"AN" NOMENCLATURE

It is thought that the following extract taken from an American contemporary, "Digest" (of Airborne Radio and Radar News) for September 25, 1944, will be of interest to personnel having to deal with American Radar equipment.

For a complete, basic equipment, you'll find AN (army-navy) on the left and usually three letters plus a figure on the right, such as any combination from these columns :

AN	/	A	I	A	-	1
		C	P	C		2
		F	R	D		3
		M	S	G		
		S	X	M		
		T		N		
		U		Q		
				R		
		P		S		
				T		
				X		

The first column stands for installation of the equipment - A, airborne; C, air-transportable; F, fixed on the ground; M, mobile on the ground; S, shipboard; T, ground-transportable; U, general utility; P, Ground Pack or portable.

In the next column, letters show type of equipment - I, interphone; P, radar; R, radio; S, special types of equipment such as magnetic detection; X, television.

Finally, the third column shows purpose of the equipment - A, auxiliary assemblies; C, communications; D, direction finder; G, gun direction; M, maintenance; N, navigational aids; Q, special; R, receiving; S, search and/or detection; T, transmitting; X, identification.

The number, as you might suspect, indicates a specific equipment used for the general purpose shown by the letters. Now, with those columns in mind, you can translate the trickiest nomenclature faster than a puzzle fan goes through a crossword book.

Here's one to try: AN/APG - 13 - airborne, radar, gun-direction equipment, specifically identified as No. 13.

Another, AN/UPM-3. You can tell that's a general utility equipment (usable both in the air and on the ground) for maintaining radar sets.

There's one catch to look out for - the number doesn't refer, as numbers did in the old Navy nomenclature system, to modifications of the same equipment. In the old nomenclature, ASB-8 is an improved version of the basic ASB. But, in the new nomenclature, AN/APS-6 is not an improved version of AN/APS-2. They're two entirely different equipments. In fact, No. 1 may be a later equipment than No. 5 - the AN/ARC-1, for example, is a radio communications set much newer than the AN/ARC-4.

That's the basis for AN nomenclature. Now you can add some suffix letters for further identification. A "T" hitched on to the main designation indicates training equipment: AN/APS-2-T2 means the second training equipment designed for use with AN/APS-2 search radar. An "X", "Y" or "Z" used after the main designation indicates a change in voltage, phase or frequency of the input power supply; AN/APX-8X means the voltage, phase or frequency of the input is different from that of the regular AN/APX-8. Suffix letters "A", "B", "C" etc, indicate a change in design (other than the voltage, phase or frequency of the input) which will not affect the equipment's military characteristics or interchangeability of the equipment as a whole. For example, various changes in the AN/APS-2 have resulted in names up to the AN/APS-2G.

Still another suffix may pop up when experimental equipment is being discussed - X plus a letter designating a certain laboratory, such as XA for the Aircraft Radio Laboratory or XN for Naval Research Laboratory. The AN/ARC-6(XN) would mean a new airborne radio communications set under development at the Naval Research Laboratory.

You'll notice that "X" is a popular letter - you may find it in four spots:

for television -

AN/AXT-1

for IFF equipment

AN/APX-8

for a change in voltage -

AN/APX-8X

for experimental equipment -

AN/APX-12(XN)

So far, nomenclature for complete, basic equipments has been given the once-over. In addition, the AN system provides designations for major units of those complete equipments. A receiver is R; dynamotor, DY; indicator, ID; test set, TS, etc., and those letters are placed left of the slant line instead of AN. It's easy to see, then, that the TS-1/ARC-5 is a test set for use with airborne communications radio set No. 5. The R-10/CRN-8 is a radio receiver for use with air-transportable radio navigation equipment. If the unit is modified, it gets a suffix letter - R-10A/CRN-8.

One more point: when a star appears in front of an AN designation (*AN/ARR-2), it means the equipment has been standardized by either the Army or Navy and any other United Nation. It does not necessarily mean that both the Army, and Navy, as well as an ally, use the equipment.

It may seem hard to work up as much affection for the "AN/APS-2F" as for a nickname like George or Easy, but that's the price of leaving radar's horse and buggy days. With all the dozens of uses being found for radar and the scores of equipments being developed, a standard method had to be developed which would be logical, easily understood, and flexible enough to meet future needs as new equipments evolve.

REPORT ON RADAR TYPE 276

IN

H.M.S. BLACK SWAN

A Number of extracts from a report received from the Senior Officer of Escort Group 37 and A.S.E. comments on them are given below :-

USE OF BRIDGE P.P.I.

"The use of the remote Bridge Indicator very greatly increased the value of the set in many ways. During operations at night it enabled the Commanding Officer to appreciate quickly the whole tactical situation, disposition of convoy, escorts etc. Stragglers could be detected, and joiners directed into position without difficulty. When meeting and passing other convoys, any alteration of course necessary could be estimated rapidly and passed to the Commodore. Even during daylight, while forming up a convoy, it was found of considerable value to have a "birds eye" view of the whole, and on several occasions it was possible to pass most useful information to the Senior Officer.

While the advantages of P.P.I. in station keeping are self-evident the navigational value of having a plot which could be compared directly with the chart, was also found to be considerable, and with practice in interpretation, blind navigation should become reliable and accurate.

The Commanding Officer proved by experience that, by the use of P.P.I., it was quite possible to enter between the convoy columns at night when necessary, and close a selected ship without great difficulty, under conditions when it would have been most difficult without the remote tube. It was also of great assistance to be able to detect and estimate alterations of course by the convoy, without delay, as cases sometimes occur when sound signals are not received by escorts".

P.P.I. RANGE SCALES.

"Experience seemed to show that 75,000 yards was unsuitable for the medium scale, being too similar to the long scale to be of real service. It was found that a medium scale of 30,000 yards was, on average, the most satisfactory, (though the use of long pulse might make 40,000 yards more suitable).

It was also considered that use could have been made of a shorter scale than 15,000 yards when conning ship between columns, or attacking at night; and it is submitted that it would be of advantage to make the scan speed, on short range, capable of adjustment at least down to 10,000 yards full scale, as with the present component values, circuit modification has to be made in order to do this."

A.S.E. Comment.

The provision of a 10,000 yard range scale has been considered but considerable technical difficulties are involved.

MAGNETRON LIVES

"Of five of these valves obtained at different times, three were completely soft, and only one worked correctly on normal H.T. and long pulse. This had been used when the set was first fitted, but afterwards it too began to show a tendency to flash over (blue glow) at gradually decreasing H.T. Voltages. It was found, however, that this valve, and one slightly soft spare, could be run on short pulse satisfactorily with normal H.T., and did not appear to deterioriate appreciably further under these conditions. The trouble in both cases appeared to be the liberation of gas from the electrodes under bombardment, as the valve heated up.

The working conditions of these valves were thoroughly checked, blowers were correct, and full hardening routine was carried out. There was no mismatching, or other indirect cause, as far as could be ascertained. As no spares were available, it was considered advisable not to run the risk of complete breakdown, so short pulse was used for normal operation.

It is understood that this tendency towards internal liberation of gas, as well as initial softness, has been a common experience. It was noticed that by using short pulse, a number of faults encountered in other sets were completely avoided, while the life of CV12's and Gas switch units (W6389) were on average increased by more than 100%".

A.S.E. Comment.

Reports received have not indicated that an excessive number of CV76's are faulty when supplied. Investigations into the lives of these, and other valves are continually being carried out. On short pulse, lives of magnetrons and spark gaps will increase owing to the reduction of mean power. This is not acceptable from the operational requirements and should never be necessary.

OFFICE NOISE.

"In spite of the sound-proof cabinet (W7556) fitted to the Transmitter blower (W1818), the noise in the operating office was still considerable. This seriously affected the efficiency of all communications, as well as tending to have an adverse effect on the concentration of the operators.

It is suggested that in ships where this is possible, the blower should be positioned outside the office, with a hose or trunk supply to the Transmitter box. The residual noise due to other blowers, aerial training motor etc. does not appear to be more than about 30% of the total, and the removal of the blower would, it is thought, go a long way to improve the situation".

A.S.E. Comment.

Further noise reductions are in hand i.e.:-

(i) Removal of the modulator blower and ventilation of the modulator from the transmitter.

(ii) Fitting of the Waveguide dryer outside the office.

(iii) Revision of the office layout so that it may be subdivided, with display equipment separated from the noisy remainder by a sound-proof partition.

MAGNETRON FREQUENCY DRIFT.

"It was found that quite appreciable changes in Magnetron performance took place during intervals of a fortnight, and it appears that for maintenance at peak operation, tuning should be checked regularly, though curves can be plotted over smaller ranges than at the first tuning."

A.S.E. Comment.

There is no evidence to support the contention of drifting in tuning. It may be, however, that the CV76 had been tuned near a frequency unstable point in which case the frequency, power etc. might easily vary over a period of a fortnight.

MAGNETRON POWER OUTPUT INDICATION.

"It is also believed that a permanently rigged output Indicator would be of considerable value for a number of purposes. If fitted with an adjustable attenuator at the aerial end, it would be possible to check the performance of the transmitter, waveguide system and reflectors, at frequent intervals, readings being taken at some given aerial training position. Losses due to waveguide or magnetron variation could be detected at once and the apparatus maintained at optimum working condition while trouble-tracking would at times be greatly assisted. The present tuning unit (W6281) fitted on the mast opposite the reflector, but with an added aperiodic (as nearly as possible) attenuator on the input side of the thermocouple, would probably be satisfactory".

A.S.E. Comment.

The new Radiation meter (patt. 56168 for Type 276/293 and patt. 56268 for Type 277) should meet this need. It is aperiodic in design and has no tuning adjustment.

I/F AMPLIFIER - FAILURE OF DECOUPLING CONDENSERS.

"Reference has previously been made to the frequent breakdown of these condensers in Types 271/2 and 271/Q, as well as to the frequent serious secondary effects (E.G. 37's report on "Radar Breakdowns" to Cap. (F), Alexandria, dated 30th November, 1943, para. 3.). As the present I/F and Mixer units are of the same construction as the old type, it is probable that the same trouble will result. Already two such cases of breakdown have been encountered. The danger of burning out the Receiver transformer as well as the destruction of rectifier valves and resistances, and the mistuning produced in the I/F stages by replacement, make these condensers a constant liability unless an H.T. fuse is fitted, as formerly suggested."

A.S.E. Comment.

The unreliability of patt. W3953 condensers as plate and screen decouplers is fully established. It was hoped that the use of a surge limiter across the H.T. line would overcome this trouble. This was included by A.F.O. 2764/44 in Type 271Q and in the design (R32 fig. 17 of H546A) of Types 276/277/293. This has reduced but not completely prevented troubles occurring. Future production will therefore use condenser patt. W2319 in lieu of patt. W3953. This replacement is slightly larger than the original but can be fitted in its place. Spares of the replacement pattern will be issued to ships but they will not be asked to replace all the W3953 condensers as there are 11 of them as plate and screen decouplers alone in M70. The use of W2319 condensers will also be applicable to a number of other sets and an A.F.O. will be issued on the subject. No retuning of the I/F circuits is necessary when plate and screen decoupling condensers are replaced.

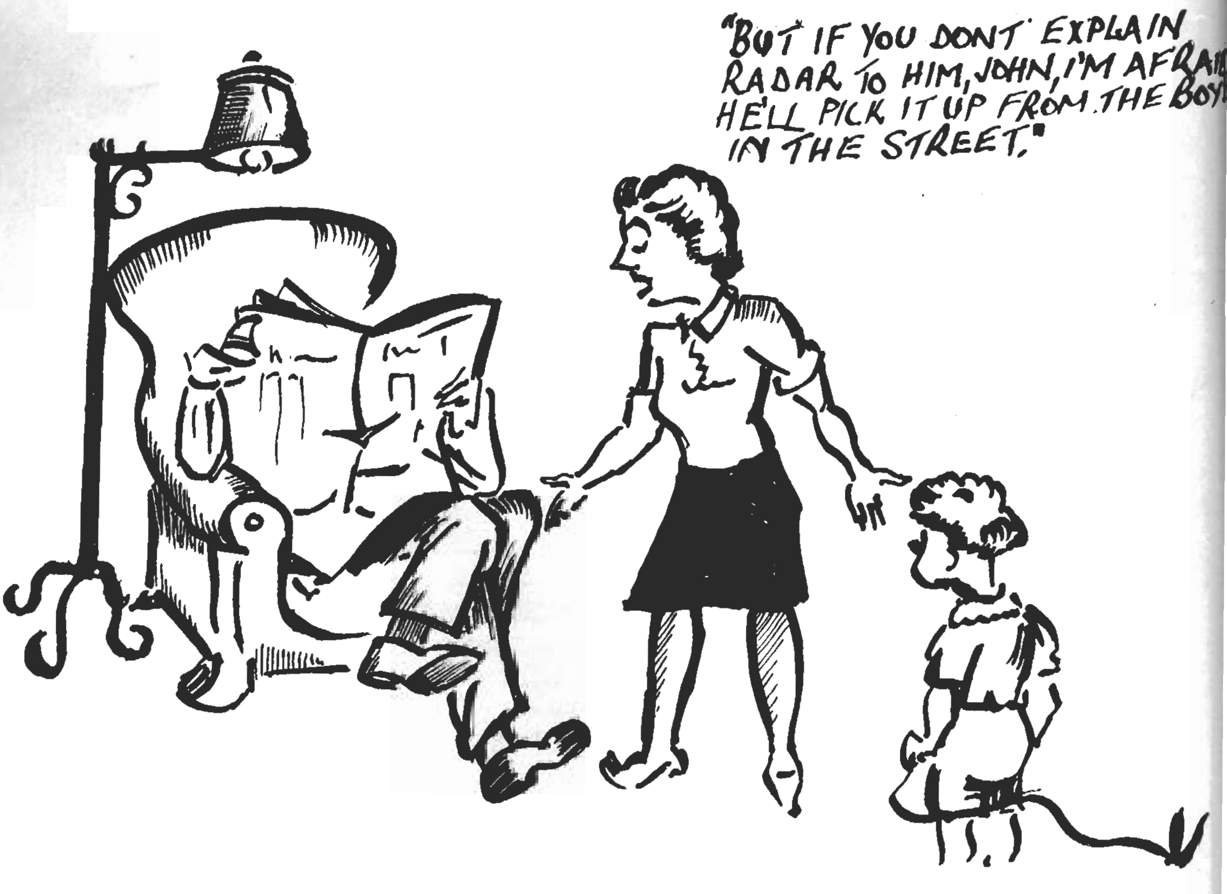
CONTROL TABLE SWITCHES - CONFUSION.

"These two switches, fitted at a low position on the AUJ control table (below the aerial training indicator) are identical in external shape and appearance. Under the lighting conditions normally used while operating it is very easy, even when used to the set, to break the wrong switch when stopping the aerials for investigation of an echo (usually done in a hurry), or for lining up. The immediate result of breaking the mains switch is to throw all P.P.I's, aerial and gyro repeaters on the set, out of line, often very badly. Up to four minutes must then be wasted in re-lining all apparatus again.

As the "Mains input" switch requires to be only of double-throw type, while the "Auto train" switch is a three way, it is suggested that some difference should be made between the two, either in action or at least by a different type of control knob. Though seeming a minor one, this point has caused considerable difficulty because, besides the delay necessary to rectify errors, in some cases operators break the wrong switch and fail to notice (because the immediate result is similar), and continue to operate until the bad error is noticed. In view of the danger involved, it is submitted that this is a case where the arrangement should be "foolproof"."

A.S.E. Comment.

These two switches have now been separated and in all later production control tables 20G and 20J the trouble will not arise. No retrospective modification is being arranged as all Types 293 will eventually replace 20G or 20J by control table 20H.



We are indebted to Lt. W.J. Middlemiss, R.N.V.R., PRADO, Belfast, for the above cartoon.

USE OF RADAR FOR NAVIGATION

EXTRACT FROM A REPORT RECEIVED FROM
THE COMMANDING OFFICER, H.M.S.VICTORIOUS

"....... The following Types of Radar are used as may be required for navigation in H.M.S. VICTORIOUS :-

Type 277 with P.P.I. in the A.D.R.

Type 293 with P.P.I. in the Plotting Office and on the Compass Platform.

American Type S.G. with P.P.I. in the Plotting Office and on the Compass Platform.

The performance of the above sets on land and the uses to which they are put are as follows.

Type 277. This is by far the longest range surface set, and also picks up low lying land at much greater ranges than the others. High mountains (5000 ft. and above) are clearly visible on the scan at 80 miles distance. (On passage from Colombo to Trincomalee keeping 30 miles off the coast, the mountains in the centre of Ceylon were never lost sight of).

A 500 foot Island (Rondo off Sabang) was on the scan as soon as the set was switched on, at a range of 43 miles.

Low lying coast north of Colombo with only the height of its trees was picked up between 20 and 25 miles. However, this set is not used for navigation as soon as enough data has been picked up by the other sets, so as to keep it free for its primary duty as a low flying Aircraft Warning Set.

Type 293. This set has greater range than the S.G. for high land, but less than the 277. Mountains of 2000 ft. and above are picked up at about 35 miles. Land of height 500 ft. at about 30 miles and low land with trees at about 20 miles. (On its large scan, its P.P.I's produce a particularly good diagram of the fleet in company and any other ships in the vicinity, so that it is generally switched to this use as soon as the S.G. has picked up sufficient data for navigation. This set is also used by the Gunnery Department for target indication).

Type S.G. This is a less powerful set but produces similar results to the 293 inside 25 miles. However, apart from its range, it has advantages over the set and is much the most suitable for pilotage and navigation at close ranges. Once the land is in its range, its P.P.I's paint an excellent picture which is exactly like the charts. All the land is clear cut and solidly painted. Capes, bays, inlets, necks of land can be picked out as clearly as the chart. The lowest land shows up well, and buoys are picked up at about 6000 yards. Channels marked by buoys (or rocks) show up well, however narrow, and the course to steer between the marks can be chosen by looking at the P.P.I. without reference to any other instrument or chart.

The following are two examples of passages which could not have been made until at least a day later without the assistance of Radar.

(a) On passage from Norfolk, Virginia to Argentia, Newfoundland, thick fog was encountered the whole way. A reasonable estimated position was maintained by soundings and W/T D/F bearings, until approach to Newfoundland. The Islands of St. Pierre and Miquelon and the Western edge of Placentia Bay were then picked up and recognised by their shape and size on the S.G.P.P.I. It was desirable for operational reasons to get in that night. VICTORIOUS then increased to 24 knots although the fog was dense and much shipping was known to be about, and was able to navigate up Placentia Bay and into Argentia Bay with perfect safety, as the chart was constantly shown on the S.G. P.P.I.

(b) On passage from the Clyde to Scapa via the Minches North bound route at night, visibility closed right down before arrival at the narrow Trodday passage, Light Buoys could not be seen until the ship was right on top of them, reduction of speed was undesirable because of the effect of the tidal stream. The Officer of the Watch was on the Compass Platform looking out but of course, could not see anything until far too late to avoid it. The Captain and the Navigating Officer remained in the Plotting Office directing the course of the ship from the S.G. P.P.I. (where everything was as clear as daylight) crossing off the marks on the chart as they were passed. In this way no risk was taken at all although VICTORIOUS purposely passed within half a mile of the invisible shore, and was stemming a cross tide.

Plotting Radar information for navigational use is simple in VICTORIOUS, as the P.P.I's are alongside the Plot on which is kept the chart. It is therefore merely necessary to transfer what is seen on the P.P.I. alongside to the chart in front. In some cases, such as narrow channels, or a lot of shipping at night, it is simpler to use the P.P.I. as a chart, and the Captain cons the ship looking at the P.P.I., the Navigating Officer providing a check with the chart. Occasional bearings and distances must be obtained from the set itself to check that the P.P.I. is reading accurately, and this is more easily done with the S.G. where there is direct voicepipe communication between Compass Platform, Plot Officer and S.G. operator, than with the other sets where communication is by telephone only. On the S.G. it is easy to point out a particular Island, Headland, Bay or Isthmus of which it may be desirable to have a range and bearing. (Edges of land are not very good as the side lobes are apt to add a couple of degrees to the real bearing, but bays and inlets invisible to the naked eye at a distance are often good Radar marks by reason of their recognisable charted shape. The best marks of all are small Islands which are easily indicated to the operator). In low visibility it is generally convenient to have one set with P.P.I. on Compass Platform and in Plot on close range, showing the movement of ships in company and close to, while the other searches on a longer range. The long range one being normally the one used for navigation.

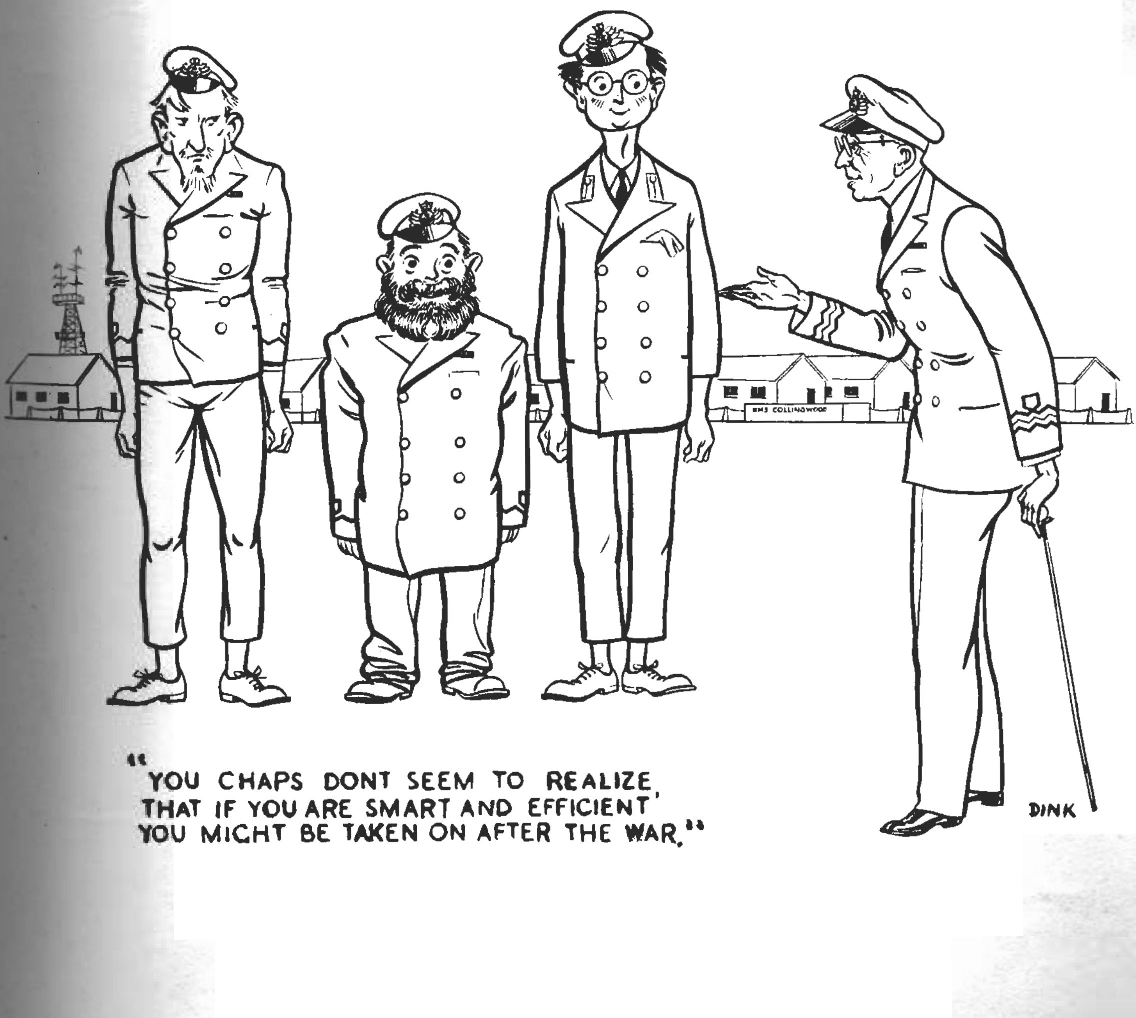
By having the P.P.I's both on the Compass Platform and in the Plot information can easily be described, both parties looking simultaneously at the same picture.

Weather effects. Anomolous propagation effects, i.e., the "bending" of the Radar beam parallel to the earth's curvature, is frequently experienced on the station and as a result exceptional surface ranges are common with Types SG/293 and 277. The range performances quoted in this report are the normal and not the exceptional effects.

A.S.E. Comment.

In the report it is stated that Type SG is preferred to Type 277 for navigation at close ranges. The higher power of Type 277 makes the P.P.I. picture at close ranges less clear than that of Type SG. It is possible, however, by use of the receiver gain control (as opposed to the P.P.I. gain) to obtain just as good a P.P.I. picture from Type 277 at Close ranges as from Type SG. This was recently demonstrated in the Copper Cliff trials, when Type 277 was used for pilotage up to and through the Clyde Boom.

The use of the receiver gain control affects all P.P.I's on the set and is therefore only acceptable when the requirement for extreme low cover can be relaxed. Although this compromise will generally be satisfactory, it is recognised that there are occasions when both extreme low cover and precise information for close range navigation, are required at the same time. A proposed modification to Type 277 will cover this requirement. The improved close range navigational performance of Type 277 which can be obtained by the use of the receiver gain control should be noted.



RANGING OUTFIT RTC

This ranging outfit which comprises a generator strobe and signal unit Design 9, a calibrator step strobe and switch unit and a range handwheel box, is an accurate ranging outfit designed to give ranges to an accuracy of down to ± 5 yards when used in conjunction with Type 277 or Type 271Q.

This unit will be fitted in all ships with either Types 271Q and 277 which carry SQUID and/or are fitted for firing SHARK.

This accurate range, which is obtained on a range scale of 3,500 yards, can be transmitted electrically via the range handwheel box to A/S set 147 to provide range marks on the range recorder so that SQUID can be operated against a surfaces submarine using Radar range. This range can also be transmitted to a five yard step counter-drum range receiver situated near "A" gun platform, and provides accurate range information for firing SHARK.

There is a follow-up device fitted in the Asdic office which can be switched into circuit if Radar ranges on a submarine are to be used. This device causes the Asdic dome to follow the Radar aerial so that the Asdic bearing recorder will record the relative bearing of the Radar aerial. Thus both the range and bearing of the target as given by the Radar is automatically displayed in the Asdic cabinet.

The display on the Radar scan (3,500 yard range) is in the form of the step strobe instead of the normal bright spot. The strobe is moved along the scan by means of the range handwheel and is lined up with the echo so that the bottom of the step coincides as closely as possible with the target echo. As the target closes the Radar operator must operate the handwheel so that the step moves smoothly in with the echo.

This smooth change of range is recorded on the A/S range recorder. During trials with the gear described it was found that a Type 271Q working in conjunction with Ranging Outfit R.T.C. was capable of giving range varying in accuracy by an amount no more than ± 8 yards. The operation obviously depends upon the skill of the operator and he should be given every opportunity for practice using any convenient ship as a target. The setting up procedure for the equipment is fully described in the Handbook* which will be issued shortly.

* The Handbook for R.T.C. is RH.669.

THE EFFECT OF PROPAGATION CONDITIONS ON RADAR SURFACE RANGES

The object of a study of propagation is to obtain an understanding of the effects of the earth and the atmosphere on the transmission of radio waves. The effect of the earth is found to be depend on the electromagnetic wavelength and the height of the transmitting aerial above the sea. These quantities are fixed values for any particular radar set and consequently for any given set the earth cannot introduce any effect that changes with time. On the other hand the properties of the atmosphere change with varying meteorological conditions. These variations are confined for the most part to the lowest thousand feet of the atmosphere, so that although the performance of surface warning radar must show corresponding changes, the performance of air warning radar will not be affected when operating against high flying aircraft. The present article describes in outline the nature of the meteorological conditions that influence propagation in the lower atmosphere.

The terminology in common usage is employed in which the following three definitions are the most important.

(a) Propagation is said to be "normal" when the atmosphere has no important effect on radar surface ranges.

(b) Propagation is said to be "subnormal" when radar surface ranges are less than their "normal" value.

(c) Propagation is said to be "anomalous" when radar ranges are markedly greater than their normal values.

Conditions intermediate between "normal" and "anomalous" exist, and indeed radar ranges may vary frequently between "normal" values and values as much as five times "normal". "Anomalous" conditions are usually regarded as giving radar ranges of at least twice "normal".

NORMAL, SUBNORMAL AND ANOMALOUS PROPAGATION.

It is well known that except at close ranges the superstructure of a ship gives the main contribution to the radar reflection from the ship, and it is possible for this reason to regard the ship as giving the same reflected signal as an equivalent area mounted at a fixed height of H feet above the sea. The value of H for radar sets operating on centimetre wavelengths is given in the following table for different classes of target ship.

Target Ship	H
Destroyer	50 feet
Cruiser	75 feet
Battleship	100 feet

If the transmitting aerial of the radar set is mounted at h feet above the sea, then optical range of a target ship is defined by $1.2(\sqrt{h} + \sqrt{H})$ sea miles, where H has the appropriate value for the target ship in question (i.e. if the target ship is a destroyer then H = 50')

For distances $d < 0{\cdot}6(\sqrt{h} + \sqrt{H})$ sea miles, the signal amplitude of the echo from the target ship is proportional to d^{-4}, and this relation is maintained whatever the atmospheric conditions. On the other hand for $d > 1{\cdot}2(\sqrt{h} + \sqrt{H})$ the signal amplitude usually depends on d through an exponential factor e^{-ad} where a is a quantity that does not depend on d but varies with the electromagnetic wavelength and with meteorological conditions. Under normal atmospheric conditions the value of a is 0·6 at a wavelength of 10 cm. while at any other wavelength, λ metres, the value of a can be calculated from the formula :-

$$a = 0{\cdot}6 \left(\frac{1}{10\lambda}\right)^{1/3} \quad (1)$$

Under subnormal conditions the value of a is greater than the value given by (1), whereas when anomalous conditions prevail the decrease of signal amplitude with d is much smaller than under normal conditions.

For values of d lying between $0{\cdot}6(\sqrt{h}+\sqrt{H})$ and $1{\cdot}2(\sqrt{h}+\sqrt{H})$ the dependence of the signal amplitude on d cannot be accurately stated in simple terms, but as a rough approximation the rules given in the following table may be employed.

Propagation	Range of d in which signal amplitude $\propto d^{-4}$	Range of d in which signal amplitude $\propto e^{-ad}$	value of a
Normal	$d<0{\cdot}9(\sqrt{h}+\sqrt{H})$	$d>0{\cdot}9(\sqrt{h}+\sqrt{H})$	$0{\cdot}6\left(\frac{1}{10\lambda}\right)^{1/3}$
Subnormal	$d<0{\cdot}6(\sqrt{h}+\sqrt{H})$	$d>0{\cdot}6(\sqrt{h}+\sqrt{H})$	$>0{\cdot}6\left(\frac{1}{10\lambda}\right)^{1/3}$
Anomalous	$d<0{\cdot}9(\sqrt{h}+\sqrt{H})$	-	-

The dependence of the signal amplitude on d for $d>0{\cdot}9(\sqrt{h}+\sqrt{H})$ is not given in the anomalous case because it cannot always be represented in terms of the simple exponential factor. Indeed the dependence on d may be highly complicated in this case and moreover it changes with varying meteorological conditions. It can be stated, however, that for $d>0{\cdot}9(\sqrt{h}+\sqrt{H})$ the signal amplitude is always larger in the anomalous case than in the normal case (and is sometimes very much larger).

THE CAUSE OF ANOMALOUS AND SUBNORMAL CONDITIONS.

The effect of the atmosphere may be understood by referring to the optical example of light propagated at a small angle to the horizontal in a medium whose refractive index varies with height. For it is known that if the refractive index decreases with increasing height then the light will be bent downwards, whereas if the refractive index increases with height the light will be bent upwards. A similar refraction phenomenon occurs in the case of radio waves transmitted through the atmosphere at small angles to the horizontal. The case of upward bending corresponds to subnormal propagation, whilst the downward bending, provided it is sufficiently pronounced, corresponds to anomalous propagation.

The variation of refractive index with height is most pronounced in the lower atmosphere and is largely due to variation in water vapour content. A rate of change with height in the partial pressure of water vapour of 1 millibar per 100 ft. is sufficient to produce anomalous propagation. Experimental work has shown that water vapour gradients of this magnitude occur within the first 200 feet of the atmosphere. Unfortunately controlled experiments have not yet been carried out to determine the maximum height up to which such gradients may extend. It is believed, however, on the basis of both the available radio data and general meteorological conditions that large water vapour gradients never persist up to heights of more than a few thousand feet, and that in general large gradients only occur in the first thousand feet of the atmosphere.

Large water vapour gradients can only be built up provided there is no appreciable amount of vertical mixing due to turbulence. It is a well known result in the theory of gases that vertical mixing is small when the temperature of the atmosphere increases with height so that conditions favourable for the building up of large water vapour gradients are most likely to occur in atmospheric temperature inversions. This association of temperature inversions with water vapour gradients would appear to provide the explanation of correlations that have often been claimed between temperature inversions and anomalous propagation. Temperature inversions occur when warm air blows off land over a cooler sea, since the air near sea level is cooled, thereby giving an increase of temperature with height. If the warm air were saturated with water vapour when it left the land then the effect of the cooling will be to produce condensation of water in the lower layers, so that an increase of water vapour content with height must occur and propagation will consequently be subnormal. If on the other hand the relative humidity of the warm air before leaving the land were sufficiently low the opposite effect must occur. This arises because the lower layers will pick up water vapour from the sea provided the original relative humidity was small enough to offset the cooling of these layers.

In the previous paragraph a simple process was described that is capable of leading to either subnormal or anomalous propagation conditions according to the relation of the sea temperature to the meteorological properties of the air. In the following tables various regions of the world are given where meteorological conditions are expected to lead to exceptional propagation conditions.

ANOMALOUS PROPAGATION.

Region	Times of year at which anomalous propagation is expected to occur frequently
Around British Isles	May to August
Around Newfoundland	April to August
Mediterranean	April to August
Between N. Australia and Dutch East Indies.	September to November.

SUBNORMAL PROPAGATION.

Region	Times of year at which subnormal propagation is expected to occur frequently
Around Newfoundland.	March to August.

The entry of the region around Newfoundland in the tables of both anomalous propagation and subnormal propagation shows that for the period April to August propagation conditions in this region may be expected to vary widely and rapidly. This behaviour is believed to be exceptional as in other regions, the Mediterranean for example, steady propagation conditions are often maintained for many days. The tendency for meteorological conditions to persist is of great value in predicting propagation conditions in regions such as the Mediterranean.

It has been found that by assuming persistence of propagation conditions correct predictions could be given in about 70% of the cases examined in the English Channel. More complicated systems of prediction based on detailed meteorological considerations have not met with any appreciably greater measure of success.

OPERATIONAL EFFECTS OF ANOMALOUS PROPAGATION.

When propagation conditions are anomalous the following points should be remembered:-

(1) The range at which the enemy may D/F a radar transmission is correspondingly increased. For example if the range at which a radar set can normally be intercepted is about 50 miles under anomalous conditions the interception range may be greater than 100 miles.

(2) The range of detection of low flying aircraft is correspondingly increased. This effect on W.A. sets may lead to incorrect estimates of the heights of closing aircraft (the estimated height is too high).

(3) The increase in surface ranges due to anomalous propagation can lead to a radar set with poor electrical performance giving an apparently good surface range. This effect is particularly serious for dual purpose sets that are also required to give warning against high flying aircraft, since the ranges of detection of high flying aircraft are not affected by anomalous propagation and depend only on the electrical performance of the equipment. It is very important when a radar set gives anomalous ranges on the surface together with poor ranges on high flying aircraft, that an examination of the electrical performance be made.

(Editor's Note: Attention is drawn to the scarcity of information on this subject, and to the necessity, therefore, for Radar and Meteorological officers to forward material likely to be of use).

RADAR REFLECTIONS FROM CLOUD AND THUNDERSTORMS

An account is given of methods by which an operator can distinguish cloud from other echoes.

THEORETICAL CONSIDERATIONS

The echo amplitude will depend chiefly on:

1. The mean size of water drop in the cloud.
2. The number of water drops per unit volume.
3. The illuminating frequency.

A cloud is formed when a region containing water vapour drops in temperature below its dewpoint: this results in the accumulation of water molecules into droplets, which increase in size as the temperature falls. In the case of fair weather cumulus air resistance is sufficient to keep the droplets from falling below the cloud, and in the heavier storm clouds the drops often evaporate again in passing through warmer regions between the cloud and earth.

The power reflected from each droplet varies as the sixth power of its diameter. The echoes from the droplets will have a random distribution of phase relative to each other, and the mean reflected power will therefore be the sum of the individual powers. The total power echoed is therefore roughly proportional to the number of drops, (so that for a given mass of water vapour the power reflected will vary as the cube of the average diameter).

These considerations account for the large echoes from thunderstorms and cold fronts, which consist of numbers of large water drops, and for the fact that a heavy shower or storm cloud will show on the screen whereas ordinary light cloud will not.

The Rayleigh scattering law applies for all wavelengths very much greater than the drop diameter: that is, reflected power inversely proportional to the fourth power of the wavelength.

For radar sets of equal sensitivity (equal power transmitted, aerial gain, receiver noise factor, etc.) the signal voltage received from a cloud will vary inversely as λ^2.

In view of the higher vertical discrimination obtainable with small mirrors as frequency is increased, the difficulty of distinguishing aircraft from cloud echoes should not be so great, but the attenuation, may be expected to cause quite considerable cloud shadows.

Echoes have been observed very occasionally at 50 cm. but not on the longer wavelengths.

PRACTICAL CONSIDERATIONS

The character of the cloud reflection enables it to be dsitinguished from most other types of radar echo, in that the random phase distribution produces a signal beating right down to zero very much like noise. This effect causes a mottled appearance on the P.P.I., with a ragged variable edge where the tapering side of the cloud has been lit by the edge of the aerial beam; for heavy storms (or high gain settings) this mottle will join up, and for very heavy thunderstorms the edge will become almost clear out. The mottled appearance can always be obtained by using sufficiently low gain. This noise structure is far more easily observed on an 'A' display and, in the case of small low clouds, the 'A' display provides the only means of detecting the spurious from the real conning tower or ship echo. Cold fronts present the additional peculiarity of a linear advancing edge, covering a distance up to 50 miles or more.

METHODS OF DISTINGUISHING CLOUD ECHOES

TYPE OF ECHO	DISTINGUISHED FROM CLOUD BY:
Permanent	Motion of cloud. Noise-like structure
Ship.	Motion of cloud if greater than 30 Knots. Constant course. 'A' display noise structure. Elevating the aerial in which case a cloud echo will increase.
Aircraft.	Clouds will be travelling with about the prevailing wind speed, rarely more than 100 m.p.h. An experienced operator will be able to distinguish between the rapid fading of an aircraft, as its aspect changes, and the cloud echo, fluttering to zero with occasional high, spiky peaks.
Window.	The cloud echo is almost exactly the same in both structure and motion as that of window, except for the latter's rapid rate of growth. The balloon structure decoy, reported to be used by Japanese aircraft, also has similar characteristics. It is perhaps more important however that operators should learn to ignore all three types, rather than to distinguish between them.

TYPE 281 BQ

Type 281 has had a proud career, and it is not without emotion that we print in this issue a picture of the new Type 281 BQ receiving office arrangement. New units are:

The coupled P.P.I.'s (0 - 80 miles and 80 - 160 miles)

The control unit 20L. On top of it sits the auto-aligning aerial indicator.

The central rack containing:
Receiver P107 (modified P23)
Panel L.50 (modified L.11)
Switch units for Type 941 and Type 243
Swept gain unit (provides anti-clutter facilities)
M.81 pre-amplifier
Video Filter Unit
Type 243Q aerial indicator
Rectifier Unit.

The right hand rack containing:
Performance meters for Type 281 BQ, Type 941 and Type 243Q.
Aerial Control Unit for Type 243Q.