SHORT NOTES

UNION RADIO MARK II IONOSONDES IN ANTARCTICA

By A. S. Rodger

During 1982 there will be celebrations to mark the centennial and fiftieth anniversaries of the First and Second International Polar Years (1882 and 1932) together with the silver jubilee of the International Geophysical Year, which began in 1957. 1982 will also be the last year in which Union Radio Mark II ionosondes will operate in Antarctica, after nearly 30 years continuously monitoring the ionosphere. This note briefly describes the long association of this equipment with Antarctica and its contribution to the advancement of our knowledge of the ionosphere.

The ionosphere is the region of the Earth's atmosphere between about 70 and 700 km above the surface, where the gases are partially ionized by solar radiation. Chemical and transport processes cause it to be subdivided into three levels, the *D*-region (70–90 km), the *E*-region (90–180 km) and the *F*-region (180–700 km). The ionosphere greatly affects the propagation of radio waves and at some frequencies (roughly between 0.3 and 30 MHz) it can act as a reflector, thus allowing communications over very large distances. It is this reflective property of the ionosphere that is used by all ionosondes and allows ground-based studies of this atmospheric region, well above the height that aeroplanes and balloons achieve, but below the altitude at which most satellites orbit. A pulsed radio wave of a known frequency is transmitted up to the ionosphere. The time delay before the reflected signal is received, at the same site, is measured and indicates the height of the echoing region above the observatory. By sweeping through a suitable range of frequencies, the ionosonde can give a vertical profile of the ionization up to the maximum, which occurs in the *F*-region, normally near a height of 350 km. Traditionally, the returned signals are displayed on a cathode-ray oscilloscope with calibrated height and frequency scales, then recorded photographically. The resulting picture is called an ionogram and a typical example, recorded by a Union Radio Mark II, is shown in Fig. 1.

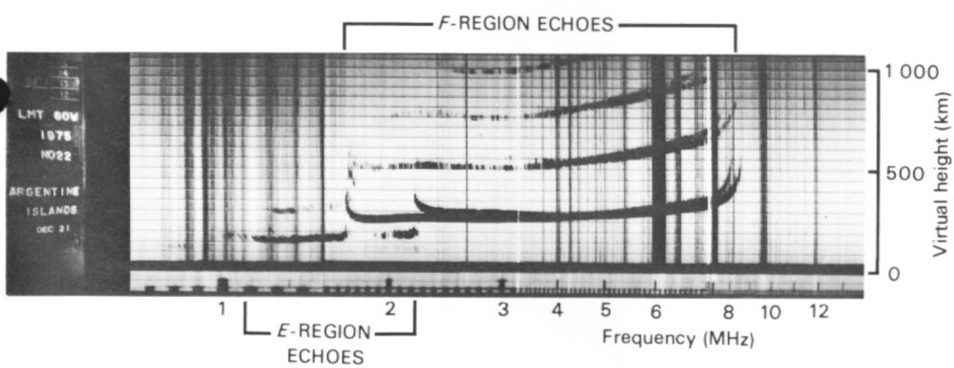

Fig. 1. Ionogram for 0213 Local Time on 21 December 1975, from Argentine Islands, showing echoes reflected from the *E*- and *F*-regions. The Earth's magnetic field causes the reflected signals to be separated into two components, the *o*- and *x*-modes. The conditions for reflection of the two modes are different, hence the two similar sets of echoes separated from each other by a frequency difference of about 0.6 MHz.

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Fig. 2. Union Radio Mark II ionosonde serial number 22 at Argentine Islands. The protective panels were originally battleship grey but have been decorated by successive generations of 'beastiemen'.

When the Union Radio Mark II ionosonde (Fig. 2) was designed and first built soon after the Second World War it incorporated what was then modern technology, such as one of the first solid state rectifiers. By today's standards the Union Radio Mark II might be considered an ungainly, slightly untidy collection of thousands of resistors, hundreds of capacitors, tens of thermionic valves, relays and switches and three bicycle chains, but, at the time of its inception, this ionosonde was a significant achievement in electro-mechanical engineering. This machine and its contemporaries were the first generation of ionosondes to allow automatic soundings of the ionosphere at frequent and regular intervals. An era of intense study of the ionosphere began, which still continues today. The ionosphere is used more extensively each year for long-distance communications, despite recent advances in satellite technology.

The association between Antarctica and the Union Radio ionosondes began early in 1953 when the third machine of this type to be built was off-loaded from the first RRS *John Biscoe* at Port Lockroy (64° 49′ S, 63° 30′ W). Even in this earliest Antarctic encounter, the ionosonde illustrated its suitability for the rugged environment. Despite some units being soaked in transportation and rough handling over many sharp rocks during unpacking, a routine programme of hourly observations soon began, which was to continue at this and three other sites in Antarctica over the next 30 years.

As part of the UK contribution to the International Geophysical Year (1957–58), a further Union Radio ionosonde was sent to the new base then being established at Halley Bay (75° 31′ S, 26° 37′ W) under the auspices of the Royal Society, London. This base was built upon an ice shelf 170 m thick, which is continually, if slowly, moving. The deployment of this ionosonde uncovered several problems not encountered at ionospheric observatories in more temperate latitudes. For example, there were difficulties with the erection and maintenance of the masts used to support the large aerial arrays required by the ionosonde. Differential movements of the base of the mast and its guying points, together with the steady accumulation of snow at about 1 m per year, caused severe stress upon the mast. In addition, frost damaged the welded seams of the cigar-shaped mast sections. It is not surprising that the mast was severely buckled less than 18 months after its erection. However, an understanding of the causes of these difficulties soon led to solutions being found.

Careful study of the early ionograms from Halley Bay shows one very interesting non-ionospheric feature. Consistent gaps in the ionospheric traces were regularly observed. These were interpreted as interference effects between radio waves which had travelled directly to (or from) the ionosonde antennae and those travelling through the 170-m-thick ice shelf and being reflected at the sea surface. These observations and subsequent interpretation greatly contributed to the development of a new method for investigating ice sheets. The technique has been termed ice-depth radio echo sounding and has since been widely used by the glaciologists of the British Antarctic Survey and by a number of other groups.

In 1960 the ionosonde programme re-opened at Halley Bay after a break of 1 year. It was also about this time that the Union Radio Mark II ionosonde became widely and affectionately known as ‘the Beastie’. It has been suggested that ‘Beastie’ is the acronym for Beamed Elecronic Automatic Sounding The Ionosphere Equipment, but its name is more likely to have arisen because the ionosonde causes severe interference to record players and radio reception at the base. Since the ionosonde records every 15 minutes and each ionogram takes over 4 minutes to complete, there was little chance of base members being able to follow a play or hear the football results broadcast by the BBC World Service. The ionospheric technicians became known as ‘beastiemen’, a name that has perpetuated to the present day.

Ionospheric sounding at Port Lockroy ceased when the base closed early in 1962, but a new programme was established, some 48 km to the south, at Argentine Islands (65° 15′ S, 64° 16′ W), in the same austral summer, using Union Radio ionosonde serial number 22 built in 1956 (Fig. 2).

The success of the International Geophysical Years – a period when the sun was very active – stimulated further international programmes to be operated at sunspot minimum (International Quiet Sun Year, 1964–65). The Port Lockroy ionosonde, which had been returned to the UK for refurbishing, was sent back into Antarctic service at Halley Bay for this important study period. Until this time, the ionograms had been recorded on 70-mm paper, with each record being about 30 cm long. The camera of the old Port Lockroy machine had been replaced to allow recording to be made on 35-mm film, each record measuring about 7 cm. This modification greatly increased the reliability of the ionosondes as the photographic paper was prone to jamming in the motorized camera.

The hut in which the ionosonde was installed at Halley Bay was buried to a depth of about 15 m and had become badly distorted and crushed by the pressure of the accumulated snow and ice. The programme was, therefore, transferred in 1967 to a new site, closer to the living quarters, which had been replaced two years earlier. Again, a refurbished ionosonde was sent from the UK to replace Union Radio number 3, which had now completed a total of 12 years' operation in Antarctica at two locations. The new ionosonde was serial number 18, which had previously been operating in the Shetland Islands, Scotland.

Over the next ten years, 'beastiemen' continually strove to improve the reliability of their machines and the quality of their data. Evidence of their success was provided at Argentine Islands from 1973 to 1975 when over 105 000 ionograms were made, with a reliability of better than 99.5%. During the 1960s and 1970s, beastiemen had designed and installed minor modifications to the Union Radio. Most of these were intended to improve the monitoring of the performance of the equipment, to provide warning of imminent failure and to indicate mistakes of the operators by checking that all switches and dials were in the correct positions.

The maximum number of Union Radio ionosondes operating simultaneously in Antarctica was three, between 1970 and 1978. The third station was at South Georgia (54° S, 27° W). Union Radio serial number 10, built in 1950, was installed and began routine 15-minute soundings in July 1970. The station was established to investigate whether there are any unusual ionospheric effects associated with the South Atlantic Geomagnetic Anomaly, a region where the Earth's magnetic field is particularly weak.

The second ionospheric observatory at Halley Bay had become severely distorted due to ice pressure and was again some 15 m below the surface. In 1979, it was decided to replace this with a surface observatory, a large red container on jackable legs to reduce the effects of snow accumulation near the hut. This hut was sent as a complete ionospheric observatory on RRS *Bransfield*, with a refurbished Union Radio Mark II (serial number 16) already installed.

The ionograms recorded in the Antarctic are interpreted and reduced to a numerical form by the beastiemen on base. Monthly summaries sent back to the UK over a radio link are circulated widely throughout the world where they are used for the prediction of high frequency radio propagation conditions. The analysed data are returned annually by the British Antarctic Survey's ship RRS *Bransfield*. Further processing is carried out in cooperation with the Science and Engineering Research Council's Rutherford and Appleton Laboratories, near Oxford. Monthly bulletins of ionospheric data are produced for each station and circulated to over 70 research institutes throughout the world, to groups interested in radio wave propagation studies and to the World Data Centres for the ionosphere in the USA, USSR, Japan and the UK.

The four stations at which Union Radio ionosondes have operated all lie in the Peninsula–Weddell Sea sector of Antarctica. In this region, the dip angle of the Earth's magnetic field, which has a very great influence on the movements of the ionosphere, is remarkably low for a given latitude, a result of the magnetic dip pole being displaced from the south geographic pole by about 23° towards Australia. The unusual configuration of the magnetic field, together with the good quality data, have meant that the ionograms produced by these British-made ionosondes have been, and continue to be, very extensively used by scientists at home and abroad to investigate the ionosphere and its complex processes.

In 1981, the era of the microchip finally started to catch up with the ageing Union Radio ionosonde. The technology of ionospheric sounding in Antarctica leapt from the valves and bicycle chains of the 1940s to the sophisticated computer-controlled equipment the 1980s, with the deployment of an Advanced Ionospheric Sounder (AIS) at Halley Bay. The final episode in this story of the Union Radio ionosonde will occur during the summer season of 1982–3 when Union Radio number 22 at Argentine Islands will be replaced after 21 years of invaluable service by modern Australian equipment. The new machine, which will fulfil the same monitoring and research roles, weighs a meagre 40 kg compared with over 500 kg of the Union Radio.

The era of the Union Radio ionosonde in Antarctica may be coming to an end, but these machines will not be forgotten; a Union Radio that operated at Halley Bay has been accepted by the British Science Museum and will be displayed as a representative of the generation of excellent ionosondes that has given unparalleled service with great reliability in Antarctica over the last 30 years.

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NECK COLLARS ON FUR SEALS, *Arctocephalus gazella*, AT SOUTH GEORGIA

By W. N. BONNER *and* T. S. MCCANN

Reports of otariid seals being found in the wild with ligatures round their necks have been increasing in recent years. Mostly, these have referred to Northern fur seals, *Callorhinus ursinus*, and Steller's sea lions, *Eumetopias jubatus*, in the Bering Sea and on adjacent coasts (Sanger, 1974; Engel and others, 1980), but examples have also been reported of collars on Cape fur seals, *Arctocephalus pusillus*, from southern Africa (Shaughnessy, 1980) and Antarctic fur seals, *Arctocephalus gazella*, from South Georgia (Payne, 1979; Bonner, 1982).

Most reports refer to rope circles, fastened with knots, often the knot known as a fisherman's bend (two half-hitches each made round the standing part of the opposite piece of rope). Characteristically, the rope is made of synthetic fibre and is buoyant. It has been suggested (Payne, 1979) that these rope rings are discards from fishing boats and that a seal finding one floating on the surface of the water plays with it and pushes its head through the ring so that it settles round its neck. Probably, the collar is usually loose enough for the seal to shake it off. Similar behaviour has been described for monk seals *Monachus schauinslandi*, entangled in fishing nets (Kenyon, 1980). If the collar fails to become dislodged, as the seal grows the ligature cuts into the tissues of the neck.

The early records of collars found on fur seals at Bird Island, South Georgia, all referred to nylon rope collars, but in recent years a variety of items have been recovered. These include nylon fishing net, nylon string, polythene bag, a rubber 'O'-ring of the type used for making water-tight joints and, most commonly, plastic packaging tape. This note refers to four specific examples of collars found on fur seals

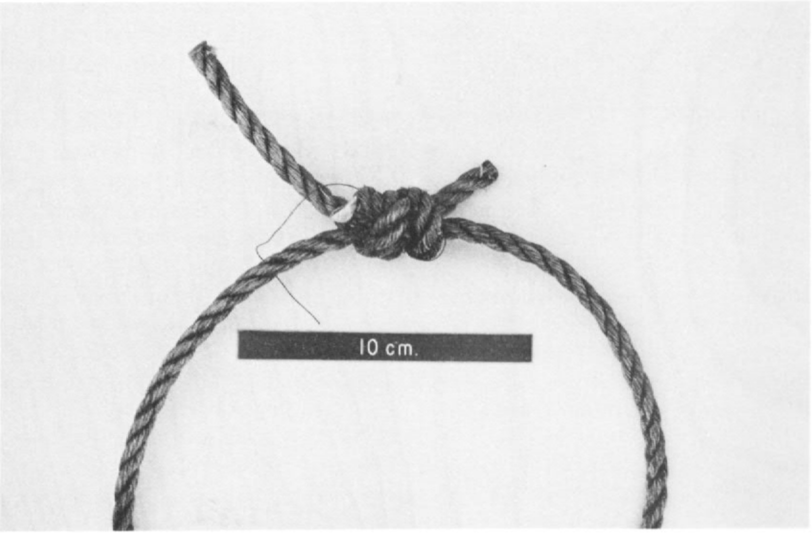

Fig. 1. A polypropylene rope collar dislodged by a female fur seal on a breeding beach. Note the fisherman's bend knot. The scale bar is 10 cm long.

at Bird Island and Elsehul, South Georgia, which are of anecdotal interest and are representative of the 40 or so ligatures that field-workers have removed from fur seals at these locations.

1. *A rope collar*. An adult cow fur seal was seen to arrive on a breeding beach with a rope collar around her neck. Four days later the collar was found lying on the beach. The seal showed no sign of injury around the neck. The collar (Fig. 1) was formed of a loop of buoyant polypropylene rope, 8 mm in diameter, the ends cut and

Fig. 2. A mature male fur seal collared by a plastic strap. The skin of the animal's neck was cut through for about three-quarters of its circumference.

heat-sealed and knotted together with a fisherman's bend. The collar had an internal diameter of 175 mm. This collar is interesting because it demonstrates a seal's ability on occasion to remove a collar, though in this case the removal may have been facilitated by the seal being on land. A few small (1–4 mm capitulum length) dead barnacles, *Lepas australis*, were attached around the knot. Small barnacles of this species are occasionally seen attached to female fur seals at South Georgia, but have not been found on bulls, nor do they occur on moored floating objects around South Georgia. It is probable that the range of this barnacle is to the north of South Georgia, and that the cows visit this area but the adult bulls do not.

2. *A plastic strap collar*. A mature (but not breeding) bull fur seal newly emerged from the sea was seen with a band of hard black plastic tape around its neck (Fig. 2). The band was 6 mm wide by 0.4 mm thick and had a circumference of 1213 mm. Its ends were fastened by a mechanical crimp. The sharp edges of the band had cut through the thick skin of the bull's neck for about three-quarters of its circumference, though otherwise the animal appeared to be in good condition. The plastic of which the band was made was buoyant. The band was of a type used for strapping packages and probably had been used for this purpose.

3. *A plastic strap collar*. A female was seen to have a collar deeply embedded into the flesh of the neck which was raw and suppurating and swollen (Fig. 4). The band was light blue in colour, 7.5 mm wide and 445 mm in circumference. The joint of the band had been made by heat sealing. The animal, although appearing to be well-fed, had difficulty moving on land. Male fur seals develop a large, muscular neck as a secondary sexual characteristic (Fig. 2). Any of the collars removed from immature male fur seals could have been potentially lethal to their bearers as their necks continued to grow. Females, lacking such neck development, are at less risk from collars.

4. *A rubber 'O'-ring collar*. An adult cow was seen on the beach with a band deeply embedded in the skin (Fig. 5). The skin surface was unbroken except for a

Fig. 3. Detail of part of the lesion shown in Fig. 2.

Fig. 4. A mature female fur seal with a plastic strap collar deeply embedded in the neck. Note the swollen tissues round the collar.

10-mm-long area on the right side of the throat. On the dorsal surface the guard hairs in the region of the band were absent, exposing the underfur. On removal, the band was found to be a soft rubber 'O'-ring of the kind used for making water-tight joints. It was 5 mm in cross-sectional diameter with an internal diameter of 105 mm. Like the other collars recorded here, the 'O'-ring was buoyant.

The examples described above, and observations by one of us (T.S.McC.) of fur seals with collars formed from the skin of penguins killed by leopard seals, *Hydrurga leptonyx* (Fig. 6), all support the hypothesis that seals collar themselves by swimming

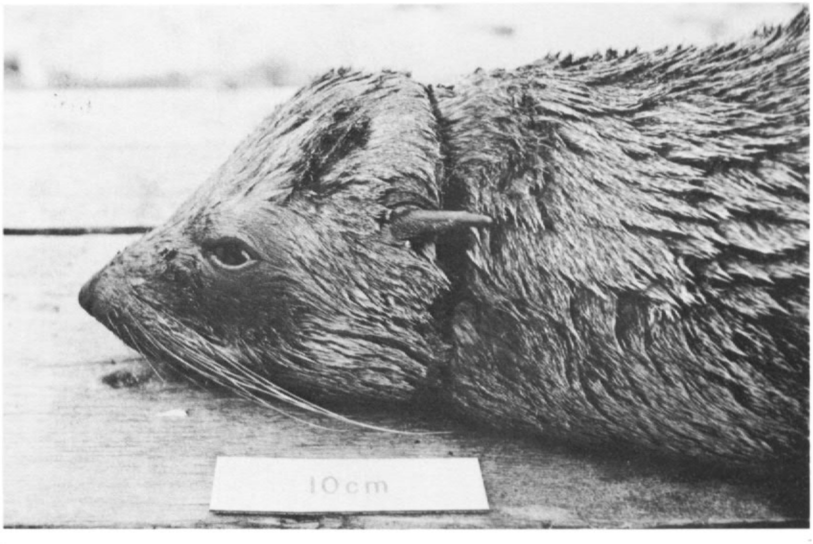

Fig. 5. A mature female fur seal collared by a rubber 'O'-ring. The scale bar is 10 cm long.

Fig. 6. A moulted pup fur seal collared by the skin of a penguin killed by a leopard seal.

into loops of floating debris at sea. Also, collars of the type described in 3 above have been found washed up on the shore at Elsehul. The rope collar, fastened with a fisherman's bend, was obviously not tightly tied round the animal's neck, as might be expected if the collaring were the deliberate work of man. Also, a fisherman's bend is not a knot that is easy to tie so as to maintain tension; it is a knot used for joining two free ends of rope together. The natural knot to use for a collar would be a reef knot.

It may be expected that with the increasing use of virtually non-perishable products such as synthetic ropes and plastic strapping, etc., collared seals will be seen even more frequently.

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