HEAD OF "P" BRANCH

RESTRICTED

(FOR OFFICIAL USE ONLY)

Not to be communicated to anyone outside H.M. Service

ADMIRALTY FLEET ORDER

ANTI-SHIP FIRE CONTROL—DIRECTOR TOWERS AND ROLL CORRECTORS VICKERS GYROS, MARKS I, I*, I, II, II**, IV, IV*, V, VI AND VII—INTERCHANGEABILITY, MAINTENANCE PROCEDURE FOR OBTAINING REPLACEMENTS, STRIPPING, REPAIR AND ASSEMBLY. (GUN MOUNTINGS—40-MM. BOFORS, MARK IV.)**

ADMIRALTY, S.W.1,
23rd December, 1943.

The following Order having been approved by My Lords Commissioners of the Admiralty is hereby promulgated for information and guidance and necessary action.

By Command of their Lordships,

H. V. Markham

To all Commanders-in-Chief, Flag Officers, Senior Naval Officers, Captains and Commanding Officers of H.M. Ships and Vessels, Superintendents or Officers in Charge of H.M. Naval Establishments, and Admiralty Overseers concerned.

NOTE:—The scale of distribution is shown in the Admiralty Fleet Order Volume, 1941, Instructions, paragraph 10.

HEAD OF "P" BRANCH

6194.—Anti-Ship Fire Control—Director Towers and Roll Correctors Vickers Gyros Marks I, I*, I, II, II**, IV, IV*, V, VI and VII—Interchangeability, maintenance procedure for obtaining replacements, stripping, repair and assembly—Gun Mountings—40-mm., Bofors, Mark IV**

Ships concerned and all Dockyards

(G. 011012/43.—23 Dec. 1943.)

The following information and instructions are promulgated primarily for Vickers fire control gyros. The instructions under maintenance are, however, generally applicable to Henderson and Elliott type gyros. Detailed information concerning these and A.R.L. oil unit gyros, will be issued separately. Certain information given below has been previously issued but in view of its importance has been included. Details of the Admiralty standard gyros which will eventually replace all Vickers gyros except Marks II**, IV, IV*, VI and VII will be given later. Drawings of the gyros are given in the relevant A.F.O. diagrams listed below.

PART I.—INTERCHANGEABILITY AND CHARACTERISTICS OF VICKERS GYROS.

Mark	A.F.O. Diagram No.	Type of bearing	Type of lubrication	Method of starting	Where fitted	Remarks
I	386/43 (1) (D.F.C. 26201)	N.1354	White Vaseline	Not direct switching	Early H, Mark II* and J, Mark I*, gyro sights.	·005-in. air gap not engraved Mark I but bearing Regd. No. "V.A. Ltd." only. Not interchangeable with other Marks except Mark I*.
I*	386/43 (2) (D.F.C. 51343)	N.1354	White Vaseline	Not direct switching	Early H, Mark II*, and J, Mark I*, gyro sights.	As above except that provision is made for unearthing of 3rd phase supply interchangeable with Mark I.
II	386/43 (3) (N.12106)	N.1354	White Vaseline	Direct switching	Later H, Mark II*, and J, Mark I*, gyro sights and onwards may also be fitted to G.M.M.(V) gyro sights of any Mark. Also fitted to roll correctors.	As Mark I but modified for direct switching. Steel casing. Air gap of ·005-in. with Regd. Nos. 7984–7994, 7950–7953, 11871–11877, 10449, 10236–10241, 9080–9089, 11018–11055, 9090–9095. Air gap of ·013-in. in remainder including those of R. B. Pullin's manufacture, may be fitted in lieu of Marks I or I*, II* and V.
II*	386/43 (4) (D.F.C. 47720)	N.1354	White Vaseline	Direct switching	As above.	As Mark II except that provision is made for unearthing of 3rd phase supply. May be fitted in lieu of Marks I, I* and II. All with ·013-in. air gap except for certain Mark IIs, which have been converted. May be fitted in lieu of Marks I, I*, II and V.

Mark	A.F.O. Diagram No.	Type of bearing	Type of lubrication	Method of starting	Where fitted	Remarks
II**	386/43 (5) (D.F.C. 46865)	N.1354	White Vaseline	Direct switching	Bofor, Mark IV, mountings *ONLY*.	Small number in service. Provision for unearthing of 3rd phase supply. May be fitted in lieu of Mark VI.
IV	386/43 (6) (D.F.C. 37120)	N.1354	White Vaseline	Direct	T.I.C. units, Marks I, I* and I**.	All with ·013-in. air gap. May be fitted in lieu of Marks IV* and VII.
IV*	386/43 (7) (D.F.C. 45874)	N.1354	White Vaseline	Direct switching	T.I.C. units, Marks I, I* and I**.	As for Mark IV except that provision is made for unearthing of 3rd phase supply interchangeable with Marks IV and VII.
V	386/43 (8) (D.F.C. 51402)	N.3720	Shell VW Grease	Direct switching	New construction gyro sights and K type gyro sights and roll correctors.	Identical with Mark II* except for bearings and lubrication. Interchangeable with Marks II, II* and may be fitted in lieu of Marks I and I*.
VI	386/43 (9) (D.F.C. 51416)	N.3720	Shell VW Grease	Direct switching	Bofor, Mark IV, mountings *ONLY*.	Identical with Mark II** except for bearings and lubrication. Interchangeable with Mark II**.
VII	386/43(10) (D.F.C. 51417)	N.3720	Shell VW Grease	Direct switching	T.I.C. units, Marks I, I* and I**.	Identical with Mark IV* except for bearings and lubrication. May be fitted in lieu of Marks IV and IV*.

PART II.—MAINTENANCE

1. In view of the present shortage of spare gyros for replacement purposes, it is most important that maintenance should be given as much attention as possible under war conditions. Gyro failures may occur through either mechanical or electrical causes or a combination of both, *e.g.*, bearing failure resulting in eventual electrical failure.

2. *Mechanical.*—(*a*) Defective bearings.

(*b*) Mechanical foul.

(*c*) Bad balance.

(*d*) Rusting.

3. It is considered that more gyros have hitherto been rendered defective due to lack of lubrication, use of incorrect or dirty lubricant, or faulty assembly after careless or unskilful stripping than by fair wear and tear.

4. The correct lubricant for Vickers gyro, Marks I, I*, II, II*, II**, IV and IV*, and these types when fitted with N.3720 bearings is *clean white acid free vaseline*. No other lubricant may be used. Shell VW grease is not suitable due to the fact that grease will not feed down a wick (only a pure mineral jelly or oil will do this). Special attention should be given to ensure that the lubricant is *absolutely clean*.

5. *Lubrication Routine for Vickers Gyros, Marks I, I*, II and II*.*—The top lubricator should be examined after every 24 hours running and refilled as necessary. The bottom lubricator should be examined after every 150 hours running time or three-monthly periods, whichever is the shorter period. The lubricant should be changed completely every six months.

6. *Lubrication Routine for Vickers Gyros, Mark II**.*—The top lubricator should be replenished after every 150 hours running time, or every three months, whichever is the shorter. The bottom bearing should be examined by dockyard whenever the ship is in hand. The lubricant should be changed completely every twelve months by dockyards.

7. *Lubrication Routine for Vickers Gyros, Marks IV and IV*.*—The top bearing should be examined at monthly intervals and replenished as necessary. The bottom bearing should be examined by dockyards at twelve-monthly intervals if possible, and the lubricant completely changed.

8. The correct lubricant for Vickers gyros, Marks V, VI and VII, is Shell VW Grease, Pattern No. 854. The grease is supplied in collapsible tubes, each tube containing sufficient grease to service one to two gyros. No other grease should be used. Servicing should be carried out annually by dockyards, unless there is reason to believe that over-heating has occurred. Ships concerned are to raise defect list items as necessary to cover examination and servicing.

9. Causes (*b*), (*c*) and (*d*), are generally inter-related and are usually caused by neglect or faulty assembly. The practice of stopping a gyro with the finger or a pencil is to cease. Rusting can generally be attributed to leaving the gyro exposed to damp air, spray and weather over long periods. The covers of all instruments in which gyros are fitted are to be kept closed, except for the minimum time required for inspection or repair. It should be noted that the gyro rotors are cellulose-sprayed by the manufacturers before assembly, so that with care, gyros should never get rusty. Abrasives should never be used if the rotor has become discoloured or rusty ; a small quantity of oil applied with a clean linen rag will provide adequate protection against further damage until the gyro can be stripped and re-cellulosed.

10. *Electrical.*—There may be :—

(*a*) Failure of gyro windings on stator.

(*b*) Defects in electrical supply caused through faulty switches, wiring, etc., or more particularly through failure of the flexible cables leading current to the gyro.

11. Both (*a*) and (*b*) may lead to the eventual burning out of the stator.

12. Of the above (*a*) is rare and need not be considered while those in (*b*) reflect largely on the efficiency of the ship's maintenance routine. Attention is drawn to the following points, in order that failures due to these causes may be reduced.

(*a*) It should be noted that in gyros where one phase is earthed at the gyro, *e.g.*, Vickers gyros, Marks I, II and IV, a failure in one of the remaining phases will result in single phase running and in the case of :—

(i) Vickers gyros, Marks II, II** and IV, with the ·013-in. air gap, the gyro will continue to run at approximately the same speed without appreciable increase in running temperature. The defect is therefore only likely to be discovered on the next occasion of starting the gyro.

(ii) Vickers gyros, Marks I, I* and II, with the ·005-in. air gap (for registered numbers, *see* classification), the gyro will come to rest within a half an hour. If the current is left on the gyro will burn out.

Thus, if any loss of speed occurs (apparent by sluggish stabilisation), the gyro should be immediately switched off to prevent further damage.

It should be noted that single phase operation is likely to occur with Marks I*, II*, II**, IV*, V, VI and VII gyros if the third phase has been earthed, due to the wiring arrangements being suitable for 3-phase wiring only.

13. To minimise the possibility of single phase running the copper coils leading the current from the gymbals to the gyro have generally been replaced by insulated plaited leads. Similar arrangements have been made in new construction instruments. Ships are to examine their instruments to ensure that this has been done, and, if not, an item should be inserted in the ship's defect list to cover the fitting of pigtail connections.

14. Care should be taken, should it be necessary to fit an " earthed gyro " (Marks I, II and IV) to an instrument having full 3-phase wiring, that the third phase of the supply cable is earthed to the instrument casing.

15. In cases where more than one gyro in a ship has been fed from the same A.C. supply, failures have occurred due to one phase of the supply having been earthed at one gyro and another phase earthed at other gyros. This results in blown fuses in one or more of the earthed lines and may cause single phase running with the attendant danger of overheating.

It will be noted that practically all danger of burn outs from purely electrical causes is removed if all three phases of each gyro and the supply lines are insulated from earth ; for this reason every opportunity for " unearthing " gyros should be taken.

16. To change the direction of the gyro phases I and II should be changed over, the change-over being effected at the terminal box of the instrument.

17. *Precautions to be Observed when starting up.*—Vickers gyros, Marks I and I* are *not* direct switching. These should therefore always be run up with the alternator. Remaining Vickers gyros are direct switching.

All Vickers gyros have a tendency to run at half synchronous speed, which may be accentuated by out of balance of the rotor or defective bearings. These defects cause vibration to be set up, reducing the speed of acceleration and preventing the gyro from rising above half normal speed. The current consumption rises to four times the normal value, resulting in burning out of the gyro. A failure of this type is usually preceded by the gyro developing excessive noise or vibration when passing the half-synchronous speed, i.e., about 2–4 minutes after starting up. Under these conditions momentary scream is given by the Vickers gyro at the critical speed ; this should be taken as a warning of incipient failure and the gyro should be switched off and defected at the earliest opportunity. Should the gyro fail to start, or fail to accelerate at the normal rate the gyro should be switched off to prevent further damage to the stator windings.

18. A " Gyro Protective Relay " has been developed and is being manufactured, which will open automatically the three phase supply lines should any of the following conditions arise :—

(i) An overload.

(ii) An open circuit on 1 phase.

(iii) An earth fault on 1 phase which is not normally earthed, in gyros where one phase is earthed at the gyro.

PART III.—PROCEDURE FOR OBTAINING REPLACEMENTS

1. Attention is drawn to C.A.F.O. 672/43 authorising the transfer of Vickers gyros, Mark II, Pattern 10479, from Vote 8II to Vote 8IIIG.

2. The number of spare gyros available at the moment for replacement purposes is very small and does not generally permit of stocks being held at the main yards or re-fitting ports. Small stocks are, however, issued as opportunity offers.

3. Pending further instructions demands for replace gyros should be made to the M.E.D. of the nearest yard or base, who should apply direct to Admiralty for replacements if none are available. Supply will then be made direct to the ship. Pending the supply of balancing machines to Portsmouth, Alexandria, Rosyth, Durban and Colombo, defective gyros should be returned direct to the Resident Assistant G.M.O., c/o Messrs. Vickers-Armstrongs Ltd., Crayford, Kent, for repair under standing contract, irrespective of the manufacturer.

4. Owing to their delicate nature gyros should be shipped in special transport boxes, details of which are shown on A.F.O. diagram 386/43(11–14) (Drawings D.F.C. 26780, D.F.C. 26800, D.F.C. 26801 and D.F.C. 42313). These transport boxes are suitable for all Vickers gyros and the Elliott H.I. gyro. Where Marks IV, IV* or VII gyros are to be transported, items 10 and 12/D.F.C. 26801 should be replaced by items 1 and 3 D.F.C. 42313. When gyros are transported by air, the carrier case only should be used.

5. Yards are to maintain a small stock of these transport boxes, sufficient to meet normal requirements, and due to urgent demands for gyros at the manufacturers' works, firm's transport boxes *should always be returned* as soon as possible. Failure to do this is liable to result in urgent demands being held up pending the manufacture of transport boxes.

6. It is anticipated that a number of Vickers gyros will shortly become available as spares, and a further A.F.O. will be issued, laying down the scale of stocks to be held at the yards and the revised procedure for demands.

7. Spare gyros will also be issued to the larger ships, in view of the number of gyros now fitted.

8. When T.I.C. gyros (Marks IV, IV* and VII) fail, the whole T.I.C. unit should be defected and a replace unit demanded in lieu.

PART IV.—STRIPPING. REPAIR AND ASSEMBLY

1. It cannot be too strongly emphasised that gyros should not be stripped by ship's staff except in the last resort.

2. The following information and instructions are promulgated primarily for guidance in dockyards ; if, however, it is essential for the work to be undertaken by ship's staff, the precautions and instructions given below are to be minutely observed.

A. Preparatory

1. A special place should be set apart for the work and the utmost cleanliness observed.

2. The following tools are essential and should be provided before the work is commenced :—

A.F.O. Diagram 386/43(15) (D.1101), Item 1	Assembly block.
A.F.O. Diagram 386/43(15) (D.1101), Item 2	Wheel block.
A.F.O. Diagram 386/43(15) (D.1101), Item 3	Wheel block.
A.F.O. Diagram 386/43(15) (D.1101), Item 4	Wheel cap for top pintle.
A.F.O. Diagram 386/43(15) (D.1101), Item 5	Wheel cap for bottom pintle.
A.F.O. Diagram 386/43(15) (D.1101), Item 6	Screw for top pintle.
A.F.O. Diagram 386/43(15) (D.1101), Item 7	Screw for bottom pintle.
A.F.O. Diagram 386/43(15) (D.1101), Item 8	Gyro ball race extractor.
A.F.O. Diagram 386/43(15) D.1101, Item 9	Wrench for nut securing bearing sleeve item 6/D.F.C.26203.
A.F.O. Diagram 386/43(16) D.F.C.53044, Item 4 ...	
A.F.O. Diagram 386/43(15), D.1101, Item 10	Spanner for nuts item 1/D.F.C.26203 securing ball-race.
A.F.O. Diagram 386/43(16), D.F.C.53044, Item 1 ...	
A.F.O. Diagram 386/43(15), D.1101, Item 11	Wrench for bearing sleeve item 5/D.F.C. 26203.
A.F.O. Diagram 386/43(16), D.F.C.53044, Item 2 ..	
A.F.O. Diagram 386/43(15), D.1101, Item 12	Screw driver for screwed ring item 6/D.F.C. 26202.
A.F.O. Diagram 386/43(16), D.F.C.53044, Item 3 or 9...	
A.F.O. Diagram 386/43(15), D.1101, Item 13	Typical melting pot and filter for white vaseline lubricant.
A.F.O. Diagram 386/43(15) D.1101, Item 14	Tool for assembling with.
A.F.O. Diagram 386/43(16) D.F.C.53044, Item 5 ...	Inner ball-race extractor for item 1/D.F.C. 26202, 11/D.F.C.51311 and 7/D.F.C.51311.
A.F.O. Diagram 386/43(16) D.F.C.53044, Item 6 ..	Outer ball-race extractor for item 4 and 6/D.F.C. 51311.
A.F.O. Diagram 386/43(16) D.F.C.53044, Item 7 ...	Extractor for use on items 4 and 6/D.F.C. 51311.
A.F.O. Diagram 386/43(16) D.F.C.53044, Item 8 ...	Screw driver for use on item 9/D.F.C.51311.
A.F.O. Diagram 386/43(16) D.F.C.53044, Item 10 ...	Screw driver for use on item 1/D.F.C.51311.
A.F.O. Diagram 386/43(16) D.F.C.53044, Item 11 ...	Extractor for separating gyro wheel from upper case.
A.F.O. Diagram 386/43(16) D.F.C.53044, Item 12 ..	Extractor for separating gyro wheel from lower case.

Note.—Where items have been reproduced on more than one drawing both types are in general use by the gyro manufacturers.

3. *General.*—For purposes of stripping repair and assembly, Vickers gyros may be divided into two classifications :—

(*a*) Those with N.1354 bearings and white acid free vaseline lubrication—Marks I, I*, II, II*, II**, IV and IV*.

(*b*) Those with N.3720 bearings and Shell VW grease lubrication—Marks V, VI and VII.

4. All Vickers gyros now in production are Marks V, VI or VII. Comparative trials have shown that the N.3720 bearing with Shell VW grease lubrication is superior to N.1354 bearings with white acid-free vaseline for the following reasons :—

(*a*) Less maintenance required.

(*b*) Freedom from possibility of ingress of dirt as the bearing is filled from single shot tubes, eliminating the danger of dirt entering bulk containers.

(*c*) Satisfactory operation at temperatures between −40° C. and +60° C.

(*d*) Greatly increased reliability and life of bearing.

5. When existing stocks of N.1354 bearings are exhausted, N.3720 bearings will be issued in lieu. No modification to the gyro is required provided the existing method of lubrication (*i.e.*, wick feed of white vaseline) is retained. It is desirable, however, when time permits, that the gyro should be modified to take Shell VW grease lubrication. This work is within the capacity of dockyards, but should *never* on any account be undertaken by ships' staffs. Sets of drawings showing the work entailed are being despatched to the gyro repairing yards.

When gyros originally fitted with N.1354 bearings are fitted with N.3720 bearings in lieu the word " Mod. 1 " should be engraved after the mark of the gyro *e.g.*,

Mark II* becomes Mark II* Mod. 1.

6. When gyros are fitted with N.3720 bearing and modified for Sheel VW grease lubrication the gyro should be engraved as follows :—

Mark II* becomes Mark V.
Mark II** becomes Mark VI.
Mark IV* becomes Mark VII.

7. Vickers gyros, Marks I or I*, need not be modified for the Shell VW lubrication in view of the small number in service ; they will eventually be replaced by Mark V gyros.

8. The following remarks are applicable to all marks of Vickers gyros.

Stripping the Gyro.

In dismantling and re-assembling, care should be taken to ensure that the parts are segregated to facilitate re-assembly in their original positions. This particularly applies to the bearings and associated parts such as nuts, etc., and small pieces of lead used for balancing. The positioning of the top bearing sleeve with respect to the 12 B.A. locating screw and registering slot ; the correct relative positioning of the top and bottom casings and the registration of the bottom screwed ring are also points requiring particualr attention.

Two important points should be borne in mind before dismantling is commenced, namely :—

(*a*) The top and bottom casings cannot be parted until the nuts securing the top and bottom ball races to the gyro spindle have been removed ; any attempt in this direction will damage the gyro.

(*b*) No attempt should be made to withdraw the sleeve holding the top bearing until the top casing has been removed from the wheel. The method of removing this sleeve is explained below and the use of any other method is likely to result in shearing the 12 B.A. screw which is used to register this sleeve.

9. *Stripping, Balancing and Assembly Instructions for Vickers Gyros, Marks I, I*, II, II*, IV and IV*.*

A. Dismantling the Gyro

Remove top and bottom lubricators by unscrewing.

Examine bottom ring to establish the presence or otherwise of a grub screw (fitted in later gyros) which prevents bottom ring from unscrewing when lubricator is removed. This screw projects into the central hole giving access to the lower bearing nuts and must be withdrawn before the spanner can be inserted to remove these nuts.

Remove grub screw if present.

Place gyro correct way up on its stand, engage lock nut on top of spindle with spanner. Free nut by a sharp anti-clockwise twist of the spanner and remove lock nut.

Invert gyro on its stand and remove lock nut on lower end of spindle by similar method.

Place gyro on its side, engage top and bottom bearing securing nuts, ease off and remove.

Note.—Should lock nuts be difficult to free by a sharp twist of the spanner, stand gyro on its side and free nuts by using two spanners ; avoid holding the wheel during this operation if at all possible. Keep top and bottom lock and securing nuts separate and restore to original positions when re-assembling.

Replace gyro on its stand the right way up and remove the sixteen 6 B.A. screws holding top and bottom casings together ; note positions of any small weights fitted under these screws and return to original positions when re-assembling

Lift off the top casing by a gentle upwards pull. If the bearings are too tight a fit on the spindle, this will be difficult and the top bearing extractor should be employed. This consists of a piece of metal screwed into the top casing in place of the top lubricator and having a central bolt which can be screwed down to press on the top of the gyro spindle.

Place a clean piece of paper over exposed wheel.

Note that the ball race should come away complete with the top casing. The sliding member securing this ball race should be removed by pressing on the bore of the ball race with a peg-wood stick ¼ in. diameter shaped like a pointed lead pencil ; the stick should be inserted from the inside of the casing.

Hold the sleeve in the special gripping spanner, with the wide slot in the base of the skirt engaging the peg in the spanner. Insert the nut-removing spanner, engage the pegs in the slot of the nut and unscrew. The outer race can now be removed from the sleeve.

Clean the inner race and not the etched line and the mark on the spindle which has been made to show the correct position for re-assembly. Use this mark when replacing bearing or fitting a new race. Take off inner race, noting the type of fit for future guidance and put all parts of top bearing together, separately from the lower bearing. *Do not detach* the cage from the inner race, as this will damage the race and cage.

To remove the bottom casing, grip the sides of this casing between the palms of the hands and support the wheel with the tips of the fingers, pressing the wheel gently downwards into the casing. Retain this pressure and lift the gyro from its stand and invert it on the stand intended for the gyro wheel. Remove the bottom casing by a gentle upwards pull. If a tight bearing renders this difficult, use an extractor adapted to fit in place of the bottom lubricator. The lower race should come away from the spindle when the lower casing is removed. This race is contained in the stator supporting column and is located by a distance piece clamped in position by the lower screwed ring. The grub screw which retains this ring has already been removed, but the alignment of the three holes through which this screw passes should be noted for replacement purposes. Use the special spanner to remove the lower screwed ring by unscrewing. The distance piece which positions the lower ball race is then exposed and an examination will show a small clearance between its flange and the stator support. Insert a sharp knife-edged tool in this clearance and lever the distance piece out. Insert a peg-wood stick from the inside of the casing through the central hole in the stator and press out the lower ball race. Note the lining up marks on the ball race and gyro spindle as with the top race.

The stator should never be dismantled from the lower casing unless imperative. Should this be necessary, disconnect the leads, noting that the blue lead comes opposite the 7 B.A. tapped hole for the earthing screw ; remove the eight 6 B.A. screws securing the stator and carefully force the stator out of position. To avoid damaging the connecting leads extreme care is necessary to work these leads through the insulating bushes as the stator is forced out and care should also be given to avoid distorting the casing and stator column during this operation.

B. Fitting New Ball Bearings

The outer rings should be assembled with the thrust portion, i.e., the smallest bore, remote from the wheel.

The bearings are manufactured to a very high degree of accuracy, the manufacturing tolerances being :—

Diameter—Outside	... ...	16 mm. ± 0·0025 mm.
Inside	... ...	4 mm. ± 0·0025 mm.
Max. eccentricity	... ...	Outer ring = 0·0002 in.
		Inner ring = 0·0001 in.

The recommendation of the bearing manufacturers for their very light bearings is that the spindles be made to the same dimensions as the bore of the bearings and that the outer race should be a sliding fit without slackness in the housing.

The fit of the bearings is of great importance and it may be necessary for several bearings to be tried before a suitable pair can be found to fit the spindle correctly. The bearing must be a GOOD PUSH FIT on the spindle so that the bearing can be pushed gently over the spindle but does not turn on the spindle when the ball cage is gripped firmly between finger and thumb and then twisted. It is usual to select a bearing that is too tight and ease the spindle to suit. It is essential that the fit should be absolutely correct as a loose fit will give rise to creep of the inner race round the spindle and a tight fit will be difficult to remove and may cause scoring of the spindle if the bearing be forced on it.

Before fitting finally, the bearing should be washed in S.B.P.4, a diluted undoped aviation spirit (*see* B.R.4, Naval Storekeeping Manual, 1938, Art. 206) and dried out thoroughly by air blast.

Once a pair of bearings has been fitted and the wheel finally balanced, it is essential that, should they be removed for any reason, they should be replaced on their own spindles in their original position. To ensure this the etched lettering on the inner race of the bearing should line up with a mark made on the end of the spindle. *The wheel is balanced for this one position only.*

C. Balancing.

This should be carried out on a dynamic balancing machine.

Tinius Olsen dynamic balancing machines are now being procured for the use of the electrical departments of the following yards :—

Portsmouth, Rosyth, Durban, Alexandria and Colombo.

This machine measures electrically the unbalanced vibrations caused by the wheel *and bearings* in two planes, and indicates the position on the perimeter of the wheel where metal must be removed to rectify the unbalance.

The procedure is as follows :—

A suitable pair of bearings having been selected, they should be placed on the spindle, the figure 1 of N.1354 etched on the inner race being placed in line with the mark on the end of the spindle.

The gyro should then be spun in the balancing machine, and the out-of-balance measured in both planes and noted.

Each bearing should in turn be removed, turned 90° and replaced, fresh measurements being taken of out-of-balance.

Repeat, turning bearings a further 90°.

From these readings, approximate positions for best balance are obtained, and the bearings fitted in this position.

A fresh set of readings should then be taken, giving the amount of out-of-balance of the gyro as a whole with its bearings, and a hole will then have to be drilled in the rotor in the correct position, obtained by readings in two planes at 10° radially. The Tinius Olsen balancing machine also calculates the quantity of metal to be removed, in terms of depth of drilling required for a 1/10-in. dia. hole.

If no quantitative readings can be obtained from the balancing machine in use, the amount and position of out-of-balance can be obtained by placing pieces of plasticine on the periphery of the wheel and the best position and quantity required, determined by trial and error.

A hole is then drilled at 180° to the piece of plasticine giving best balance, the necessary depth being calculated from the weight of the plasticine.

This method cannot, of course, be expected to give very accurate results.

A check reading on the balancing machine should then be taken and the radial position of the bearings finally adjusted, a fresh mark being then made on the spindle, to enable the bearing to be replaced correctly if it is removed at any time.

Note :—The bottom spindle bearing is always placed at the bottom of the tin containing a pair of bearings, after test at Crayford.

D. Assembly

Assembly can be carried out in the reverse order to dismantling.

If the lubricating wicks are dirty they should be replaced by new. The holes through which these wicks pass are carefully calibrated to ensure correct lubrication and must on no account be enlarged to facilitate inserting the new wicks. The lower wick requires a special tool to facilitate insertion ; this consists of a piece of steel about ·1-in. diameter reduced to ·05 at one end which is bent at right angles. The bent end is provided with a fine hook on its side to pick up the strands of the wick when it is inserted in the hole and pushed to the bottom. The end can then be pulled into the central hole and caught by a pair of fine pointed pliers which are used to draw the wick through the necessary distance. To start the wick in the hole, pull back the outer braided part so as to expose about 1 in. of the centre core. Cut this amount of centre core away and draw the core back into the braid. Pare the end of the braid down until it can be brought to a point by moistening it between the fingers with a smear of vaseline. The pointed end can then be introduced into the hole and the wick drawn through as described. Make sure that the centre core is drawn right through the hole, trim off the waste end and tuck the wick round annular space provied.

The top wick is passed through the lubricator hole by a similar method, after which the end is trimmed and splayed out.

When inserting the ball races, pack the balls in the cage with white vaseline, which should be filtered before use. This will prevent the balls dropping out of position and jamming in the cage during assembly.

The relative positions of the bearings and the marks on the ends of the spindles should be maintained when the gyro is assembled.

Clean the lubricators and fill them up with filtered vaseline before replacing.

Final Tests.

(*a*) The gyro should then be run at 25,000 r.p.m. for 15 minutes without noticeable increase in bearing noise.

If the bearing noise increases perceptibly during this test, the bearing is probably too soft and both bearings will have to be scrapped.

(*b*) The gyro should then be run for eight hours at normal speed and the bearings inspected visually at the end of the run.

If any blackening of the balls or race is observed, *both* races should be scrapped and a new pair fitted.

Bearing noise should be watched during this test as in the case of the overspeed test.

10. *Stripping Instructions for Vickers Gyros, Mark II***.—The procedure for these gyros is essentially the same as that in paragraph 9 above, except that it should be noted that a locking screw item 1/D.F.C.47028 must be removed before the combined hydraulic damper and lubricator can be unscrewed.

Assembly should be carried out in the reverse order, care being taken to replace item 9/D.F.C.47028.

11. *Stripping, Balancing and Assembly Instructions for Vickers Gyros, Marks V, VI and VII.*—Remove locking screw for cap item 3/D.F.C.51311.

Unscrew cap item 3/D.F.C.51311 and lift out spring item 9/D.F.C.26203.

Before removing the lubricator item 2/D.F.C.51517 unscrew locking screw item 2/D.F.C.51517. Unscrew locking ring item 1/D.F.C.51311 and remove the 16 B.A. screws securing the gyro casing, noting the positions of any small weights fitted under these screws, care being taken to restore these to their original positions of assembly.

Lift the top half casing complete with bearing sleeve item 4/D.F.C.51311 and outer race, the top bearing extractor being used if necessary.

Invert the gyro on the wheel block and unscrew locking ring item 1/D.F.C.51517, and withdraw the distance piece item 5/D.F.C.51311. The bottom half casing should now be removed as previously described, complete with pedestal item 6/D.F.C.51311, Stator item 2/D.F.C.26204 and the outer ball race.

Note.—For gyros converted from Marks II, II*, II**, IV and IV*, it is necessary to unscrew grease retainer item 9/D.F.C.51311 before withdrawing the outer race.

The stator should never be detached from the lower casing unless it is essential. Should this prove necessary the procedure is the same as previously described. In the Marks V, VI and VII gyros the inner ball races should not be removed from the pintles unless they are being replaced, owing to the interference fit on the pintles.

B.—Fitting New Ball Bearings and Balancing.—The procedure is generally similar to that for N.1354 bearings except that the inner races, once fitted, should not be removed. The N.3720 bearing is generally similar as regards tolerances and main dimensions, to the N.1354 bearing. There are seven in No. $\frac{1}{8}$-in. diameter balls held in a *bakelite* cage in lieu of the eight in No. $\frac{1}{8}$-in. diameter balls held in a brass cage in the N.1354 bearing. Each bearing is clearly marked " N.3720."

Diameter of outer race ... 16 mm. $\pm$ ·0025 mm.
Diameter of inner race ... 4 mm. $\pm$ ·0025 mm.

A revision of these tolerances is under consideration ; any alteration will be published in a later A.F.O.

Concentricity of the outer ring is within ·0002 in.
Concentricity of the inner ring is within ·0001 in.

Note.—It is important when fitting N.3720 bearings that the open side of the inner race is assembled on the same side as the chamfer in the bore of the outer.

C. Assembly should be carried out in the reverse order to stripping, the bearings being packed in Shell VW grease to retain the balls in the races. The lubricator should be meticulously cleaned and packed with fresh grease before replacing.

D. Final Tests as detailed in the foregoing paragraphs.

Conclusion.—Abridged stripping instructions for all types of Vickers gyros are shown in tabular form in A.F.O. Diagram 386/43 (17) (D.F.C.51687).

It is emphasised that this work is of a highly specialised nature and that the exchange of gyro bearings can only be successfully effected if *meticulous cleanliness* and strict observance of the procedure outlined above is maintained throughout.

(*B.R. 4.*)

(*C.A.F.O. 672/43.*)

(65643) Wt. 8153/2290 17,100 12/43 Hw. G.338/10.