CARE AND USE OF CRYSTAL VALVES

HANDLING - MARKING - INTERCHANGEABILITY - CHECKING

GENERAL.

These notes concern the crystal valves used as mixers and rectifiers. They are classed with thermionic valves for the purposes of specification and nomenclature, and have titles in the "CV" range. They consist of a silicon capsule and catswhisker mounted inside a ceramic tube fitted with brass contacts.

HANDLING.

The crystal can be damaged by mechanical shock and by "electrical shock" i.e. the passage through it of an excessive current such as is caused by exposure to R/F fields, or by the discharge, through the crystal, of accumulated static charges. The use of a damaged crystal will result in a poor signal-to-noise ratio in the unit in which it is employed; the consequences of this may be serious and the precautions detailed below should always be taken.

Spares

From February 1945, all crystals will be sent out individually packed in metal foil, in which they should be left until actually required. Crystals received without this packing should be placed in cotton-wool, or some soft material, and kept in a metal box: any box or tin with a tight-fitting lid (such as a tobacco tin) will serve if no special box is supplied with the set. The individually wrapped crystals should also be placed in a metal box if kept near the transmitter.

Crystals should not be carried about unscreened, even for short distances, or left lying about the bench, or placed unscreened on metal surfaces of the transmitter.

At all times avoid dropping or jarring the crystal, which should be handled as carefully as a glass valve.

Insertion and Use.

If the apparatus into which a crystal is inserted is not earthed, there may be a difference of potential between this apparatus and earth. It is also possible for a static charge to accumulate between the equipment, earth or operator. To ensure that such a potential or charge does not discharge through the crystal on insertion, the following precautions should be taken:-

(a) If possible, switch off the equipment when changing crystals.

(b) Ensure that the hand used to insert the crystal touches the metal of the unit, and remains in contact with it, both before and during insertion.

If a circuit is connected across the unit containing the crystal, for the purposes of measurement, use short, shielded or twisted leads and avoid open loops into which voltages may be induced by adjacent electrical apparatus such as motors, field coils etc.

Avoid exposing open end wave-guide sections containing crystals to intense centimetre-wave fields. Such guides act as fairly efficient antennas, and may absorb sufficient power to damage the crystal. If possible, avoid directing the receiver paraboloid against a large

reflecting surface at close range, or against the transmitting paraboloid of another equipment, as in both cases an undually large signal will be received. (Most modern equipments are, of course, fitted with devices to protect the crystal from such signals).

NOMENCLATURE AND MARKING.

Crystal valves have "CV" numbers, but owing to the small physical size of the article, colour marking has hitherto been used on the crystal itself. In future, some crystals will bear the CV number and no colour code, so users should be prepared to recognize either marking. The following table gives details of existing types of crystal valves:-

CV Title	Colour Code	Function.
CV101	Yellow	Low burn-out S-band mixer
CV102	Yellow + Orange	Medium burn-out S-band mixer
CV103	Yellow + Red	High burn-out S-band mixer
CV111	Green	Low burn-out X-band mixer
CV112	Green + Orange	Medium burn-out X-band mixer
CV113	Green + Red	High burn-out X-band mixer
CV226	Black band	Noise generator
CV241	Yellow + Blue	Is CV101 with worse noise factor. Used in wavemeters etc.
CV246	None. The CV title is used.	Low level detector, matched for use in pre-plumbed S-band circuits. Low burn-out grade. Is selected. CV111.
CV247	None. The CV title is used.	Low level detector, matched for use in pre-plumbed S- and X-band circuits. Medium burn-out grade. Is selected CV112.
CV253	Green + Green, or the CV title.	Mixer for use in pre-plumbed X-band circuits. Low burn-out grade.

INTERCHANGEABILITY.

Certain crystals are replaceable by others, as follows. Obviously it is most economical to use the proper crystal specified for the gear. It is emphasised that the use of one of the emergency replacements may result in inferior performance not immediately apparent to the operator. It is most important that the correct crystal be used as soon as possible.

Type of Crystal	May be replaced by:-
CV101	CV102, CV103, CV111, CV112, CV113, CV246, CV247, CV253
CV102	CV103, CV112, CV113, CV246, CV247.
CV103	CV113
CV112	CV113, CV247
CV113	The above crystals may be tried in emergency only, the proper crystal must be fitted as soon as possible
CV226	-
CV241	CV101 and its alternatives in some cases only. See Handbook of set.

Type of Crystal	May be replaced by:-
CV246	CV111 and its alternatives may replace it, but should be tried in emergency only. The proper crystal must be fitted as soon as possible.
CV247	CV112 and its alternatives may replace it, but should be tried in emergency only. The proper crystal must be fitted as soon as possible.
CV253	CV111 and its alternatives may replace it but should be tried in emergency only. The proper crystal must be fitted as soon as possible.

CHECKING OF CRYSTALS IN SERVICE.

There is no simple, single test that will check the overall "goodness" of a crystal, which depends on three factors:-

(a) The ratio of the resistance in the backward direction (i.e. with the tip negative and cap positive) to the resistance in the forward direction. This should normally be greater than 8:1.

(b) The capacity of the contact (virtually a shunt capacity across the crystal which, if unduly large, wastes the R/F input power).

(c) The "noise-temperature" (i.e. the amount of unwanted noise which the crystal itself generates and mixes with the signal).

These three factors may vary independently, and so a check on (a), the only one practicable with ordinary instruments, is not a complete check on the crystal, although it may enable some defective crystals to be rejected. In the past this check has sometimes been applied by measuring the forward and backward resistances of the crystal by means of an Avometer Patt.47A set to the 10,000 ohm range, or by a "measuring Unit", Patt.W3417 as supplied with early sets of the Type 271 series. Both of these methods, however, are unsafe, as they result in passing excessive current through the crystal, which may be damaged by currents greater than about 2 mA. Investigations are in progress to devise a safe and simple method of testing, and the results will be given in the next Bulletin.

It is emphasised that crystal instability characterised by a fall in backward resistance is usually due to some fault developing in the electrical unit, which should be investigated before a new crystal is inserted.

RESTORATION OF CRYSTALS.

It is not normally possible to restore defective crystals in the field.

FORTHCOMING A.F.O.

When the question of testing crystals has been cleared up, an A.F.O. will be prepared summarizing the matters dealt with in the above notes.

A.S.E. EQUIPMENT NOMENCLATURE

When the development of a new equipment is started, one of the first things to be done is to allocate it a Type number or outfit name. These numbers or letters are allocated on a definite system which has been built up over many years and which in many cases has to fit in with an Admiralty system.

Ships often hear of a new piece of equipment by its Type number before they have any idea of the object or form of the equipment itself. It is hoped that the de-code given in this article may help the users to recognise the use of the equipment from its Type number or outfit name.

W/T EQUIPMENTS.

Type No.	Use.	Type No.	Use.
1 - 13	Spark W/T sets.	501 - 549	Internal communication and Remote Control equipments.
14 - 19	Arc W/T sets.		
20 - 29	Shore Station W/T sets.		
30 - 69	Valve W/T sets.	601 - 644	Transmitting sets for communication purposes H/F and/or M/F frequencies.
71 - 78	Transmitting sets H/F (not attachments).		
81 - 89	Transmitting sets R/T (not attachments).	645 - 649	Transmitting sets for Television purposes.
90 - 99	Miscellaneous sets.		
201 - 205	Distant Control Transmitting sets.	650 - 679	Transmitting sets for other than communication purposes (e.g. R.C.M. & Y.)
301 - 350	Sc/S sets.		
401 - 449	Wa/T sets (including Loud Hailing equipment)	680 - 699	Transmitting sets for communication purposes V.H/F and U.H/F frequencies.
451 - 499	Sound Reproduction Equipments.		

RADAR EQUIPMENTS.

Type No.	Use.	Type No.	Use.
241 - 244	Interrogators.	930 - 939	Gunnery Fire Control - Surface (i.e. low angle).
251 - 259	I.F.F. and Beacon sets.		
262 - 293	Radar sets - various.		
900 - 909	Gunnery Fire Control - Aircraft High Angle (or combined low and high angle).	940 - 949	Interrogators.
		950 - 959	I.F.F.
		960 - 969	Warning of Aircraft.
		970 - 979	Warning of surface craft.
910 - 919	Gunnery Fire Control - Barrage.	980 - 989	Warning (Combined Aircraft and Surface with accurate height finding).
920 - 929	Gunnery Fire Control - Close range, high angle.		
		990 - 999	Warning (Combined Aircraft and Surface).

In order to keep the range of Type numbers allocated to sets within reasonable limits, various applications of the same basic set are not given separate Type numbers but are denoted by the addition of suffix letters to the Type. The suffix letters are added in accordance with the following C.A.F.O's.

(a) For W/T Transmitting sets - In accordance with C.A.F.O. 2838/38 as amended by A.F.O. 5678/42.

(b) For Radar sets. - In accordance with C.A.F.O.477/43.

SYSTEM FOR NAMING ASSOCIATED OUTFITS.

The outfits of stores necessary to complete the Radio equipments in ships are classified as associated outfits (e.g. Aerial, Battery, Receiver, Power Supply, etc. outfits). The nomenclature systems for associated outfits are as follows :-

Letter Group	Associated Outfit Group	Letter Group	Associated Outfit Group
AR, S	Aerial Outfits (Submarines)	HRA - HRZ	Radar Teacher Outfits
ACA - ADZ)	Aerial Outfits	JA - JZ	Indicator Outfits
ANA - AUZ)			
AWA - AWZ	Aerial Outfits(Whip)	KBA - KBZ	Separated Aerial Control Outfits.
BBa - BBz	Battery Outfits.	KCA - KCZ	W/T and R/T Control Outfits.
CN - CQ)		KDA - KDZ	C.W.S.Control Outfits
CAA - CBZ)	Receiver Outfits W/T	KEA - KEZ	Remote Control " (Shore Station)
CDA - CDZ)			
CJA - CJZ)		KFA - KFZ	Fighter Direction Control Outfits
CEA - CEZ)			
CPA - CPZ)	Receiver Outfits	KGA - KGZ	Speech Control Outfits
CRA - CRZ)	Radar	KSA - KSZ	V.H/F Control Outfits
CSA - CSZ	Receiver Outfits W/T		
CTA - CTZ	Receiver Outfits Television.	MRA - MRZ	Morse and R/T Training outfits
CUA - CUZ	Receiver Outfits W/T		
		REA - REZ	Recording Outfits
DE - DO)		RHR(1)/(2) etc.	Auto High Speed Receiving Outfits
DDA - DDZ)			
DHA - DHZ)	Power Supply Outfit	RHT(1)/(2) etc.	Auto High Speed Transmitting Outfits
DJA - DJK)			
DLA - DLZ)		RIS(1)/(2) (3) etc.	Interference Suppression Outfits
DPA - DXZ)			
		RTA - RTZ	Ranging Outfits
EA - EZ	Aerial Exchange Outfits.	TA - TZ	Aerial Trunk Outfits
ESA - ESZ	Aerial Switching Outfits	TEA - TEZ	Tool Outfits.
		TOA - TOZ	Testing Outfits.
		QA - QZ	Receiver Outfits, (R.C.M. & Y.)
GA - GZ	Wavemeter Outfits.		

SYSTEM FOR NAMING D/F OUTFITS.

D/F Outfits are distinguished by a nomenclature system which employs a two letter code. The significance of the letters employed is as follows :-

First Letter.

A - Adcock Aerial System.
F - Fixed Frame Coil Aerial System.
L - Loop Aerial System.
R - Rotating Frame Coil Aerial System.

Second Letter

A - Alternative H/F, D/F or M/F, D/F
C - Common Aerial. Simultaneous reception on H/F and M/F but alternative D/F.
H - H/F, D/F only.
M - M/F, D/F only.
U - U.H/F only.
V - V.H/F only.
S - Simultaneous H/F, D/F and M/F, D/F.

NAVIGATIONAL AID - QM

Radio navigational aids at present in use at sea are QH, Loran, QM and Consol. QH and Loran were discussed in Bulletin No. 1 and it is hoped to complete an article on Consol for the next issue.

Outfit QM, sometimes referred to as "Decca" is a navigational aid of extreme accuracy over short ranges up to 150 miles. Its operation is based on the principle that if two transmitting stations radiate C.W. signals, exactly similar in frequency and locked in phase relationship, a pattern is set up which consists of an infinite number of lines, along each of which the phase relationship between the signals is constant and on different lines the phase relationship between the signals is different. These lines, which are the loci of points of constant phase difference, are hyperbolic curves with the two transmitting stations as foci.

If the pattern of these hyperbolae be superimposed upon a chart and a vessel be equipped with a receiver capable of measuring the phase difference between the received signals from the transmitters, it is obviously possible to state at any instant, upon which hyperbole, or "line of position", the vessel is situated.

Now if a third transmitter be used, so that two pairs of transmitters are provided, two families of hyperbolae are formed and it is possible to state upon which two lines of position the vessel is situated. This must obviously be at the point of intersection of two lines of position and the point of position on the chart, or a "fix" of the vessel is given.

In actual practice it is not possible to have the transmitters operating upon exactly the same frequency, since it would not then be possible to separate the received signals and measure their phase relationship. The transmitters operate on different but simply related frequencies and, in the receiver, both pairs of the three are changed to two common frequencies for the operation of two indicating meters.

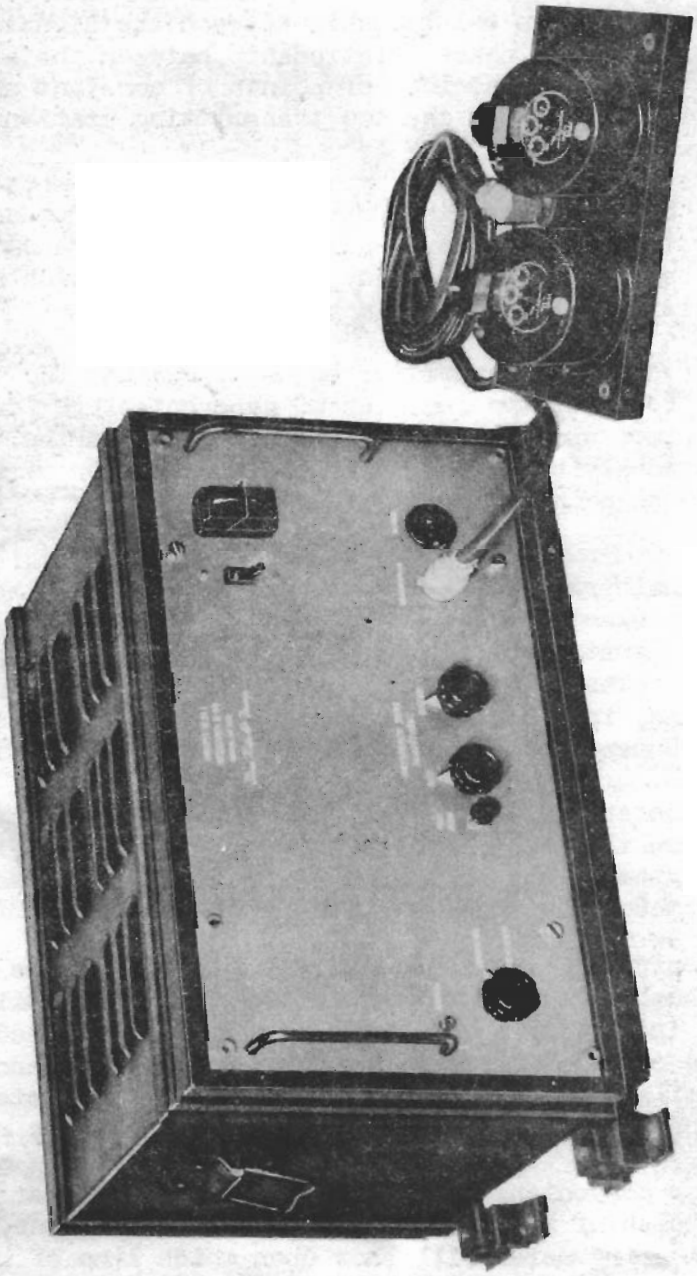
These meters indicate the index numbers of the hyperbolae, which are numbered on the chart, and thus at any time the position of the vessel is obtained by selecting on the chart the hyperbolae bearing the numbers indicated by the meters.

It should be appreciated that, if the pattern be traversed by a receiver, a number of complete phase changes of 360° will be gone through and that the indicating meters, whose scales are divided into one hundred parts, rotate once for each complete phase cycle. Through gearing, small pointers, similar to those in an electricity or gas meter, indicate in hundreds, tens and units the whole numbers of complete rotations of the main pointer. That is, the complete numbers of phase cycles passed through. For convenience, the term "lane" is used for the area bounded by two hyperbolae of zero and 360° phase difference and, although at any time the indicating meter will show upon which line of position within a "lane" the vessel is situated, it is not known within which lane the vessel is situated, unless the whole number indicating pointers are set correctly at some time and the system - transmitters and receivers - are then kept continuously operating.

In other words, if from outside the operating range the service area be entered or the transmitters or receivers be switched off for a period long enough for one or more lanes to be crossed by the vessel without the indicating meters rotating, some method of "lane number identification" is necessary for setting the whole number indicators on the meters. This can be done by positioning the vessel to within the width of one lane by dead reckoning or D/F but a lane identification method, associated with the system is what is really required and such a development is now under consideration.

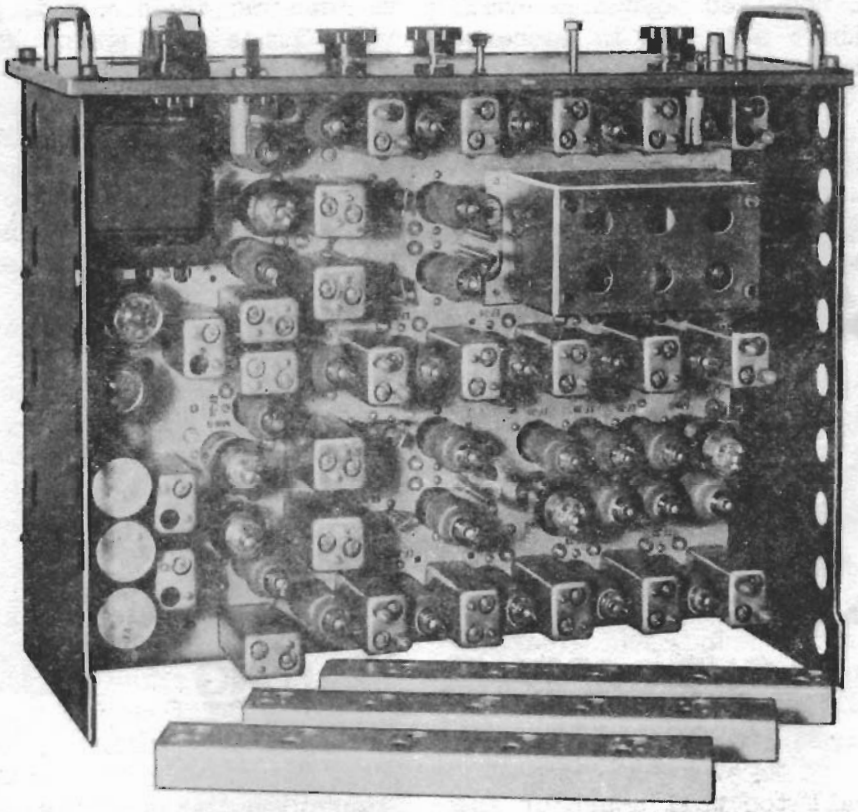
OUTFIT QM

EXTERIOR VIEW

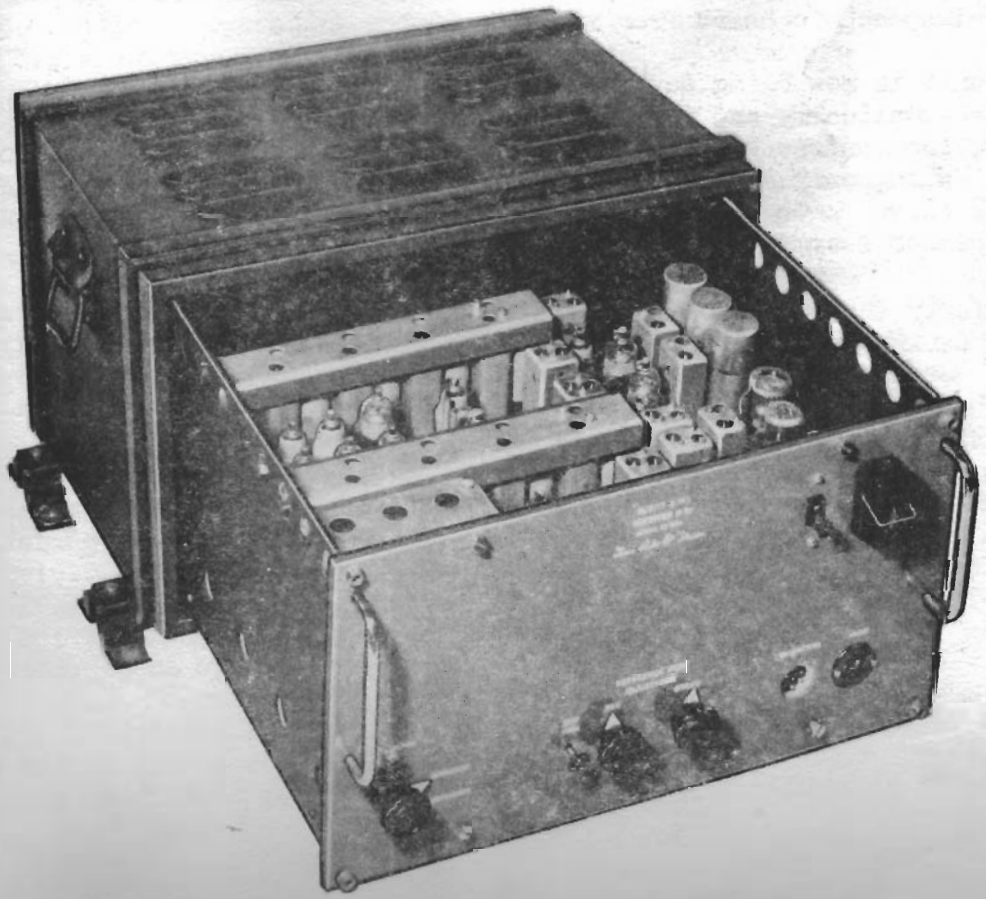


OUTFIT QM

TOP VIEW - COVERS REMOVED



METHOD OF WITHDRAWAL OF CHASSIS



As regards accuracy of the system, in recent operations accuracies of the order of 100 yards at a range of 100 miles have been achieved.

The equipment in the ship is simple to operate, and, in fact, no training is required beyond an ability to read two dials and to relate the numbers obtained to numbered lattice lines on a specially prepared chart.

The transmitters which are shore-based have, in operations to date, been mobile equipments and have been spaced about 40 miles apart. The aerials employed are of the symmetrical "T" type with a 600 foot span supported by three 100 ft. sectional, steel, guyed masts. The transmitter power output to the aerial is 2·5 kW. Each transmitter is supplied from a Diesel Alternator set and all equipment including ancilliary phase-locking equipment, is housed in lorries and trailers.

At present the system operates in the region of 100 kc/s but investigations are proceeding on the possibility of using lower frequencies to extend the effective range.

LOUD SPEAKER MUTING

We are all too well aware of the unpleasant noise which issues from a loudspeaker connected to a high gain receiver similar to a B.28, when no carrier is being received. In the case of convoy escorts this noise on the convoy R/T loudspeaker is frequently such that it interferes with the passing of orders on the bridge, and as it may continue for days at a time during periods of W/T silence, it is frequently found desirable to fit the loudspeaker in a box whose door is kept shut until faint speech is heard from within.

A unit is now being developed which in effect opens and shuts the door automatically and thus obviates the human element. This unit mutes the loudspeaker a few seconds after the end of a transmission, leaving only a faint background noise to indicate that the circuit is alive. On a message commencing, the mute is removed and the loudspeaker resumes at full volume.

Briefly the equipment discriminates against sounds of the nature of background noise and switches off the speaker, whilst accepting normal speech, and switching the loudspeaker into circuit. There are a few peculariticos, however, soft speech, such as Spanish, is discriminated against, as also is music, therefore if used on the B.B.C. one would receive the announcements but <u>not</u> the crooners. If used on the Spanish "B.B.C." neither would be heard unless the announcer spoke Spanish with a Nazi accent!