CHAPTER XI

ELECTRICAL TRANSMISSIONS IN DIRECTOR SYSTEMS

SECTION 1. GENERAL DESCRIPTION OF TYPES OF TRANSMISSION

185. There are three main types of transmission used for passing information from one part of the director system to another.

(1) **"M" TYPE.** This may be subdivided into:—

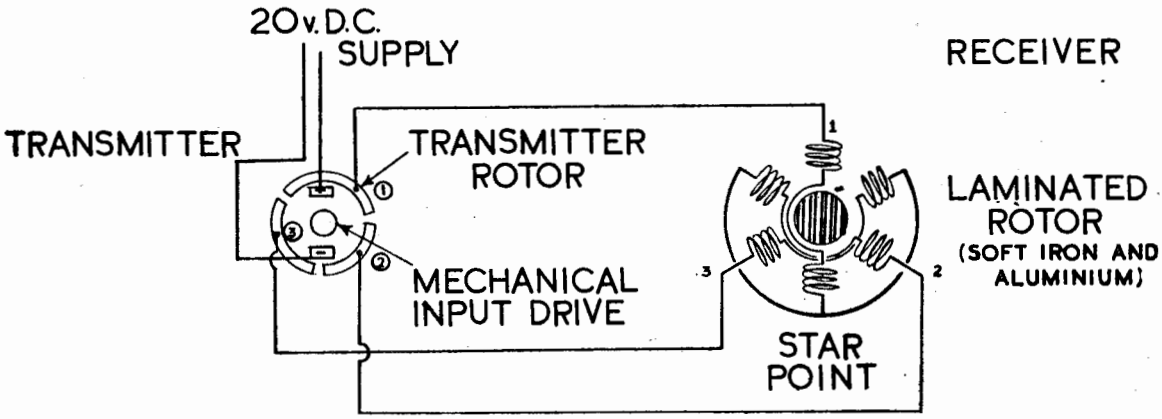
(*a*) *Direct Transmission from "M"* type transmitter to receiver. (Usually known as *"Step-by-step transmission.*)

(*b*) *Synchronous Transmission.*

186. **Direct "M" type transmission** (*Diagram 10*) functions by the transmission of successive electrical impulses from a mechanically-rotated transmitter to an "M" motor receiver. It is used where the speed of transmission is within the limits that the "M" motor can handle, without missing step, and where no question of a change-over between two different controlling positions arises. Examples are the outgoing transmissions to gun elevation and training receivers from the fire-control clocks and tables of destroyers and of cruisers with marks of table earlier than Mark VI.

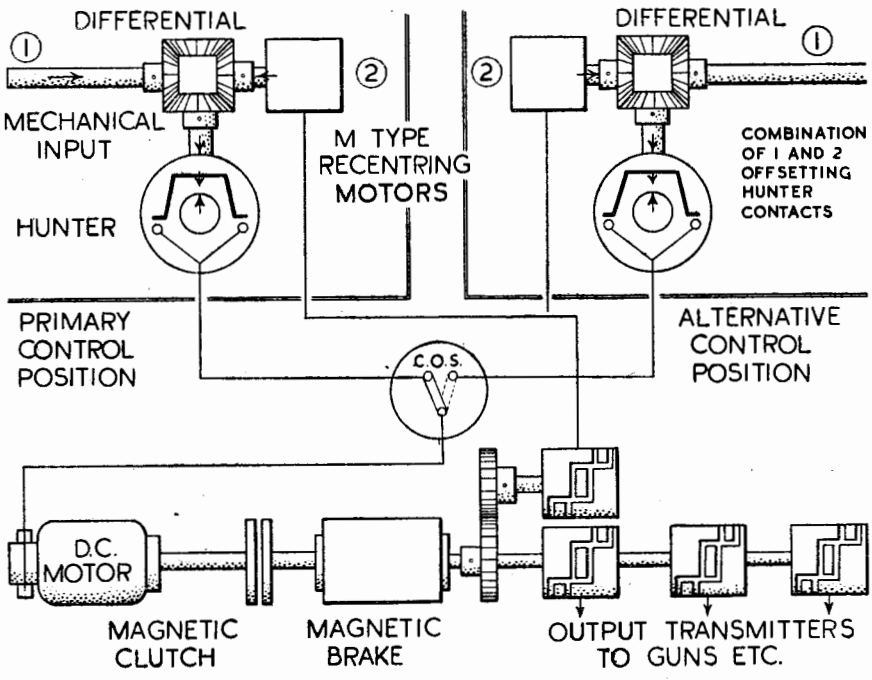
This system is simple and robust and accurate to within half a step value. It has, however, the disadvantage that failure of power when the transmitter is moving causes loss of alignment, and that the speed of transmission is limited. In addition, if it should be necessary to change over the controlling position (e.g. changing to after director from forward), it is necessary to carry out a full lining-up procedure.

Diagram 10. **Principle of "M" Type Direct Transmission.**



NOTE :—One transmitter may control several receivers.

Diagram 11. **Principle of Synchronous Transmission.**



187. **The Synchronous System** (*Diagram 11*) is a step towards the self-aligning system. It is a development of the direct " M " type transmission and uses the same type of transmitters and receivers, but is partially self-aligning. It was first fitted to ships in which two directors could control the main armament to avoid the necessity of lining-up when the change-over was made. It is, however, not self-aligning if a failure of power supply takes place when the gear is moving fast, owing to overrun of the motors.

The operation of the gear is fully described in *Chapter 3 of Part 3* of this series.

Examples of where it is used are gun-elevation, gun-training and director-training circuits from the director to the T.S. in " Nelson " class, 8-in. cruisers, earlier 6-in. cruisers and director-training circuits in destroyers fitted with the A.F.C.C.

188. (2) **A.B.C. TRANSMISSION.** *Diagram 12*

This was the predecessor of Magslip transmission to which it is akin. " M " transmission is, however, used to re-centre the displacer so that a failure of the 20-volt supply to this will cause the system to get out of alignment. Apart from this it is self-aligning, and provides a power follow-up to the maximum speed of the oil motor.

The gear consists of three elements :—

The " *A* " element, known as the **" Displacer ",** corresponds to the hunter in a synchronous system and is offset by the controlling force, e.g. the training of the director.

The " *B* " element which controls the sensitive valve of an oil motor which provides the power follow-up.

The " *C* " element, known as the **" Runner "** which reduces the lag of B on A. Where speed of follow-up is not of great importance this third element is not always fitted.

The " *A* " element is re-centred by an " M " type receiver driven by a transmitter mechanically connected to the oil motor.

The three elements are supplied from a 50-volt, 50-cycle, A.C. supply. The re-centring motor is supplied from the normal 20-volt L.P. supply and the oil motor is supplied with oil from a pump driven off the ship's high-power supply. Failure of the 20-volt supply to the re-centring motors while the gear is running is the only likely cause of a misalignment.

NOTE :—A full description of the gear is given in the " Electrical Manual ".

(3) MAGSLIP TRANSMISSION

189. This may be subdivided into two types :—

(a) **Indicator Magslip**

This is a fully self-aligning system and is used in modern transmission systems where little torque is required at the receiving end of the system, e.g. elevation and training receivers.

(b) **Power Magslip**

This is a development of the above and has to be used wherever any effort is required at the receiving end, e.g. director training input to the Mark VI A.F.C.T.

Both systems are fully self-aligning in the sense that after initial installation no routine lining-up is necessary, but, in the case of power magslip, owing to the reduction gearing which is necessary to achieve the required degree of accuracy, it can get out of the true alignment by any number of " *Sectors* " ; these are usually of 20-degree value and a hand or automatic sector control is fitted to enable this misalignment to be removed as soon as it occurs.

The following brief descriptions do not attempt to go into details of the systems. These are given in the " *Electrical Manual* ".

Indicator Magslip. *Diagram 13*

GENERAL DESCRIPTION

With certain types of transmission, when one transmitter controls several receivers and one of them is damaged or fails to follow satisfactorily, the electrical balance of the system is disturbed. " *Stuck position error* " then occurs and causes misalignment at all the other receivers of the system.

Indicator Magslip is designed to avoid this error, but to meet the requirement it was necessary to accept the fact that only very small torques would be produced at the receiver end. This in turn entailed the use of very light and delicate gear in the receiving instrument, including accurately-balanced pointers, etc.

Magslip indication is accurate to within one degree of pointer angle. This accuracy is insufficient for most gunnery purposes, but the difficulty is overcome by the fitting of a second transmitter which is driven through reduction gearing. There are therefore usually two transmitters, which may be distinguished by their black terminal ends, and two receivers in any indicator Magslip system, a *Coarse* transmitter which never makes more than one complete revolution so that it cannot possibly line itself up 360 degrees out of step, and a *Fine* transmitter which is geared down to give the required degree of accuracy. For example in the drive to the training receiver of a gun the coarse transmitter will revolve once every 360 degrees of training. The fine transmitter will probably be driven through a 72 to 1 reduction gear and will therefore rotate once for every 5 degrees of training, thus giving 72 different lining-up positions in the full 360° of training. The accuracy of the coarse transmission will be plus or minus 1 degree, and of the fine about one minute. The gear ratio can be adjusted to give the required degree of accuracy for any particular system.

Diagram 12. **Principle of A.B.C. Transmission.**

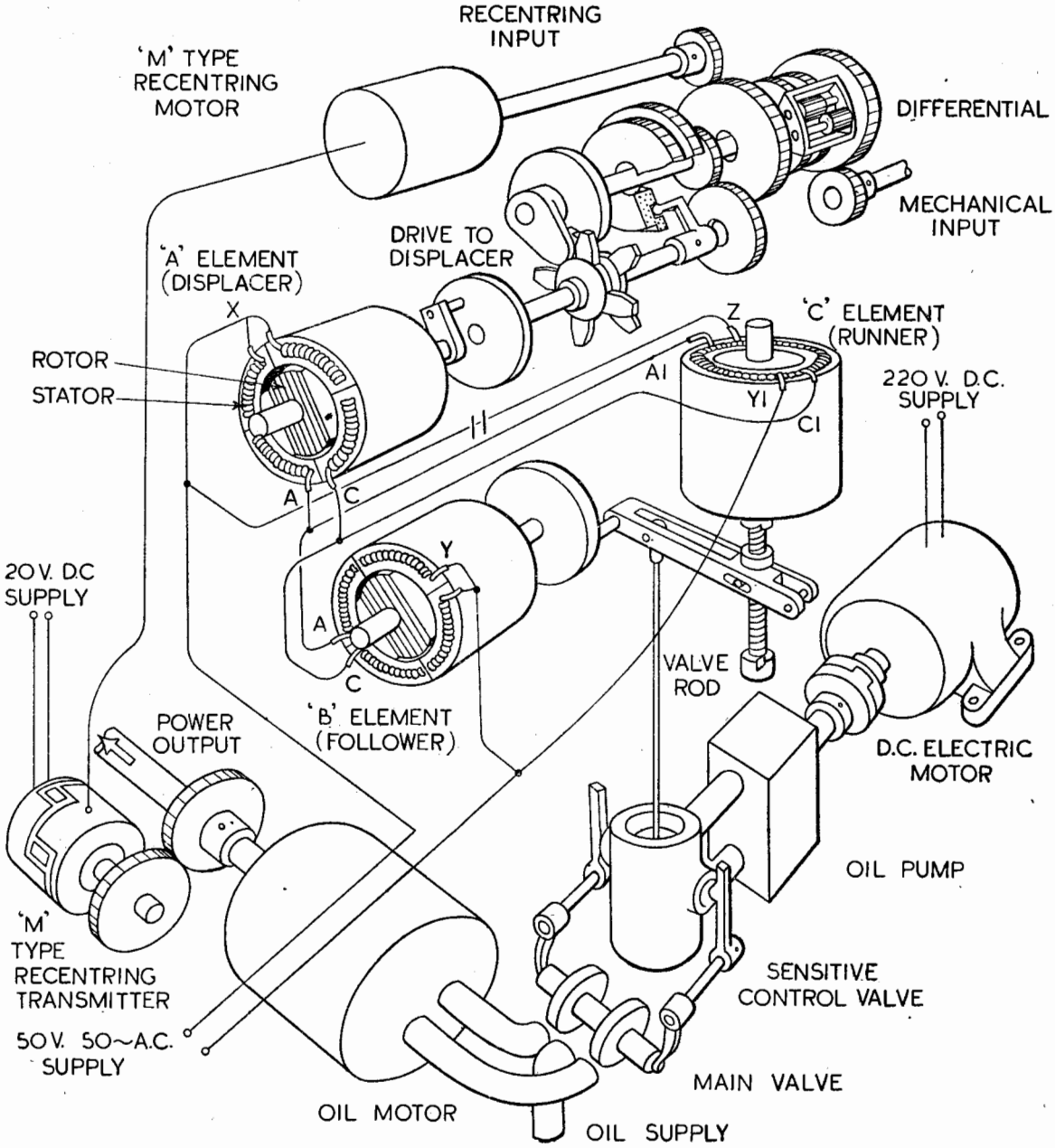
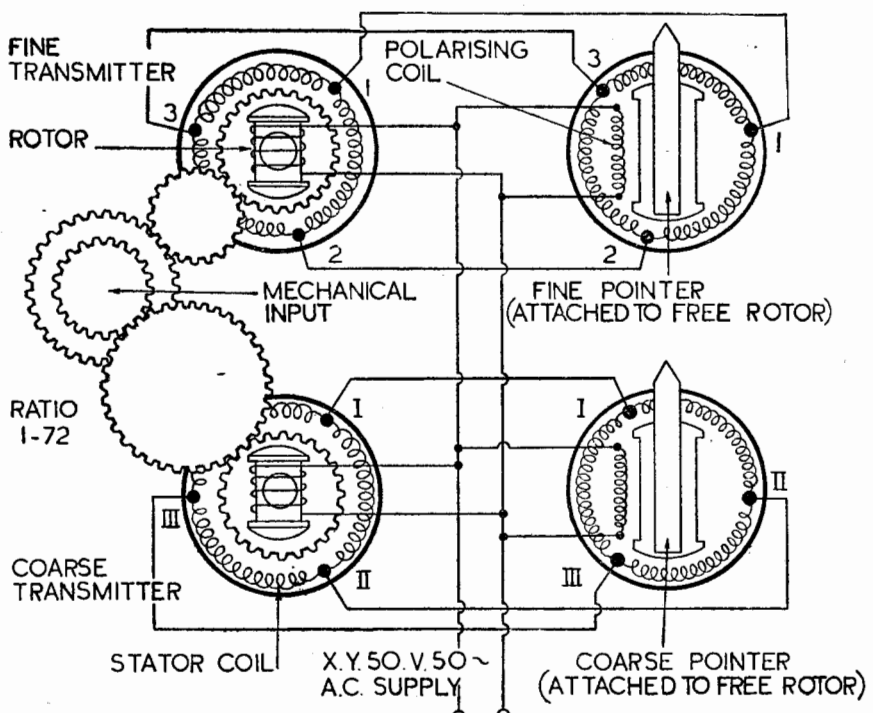


Diagram 13. **Principle of Indicator Magslip Transmission.**



OPERATION OF THE GEAR

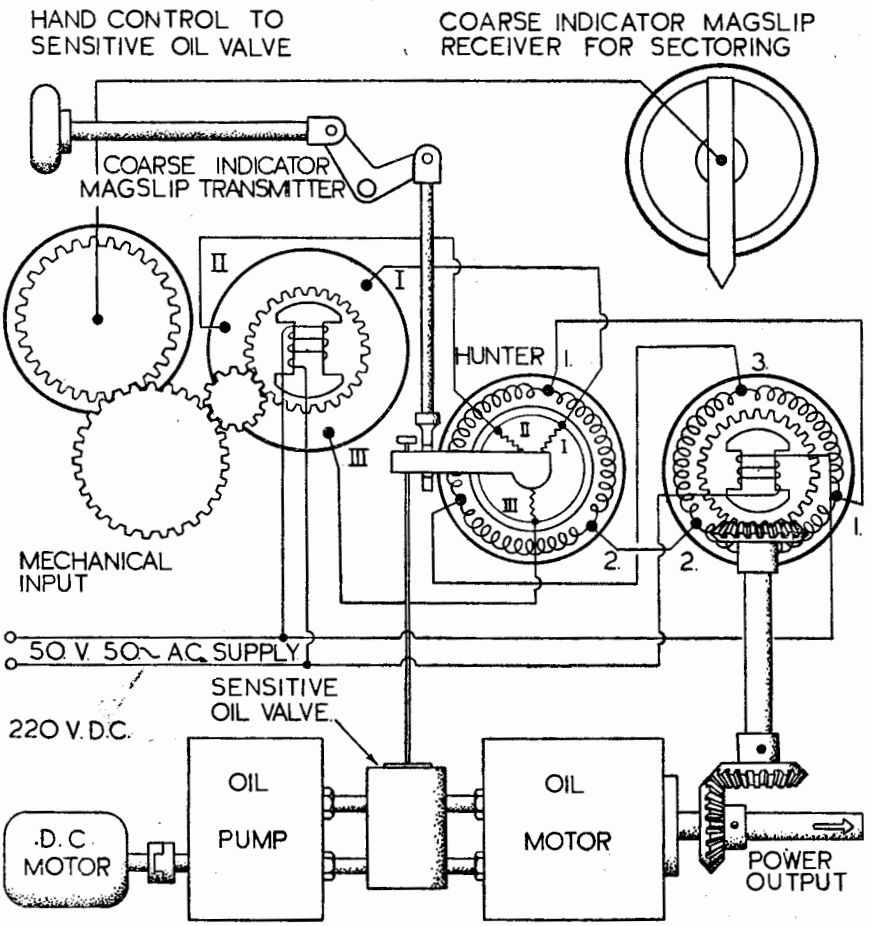
The system is energised by a 50-volt, 50-cycle supply. In the *transmitter* a rotor, with a winding around it excited by the A.C. supply, induces E.M.F.s in the stator windings. The rotor is driven mechanically by the controlling mechanism whose movement is to be transmitted, and this alters the direction of the flux from the rotor windings and hence the induced E.M.F.s in the stator. The E.M.F. in the stator therefore gives a direct indication of the movement put into the rotor.

The stator windings of the transmitter are directly connected to exactly similar stator windings in the *receiver*. When the E.M.F.s in the transmitter stator alter, the induced currents in the connecting lines produce a similar change of E.M.F.s in the stator windings of the receiver and will therefore change the direction of the magnetic field induced by the receiver stator until it is exactly parallel to that of the transmitter rotor.

A very light pointer is attached to an armature (the receiver rotor) in the centre of the receiver stator. When the direction of the magnetic lines of force inside the receiver is changed, the armature carrying the pointer will turn correspondingly, thereby aligning itself with the rotor of the transmitter.

To ensure that the rotor cannot line itself up 180 degrees out of step with the transmitter, it rotates in a polarising field caused by a fixed polarising coil supplied by the 50-volt, 50-cycle supply. This arrangement has the added advantage that the alternating nature of the magnetic flux causes the armature to bounce or dither on a dither spring, thus reducing friction and making the instrument very sensitive.

Diagram 14. **The Principle of Power Magslip Transmission.**



190. **Power Magslip.** *Diagram 14*

GENERAL DESCRIPTION

This is the most modern form of power follow-up fitted in director systems. It is self-aligning in all respects but, where coarse and fine transmitters are fitted, some form of sector control is required.

The standard magslip chain consists of three elements :—

A transmitter, the rotor of which is offset mechanically by the controlling agent whose movement is to be transmitted.

A hunter whose rotor is displaced electrically by the transmitter and operates the sensitive valve of an oil motor, this may be distinguished by the *red* terminal end cover.

A re-setter, which is driven mechanically by the movement of the oil motor and which re-centres the Hunter electrically, by altering the flux from its stator. This closes the valve and stops the motor as soon as the re-setter has been rotated through exactly the same amount as the transmitter was originally offset by the controlling agent.

Where it is possible to re-centre the transmitter by a mechanical drive from the oil motor, i.e. when the transmitter, hunter, and oil motor are all close to each other, a *two-element* chain only is used. In this case the stator of the hunter is fed with a 50-volt, 50-cycle supply instead of being connected to the stator windings of the re-setter as shown in the diagram.

OPERATION OF THE SYSTEM. *Diagram 14*

The transmitter rotor which is fed from the A.C. supply is driven by the controlling agent mechanically. This alters the E.M.F.s induced in the stator windings of the transmitter by an amount proportional to that by which the rotor turns for small displacements. These stator windings are connected as shown to the rotor of the hunter, and any variation in the E.M.F.s produced in them will cause a similar variation in the windings of the hunter rotor. To keep the hunter rotor and stator fluxes in alignment, the rotor of the hunter must turn. To this is connected the spindle of a sensitive oil valve which controls the running of an oil motor.

The oil motor provides the necessary power follow-up, and also drives mechanically to the rotor of the re-setter. The re-setter is exactly the same as the transmitter, except that its stator windings are connected to the *stator* of the hunter.

When the motor has rotated through an angle exactly the equivalent of the movement of the controlling agent, the rotor of the re-setter will have been turned and its flux will induce E.M.F.s in the stator coils of the re-setter exactly similar to those induced in the stator of the transmitter by the rotation of its rotor by the controlling agent. To keep its displaced rotor and stator fluxes in line, the hunter rotor will have turned until it has closed the oil valve and stopped the oil motor.

When the transmitter has been offset and the remainder of the gear has gone through the process described above to re-centre itself, the position of the rotors will be :—

Transmitter .. Rotor offset by the amount of movement put in by the controlling agent.

Hunter .. .. Central, in which position the oil valve is closed.

Re-setter .. Rotor parallel to the Transmitter Rotor.

The *speed of transmission* is infinitely variable up to the maximum speed of the oil motor.

The *nominal accuracy of the transmission* with a 3-element chain is $\pm \frac{1}{4}$ degree where the rotational value of the transmitter is 360°. By gearing the transmission down to 18 to 1 the required degree of accuracy of $\pm$ 1 minute follow-up is obtained. This ratio is more or less standard for fire-control purposes, one revolution of the transmitter thus corresponding to 20°. This means that the rotor of the transmitter goes round a large number of times during the full travel of the controlling agent. For instance, if the system is being used for transmitting director training to the A.F.C.T., the rotor of the transmitter will revolve 18 times during 360 degrees of training. There would therefore be no indication at the receiver end of which particular 20-degree sector was being indicated. A coarse indicator Magslip transmitter and receiver is therefore fitted to transmit this information to the table. The correct sector must then be selected by a hand drive fitted for the purpose. Apart from this the gear is completely self-aligning.

CH. XI. SECTION 2. LINING UP ELECTRICAL SYSTEMS

GENERAL

191. Any electrical transmission system which depends upon successive impulses of electrical current for transmitting movement will be liable to get out of step under certain conditions. These conditions will occur, for example, if the transmitter is moved when power is off the system, or if the transmitter is moved so fast that the impulses merge into one continuous flow, thus causing the receiver to miss step. Any electrical system which employs "M" type (*Step-by-step*) transmission, is therefore liable to these misalignments. This is not so in the case of Magslip transmission which depends upon the principle of the fields of force induced in a rotor by a stator or vice versa.

In order to ensure that no misalignment exists between transmission in step-by-step, auto-synchronous, and A.B.C. transmissions, periodical lining-up and checking is necessary. The object of lining-up is to make electrical receivers show the same reading as the transmitters; checking is to ensure that none of the receivers have fallen out of step with their transmitters since they were lined up.

Receivers are always checked at the change of the watches and when for any reason it is thought that the supply circuits have been switched off or have failed temporarily.

Lining-up, which is a more laborious process, must be carried out whenever supply has been switched off for maintenance purposes, or inadvertently, or because the fire-control system is no longer required. The organisation with regard to the latter differs in various ships, but in war-time it is a sound practice to keep power on all fire-control circuits whether the quarters are manned or not. This has the advantage of reducing the lining-up required on first closing up and also keeps the instruments warm and dry. It must be so arranged, of course, that power is not kept on circuits where damage might be caused to contacts by ceaseless hunting when unattended.

Whether the system requires a full lining-up when the crew closes-up or whether a check-

ing of receivers will suffice, depends on whether power is normally taken off or not, when not manned.

The main requirement of any lining-up system is that it shall be quick and that the number of reports and orders shall be as few as possible.

Although the various armaments differ slightly in the details of their transmission systems, it is very desirable that the lining-up methods employed should be as nearly as possible the same. The following method meets the requirements of systems using Synchronous or A.B.C. Transmissions and should be used on all occasions.

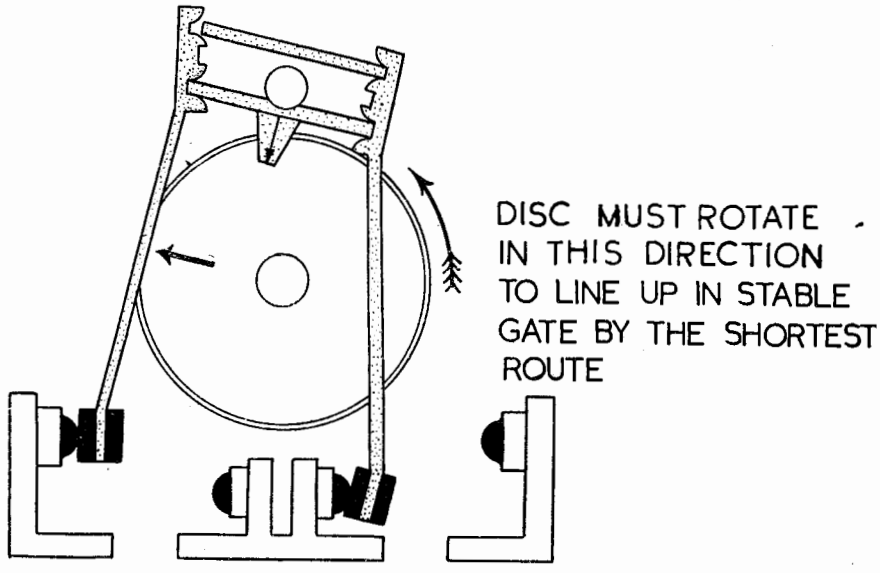
(*i*) First check that the circuits to which lining-up arrangements are fitted, are all switched "*OFF*". The T.S. then orders **"Line Up"** and the directors, guns, control positions, and T.S. set all their instruments to the positions shown on the check cards and centre their hunters. Wherever an instrument or a hunter has to be lined up, a milled knob for doing so is provided. When this operation is completed, all positions report to the T.S. "*LINED UP*".

(*ii*) The T.S. then reports to all out-positions "*CIRCUITS CLOSED*" and closes the circuits. The report is passed before the circuits are actually closed, in order to make certain that the out-stations are looking at their pointers to see that they do not move at the instant that power comes on. All positions report " Receivers correct " or, if not correct, what they are actually showing.

(*iii*) Then, with power "*ON*", the director trains and lays to a pre-arranged bearing and elevation, the T.S. and control positions set pre-arranged settings on some of their instruments and the order **" Check receivers "** is passed by the T.S. to all positions. The readings of the various receivers are checked by means of a card. All positions then report to T.S. "*RECEIVERS CHECKED*".

For those step-by-step transmissions in which stops are fitted, the correct method of lining-up is to run them against their stops in both directions with power "*ON*" before setting them to the lining-up position. Examples are the transmissions of range and deflection to director and guns in certain director installations. Such circuits can always be distinguished by the fact that no lining-up knobs are fitted at the receivers.

Diagram 15. **Synchronous Hunter Fully Offset.**



LINING UP SYNCHRONOUS HUNTERS

192. A description of the hunter is given in *Chapter III of Part III* of this series. It is lined up as follows :—

(*i*) Remove the cover over the lining-up knob.

(*ii*) Rotate the milled knob so as to turn the central disc in the direction indicated by the pointer on the arm connecting the hunter contacts. The required direction of rotation in the position shown in *Diagram 15* is indicated by the arrow. Continue to turn until the arrow on the central disc is in line with the red or black index mark scribed on the pointer (*see Diagram 16*) and the **hunter contacts are central between the contact blocks.** This is most important as the hunter is not lined up correctly until both contacts are disengaged.

If the hunter is a long way out of alignment, it may be necessary to make a large number of revolutions with the inner disc, and it should be noted that, although the arrow and the pointer index will come in line each time that they pass, the hunter is not lined up by virtue of that fact alone. It is easy to know when the contacts are in the neutral position for the index line on the pointer attached to the yoke of the contacts will then be pointing directly towards the centre of the disc. In addition the contact arms will move *rapidly* to the open position.

When lining up a hunter it is **essential to see that it is not centred in the unstable gate** (*see para. 56 part 3 of this series*) unless the director tower is carrying out the lining-up procedure whilst secured 180 degrees from the datum director or remainder of the system.

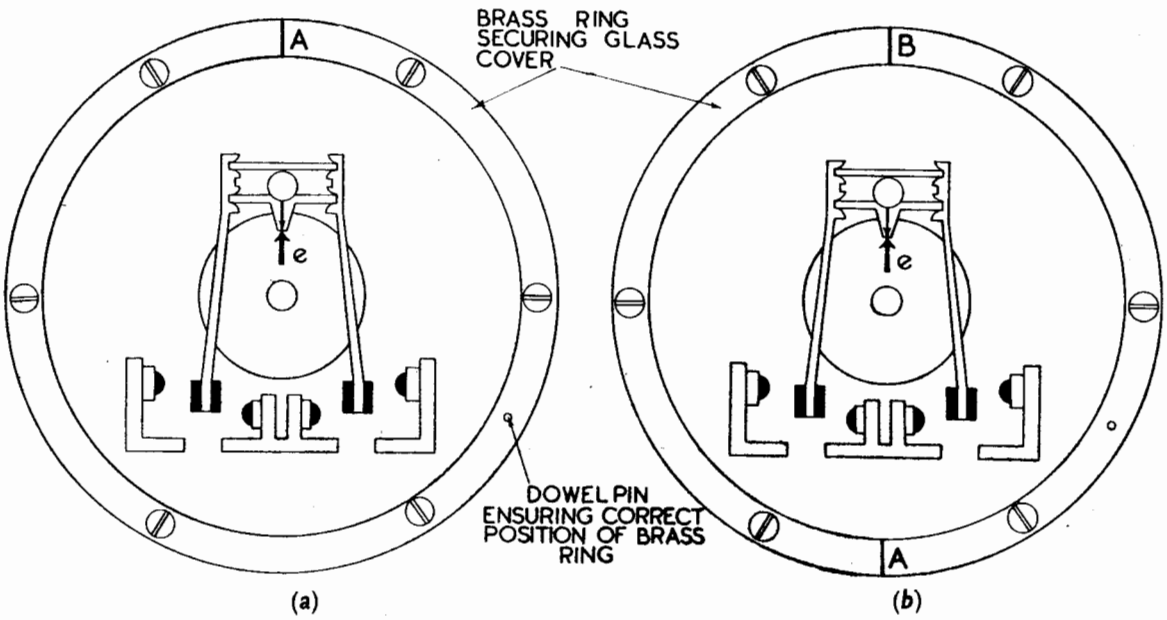
This latter procedure is not recommended, and it is preferable for all directors to train on 000 before lining up, also before power is switched off prior to securing the armament. The reason for the latter is to avoid having to run the hunter by hand through 180 degrees of training when lining it up on the next occasion of closing up.

To enable the stable and unstable gates to be detected, two marks " A " and " B " at after directors and one mark " A " at other positions are engraved on the outer ring of the hunter casing. At a forward director, when lined up in the stable gate, the broad arrow " e " must be in line with the index scribed on the pointer and with the line on the hunter casing marked " A ". (*Diagram 16a.*)

At an after director trained on the same bearing (000 degrees) the hunter will be correctly lined up in the stable gate when the broad arrow " e " is in line with the index on the pointer and is pointing towards the line labelled " B " on the casing. (*Diagram 16b.*)

If for some reason the after tower is trained on 180 degrees when lining up, then the arrow " e " must point towards the line " A ". The hunter will then be lined up in the **unstable** gate.

Diagram 16. **Synchronous Hunter Lined Up in Stable Gate.**

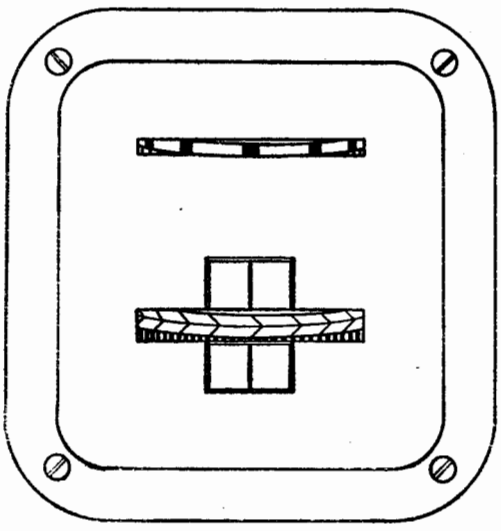


LINING UP A.B.C. TRANSMISSION

193. The principle of this is exactly the same as for an auto-synchronous system. The design of the hunter is slightly different, only the edge of the revolving disc being visible. A line is drawn on this edge, which must be put in line with two marks engraved on the hunter casing, to line it up (*Diagram 18*). When it is not in the lined up position, an arrow shows the direction in which the disc must be made to rotate to bring the marks in line (*Diagram 17*).

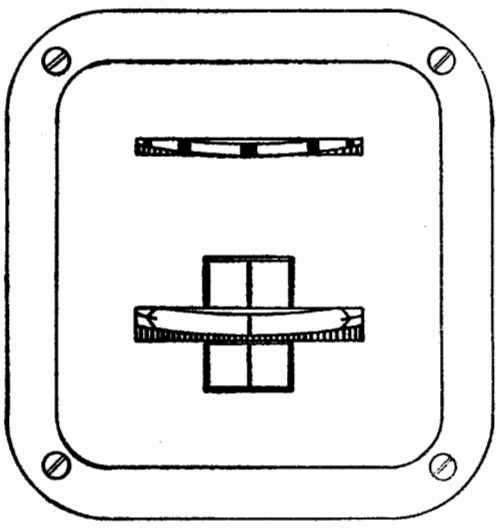
It is possible to line up an A.B.C. hunter in the unstable gate, this position being indicated by a *red* line engraved on the wheel. The line which shows when the hunter is in the stable gate is black.

Diagram 17. **A.B.C. Hunter Offset.**



ARROWHEADS ON LOWER DISC INDICATE DIRECTION UPPER DISK MUST REVOLVE TO LINE UP IN THE STABLE GATE

Diagram 18. **A.B.C. Hunter Lined Up.**



Magslip

194. After initial installation, no lining up of Magslip transmission systems is necessary.

CH. XI. SECTION 3. THROWING OFF THE DIRECTOR

195. When carrying out a throw-off firing a divergence of a certain number of degrees is introduced between the director and the guns, in order that, when the director is pointing at the target, the guns will be aiming a definite number of degrees ahead or astern.

With Cross-levelling Gear fitted

196. In ships where a cross-levelling system is fitted, the simplest (and, in the case of Magslip transmission, the only) way of applying the throw-off, is to use the special handwheel provided for the purpose on the side of the instrument or on the fire-control table. This handwheel is normally kept locked to avoid unauthorised use. When it is turned it adds an angular correction differentially to the gun training, the amount showing on a dial by the side of the handwheel.

Without Cross-levelling Gear

197. In ships with synchronous or A.B.C. transmission not fitted with a cross-levelling unit, there are two convenient ways of throwing the director off from the guns. Which one is used depends largely upon whether a separate lining-up switch is fitted in the gun-training circuit. Where it is not fitted, *Method 2* must be adopted. *Method 1* has the great advantage over the other that the only divergence from the normal lining-up procedure, namely the re-aligning of the director training hunter with the director off the fore-and-aft line, is done right under the eye of the Control Officer, who can therefore personally make sure that it is done correctly.

METHOD 1. **Applicable to 6-inch and 8-inch cruisers fitted with A.B.C. and/or synchronous transmission**

Throw-off required. Guns 6 degrees RIGHT of Directors.

(i) All positions line up in the ordinary way. Close the circuits.
(ii) Control Officer orders, **"Open the Gun-Training switch."**
(iii) Control Officer orders **"Directors to train on to Red 6, and centre their training hunters by the milled knob."** In ships fitted with R/FD units this is the gun-training hunter. In ships with R/E units this is the Director-Training Hunter. The procedure is the same in either case.
(iv) Control Officer orders, **"Close the Gun-training switch."**
(v) Receivers are now checked in the ordinary way. If the check position for training is *Green 90*, the Director should train on *Green 84*. The check readings at the guns will then be as shown on their check cards.
(vi) If a second director is fitted, change to after director and check training.

METHOD 2. **Applicable to destroyers and to other ships with A.B.C. or auto-synchronous training circuits, where no separate training lining-up switch is fitted.**

Throw-off required. Guns 6 degrees RIGHT of Director.

(a) All positions line up in the normal way.
(b) Close all circuits.
(c) Control Officer orders director to **"Train on Red 6"**.
(d) Control Officer orders, **"Open the circuits."**
(e) Control Officer orders all guns, **"Line up Training Receivers."**
(f) Close the circuits when the guns report lined up.
(g) Check receivers in the normal manner.

198–202.

CHAPTER XII

DIRECTOR FIRING CIRCUITS

GENERAL PRINCIPLES

203. To make firing by director possible, three circuits are required between director and guns. These transmit elevation and training and enable the Director Layer to fire all guns. In view of the importance of the system, duplicate-sided circuits should be fitted wherever possible. Since the failure of any one of these circuits is just as serious as the failure of the whole of them, in an ideal system, all three circuits, whether sided or not, should be run together, preferably in the same multicore. Furthermore, where duplicate firing circuits are run, all guns in any one mounting should use all three circuits run on the same side of the ship to reduce the chances of the mounting being put out of action by damage to the leads. When firing by director much dislocation of the control is caused by a missfire of the whole armament, whereas a failure at half the guns can be dealt with locally without upsetting the control. It is therefore desirable that alternate mountings should use circuits run on opposite sides of the ship.

The requirements of the system outlined above are not implemented in all ships; in some because the fitting of duplicate circuits is not justified by the importance of the armament, and in some older ships because the circuits were fitted with a view to avoiding electrical maintenance failures rather than those arising from action damage.

A new policy of wiring director circuits was adopted in 1941 and was applied to ships under construction at that period. In earlier ships some modifications are being made to the older system to bring it as nearly as possible into line with the new. The new system and the modified arrangements in older ships are described below.

MODERN WIRING SYSTEM

204. (*A*) **Main Armaments of Capital Ships and Cruisers**

(*i*) Elevation, training and firing circuits are run together. These circuits are duplicated, one set being run each side of the ship, to a single change-over switch at each mounting. Thence, through single circuits, to the receivers and interceptors. The switch is marked "*STARBOARD*" and "*PORT*", the terms "*main*" and "*auxiliary*" no longer being used for these switches.

(*ii*) "*A*", "*Q*" and "*X*" turrets will normally use the starboard circuits, and "*B*" and "*Y*" turrets the port circuits. In the event of any failure, the switch will be put over, thus changing all circuits to the alternative run. In cruisers with an H.A./L.A. main armament all turrets are to use the starboard circuits for H.A. fire. In the event of a missfire by one gun of a mounting, the other gun or guns having fired in the salvo, the missfire drill will therefore be to shift tube only.

(*B*) **H.A./L.A. Armaments of Capital Ships and Aircraft Carriers, H.A. Armaments of Cruisers and Main Armaments of Destroyers and all other Ships**

The provision of duplicate circuits is not practicable, and single circuits only are run; where alternative controls are fitted, some safeguard against action damage is provided thereby. The present practice of fitting duplicate firing circuits in a common cable run provides no safeguard against action damage and will be discontinued.

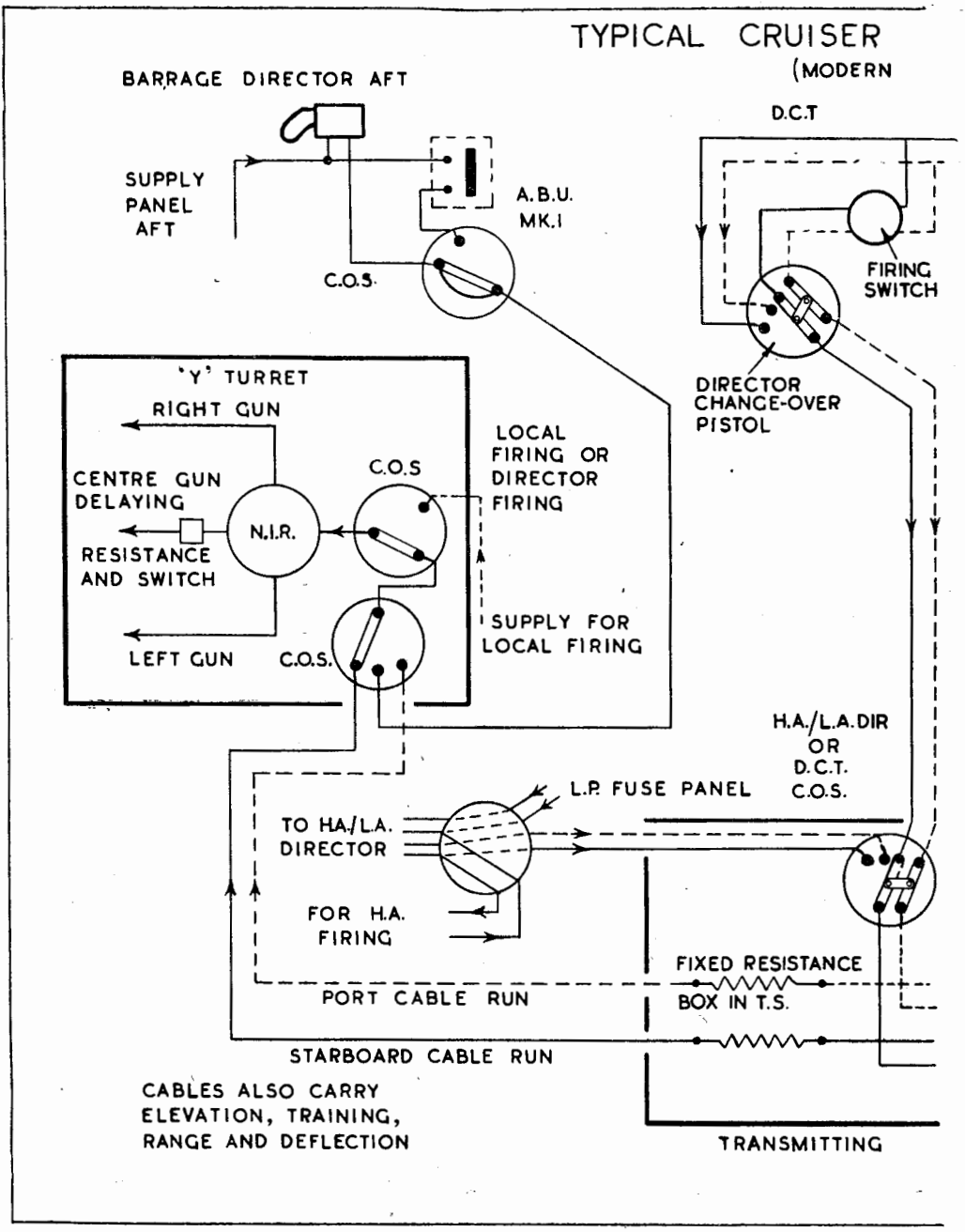
This policy entirely does away with changing over the firing circuit at the interceptor, and single-circuit interceptors will therefore be fitted in all ships when the present stocks of double-circuit interceptors have been expended. Pending the supply of single interceptors, the two firing contacts of interceptors are connected together in ships in which this system is fitted.

WIRING SYSTEM IN OLDER SHIPS

205. It is not practicable to carry out the above policy in full in existing ships, but in order to meet the requirements as far as possible, certain modifications to existing arrangements are desirable. The modifications made in various classes of ships are dealt with below.

"King George V" Class Main Armament.—The full policy is implemented except as follows:—

(*a*) The duplicate firing circuits are not led through the change-over switch but are selected at the interceptor. In "*B*" and "*Y*" turrets all guns are wired so that the starboard firing circuits are in use with interceptors to "*MAIN*" and the trainer's change-over switch is tallied "*STARBOARD (MAIN)*" and "*PORT (AUXILIARY OR 'B')*". In "*A*" turret the guns are wired so that the port firing circuits are in use with interceptors at "*MAIN*" and the trainer's change-over switch is tallied "*STARBOARD (AUXILIARY)*" and "*PORT (MAIN OR 'B')*".

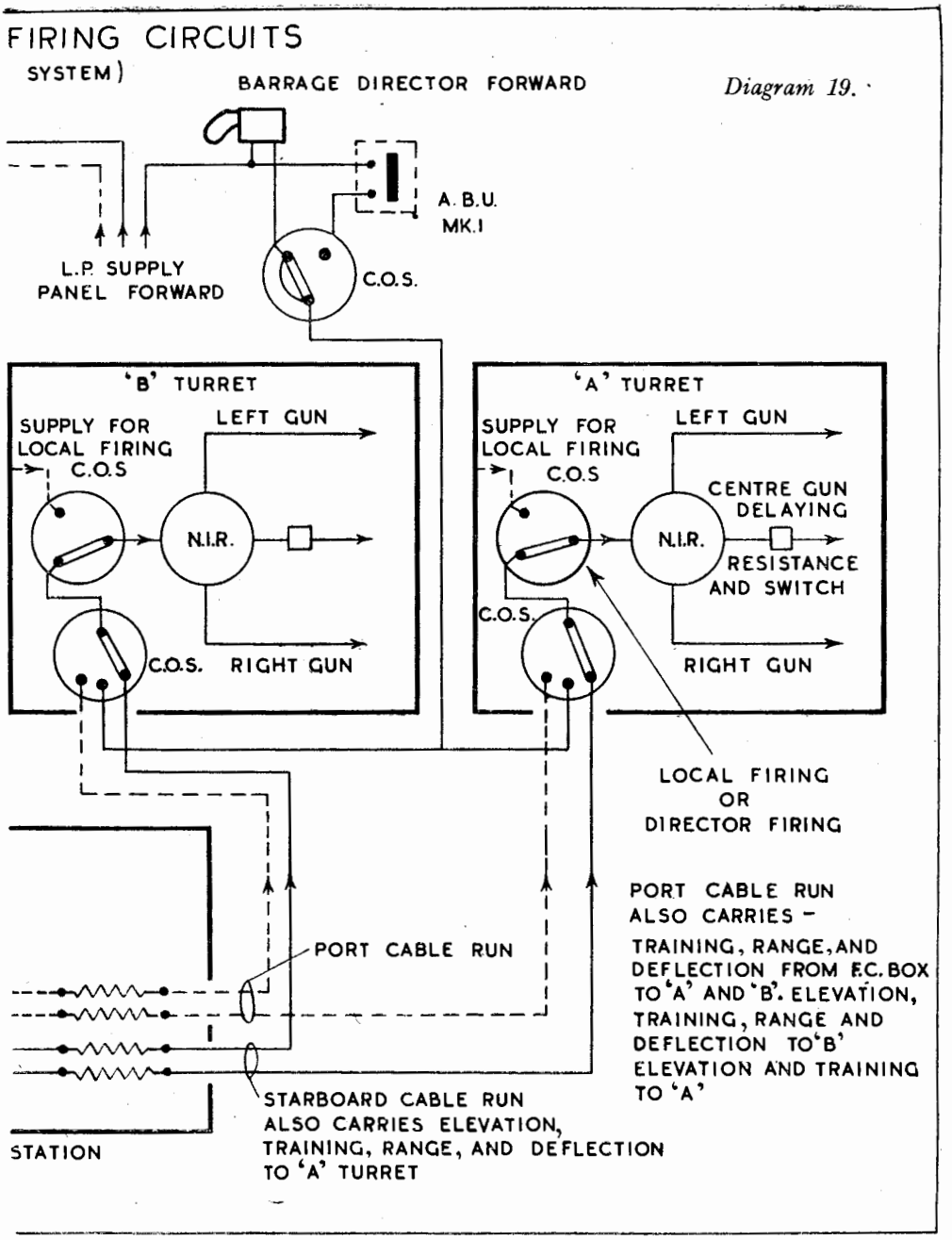


(*b*) The director control circuits from "*B*" turret have duplicate training, but only single elevation circuits run the port side with two firing circuits, hence the above method of tallying of the change-over switches.

Drill is therefore standard in all turrets, e.g. all guns start with interceptors and switches at "*MAIN*" and, whatever change-overs are made, the Trainer's change-over switch and all interceptors in the turret must be moved together.

"Nelson" Class and 8-in. Cruisers.—No change-over switches are required as "*M*" type transmissions are used, and duplicate pointers are provided at the receivers. The firing circuits are wired so that, in "*A*" and "*X*" turrets, the starboard circuits are in use with interceptors to main, and vice versa in "*B*" and "*Y*" turrets. All gun interceptors in any one turret must be over the same way, and Gunlayers and Trainers must be instructed as to which coloured pointer they should follow according to the position of the interceptors. All turrets start with their "*MAIN*" circuits in use.

1936 and 1937 "Dido", 1937 "Fiji" Classes, and all earlier 6-in. Cruisers with Magslip Transmissions.—Only single-elevation circuits are fitted, and those for the main armament are run the starboard side, together with both main and auxiliary firing circuits. Although these duplicate firing circuits provide no safeguard against action damage (being run together), they are supplied from separate generators. "*A*", "*Q*" and "*X*" turrets are therefore wired main to main, and "*B*" and "*Y*" turrets main to auxiliary at the interceptors, so that the failure of one generator will not cause a missfire of the whole broadside. The change-over switches for the duplicate training circuits should all be to starboard for director firing, being put over to port for Gunlayers' firing in the event of failure.



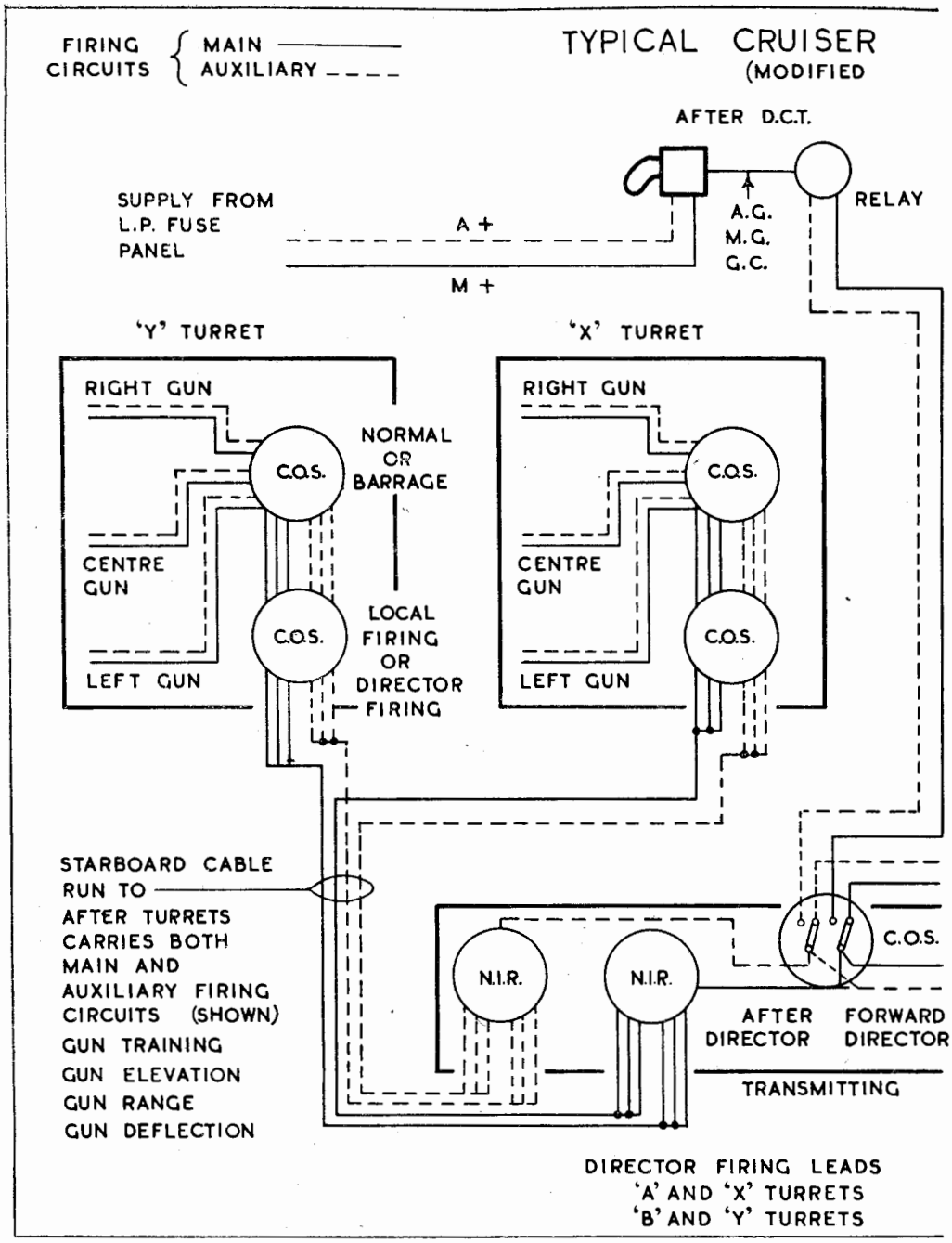
6-in. Turret Cruisers with " M " Type Transmissions.—As described above, except that no change-over switch is fitted. Trainers should be instructed to follow the correct pointer for the starboard circuits when in director firing, changing to the other pointer for Gunlayers' firing.

Other existing Ships not included above, and Secondary and H.A. armaments.—Only single elevation and training circuits are run, and the main and auxiliary firing circuits are run together. No safeguard against action damage is therefore provided, the only safeguards being against maintenance failures. The provision of duplicate firing circuits of this type will be discontinued in future construction.

FIRING CIRCUITS. DETAILS OF NEW METHOD OF WIRING. *Diagram 19*

206. Each controlling director is supplied from a separate 20-volt motor generator. The generator feeds through a L.P. supply panel and fuse direct to the Layer's combined change-over switch and firing pistol in the D.C.T. The standard Director Layer's pistol has three positions: *GYRO PORT, GYRO STARBOARD* and *DIRECTOR*. The firing pistol fitted with *the " P " sight has only two: GYRO* and *DIRECTOR*. In the first case the fact that the switch is labelled Gyro Port or Starboard only means that the relay is energised from the port or starboard supplies, since in either case both the common leads are energised when the relay closes. In the case of the " P " sight pistol, there is no gyro relay, so the two alternative positions are not necessary, both common leads being energised by the closing of the firing switch on all occasions.

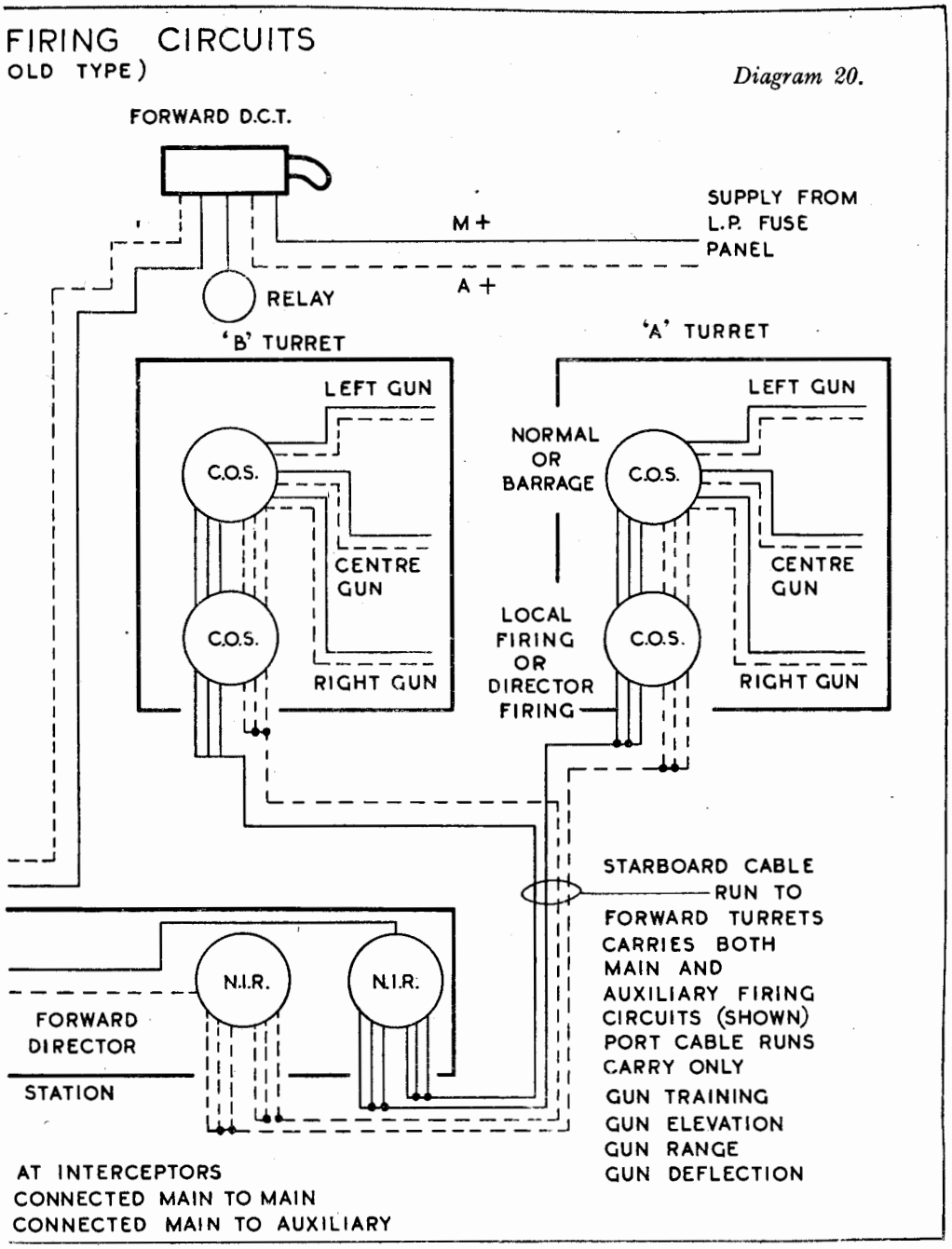
The lead from the director to the T.S. is known as the " *Common Lead* ". Where duplicated firing circuits are fitted as shown in the diagram, they are run on opposite sides of the



ship. Both are always energised either when the Director Layer presses the trigger in director firing or when the gyro relay contact or switch is closed in gyro fire. Either of the above actions therefore completes the firing circuits up to the T.S. change-over switch. This C.O.S. decides whether the guns are to be fired from the forward or after directors, and from it are taken the "*Branch leads*" to each turret. Where duplicated circuits are fitted, one branch leads down each side of the ship. Where only single circuits are fitted, the branch lead runs inside the same multicore as the elevation and training circuits, on the opposite side of the ship to that on which the range and deflection transmissions are led to the turret.

Since the distance between the T.S. change-over switch and the turret is considerable, a protecting resistance is fitted in series with the branch lead to prevent damage to the lead to any one turret blowing the supply fuse and putting all turrets out of action. This is *not* the N.I.R., although it is of similar type and performs the same function. The circuit then passes through the turret change-over switch which decides whether the port or starboard run is to be used. In individual turrets the switch is to be positioned as stated in *para. 205* so that alternate turrets will use alternately-sided runs of cable. Whichever circuit is in use is then connected to another change-over switch which decides whether director or local firing is to be used. From this switch the firing circuit passes into the non-inductive resistance box in which it is split into two or three separate leads depending upon the number of guns in the turret. The lead from the N.I.R. to each interceptor is a single circuit, and no change-over arrangements exist at the guns.

In most modern ships, arrangements are made to fire the low-angle armament at aircraft by means of a barrage director and auto-barrage unit. It can be seen in *Diagram 19* that the circuits for this are entirely separate from the normal L.A. firing circuits up to the point at which they enter the Normal/Barrage change-over switch. When using this firing system the guns can be fired direct by the barrage Director Layer or by means of the firing switch in the A.B.U. Which method is to be used is selected at the C.O.S. in the barrage director.



FIRING DELAY RESISTANCES

207. All cruisers other than 5·25 are wired with resistances in the firing circuit of the centre gun of triple turrets or in one of the firing circuits of double turrets to prevent the shells from adjacent guns leaving the muzzles at exactly the same instant and mutually interfering with their trajectories. It has been found that this interference is considerable and that the "*spread*" of broadsides is greatly reduced under nearly all conditions when firing delay resistances are used.

A switch is fitted in the T.S. to enable these resistances to be cut out of the firing circuits, but they should be **kept in the circuit under all conditions except the following :—**

(*a*) When rolling 5 (Vertical to Out) or more, at ranges below 8,000 yards.
(*b*) When rolling 10 (Vertical to Out) or more, at ranges below 12,000 yards.

FIRING CIRCUITS. DETAILS OF MODIFIED OLD SYSTEM OF WIRING. *Diagram 20*

208. The system up to the T.S. change-over switch is the same as described above, except that the supply may be of 20 or 40 volts, and from motor generators, the number of which may vary considerably between different ships. In this system, however, the N.I.R.s are fitted in the T.S., and the individual circuits to each gun of each turret therefore separate in the T.S. instead of in the turret. If delaying resistances are fitted they will accordingly be fitted in the T.S. instead of in the turret. Where duplicate firing circuits are fitted (*as in the diagram*) **both firing circuits run down the same side of the ship in the same multicore.** This system therefore gives no protection against action damage. It will be seen from the diagram that the same cable that carries the main and auxiliary firing circuits also carries one of the duplicate training circuits and the **only** elevation circuit. Damage to this run of cable therefore prevents any form of director firing at the turret affected. The wiring carrying the

necessary information for the turret to carry on in Gunlayers' or quarters firing (gun range and deflection and director training) is therefore run down the opposite side of the ship.

In the turret the director firing circuits pass through a quarters change-over switch which has two positions. In "*DIRECTOR*" the guns are fired from the director and the elevation is transmitted from the T.S., while in "*LOCAL*" the guns are fired by the local firing pistol, fed from a local source of supply, and the elevation is transmitted from the local director sight.

Where barrage-fire arrangements are fitted, the circuits pass through a further C.O.S. which selects the type of fire to be used; "*NORMAL*" in the case of L.A. fire, and "*BARRAGE*" when the separate barrage director is controlling.

After this last C.O.S. the firing circuits split up, **two** circuits, (*main and auxiliary*) going to the interceptors at each gun. These are normally to be wired so that when all their interceptor switches are showing the same, alternate turrets use alternate circuits.

209–212.