on the differential box.

TO STRIP POWER FIRING CLUTCH (*Plate 9*)

21. (*i*) Drain off the oil.

(*ii*) Remove the split pin and nut securing the **coupling disc** to the **clutch shaft.**

(*iii*) Remove the coupling disc and distance piece.

(*iv*) Unbolt the **end plate** and remove this together with the ball bearing and **oil seal.**

(*v*) Remove the clutch operating shaft end cover plate.

(*vi*) Unpin and remove the clutch operating lever.

(*vii*) Remove the grub screw connecting the **clutch operating shaft** to the **clutch operating fork.**

(*viii*) Remove the taper pin and the collar which retains the operating shaft.

(*ix*) Withdrawn the operating shaft.

(*x*) Withdraw the clutch shaft and the **holding clutch** assembly.

(*xi*) Unpin and remove the muff coupling from the worm shaft.

(*xii*) Remove the two plates covering the worm shaft bearings.

(*xiii*) Withdraw the worm, shaft and bearings.

(*xiv*) Remove the wormwheel **cover** plate.

(*xv*) Withdraw the **wormwheel, running shaft** and bearings.

Re-assembly

22. Re-assembly takes place in the reverse order to that in which the parts were removed.

(*i*) At each stage of assembly check that all parts are free moving.

(*ii*) On completion ~~fill with oil~~ refill with 1½ pts. of O.C.160.

Note : When reassembling the power firing clutch, care should be taken to ensure that the various couplings, etc., are mounted on their splines in the correct angular relationships as shown at the bottom of Plates 21 and 22 of B.R. 1107.

(*Amendment No. 12.*)

TO DISMANTLE DIFFERENTIAL BOX (Diagram 6, Plate 9)

23. (*i*) Remove the power firing clutch as described above.
(*ii*) Disconnect the **return spring** and remove the pin from the lever connecting the **intermediate firing shaft** to the **firing pedal.**
(*iii*) Unbolt the bracket supporting the foot rest, and withdraw this, together with the short shaft that will disconnect it from the intermediate firing shaft.
(*iv*) Remove the **link** connecting the **firing shaft** and intermediate firing shaft.
(*v*) Remove the pins from the levers connecting the firing shaft to the **spring coupling rods.**
(*vi*) Unbolt the two brackets supporting the firing shaft. Remove the brackets and shaft.
(*vii*) Disconnect the **elevation component rod** and spring plunger rod from their respective levers.
(*viii*) Unbolt and remove the differential box.

TO STRIP DIFFERENTIAL BOX (Diagram 6, Plate 9)

24. (*i*) Drain off the oil.
(*ii*) Remove the top and front cover plates.
(*iii*) Unscrew the set bolt securing the **coupling** to the **intermediate firing shaft** and remove the coupling. Remove the set screw securing the **lever** to the **fixed clutch member.** Remove the lever.
(*iv*) Remove the intermediate firing shaft end covers. These form the bearings for the shaft.
(*v*) Withdraw the shaft and **clutch spring** to the right. Remove the **safety firing clutch.**
(*vi*) Disconnect the two external oil pipes from the oil feed box.
(*vii*) Disconnect the oil pipes and remove the feed box.
Note: Care must be taken not to damage the oil pipes.
(*viii*) Remove the lever from the **training component quadrant** shaft.
(*ix*) Unscrew the set bolt securing the **training component quadrant** to its shaft.
(*x*) Withdraw the shaft and then remove the quadrant.
(*xi*) Remove the set bolt securing the lever to the elevation component quadrant shaft.
(*xii*) Withdraw the **elevation component quadrant** together with the shaft.
(*xiii*) Disconnect the supply pipe from the oil pump.
(*xiv*) Unbolt and remove the pump cover plate.
Note: The oil pump is bolted to the cover.
(*xv*) Unscrew and remove the two dowels, locating the **differential** support bracket, from the underside of the casing.
(*xvi*) Remove the four bolts securing the differential support bracket.
(*xvii*) Withdraw the bracket, differential gear, **clutch operating cam** and shaft.
(*xviii*) The remaining clutch operating gear can then be removed.

Re-assembly

25. Re-assembly takes place in the reverse order to that in which the parts were removed.
(*i*) At each stage of assembly check that all parts are free moving.
(*ii*) The clutch operating spring should be adjusted with the **least** compression possible to engage the clutch.
(*iii*) The quadrants and cam should be fitted on their respective shafts with engraved lines vertical when levers are horizontal, as indicated by the engraved lines on the levers and bearings.

JOYSTICK

TO DISMANTLE JOYSTICK ASSEMBLY (Plate 11)

26. (*i*) Remove the covers from both controllers.
(*ii*) Disconnect the cables to each controller.
(*iii*) Slacken back the glands and pull out the cables.
(*iv*) Replace the covers and plug up the cable glands.
(*v*) Remove the seat and its support bracket.
(*vi*) Remove the screws and lift away the floor plates.
(*vii*) Remove the **elevation controller** as described below.
Note: This is necessary because of the proximity of overhead electric cables.
(*viii*) Remove the eight bolts securing the joystick **platform** to the support brackets.
(*ix*) The joystick assembly can then be lifted away.

TO STRIP JOYSTICK (Plate 11)

27. (*i*) Withdraw the two pins which secure the **joystick handle** with the firing switch box.
(*ii*) Withdraw the other handle and shaft complete.
(*iii*) Remove the split pin and nut which secures the **top swivel coupling** to the lever.
(*iv*) Remove the lever from the swivel.
(*v*) Disconnect the **elevating rod** from the **elevation toothed quadrant** by removing the nut at the bottom of the rod.
(*vi*) Remove the bolts which secure the elevation controller supporting bracket to the underside of the platform. The elevation controller and its supporting bracket can now be removed downwards so as to free the swivel coupling from its pivot on the end of the rod.
(*vii*) Withdraw the elevating rod upwards.
(*viii*) Remove the bolts which secure the bracket supporting the **training controller** to the underside of the platform.
(*ix*) This bracket, complete with controller, can now be moved clear of the **training toothed quadrant** and taken away.
(*x*) Unbolt the bracket supporting the **training centring gear.**
(*xi*) Remove the retaining nut and the two set bolts securing the training toothed quadrant to the lower end of the **training tube.**
(*xii*) Remove the training quadrant together with the centring gear.
(*xiii*) Unbolt and remove the **joystick column** from the pedestal.

Re-assembly

28. Re-assembly takes place in the reverse order to that in which the parts were removed.
(*i*) All moving parts are to be adequately lubricated.
(*ii*) At each stage of assembly check that all parts are free moving.
(*iii*) When re-assembling the controllers, the pinions must be correctly meshed with the toothed sectors. Reference marks are stamped on both the pinions and sectors and when these marks are in alignment the teeth are correctly meshed.

COOLING SYSTEM (*Plate 14*)

TO REMOVE PUMP IMPELLER

29. (*i*) Remove the pump casing and the bearing cover plate at the commutator end of the **pump motor.**
(*ii*) Hold the motor shaft by the flats provided at the commutator end, and unscrew the **impeller** by inserting a square bar in the square recess provided.

TO REMOVE GLAND ASSEMBLY

30. (*i*) The **spring, former, rubber washer** and **carbon ring** will probably all come away with the impeller, but the bronze **sealing ring** will probably remain in the **pump cover.**
(*ii*) If it is desired to remove the sealing ring, remove the two countersunk head screws and withdraw the pump cover. The bronze sealing ring can now be tapped out from the motor side of the cover.

TO RENEW ITEMS OF GLAND ASSEMBLY

31. (*i*) If the carbon ring and the bronze sealing rings are found to be ribbed, it is essential that the contacting surfaces should be machined smooth, and lapped together before re-assembly.
(*ii*) To fit a new sealing ring first ensure that the housing is clean. Smear the back and periphery of the ring with jointing compound ("stag" compound or similar), and then tap the ring into position in the pump cover, taking care not to tap on the lapped surface.
(*iii*) A new carbon ring can easily be fitted merely by straightforward replacement, but care should be taken to ensure that the slot in the ring engages the driving pin in the impeller boss.
(*iv*) A new rubber washer may be fitted after removing the driving pin, care being taken to replace the driving pin. If difficulty is experienced in fitting the washer over the impeller boss, it may be stretched as necessary by pulling it over a cone of wood. French chalk or petrol will assist fitting of washer.

Re-assembly

32. (*i*) Assemble the impeller, gland assembly and pump cover as a complete item. Ensure the slot in the carbon ring is engaging the driving pin, and then compress the impeller spring and pump cover as far as possible.
(*ii*) Bind a piece of thin cord around the impeller, passing the ends through the stud holes in the pump cover so that the gland assembly is held in its normal position, and the carbon ring is unable to disengage from the driving pin.

(*iii*) Screw the impeller on to the motor spindle, turning the pump cover with it, until, when the pump cover is nearly butting on the flange, cut the cord and withdraw it entirely. Insert and tighten the two countersunk head screws securing the pump cover.

(*iv*) Finally, tighten the impeller and replace the pump casing, with a thin paper joint between the flanges of the pump cover and casing.

JOYSTICK CONTROLLERS (*Ships Officers Drawings Nos. 68 and 69*)

REPLACEMENT OF INNER AND OUTER MOVING CONTACTS

33. Remove the insulating barrier (item 13) by removing the one OBA fixing screw. Both sets of 4BA fixing screws for items 15 and 16 are now accessible. When adjusting a new set of contacts the pressure should be 4¼ to 4½ ounces.

REPLACEMENT OF AUXILIARY CONTROL RESISTANCES

34. Remove all connections to the faulty unit, slacken the 2BA locknuts at the base casting end of the resistance unit support rods (item 28) and remove the unit by lowering the vertically slotted end and sliding out to the left when looking at the base casting end of the controller. Replace the new unit by reversing the above procedure.

REPLACEMENT OF MAIN CONTROL RESISTANCES

35. Half of the main control resistances are accessible immediately the protective cover (item 3) is removed. Access to the remaining units can be obtained by either of the following methods :—

(*i*) remove the resistance slab fixing screws and the fixing bracket (item 33) and slide the resistance slab up until it can be turned over, thus exposing the back units ;

(*ii*) slacken the two OBA locknuts and the two OBA fixing screws which hold the main slab in position. Slacken the resistance slab fixing screws. With a tommy bar unscrew the 4 main support posts (items 20, 21 and 22). Now, providing the two connections to the capacitor have been removed the whole electrical unit may be removed from the baseplate and any repairs, electrical or mechanical, may be carried out with the maximum of accessibility.

REPLACEMENT OF BALL RACES AND OIL SEAL

36. Proceed as detailed for the second method of replacing the main control resistances and then proceed as follows :

To remove the front ball race remove the moving bearing support arm (item 12) and the front bearing cover (item 18) and extract the front ball race.

To extract the rear ball race first remove the centre location device and then remove the rear bearing cover (item 38) and extract the ball race.

Note : Before fitting a new ball race first remove all the existing oil. Lubricate the new bearing with OM.35 oil.

To remove the oil seal remove the oil seal cover and extract the seal.

REPLACEMENT OF QUICK-BREAK SWITCH

37. If it is only necessary to replace the switch contacts, access to these is gained immediately the protective cover (item 3) has been removed. Should it be necessary to replace the quick-break switch complete, first proceed as detailed for the second method of replacing the main control resistance. Access is then gained to both front and back of the main slab.

THE METADYNE SET

METADYNE SET FOR BRITISH EQUIPMENT

38. In the event of any major repairs being necessary involving the withdrawl of armatures, the following procedure should be adopted.

The machines must first be separated at the spigotted joint as shown on the "ship's officers" drawings.

To Remove Metadyne Driving Motor Armature

39. Remove the shaft end cover at the commutator end, remove the nuts and bolts securing the outer bearing caps and lift the brushes clear of the commutator. The machine should then be stood vertically on end and the armature lifted out by means of the housing, at the same time the housing should be forced away from the yoke by means of forcing off screws in the tapped holes provided. When the housing is free, steady the armature against oscillation to avoid damage to the commutator.

To Remove Metadyne Armature

40. Take off the outer bearing cap at the non-driving end, disconnect the field to brushgear leads of the driving end metadyne and lift all brushes clear of the commutator. The machine should

then be stood vertically with the driving end uppermost and after removing the housing bolts the armature should be lifted out by means of the housing, the latter being forced away from the yoke using "forcing off" screws in the tapped holes provided. When the housing is free, steady the armature against oscillation to avoid damage to the commutators.

When remaking spigot joints, smear the steel faces with "luting" compound. The "luting" should be just thin enough for brush application. Thinning can be carried out with castor oil or white spirit.

METADYNE SET FOR CANADIAN EQUIPMENTS

41. As will be seen from the "ship's officers'" drawing the most convenient way of withdrawing the armature is to remove the fan cover, the fan hub and key, together with the bearing nut and lubricator from the metadyne end: the motor brush gear leads should be disconnected and the set then stood on end, if at all possible, with the motor end uppermost. After removing the housing bolts the armature may be lifted by means of a nut screwed on to the shaft end; at the same time the motor end housing should be forced from the yoke using forcing off screws in the tapped holes provided.

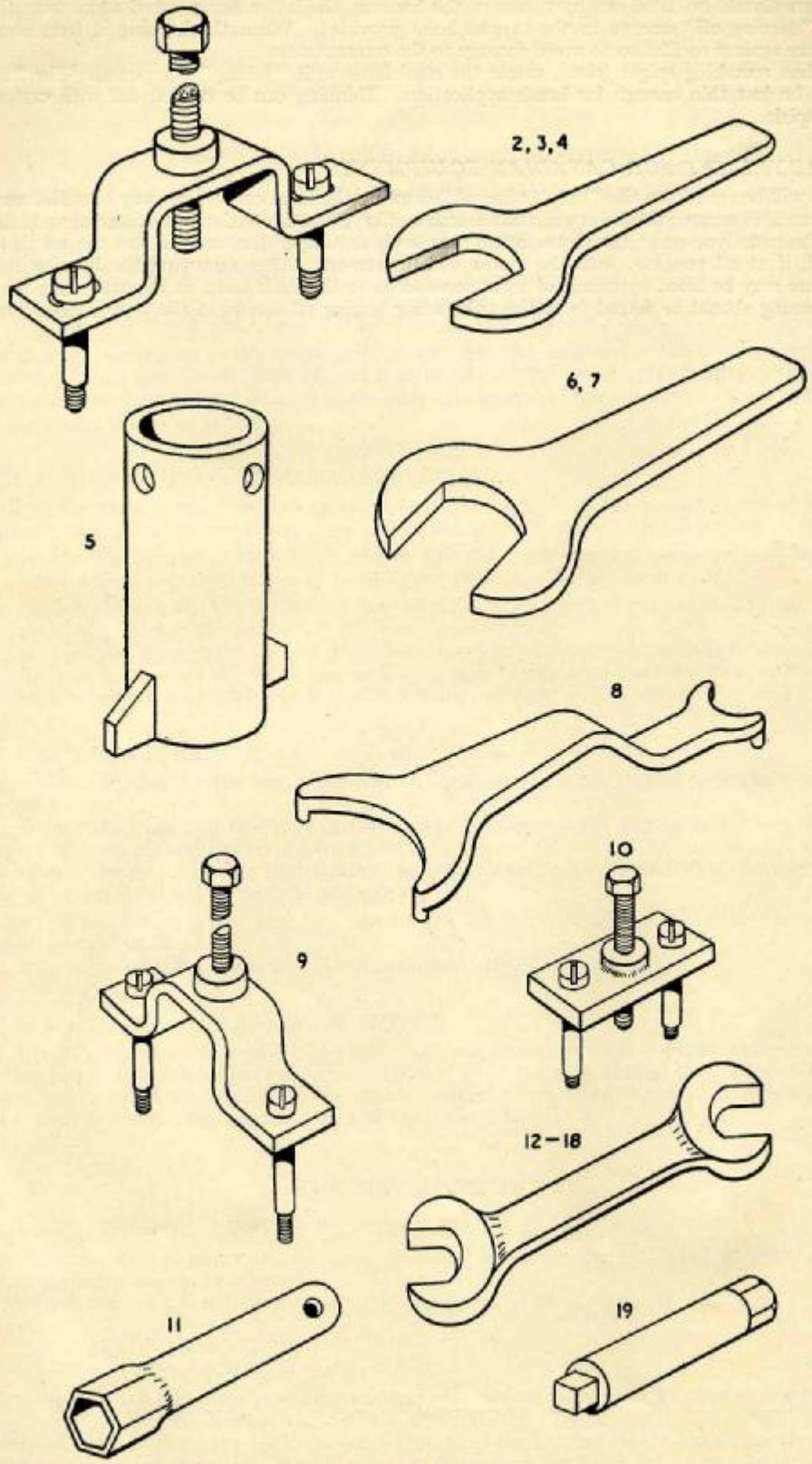


Diagram 20. Special Tools

APPENDIX I

SPECIAL TOOLS (*Diagram 20*)

INDEX NO.	USE	TO FIT ITEMS (DRG. AND ITEM NOS.)
1	Strongback for withdrawing wormwheels, elevating and training worm gear boxes.	1/GR.6552
2	Spanner to fit end cap, elevating and training worm gear boxes, and locknut and collar, hand friction clutch.	2/GR.6555 8 & 10/GR.6566
3	Spanner for cap, elevating and training hand gear box, and cover, elevating and training hand gear box.	5/GR.6558 9/GR.6571
4	Spanner for retaining nut, motor pinion bearing, glands, elevating and training worm gear boxes and for cover, elevating limit switch operating gear.	1/GR.6580 1/GR.6559 3/GR.6555
5	Spanner for retaining ring, elevating and training worm gear boxes.	4/GR.6552
6	Spanner for cover, elevating and training main gear boxes.	1/GR.6571
7	Spanner, single ended 1·0-in. B.S.F. for general use.	
8	Pin spanner to fit plug for cover and retaining nut, elevating and training main gear boxes.	12/GR.6555 7/GR.6562
9	Strongback for withdrawing wormwheel power firing clutch.	11/GR.6700
10	Strongback for withdrawing worm shaft bearing sleeve, elevating and training main gear box.	12/GR.6552
11	Box spanner 1·0-in. B.S.F. for nuts securing depression stop.	18/GR.6570
12	Double ended B.S.F. spanner for general use ·25-in.—·3125-in.	
13	Double ended B.S.F. spanner for general use ·3125-in.—·375-in.	
14	Double ended B.S.F. spanner for general use ·375-in.—·5-in.	
15	Double ended B.S.F. spanner for general use ·5-in.—·625-in.	
16	Double ended B.S.F. spanner for general use ·625-in.—·75-in.	
17	Double ended B.S.F. spanner for general use ·75-in.—·875-in.	
18	Double ended B.S.F. spanner for general use ·875-in.—1·0-in.	
19	Key for water pump impeller.	26/GR.6582

APPENDIX II

FAULT FINDING TABLE

FAULT	POSSIBLE SOURCES OF TROUBLE	PROCEDURE
1. METADYNE RUNNING lamp burning but POWER ON lamp not burning and mounting inoperative when ON push button is pressed.	(*i*) Test switch on amplifier not to RUN.	Check.
	(*ii*) Control contactor coil fuses blown.	Rewire.
	(*iii*) Clutch lever in HAND position.	Check.
	(*iv*) Control contactor overload operating due to overload on dead side of contactor.	If contactor closes and immediately opens when ON push is operated search for short circuit.
2. A.C. ON lamp not burning.	(*i*) Amplifier not switched on.	Check.
	(*ii*) Amplifier test switch not to RUN.	Check.
	(*iii*) Indicating lamp fuses blown or failure of lamp.	Replace fuse AP. 648 or lamp.
	(*iv*) No H.F. supply set running.	Check.
3. POWER ON lamp burns out mounting inoperative.	(*i*) Amplifier not switched on.	Check.
	(*ii*) Fault on amplifier.	Carry out amplifier tests.
	(*iii*) Motor field circuit broken.	
	(*iv*) Output relay circuit broken.	
4. Mounting hunts over a small arc (5 to 10 min.) with director stationary or when following the director follows very jerkily.	(*i*) Too much fine sensitivity or fine pre-retardation setting.	Decrease as necessary.
	(*ii*) Backlash between fine coincidence transmitter magslip and motor.	Examine resetter box and drive and rectify, or, as a temporary measure, reduce fine sensitivity and adjust fine pre-retardation to give best running.
5. Mounting follows director but with abnormal lag.	(*i*) Mechanical stiffness in drive from motor to mounting (for example brake incorrectly adjusted).	Move director very slowly and note armature current meter on amplifier. If the reading is more than about 12 amps. mechanical stiffness is indicated (assuming motor field current is normal).
	(*ii*) Amplifier sticking on coarse control.	Note if red or green lamp is illuminated on amplifier. If red, carry out appropriate amplifier tests. If tests prove amplifier correct, then magslips are incorrectly aligned.
	(*iii*) Amplifier sensitivity low.	Test amplifier.
	(*iv*) Weak signal from coincidence transmitter.	With no power on mounting operate director and measure maximum volts across SX-SY terminals of amplifier. This should be between 28 and 32 Volts. If much less replace coincidence transmitter.
	(*v*) Limit switch jammed, or fault in limit switch wiring causing auxiliary variator to be continuously energised and limit relay to be de-energised.	Operate push button and check correct functioning of limit relay. Offset director and switch power on. Mounting should run into line at about 25°/sec. If it runs in much slower then auxiliary variator may be energised.

FAULT	POSSIBLE SOURCES OF TROUBLE	PROCEDURE
6. Mounting runs round to stops although director is set between the stops.	(*i*) Amplifier failure.	Run through amplifier tests and repair or re-adjust as necessary. Check and rectify.
	(*ii*) Coarse magslip connections either X and Y crossed, SX and SY crossed or 1, 2, 3 stator connections incorrect.	*See* " Lining-up ", Chapter 5, para. 117. Check and rectify.
	(*iii*) Phase change in 1100 cycle supply.	Check.
7. When mounting runs in from large misalignment it either over-shoots or hesitates before lining up.	(*i*) Coarse pre-retardation setting incorrect.	(*i*) Increase pre-retardation to correct over-shoot or reduce pre-retardation to correct hesitation.
	(*ii*) Suspect coarse pre-retardation capacitors.	(*ii*) Check by measuring insulation or voltage across circuit.

" If adjusting the pre-retardation has no effect on the fault, the coarse pre-retardation capacitors should be tested by the following method :—

Make up a test lead with a length of 2 core cable, connecting a 47K, ¼ watt resistor in one lead and an insulated crocodile clip on the end of each lead. Remove the amplifier from its case and connect one end of the lead across one of the phase advance capacitors and the other end to the 200V, 1,100 cycle supply on the terminal grid. With an avometer, read the voltage across the capacitor. A short circuited capacitor will give no reading and an open circuited capacitor a 200V reading. If an intermediate reading is obtained the capacity in microfarads of the condenser is given by $\frac{0{\cdot}62}{V}$, where V is the voltmeter reading. When arriving at this figure, the tolerances of the capacitor (±20–25 %), the resistor (±1, 2 or 3%) and mains voltage and frequency (±5%) should be taken into account."

(G. 4041/55.—Amendment No. 8.)

8. With director stationary mounting hunts 2 or 3 degrees.	(*i*) Coarse zero point out of coincidence with fine zero point.	Observe amplifier pilot lamps. If they are repeatedly changing from red to green cut out the coarse control by withdrawing chassis at the instant red is changing to green and remove the coarse-fine relay valve or wedge pilot relay open. Replace chassis and put power on again. If hunting stops and the mounting lines up then coarse coincidence point is out of adjustment. Test amplifier balance. If correct then coarse magslips must be out of adjustment. Refer to " Lining up " Chapter 5, para. 117
	(*ii*) Fine coincidence point out of adjustment.	If, after removing the relay valve or wedging open the pilot relay as above, the hunting stops but the pointers do not line up (several degrees out) the fine magslips require realigning. Refer to " Lining up ", Chapter 5, para. 117.
	(*iii*) Fine magslip rotor connections, X, Y or SX, SY reversed.	Cut out the coarse control as above. If hunting stops but pointers line up 20 degrees out ; connections incorrect. Refer to " Lining up ", Chapter 5, para. 117, and correct connections.
	(*iv*) Fine magslip stator connections reversed.	Cut out the coarse control as above. Operate director and note direction of movement of mounting. Refer to " Lining up ", Chapter 5, para. 117, and correct stator connections if necessary.

APPENDIX III

SCHEDULE OF TESTS

(G.642 — British Manufacture. G.643 — Canadian Manufacture)

AUTO OPERATION OF 40 mm. BOFORS TWIN R.P. 50 MARK 5 MOUNTINGS

PERFORMANCE OF AUTO OPERATION SYSTEM

1. The mounting shall follow the auto transmissions so that the misalignment between the power transmitters and the motors driving the various motions of the mounting shall not exceed 3' of arc (except as may be otherwise stated) under any of the following conditions :—

2. *Training*

(*a*) At all speeds of transmission in the range from 4°–8°/min. up to 20°sec. and 4' (6' *for Canadian mountings*) of arc up to a speed of 30°/sec.

(*b*) With an acceleration or deceleration up to 15°/sec.².

(*c*) Under conditions of harmonic roll of amplitude ± 30° in 9 seconds period (maximum velocity 20·9°/sec. and acceleration of 14·6°/sec.²) except that a maximum misalignment of 6' will be accepted momentarily at the end of roll.

3. *Elevation.*

(*a*) At all speeds of transmission in the range from 4–8°/min. up to 20°/sec. and 4' (6' *for Canadian mountings*) of arc up to a speed of 25°/sec. (30°/sec. for Canadian mountings).

(*b*) With an acceleration or deceleration up to 15°/sec.

(*c*) Under conditions of harmonic roll of amplitude ± 30° in 9 seconds (maximum velocity 20·9°/sec. and acceleration of 14·6°/sec.²) except that a maximum misalignment of 6' will be accepted momentarily at the end of roll.

4. The motors driving the mounting shall line up with the director when the latter is stationary, within ± 1' of arc both in training and elevating under all conditions.

5. The motion of the mounting when auto operated from the director shall be free from jerk and oscillation under the conditions laid down in section 1 of this clause.

It shall also be free from oscillation about the alignment position and the overshoot when coming into line shall be reduced to a minimum, the important consideration being that the mounting shall line up with the transmission in the shortest possible time. In this connection the mounting should normally line up after one overshoot in one direction only (*after two overshoots for Canadian mountings*).

GENERAL

6. Each mounting is to be tested for performance in auto and joystick operation before despatch from the contractor's works.

7. Except where fundamental changes in design have been made which necessitate the first equipments being tested as a whole before despatch, the metadyne generators, amplifiers, etc., may be despatched direct to the Shipyard in advance of the mounting.

In such cases the mounting is to be tested with standard metadyne generating sets and amplifier which should be made available for this purpose.

8. Those portions of the equipment which are to be delivered in advance of the mounting (*see* para. 4 above) are to be subjected to the standard electrical tests before despatch and also such tests for individual items of equipment as are called for from time to time.

9. When the mounting is ready for test, the inspecting officers shall satisfy themselves that the misalignment meters are reading correctly by checking them against movement of the dummy director (*see* below) as read on the training and elevating dials of this instrument, power to the mounting being switched off and the mounting remaining stationary during this test. The amplifier settings for sensitivity and pre-retardation and the amount of armature current for 6 min. misalignment shall be recorded on the test sheets before commencing the trials and shall not be altered thereafter. Voltmeter and ammeter readings of the motors driving the metadyne sets and of the metadyne generators are to be measured and recorded on the test sheets for each test as may be applicable.

TEST RIG (DUMMY DIRECTOR)

10. In order to ascertain the overall performance of the control system when testing the complete equipment, a dummy director capable of simulating the motions produced by an actual director shall be used.

SCHEDULE OF TESTS AT MANUFACTURERS

The gun shall be on a level base for the purpose of these tests unless tests on a sloping platform are specifically called for by the Admiralty.

Copies of the results of these tests are to be forwarded through the Gun Mounting Overseer as follows :—

Original — To C.O. of Ship or Establishment in which the mounting will be installed.

3 *copies* — To Secretary of the Admiralty, "G" Branch, Bath. (Two will be retained by D.N.O. and one by D.E.E.)

1 *copy* — To the Electrical Sub-Contractor who manufactures the main electrical components of the particular mounting.

1 *copy* — Retained by the G.M.O. for record.

1 *copy* — Retained by the A.R.E.E. for record.

1 *copy* — To be passed by the A.R.E.E. to the outside erection staff of the electrical Sub-Contractor responsible for the installation, testing of the particular mounting at the ship or establishment concerned.

The original should be typed on paper of good quality and bound in a suitable folder to preserve it against wear and tear.

TEST NO. 1—BACKLASH TEST

Backlash

between the driving motors and the mounting ; and

between the mounting and the black pointers of the director receivers,

is to be measured and recorded for both training and elevating motions for various angular positions of the training and elevating racks.

The tests are to be carried out to the satisfaction of the Inspecting Officers.

TEST NO. 2—TEST OF LIMIT SWITCH AND BRAKING ARRANGEMENTS

Attempt to run into all stops (training and elevating) under power drive, *both auto and joystick* at all speeds up to maximum mounting speed. Impact on the stops and braking effect on the mounting due to the action of the limit switches to be observed in each case.

TEST NO. 3—OPERATION OF MAGNETIC BRAKES

"Stop" push to be pressed whilst the mounting is running at maximum speed. The mounting should be arrested without undue shock and the pressure of the brakes shall be such as to hold the mounting effectively.

TEST NO. 4—CONSTANT SPEED TEST

Train right and elevate simultaneously at constant rates of :—

(*a*) between 4° and 8°/min.—actual speed to be recorded on the test sheet ;

(*b*) 5°/sec., 10°/sec., 15°/sec., *20°/sec. (elevation only)—25°/sec. (training only) and maximum specified speeds.

Repeat training left and depressing.

Misalignment to be recorded and shall conform with the requirements of para. 1 of this schedule.

TEST NO. 5—HARMONIC ROLL TEST

Train and elevate simultaneously under simple harmonic motion at amplitude of ± 30° and periodic time of 9 sec. for both motions. Misalignment at mid point and end of roll to be recorded and shall conform with the requirements of para. 1 of this schedule.

TEST NO. 6—ALIGNMENT FROM INITIAL DISPLACEMENT

Offset dummy director to right training to angular values of 10', 2°, 15° and 80° and switch in the system. Repeat with mounting offset to left training, elevation and depression. Error in final misalignment to be recorded and shall conform with the requirements of para. 4 of this schedule. The extent of the overshoot, the number of oscillations before final alignment and the total time to come into stable alignment under each test shall also be recorded.

Note : The following data should be recorded during tests 4, 5 and 6 above.

(*a*) voltages, currents and speed of the motor driving the metadyne set ;

(*b*) metadyne armature current . voltages.

TEST NO. 7—OVERALL SENSITIVITY TEST

With mounting stationary at zero training, train director (*a*) right, (*b*) left *very slowly*. Record displacement of director in minutes of arc which just causes mounting to move.

Repeat test for elevation motion (elevating and depressing) at 45° of gun elevation.

TEST NO. 8—ACCELERATION TEST

(*a*) For the first mounting of a type or when specifically called for by the Admiralty the time to accelerate to maximum specified velocity in elevation and training, simultaneously and separately and also the number of degrees taken to reach maximum specified speed under these conditions should be recorded.

This test should be carried out as follows :—

Obtain values of the dummy director transmission speeds for training and elevating in each direction at which the mounting lag gradually increases, *i.e.*, speeds slightly above the maximum mounting speeds. With the appropriate speed setting for the motion under test and the director and mounting lined up, switch on power and then switch on the dummy director.

(*b*) Oscillograms of training and elevation driving motor voltage and current or a photographic record of training and elevation receivers against a time base taken with a cine-camera running at 32 or 64 frames/sec. should be taken. Copies should be included in the test report.

From the information thus obtained, velocity time curves should be plotted from 0°/sec. to the balancing speed of the mounting.

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* Applies to British mountings only.

(*c*) The time taken for the mounting to traverse from rest through arcs of 60° and 120° in training and 40° and 70° in elevation, should be recorded.

This test is required for all mountings and should be taken by off-setting the dummy director by a sufficiently large angle to prevent retardation commencing and switching in the system. (The elevation motion must be off-set beyond the mounting stops in this case.) These times should be taken with the motions operating separately.

TEST NO. 9—OPERATION OF SECTOR CONTROL

The maximum constant speed of the mounting in training (right and left) when in sector control is to be determined. This shall be done by recording the time taken by the mounting to train from rest through arcs of (*a*) 60°, and (*b*) 120°.

TEST NO. 10—JOYSTICK OPERATION

This is to be tested to the satisfaction of the Admiralty Inspecting Officers. It should be capable of [illegible] laid down in para. 1 of this schedule.

The electrical circuits are to be so adjusted that the speeds in training and elevation will be within [illegible]ien the following limits :—

Training, 35°/sec. maximum, 33°/sec. minimum.

Elevation, 28°/sec. maximum, 26½°/sec. minimum. 40°

(33 to 31½°/sec. *for Canadian mountings*).

(G. 3941/57.—Amendment No. 9.)

TEST NO. 11—HAND EFFORTS

Hand efforts, training right and left, to be recorded at intervals of 30° and elevating and depressing every 15°.

TEST NO. 12.—The rendering device should be adjusted both in elevating and training motions to render in either direction with a torque of 24 lb. ft. using clutch setting gear shown on drawing D.N.O. 8989 (*see* Diagram 4A) applied at the motor coupling.

(G. 181/57.—Amendment No. 9.)

TEST NO. 13—FIRING GEAR

With firing motor running, operate joystick trigger to ensure correct functioning of firing gear.
Test to be carried out to the satisfaction of the Inspecting Officer.
Firing motor voltage and amps. under load and no load conditions to be recorded.
Foot pedal effort to be recorded.

TEST NO. 14—SAFETY FIRING GEAR

With firing gear in fired position, both power and pedal, correct functioning of safety firing gear to be checked.

Test to be carried out to satisfaction of the Inspecting Officer.

The backlash in this gear is not to exceed 2° in elevation.

TEST NO. 15—CLUTCH INTERLOCK SWITCHES

With elevating and training Hand/Power clutches set to HAND positions ensure that clutch interlock switches operate, *i.e.*, that power cannot be applied to either motion.

TEST NO. 16—WATER CIRCULATING SYSTEM

To be to the satisfaction of the Inspecting Officer. Voltage and amps. under load to be recorded.

TEST NO. 17—SIGHTS TO BE LINED UP TO DIAGRAM G.R. 6890

TEST ON ROLLING PLATFORM. If desired by the Admiralty, tests will be called for with the mounting on a rolling platform. Details of the tests required will be forwarded should this be required.

OSCILLOGRAPHIC RECORDS For the first mounting of a type or when specifically called for by the Admiralty oscillographic records shall be taken of (*a*) voltages and currents of metadyne set driving motor, (*b*) gun driving motor currents and voltages, (*c*) misalignment (where applicable) for tests 2, 5, 6 and 10. For tests 2 and 10 the oscillograms shall be obtained with the elevating and training motions being tested separately and for tests 5 and 6 simultaneously.

Notes

TEST 2. Oscillograms of gun driving motor currents and voltages for maximum speeds, right training and elevating only are required. Oscillograms are to show mounting coming off the stops.

TEST 6. Oscillograms to be taken when running in from 80° misalignment, right training and elevation only.

TEST 10. Maximum braking information is also to be obtained by throwing the joystick controllers in the reverse direction, once maximum speed has been attained to stud 20, the point on which the external resistances in the main and auxiliary variator circuits are zero.

RESTRICTED

40 mm. Twin R.P. 50 Mk. 5 Mtg.

Mtg. Reg. No.

Report of tests at Maker's Works before delivery.
In accordance with Admiralty Schedule of Tests, G. 642 (or G. 643 for Canadian Mountings).

Admiralty Contract No.

Ship or Service.

Manufacturer.

Date

ADDENDUM TO SHOP TRIAL REPORT

40 mm. Twin R.P. 50 Mk. 5 Mtg.

Auto Operation History Sheet

DESCRIPTION	MANUFACTURED BY	MARK NO.	MAKER'S DRAWING NUMBER	MAKER'S SERIAL NUMBER
Gun Training Motor				
Gun Elevating Motor				
Trg. Resetter Box...				
Elev. Resetter Box				
Trg. Joystick Controller				
Elev. Joystick Controller...				
Trg. Clutch Interlock				
Elev. Clutch Interlock				
Trg. Limit Switch...				
Elev. Limit Switch				
Lamp Box 3 Way...				
Push Button Box				
Trg. Sector Switch				

AUXILIARY MOUNTING EQUIPMENT

DESCRIPTION	MANUFACTURED BY	MARK NO.	MAKER'S DRAWING NUMBER	MAKER'S SERIAL NUMBER
Water circulating Pump Motor				
Firing Motor				
Type 6 Mk. 2 Sight				
Range Unit				
Dimmer Unit				
Regulator Unit				
Immersion Heater...				

SHOP SLAVE TESTING EQUIPMENT

DESCRIPTION	MARK NO.
*Metadyne Motor Generator Set	
Amplifier	
Metadyne Auto Starter	
Metadyne Contactor and Relay Panel	
Motor Alternator Set	

* Elevation and training sets quoted separately for Canadian equipments.

40 mm. Twin R.P. 50 Mk. 5 Mtg.

Reg. No.

Date of Trial

Amplifier Settings *Trg.* *Elev.*

Sensitivity (with meter)

Pre-retardation

Armature current for 6 mins. displacement

Check of misalignment meters

TEST NO. 1—BACKLASH TEST

(*i*) Between driving motors and mounting.

Elevating

ANGULAR POSITION	~~18°~~ 14° D	0°	15°	30°	45°	60°	75°	90°
Backlash								

Training

ANGULAR POSITION	0°	60°	120°	180°	240°	300°	
Backlash							

(*ii*) Between Mounting and Black pointer of Director Indicator.

Elevating

ANGULAR POSITION	~~15°~~ 14° D	0°	15°	30°	45°	60°	75°	90°
Backlash								

Training

ANGULAR POSITION	0°	60°	120°	180°	240°	300°	
Backlash							

TEST NO. 2—TEST OF LIMIT SWITCH AND BRAKING ARRANGEMENTS

Impact on the stops and braking effect due to limit switches to be observed.

CONDITION	OBSERVATION		
	AUTO CONTROL	JOYSTICK CONTROL	SECTOR CONTROL
Training Right			
Training Left			
Elevating			
Depressing			

TEST NO. 3—OPERATION OF MAGNETIC BRAKES

"Stop" push to be pressed while mounting is running at maximum speeds.

Observation .....

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TEST NO. 4—CONSTANT SPEED TESTS

Train right and elevate, and train left and depress at constant speeds of between 4° and 8°/min. (actual speed to be recorded) 5°/sec., 10°/sec., 15°/sec., 20°/sec. (elevation only), 25°/sec., 30°/sec. (training only).

Training Right and Elevating

SPEED	LAG		MOTOR DRIVING METADYNE SET			TRG. GENERATOR		ELEV. GENERATOR	
	Trg.	*Elev.*	*Volts*	*Amps.*	*R.P.M.*	*Volts*	*Amps.*	*Volts*	*Amps.*
per min.									
5° per sec.									
10° ,, ,, ...									
15° ,, ,, ...									
20° ,, ,, ...	—					—	—		
25° ,, ,, ...		—							
30° ,, ,, ...								—	—

Training Left and Depressing

SPEED	LAG		MOTOR DRIVING METADYNE SET			TRG. GENERATOR		ELEV. GENERATOR	
	Trg.	*Elev.*	*Volts*	*Amps.*	*R.P.M.*	*Volts*	*Amps.*	*Volts*	*Amps.*
per min.									
5° per sec.									
10° ,, ,, ...									
15° ,, ,, ...									
20° ,, ,, ...	—					—	—		
25° ,, ,, ...		—							
30° ,, ,, ...								—	—

Separate tables required for elevation and training metadyne generators in Canadian equipments

TEST NO. 5—HARMONIC ROLL TEST

Training and elevate simultaneously under simple harmonic motion at amplitude of ± 30° and periodic time of 9 sec. for both motions (max. vel. 20·9°/sec. and accel. 14·6°/sec.²).

MOTOR DRIVING METADYNE SET			MOTION	METADYNE ARMATURE CURRENT	
Volts	*Amps.*	*R.P.M.*		*Volts*	*Amps.*
			Peak—Training ... ... Peak—Elevating		

Misalignment

MOTION	END OF ROLL	MIDDLE OF ROLL
Training Right ... ... Training Left ... ... Elevating ... ... Depressing		

TEST NO. 6—ALIGNMENT FROM INITIAL DISPLACEMENT

Offset dummy director to right training to angular values of 10 min. 2°, 15° and 80° and switch in system. Repeat with mounting offset to left training, elevating and depressing.

DIRECTOR OFFSET	ERRORS IN ALIGNMENT	MOTOR DRIVING METADYNE SET			GENERATOR	OVER-SHOOT	OSCILLA-TIONS	TIME *Sec.*
		Volts	*Amps.*	*R.P.M.*				
Trg. Right								
10 min.								
2°								
15°								
80°								
Trg. Left								
10 min.								
2°								
15°								
80°								
Elevating								
10 min.								
2°								
15°								
80°								
Depressing								
10 min.								
2°								
15°								
80°								

TEST NO. 7—OVERALL SENSITIVITY TEST

Train dummy director very slowly until mounting just moves and record displacement. Repeat for elevation and depression at 45°.

	TRAINING RIGHT	TRAINING LEFT	ELEVATING	DEPRESSING
Displacement				

TEST NO. 8—ACCELERATION TEST

Time taken for mounting to move from rest through arcs of 60° in training and 40° in elevation.

MOTION	ANGLE	TIME (SECS.)	
		PERMISSIBLE MAXIMUM	ACTUAL
Training Right	60°	2·8	
Training Left	60°	2·8	
Elevating	40°	2·2	
Depressing	40°	2·2	

(2) Starting from rest at extreme limit of depression, record the time taken for the mounting to elevate from +40° to +70° at maximum speed, and repeat for depressing from extreme elevation, recording between +30° and 0°.

MOTION	ACTUAL TIME IN SECS. (TO BE DETERMINED WITHIN ACCURACY OF RECORDING METHOD USED)	PERMISSIBLE THEORETICAL TIME	
		MAX. (SECS.)	MIN. (SECS.)
Elevating		1·13	1·07
Depressing		1·13	1·07

(G. 4041/55.—Amendment No. 8.)

Time taken for mounting to traverse from rest through arcs of 60° and 120° in training and 40° and 70° in elevation to be determined. ~~The maximum training speed not to exceed 35°/sec. and elevation speed~~

The speeds in training and elevation are to be within the following limits :—

Training, 35°/sec. maximum, 33°/sec. minimum.

Elevation, 28°/sec. maximum, 26½°/sec. minimum.

(G. 3941/57.—Amendment No. 9.)

Training Right ...	60°		Elevating	40°	
	120°			70°	
Training Left ...	60°		Depressing	40°	
	120°			70°	

TEST NO. 11—HAND EFFORTS

MOTION	0°	60°	120°	180°	240°	300°
Training right						
Training left						

MOTION	14° ~~15°~~ D	0°	15°	30°	40°	60°	75°	90°
Elevating								
Depressing								

TEST NO. 12—RENDERING DEVICE

Rendering device should be adjusted both in elevating and training motions to render in either direction with a torque of 24 lb. ft. using clutch setting gear shown on drawing D.N.O. 8989 (*see* Diagram 4A) applied at the motor coupling.

(G. 181/57.—Amendment No. 9.)

OBSERVATION.

TEST NO. 13—FIRING GEAR

With firing motor running operate joystick trigger to ensure correct functioning of firing gear. Guns to be cocked.

Observation

Firing Motor Current and speed.

CONDITION	VOLTS	AMPS.	R.P.M.
No load			
Firing load			

Foot pedal effort, guns cocked. lb.

TEST NO. 14—SAFETY FIRING GEAR

With firing gear in fired position, both power and pedal, correct functioning of safety firing gear to be checked.

Observation .....

TEST NO. 15—CLUTCH INTERLOCK SWITCHES

With elevating and training Hand/Power clutches set to HAND positions ensure that clutch interlock switches operate.

Observation .....

TEST NO. 16—WATER CIRCULATING SYSTEM

	VOLTS	AMPS.
Pump running		

Circulation of water.

Observation .....

TEST NO. 17—Sights to be lined up to Diagram G.R. 6890.

Observation .....

TEST NO. 18

Clip roller clearance set at .....

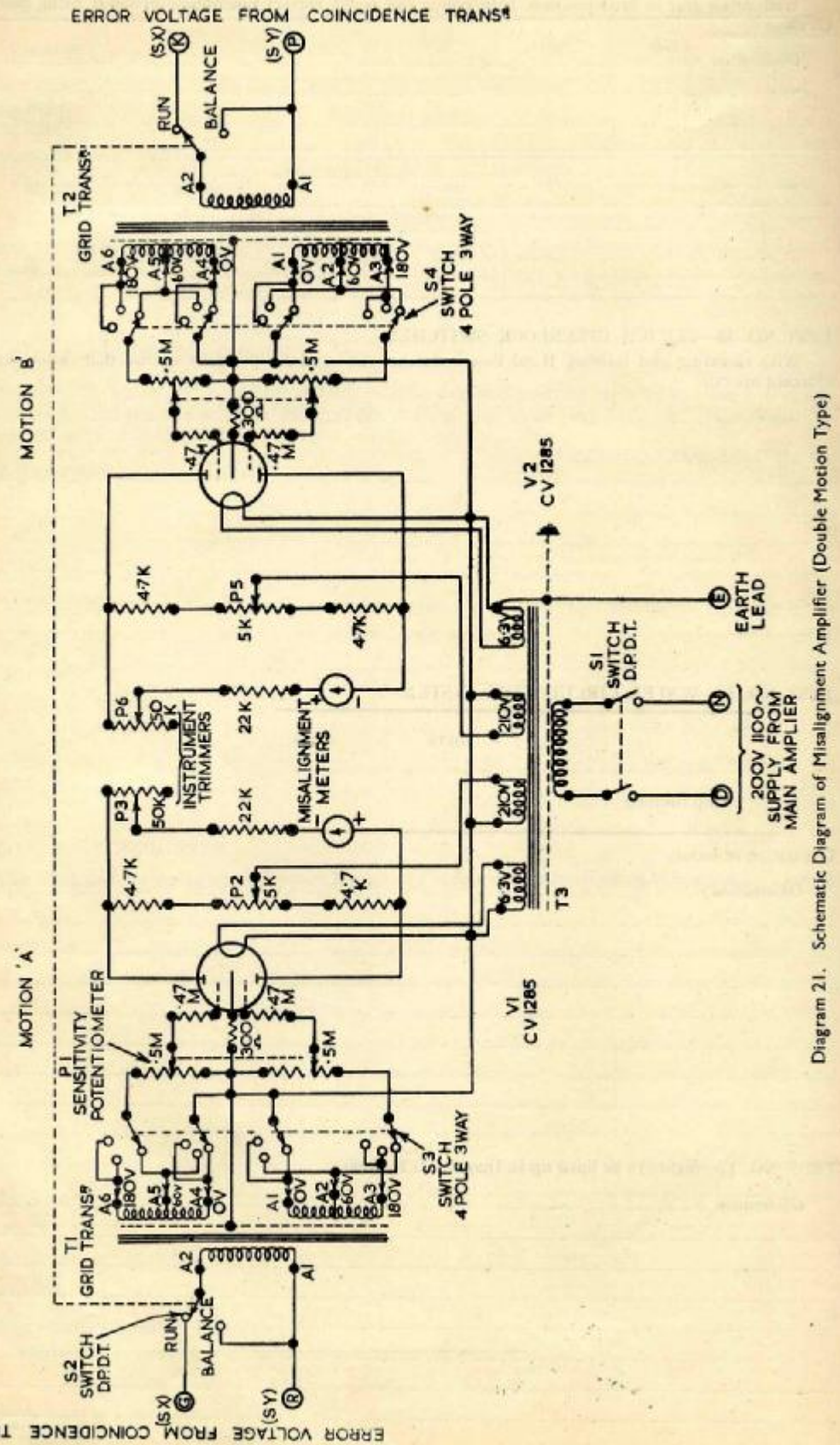

Diagram 21. Schematic Diagram of Misalignment Amplifier (Double Motion Type)

APPENDIX IV

MISALIGNMENT AMPLIFIER UNIT (DOUBLE MOTION TYPE)

(see Diagram 21 for circuit arrangement)

The function of the amplifier unit is to measure the voltage of the coincidence transmitter magslips in auto systems. This voltage is proportional—within the working range of the amplifier unit—to the misalignment between the director and the mounting. Therefore, the amplifier output is a direct measure of the misalignment. The output is indicated on a centre zero instrument scaled 10–0–10, which has to be calibrated against a known misalignment before use.

The amplifier unit is a two motion unit, that is, it consists of two independent misalignment amplifiers, which can be used simultaneously.

The coincidence transmitter voltages are applied to the primaries of the grid transformers T1 and T2. The secondary windings are provided with a number of taps so that the transformer ratios may be varied by means of the "coarse sensitivity" switches S3 and S4; these switches have 3 positions—LOW, MEDIUM and HIGH. Ganged "fine sensitivity" potentiometers P1 and P4 are connected across the outputs from the selected secondary windings and the sliders of the potentiometers are connected to the grids of double triode valves type NR.73 (CV 1285). These circuits are arranged so that grids are in push-pull.

The coarse and fine sensitivity controls are necessary so that the amplifier can be used with magslips having sector values between 5° and 180°. The maximum sensitivity at which the amplifier can be set is normally only required at the highest sector value, and the following figures will give some idea of the results which may be expected if this setting is used :—

SECTOR VALUE	MISALIGNMENT FOR 10 DIVISIONS DISPLACEMENT OF METER
5°	1 min.
10°	2 min.
40°	8 min.
180°	36 min.

Normally, with sector angles up to and including 40° it will not be necessary to use a sensitivity higher than that which will give a meter displacement of 10 divisions for a misalignment of 10 min.

The anodes of the valves are supplied with A.C. from the same source as the magslip chain, a transformer being used to obtain the correct voltage. The anodes are arranged to be in phase. When the coincidence transmitter voltage is zero, that is, when there is no misalignment, the currents in the two halves of the valves are equal, and therefore the voltage across the anodes is zero. Any out of balance due to manufacturing tolerances in valve characteristics and component values is adjusted by means of amplifier trimmer potentiometers, P2 and P5 in the anode circuits.

A voltage from the coincidence transmitter corresponding to a certain relative displacement of the director and the mounting causes the current in one half of the valve to increase and that in the other to decrease. A difference of voltage now occurs across the anodes and is measured by the instrument connected between these two points. Adjustable resistances P3 and P6 known as "instrument trimmers" enable the instruments to be calibrated against a known applied signal.

Method of calibrating the Misalignment Meter

As the misalignment meter is more accurate than any of the indicators fitted on auto systems it is necessary to calibrate the meter independently. To do this the following procedure is to be adopted.

1. Ascertain the maximum voltage which can be obtained from the magslip chain concerned. This can be done by rotating a magslip and measuring the maximum coincidence transmitter voltage with an Avo.

2. Decide on the misalignment that the full scale deflection of meter shall represent.

3. From the above determine the magslip voltage appropriate to the maximum misalignment. The following example illustrates this.

The maximum magslip voltage Vm is 25 volts. The sector value of the magslip chain is S – 40° whilst the full scale deflection shall be made equal to Mx = 10 min.
Misalignment voltage for 10 min.

$$V = Vm \sin \frac{360}{S} Mx$$

$$= 25 \sin \frac{360}{40} 10$$

$$= 25 \sin 90' = 25\ 0{\cdot}0262$$

$$= 0{\cdot}655 \text{ volts}$$

4. Connect up to the main amplifier using the flexible multicore lead provided.

5. Set the pointer of the instrument to zero by means of the mechanical adjustment provided on the instrument.

6. Turn the run/balance switch to BALANCE and, using the amplifier trimmer, balance the amplifier, when this is done turn the switch to the RUN position (the instrument should read zero).

7. Insert the maximum resistance in the instrument circuit by turning the instrument trimmer in a counter clockwise direction.

8. Select the motion to be tested by means of the Motion A—Motion B selector switch.

9. Switch the Instrument run/balance switch to RUN and switch the main amplifier Test/Run switch to TEST.

10. Check that the instrument amplifier is still balanced with zero input test signal from the main amplifier.

11. Apply a test signal voltage equal to 125 per cent. of the maximum misalignment voltage (V).

12. With this voltage select the first valve of coarse sensitivity beginning with the lowest at which saturation may be obtained by increasing the fine sensitivity. Saturation will be indicated when an increase in fine sensitivity produces no further (or very little) increase in meter deflection. The fine sensitivity setting at which this condition first exists is the correct one.

13. Reduce the test signal voltage to the maximum misalignment voltage and using the instrument trimmer adjust the instrument to read 10 divisions.

14. Apply an equal test signal in the opposite direction. The instrument should again read 10, but on the other half of the scale. If this is not the case, compromise by adjusting the instrument trimmers to obtain equal error on the instrument for clockwise and counter-clockwise signal.

Note: This error will be positive in one direction and negative in the other, *i.e.*, the instrument will read slightly over " 10 " one way and slightly under " 10 " in the other.

15. Reduce the test voltage by 50 per cent. The instrument should now indicate half its original value. If this is not so it is an indication that the amplifier is saturating during its working range. It will therefore be necessary to repeat the adjustments as outlined above substituting say 150 per cent. instead of 125 per cent. in the saturation test.

Note: Once the meter has been set up for a particular magslip chain it should not be necessary to recalibrate it for a very long period unless some of the components of the instruments are changed. As the meter settings will vary from one magslip chain to another it is suggested that paper dials be pasted on the front of the meter and the dial settings for each magslip chain be marked on them.

APPENDIX V

ELECTRICAL DIFFERENCES BETWEEN MARK 5 AND MARK 5* MOUNTING

	MARK 5	MARK 5*
Firing motor	220 volt D.C.	440 volt, 3 phase, 60 cycle, A.C.
Water circulating pump motor	220 volt D.C.	440 volt, 3 phase, 60 cycle, A.C.
Immersion heater	220 volt D.C. 3 heat	440 volt, 3 phase, 60 cycle, A.C. 2 heat
Metadyne driving motor ..	220 volt D.C.	440 volt, 3 phase, 60 cycle, A.C.

The Mark 5* has, in addition, a metrosil fitted across the training limit switch to limit the maximum training speed to 35°/sec., and an interlocking relay, I.R.1, to ensure that the 220 volt D.C. control circuits are not energised until the metadyne set is running (*see* Plate 17A).

APPENDIX VI

DETAILS AND NUMBERS OF MODIFICATIONS TO THE MOUNTINGS

Serial numbers have been allocated to all modifications authorised to the 40 mm. Bofors Twin R.P. 50 Mark 5 mountings as follows. Details of future modifications with their modification numbers will be promulgated as amendments to this handbcok.

AUTHORITY	DESCRIPTION	DRG. OR DIAG. NO.	CATEGORY OF MOD.	SUPPLY OF MATERIAL	BY WHOM TO BE DONE	MOD NO.
—	Elevating and training friction clutches. Brass liner introduced between steel sliding surfaces to prevent seizure.	G.R.6560	—	—	Prior to delivery and retrospective only if defects develop.	1
	Safety firing gear differential box. Stop provided on G.M. cover, 4/G.R. 6658 replaced by steel insert.	G.R.6658	—	—		2
	Clutch operating gear lever. Travel increased to cut out switch before hand clutch is engaged.	G.R.6572 G.R.6574	—	—		3
	Elevation limit switch operating gear. Quadrant and gear teeth strengthened by increase in width.	G.R.6580	—	—		4
	Fitting of armament broadcast loudspeakers on mounting.	G.R.6668 Sh. 1 and 2	—	—	Prior to delivery. Not retrospective unless approved as a definite requirement.	5
A.F.O. 6722/45.	Provision of canvas cover, scotchman and muzzle bags.	A.F.O. Diagrams 411/45 (1–4) DRG NO G.3000. SH.1-4	As required	—	Prior to delivery and retrospectively if necessary.	6
A.F.O. 6874/45.	Fitting of training balance weight.	A.F.O. Diagrams 415/45 DRG. NO. G.R. 6847	Defect	—	Ships' staffs assisted where necessary by Dockyards and Repair Establishments.	7
A.F.O. 1027/46	To make a tool for removing trunnion ball races.	A.F.O. Diagram 41/46 DRG NO G.R. 7145	Defect	—	Ships' staffs, depot ships or repair establishments	8
A.F.O. ~~1449/46~~ 3361/51	Replacement of firing cam, to prevent a runaway gun in cases of faulty adjustments.	A.F.O. Diagram ~~58/46~~ 72/51 DRG NO G.R.6594	~~Classification "A"~~ DEFECT	—	Ships' staffs, assisted where necessary by Dockyards and repair establishments	9
A.F.O. 4195/47 (cancels A.F.O. 4030/47)	Drain hole provided in support tube between carriage plates.	A.F.O. Diagram 168/47 PART DRG. NO. G.R.6515/R.B. SH.2, ITEM 15	Defect	—	Ships' staffs and G.E. depots for mountings in store	10
A.F.O. 585/49	Repositioning of last cable clip on mounting to clear hole in gun for extractor spindle.	A.F.O. Diagram 26/49 DRG. NO. G.R.7439	Defect	—	Ships' staffs	11

AUTHORITY	DESCRIPTION	DRG. OR DIAG. NO.	CATEGORY OF MOD.	SUPPLY OF MATERIAL	BY WHOM TO BE DONE	MOD NO.
A.F.O. 689/52	Fitting Type 6 Sight of British manufacture	A.F.O. Diagram 13/52 DRG NO. GR.7503 (MOD IF REQ)	Defect	—	Ships' staffs assisted where necessary by Dockyards and Repair Establishments	12
A.F.O. 2473/52	Welding ends of segments in Differential Gear Box	—	Defect	—	Ships' staffs with assistance of Dockyards, Repair Establishments and Depots	13
A.F.O. 2598/52	Modified bolt to clear rate testing telescope of Type 6 Sight	A.F.O. Diagram 59/52 DRG. NO. D.N.O. 8638	Defect	—	Ships' staffs with assistance of Dockyards, Repair Establishments and Depots	14
A.F.O. 2660/52	Mods to cover of Differential Gear Box Cover	—	Defect	—	Ships' staffs with assistance of Dockyards, Repair Establishments and Depots	15
A.F.O. 1831/53 (Amended by A.F.O. 2252/53)	Power and hand clutches —locking plates added	A.F.O. Diagram 30/53 DRG. NO. G.2383	Defect	—	Ships' staffs, Repair Establishments and Depots	16
A.F.O. 3038/53	Addition of stop piece on door connecting link	A.F.O. Diagram 49/53 DRG. NO. D.N.O. 9298	Defect	—	Ships' staffs, Dockyards, Repair Establishments and Depots as applicable	17
A.F.O. 187/54	Repositioning of battery lubricator plate	A.F.O. Diagram 2/54 PART DRG. NO. G.R. 6581	Defect	—	Ships' staffs, Repair Establishments and Depots	18
A.F.O. 550/54	Conversion of Mark 4 to Mark 11 Gun Modifications to sight bracket bolts	A.F.O. Diagram 8/54 DRG. NO. D.N.O. 9334	Defect	—	Ships' staffs, Repair Establishments and Depots	19
A.F.O. 778/54	Reduction of angles of depression	A.F.O. Diagram 11/54 PART DRG. NO. G.R. 6570	Defect	—	Ships' staffs, Repair Establishments and Depots	20
A.F.O. 1072/54	Pedal Firing Gear Provision of positive top	A.F.O. Diagram 17/54 PART DRG. NO. G.R. 6834	Defect	—	Ships' staffs, Repair Establishments and Depots	21

A.F.O. 1346/54	Check Fire Lamp to point upwards to layer's eyes	—	Defect	—	Ships' Staffs, Repair Establishments and Depots	22
A.F.O.	Backlash in Receiver	—	Defect	—	—	23
A.F.O. 287/56	Elevating and Training zero Alignment Indicators	A.F.O. Diagram 8/56 (1) and (2) Drg. No. D.N.O.9623 and D.N.O.9624	Defect	—	Ships' Staffs, assisted by Dockyards if necessary, Shore and Repair Establishments and G.E. Depots	27

AUTHORITY	DESCRIPTION	DRG. OR DIAG. NO.	CATEGORY OF MOD.	SUPPLY OF MATERIAL	BY WHOM TO BE DONE	MOD NO.
A.F.O. 689/52	Fitting Type 6 Sight of British manufacture	A.F.O. Diagram 13/52 DRG NO. GR.7503 (MODIFIED)	Defect	—	Ships' staffs assisted where necessary by Dockyards and Repair Establishments	12
A.F.O. 2473/52	Welding ends of segments in Differential Gear Box	—	Defect	—	Ships' staffs with assistance of Dockyards, Repair Establishments and Depots	13
A.F.O. 2598/52	Modified bolt to clear rate testing telescope of Type 6 Sight	A.F.O. Diagram 59/52 DRG. NO. D.N.O. 8638	Defect	—	Ships' staffs with assistance of Dockyards, Repair Establishments and Depots	14
A.F.O. 2660/52	Mods to cover of Differential Gear Box Cover	—	Defect	—	Ships' staffs with assistance of Dockyards, Repair Establishments and Depots	15
A.F.O. 1831/53 (Amended by A.F.O. 2252/53)	Power and hand clutches —locking plates added	A.F.O. Diagram 30/53 DRG. NO. G.2383	Defect	—	Ships' staffs, Repair Establishments and Depots	16
A.F.O. 3038/53	Addition of stop piece on door connecting link	A.F.O. Diagram 49/53 DRG. NO. D.N.O. 9298	Defect	—	Ships' staffs, Dockyards, Repair Establishments and Depots as applicable	17
A.F.O. 187/54	Repositioning of battery lubricator plate	A.F.O. Diagram 2/54 PART DRG. NO. G.R. 6581	Defect	—	Ships' staffs, Repair Establishments and Depots	18
A.F.O. 550/54	Conversion of Mark 4 to Mark 11 Gun Modifications to sight bracket bolts	A.F.O. Diagram 8/54 DRG. NO. D.N.O. 9334	Defect	—	Ships' staffs, Repair Establishments and Depots	19
A.F.O. 778/54	Reduction of angles of depression	A.F.O. Diagram 11/54 PART DRG. NO. G.R. 6570	Defect	—	Ships' staffs, Repair Establishments and Depots	20
A.F.O. 1072/54	Pedal Firing Gear Provision of positive top	A.F.O. Diagram 17/54 PART DRG. NO. G.R. 6834	Defect	—	Ships' staffs, Repair Establishments and Depots	21

A.F.O. 1346/54	Check Fire Lamp to point upwards to layer's eyes	—	Defect	—	Ships' Staffs, Repair Establishments and Depots	22
A.F.O.	Backlash in Receiver	—	Defect	—	—	23
A.F.O. 287/56	Elevating and Training zero Alignment Indicators	A.F.O. Diagram 8/56 (1) and (2) Drg. No. D.N.O.9623 and D.N.O.9624	Defect	—	Ships' Staffs, assisted by Dockyards if necessary, Shore and Repair Establishments and G.E. Depots	27

AUTHORITY	DESCRIPTION	DRG. OR DIAG. NO.	CATEGORY OF MOD.	SUPPLY OF MATERIAL	BY WHOM TO BE DONE	MOD. NO.
A.F.O. 3136/56	Training and Elevation motor clutch testing gear. Provision of access through floor plates to Elevation motor clutch.	A.F.O. Diagram 63/56 (1–2) Drg. Nos. D.N.O. 8989 and	Defect	On demand —	Ships' Staffs, with assistance of Dockyards and Gunnery Equipment Depots.	28
A.F.O. 3010/57	Elevation and Training Receiver Support Brackets —Waterproofing Arrangements— fitting of G.A.C.O. " Hat " seal	A.F.O. Diagram 41/57 D.N.O. 10247	Defect	To be demanded	Ships' Staffs, Shore Establishments, Dockyards, Repair Establishments and Gunnery Equipment Depots	29
A.F.O. 691/58	Hand Elevating and Training Lower Bevel Boxes— arrangements for water-proofing	A.F.O. Diagram 8/58 Drg. No. Part G.R. 6578	Defect	To be demanded	Ships' Staffs, Shore Establishments, Dockyards, Repair Establishments and Gunnery Equipment Depots	30
A.F.O. 1205/57	Elevating and Training Drives— Friction Clutches— Lockwasher for Set Screw	— Dwg N's GR 6660 & GR6772.	Defect	To be demanded	Ships' Staffs, Shore Establishments, Dockyards, Repair Establishments and Gunnery Equipment Depots	31
A.F.O. 3153/57	Firing Clutch Solenoid—Modification to ensure freedom of the core to reset on interruption of the firing circuit	A.F.O. Diagram 48/57	Defect	—	Ships' Staffs, Base Staff and Fleet Shore Establishments and Depots	32
A.F.O. 419/58	Elevating and Training Receiver Drives—provision of additional grease ways in bearing bushes to relieve grease pressure—*See* Ch. 6, para. 10	A.F.O. Diagram 6/58 (1) and (2) Drg. No. G.R. 6602 Mod. No. 4 and G.R. 6780 Mod. No. 4	Defect	—	Ships' Staffs when necessary (with Dockyard assistance), G.E. Depots and Dockyards when preparing or refitting mountings for service	33
A.F.O. 1173/58	Power Firing Gear Clutch— elimination of sluggishness in operation	A.F.O. Diagram 15/58 D.N.O. 11041	Defect	—	Ships' Staffs and Shore Establishments	34

(Amendment No. 12.)

(73592-2) Wt. 8072/P.P.2940 1,500 8/58 Hw.

APPENDIX VI

HORITY	DESCRIPTION	DRG. OR DIAG. NO.	CATEGORY OF MOD.	SUPPLY OF MATERIAL	BY WHOM TO BE DONE	MOD. NO.