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**ADMIRALTY FLEET ORDER**

**RANGEFINDERS—ELEVATION ERRORS—AIR DISTURBANCE  
GEAR—RHODIUMISED WINDOWS—CARE AND  
MAINTENANCE—TESTS AND REPORTS**

ADMIRALTY, S.W.1,

29th June, 1944.

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, Vessels, and C.O. Craft (see A.F.O. 494/44), Superintendents or Officers in Charge of H.M. Naval Establishments, and Admiralty Overseers concerned.*

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

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### 3481.—Rangefinders—Elevation Errors—Air Disturbance Gear—Rhodiumised Windows—Care and Maintenance—Tests and Reports

(G. 2211/44.—29 Jun. 1944.)

War experience has shown that there is a very marked tendency for long-range anti-aircraft fire to be short of the target, very often by a considerable amount. In peace practices with targets at comparatively low heights and short ranges, this error was not so apparent, particularly as bursts within 100 yards short of the target were considered the most dangerous to the attacking aircraft. War experience with targets at heights up to 20,000 ft. and correspondingly long ranges have now shown that a considerable short error exists under certain conditions with long-range H.A. fire.

2. Investigation was carried out to ascertain the cause of this short error. This led to the discovery that a rangefinder which was in coincidence adjustment when horizontal, developed large errors on being elevated, the size of the error varying with the elevation of the rangefinder, and the extent to which the casing of the rangefinder was affected by the sun, shade and wind temperature effect.

3. The size of this error has been found in Naval rangefinders to amount to as much as —10 divisions at infinity at 45 degrees elevation, which would cause bursts to be 1,000 × short of the target at 10,000 ×.

4. Investigations show that the cause of these elevation errors is due to layers of air of different density forming inside the barrel casing caused by difference of temperature between the top and bottom inside the casing. As the rangefinder is elevated these layers of air remain horizontal and the rays of light passing through the rangefinder are deviated on passing through these different layers.

A number of valuable reports have been received from ships at sea; these confirm that:—

Very large errors may occur when taking ranges at moderate or high elevations. Errors up to 18 divisions at infinity have been recorded in rangefinders correctly adjusted on a shore object.

5. The problem of effecting a cure for this meant producing a simple device which would equalise the temperature along the light pattern inside the rangefinder. A satisfactory method has been produced by a vigorous mechanical stirring of the air in the barrel of the rangefinder by means of a pump.

(These errors are effectively removed by the use of air disturbance gear, or, if not entirely removed, then reduced to a figure which seldom exceeds two divisions.)

6. The system adopted after trial is as follows:—The rangefinder is fitted with two internal disturbing tubes; a series of air jets, drilled along the tubes, point directly towards the horizontal axis of the instrument, the tubes being connected to either side of the cylinder of a pump. A downward stroke of the piston causes a surge of air through the jets in one tube at one end of the rangefinder, and, at the same time, an outward surge through the jets in the other tube at the other end of the rangefinder, and *vice versa*. The rate of operation of the pump is about one single stroke per second. It will be observed that no fresh air from the atmosphere is introduced at any stage into the rangefinder. The system is closed; no dust, moist external air or air at a temperature sensibly different from that within the instrument can enter.

7. Using this method, exhaustive trials were carried out on both 15 ft. U.D.4 and 12-ft. U.K.4 rangefinders under all conditions during an English summer. During the trials, errors were recorded of as much as —11 divisions at infinity, but these were instantly reduced to 1.5 divisions by using the pump. The errors will again begin to appear on stopping the pump, and will reach a maximum again within 30 seconds, therefore continuous pumping is essential. This remaining error will vary with each individual equipment, as it is considered to be the residual error of the rangefinder.

8. A.F.O. Diagram 196/44 (1-4) shows the designs of internal tubes, types of pump and the modifications to the various equipments which are to be carried out by ships' and depot ships' staffs, under the direct supervision of an Ordnance Officer, at the earliest possible opportunity.

After the air stirring device has been fitted, it is of the utmost importance that all tests and adjustments for coincidence and halving are carried out with the stirring device in operation.

9. Seven pumps, Pattern No. 10465, incorporating the above modifications, have been supplied by Messrs. Barr and Stroud for use with rangefinder disturbing gear in rangefinders, Types U.D.3, U.D.4, U.D.5, U.L.1, U.L.2, U.K.3, U.K.4, U.R.1, U.R.2 and U.R.4. As a result of the general policy of fitting of Q.G.II units for air disturbing purposes in all ships where the above rangefinders are fitted, no further pumps will be supplied, nor will it be necessary to modify existing pumps as described above.

#### 10. Method of Fitting the Air Disturbing Tubes

U.D.4, U.D.5, U.K.III and U.K.IV

- (1) Remove lower set of screws around the temperature covers about the end reflector castings. Remove lower cover.
- (2) Remove screws securing outer temperature covers around the barrel of the rangefinder. Slide covers towards the eyepiece.
- (3) Mark off holes for air disturbing tube connections. For U.D. types 30° abaft the lower centre line, for U.K. types, on the lower centre line.
- (4) Remove screws around the covers of the end reflectors, remove the covers.
- (5) Place a clean cotton cloth inside the barrel, a little distance beyond the position for the air disturbing inlets.
- (6) Drill holes for pipes in the end reflector temperature covers.
- (7) Drill holes for air disturbing connections in the barrel. These holes are to be pierced by drilling a close series of small holes around the finished circumference.
- (8) Carefully remove cloth and clean out drillings, etc.
- (9) Fit air disturbing tubes, care being taken to make a perfect air-tight joint.
- (10) Re-assemble parts.

U.D.3

- (1) Cut clearance holes for pipes in the temperature covers (where fitted).
- (2) Unscrew end covers.
- (3) Remove pentagonal holders.
- (4) Place a clean cotton cloth in the barrel of the rangefinder.
- (5) Follow directions for U.D.4 and 5.

The day selected for opening up the rangefinder is to be of low humidity and with very little or no wind.

The work is to be undertaken when the atmosphere is clear of dust, therefore it is preferable for the opportunity to be taken when the ship is at anchor rather than alongside.

No work should be in progress in the vicinity of, or before, the rangefinder, which may cause dust to rise.

The rangefinder should not be open any longer than essential. The end covers are to be temporarily replaced during any pause in the work.

#### Important

All end reflectors of rangefinder are set at exactly 45° angle to one another. If this angle is disturbed by grit getting between the mirrors and their seatings, the rangefinder will be put completely out of adjustment. It is, therefore, most important that grit or dust should be kept completely clear of the end reflector, otherwise it may work into the seatings when vibration occurs.

#### Power Pump

Pattern No. 10609 has been assigned to the complete air disturbing unit, and it is described as "Combined Air Disturbing, Desiccating and Window Cleaning Unit, Type Q.G.II".

The components are:—

- (i) One H.P. motor with dual rotary pump, silencer, complete in shock and weatherproof metal box.
- (ii) Window cleaning solution tank, complete with two control valves and fixing bracket. Barr and Stroud symbol Q.H.I. (This tank is similar and interchangeable to that supplied with the Q.G.I. window cleaning unit for D.C.T. rangefinders.)

- (iii) Silica gel desiccating tank. Barr and Stroud symbol Q.A.IX. (This is the standard tank for silica gel for all types of rangefinder desiccators.)
- (iv) Necessary tubing, connections, etc.
- (v) Window cleaning nozzles. This item becomes a component of the rangefinder when fitted.

11. Arrangements have been made for spare rotary pump vanes to be supplied with the units, viz. :—

Pattern 10612—Vanes, laminated carbon, medium, for Q.G.II units.

Pattern 10613—Vanes, laminated carbon, small, for Q.G.II units.

All rangefinders mounted in rangefinder directors, three-man rangefinders and destroyer H.A./L.A. D.C.Ts. will be fitted with Q.G.II units as soon as they are available.

12. Ships concerned should insert an item, classification "A\*", in their lists of Alterations and Additions, as follows :—

"To fit Q.G.II combined air disturbing, desiccating and window cleaning units to rangefinder director or three-man rangefinder or H.A./L.A. D.C.T." The work of fitting the units will be carried out by dockyards.

13. The Q.G.II unit replaces the Q.C.III unit which is now fitted in H.A.C.S. directors, Marks III and IV. The Q.C.III unit is to be returned to Naval stores on replacement.

The hand pump taken from the Pattern 8011 hand desiccator and modified in accordance with paragraph 8 (hand pump) is to be reconverted for its former use by ships' staffs.

Ships with more than one H.A.C.S. director and which have been supplied with extra hand pumps above the authorized complement of Pattern 8011 desiccators are to retain one pump on board for use in the event of the Q.G.II unit being under repair. Any pump in excess of this one spare is to be returned to Naval stores.

14. The work involved in installing the unit can be undertaken by ships' staffs, but with the fitting of the new window cleaning nozzles to U.D.4 and U.D.5 rangefinders, dockyard assistance will be required.

It has been ascertained that the capacity of the Q.C.III unit is definitely unsuitable for using in conjunction with the air disturbing tubes.

15. Ships fitted with Q.C.III gear are not to use the unit for air disturbing but are to employ the hand pump.

16. Breakdowns have occurred in the rangefinder blower of Q.G.II units. These have been caused by the entry of water into the rotor chambers, setting up corrosion between the rotors and their separating plates. Seizures have followed, resulting in fractured rotors and other damage.

17. The weatherproof metal box containing the rangefinder blower cannot be made watertight due to the breathing pipe or air inlet at the motor end of the box. Ships should, however, keep the probability of entry of water into the box to a minimum by frequent drying, especially after bad weather. Water may also enter by seeping back from the silica gel container, if this is not kept dry and the gel active, or from the solution tank. In the latter case this could only occur in early types where the lead of pipe from the blower is not at some point higher than the surface of solution in the tank, or in setting up a pressure in the tank by running the blower with both outlet valves closed and pressing the operating plunger when the blower is topped. Water can also enter through bad connections.

18. Ships concerned are to carry out the following maintenance routine :—

Daily ... Run Q.G.II units for 5 minutes.

Monthly ... Inspect rotors of the rangefinder blowers and ensure that leads of pipe are correctly connected and connections watertight.

Attention is also drawn to Barr and Stroud Pamphlet No. 927b, issued with each Q.G.II unit.

19. To enable repairs and replacements to be carried out at dockyards and repair bases, arrangements are being made to supply the undermentioned spare Q.G.II units and parts with instructions to fit.

Pattern	Description	A. No.	B. No.
10609	Combined air disturbing, desiccating and window cleaning units, Type Q.G.II.	2	1
10612	Vanes, laminated, carbon, medium ...	20 sets.	10 sets.
10613	Vanes, laminated, carbon, small ...	60 sets.	30 sets.
10713*	Cylinders, large ...	4	2
10714*	Cylinders, small ...	12	6
10715*	Carbon discs, with hole ...	30	10
10716*	Carbon discs, without hole ...	15	5
10717*	Rotors, large ...	4	2
10718*	Rotors, small ...	12	6
—	Drawings and instructions ...	1 set.	1 set.

\* New patterns are being introduced under Subhead F, Item IB.

Shipment of quantities under column A will be arranged by the Superintending Naval Store Officer, Park Royal, to the following :—

Simonstown	Wellington	Halifax
Durban	Alexandria	B.A.M.B.
Colombo	Malta	Scapa
Sydney	Gibraltar	Belfast
Fremantle	Freetown	

Quantities under column B will be supplied direct from contractors to :—

Chatham	London	Rosyth
Devonport	Hull	Liverpool
Portsmouth	Newcastle	Greenock

20. The inlet fitted on the metal box should be periodically examined and cleaned.

It is essential that the unit is kept continuously running whenever the rangefinder is actually in use. The accuracy of the rangefinder is dependent on the continuous air disturbance within the barrel of the instrument under all climatic and temperature conditions.

21. A.F.O. Diagram 196/44 (5) (Drawing 14362) shows the general arrangement of the dual blower pump, giving the principal overall dimensions and position of the bolt holes for securing purposes.

In Marks III and IV directors this unit is to be fitted in the place now occupied by the Q.C.III unit.

In Marks I and II directors it has been found convenient, in ships already fitted, to site the unit on the floor of the director to the left of the manhole. It is necessary to remove the radiator and re-site minor gear.

22. A.F.O. Diagram 196/44 (6) (Drawing 14367) shows the external views of the cleansing solution tank. This diagram also shows the principal overall dimensions and particulars of fixing arrangements.

The support bracket, Item 5, consists of a simple bent plate, and can be readily altered to suit requirements.

The tank should be situated within easy reach of the range taker.

On U.D.4 and U.D.5 rangefinders only one outlet to the windows is required. In this case the valve to the outlet not used can be closed, or the complete valve unit removed by unscrewing completely at Item 12 and fixing a cover cap or plug to close the aperture, the removed valve being retained in the accessory box as spare.

23. A.F.O. Diagram 196/44 (7) (Drawing 14069) shows the general arrangement of the silica gel container and principal overall dimension and positions of the fixing-down bolts.

24. A.F.O. Diagram 196/44 (8) (Drawing 14369) shows the diagrammatic arrangement of the various units and pipe connections between the units and the rangefinder on instruments which have been fitted with air disturbing tubes by Messrs. Barr and Stroud.

The lead of pipes for air disturbing on U.D.3 rangefinders will be inlet to the air-disturbing tubes and outlet from the existing desiccator connections in the end covers.

For U.D.4 and U.D.5 rangefinders modified in accordance with paragraph 11, the inlet will be to the air disturbing tubes and outlet from the connection shown at 10 on this diagram.

25. A.F.O. Diagram 196/44 (9) (Drawing 14393) shows the position and arrangement of the new outlet connection, Item 5 to be fitted to the left of the facepiece, on all U.D.4 and U.D.5 rangefinders. The section A-A shows the existing screw and cover cap which are to be removed and replaced by means of the new adaptor. To locate this position a hole has to be cut in the temperature tube about 2 in. diameter 10.35 in. from the centre line of the rangefinder, i.e., centre line of facepiece, and 15° from the vertical. The temperature tube has a thin wall and the hole can readily be cut by ship's staff without dismantling the rangefinder.

26. A.F.O. Diagram 196/44 (10) shows the new nozzles to be fitted to U.D.4 and U.D.5 rangefinders. The removal of the existing nozzles will require dockyard assistance.

Instructions for this modification are :—

- (i) Unscrew the couplings 1 and 2 on the feed pipes.
- (ii) Unscrew the window holder fixing screws and remove the window holder from the rangefinder and casting.
- (iii) Unscrew the window bezel ring and remove the window from the holder.  
*Note.*—It is advisable to mark the window relative to the holder so that it can be replaced in the original position.
- (iv) Remove the top and bottom nozzle blocks, Items 3 and 4, from the window holder by unriveting and removing the three screws in each block.
- (v) Plug the six holes in the window holder previously used for fixing the nozzle blocks.
- (vi) Replace the window in the holder and mount holder in position on the rangefinder.
- (vii) Place the new nozzle, Item 6, in position and connect to the top feed pipe by means of coupling, Item 1.
- (viii) Place the blank plug, Item 8, in position and connect to pipe by coupling, Item 2.

Access to the couplings 1 and 2 can be obtained by sliding the temperature tube endwise as shown in the top view of this diagram.

- (ix) The right-hand window is indicated on the diagram and modification to the left end is similar.

It should be noted that the nozzles are handed and that slight adjustment in positioning may be necessary to obtain the most effective air jet across the window.

#### Approximate Ballistic Correction for Rangefinder not Fitted with Correction Gear

In ships where it is not possible to fit the internal tubes and hand pump immediately it is desirable, if possible, to make some allowance for this tendency to shoot short.

Trials so far carried out show that the factors which contribute to the size of the error are so variable and so unpredictable that it is extremely difficult to lay down any rule-of-thumb table for correction of the error.

27. The following method will, however, give an indication of the size of the error and as the error is always in one direction, the application of a correction based on this method should give a better result than a permanent arbitrary plus ballistic correction which many ships have used.

28. It must be clearly understood, however, that the modification of fitting a pump is the only certain way of curing this error, and the use of this approximate correction is only a temporary measure.

29. From trials already carried out in England, it is known that the error varies from hour to hour, and that it is affected by temperature, and temperature changes caused by sun, shade and wind effects on the outer casing of the rangefinder. Some similarity is apparent between curves plotted against time on similar days and nights.

It is probable that in climates where conditions do not change appreciably from day to day, error curves of this type might be of value for correcting the rangefinders.

The error E (in divisions at infinity) varies as the Sine Angle of Sight. It is, therefore, a maximum at 90° angle of sight, and the value of the error at this angle is called *k*.

$$\text{Thus, } k = \frac{E}{\text{Sine } A/S}$$

#### Determination of *k*

A set of coincidence tests should be carried out daily when possible on the sun moon or stars, and the value of *k* deduced. Special testing mirrors must be used for the tests on the sun, but not on the moon or stars. A note on these special testing mirrors will be found at the end of this order. It should be noted that the most reliable value of *k* will be obtained at high angles of sight. The values of *k* for any one twenty-four hours should then be plotted on a basis of time of day. The air temperatures (near the rangefinder, and in the sun if out) may also be recorded if desired so that plots on days with similar temperature conditions may be compared. The error curve at night will be different from the day error curve.

#### Application of the Correction

It is simplest to use the value of *k*, not E, to make the correction on the H.A.C.S. table, because for any given height of target the additional B.H.C. required to compensate, at all ranges and angles of sight, for the error of the rangefinder is a simple multiple of *k*.

It can be proved that, where *h* is the height in feet, and *k* in divisions at infinity, the additional B.H.C. to apply is :—

- (a) For rangefinders in which 1 division at infinity is equivalent to 1 yard in 1,000 yards, e.g., U.D.4, U.D.5, U.L.1 and U.L.2

$$\frac{h}{30,000} \times k \text{ per cent.}$$

- (b) For rangefinders in which 1 division at infinity is equivalent to 10 yards at 1,000 yards, e.g. U.B.3, U.B.4 and U.D.3.

$$\frac{h}{3,000} \times k \text{ per cent.}$$

Hence the following table for use in the H.A.C.P. can be made out :—

Height of aircraft in feet	Factor by which <i>k</i> must be multiplied to give the additional B.H. correction to set	
	(a)	(b)
3,000	1/10th	1
5,000	1/6th	1 2/3rds
10,000	1/3rd	3 1/3rd
15,000	1/2	5
30,000	1	10

Then, if the value of *k* is known in the H.A.C.P. as soon as a height of the aircraft is obtained *k* can be multiplied by the factor for that height and applied as an additional B.H. correction on the B.H.C. dial. If the height alters the additional B.H.C. applied must be altered according to the same table.

It is suggested that, after making out curves of *k* against time of day for different types of day or night conditions, gunnery officers should issue cards to the H.A.C.P. (different cards for different types of days), from which the Officer of Calculating Positions must take the value of *k* to be used at the time each engagement takes place.

Example :—

Card given by G.O. to O.O.C.P.

Card No.	Daytime
Time	<i>k</i>
0800	2
1000	10
1200	14
1400	14
1600	13
1800	4
2000	6

*Note.*—The card shown here is entirely fictitious. These cards must be made out from trials carried out in the ship.

G.O. decides to use No. 1 card and informs O.O.C.P.

At 1330 an attack takes place, and an aircraft is reported approaching at 15,000 ft. From Table (a) O.O.C.P. sees that he has to use the value  $\frac{1}{2}k$ , which is +7 per cent. B.H.C. at 1330. He orders an additional +7 per cent. to be set on the B.H.C. dial. At "Have Height" the observed height is 10,000 ft., for which the factor is  $\frac{1}{2}k$ , i.e., +4  $\frac{2}{3}$  per cent. He accordingly orders the total B.H.C. setting to be reduced by 2  $\frac{1}{3}$  per cent.

#### Rhodiumised Windows

30. Reports show that a series of observations on a shore object in general agree closely with tests taken on the sun if the pump is operated during both series.

A satisfactory sun test requires the use of special testing mirrors known as "Rhodiumised testing windows", which are now in full production, and supply to ships of one pair for each equipment concerned will be made without demand; until supply becomes general ships without them should borrow from ships in company.

31. These windows are in essential merely dense filters, and when mounted externally to the rangefinder, as described herewith, they enable the sun, whenever available, to be used as an object at infinity without risk of damage to the eyes of the rangefinder or to the instrument. They are accurately plane parallel on the horizontal diameter and cause no deviation in this plane to light passing through them. The necessary reduction in light intensity has been effected by depositing on one surface a film of rhodium of appropriate thickness. Rhodium possesses good weathering properties, and has been selected as the most suitable metal for the present purpose.

32. The normal procedure for carrying out infinity tests is to be adopted as laid down in B.R. 295, Handbook for Naval Rangefinders and Inclinometers, Vol. 1, General. A.F.O. Diagram 196/44 (11) shows the correct position of the sun on the dividing line to obtain the readings for infinity tests. The astigmatizers are not to be used. With the aid of these windows to take infinity tests on the sun, coincidence tests can be carried out at all angles of sight and under all temperature conditions. Records of tests are to be recorded in the Rangefinder Log (S.328) stating the object used and whether with rhodiumised windows.

33. Rhodiumised windows are graded in pairs, right and left, and are so marked, together with the serial number. The grading is governed by the density of the rhodiumised surface, which may vary between 4.0 and 4.9 density, and by the vertical inaccuracy of the windows. It is, therefore, essential that the windows are kept in pairs; that is, identical serial numbers.

34. Due to the difficulty in manufacturing windows without any errors a slight error of refraction has been accepted. The error will be positioned optically vertical in the rhodiumised window holders, and positioned by a key and keyway. The windows, therefore, will be optically accurate for coincidence tests but may possess a very fine error of halving which should hardly be noticeable. It will be observed that the windows should be correctly fitted to the rangefinders.

35. Two types of rhodiumised windows are being supplied, the difference being in the holders to suit the equipments for which they are provided, viz. :—

Pattern 10607 ... Windows, rhodiumised, for testing U.D.III rangefinders (A.F.O. Diagram 196/44 (12)).

Pattern 10608 ... Windows, rhodiumised, for testing U.D.IV, U.D.V, U.L.I, U.L.II, U.K.III, U.K.IV, U.R.I, U.R.II, U.R.IV rangefinders (A.F.O. Diagram 196/44 (13)).

The windows will be supplied in an airtight metal box which is fitted with a silica gel static desiccator.

When the windows are not actually in use they are invariably to be kept in the boxes supplied. The normal stowage for these boxes should be in the rangefinder accessory box provided with the equipment. The metal boxes will be fitted with an instructional plate.

#### Modifications Necessary to the Parent Equipment for Fitting the Window Holders, Rangefinders, Type U.D.III (A.F.O. Diagram 196/44 (14))

36. (1) Remove existing rayshade, Item (8), at rangefinder window.
- (2) Mark off position on socket, Item (9), for four holes equally spaced 0.25 in. from the outer edge.
- (3) Screw the seating adapter ring, Item (11), into position in Item (9) until the flange binds hard against the outer edge of Item (9).
- (4) Drill four holes No. 4 B.A. tapped size and countersink to suit No. 4 B.A. screw head in spotted position.
- (5) Tap four holes No. 4 B.A. and insert securing screws. Item (12).
- (6) Assemble reflecting window castings, Item (10), to adapter ring, Item (11), and secure by means of clamp nuts and bolts, Items (13) and (14), so that the pins, Item (7), lie in a line with the horizontal axis of the rangefinder.
- (7) The rhodiumised window holder is mounted on the locating pins, Item (7), and locked in position by means of the locking bolt, Item (5).

#### Rangefinders, Types U.D.IV, U.D.V, U.L.I and U.L.II (A.F.O. Diagram 196/44 (15))

- (1) Remove rangefinder window holders (if not convenient to work about the instrument). Care should be taken that grit, dust, etc., does not enter the rangefinder.
- (2) To suit the inboard location pin 8. Mark off position on window flange diametrically opposite the existing hole in the flange for the other locating pin 7, and on the same pitch circle (4.65 in.). In this position drill a No. 2 B.A. clearing hole and pin drill 0.14 in. deep to suit lower head of locating pin.
- (3) Assemble window holder to rangefinder, if removed for procedure (i), and spot drill position of hole for locating pin in end casting.
- (4) On position spotted, drill and tap hole to suit No. 2 B.A. thread 0.4 in. deep (this depth must not be exceeded).
- (5) Screw in locating pins.
- (6) Windows can now be shipped as for U.D.III.

Note.—On some equipments where the window shutters have been fitted it will be found that the shutter will foul the inner locating pin. Where this difficulty is found a small slot should be cut in the shutter to clear the head of the inner locating pin.

#### Rangefinders, Types U.K.III, U.K.IV, U.R.I, U.R.II and U.R.IV (A.F.O. Diagram 196/44 (16))

- (1) Remove window securing screws at 7.
- (2) Replace with locating pins.
- (3) Windows can now be shipped as for U.D.III.

Note.—On some equipments where the window shutters have been fitted it will be found that the shutter will foul the inner locating pin. Where this difficulty is found a small slot should be cut in the shutter to clear the head of the inner locating pin.

#### Care and Maintenance

37. The film of rhodium deposited on the outer surface of the glass is very delicate and must be treated accordingly; although possessing good weathering properties it will not withstand rough usage and will very easily scratch by contacting another hard surface and also deteriorate with rough rubbing. Absolute cleanliness of the windows is not essential, since the light passed through them is cut down to one part in 30,000. A large film of foreign matter will not materially affect their performance as dense light filters; only in extreme cases where deterioration of definition is suspected should cleaning be resorted to.

Funnel fumes, grit and salt deposit can be easily removed. In the case of loose dust, etc., the surface should be lightly brushed with a 1-in. camel-hair brush. In the case of deposit which adheres to the surface, a solution of distilled water and pure

soap should be applied with a swab of cotton-wool, care being taken that in removing grit the rhodiumised surface is not damaged. The holders should be thoroughly dry before replacing in the airtight boxes.

The silice gel static desiccator should be periodically examined and dried when necessary.

Should careless handling have caused minor damage to the film, the windows will not of necessity become useless; the field, when ranging on the sun, will, however, be subject to glare, and cuts will tend to be less accurate. There is no objection to minor scratches and pin-holes being spotted out with Indian ink or enamel; this should, however, not be done unless the glare in the field becomes noticeable.

#### Reports of Tests

38. In order that investigations into the causes of rangefinder errors shall be continued at A.R.L. it is essential that ships supplied with the rhodiumised windows shall forward until further notice certain particulars regarding tests carried out in the sun.

While the difficulty of obtaining long series of observations in war conditions is fully appreciated, it is emphasized that the results are of great value and are urgently required for the important investigations still in hand.

39. Few reports in accordance with previous instructions have been received; although these reports confirm that the air disturbance gear fitted to rangefinders is proving effective and has a most beneficial effect on accuracy, there appears to remain a residual error in some rangefinders which has not so far been explained. Investigations concerning this error are being pressed forward, but are at present being hindered by lack of information from ships in service.

40. Several series of readings which have been received have been vitiated by the fact that the data required in Tables I and II has been only partially complete. In particular, insufficient observations on the sun have been accompanied by a series of tests on a terrestrial object taken immediately afterwards. To obtain the data required it is desirable that these observations should be nearly as simultaneous as possible. The best routine to adopt at each observation is as follows:—

- (a) Test on terrestrial object with pump not in operation.
- (b) Test on sun with pump not in operation.
- (c) Test on the sun with pump in operation.
- (d) Test on terrestrial object with pump in operation.

The information required should be forwarded direct to the Superintendent, Admiralty Research Laboratory, Teddington, Middlesex, in the tabular form shown below.

TABLE I  
*Details of Rangefinder*

Type	Baselength	Number	Any other details available such as date of manufacture, etc., including type of air disturbance gear fitted and type of pump used

TABLE II  
*Observations*

Date	Time of		Time of observation	Sun's altitude at time of observation	Rangefinder error expressed in divisions at infinity		Temperature	Weather conditions
	Sunrise	Sunset			Pump in operation	Pump not in operation		

The results of normal surface tests of rangefinders should, where possible, be forwarded with each report and should be based on tests carried out at the same time as the sun tests, as described above.

It is desired that any remarks regarding the use and the weathering properties of these rhodiumised testing windows may be forwarded to the Admiralty.

#### Rhodiumised Windows—Repair

42. A standing contract dated 20th February, 1943, C.P. 59221/43/F.I.B./F.183 (D.N.O.) has been arranged with Messrs. Adam Hilger, Ltd., 98, St. Pancras Way, Camden Road, London, N.W.1, for the repair of all rhodiumised windows, Patterns 10607 and 10608.

43. Damaged windows, including those of Messrs. Barr and Stroud's manufacture, are to be returned to Messrs. Adam Hilger, Ltd., for repair.

(C.A.F.O. 1999/41, and A.F.Os. 4036/43, 5868/43 and 6246/43 are cancelled.)

TABLE II

Government of ...

Date	Description	Amount	
		...	...

The results of ...

42. Damaged windows ...

43. Damaged windows ...

...

...

TABLE I

Type	...	...	...