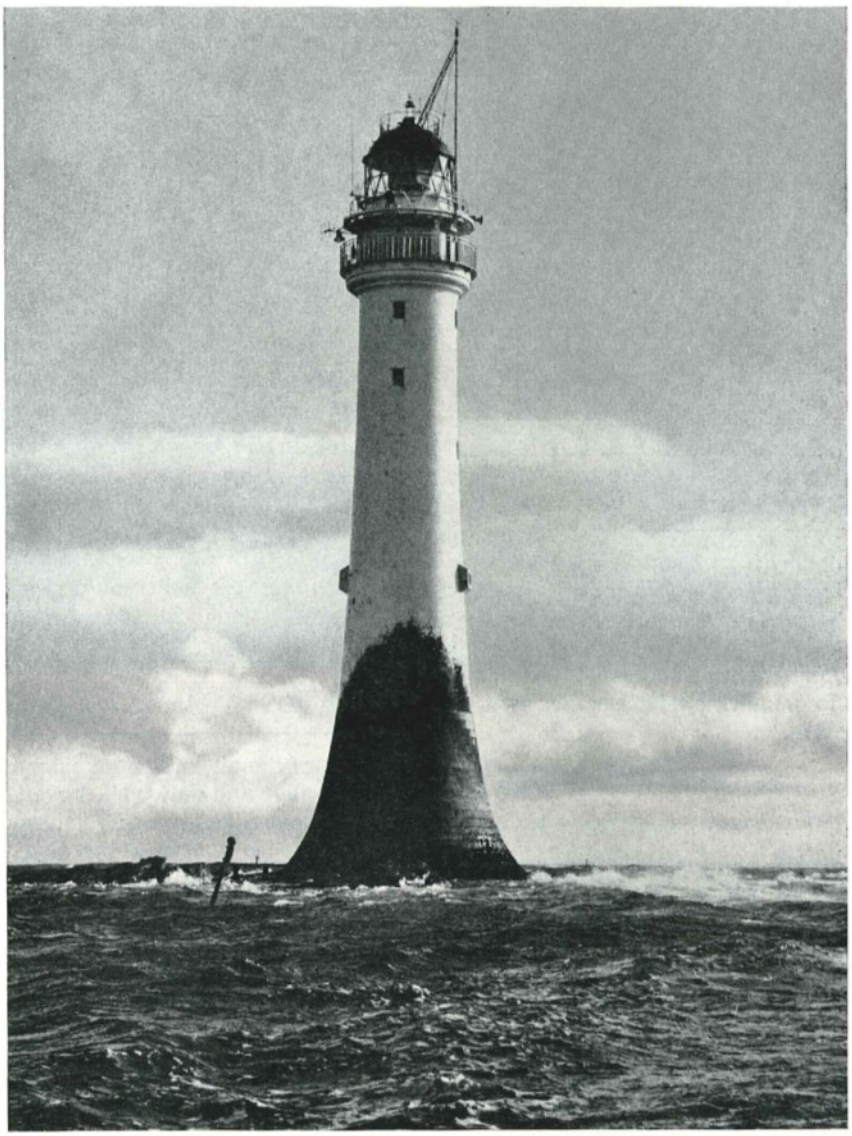
Marconi Radar Data Sheet P1

Sea-Watch 300 Radar Beacons



Bell Rock Lighthouse

Courtesy Northern Lighthouse Board

Power output 300mW.
Low power ; wide supply voltage tolerance.
Designed for operation at unattended sites.
Fully sealed, robust case styles.
Accepted for worldwide operation.
Wide choice of interchangeable aerial units.
Full morse alphabet coding.

The Sea-Watch 300 range of radar beacons ('racons') are compact transponders, proven to be fully capable of providing a reliable service on navigational stations of all kinds, including buoys. Arrival of an interrogatory signal from a horizontally-polarized 3cm X-band marine radar causes the racon to transmit an amplified reply pulse. The receipt of this coded reply pulse by the radar results in a characteristic 'paint' being displayed, readily providing both the range and bearing of the beacon. The response paints are coded in morse for ease of identification.

The well-established Sea-Watch 300 design has found wide international acceptance, units being extensively used in important navigational systems throughout the world.

Features

Range

Even in adverse weather conditions range can exceed 40km, i.e. 22 nautical miles (n.m.), on fixed sites with adequate mounting height, or 12 to 18km, 6·5 to 10 n.m. when horizon-limited on buoys – several times the range of radar reflectors.

Aerials

Standard Type 2 and Type 5 aerials provide omnidirectional azimuth response for floating and fixed sites respectively. In addition some 7 other aerial types are available to cover special siting requirements. Each aerial type has been designed for a specific purpose, and units are interchangeable.

Table 1 (page 7) shows the complete range of aerials available.

Power Supply

The versatile nature of the unit enables operation from any input voltage within the range 8–36Vd.c. Power supply requirements are light and consumption under working conditions is generally less than 1·0W, enabling a small power source to be employed. A 0·06m^3 (2ft^3) primary battery, for instance, will provide over 12 months of unattended operation. Batteries, battery boxes, transformer-rectifier units for a.c. mains operation, etc. can be supplied to special order.

Response Identification

All Sea-Watch 300 racons include a versatile coder as an integral part of the equipment. The response displayed on the radar screen is broken into one to four morse digits, longs or shorts, enabling individual racon sites to be readily identified. All letters of the morse alphabet can be chosen although, to guard against possible reading errors only letters with an initial long character are recommended. The overall duration of the code can be chosen to harmonize with the radar range scales which will commonly be in use at individual sites.

Environment

Operation is to full specification within the temperature range −20° to +55°C (−4° to +131°F). Lower temperature units are available to special order. All racons are waterproof and robust. The standard case is designed for outdoor mounting on buoys, lightvessels and lighthouses and weighs 16kg (35lb) complete with built-in aerial. Mounting is straightforward and the plan area is only 570cm^2 (89in^2). There is an optional protective handrail. An alternative lightweight case weighing only 4·5kg (10lb) is available for use with a separate external aerial unit connected by waveguide and weighing 1·8kg (4lb). A flameproof racon with the same capabilities as the standard racon has been designed.

Options

In addition to the variety of aerials, transmitter sweep rates, and case constructions, the Sea-Watch 300 range offers certain additional functions. A transmitter gating facility, for instance, enables the racon transmission to be blanked from the screen of any radar at the racon station.

Reliability

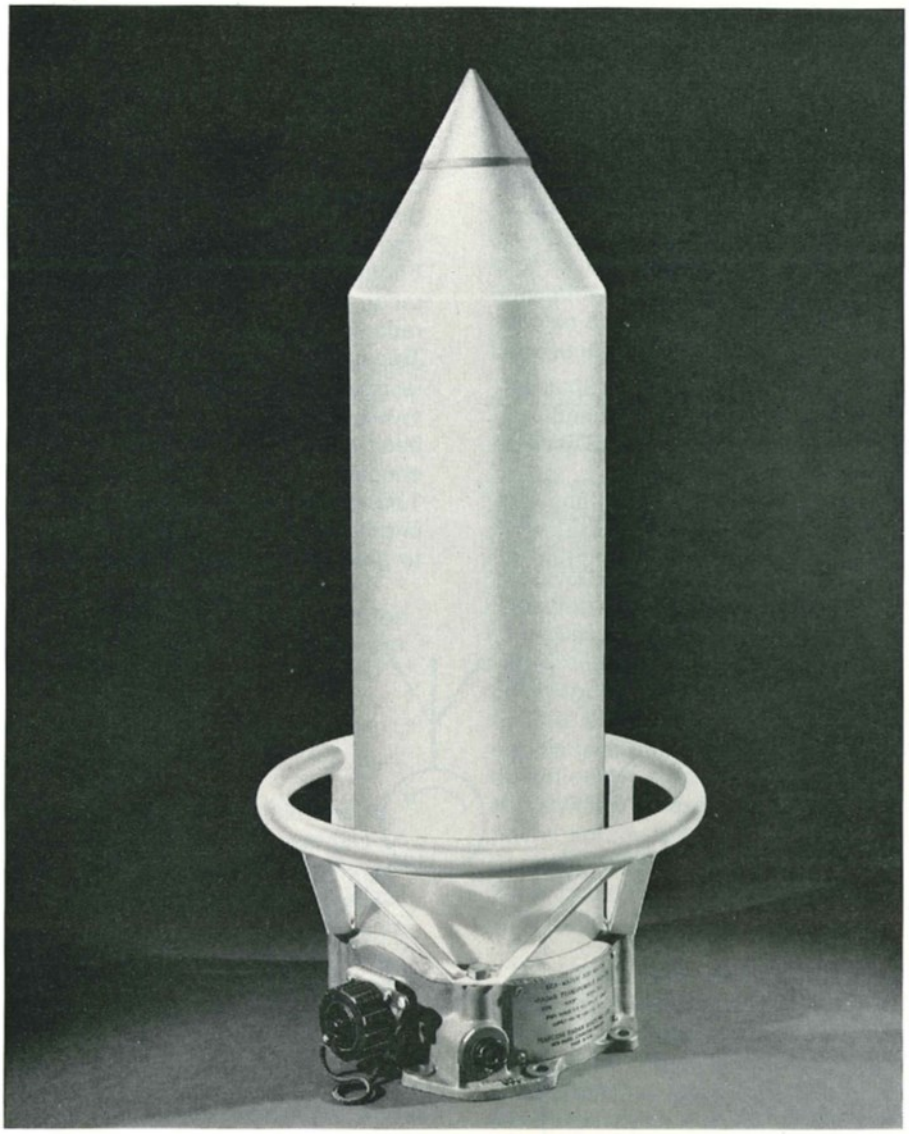
Design of the all solid-state silicon circuits is conservative and only well-proven components are employed. There are no valves or moving parts to cause trouble so that Sea-Watch 300 racons give long periods of reliable service. Estimated mean time between failure exceeds 2·7 years.

Applications

Standard Sea-Watch 300 racons operate with ships' X band navigation radar. No special modifications are needed to the radar, neither do special operating techniques have to be used. Clear and unambiguous responses indicate target identity and position to a high degree of accuracy, generally equal to that of the radar itself.

All racons are identifiable by type numbers. Aerials carry separate type numbers. Standard racons, designated Type 2, can be used for:

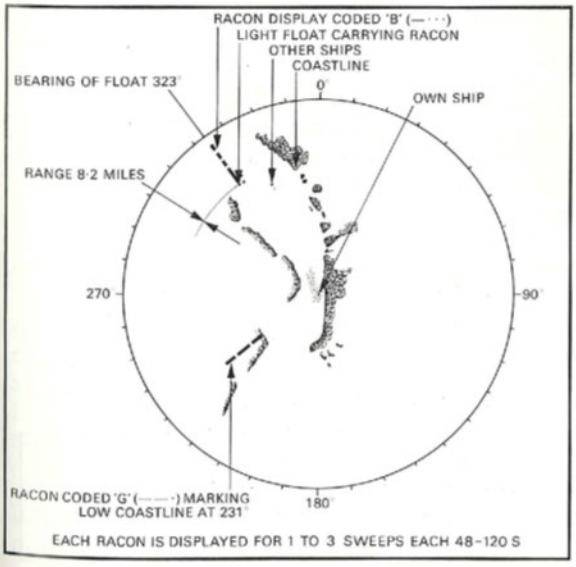
1) Identification of channel and turning point buoys in harbours, estuaries, and rivers. Range considerably exceeds detection range of buoys fitted with passive radar reflectors and coded racon buoys are easily recognized amid other targets, sea clutter, etc.



Racon in standard case, suitable for most applications, shown fitted with optional handrail

2) Perception and identification of sea-stations, lightvessels and lighthouses, not only amid other shipping at short range but when making landfall.
3) Marking permanent obstructions – offshore installations, sand banks, etc.

Fig. 1 Typical radar display with racons



Special Racons

The Standard Type 2 racon is supplemented by special racon Types 3 – 10 enabling a racon to be chosen to suit the conditions at individual sites. Marconi Radar Systems Limited have pioneered several important improvements in racon techniques, and as Industrial members of the International Association of Lighthouse Authorities keep in constant touch with worldwide racon developments. We are therefore able to advise on correct choice of racons for all purposes, and can, if necessary, develop racons for special applications and other frequency bands.

There are several duties for which variants of the standard Sea-Watch 300 racons have been specially developed. These include:
Wreck and obstruction marking
Survey, cable laying
Channel marking for ferries
Lightvessels, etc. carrying their own pulse radar
Pilot cutters, tugs, etc. in harbour radar systems
Marking large vessels of limited manoeuvrability
Identification and marking of oil installations requiring flameproof constructions

For particulars of the special racon types available turn to page 8.

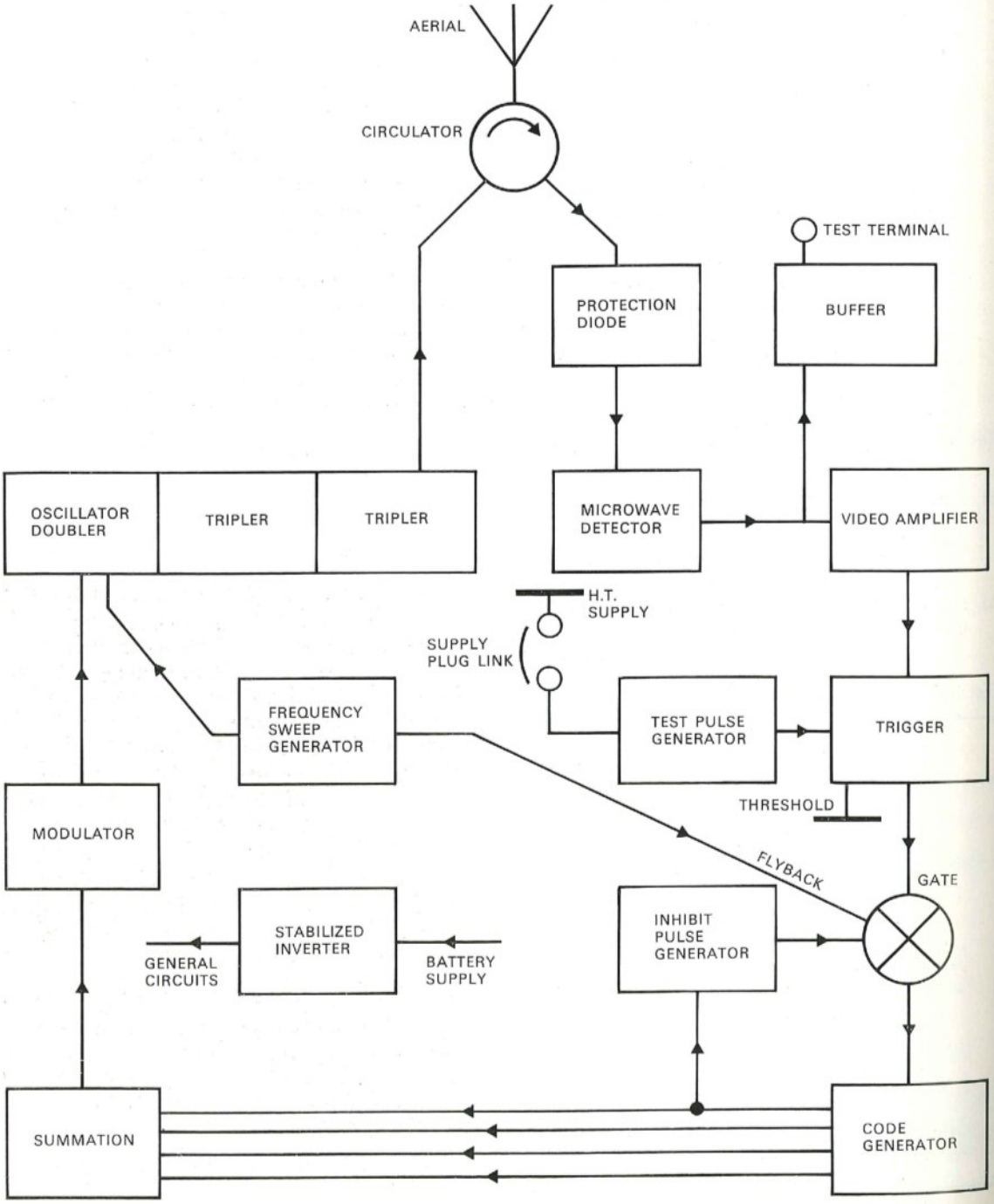
Principle of Operation

The racon receives transmissions from the ship's radar and responds by re-transmitting coded reinforced echoes. A line is thereby repeatedly superimposed on the radar display giving the precise range, bearing, and identity code of the racon station. Because scanning beam aerials are used for the radars, each racon can give service to a large number of ships on a time-sharing basis, without appreciable interference or loss of signal.

The radar of each ship transmits short pulses at a fixed frequency within the 3cm X band marine frequency allocation (9300 to 9500MHz). As the radar aerial rotates, each pulse illuminating the racon aerial is detected and, after amplification, triggers a coded group of longer pulses which activates the transmitter.

For normal navigational use (Type 2 racons) the racon solid-state transmitter is swept repetitively through the radar frequency band. One of four preselected sweep rates lying within the range of 48 to 120 seconds is chosen. As the racon sweeps through the radar frequency, the pulse groups are received and appear on the radar display. The 48 to 120-second frequency sweep rate is fast enough to up-date the radar display frequently, yet slow enough to prevent the racon transmitter from passing through the radar receiver bandwidth between aerial scans. The sweep time is sufficiently long for the racon response to clear from the screen between sweeps and reveal any targets which may have been masked. The 48-second sweep should be chosen where ranges are short, and the 96 or 120-second sweep where maximum range is important. The 72-second sweep is often found to give good general results. Other types of

Fig. 2 Block diagram for Type 2 Racon



racon should be used where more frequent responses are required. The stepped-sweep variant (Type 10) with more frequent up-dating is recommended for general navigation-aid purposes; refer to Table 2.

The responses are synchronized to the radar transmissions. As shown in Fig. 1 the pulse group is displayed at the range and bearing of the station, extending outwards as a number of code dashes giving positive identification and allowing the ship's position to be determined with accuracy. If not required, the responses may be suppressed using the radar's differentiator control. This control does not affect reception of fast sweep (Type 8) racons.

The racon is displayed with the full bearing accuracy of the radar. Delay between reception and re-transmission causes the start of the response to appear about 75m (246ft) behind the true racon position. At ranges sufficiently short for this to be significant, the racon station structure echo is normally visible and range can be measured to full radar accuracy.

Mechanical Features

Weight and plan area have been minimized to simplify mounting (see Fig. 3) and materials have been chosen with full regard to the environment. The radome of the standard case is 9·5mm ($\frac{3}{8}$in.) Perspex, bonded to a corrosion-resistant nickel-gunmetal base casting which carries drilled fixing lugs. The structure will withstand sideways loading equivalent to immersion in a 70-knot (130km/hour) water stream. An optional protective handrail can be bolted to the base.

The capsule is fully sealed and contains a readily changed desiccator whose condition is visible through a sealed window. The top of the radome is steeply coned to deter birds from perching.

The circuits are housed in an internal metal screening canister to the top of which the aerial is attached. The canister is secured to the base by a shrouded waterproof joint. This double-hull construction permits the radome to move freely under wave impacts and during thermal expansion without stressing the circuit core or the aerial. If the radome is fractured, the screen will still give some protection to the circuits against water damage.

The lightweight Type 9 racon comprises the well-established circuitry of the standard Type 2 with a watertight aluminium alloy casing, reducing the weight of the unit to 4·5kg. A separate aerial unit weighting 2kg is then mounted aloft and coupled by detachable waveguide enabling the racon to be fitted to a wide variety of sites. Special circuit functions can be accommodated either in this or the standard casing and are, in general, capable of being operated with the various available aerials.

A flameproof casing is under development which will prove of interest to the oil and natural gas industry.

Electrical Features

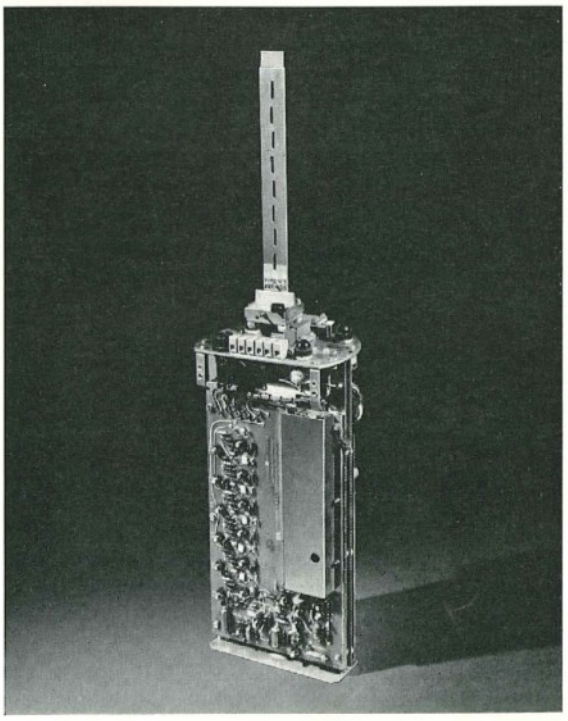
The block diagram (Fig. 2) shows the circuit arrangement. The canister houses two printed-circuit cards. One carries the receiver circuits with the code, inhibit and test pulse-generators. The code summation, modulator, frequency sweep, and power supply circuits are located on the other card. Provision is made for a third card for special circuits when required. The transmitter and strip-line microwave components are also housed in the canister; the aerial connection is on top.

Power Supply

Sea-Watch 300 will often be fitted to buoys having very restricted battery space, but the wide voltage tolerance and low power consumption often allow existing power sources to be used. Typical supply current consumption varies between 85mA at 8V supply and 40mA at 36V supply. Among many possible sources, a bank of eight Le Carbone Ltd, EMU1 air-depolarized primary cells gives one year's operation for a total weight of 55kg (120lb) and volume of less than 0·06m^3 (2ft^3). The power source is external to the racon and is not normally supplied, but a 4·5m (15ft) input cable is provided with a socket to mate with the waterproof input plug.

A built-in static inverter with single voltage setting handles the complete input voltage range and provides the necessary stabilized voltages for internal circuits. The inverter output is stabilized by pulse rate control, comparing the output with a zener voltage reference diode. Use of a stabilized inverter maintains high efficiency over wide input voltage and circuit-loading ranges. A fuse protects the battery in

Racon internal view



case of circuit failure. The circuits are also protected against accidental application of alternating voltage, over-voltage, or inverse polarity.

Transmitter

The microwave transmitter uses silicon semiconductors throughout. It is adapted from a design used in guided missiles to meet the most stringent Services environmental and shock conditions.

A collector-modulated transistor oscillator is arranged to produce maximum output power at the second harmonic near 1000MHz. The oscillator is followed by two varactor-diode tripler stages. Power at unwanted frequencies is suppressed by mode filters. A co-axial line connects the transmitter to the aerial circulator.

The oscillator is tuned by a varactor diode, whose capacitance is varied by the sweep voltage, which in slow sweep racons is derived from a sawtooth generator.

Receiver and Pulse Processors

A crystal-video receiver is used. A hot-carrier diode detector of high sensitivity and high burn-out resistance is soldered directly to the aerial circulator strip-line to eliminate contact problems. A crystal-protection diode, operative whether or not the racon is energized, is fitted. A receiver sensitivity of −66dBW would suffice. But tests show that a useful improvement of display quality is obtained from the further 6dB gain employed, there being a higher probability of responding to each radar transmitter pulse at extreme range.

At short range, racons can be triggered by side-lobe off-axis transmissions from the radar aerial, causing response to be displayed at false bearings. At ranges sufficiently short to cause spurious 'spoking' responses, Sea-Watch 300 is generally below the radar aerial beam and experience at sea confirms that little interference is caused. Where it is desirable to sacrifice some long-range performance to minimize close-range interference the racon receiver gain may be reduced. There are five stages of video amplification. The amplifier is followed by a trigger circuit.

Coding

On receipt of a signal, the trigger operates a chain of time delay monostables whose outputs are added to give a coded pulse group which actuates the transmitter. After each transmission another delay briefly inhibits the racon to prevent self-triggering from close-range echoes.

Up to four digits may be used in the code, covering the full morse alphabet. The length/spacing of each digit is variable. The overall duration of the code is a compromise, between the need for legibility at sites where the shipping generally uses long range display scales and the possibility of mis-reading should the code overlap the display circumference on a short range scale.

A length generally considered useful is 15 microseconds (2·3km, 1·25 nautical miles).

Servicing

It is often impracticable to effect repairs or adjustments on site. All components are clearly identified and are readily accessible when the core of the racon is on the workshop bench. The number of adjustable components has been minimized. Fault-tracing is aided by the use of the built-in test signal generator and by provision of monitoring sockets and a detailed servicing handbook. A simple portable Test Set is available.

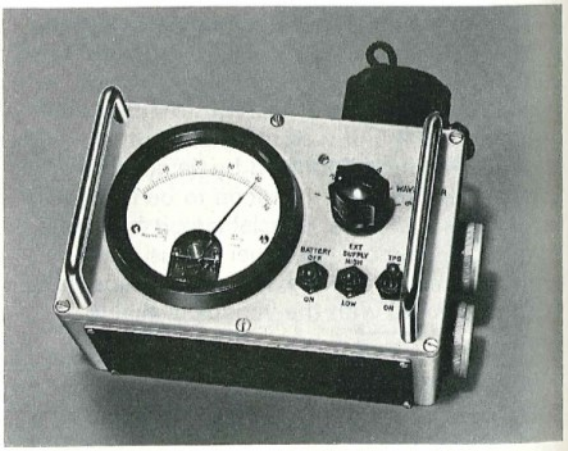
Test Set

This inexpensive and compact instrument facilitates checking the performance of Sea-Watch 300 racons on site or in the workshop. The set is robust and completely self-contained, permitting site use by semi-skilled personnel and is supplied complete with a sturdy carrying case, and instruction manual. Operation is rapid and straightforward using instructions printed on the body of the Test Set. Important parameters are displayed on a large and clearly scaled meter, which is fully sealed.

The Test Set is powered by mercury batteries of wide availability. Using the Test Set as a plug-in loading unit, the condition of storage batteries or other racon power sources may also be tested. The Test Set will temporarily power the racon should normal power be interrupted.

The racon transmitter frequency is measured using the Test Set with an optionally available wavemeter.

The Racon Test Set



Aerials

A wide range of aerials is available, permitting the correct choice to be made for individual users' requirements:

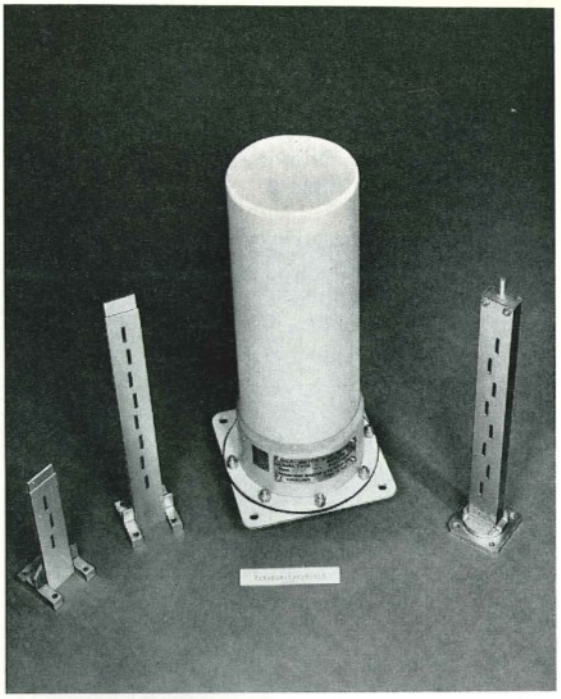
azimuth directivity (omnidirectional for floating and some fixed stations, directional for leading lines etc.)
elevation directivity (wider beamwidth needed for floating structures subject to roll)
gain (longest range demands high-gain directive aerials)
plane of polarization (horizontal for use with ships, vertical for certain harbour radars)
operating frequency (9300 to 9500MHz for ships)

The aerials currently available are listed in Table 1.

All aerials are static, with no moving parts and are of the common transmit-receive type. The aerial Types 2, 3, 5, 8, 9, and 10 fit the standard racon and can be housed within the standard radome. Aerial units on the lightweight racon are attached by a length of interconnecting waveguide. The lightweight radome shown in the photograph is capable of housing aerial Types 2, 3, 5, and 8. The aerial is connected to the receiver and transmitter by a strip-line circulator.

'Upstream–Downstream' aerials, Types 6 and 7, are for marking rivers and narrow channels with lightweight racons.

In situations where a particularly long range is desirable the Type 8 aerial should be used. It can be fitted to either the standard or lightweight versions.



Selection of aerials with lightweight radome

The standard aerials are horizontally polarized, in the form of a reduced height waveguide with broad-face slots giving omnidirectional azimuth radiation, and are based on a design by the British Admiralty Surface Weapons Establishment.

Table 1. Aerials for Sea-Watch 300 Racons (bold type shows standard aerials)

Aerial Type	Frequency (MHz)	Plane of Polarization	Azimuth Response	Elevation Response Between −3dB Points	Gain (dB)	Form of Construction	Notes
2	**9300–9500**	**H**	**360°, ±1dB**	**25°**	**5**	**Reduced height W/G 3 slots**	**Standard for floating sites**
3	9300–9500	H	360°, ±1dB	17°	7	Reduced height W/G 4 slots	Alternative for floating or fixed sites
4	9300–9500	H	360°, ±1dB	25°	5	Reduced height W/G 3 slots	Self-contained unit for Lightweight Racons
5	**9300–9500**	**H**	**360°, ±1dB**	**8·5°**	**10**	**Reduced height W/G 8 slots**	**Standard for fixed sites**
6	9300–9500	H	Two beams 45° wide between −3dB points, axes 180° apart	8·5°	16	8 slots	'Upstream-Downstream' Lightweight Racons
7	9300–9500	H	Two beams 22° wide between −3dB points, axes 180° apart	8·5°	19		'Upstream-Downstream' Lightweight Racons
8	9300–9500	H	Single beam 105° wide between −3dB points	8·5°	15	Full height W/G 8 slots	'Cardioid'
9	9000–9300	H	360°, ±1dB	25°	5	Reduced height W/G 3 slots	For Harbour Radars
10	9000–9300	V	360°, ±1dB	25°	5	Bi-conical horn	For Harbour Radars

H=Horizontally polarised. V=vertically polarised.

Special Purpose Racons

In addition to the alternative aerials listed in Table 1, a number of variant types of Sea-Watch 300 racons are available for special purposes, as already mentioned. Brief details of the various types are given in Table 2.

Considerable numbers of the recently developed Sea-Watch 300 lightweight series of racons have already been supplied. As will be seen from the illustration on page 10, the racon consists of a fully weatherproof aerial unit (see Table 1) connected by waveguide to a circuit unit. This arrangement permits great flexibility of installation and is of particular use on lightweight plastic buoys where the plane of the aerial can be mounted high enough to give good horizon range without excessive top weight. The circuits unit is fully sealed and is installed in a pocket in the buoy to protect it from the sea.

Lightweight racons are useful for temporary obstruction marking and whenever an equipment has to be deployed rapidly. They are also suitable for transponder service in ship-ship, ship-shore and airborne applications.

The circuits unit carries the standard Sea-Watch 300 circuit core on to which alternative sweeps and other facilities may be specified in the usual way.

Sea-Watch 300 flameproof racons use the same lightweight aerials which are intrinsically safe. The circuits unit is mounted in a substantial fully-sealed and flameproof aluminium case.

These features taken together with the versatile coder and power supply arrangements, standard to all types, serve to demonstrate why the range of Sea-Watch 300 racons is able to provide such a powerful solution to so many navigational problems.

Table 2 shows the main features of the Sea-Watch 300 X band range of racons. Numbers in the body of the Table refer to the key. The standard racon is Type 2, other types are available to special order. A production batch letter is added to the type number.

Selecting Your Type of Racon

Table 2, together with its 'key notes' will assist with the selection of the correct racon type for your navigational problem. Marconi Radar Systems Limited or their Agents will be pleased to advise and propose schemes for individual locations.

Table 2. Type numbers of Sea-Watch 300 Racons

Racon Type	**2**	3	4	5	6	8	9	9X	10
Case Style	**11**	11	12	11	11	11	12	12	11
Purpose	**21**	22	23	24	25	26	21	22	27
Transmitter Frequency	**31**	31	32	32	33	34	31	31	35
Gating Facility	**41**	42	41	42	41 or 42	41	41	42	41
Aerials	**51**	51	52	51	53	51	52	52	51
Power Supply	**61**	61	62	62	62	62	61	61	62
Test Set	**71**	72	71	72	71 or 72	71	71	72	71

Key to Table 2

Case Style
11 Standard Case.
12 Lightweight case for use with aerial unit Type 4, 6, or 7.

Purpose
21 General navigation aid.
22 General navigation aid with gating to prevent interference with radar fitted on same station.
23 Identification by a specific radar of racon-fitted target; e.g. light aircraft tracked by ground radar.
24 Special purpose.
25 Identification of racon-fitted buoys or work-boats by harbour radars.
26 General purpose obstruction marking; racon leading lines.
27 General navigation aid with updating each 12 seconds.

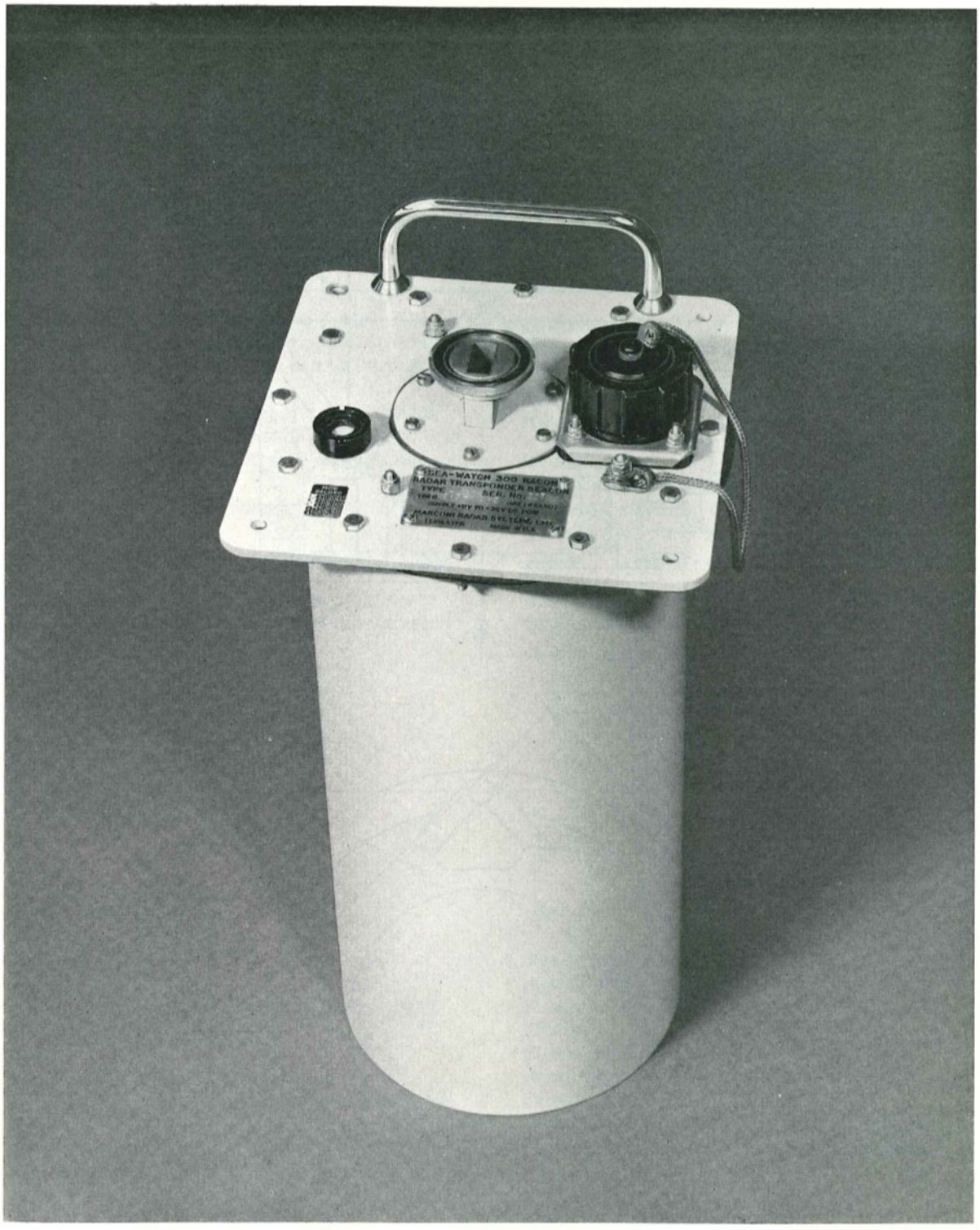
Transmitter
31 9300 to 9500MHz. Slow sweep (48, 73, 96, 120s) with fast flyback. Transmissions inhibited during flyback.
32 Any 50MHz band within the range 9300 to 9500MHz. Sweep rate 600Hz. Forward and return sweep times equal. Purpose of sweep is to remove errors in a nominally fixed-tuned system.
33 50MHz band centred on 9175MHz (or to order). Sweep rate 600Hz. For use with harbour radars.
34 Fast sweep 9300 to 9500MHz. Sweep rate 420KHz. Equal forward and return sweep times.
35 Step sweep 9300 to 9500MHz in 4 steps. Interpulse sweep rate 1·7 to 4MHz/second, stepping to next 50MHz band after each response.

Gating Facility
41 Not fitted.
42 Racon receiver is inhibited by transmitter pre-pulse of adjacent radar. Output available to blank racon transmission off radar screen.

Aerials
51 Can be supplied fitted with aerials Type 2, 3, 5, 8 and, by special arrangement, 9 and 10.
52 For use with external aerial unit Type 4, 6 or 7.
53 Supplied fitted with aerial Type 9 or 10.

Power Supply
61 8 to 36Vd.c. Current as specified for standard Type 2 racon.
62 8 to 36Vd.c. Current approx. 25% greater than Type 2 racon.

Test Set
71 Type 1 Test Set.
72 Type 2 Test Set (required when gating facility note 42 is fitted).



Sea-Watch 300 lightweight racon. The Aerial Unit is connected by standard size 16 (WR90/R100) waveguide of length up to at least 10m (33ft) to the flange seen protruding from the top panel

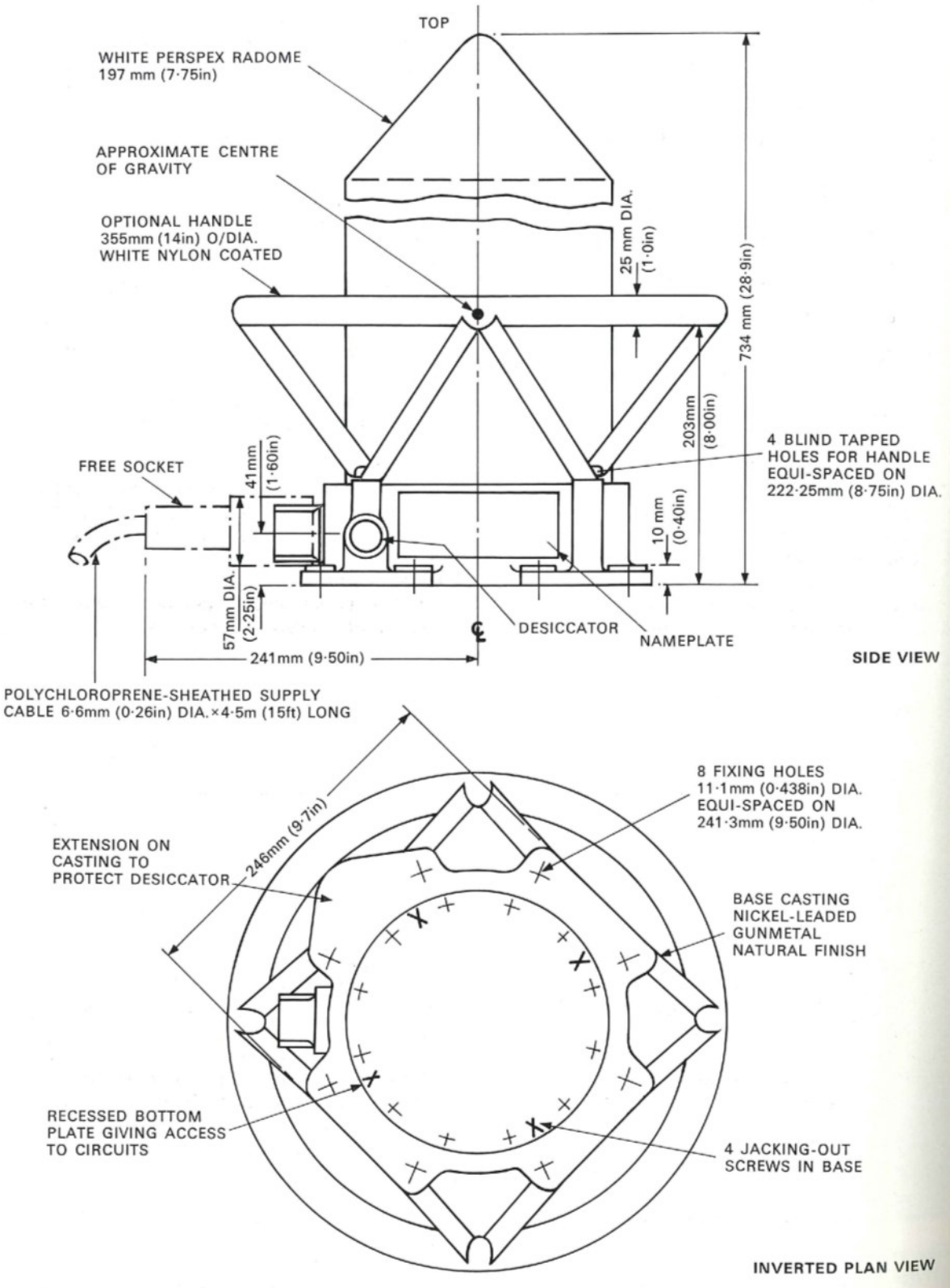


Fig. 3 Sea-Watch 300 Racon outline – standard case style

Data Summary

Type 2 Racon

Power requirements:
Supply: Within the range 8Vd.c. to 36Vd.c. (negative earth). Internal supply lines stabilized by efficient inverter.
Consumption:
420mW standby (750mW triggered) with 12Vd.c. supply.
750mW standby (1·5W triggered) with 36Vd.c. supply
Current: Not greater than 250mA peak.

Transmitter:
Type: All solid state X Band varactor-multiplier, unwanted harmonics suppressed by filters.
Frequency:
Normal range 9300 to 9500MHz.
Sweep time: 48, 72, 96 or 120s. Spurious transmissions suppressed during flyback.
Variants: Special editions are available (see Table 2) and frequency range can be restricted if required.
Pulse form: Coded groups of up to 4 pulses.
Pulse length: Individually adjustable from 1 to 45μs corresponding to 150 to 6750m (500ft to 3$\frac{3}{4}$mile).
Duty: Transmission inhibits racon for 200μs to prevent re-triggering.
Output pulse power: 300mW nominal, 120mW min. at band edges.
Range accuracy: Response delay less than 0·5μs corresponding to 75m (246ft).

Receiver:
Type: Untuned crystal video type with crystal protection.
Sensitivity: −72dBW (8×10^{-8}W) throughout operating range. Reducible in 3dB steps for short-range stations.
Video amplifier bandwidth: 0·5 to 10MHz (to −3dB points).
False transmission rate: Signal-to-noise ratio of 17dB restricts spurious transmission to less than 1 per second.

Aerial:
Full range available (see Table 1).

Dimensions:
For dimensions see Fig. 2.

Weight:
Racon: 16kg (35lb).
Racon with handle: 18·3kg (40lb).

Environment:
Rugged construction with sealed case; floats in water.
Temperature: −20 to +55°C (−4 to +131°F).
Relative humidity: No restriction.

Handbook:
All equipments are supplied complete with a detailed Installation and Servicing Manual, including full parts lists with alternatives.

Optional Extras:
Handrail, battery and battery box, spares kit and test set are available as required.

Test set

Type 1:
For standard Type 2 racons, also Types 4, 8, 9 and 10.
Type 2:
For Types 3, 5 and 9X racons.
Test sets for other racons can be made available.

Battery:
Type: Internal battery of 12 Mallory RM–3R primary cells.
Life: Service 30 hrs, storage 2 years.

Meter:
Sealed, multi-range scale of length 70 mm.

Readings:
Internal battery volts 0 to 20V.
Racon supply current 0 to 250mA (fused at 250mA).
Racon busbar voltage 0 to 10V.
Racon test detector output 0 to 100μA.
External wavemeter 0 to 100μA.
External power supply voltage (two ranges, 0 to 20V and 0 to 40V with loading resistors).

Switches:
Internal battery on–off.
Meter selector.
Racon internal test pulse generator.
External supply voltage selector.