AR-004-852

DEPARTMENT OF DEFENCE

DEFENCE SCIENCE AND TECHNOLOGY ORGANISATION

ELECTRONICS RESEARCH LABORATORY

MANUAL

ERL-0383-MA

THE INSTALLATION REQUIREMENTS AND PROCEDURES FOR THE OMNIDIRECTIONAL GROUND PLANE CORNER REFLECTOR

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S U M M A R Y

A new type of radar enhancement device, the Ground Plane Corner Reflector (GPCR), has been developed and patented by the Electronics Research Laboratory (ERL) at the Defence Research Centre Salisbury (DRCS), South Australia. This manual describes the requirements and procedures recommended for installing a GPCR system on an airfield.

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1. INTRODUCTION

The Ground Plane Corner Reflector (GPCR) is a novel type of radar reflector developed for the RAAF in the 1970s by the Electronics Research Laboratory (ERL) Salisbury. It was designed specifically for use as an airfield location beacon and approach aid(ref.1). A number of GPCR systems have been manufactured and installed on various RAAF airfields with the assistance of ERL personnel. The purpose of this document is to establish criteria for the selection of suitable sites for these reflectors, and procedures to be followed when carrying out future installations.

2. THE DESIGN OF THE GPCR

The GPCR is a trihedral radar reflector, differing in design to standard reflectors in that it uses the ground as one of the three reflecting surfaces, the other two being formed by the reflector panels themselves (figure 1). With a reflector of this size, it is extremely important to ensure that the line of reflector panels is precisely straight, the angle between the reflector panels is as close to 90° as possible, and the panels are vertical to the ground. The method by which these requirements are met is detailed in Section 4 below.

A GPCR cross consists of three basic parts (figure 2).

(1) The ground frame

(2) The panel support frames

(3) The reflecting panels

However, each omnidirectional reflector consists of two crosses. The reason for this is that one cross has four major reflection lobes with deep nulls between. A second cross oriented at 45° with respect to the first one fills in the nulls (see figure 3). The separation distance depends on a number of factors - the range at which observations are to take place, the pulse width of the radar, and the positional accuracy requirements of the return. Normally the two halves are spaced about 50 m apart so that they lie in the same radar footprint, but for use at very long range this could be increased considerably. The two halves are not likely to be seen as separate returns, and the chance of mutual obscuration will be reduced. In this context the orientation of the two halves is important. Consider their positions in figure 4(a). The legs of the two halves are at the required 45° relative to one another, but when viewed from the approach direction at low elevation angles Cross A is obscured by Cross B, and Cross B presents a null to the direction of observation. However, if the crosses are positioned as in figure 4(b), they still have a relative orientation of 45°, but neither presents a null to the direction of the arrow.

A pattern of three approximately equispaced omnidirectional reflectors in a straight line has been found to constitute an easily recognisable and unambiguous pattern which can be used as a location beacon. Resolution by the radar of the three reflectors depends basically on the pulse width and beamwidth of the radar, and the direction relative to the line of reflectors from which the system is viewed. Spacings of 1000 to 2000 m have been used in Australia, however at very long range the discrimination of the radar crt will govern the spacing, and possibly even greater separation would be required if resolution is needed.

A GPCR system also includes four smaller, unidirectional, touch-down reflectors. These are normally installed one on each side of the runway, abeam the touch-down points, with one pair at each end of the runway.

3. SITE SELECTION

Because the GPCR uses the ground as one of its reflection surfaces, it is important to choose an installation site as flat and level as possible. It is difficult to specify a maximum slope or maximum roughness that can be tolerated, as this depends amongst other things on the radar frequency, the elevation angle from which observations are being made, and the reflectivity required. However it is known from experience that excellent results have been achieved with installations on airfields without recourse to grading or filling. Sites chosen would generally have slopes of less than 0.5° and would be flat to within approximately ±10 mm, with the grass or vegetation cut as short as possible. It is also important to avoid installation in hollows wherever possible, as water lying in such areas can make grass cutting difficult.

It should be remembered that the reflector is designed for use at low elevation angles. As the elevation angle increases, the reflectivity decreases and ground clutter increases, and 10° has been found to be the maximum practical elevation angle for RAAF airborne radars. Ideally, to extend the usefulness of the reflectors to maximum range, flat ground extending up to 140 m from their centres is required.

If the system is to be used to indicate the position and alignment of a runway, the reflectors should be as close to that runway as possible. However, current RAAF regulations define a flight strip, inside which no buildings or structures are allowed to intrude. This flight strip extends to 115 m each side of the runway centreline, at ground level, and then rises along a 1 in 7 slope. The top of the GPCR panels are approximately 1.6 m above the ground, so the closest that any part of a GPCR reflector can be to a runway centreline is 115 m plus approximately 12 m (127 m). It is suggested that these figures be checked with the Senior Air Traffic Control Officer before any installation work is carried out.

The next consideration is exactly where to install the omnidirectional GPCR pairs. As mentioned in Section 2 above, a pattern of three approximately equispaced omnidirectional reflectors in a straight line is considered ideal. The obvious layout therefore is one pair near the centre of the runway, and the other two at each end, far enough from the touch-down markers to avoid confusion on radar (400 m will suffice). Should the ground prove to be insufficiently flat beyond the runway thresholds, and levelling be out of the question, consideration may have to be given to installing the omnidirectional GPCRs near to the touch-down points and eliminating the touch-down reflectors.

The GPCR cross which gives reflection maxima in line with the runway, where possible, should be positioned closest to the runway in each case. This gives four possible positions for the second cross of each pair (figure 5) and each position is equally acceptable. The layout of the GPCR system at RAAF Williamtown, installed in June 1985, is shown in figure 6 as an example of a complete system.

4. INSTALLATION

Once a smooth level site has been selected, the reflectors have to be erected such that the panels of each arm are, within the limitations of the methods used, as close as possible to being in a perfectly straight line, exactly vertical and hence at 90° to the ground, and at exactly 90° to the adjacent lines of panels.

The installation procedure for the GPCR system can be divided into four distinct phases.

(1) The positioning and levelling of the ground frames

(2) The attachment of the panel support frames

(3) The attachment and alignment of the panels

(4) The positioning of the touch-down markers.

4.1 The positioning and levelling of the ground frames

The ground frame for each cross consists of a central yoke and four legs (figure 7). The correct orientation of the framework relative to the runway, and the other cross in each pair, can be achieved satisfactorily using a compass. The yoke has four adjustable supporting bolts with footpads and the legs four more each (figure 8) such that by careful adjustment the whole framework can be levelled. Experience has shown that this is best done using a theodolite, the levels at six points on each leg and four points on each yoke being read off from a surveyors staff (figure 9). With care it is possible to adjust the 28 points to be level to ±0.01 ft (±3 mm).

4.2 The attachment of the panel support frames

There are twenty panel support frames for each cross, each of which being attached to the ground frames with two bolts (figure 10). Each panel support frame has six bolts for attaching the reflector panels, three for each adjacent panel, with the exception of the outer frame on each leg which has only three. The orientation of the support frames doesn't matter, as long as they are the same from one end of a leg through to the other end of the opposite leg. It will be noticed that the holes in the base of each panel support frame are larger than the normal clearance size for the bolts used. This allows for some adjustment, if required, at a later stage of the installation, and it is suggested that one begins with the bolts central in the holes.

4.3 The attachment and alignment of the panels

This is the most important, and the most difficult part of the operation. As discussed earlier, it is of the utmost importance to ensure that the panels are in a straight line, at 90° to those of the adjacent legs, and vertical. The method of achieving this is as follows. A theodolite is placed over the exact centre of the groundframe yoke (figure 11). A large washer is attached to the top panel mounting bolt on one of the outer panel support frames and the theodolite focussed onto the washer with the vertical cross hair on either the inner or outer edge. Washers are then fitted to each of the top panel mounting bolts in turn, and aligned using the theodolite (figure 12). Once one leg is complete, the theodolite is rotated through exactly 90°, the procedure repeated for the next leg and so on until all four legs have been done. When the washers are placed on the bolts, two nuts should also be placed on the inner side of the washer. Once the correct position of the washer has been achieved, these nuts are locked together. It will be found that the four innermost panel support frames are too close to the theodolite for the telescope to be focussed on the washers. On a calm day this can be overcome by stretching a fine cord along the faces of the washers already positioned and using this line to adjust the inner washers. However, on a windy day the alignment is best done by moving the theodolite to the outer end of the legs.

Manufacturing tolerances on the groundframe will usually add to the difficulty of this procedure. Often the adjustments at the base of the panel support frames, mentioned in Section 4.2, have to be used, and in extreme cases shims may have to be inserted between the yoke and one or more of the legs in order to achieve alignment. It is recommended that one starts by positioning a single washer to the outer end of each leg, checking that these can be adjusted to give a 90° angle between them, before attempting to position the remainder.

Once all the upper washers have been set in their correct positions and the rear nuts locked together, the washers can be removed and the reflector panels attached (figure 13). These are made vertical by adjusting the position of the nuts on the lower bolts, verticality being checked by means of a spirit level (figure 14). It will be noticed that there is a front and back to each panel, the front being smooth and the rear having strengthening ribs. As the front has a slightly higher reflectivity than the back, they should be fitted such that each reflector segment has one leg with all "fronts" and one leg with all "backs". In this way the radar return maxima will be the same for all four segments on each cross. In order to conform with current RAAF practise, the two most recently constructed GPCR systems have panels painted red or white, which should be installed alternately.

A completed pair of GPCR crosses, installed at RAAF Edinbrugh in 1978, is shown in figure 15. It should be emphasised that for maximum reflectivity the grass around the reflectors, especially between the legs, should be kept short. The weight of the GPCR crosses is considerable. However, strong winds could conceivably move one or more of the legs slightly, thus changing the 90° between them. It is therefore advisable to hold the end of each leg in place with metal pegs.

4.4 The positioning of the touch-down markers

The smaller uni-directional touch-down markers were designed to provide an indication of the touch-down point on a runway for aircraft with high performance radars. They are, in essence, small GPCRs, so the same requirements for alignment apply. However, because of their size it is more practical to use a large specially made square to adjust the 90° between the legs. Figure 16 shows the panels being fitted to the framework on a touch-down marker, and a completed reflector is illustrated in figure 17.

5. CONCLUSIONS

The siting requirements and procedures recommended for installing GPCR systems on airfields have been discussed in detail. By following these procedures it should be possible for inexperienced personnel to successfully install reflectors on suitable sites.

REFERENCES

No.	Author	Title
1	Triggs, R.	"The development and application of the Ground Plane Corner Reflector System for RAAF use as a Navigation and Approach Aid". ERL-0203-RE, April 1981

A, B and C are reflection points

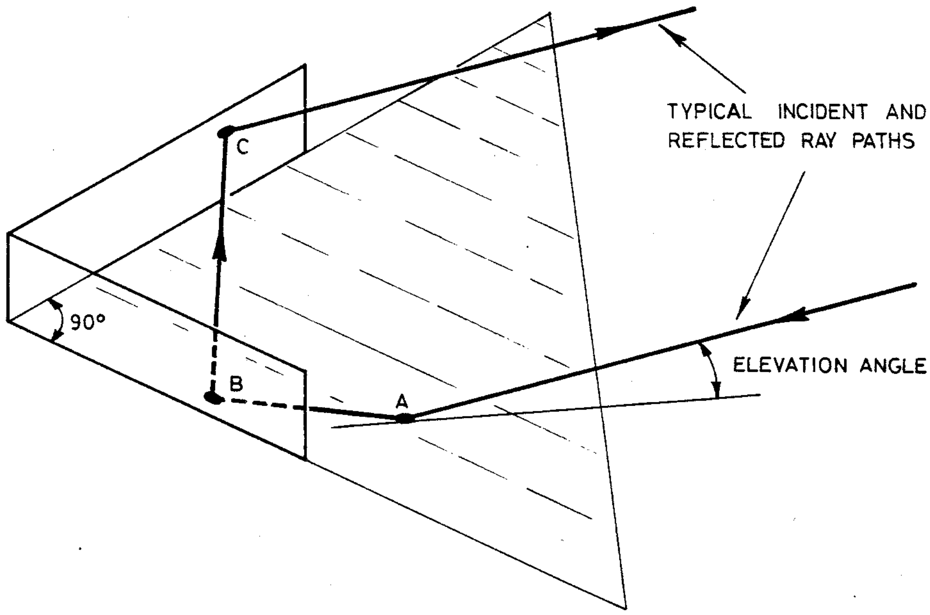


Figure 1. The Ground Plane Corner Reflector general arrangement

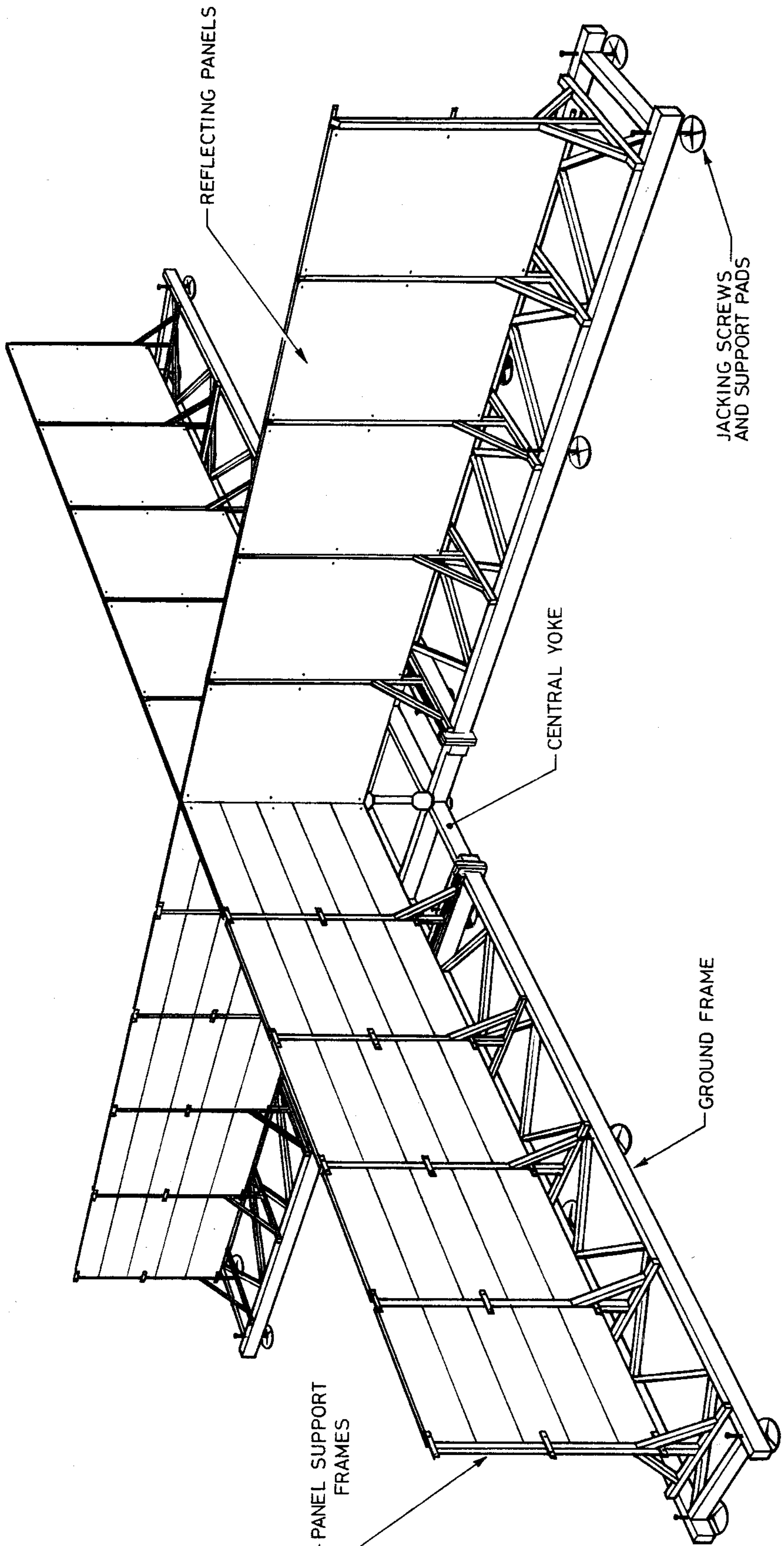
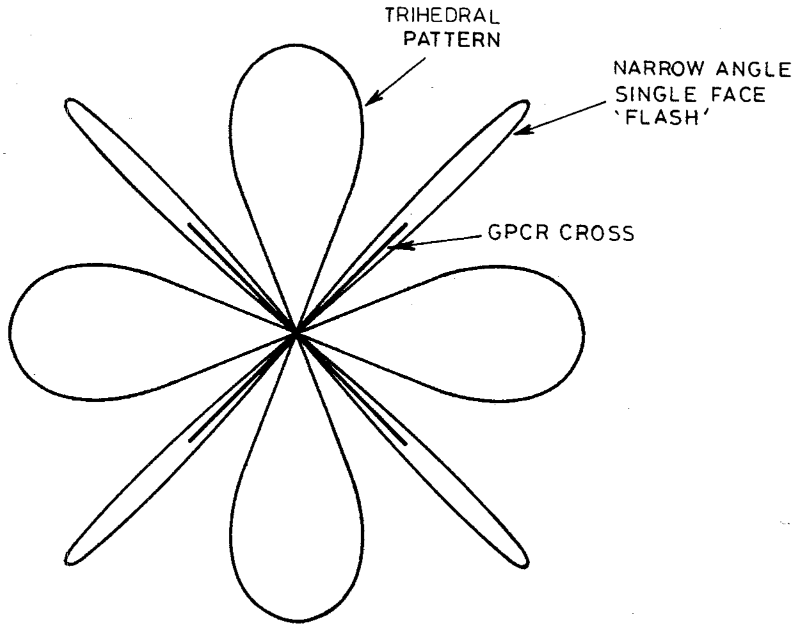
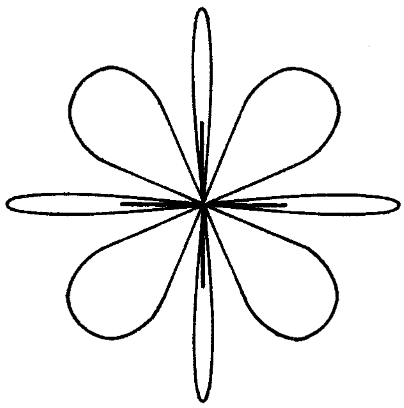


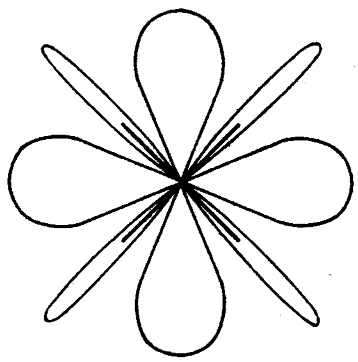
Figure 2. Component parts of the GPCR cross



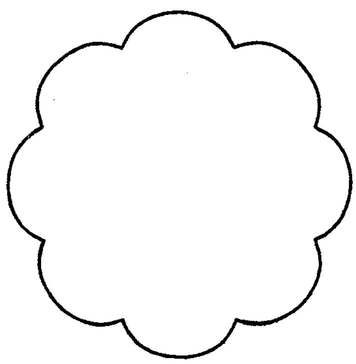
Reflectivity pattern of single GPCR cross



cross 1 pattern



cross 2 pattern



combined pattern

Figure 3. Reflectivity pattern of the omnidirectional GPCR

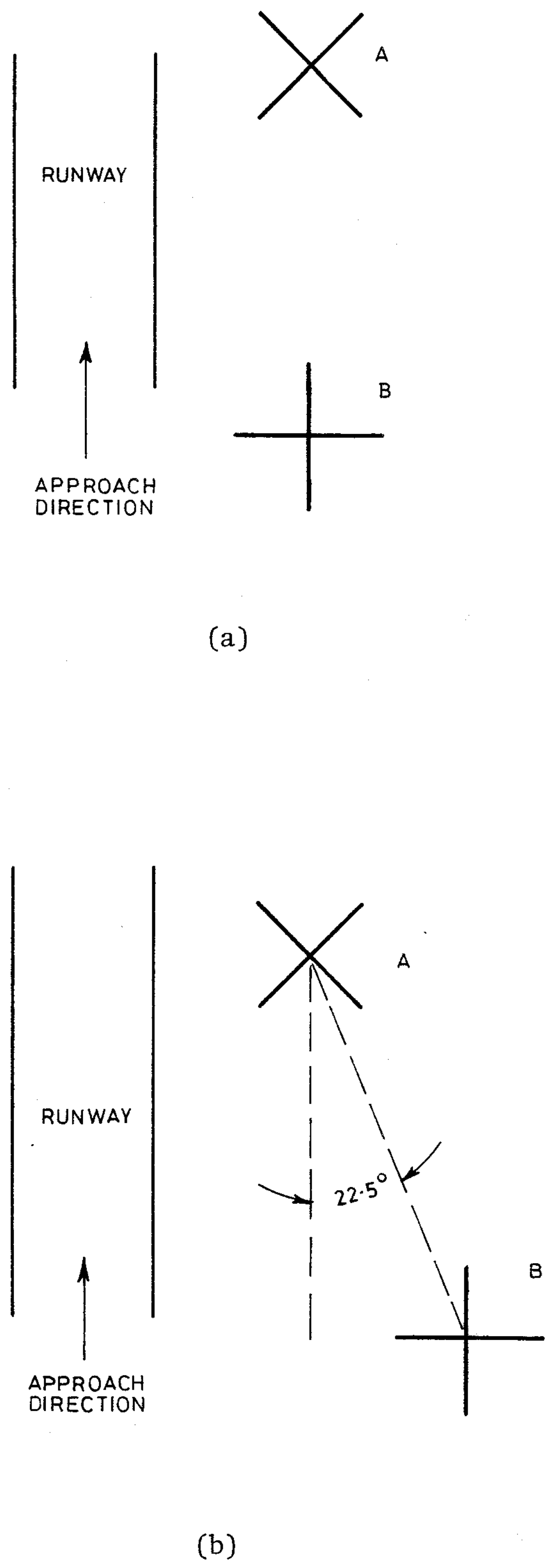


Figure 4. Explanation of the importance of relative positions of GPCR crosses

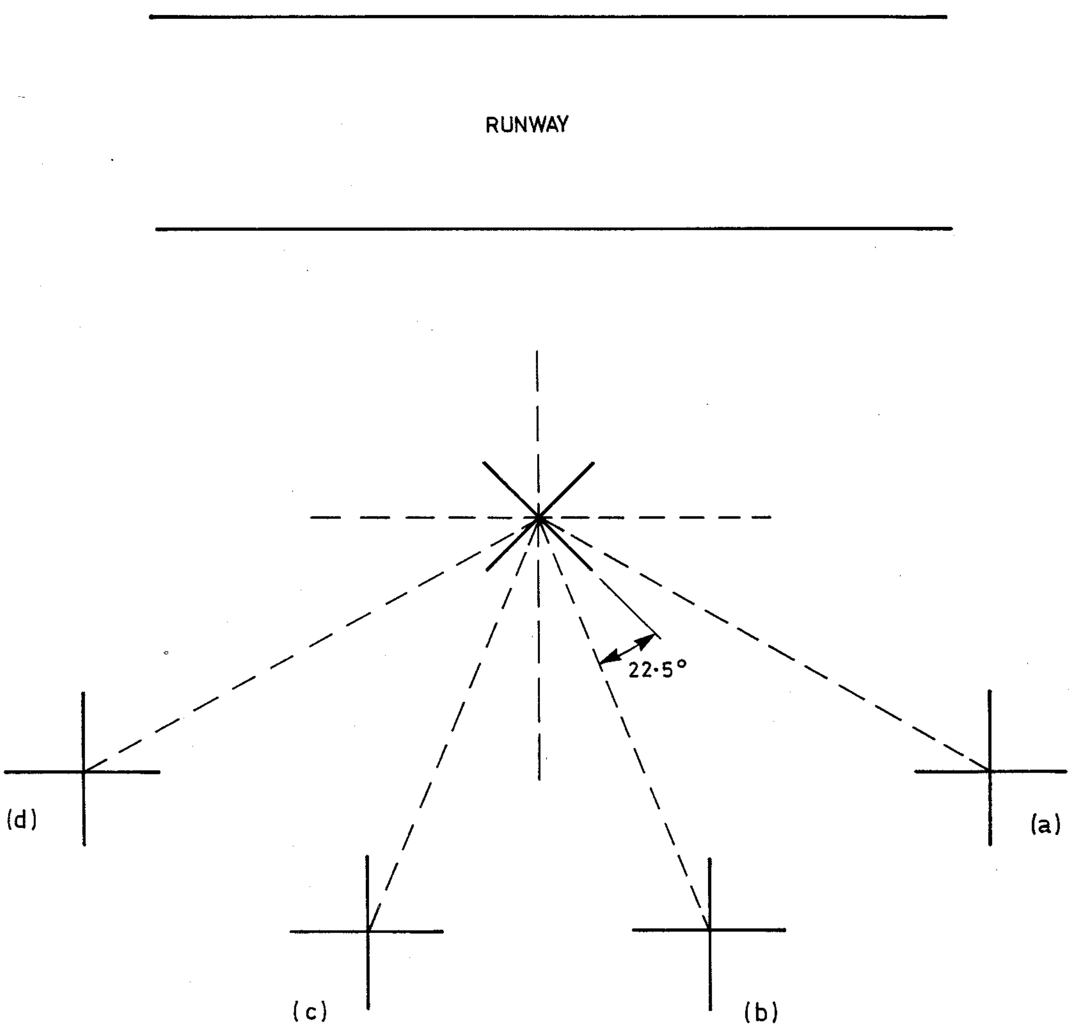


Figure 5. Relative positioning of the two halves of the omnidirectional GPCR

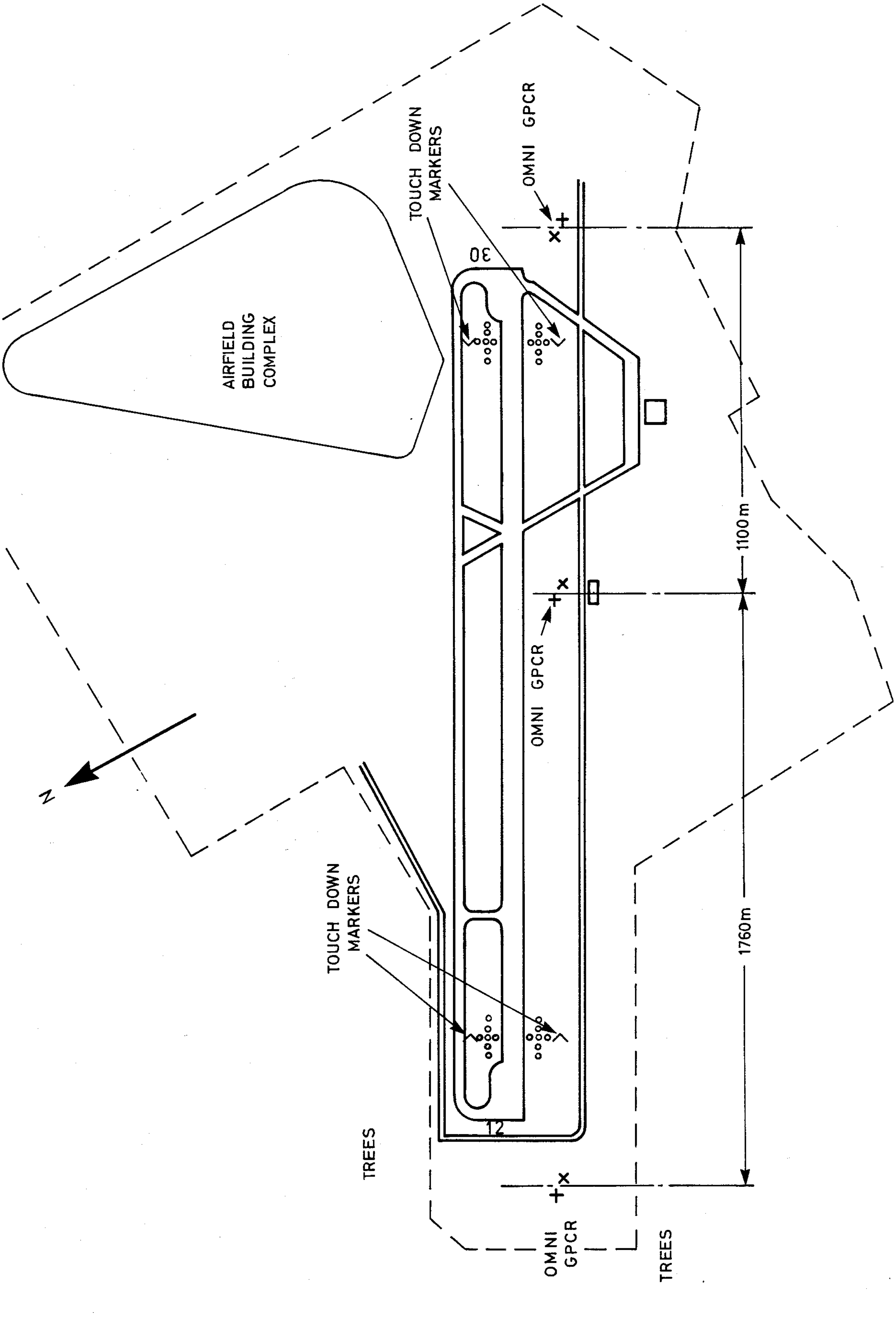


Figure 6. Omnidirectional GPCR system layout at RAAF Williamstown

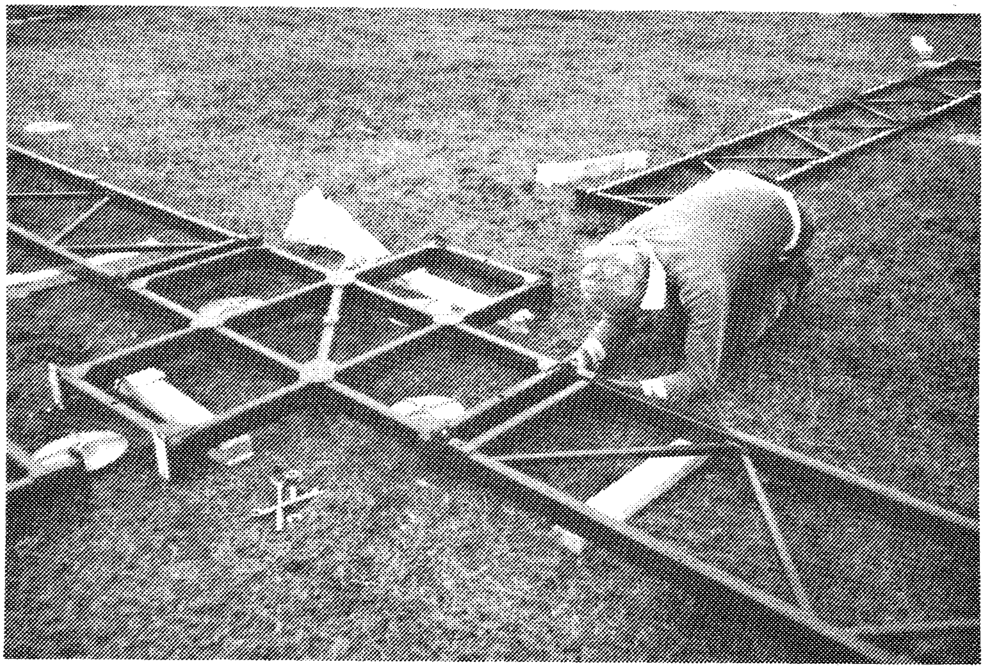


Figure 7. The attachment of the ground frame legs to the yoke

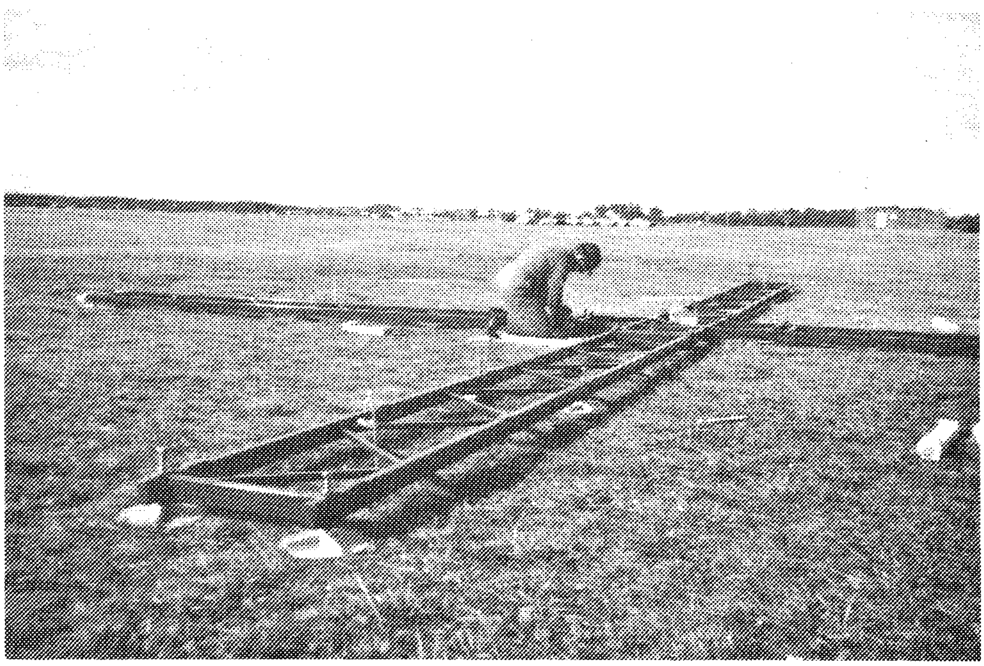
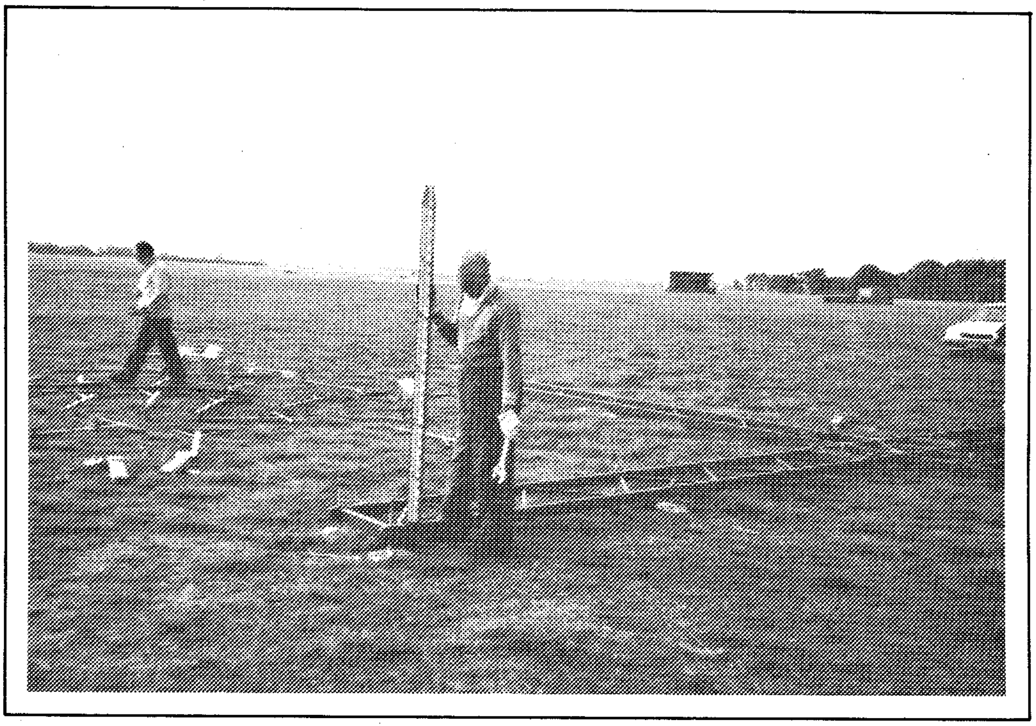
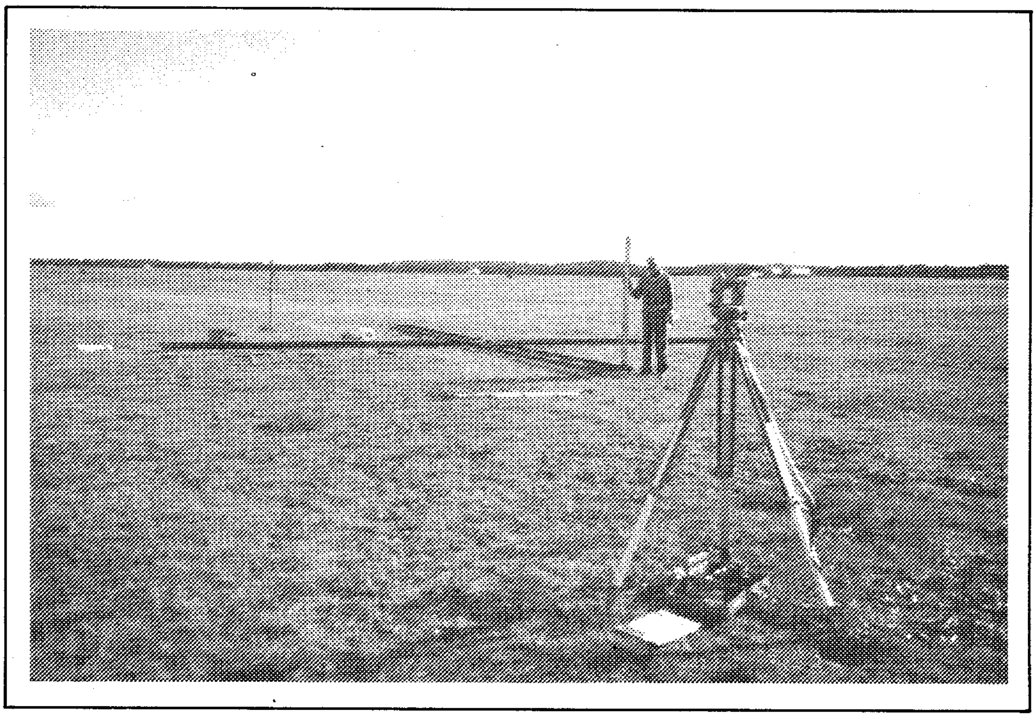


Figure 8. The ground frame footpads and jacking screws



(a)



(b)

Figure 9. Levelling the ground frame using a theodolite and staff

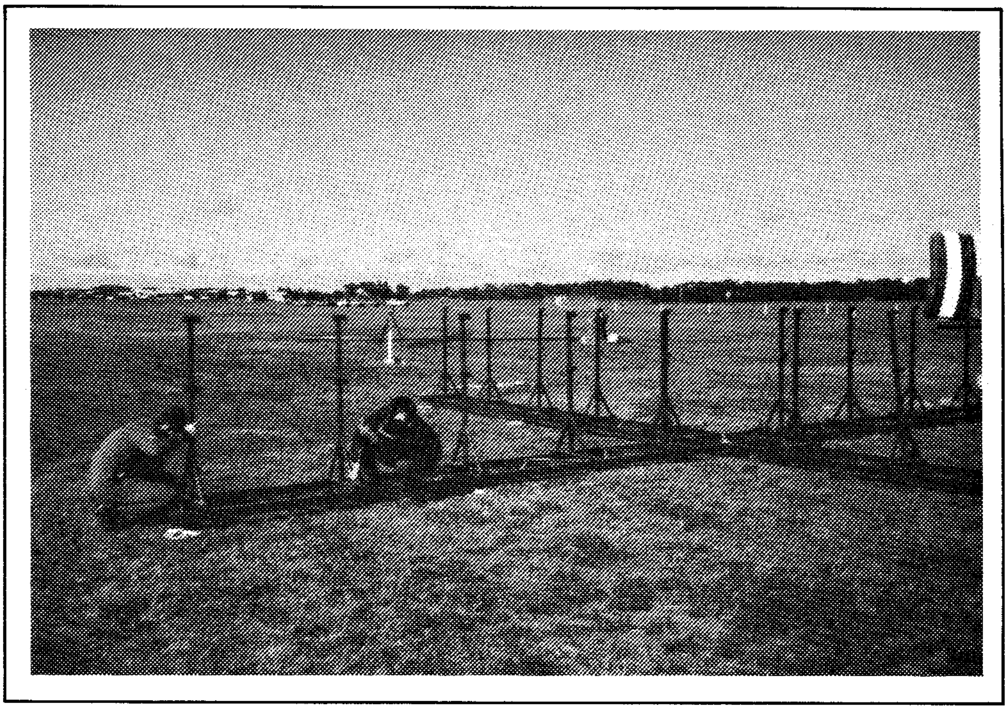


Figure 10. The attachment of the panel support frames to the ground frames

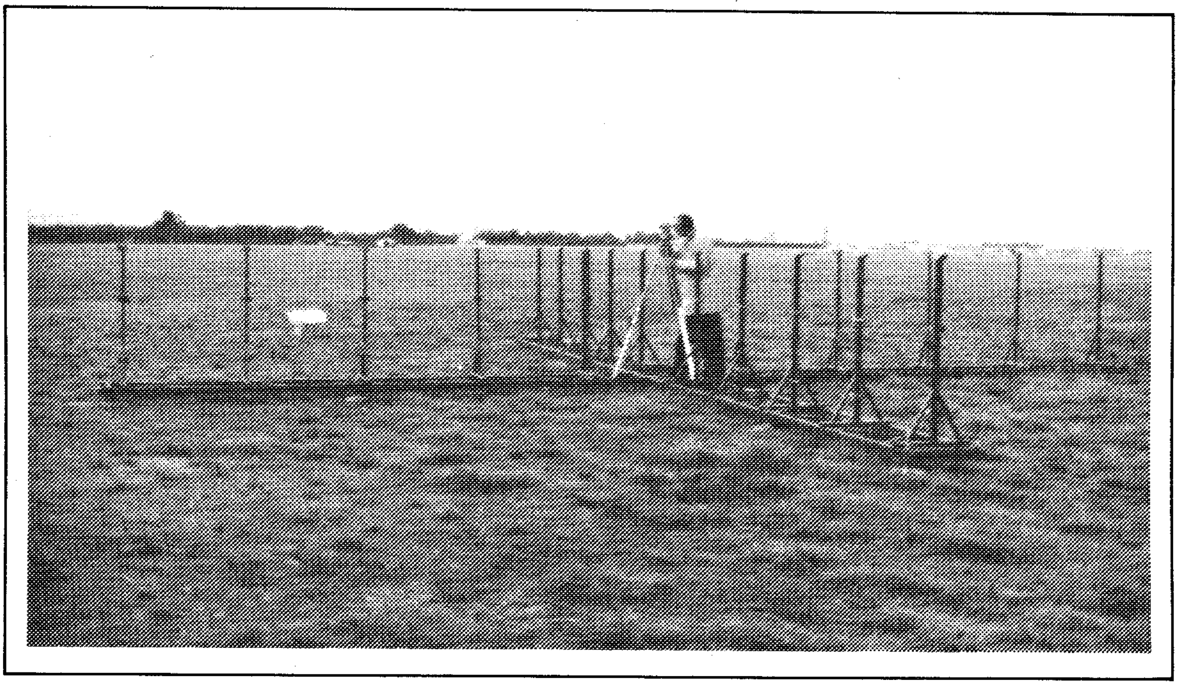


Figure 11. The theodolite positioned over the yoke

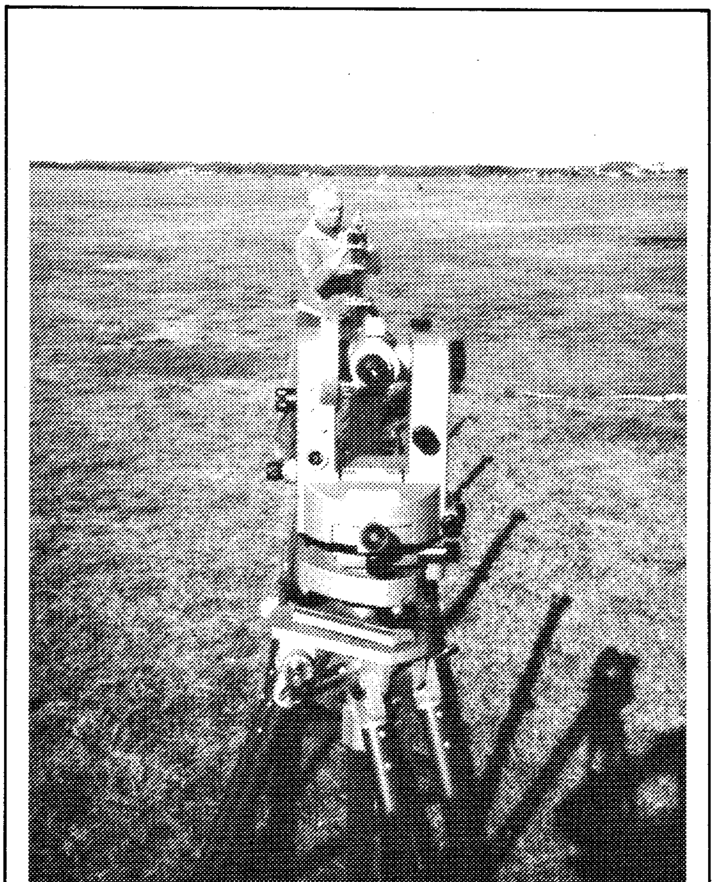


Figure 12. The alignment of the top washers

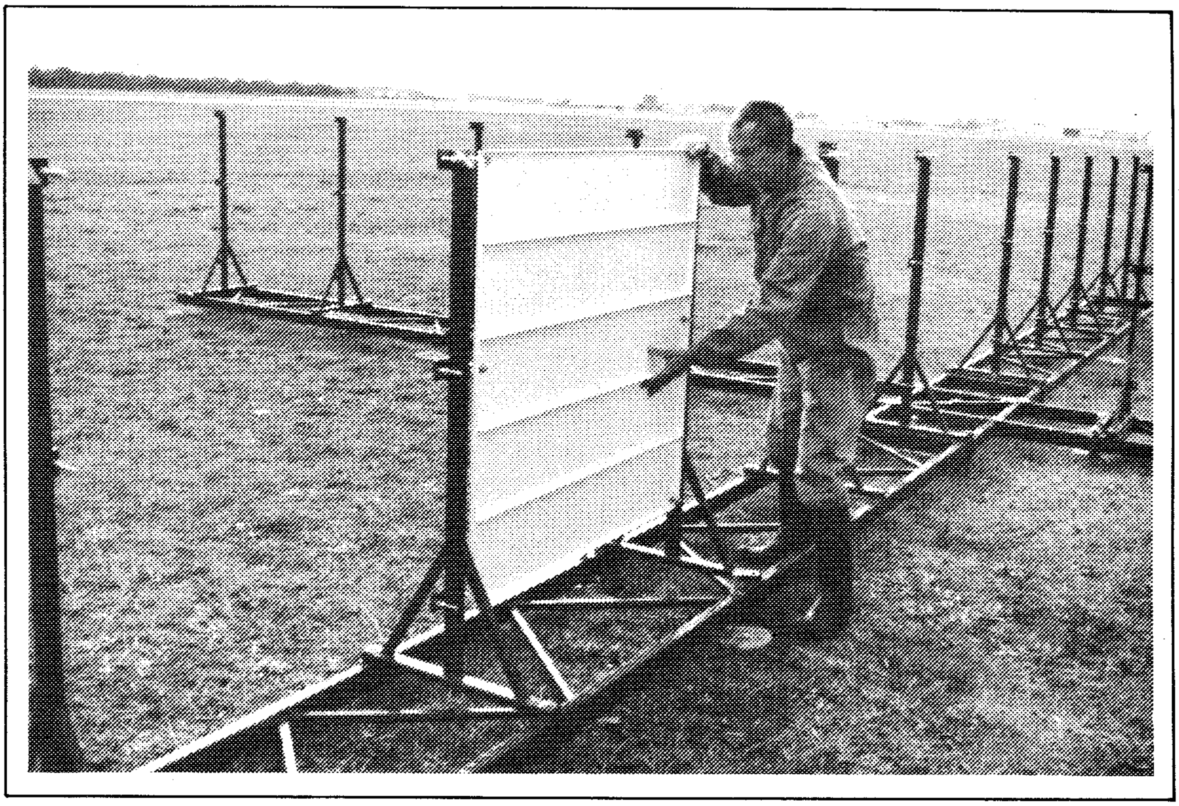


Figure 13. Attachment of a reflector panel

Figure 14. Adjusting the verticality of a panel

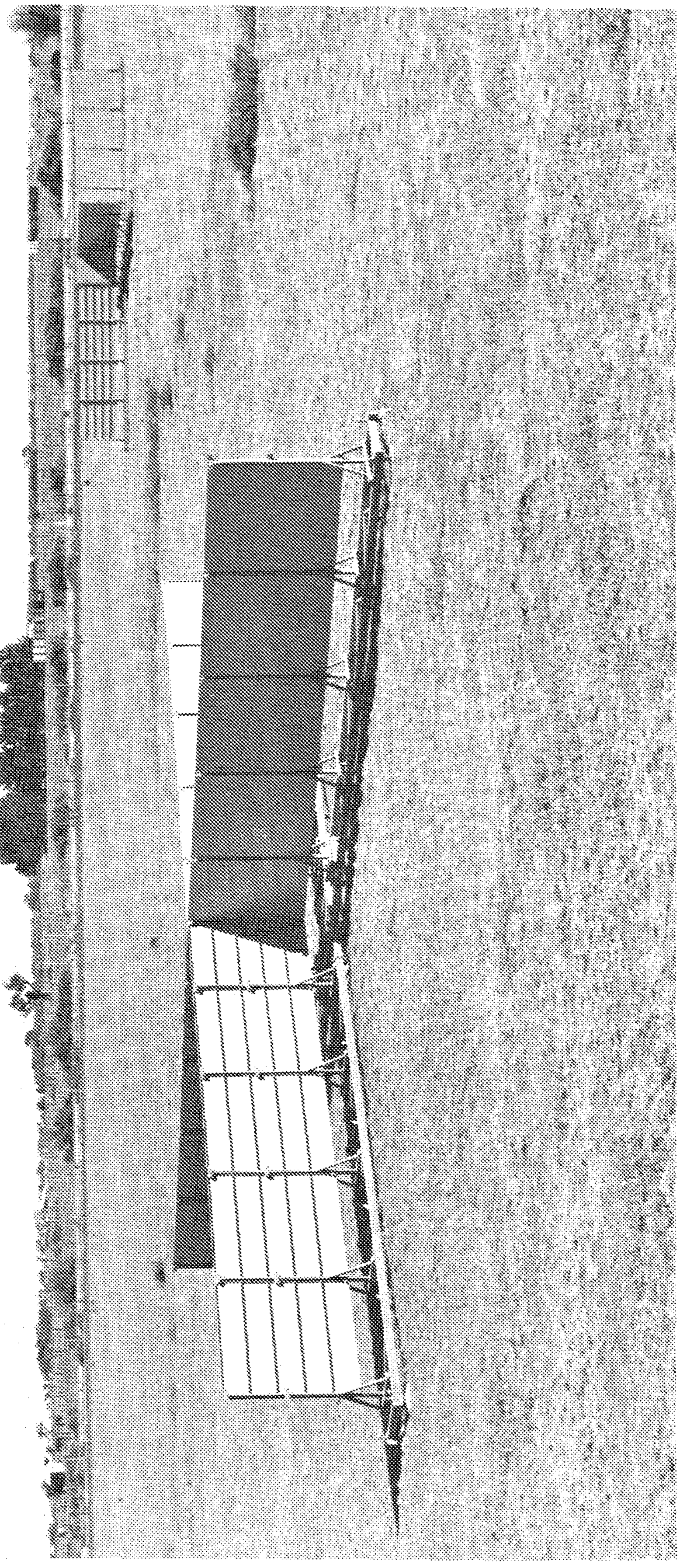


Figure 15. A completed omnidirectional GPCR

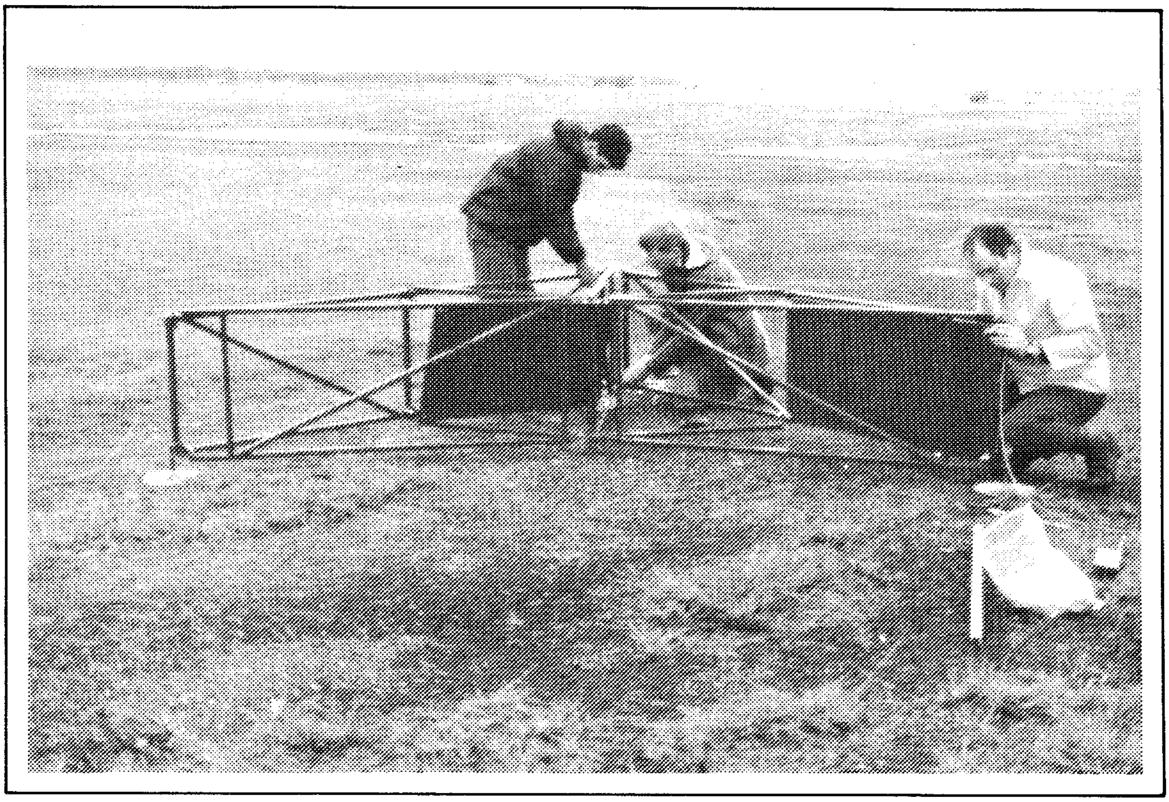


Figure 16. Panels being fitted to a touch-down marker framework

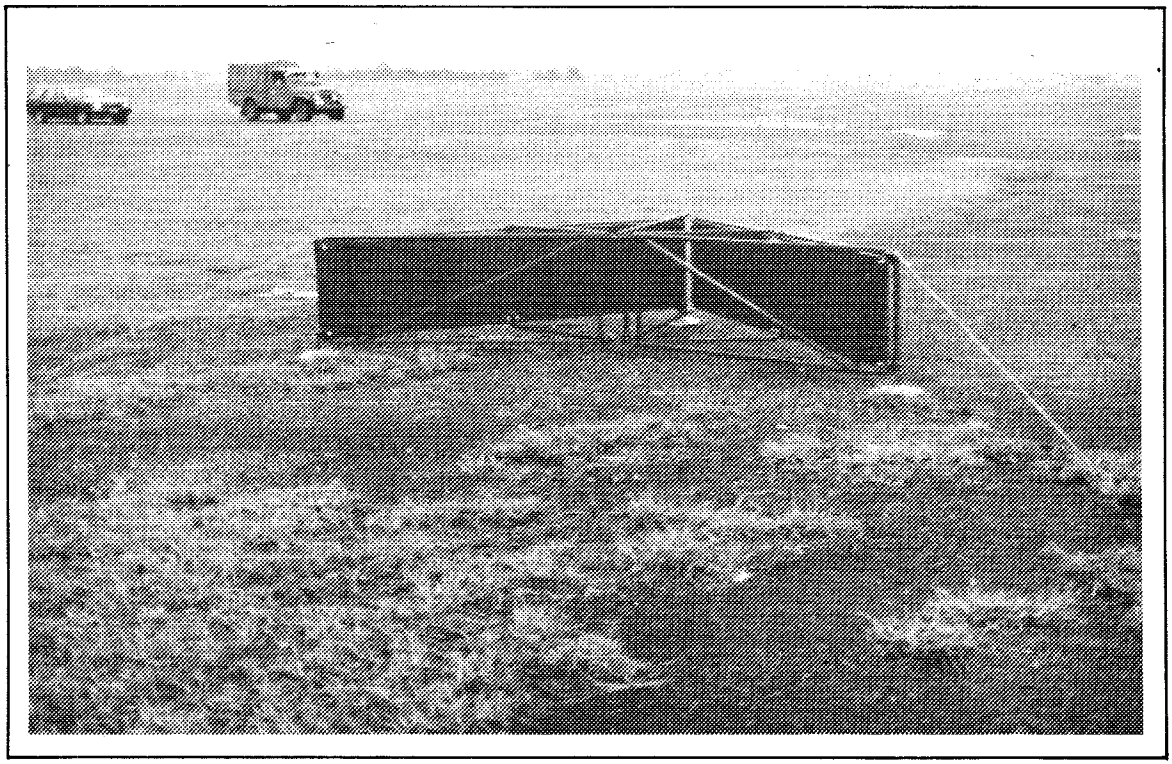


Figure 17. A completed touch-down marker reflector

DOCUMENT CONTROL DATA SHEET

Security classification of this page: UNCLASSIFIED

1 DOCUMENT NUMBERS	**2 SECURITY CLASSIFICATION**
AR Number: AR-004-852	a. Complete Document: Unclassified
Series Number: ERL-0383-MA	b. Title in Isolation: Unclassified
Other Numbers:	c. Summary in Isolation: Unclassified

3 TITLE

THE INSTALLATION REQUIREMENTS AND PROCEDURES FOR THE OMNIDIRECTIONAL GROUND PLANE CORNER REFLECTOR

4 PERSONAL AUTHOR(S):	**5 DOCUMENT DATE:**
R. Triggs	September 1986
	6 6.1 TOTAL NUMBER OF PAGES 18
	6.2 NUMBER OF REFERENCES: 1

7 7.1 CORPORATE AUTHOR(S):	**8 REFERENCE NUMBERS**
Electronics Research Laboratory	a. Task: AIR 92/224
	b. Sponsoring Agency: RAAF
7.2 DOCUMENT SERIES AND NUMBER	**9 COST CODE:**
Electronics Research Laboratory 0383-MA	715985

10 IMPRINT (Publishing organisation)	**11 COMPUTER PROGRAM(S)** (Title(s) and language(s))
Defence Research Centre Salisbury	

12 RELEASE LIMITATIONS (of the document):

Approved for Public Release.

Security classification of this page: UNCLASSIFIED

Security classification of this page: UNCLASSIFIED

13 ANNOUNCEMENT LIMITATIONS (of the information on these pages):

No limitation

14 DESCRIPTORS:

a. EJC Thesaurus Terms: Radar corner reflectors; Omnidirectional

b. Non-Thesaurus Terms: Ground plane corner reflector

15 COSATI CODES:

17090

16 SUMMARY OR ABSTRACT:
(if this is security classified, the announcement of this report will be similarly classified)

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Security classification of this page: UNCLASSIFIED