COSMIC NOISE

For some time Radar Officers have opened mouths of awe by whispering the magic phrase "anomalous propagation". Now that executive officers with two day courses in Radar know all about it, and even Dink has exposed it with a cartoon, it has been found necessary to reinstate the Radar Officer, whose boasts of extraordinary results by means of super-maintenance are merely met by the knowing wink and the laconic phrase "A.P. of course".

It has been found during recent tests in home waters that there is a considerable amount of noise picked up by radar receivers which cannot be explained in terms of man-made interference. It is suspected that this noise is caused by certain emanations from outer space, (Right ascension 18 hours Declination 20°S), to obtain information on the magnitude of the effect at various latitudes and longitudes in order that tables of corrections may be prepared for performance meters and height estimation. To this end Radar Officers are asked to make measurements with Type 281 series. This is at present only possible easily, with 281BP/BQ, but details for 281/B will be made known, but are not available at the time of going to press.

Obviously the existence of this noise adversely affects the performance of radar receivers, as it tends to reduce the signal/noise ratio. It must not be thought however, that the performance of radar sets is now in any way inferior on this account to that obtaining before the existence of this extra Cosmic Noise was suspected.

The following is the drill for measuring :-

(1) Tune the diode switch preamplifier and receiver as described in the handbook for optimum conditions.

(2) Turn off the transmitter and bias the diode switch as follows :- Remove the meter from the diode switch supply Unit and connect an 18 - 20 volt battery in its place. The negative side of the battery should be taken to the left-hand socket viewed from the front. Place the switch on the diode power supply Unit in the "down" position. Connect a 39 ohm. $\frac{1}{4}$ watt resistor across a "Pye" elbow socket to act as an artificial aerial of equivalent load, but without pick-up possibilities. The leads must be kept to the absolute minimum.

(3) Remove the lead which feeds the M81 from the diode switch by pulling out the Pye elbow socket from the front panel of the M81. Insert artificial aerial. Set the gain control situated on the panel of the receiver to "5" Units or half-way position if no calibration is provided. Then change the gain control on the anti-jamming Unit to such a value that the second detector current reading is 100 micro-amps, when the M81 circuit has been tuned to give maximum second detector current.

N.B. It is important to ensure that the zero reading of this meter is correct. To do this, place the selector switch for wide and narrow band critically in its mid-position. In this case no signal reaches the second detector and the meter should read zero.

(4) Remove the artificial aerial from the M81 and replace it by the lead running to the diode switch. (The receiver aerial is now connected to the M81). Retune the M81 for maximum noise. Note the reading of the second detector current meter. Observe these readings with the aerial beam pointing at 10° intervals all round the ship. Every 120° make sure that the zero reading of the second detector current meter has not changed by using the switch as mentioned in (3) above.

(5) Tests to be repeated every two hours for twenty-four hours. The results should be signalled in the form shown below.

NOISE FACTOR MEASUREMENT FOR P107 USING NOISE DIODE

If possible the results obtained as above should be supplemented by information concerning the law of the second detector. This will only be possible if a noise generator is available, but the results will be well worthwhile even without this information.

NOTE : Throughout, the preset gain control should be set at 5 or the mid-point if not calibrated, and the noise level adjusted by the gain control on the A-J box. Allow the receiver and M81 to warm up for 15 minutes.

(i) Connect the Noise Diode to the input of the M81. Adjust the receiver gain until the 2nd detector current meter reads about 100. Switch on H.T. to the Noise Diode and adjust its noise output until the 2nd detector reading is about doubled. Tune up all the R/F tuning controls for maximum reading on the 2nd detector meter.

(ii) Switch off the Noise Diode and carefully adjust the 2nd detector meter zero as shown above.

(iii) Carefully adjust the gain control so that 100 /uA. Receiver Noise Signal is obtained. Switch on the Noise Diode and adjust its noise output so that the Receiver noise is increased to 200 /uA. exactly. Measure the Noise Diode anode current. With an M81 Pre-amplifier this will be about 3·2 mA. (I_1)

(iv) The Noise Factor (in dbs.) is given by :- $10 \log_{10} 20\ IR$.

Where I is the Noise Diode current in amperes required to increase the receiver noise from 100 - 200 /uA. and R is the matching resistance of the Noise Diode i.e. 40 ohms.

$$\text{Noise Factor} = 10 \log_{10} \frac{20 \times 3{\cdot}2 \times 40}{1000} = 4{\cdot}7 \text{ dbs.}$$

This is for an ideal square law detector, but in practice the Noise Diode current is rather more than 3·2 mA. and it is necessary then to apply a correction factor determined by the law of the second detector and the amount of its departure from the square law.

(v) Still further increase the Noise Diode current to any arbitrary level until the 2nd detector current reads say 230 /uA. Call this Noise Diode Current I_2 the original reading being I_1.

(vi) Now reduce the gain so that the second detector meter reads exactly 100 /uA. Then still further increase the Noise Diode current so that the second detector meter reads exactly 200 /uA.

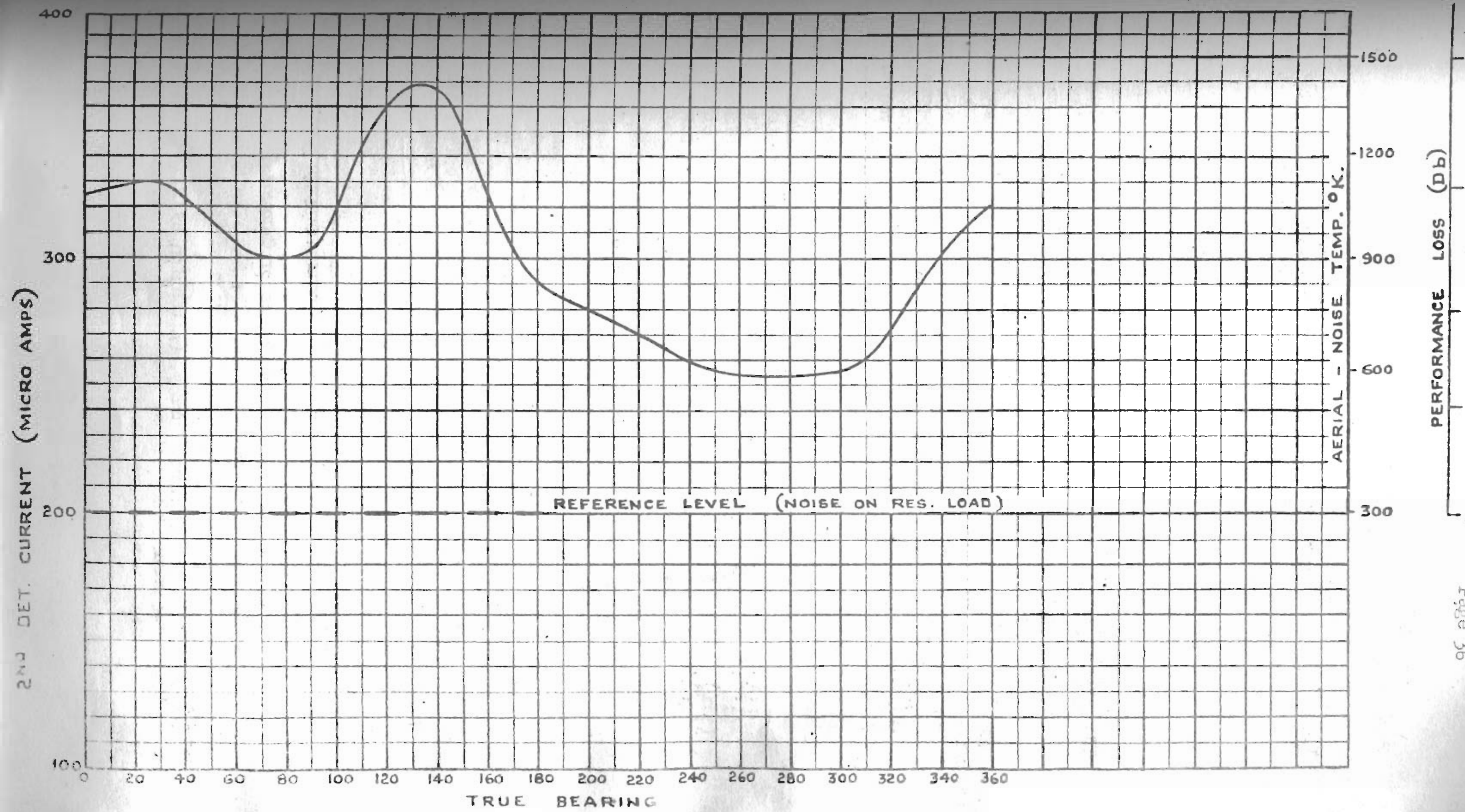
Call this Noise Diode current I_3

Then the Correction Factor is equal to

$$\left\{ \frac{I_3 - I_1}{I_2} \right\} - 1$$ and is usually about 1·4.

A. COSMIC NOISE ON 281 BQ AT WITLEY PARK

TIME:— 18·15
DATE:— 11/8/45



The Noise Factor formula is then modified accordingly. e.g. suppose a 100 - 200 μA. Noise increment requires a Noise Diode current of 5·5 mA. and the Detector Law Correction Factor is 1·7 then Noise Factor =

$$10 \log_{10} \frac{20 \times 5{\cdot}5 \times 40}{1000 \times 1{\cdot}7} = 4{\cdot}1 \text{ dbs.}$$

If the second detector valve is changed or the gain controls altered, or the doubling of the receiver Noises is done at higher or lower Noise levels, e.g. 200 - 400, a new correction factor must be determined.

At present few Noise Diodes are available but reports from all those ships that have them will be invaluable. Instructions for making a Noise Diode will be issued shortly.

Meanwhile when the Radar short course executive whispers "No A.P. today", you may whisper back "Yes, and Altair is in the ascendant at 1700, so keep a good look out to the South, won't you?".

FORM OF REPLY FOR 281 COSMIC NOISE DATA

(i) Condition of set.
(ii) Times and date.
(iii) Ships latitude.
(iv) Ships longitude.
(v) Noise factor results where available :-

e.g. 100 - 200 = I_1 Noise diode current.

100 - 150 = I_2

Reduced gain

100 - 200 - I_3

giving Noise Factor X dbs.

(vi) Results tabulated :-

TIMES	BEARINGS -------→
↓	2nd Detector Currents.

Address to A.S.E. Haslemere, Surrey, (Attention B9).

SOME NOTES ON AERIALS FOR CENTIMETRIC RADARS

SEA REFLECTIONS - THE IDEAL CASE

If the sea were a perfect specular reflector, interference between direct and reflected waves would produce a rapid variation of field strength with angle of elevation. At angles at which the two waves are in phase, the field strength would be twice the free space field strength. At angles at which the two waves are in anti-phase, the field strength would be nearly zero.

For centimetric Radars with aerials at the height usually used, the lobe spacing is very close. Practically all targets will be detected at a range near the limiting range at the tip of the lobe, giving nearly twice the free space detection range.

SEA REFLECTIONS - THE PRACTICAL CASE

As sea-going readers no doubt remember, the surface of the sea is not perfectly flat, and specular reflection is not obtained at all angles of incidence. The effect of the "roughness" of the surface increases with the graying angle (graying angle = angle of elevation of the target). With a reasonably calm sea and S band Radar, specular reflection starts to be appreciable at graying angles of less than 5 degrees and is nearly perfect at zero degrees. For shorter wavelengths, the graying angle for a given coefficient of reflection is proportional to the wavelength.

TILTED AERIALS.

The effect of non specular reflection at graying angles greater than 5 degrees is to waste the energy radiated downwards below this angle. To reduce this wastage certain aerials are tilted upwards at an angle determined by the vertical beam width. This has the effect (a) of increasing the range of detection at the higher angles of elevation, and (b) of reducing the range of detection at low angles of elevation. Since however, the range at low angles is increased above the free space range by sea reflections, this reduced range is still greater than that obtained at higher angles. The angle of tilt is chosen so that at no angle does the operational range become less than it would be with an untilted aerial and no sea reflections. This analysis applies only to targets above the first maximum of the sea reflection interference pattern. The range on targets below this maximum is necessarily reduced by tilting the aerial.

EFFECTS OF ROLL AND PITCH.

The effects of Roll and Pitch are that the efficiency of the aerial system is reduced by pointing the polar diagrams in the wrong direction for part of the time. With unstabilised aerials the best compromise is to design the system to meet the requirements correctly for level deck conditions.

RADAR IN A MODERN CRUISER

The photographs on pages 40 - 42 show a series of views of the W.A. office, A.D.R. and R.D.R. of a modern cruiser fitted with Type 281BP, Type 277P and Type 293P and serve to illustrate the latest ideas in the grouping of equipment. Photograph No. 1 shows the 'inner' and 'outer' P.P.I. placed on the left of the 281 receiver over Control Table 20D. in the W.A. (R) office. The principle of watching on, and telling from, the two P.P.I's (the inner 0 - 80 miles and the outer 80 - 160 miles) is now firmly established. When space allows "twin pair" are sited in the R.D.R. so that telling may be supervised by the Radar Officer, one P.P.I. remaining in the W.A. (R) office for monitoring purposes.

Photograph No. 2. gives a general view of the R.D.R. with the Type 277 Control Table on the left, H.P.I. just visible on the extreme left, and P.P.I. on the further side. Type 281 P.P.I. azicated from Type 277 is placed immediately above and inclined at an angle downwards towards the operator. This should be inclined at 45° or if space does not permit, placed on the right of the P.P.I. from Type 277 - inclined inwards at a suitable angle for easy correlation between the two.

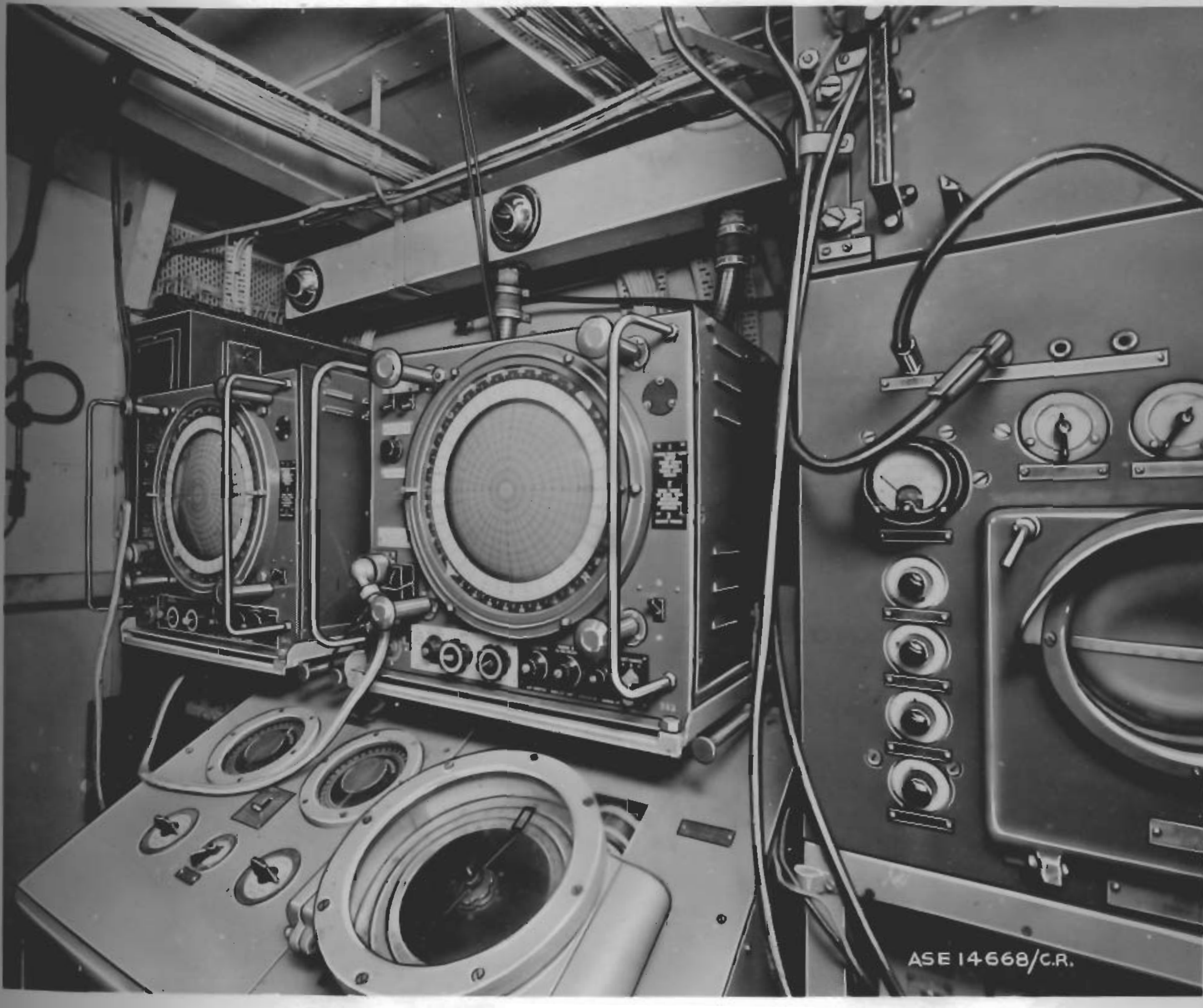
Directly facing is Outfit RTE which is now considered superfluous since Outfit JH2 (277) can supply tactical ranges in lieu. This latter is here sited in the far right hand corner, but if space permitted, would be better placed alongside the 277 P.P.I. Next to this is the Sector Display JH (281) with control of independent Interrogator 243Q. The operator here has ready reference to the 281 P.P.I. and Filtered Plot which is immediately on his right for determination of the present position of the echo it is desired to interrogate. Photograph No. 3 shows the 277 Control Table in more detail with the three Controls (reading from left to right), (a) Elevation Control, (b) Local Control of Interrogator Aerial, (c) Aerial Training Control. The two JH's are shown in more detail in Photograph No. 4.

Photograph No. 5 shows the Filter Plot and P.P.I. from Type 281 sited above, and on the right Outfit JJ1 (Type 281) with Sector Selector for height estimation purposes, ready reference to the up-to-date picture being again available. Under the JJ1 and parallel to the Filter Plot is the sloping Height Plot for polar diagram reference and for amplitude curve plotting. Of the two dials on the selector unit of JJ1, the upper one is a survival from Outfit RTE and is not used. The small unit at the bottom right hand side of the 281 P.P.I. is the remote switch from Type 944 "G" band interrogator and is merely a reserve position.

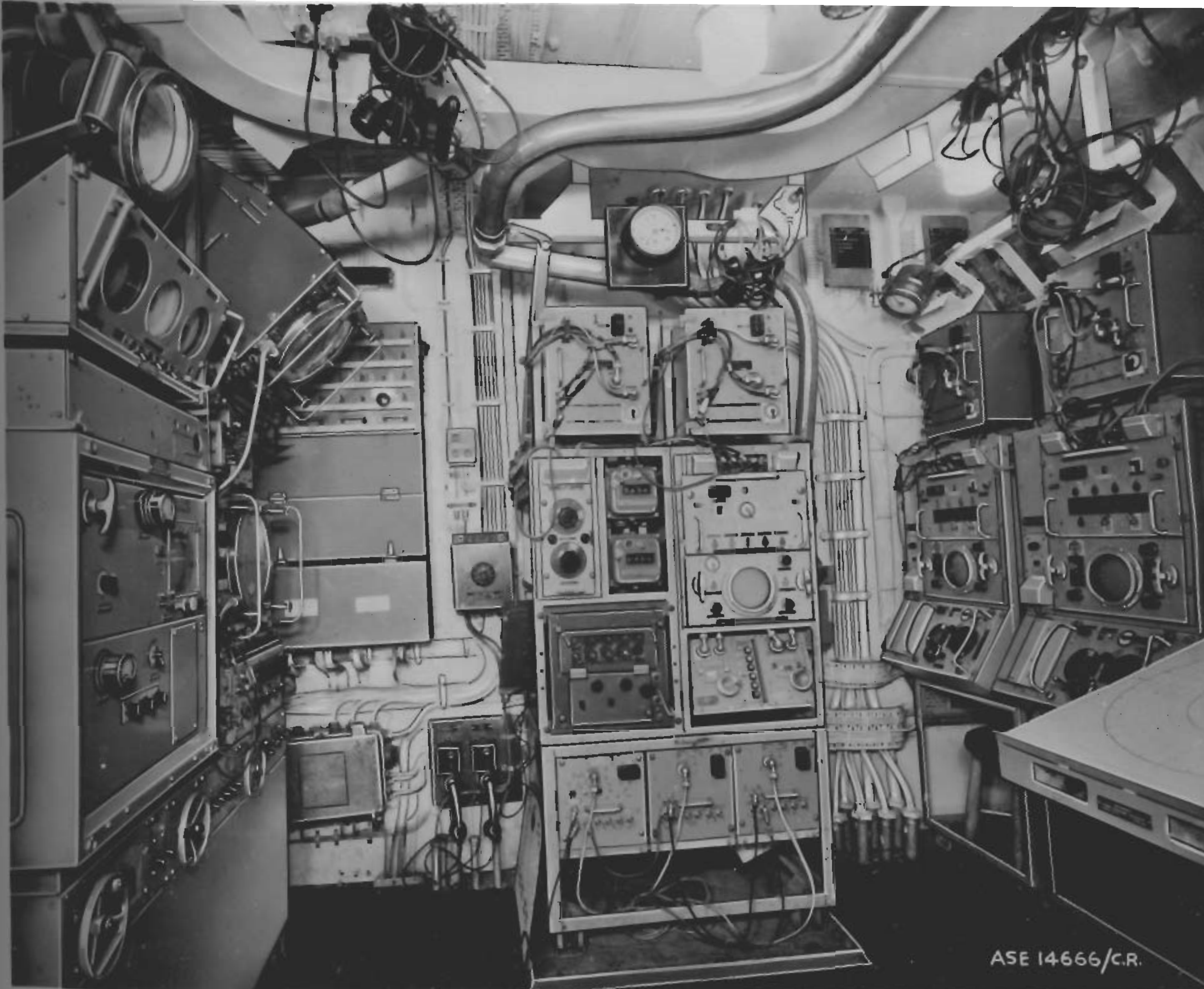
Photograph No. 6 shows the combined A.D.R. and T.I.R. On the left is the T.I.U. with P.P.I. from Type 293/277 with two Ranging Outfits RTB. Immediately in front is the A.R.L. Table and P.P.I. from Type 281/277. At right centre is the Skiatron and F.D.O's Table with R/T Control Units and telephone from which a view of the M.A.D.P. is possible, though this is badly obscured by the very awkward siting of the 277/281/293 P.P.I. which is a blot on an otherwise well laid out room.

Clocks, Pitometer Log, Aircraft State Board and Ship's head Indicator are grouped on and around the M.A.D.P. Quiet speakers are sited on the deck-head. During the visit of the writer these were by no means "quiet" and were the "popular" means of communication. Noise of gunfire was audible through them all the time and the A.D.R. section suffered accordingly.

RADAR IN A MODERN CRUISER.

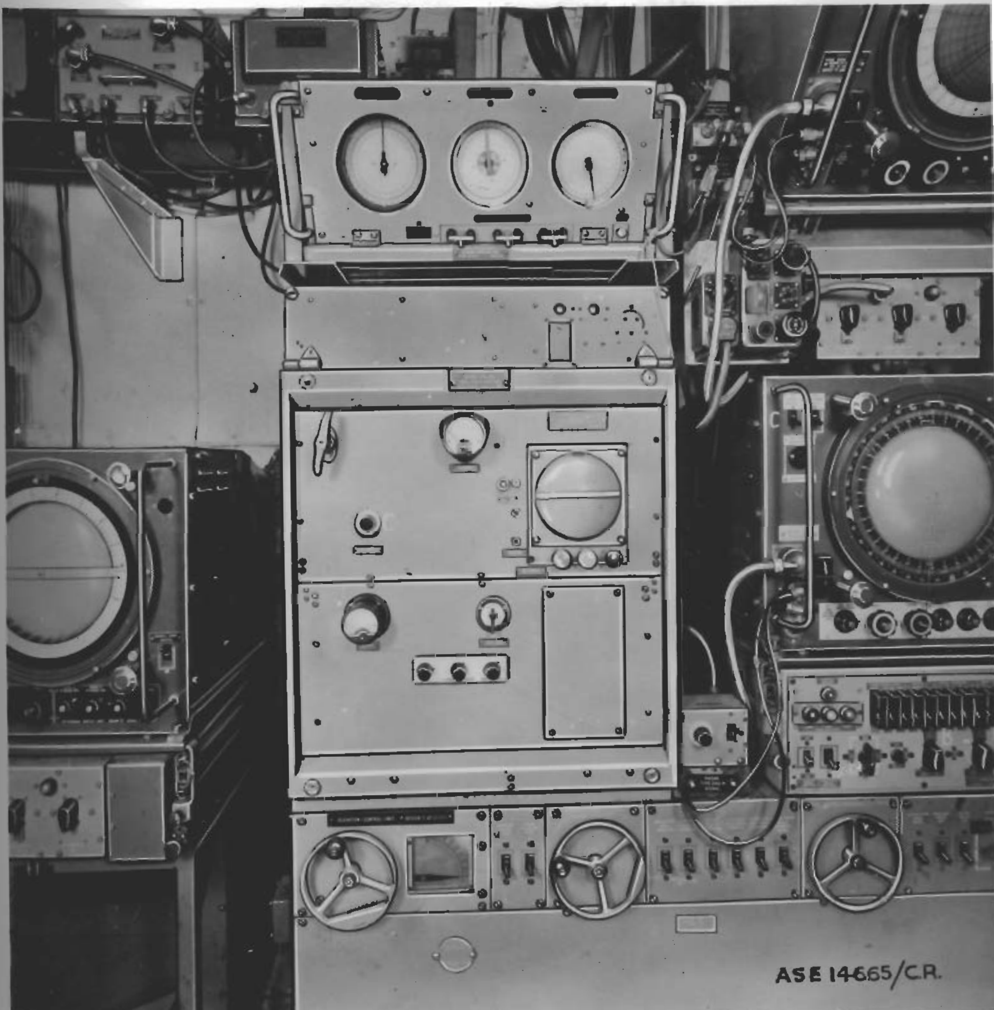


① "INNER" & "OUTER" P.P.I.



② General View R.D.R.

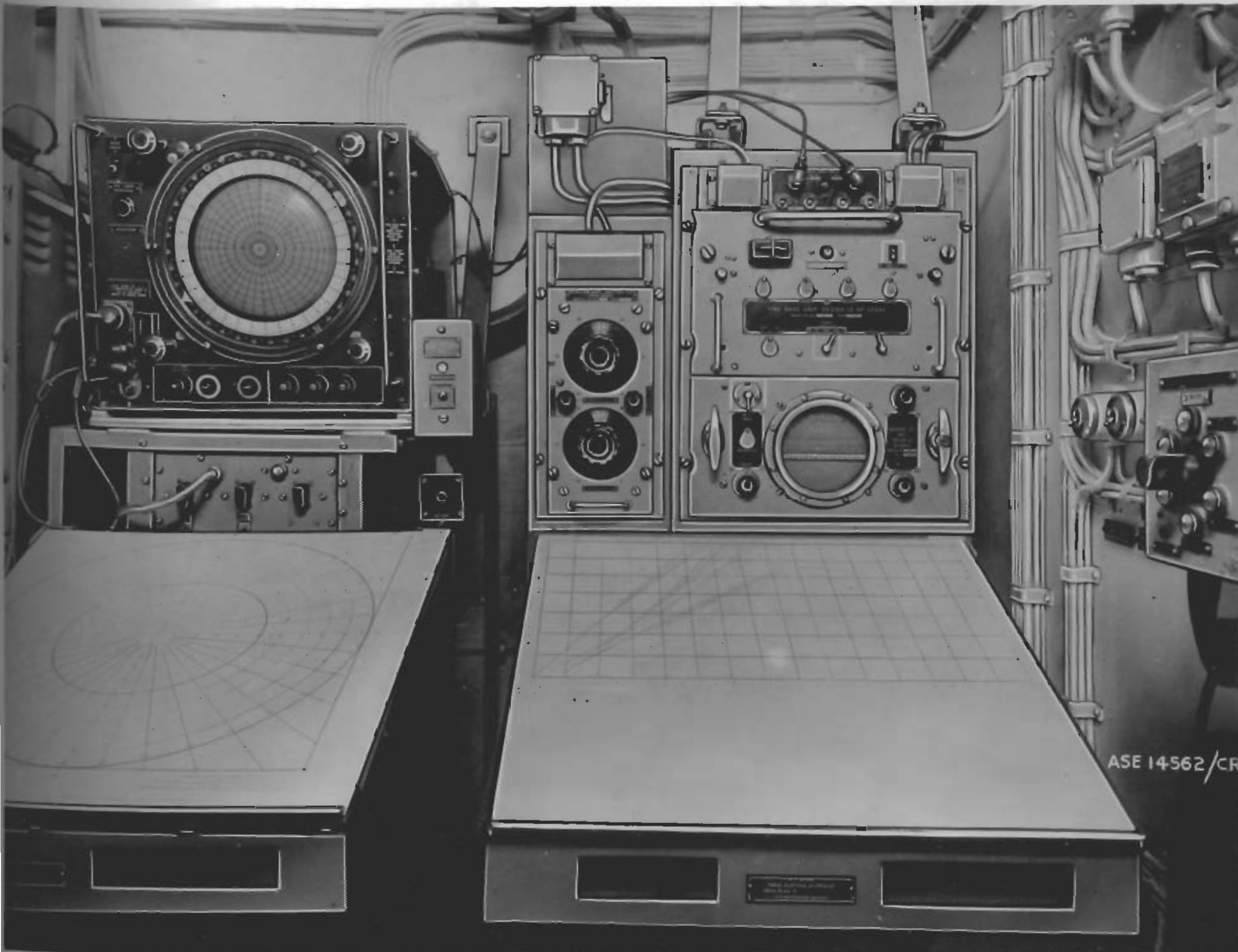
RADAR IN A MODERN CRUISER.



③ TYPE 277 CONTROL

④ OUTFITS J. H.

RADAR IN A MODERN CRUISER.



(5) FILTER PLOT & P.P.I. FROM TYPE 281

⑥ COMBINED A.D.R & T.I.R.

COMPARISON OF WEIGHTS OF AIRCRAFT AND NAVAL RADAR EQUIPMENT

First of all it is to be noted that the disparity between the weights of American Naval and American Airborne Equipment is similar to the disparity between British Naval and British Airborne Equipment.

Similarly, the disparity in weight between Aircraft and Naval Fire Control equipment is very similar to the disparity in weight between Aircraft and Naval Radar equipment.

Aircraft Equipment can, in general, be lighter than Naval Equipment because :-

(1) A much lower degree of accuracy is required.

(2) High discrimination between targets is not required except in the case of the H2S series.

(3) In the air to air case, great ranges are not as a rule required and in the air to ground case, great ranges are much more easily obtained than from ground equipment. The greater the height, the greater the ground range.

(4) Aircraft equipment has to be in operation only for a few hours at a time and is then removed for servicing.

(5) Aircraft Equipment does not have to withstand such severe conditions of blast as Naval Equipment.

(6) Naval Equipment is expected to run for thousands of hours without replacement of any major component. Further Naval Equipment is likely to be in service for 10 to 12 years without replacement.

—

(7) Size **and weight** can be reduced by the use of smaller components such as electrolytic condensers which have inherently a short life. Smaller transformers and chokes can also be used if a short life is accepted.

(8) Manufacture of small components in this country is very limited and Airborne Equipment has priority in this matter. A.S.E. are not allowed to use them in Seaborne Equipment. It is not thought, however, that the use of these components would result in a major reduction in size and weight.

(9) The layout of components in Radar Units for Naval service is such that each component may be withdrawn for replacement. For Airborne Radar, the components are squashed together with no idea of being able to withdraw each component separately.

(10) In Naval Equipment, owing to sea conditions, aluminium and magnesium alloys are unsuitable unless special precautions are taken to protect them from the weather. In Airborne Equipment, those alloys are freely used. In addition, magnesium is not allowed in Naval Equipment because of the fire risk, which risk is apparently allowed in Airborne Equipment.

(11) Aircraft wiring is carried out by means of a harness built up of individual cables designed to be of the lightest possible weight. When one cable fails, the whole harness is replaced. More robust cables must be used for Naval wiring and, in general, the requirements of fitting-out do not allow of the use of a harness.

(12) In Ship Radar, R/F Cables have to carry the power for longer distances than in aircraft and therefore have to be correspondingly heavier.

(13) In Ships, the complete Test Equipment and kit of spares has to be carried, necessitating either increased office accommodation or Radio Maintenance Rooms.

AN EXAMPLE OF WEIGHT REDUCTION

Possible reductions of the weight of Type 262 will now be considered as a practical example :-

The existing Type 262 on the S.T.A.A.G. is comprised of the following parts, weights of which are given in the following Table :-

	Weight of Cubicle	Weight of Chassis in Cubicle	Total Weight
Aerial APE (1).			850 lbs.
Cubicle A	701	258	959
Cubicle B	321	212	543
Cubicle C	291	144 (89 + 59)	435
Control Officer's Display		24½	24½
Alternator and Control Panel			250
Blower	160	240	400
Filter and Ducting.			300
Cables		approx.	200
		GRAND TOTAL	3961½ lbs.

If as much as possible of the equipment was removed from the mounting and fitted down below, the total weight of the Radar Equipment on the mounting could probably be reduced to 1,675 lbs., made up as follows :-

Aerial APE (3) instead of APE (1)		650 lbs.
Half of Cubicle A.		500 lbs.
Control Officer's Display.		25 lbs.
Slip-rings and Cables.	say	300 lbs.
Blower.		200 lbs.
		1,675 lbs.

The remainder of the equipment could be fitted below decks, but a blower smaller than the existing one would be required for the equipment on the mounting.

If the equipment is split up like this, between 100 and 200 slip-rings would be required and the cabling would be more complicated.

The Aerial Outfit APE (3)

When the aerial is enclosed in a dome as in the aircraft case, no allowance has to be made for windage or blast. In the Naval case, the elimination of the blast requirement would have enabled a very much lighter dish to have been designed. This would have resulted in a smaller and lighter spinning motor. The lighter dish assembly and the elimination of windage would have resulted in smaller and lighter servos being permissible. In this way, a reduction of weight of about 50% could be achieved.

The weight of the dome, and if it had to withstand 10 lb. per sq. in. blast pressure, would probably be as great, or greater than the saving of weight on the aerial assembly.

The use of lighter cables would also effect a reduction in weight.

A reduction of the accuracy and maximum range requirements to the same order as called for A.G.L.T. would enable a smaller size of dish and very much smaller servos to be used, resulting in a still further reduction in weight. The use of aluminium would also reduce the weight.

Cubicles A. B. and C.

These cubicles contain 7½ standard chasses, the average weight of which is 70 lbs. By the use of aluminium and aircraft components and if no provision was made for replacement of individual components, this average weight could be reduced to 40 lbs. without appreciable circuit modifications. Of these chasses, the Range Follow-Up Unit is only required because of the special range requirements of the S.T.A.A.G. Mounting, and can be dispensed with. If the requirements for auto-search and lock-on were dropped, the search unit would not be required and the auto-strobe and display chasses could be combined into one. Thus, the total number of chasses could be reduced to five and under aircraft conditions, these could be fitted in a framework weighing under 200 lbs. In this way, the total weight would be reduced from 2,000 to 500 lbs.

The remaining items can, in an aircraft, also be very much reduced in weight. The Control Officer's Display would probably not be required; the alternator would be a light weight machine driven directly from the main engine, probably weighing with its control panel, not more than 50 lbs; the blower could be dispensed with since air conditioning would not be required and special cables would be used, probably reducing their weight to 30 lbs.

It is thus seen that if the equipment was designed for airborne use, with very little difficulty the weight could be reduced to a quarter if the auto-search and lock on facility was given up. If concessions were also made in the Staff Requirements for range and angular accuracy and picking up range, then a further reduction could be made, the greatest saving in weight being the aerial unit since then a smaller dish could be used.

THE EFFECT OF WEIGHT REDUCTION

If, however, the equipment had been designed on this basis, the Navy would find that they had an equipment which :-

(a) Would not operate efficiently for more than a few hours at a time (judging from M.A.P. reports).

(b) Would be very nearly impossible to service under sea conditions when it did break down.

(c) Would be of little use since fast Close Range Aircraft targets could not be picked up and followed due to lack of the automatic search and lock on feature, combined with the comparatively narrow beam.

(d) Would after a few years have to be completely replaced if it was to be kept in operation for reasonable periods.

The development of miniature components is proceeding slowly and as miniature technique is developed, some saving of size and weight of Naval Equipment can be expected.

It must be realised, however, that the introduction of miniature components into equipment designed to make each component accessible for servicing, cannot result in a big reduction in size.

Experimental work is continually proceeding with a view to simplifying circuits and so reducing the number of components. This, however, in the finished article, is always counteracted by the necessity for complications, either due to increased Staff Requirements or to overcoming the counter measures of the enemy.